2022 Tongue River Watershed Interim Monitoring Project Final Report

Sheridan County Conservation District
SCCD Water Quality Improvements #6 NPS2019D

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EXECUTIVE SUMMARY

The Tongue River originates in Wyoming on the eastern side of the Big Horn Mountains and flows through the Towns of Dayton and Ranchester east and north into Montana. The project area, which begins at the Wyoming-Montana state line, consists of approximately 463,990 acres. Annual precipitation ranges from 32 inches in the headwaters to 12 inches near the state line. Major tributaries of the Tongue River above the Town of Ranchester include Little Tongue River, Smith Creek, Columbus Creek, Fivemile Creek, and Wolf Creek. Goose Creek and Prairie Dog Creek are the primary perennial tributaries in the lower portion of the project area, however intermittent draws may contribute to stormwater run-off during precipitation or snowmelt events. Tongue River serves as the municipal water supply for the Towns of Dayton and Ranchester. Tributaries provide irrigation water and make up a portion of the water supply to rural residents in the watershed. The project area includes a combination of private, state, and federal lands, with private lands dominating the portion of the watershed downstream of the Bighorn National Forest (BNF). Land uses include irrigated and non-irrigated hay and crop lands, pasture, livestock grazing, energy development, recreation, the Towns of Dayton and Ranchester, and wildlife habitat. The Tongue River and major tributaries are perennial waterbodies expected to support drinking water supplies (when treated), fish and aquatic life, recreation, wildlife, industry, and agriculture uses. Fivemile Creek and other draws are not expected to support fish populations or drinking water supplies. The State of Wyoming has identified the Tongue River and several tributaries as impaired for recreational use because of bacteria concentrations. Some lower Tongue River segments have also been identified as impaired for cold water fisheries because of high water temperatures.

The Sheridan County Conservation District (SCCD) initiated water quality monitoring on the Tongue River Watershed in 1996. The original project area consisted of 12 sites in approximately 313,121 acres upstream of the Town of Ranchester. The assessment included three sites on the Tongue River, a high and low site on each major tributary (Wolf, Little Tongue, Smith, Columbus and Fivemile), and a lower site on Fivemile Creek. The 1996-1999 Tongue River Watershed Assessment Final Report was completed in September 2000 and resulted in the development of the Tongue River Watershed Plan. The plan outlined the goals, objectives, and action items for addressing bacteria concerns within the watershed.

In 2003, monitoring was completed at eight sites, including the three mainstem sites and the five lower tributary sites. Upper tributary sites had relatively low bacteria levels that were not in exceedance of the standard and were not included in future monitoring. The project boundary was expanded twice since the Tongue River Watershed Assessment. The first expansion, in 2006, included two new sites on the Tongue River between the Town of Ranchester and the confluence with Goose Creek. The section from Goose Creek to the Montana state line was added in 2013 to tie into existing efforts on adjacent watersheds. In the 2013 expansion, four sites on the Tongue River were added, along with the lowermost sites on Goose Creek and Prairie Dog Creek.

There have been seven rounds of interim water quality monitoring since 1999; one in 2003, 2006, 2010, 2013, 2016, 2019, and the most recent in 2022. Interim monitoring includes water quality monitoring along with benthic macroinvertebrate collection and habitat assessments at select sites. Interim monitoring evaluates trends in bacteria and other water quality parameters, including water temperature, pH, conductivity, dissolved oxygen, discharge, and turbidity.

Implementation of the Tongue River Watershed Plan resulted in the development and administration of a water resources improvement program, which included cost-share funding for projects with the potential to benefit water quality. Despite improvement efforts, bacteria concerns continued to exist, and the initial watershed plan was updated in 2007. In 2012, the plan was updated to meet the nine essential elements of a Watershed Based Plan, required by the U.S. Environmental Protection Agency. The plan was most recently updated in 2018 and included updated load reductions and separate load estimates and priority rankings for tributary drainages. Results from interim water quality monitoring influenced the decisions, priority areas, and action items within the updated plan.

Water quality monitoring for 2022 was performed at 13 sites including six sites on the mainstem of the Tongue River, and seven sites on the major tributaries that flow into the Tongue River. These seven tributaries include Smith Creek, Little Tongue River, Columbus Creek, Fivemile Creek, Wolf Creek, Goose Creek, and Prairie Dog Creek. Stations were equipped with a SCCD calibrated staff gauge or located at active USGS gauging stations. Grab samples for bacteria and turbidity were collected five times in the early season from May-July and five times in the late season from July-September. Instantaneous temperature, pH, conductivity, dissolved oxygen (% and mg/L), and gauge height were measured on-site during sampling events. Continuous temperature loggers were used to monitor water temperature at five mainstem stations. Macroinvertebrate collections and habitat assessments were conducted on five mainstem sites of the Tongue River during the month of September. All monitoring methods, standard operating procedures, and QA/QC protocols used for this project were described in the Quality Assurance Project Plan (SCCD, 2022b) and the 2022 Tongue River Watershed Monitoring Project Sampling and Analysis Plan (2022a).

Data quality objectives (DQOs) were established for each monitoring parameter for precision, accuracy, and completeness at levels sufficient to allow SCCD to recognize project goals and objectives. With a few exceptions, all parameters met the DQO's, and data were accepted.

Instantaneous water temperature measurements were recorded above the maximum 20°C instream temperature standard at ten of the 13 sites on at least one occasion; Little Tongue River and the uppermost mainstem, TR09, did not have any temperature measurements above 20°C. Continuous temperature loggers recorded temperatures above 20°C at all but the uppermost site in Tongue River Canyon (TR09).

Conductivity and pH were within the expected ranges. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages, apart from one measurement taken at Fivemile Creek (FMC01) on July 20. Two mainstem sites and three tributary sites had one or more samples that were below the 8.0 mg/L water column concentration recommended to achieve the inter-gravel concentrations for early life stages. Early season turbidity averages were higher at all sites than late season averages.

Bacteria geometric mean concentrations were higher during the early season than in the late season at all mainstem sites and all but one of the tributary sites. All sites, apart from TR09, had early season concentrations in exceedance of the Wyoming water quality standard of 126 organisms/100 mL. Late season concentrations were lower; however, there were still exceedances at all the tributaries, except for GC01, and at mainstem site TR08. Geometric means exceeded the standard during the mid-season at all tributary sites. The opposite was true for mainstem sites, except for TR05.

Early season geometric means increased between 2019 and 2022 at most sites, apart from GC01, PD01, TR08, and SC01. During the late season, most sites decreased or increased only slightly between 2019 and 2022, apart from FMC01, CC01, TR08, and LTR01. Early season bacteria geometric mean concentrations increased at all sites from 2003-2022, apart from Fivemile Creek and Smith Creek. Late season geometric

means increased at most of the lower sites from 2003-2022, whereas means at most of the upper sites decreased compared to late season means in 2003. Early season geometric mean trendlines appear to be increasing across the years at most sites, apart from Goose Creek, Fivemile Creek, and Smith Creek. Trendlines are more varied for late season geometric means, with a positive, or increasing trendline, occurring at TR01, Prairie Dog Creek, TR03, TR05, and TR07. Goose Creek, Fivemile Creek, Wolf Creek, TR08, CC01, LTR01, SC01, and TR09 show a decreasing geometric mean trend across the years.

Macroinvertebrate sampling began by Wyoming Department of Environmental Quality (DEQ) in 1993 and SCCD in 1996 using the same collection and analytical methods to allow for comparison of data sets in the evaluation of biological condition for water bodies sampled within the project area. The collection and analysis of stream benthic macroinvertebrate samples during 2022 revealed similar trends in biological condition observed during previous monitoring at Tongue River mainstem stations. No Tongue River tributary stations were sampled during this 2022 report period. Biological condition scores at reference station TR09 varied little over the years. With the exception of 1995 and 2007, the biological condition scores indicated full support for aquatic life use. The slightly positive trendline showing improvement in biological condition at station TR09 over the years indicated stability in the biological community and confirmed that station TR09 was a representative reference station. The biological condition of the benthic macroinvertebrate community at Tongue River TR07 station varied little from the period of 1996 through 1999 and indicated indeterminate or full support for aquatic life use each year. However, a slight negative trendline indicated a general decline in biological condition since sampling began in 1996 to the present. The biological condition at station TR05 from 1995 to 2004 indicated full support for aquatic life use. Sampling from 2006 to 2022 indicated indeterminate support for aquatic life use. The negative trendline for biological condition at TR05 indicated a gradual downward trend in biological condition since sampling began in 1995. Intermittent sampling at station TR03 just upstream of the Decker Highway bridge from 1998 to 2022 indicated full support for aquatic life use. However, there has been a slight downward trend in biological condition over the years. Biological condition scores at the most downstream station TR01 located near the Montana border indicated full support for aquatic life use during each year since 1998. However, a graph of biological condition scores indicated that biological condition has declined over time. Full support for aquatic life use may change should the decline in biological condition continue.

No threatened or endangered benthic macroinvertebrate taxa or fish species have been identified since sampling began in the Tongue River watershed project area in 1993. The generally widespread occurrence of taxa sensitive to toxics indicated that water contained no toxic substances in sufficient concentration to prevent the establishment and survival of these taxa. The disappearance of stoneflies since the latter 1990's noted at some mainstem Tongue River stations continued. The general disappearance of stoneflies at Tongue River stations downstream of TR09 since the 1990's indicates that water quality and habitat change have negatively affected this pollution intolerant group of aquatic insects. Monitoring of aquatic benthic macroinvertebrate communities in the Tongue River watershed have not identified the presence of aquatic invasive species of concern to the Wyoming Game and Fish Department. No zebra mussel (*Dreissena polymorpha)*, quagga mussel (*Dreissena rostriformis bugensis),* New Zealand Mudsnail (*Potamopyrgus antipodarum)* and the Asian Clam (*Corbicula fluminea*) have been identified in the Tongue River watershed. Recommended future benthic macroinvertebrate monitoring by SCCD will be attentive to the presence of aquatic invasive species.

Tubifex tubifex, a species of aquatic worm, involved in the whirling disease life cycle that may decimate trout populations, have not been collected at Tongue River stations since monitoring began indicating a low probability for the occurrence of whirling disease. However, the presence of the genus *Tubifex* and immature Tubificid worms in samples collected in the Tongue River watershed suggest the future potential occurrence

of *T. Tubifex*. Whirling disease has not been detected in the Tongue River watershed or nearby Little Goose Creek and Big Goose Creek watersheds.

Like other watersheds in Sheridan County, the Tongue River watershed serves as an important resource for agriculture, wildlife, and scenic and recreational value. Best management practices addressing bacteria and sediment sources, irrigation water conservation and management, and riparian livestock management can be implemented to improve water quality and the overall health of the watershed.

Attempts to determine if improvements in overall water quality have been achieved are often difficult, particularly when comparing water quality data that has been collected during seasons with different hydrological and meteorological conditions. Although normal flow conditions cannot be anticipated nor expected during monitoring, these varying conditions do make water quality comparisons more difficult.

SCCD will continue to monitor water quality in the Tongue River watershed on a three-year rotation, pending available funding sources. The SCCD anticipates that voluntary, incentive-based watershed planning and implementation efforts will eventually be successful; however, it may require several years to measure these achievements. Nonetheless, each improvement project implemented in the watershed certainly induces positive water quality changes, whether they are immediately evident or not.

CHAPTER 1 PROJECT AREA DESCRIPTION

1.1 WATERSHED DESCRIPTION

The Tongue River originates in the Bighorn National Forest (BNF) on the eastern side of the Big Horn Mountains, flows east and north through the towns of Dayton and Ranchester, and eventually into the Yellowstone River in Montana. The project area, which begins at the Wyoming-Montana state line, consists of approximately 463,990 acres in northern Sheridan County, in north-central Wyoming and Big Horn County in south-east Montana (Appendix A). Of the 463,990 acres, 81,207 acres (17.5 %) are in Montana adjacent to smaller, ephemeral tributaries and draws and are not included in the following project area description. This area did not include the entire Goose Creek and Prairie Dog Creek watershed areas, which have separate monitoring and improvement efforts. The designated project area, including the project area description, includes only a small area above the sampling site at those stations.

Elevation of the Tongue River within the project area starts at 4,160 feet in the Tongue River canyon (TR09) and drops to 3,420 feet just below the confluence with Prairie Dog Creek at TR01. The total elevation difference is 740 feet over approximately 53.01 miles (13.96 ft/mile or 0.07% slope). The annual precipitation is 28 to 32 inches at the headwaters in the BNF. At the uppermost monitoring station in Tongue River Canyon (TR09), the annual precipitation is 16 to 18 inches. Downstream of the Town of Ranchester, the watershed transitions to a drier precipitation zone; near the Wyoming-Montana state line, at TR01, the precipitation is only 12 to 14 inches (Appendix A). The watershed is comprised of three ecological site groups (Appendix A). Sites within the lower watershed, below the Town of Ranchester to the State Line, are in the 10-14" Northern Plains Ecological Site Group. The middle to upper portion of the watershed, including Tongue River Sites TR07 and TR08, are within the 15-19" Northern Plains Ecological Site Group. The 20+" Mountains Ecological Site Group encompasses the remaining portion of the watershed, including all the area within the BNF and the uppermost sample station.

Major tributaries of the Tongue River above the Town of Ranchester include Little Tongue River, Smith Creek, Columbus Creek, Fivemile Creek, and Wolf Creek. Goose Creek and Prairie Dog Creek are the primary perennial tributaries below the Town of Ranchester, however intermittent draws may contribute stormwater run-off during precipitation or snowmelt events. The largest of these draws include Six-mile Creek, Earley Creek, North Dry Creek, Slater Creek, South Dry Creek, and Hidden Water Creek. Tongue River serves as the municipal water supply for the Towns of Dayton and Ranchester. Tributaries provide irrigation water to ranches and make up a portion of the water supply to rural residents in the watershed. Diversions result in the transferring and mixing of waters from different areas of the watershed.

1.2 LAND OWNERSHIP AND USES

Descriptions of land ownership and uses are limited to 382,783 acres within the State of Wyoming. The project area includes a combination of private, State, and Federal lands with private lands dominating the portion of the watershed downstream of the BNF (Appendix A).

Nearly 177,127 acres (46%) are privately owned. State lands comprise approximately 24,664 acres (6%) and include the Amsden Creek Big Game Winter Range. Federal lands constitute approximately 180,993 (47%) of the total acres, including:

- 174,111 acres managed by the BNF,
- 5,207 acres managed by the Bureau of Land Management (BLM),
- 1,150 managed by the Department of Defense, and
- 525 acres managed by the United States Fish and Wildlife Service (USFWS).

Land uses within the watershed include irrigated and non-irrigated hay and crop lands, dry land pasture, livestock grazing, energy development, various types of recreation, the urban areas of Dayton and Ranchester, and prime wildlife habitat that is concentrated along stream bottoms and brushy draws where riparian zones are intact (Appendix A). Sensitive species including warm water game and non-game fish, sage grouse and prairie dog populations occur within the project area. The headwaters, located in the BNF, supports wildlife habitat, livestock grazing, logging, recreation, including angling, camping, hiking, ATV trails, and other uses. A railroad, local highway, and the interstate run parallel to the Tongue River between the Town of Ranchester and Acme. Near the old Acme townsite, the former Acme Power Plant Brownfield site is located adjacent to the Tongue River. The lower portion of the project area has more coal bed methane, mining, and other energy development than other areas of the watershed.

There are five permitted point source discharges (not including storm drains) within the upper portion of the project area; four are from sanitary wastewater facilities (including the Towns of Dayton and Ranchester), and one from a Concentrated Animal Feeding Operation (CAFO). The lower portion of the project area contains point source discharges from coal bed methane production, although some of these are inactive. The City of Sheridan Wastewater Treatment Plant discharges into Goose Creek approximately 7 miles upstream of the GC01 site. Approximately 5 miles upstream of the GC01 site, the KOA campground also had a permitted discharge from a small wastewater facility; however, that system was replaced with a connection to the City of Sheridan sanitary sewer system in 2017.

The mainstem of the Tongue River and major tributaries contain numerous small to very large ranches. Status for domestic wastewater treatment on ranches and rural subdivisions is unknown. Agriculture-related land use dominates the watershed. Agricultural operations center on cattle and hay production enhanced by irrigation water from the Tongue River and its tributaries during the summer growing season. A more comprehensive, detailed description of the project area has been previously provided in the 1996-1999 Tongue River Watershed Assessment Final Report (SCCD, 2000a), which includes narrative descriptions of water uses, land uses, surface geology, soil types, and other factors.

1.3 STREAM CLASSIFICATIONS AND BENEFICIAL USES

The Wyoming Department of Environmental Quality (WDEQ) is charged with implementing the policies of the Clean Water Act and providing for the "highest possible water quality" for activities on a waterbody (WDEQ, 2018b). Depending upon its classification, a waterbody is expected to be suitable for certain uses (Table 1-1).

Table 1-1. Wyoming surface water classes and use designations (WDEQ/WQD, 2021a)

Class	Drinking Water[2]	Game Fish[3]	Non-Game Fish[3]	Fish Consumption[4]	Other Aquatic Life[5]	Recreation[6]	Wildlife[7]	Agriculture[8]	Industry[9]	Scenic Value[10]
1[1]	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	Yes	Yes	Yes	Yes	Yes
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2A	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2C	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2D	No	When present	When present	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3 (A-D)	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4 (A-C)	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

[1] Class 1 waters are not protected for all uses in all circumstances. For example, all waters in the National Parks and Wilderness are Class 1, however, all do not support fisheries or other aquatic life uses (e.g., hot springs, ephemeral waters, wet meadows etc.). For stormwater permitting, 401 Certification, and WQ assessment purposes, the actual uses on each particular water must be determined independently.

Stream classifications are assigned by WDEQ and identified on the Wyoming Surface Water Classification List (WDEQ/WQD, 2021a) or in subsequent reports. Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2018b) describes the surface water classes and designated uses, and the water quality standards that must be achieved for a Wyoming waterbody to support its designated uses.

Streams within the Tongue River watershed project area are classified as either 2AB or 3B (Table 1-2). Class 2AB waters are perennial waterbodies expected to support drinking water supplies (when treated), fish and aquatic life, recreation, wildlife, industry, and agriculture uses (WDEQ/WQD, 2021a). Fivemile Creek and other draws, which are Class 3B surface waters, are not expected to support fish populations or drinking water supplies.

1.4 STREAM IMPAIRMENTS AND LISTINGS

States are required to summarize water quality conditions in the state through section 305(b) of the Clean Water Act; this report is commonly known as the 305(b) report and is published every two years. If a waterbody exceeds narrative or numeric water quality standards, it is considered impaired or not meeting its designated uses. Section 303(d) of the Clean Water Act requires states to identify waters that are not supporting their designated uses and/or need to have a Total Maximum Daily Load (TMDL) established to support the designated uses. A TMDL describes the amount of a given pollutant a waterbody can receive and still meet water quality standards. Currently, impaired waterbodies are first included on the Wyoming 303(d)

list of Waters Requiring TMDLS under Category 5 (WDEQ/WQD, 2020). Once a TMDL is completed, a waterbody is moved from Category 5 to Category 4, which includes the list of waterbodies with TMDLs.

Some streams within Tongue River Watershed were listed as early as 1996 but were removed or included in the list of waterbodies requiring further monitoring in the 1998 list. Subsequent monitoring resulted in impairment designations on the Tongue River and several tributaries (Table 1-2). The Goose Creek Watershed TMDL (SWCA, 2010) was completed in 2010 and the Prairie Dog Creek Watershed TMDL (Tetra Tech, 2017) was approved in 2018, therefore the listed segments within those watersheds are included on the Category 4 list. Completion of the Tongue River watershed TMDL is underway.

Table 1-2. Impaired stream segments within the Tongue River watershed (WDEQ/WQD, 2020)

Name	Class	Location	Miles	Impairment	List Date
Tongue River	2AB	From Wolf Creek Road upstream to the confluence with Smith Creek	7.5	*E. coli*	2018
Tongue River	2AB	From Monarch Road upstream to Wolf Creek Road	13.5	*E. coli*	2010
Tongue River	2AB	From the confluence with Goose Creek to Monarch Road	4.7	*E. coli*	2018
Tongue River	2AB	From Goose Creek downstream to the Montana border	22.1	Temperature	2002
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Fecal Coliform	2004
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Manganese	2012
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Temperature	2012
Prairie Dog Creek	2AB	From Tongue River to a point 6.7 miles upstream	6.7	Fecal Coliform	2004
Prairie Dog Creek	2AB	From Tongue River a point 6.7 miles upstream	6.7	Manganese	2002
Prairie Dog Creek	2AB	From Tongue River a point 6.7 miles upstream	6.7	Temperature	2012
Goose Creek	2AB	From Little Goose Creek downstream to the Tongue River	12.7	Habitat Alterations, Sediment	2006
Goose Creek	2AB	From Little Goose Creek downstream to the Tongue River	12.7	Fecal Coliform	2000
Wolf Creek	2AB	From Tongue River upstream to East Wolf Creek	10.6	Fecal Coliform	2002
Fivemile Creek	3B	From Tongue River upstream to Hanover Ditch	2.1	Fecal Coliform	2002
Columbus Creek	2AB	From Tongue River to a point 3.1 miles upstream	3.1	Fecal Coliform	2002
Little Tongue River	2AB	From Tongue River upstream to Frisbee Ditch	4.8	*E. coli*	2002
Smith Creek	2AB	From Tongue River to a point 5.8 miles upstream	5.8	Fecal Coliform	2002
North Tongue River (Bighorn National Forest)	1	From Road 171 upstream to Pole Creek	11.1	Fecal Coliform	2004

CHAPTER 2 PROJECT BACKGROUND

2.1 PREVIOUS SCCD MONITORING EFFORTS

The Sheridan County Conservation District (SCCD) initiated water quality monitoring in the Tongue River Watershed in 1996, in partnership with the USDA Natural Resources Conservation Service (NRCS) and the Tongue River Watershed steering committee. The original 1996 project area consisted of approximately 313,121 acres and contained twelve water quality monitoring sites: three mainstem sites and eight tributary sites. The 1996-1999 Tongue River Watershed Assessment Final Report was completed in September 2000 and identified fecal coliform impairments on Fivemile Creek, Columbus Creek, Smith Creek, Little Tongue River, and Wolf Creek (SCCD, 2000a). The Lower Tongue River station, near the Ranchester Water Treatment Plant intake, also exceeded the Wyoming water quality standard for fecal coliform on one occasion. Other water quality parameters monitored during this assessment (including nutrients and pesticides) were found at low or non-detectable levels, suggesting fertilizers and pesticides appeared well managed within the watershed.

Previous interim water quality monitoring was conducted in 2003, 2006, 2010, 2013, 2016, and 2019 utilizing many of the same monitoring sites, water quality parameters, and sampling periods (SCCD, 2004; SCCD, 2007a; SCCD, 2012a; SCCD, 2015; SCCD, 2017; SCCD, 2020). Upper tributary sites were not monitored after 2000 because no water quality impairments were identified at these stations during the initial assessment. In addition, SCCD did not collect nutrient, pesticide, or herbicide data because these parameters were found at low or non-detectable levels during the initial assessment. Interim monitoring included water quality monitoring along with benthic macroinvertebrates and habitat assessments at a limited number of stations. In 2003 and 2006, SCCD collected fecal coliform and *E. coli* samples to correspond with changes in WDEQ water quality standards. The water quality parameters included water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, and *E. coli* bacteria.

The project boundary was expanded in 2006 and again in 2013. The 2006 expansion included two new sites on the Tongue River between the Town of Ranchester and the confluence with Goose Creek. The section from Goose Creek to the Montana state line was added in 2013 to tie into existing efforts on adjacent watersheds. SCCD added four new Tongue River sites, along with sites on Goose Creek (GC01) and Prairie Dog Creek (PD01), which are the primary tributaries in the lower watershed.

Bacteria concentrations at Tongue River sites were typically higher in the early season than in the late season, while tributary concentrations were much more variable. Early season geometric means increased between 2019 and 2022 at most sites, apart from GC01, PD01, TR08, and SC01. During the late season, most sites decreased or increased only slightly between 2019 and 2022, apart from FMC01, CC01, TR08, and LTR01. Extremes in short and long-term weather conditions have produced bacteria data that are not directly comparable among years. Nonetheless, values that exceed bacteria standards were observed on essentially the same stream reaches year after year and indicate water quality impairments continue to exist, regardless of hydrologic conditions.

2.2 WATERSHED PLANNING AND IMPLEMENTATION

The 1996-1999 Tongue River assessment served as the foundation of a local watershed planning and improvement effort. The Tongue River Watershed steering committee, which consisted of stakeholders

representing rural, urban, and other local interests, recognized bacteria levels as a major concern. Wildlife, livestock and other domestic animals, and humans were identified as possible bacteria sources. The Tongue River Watershed Plan was developed to address these concerns and was approved by WDEQ in 2000 (SCCD, 2000b). The plan outlined the goals, objectives, and action items for improving water quality with the Tongue River watershed, along with prioritizing best management practices, and providing future recommendations. This initial plan included recommendations for continued monitoring, information and education, and improvement projects.

Since the completion of the original Tongue River Watershed Management Plan, there have been two revisions and one update. The Tongue River Watershed Management Plan, Revision 1 (SCCD, 2007b) recommended continuation of improvement efforts and monitoring. Although excess sediment was not identified as a source of impairment in the Tongue River watershed, it remained a concern for watershed residents. As a result, sediment contributions related to unstable channels and irrigation diversions were included in the 2007 Plan. In 2012, the SCCD and steering committee developed the Tongue River Watershed Plan, Revision 2 (SCCD, 2012b) to include the nine essential elements required by the USEPA. The 2012 Plan identifies impaired waters; designates and characterizes distinct subwatersheds; quantifies existing pollutant loads from previous monitoring efforts; develops estimates of the load reductions required to meet water quality standards; and develops effective management action items to reduce pollutant loads.

The Tongue River Watershed Plan, 2018 Update (SCCD, 2019) included updated load reductions to meet State of Wyoming Water Quality Standards for primary contact recreation and proposed action items for meeting those requirements. Separate load estimates and priority rankings were calculated for tributary drainages. Results from interim water quality monitoring influenced the priority areas and action items within the Tongue River Watershed Plan, 2018 Update. As part of the update, SCCD/NRCS will continue to implement the following recommendations:

- Maintain a viable watershed improvement effort by providing leadership and project oversight
- Continue mitigation efforts in the highest priority reaches, which include Smith Creek, Little Tongue River, Columbus Creek, and Fivemile Creek, along with their tributaries
- Reduce water quality impacts, other than bacteria, such as nutrient concentrations, organic matter, temperature, and sediment loads
- Increase awareness and encourage participation in the watershed improvement efforts

As of March 2023, there have been numerous improvement projects completed within the Tongue River watershed, including 23 fencing and stockwater projects, 13 irrigation projects, 12 septic system replacements, seven diversion projects, five invasive grass treatments, four pet waste station installations, one reservoir improvement, one Russian Olive removal, and numerous stream stabilization projects, willow plantings, and riparian buffers (Appendix A). Some projects, mostly the invasive grass treatments and irrigation projects, were contracted through USDA programs while others were completed by the landowner without assistance from SCCD or USDA. Addition of other partner projects to the progress register is an ongoing process.

The Tongue River Watershed improvement effort has helped to increase awareness about several important resource issues and has led to more public interest in the watershed. The SCCD anticipates that voluntary, incentive-based watershed planning and implementation efforts will eventually be successful; however, it may require several years to measure these achievements. Continued monitoring can provide information on water quality changes over the long-term.

2.3 PROJECT PURPOSE AND OBJECTIVES

The purpose of this project was to complete the 2022 interim monitoring milestone in the Tongue River Watershed Plan, 2018 Update (SCCD, 2019). The 2022 monitoring is part of a three-year monitoring rotation currently conducted by SCCD on the Tongue River, Goose Creek, and Prairie Dog Creek watersheds and is funded through the Sheridan County Watershed Improvements #6 Project funded by WDEQ through Section 319 of the Clean Water Act.

The project was consistent with the goals and overarching principles outlined in the Wyoming Nonpoint Source Management Plan Update (WDEQ, 2013). The monitoring is part of a locally led collaborative process that includes information and education programs and project implementation through the organization and facilitation of local stakeholder groups.

The specific objectives of this project were to use water quality monitoring information/trends:

- To calculate load reduction estimates needed to meet primary contact recreation standards,
- To identify and prioritize areas affected by nonpoint source pollution, and
- To evaluate effectiveness of implementation of improvement projects and other activities.

CHAPTER 3 HISTORICAL AND CURRENT DATA

Historical data, for the purposes of this project, are defined as data greater than five years old from the start of the 1996-1999 Assessment. The 1996-1999 Tongue River Watershed Assessment Final Report included a comprehensive compilation of known water quality data for the watershed and contained historical and current data through 1999 (SCCD, 2000a). Data collected by SCCD, government agencies, and various other sources were provided in tabular form and are not repeated in this document.

Summaries of current water quality data collected after the 1996-1999 Assessment were provided in the reports for the 2003, 2006, 2010, 2013, 2016, and 2019 interim monitoring (SCCD, 2004; SCCD, 2007a; SCCD, 2012a; SCCD, 2015; SCCD, 2017; SCCD, 2020).

In the past, the U.S. Geological Survey (USGS) has collected water quality and hydrologic information from various stations in the Tongue River watershed; however, data collection from most of these stations has been discontinued or has been taken over by the State Engineer's Office (SEO). Current and historical flow data were available for Stations 06306000 (TR01), 06306250 (PD01), 06306250 (GC01), and 0629800 (TR09) in 2022. SCCD instantaneous discharge measurements were compared to hydrographs developed for each of the stations listed, apart from TR09, where the SCCD used real-time flow data from the SEO (Appendix C).

CHAPTER 4 MONITORING DESIGN

4.1 KEY PROJECT PERSONNEL AND RESPONSIBILITIES

This project involved various individuals from the SCCD, NRCS, WDEQ, and others (Table 4-1). The District Manager provided project oversight and assisted with field monitoring and reporting review. The Program Specialist supervised field monitoring and was responsible for the implementation of the Quality Assurance/Quality Control (QA/QC) procedures and report development. The seasonal intern and NRCS personnel assisted with the project as needed. WDEQ provided oversight as well as administration of the funds provided through Section 319 of the Clean Water Act. Stakeholders and landowners provided site access for sampling and other information.

Table 4-1. Key personnel and organizations

Personnel/Organization	Project Role
Carrie Rogaczewski, District Manager	Project oversight; assistance with field monitoring; QA/QC oversight; reporting review
Jackie Turner, Program Specialist	Field monitoring; data collection and validation; QA/QC protocols, and reporting
Lila Walker, Watershed Intern	Assisted with site set-up, field monitoring and data entry
NRCS Sheridan Field Office Staff	Field monitoring assistance
SCCD Board of Supervisors	Project review; field monitoring assistance
Wyoming Department of Environmental Quality	Project review; QA/QC review; field audits; funding administration
Inter-Mountain Laboratories	Laboratory analyses of water quality samples
Aquatic Assessments, Inc.	Macroinvertebrate sample sorting and midge identification; macroinvertebrate data interpretation
Aquatic Biology Associates	Macroinvertebrate sample identification and analyses
Landowners/ Steering Committee	Project and data review; sampling access

4.2 MONITORING PARAMETERS

Water quality parameters monitored in 2022 included water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, and *E. coli*. Monitoring was performed at 13 sites including six sites on the mainstem of the Tongue River and seven sites on the major tributaries (Appendix A). Samples were collected five times from May-July and five times from July-September. Continuous data loggers recorded water temperatures at five mainstem sites at 15-minute intervals. Macroinvertebrate sampling and habitat assessments were performed at five mainstem sites in September.

4.3 SAMPLING AND ANALYSIS METHODS

Water quality samples, discharge measurements, macroinvertebrate sampling, and habitat assessments were performed according to the methods described in the Sampling Analysis Plan (SCCD, 2022a) and the SCCD Water Quality Monitoring Program Quality Assurance Project Plan (2022b). These documents were developed according to the WDEQ Manual of Standard Operating Procedures for Sample Collection and Analysis (WDEQ/WQD, 2021b) and accepted analytical methods (Table 4-2). Samples were obtained from representative sample riffles.

Table 4-2. Standard field and laboratory methods applicable to 2022 monitoring

Parameter	Sample Method / SOP *	Reporting Units	Analytical Method	Preservative	Holding Time	Reporting Limit
Temperature, Water (Instantaneous)	See SOP for *Temperature, Water*	°C	SM 2550-B	Measured *in situ*	NA	0° to 100 °C 0.1 °C
Temperature, Water (Continuous)	See SOP for *Temperature Logger Calibration and Placement - Wadeable Streams and Rivers*	°C	SM 2550-B	Measured *in situ*	NA	-20° to 70°C 0.14°C (at 25°C)
pH	See SOP for *pH*	SU	SM 4500-H+B	Measured *in situ*	NA	0.0-14.0 ± 0.01
Conductivity	See SOP for *Conductance, Specific (Conductivity)*	µS/cm	SM 2510-B	Measured *in situ*	NA	0-1999 µS/cm ± 0.10
Dissolved Oxygen (Probe)	See SOP for *Dissolved Oxygen (DO)*	mg/L; % saturation	ASTM D 885-05 / SM 4500-O-G / EPA 360.1	Measured *in situ*	NA	0-50 mg/L ± 0.01
Escherichia coli (E. coli) Bacteria	See SOP for *Coliform Bacteria Sampling Procedure*	MPN/100 mL	SM 9223-B Pace Analytical	Iced to ≤ 10°C	8 hours	1 MPN/100 mL
Turbidity	See SOP for *Turbidity*	NTU	SM 2130-B Pace Analytical	Iced to ≤ 6°C	48 hours	± 0.10
Stage height	See SOP for Calibrated Staff Gauge	cfs	See SOP for *Stream Discharge - Wadeable Streams and Rivers*	None, FM	NA	NA
Discharge	See SOP for *Stream Discharge - Wadeable Streams and Rivers*	cfs	See SOP for *Stream Discharge - Wadeable Streams and Rivers*	None, FM	NA	0.01
Macroinvertebrates	See SOP for *Macroinvertebrate Sampling – Targeted Riffle/ Macroinvertebrate Sampling –Depths Up to 1.5 Feet*	Metrics	Targeted Riffle Method (King, K.W., 1993)	99% Ethyl Alcohol; see SOP for *Macro-invertebrate Sample Preservation*	Indefinite	NA

* Data collection methods typically follow referenced standard operating procedures; however, modifications may be made on a case-by-case basis. Modifications to the method will be documented either in the SAP or within the Methods section of publications presenting the data.
Abbreviations: SOP - Standard Operating Procedure (unless otherwise stated all SOPs can be found in WDEQ/WQD 2021b); SM – Standard Methods; NA – Not Applicable; FM – Field Measurement; MPN – Most Probable Number.

Sample sites were equipped with a staff gauge for flow estimation apart from TR09, which was already equipped with a USGS gauge (Station 06298000). During site reconnaissance, staff gauges were inspected, surveyed, and replaced if needed. Upon installation and inspection, gauges were surveyed and compared with a permanent benchmark. Staff gauge calibrations were performed by measuring instantaneous discharge with a Marsh-McBirney 2000 current meter using the mid-section method (WDEQ/WQD, 2021b). The resulting stage-discharge relationships were used to estimate flow during sampling events.

Grab samples for *E. coli* and turbidity were collected within two separate 60-day periods in May-July and July-September. Gauge height, pH, conductivity, dissolved oxygen, and instantaneous water temperature were also measured during these sampling events. Continuous temperature data were collected by securing data loggers to the staff gauges and downloading the recorded information.

Sample containers for bacteria and turbidity were provided by the contract laboratory and left unopened until sample collection. The bacteria containers were sealed, clear, cylindrical, IDEXX bottles that contained the sample preservative. The turbidity containers were 125 mL plastic, opaque bottles. Bacteria and turbidity containers had blank labels, which were completed in the field. Containers for macroinvertebrate samplers were 32 ounce, pre-cleaned, HDPE wide mouth bottles. Labels were completed and affixed in the field with packing tape.

Turbidity and *E. coli* samples were hand delivered to Pace Analytical in Sheridan, Wyoming for analysis. Macroinvertebrate samples were sorted by Aquatic Assessments, Inc. (AA) in Sheridan, Wyoming and analyzed by Aquatic Biology Associates, Inc. (ABA) in Corvallis, Oregon.

4.4 SITE DESCRIPTIONS

Sites were selected based on a review of the historical data, historical SCCD sampling sites, availability, and access (Table 4-3). All sites chosen for this project were previously used in the 1996-1999 assessment and/or in subsequent monitoring years. During the initial site reconnaissance and site set-up, SCCD identified land uses and other site characteristics. Considerations for site selection included the ability to reveal types and regions of non-point source pollution at a level that would optimize landowner participation in the watershed planning process and would allow SCCD to direct remediation assistance in the most cost-effective and environmentally sound ways.

Historically, SCCD requested and documented verbal permission to collect water quality samples and publish the data in a report. On July 1, 2012, changes to the Wyoming Public Records Act (W.S. 16-4-291 through 16-4-205) required written permission to release any information collected on agricultural operations. In addition, Wyoming Statute W.S. 6-3-414 through the 2015 Enrolled Act #61 requires written permission to access for the purpose of collecting data. Signed consent forms were maintained for all sample sites; all sites were accessed using public highways/roads or private driveways/parking areas where consent forms had been received.

Table 4-3. Tongue River watershed sample site descriptions

Site ID	1996-2010 Site Name	Sample Site Description	UTM Zone 13 (NAD83)	Latitude Longitude	HUC	Elevation (ft)	Land use(s)
Water Quality Stations							
TR01	____	On Tongue River, approximately 200 meters downstream of river bend off of well pad road from County Road 1211	4983391N 0356305E	44.989417N 106.822850W	100901010407 Tongue-Beatty Gulch	3,435	Cattle grazing, irrigated hay lands, and wildlife habitat.
PD01	____	On Prairie Dog Creek approximately 150 meters downstream USGS station 06306250	4982905N 0354972E	44.984772N 106.839611W	100901010307 Lwr Prairie Dog Creek	3,484	Cattle grazing, irrigated hay lands, and wildlife habitat.
TR03	____	On Tongue River, approximately 20 meters downstream of Hwy 338 bridge crossing	4978650N 0346809E	44.944778N 106.941806W	100901010407 Tongue-Beatty Gulch	3,530	Primarily wildlife habitat. Winter cattle grazing only.
GC01	____	On Goose Creek between USGS Station No. 06305700 and HWY 339 bridge crossing.	4971871N 0343029E	44.882964N 106.987586W	100901010109 Goose Creek-Soldier	3,660	Cattle grazing, irrigated hay land, and wildlife habitat. Parallel to railroad.
TR05	TR1	On Tongue River at Kleenburn Road Recreational Picnic Area approximately 0.7 miles downstream of USGS Station 06299980	4974509N 0341274E	44.906308N 107.010622W	100901010211 Tongue-Slater Creek	3,600	Primarily wildlife habitat. Reclaimed mining lands made into recreational picnic area.
TR07	TRL	On Tongue River, approximately 3 meters downstream of the Ranchester Water Treatment Plant intake	4974822N 0329198E	44.9063314N 107.163592W	100901010210 Tongue-Fivemile	3,750	Urban: Ranchester City limits. Site of City water intake.
WC01	WCL	On Wolf Creek, upstream of the County Road 67 bridge crossing	4973965N 0328604E	44.898478N 107.170822W	100901010209 Lower Wolf Creek	3,775	Rural residential, wildlife habitat, cattle grazing, and irrigated hay lands.
FMC01	FMCL	On Fivemile Creek upstream of the Hwy 14 Bridge in Ranchester	4975029N 0328632E	44.908056N 107.170828W	100901010210 Tongue-Fivemile	3,773	Urban, Ranchester City limits. Rural residential livestock.
TR08	TRM	On Tongue River, downstream of the Halfway Lane County Road bridge	4973233N 0325504E	44.891139N 107.209803W	100901010210 Tongue-Fivemile	3,810	Cattle grazing, irrigated hay lands, and wildlife habitat. Some rural residential.
CC01	CCL	On Columbus Creek downstream of the Hwy 14 bridge crossing	4973513N 0323343E	44.893125N 107.237247W	100901010207 Tongue-Columbus	3,869	Cattle grazing, feedlot, irrigated hay, and wildlife.
LTR01	LTRL	On Little Tongue River, approximately 300 meters upstream of Tongue River confluence	4971697N 0321030E	44.876214N 107.265875W	100901010206 Little Tongue River	3,890	Urban: Dayton city limits. Occasional wildlife habitat.

Table 4-3. Tongue River watershed sample site descriptions (cont.)

Site ID	1996-2010 Site Name	Sample Site Description	UTM Zone 13 (NAD83)	Latitude Longitude	HUC	Elevation (ft)	Land use(s)
SC01	SCL	On Smith Creek downstream of County Road 92 bridge crossing	4971936N 0321170E	44.878397N 107.264189W	100901010207 Tongue-Columbus	3,885	Urban: Dayton city limits.
TR09	TRU	At the USGS Station No. 06298000	4968747N 0317895E	44.848883N 107.304475W	100901010207 Tongue-Columbus	4,060	Primarily wildlife habitat. Recreational camping. Parallel to County Road.
Macroinvertebrate Stations							
TR01	____	On Tongue River, approximately 50 meters downstream of river bend off of well pad road from County Road 1211	4983391N 0356305E	44.989417N 106.822850W	100901010407 Tongue-Beatty Gulch	3,435	Cattle grazing, irrigated hay lands, and wildlife habitat.
TR03	____	On Tongue River, approximately 500 meters upstream of Hwy 338 bridge crossing	4978650N 0346809E	44.944778N 106.941806W	100901010407 Tongue-Beatty Gulch	3,530	Primarily wildlife habitat. Winter cattle grazing only. BLM recreation area.
TR05	TR1	On Tongue River at Kleenburn Road Recreational Picnic Area approximately 0.7 miles downstream of USGS Station 06299980	4974509N 0341274E	44.906308N 107.010622W	100901010211 Tongue-Slater Creek	3,600	Primarily wildlife habitat. Reclaimed mining lands made into recreational area.
TR07	TRL	On Tongue River upstream County Road bridge crossing	4974822N 0329198E	44.9063314N 107.163592W	100901010210 Tongue-Fivemile	3,750	Wildlife habitat, irrigated hay lands, rural residential.
TR09	TRU	On Tongue River at USGS Station No. 06298000	4968747N 0317895E	44.848883N 107.304475W	100901010207 Tongue-Columbus	4,060	Primarily wildlife habitat. Recreational camping. Parallel to County Road.

4.5 MONITORING SCHEDULE

The 2022 monitoring schedule included sampling to determine the geometric means of *E. coli*, based on five samples collected within a 60-day period from May-July and five samples collected within a 60-day period from July-September (Table 4-4). Other field water chemistry parameters were also measured. A total of ten water quality samples were collected at each site.

Sample dates were randomly selected from Monday-Thursday due to lab availability and sampling holding times. Continuous temperature data loggers were deployed to measure instream temperatures from mid-May through mid-September. Macroinvertebrate collections and habitat assessments were completed in September.

Table 4-4. Sample schedule for 2022 Tongue River watershed monitoring

Date(s)	Sites	Parameters
May 18th-September 8th	TR01, TR03, TR05, TR07, TR09	Continuous Temperature
May 18th	TR01, PD01, TR03, GC01, TR05, TR07, WC01, FMC01, TR08, CC01, LTR01, SC01, TR09	Instantaneous temperature, pH, Conductivity, Dissolved Oxygen, Stage Height/Discharge, Turbidity, and *E. coli*
May 31st		
June 13th		
June 28th		
July 7th		
July 20th	TR01, PD01, TR03, GC01, TR05, TR07, WC01, FMC01, TR08, CC01, LTR01, SC01, TR09	Instantaneous temperature, pH, Conductivity, Dissolved Oxygen, Stage Height/Discharge, Turbidity, and *E. coli*
August 1st		
August 9th		
August 24th		
September 8th		
September-October	TR01, TR03, TR05, TR07, TR09	Macroinvertebrates, Habitat, Photo

CHAPTER 5 QUALITY ASSURANCE/QUALITY CONTROL

5.1 FUNCTION OF QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance (QA) may be defined as an integrated system of management procedures designed to evaluate the quality of data and to verify that the quality control system is operating within acceptable limits (Friedman & Erdmann, 1982; USEPA, 1995). Quality control (QC) may be defined as the system of technical procedures designed to ensure the integrity of data by adhering to proper field sample collection methods, operation and maintenance of equipment and instruments. Together, QA/QC functions to ensure that all data generated are consistent, valid and of known quality (USEPA, 1980). QA/QC should not be viewed as an obscure notion to be tolerated by monitoring and assessment personnel, but as a critical, deeply ingrained concept followed through each step of the monitoring process. Data quality must be assured before the results can be accepted with any scientific study. Project QA/QC is fully described in the SCCD QAPP (2022b) and the Project SAP (SCCD, 2022a).

5.2 SAMPLING PERSONNEL AND QUALIFICATIONS

Water quality monitoring, data management, and reporting were performed by SCCD personnel with the appropriate training and qualifications to implement the project (Table 5-1). SCCD NRCS Sheridan field office staff assisted with site set-up, surveys, discharge measurements, water quality monitoring, and macroinvertebrate collection when needed. During monitoring activities, SCCD personnel collected the samples/measurements, while the other staff recorded the information on the appropriate data sheets. Assisting personnel were under the direct supervision of SCCD staff. The SAP defined all necessary field protocols and was available to the sampling team for every sampling event.

Table 5-1. SCCD Sampling personnel and qualifications

Personnel	Qualifications
Carrie Rogaczewski District Manager	M.S. University of Wyoming in Rangeland Ecology and Watershed Management with an emphasis in Water Resources; BKS Environmental; 20+ years of experience with the SCCD; WACD Water Quality training
Jackie Turner Program Specialist	B.S. University of Wyoming in Geography and Environment and Natural Resources with a Journalism Minor; Natural Resource Management and GIS Concentrations; WACD Water Quality training; 5+ years of experience with SCCD

5.3 SAMPLE COLLECTION, PRESERVATION, ANALYSIS, AND CUSTODY

Accepted referenced methods for the collection, preservation and analysis of samples were adhered to as described in the SAP. In addition to field data sheets, samplers carried a field logbook to document conditions, weather, and other information for each sample day and/or site. Calibration logs were completed for each instrument every time a calibration was performed.

Project field measurements were recorded on field data sheets. Water samples requiring laboratory analysis were immediately preserved, placed on ice, and hand delivered to the laboratory. A Chain of Custody (COC) form was prepared and signed by the sampler before samples entered laboratory custody. A laboratory

employee would then sign and date the COC form after receiving custody of the samples. After samples changed custody, internal COC procedures were implemented by the laboratory.

Benthic macroinvertebrate samples were preserved in the field, placed in a cooler, and transported to the SCCD office in Sheridan. A project specific macroinvertebrate COC form was completed. After all macroinvertebrate samples were collected, samples and COC forms were hand delivered to the contractor for initial sorting. COC forms were signed by SCCD and the contractor receiving the samples. Sorted samples, COC forms, and lab bench sheets were hand delivered to SCCD and then shipped to the contract laboratory for identification. Upon receipt, the contract laboratory performed a visual check for the number and general condition of samples and signed the COC form. The completed COC form was returned to SCCD.

5.4 CALIBRATION AND OPERATION OF FIELD EQUIPMENT

The project SAP outlined requirements for calibration and maintenance of field equipment. On every sampling day, before leaving the office, the pH meter, conductivity meter, and dissolved oxygen were calibrated according to the manufacturer's instructions.

The Hanna 9025 pH meter was calibrated using a two-point calibration method with pH 7.01 and pH 10.01 buffer solutions. The Hanna 9033 specific conductivity meter was calibrated using a 1413 µmhos/cm calibration standard. All calibration solutions were discarded after each use. This process was repeated after sampling as a continuing calibration verification (CCV) check. Pre- and post-sampling calibration results were recorded in the corresponding instruments' calibration logbook.

The YSI Pro20 dissolved oxygen meter membrane cap was replaced the night before each sampling event. The meter was calibrated by inserting the probe into the moist calibration chamber. The barometric pressure on the dissolved oxygen meter was cross referenced to the barometric pressure at the Sheridan County airport to check calibration accuracy before leaving the office. The meter was recalibrated after every 500-foot change in elevation; this was completed prior to sampling at TR09 each sampling day. Calibration results were recorded in the meter's logbook.

Equipment maintenance, including battery replacement, was performed according to the SAP and manufacturer's instructions. All maintenance activities were documented in the calibration logs.

The Marsh-McBirney flow meter was factory calibrated and did not require field calibration; however, SCCD conducted a zero check at the beginning and end of the field season using a five-gallon plastic bucket of water. Factory calibration of Onset HOBO data loggers, used for continuous temperature monitoring, was checked by performing a crushed-ice test at the beginning and end of the season to validate the loggers' accuracy.

Equipment used for benthic macroinvertebrate sample collection and reach level habitat assessments did not require calibration. Surber sampler nets and other equipment were checked for damage prior to entering the field.

5.5 SUMMARY OF QA/QC RESULTS

Data quality objectives (DQOs) are qualitative and quantitative specifications used by water quality monitoring programs to limit data uncertainty to an acceptable level. DQOs were established for each monitoring parameter for precision, accuracy, and completeness at levels sufficient to allow SCCD to realize

project goals and objectives (Table 5-2). SCCD evaluated collected data according to the DQOs in the SAP (SCCD, 2022a) and WDEQ protocols (WDEQ/WQD, 2021b).

Table 5-2. Data quality objectives (DQO)*

Parameter	Precision (%)[1]	Accuracy (%)[2]	Completeness (%)	Reporting Limit
Temperature	10	10	95	0.2°C
pH	0.3 SU	5	95	0.01 SU
Conductivity	10	10	95	1 µmhos/cm
Dissolved Oxygen	10	20	95	0.1 mg/L
Turbidity	20	20	95	0.1 NTU
E. coli	50[3]		95	1 MPN/mL
Macroinvertebrates	Total Abundance = ± 50% Total Number of Taxa = ±15%		95	
Total Taxa	15		95	
Habitat Assessment			95	
Intra-Crew	15		10	
Discharge			95	
Stage-Discharge Relationships			95	$r^2 \geq 0.95$

*Precision DQOs from WDEQ Quality Assurance Program Plan. Reporting limits from WDEQ Manual of Standard Operating Procedures, except for current laboratory analyzed parameters (turbidity and *E. coli*).

[1] For parameters with reporting limits, see WDEQ Quality Assurance Program Plan for values below 10 times the reporting limit (WDEQ, 2018a).

[2] Accuracy values shown are acceptable departures from 100 percent accuracy. A 10% accuracy value means accuracy values of 90 to 110% are acceptable.

[3]. The Relative Percent Difference (RPD) between Most Probable Number (MPN) duplicate samples should be <50% for MPNs >100. Due to the increased variability for MPNs <100, no RPD limit is required for duplicate pairs in which at least one of the MPNs is below 100.

5.5.1 Comparability

Comparability refers to the degree to which data collected during this project were comparable to data collected during other past or present studies. Current project data must be comparable to future data to detect water quality change with confidence. Recognizing that periodic adjustments to locations, parameters, and/or sampling methods are needed, several steps were taken to assure data comparability including:

- Collection of samples at previously used monitoring stations
- Collection of samples during the same time of year
- Collection of samples using the same field sampling methods and sampling gear
- Analysis of samples using the same laboratory analytical methods and equipment
- Use of the same reporting units and significant figures
- Use of the same data handling and reduction methods (rounding and censoring)
- Use of similar QA/QC processes

Chemical, physical, biological, and habitat data collected during this project were highly comparable because of close coordination prior to initiation of sampling. Where possible, each step identified above was implemented to assure comparability.

Prior to 2014, *E. coli* standards were based on a geometric mean of five samples collected within a 30-day period. SCCD collected water quality parameters on the same schedule as the *E. coli* samples; five sample geometric means were calculated for all water quality parameters for the 30-day periods. During revisions to water quality standards and methods in 2014, WDEQ changed the basis for the *E. coli* standard to a geometric mean of five or more samples collected within a 60-day period (WDEQ, 2014). As a result, SCCD incorporated 60-day geometric means into future schedules. Comparisons among years are still valuable for evaluating water quality trends; both the 30-day geometric means and the 60-day geometric means capture samples collected during early season (May-July), mid-season (June-August), and late season (July-September) conditions. Arithmetic means are used for all other non-bacteria parameters.

5.5.2 Continuous Temperature Loggers

Onset's HOBO Pendent Temperature Loggers were deployed at TR01, TR03, TR05, TR07, and TR09 to record water temperature during the 2022 monitoring project. These loggers are factory calibrated, encapsulated devices that cannot be re-calibrated.

To verify the accuracy of the factory calibration, SCCD performed a crushed-ice test before and after the sampling season. A seven-pound bag of crushed ice was emptied into a 2.5-gallon bucket. Distilled water was added to just below the top level of the ice and the mixture was stirred. The data loggers were submerged in the bath and placed in a refrigerator to minimize temperature gradients. If the ice bath was prepared properly and if the loggers maintained their accuracy, the loggers record temperatures between 0°C and 0.232°C while in the ice bath. Both pre- and post-season ice bath results were within the manufacturers recommended range (Appendix B). Onset suggests the loggers should maintain their accuracy unless they have been utilized outside their range of intended use (-20°C to 50°C). None of the loggers were used outside of this range.

5.5.3 Stage-Discharge Relationships

The relationship between stage height and discharge for a given location yields an equation that allows the calculation of discharge at various stage heights recorded on a staff gauge. Stage-discharge relationships were established for all staff gauges installed by SCCD. These relationships were developed by recording the stage height and measuring discharge using the mid-section method (WDEQ/WQD, 2021b) on at least three occasions with varying flow conditions. A correlation coefficient (R2 value) of at least 0.95 (95%) is desirable for proper gauge calibration (Table 5-3).

Staff gauges installed by SCCD were surveyed against established benchmarks upon installation and at the end of the season. The difference between pre- and post-season survey results were compared to verify gauge stability (Table 5-3). A difference equal to or less than 0.05 is preferred between the pre- and post-season surveys. When the difference is greater, the survey should be repeated, and the stability of the benchmark and gauge should be checked.

Table 5-3. Summary of R^2 values for 2022 stage-discharge relationships

Site	Pre-Season Survey	Post-Season Survey	Pre/Post Survey Difference	Stage-Discharge Relationship R^2 Value
TR01	1.38	1.38	0.00	0.999
PD01	5.68	5.69	0.01	0.9946
TR03	4.51	4.51	0.00	0.9998
GC01	1.62	1.64	0.02	0.9702
TR05	2.72	2.72	0.00	0.9997
TR07	1.53	1.53	0.00	0.9588
WC01	6.38	6.39	0.01	1
FMC01	0.52	0.50	0.02	0.9675
TR08	4.65	4.65	0.00	0.9991
CC01	3.78	3.78	0.00	0.9936
LTR01	2.25	2.24	0.01	0.9983
SC01	3.00	2.83	**0.17**	0.9961
TR09	NA-USGS	NA-USGS	NA-USGS	NA-USGS

*Bold values are outside of desired range.

Flow information for TR09 was obtained from USGS Station 06298000. All pre- and post-survey differences were within the desired range apart from Smith Creek (SC01). If comparing the post season survey results in 2022 to the 2019 survey results, the difference would be within the threshold of 0.5. Due to this fact, and because the gauge appeared to be stable throughout the season, it is likely the 2022 pre-season survey result was recorded incorrectly. As such, the data for this site was retained. Additionally, despite having the desired R^2 value, discharge values at Little Tongue River (LTR01) were discarded from May 18-June 28 due to being outside of the calibrated range.

5.5.4 Blanks

Trip blanks were prepared to determine whether samples might be contaminated by the sample container, preservative, or during transport and storage conditions. One blank for every 10 samples for each parameter is required. Two *E. coli* and turbidity trip blanks were prepared for every sampling event. Prior to sampling, the contract laboratory filled sample containers with laboratory deionized water and the appropriate preservative. The trip blanks were maintained in the cooler with the collected samples and returned to the laboratory for analysis. No trip blanks used during the project contained detectable levels of *E. coli* (Appendix B). Turbidity readings of 0.1 NTU were reported on 5/18 and 9/8 for Trip Blank 01 and on 5/31 for Trip Blank 02. These data were considered acceptable because they were near the minimum detection limit. Trip Blank 02 bottles were not filled with water prior to leaving the lab on 9/8 and therefore those results were discarded; however, the associated data for that sampling event was retained because Trip Blank 01 bottles were prepared according to standard operating procedures.

Field blanks were prepared to determine whether samples might be contaminated by conditions associated with sample collection procedures. One blank for every 10 samples for every parameter is required. *E. coli* and turbidity field blanks were prepared at two separate sites during every sampling event. At the designated sites, sample bottles were labeled, rinsed (if turbidity), and filled with deionized water provided by the contract laboratory. The bottles were then placed in the cooler and delivered to the contract laboratory with the other samples. No field blanks prepared during the project contained detectable levels of *E. coli*. Turbidity readings

ranging from 0.1-0.3 NTU were detected on most sampling days but were considered acceptable because they were at or near the minimum detection limit of 0.1 NTU. On 8/1, Field Blank 02 had a reading of 1.6 NTU. Though higher than typical, the associated data for this sampling event was retained because the reading was relatively low, and the other turbidity Field Blank collected that day was within the typical range.

5.5.5 Sample Holding Times

All laboratory data sheets were reviewed to ensure all samples were analyzed before their holding times had expired. This review found that all *E. coli* samples were analyzed within their required 8-hour holding time, apart from TR01 on June 28. This data was retained because the sample had been kept on ice and the exceedance was only two minutes past the 8-hour holding time. All turbidity samples were analyzed within the required 48 hour holding time. All water quality field samples were analyzed on-site immediately following sample collection. Benthic macroinvertebrate samples were preserved on-site upon sample collection; there is no holding time for benthic macroinvertebrate samples.

5.5.6 Duplicates

The project SAP specified that duplicate chemical, physical, biological, and habitat samples be obtained for at least 10% of all field samples. Duplicate water quality samples were obtained by collecting consecutive water quality samples from a representative stream riffle. Duplicate macroinvertebrate samples were collected by two field samplers, each equipped with a Surber net, collecting samples simultaneously and adjacent to one another. Intra-crew habitat duplicates were conducted simultaneously by each observer performing independent assessments without communication, at the same site and same time. All DQOs for duplicates were met (Table 5-4).

Table 5-4. Summary of 2022 Tongue River watershed monitoring duplicates

Parameter	No. of samples	No. of Duplicates	% Duplicated	DQO (%)
2022 Water Quality Samples (13 sites X 10 samples)	130	20	15%	10%
Macroinvertebrate Samples in 2022	5	1	20%	10%
Habitat Assessments in 2022	5	1	20%	10%

5.5.7 Precision

Precision was defined as the degree of agreement of a measured value as the result of repeated application under the same condition. The Relative Percent Difference (RPD) statistic was used because the determination of precision is affected by changes in relative concentration for certain chemical parameters. Precision was determined for water quality samples by conducting duplicate samples at ten percent of the sample sites. RPD is calculated by the formula: RPD = [(A-B) / (A+B)] X 200 where A is the value for the duplicate and B is the value for the original sample. With a few exceptions, all parameters met the data quality objectives (DQOs) for precision (Table 5-5).

The relative percent difference for the Dup01 turbidity sample exceeded the DQO of 20% on May 18 and June 13, as did the Dup02 turbidity sample on September 8. The *E. coli* RPD for Dup02 was above the DQO of 50% on May 31 and August 1. These data were retained as the RPD for the other duplicate sample for those days and parameters were within the DQO. On July 7, samplers forgot to take duplicate measurements for the field parameters at GC01. Thus, Dup01 lab samples were collected at GC01, but Dup01 field measurements were taken later at TR08.

Table 5-5. Precision of 2022 Tongue River watershed water quality monitoring data

Date	Duplicate Sample ID	Site Duplicated	TEMP RPD (%)	pH RPD (%)	COND RPD (%)	DO mg/L RPD (%)	DO % RPD (%)	TURB RPD (%)	*E. coli* RPD (%)
WDEQ DQO Relative Percent Difference or Other:			*10*	*± 0.3 SU*	*10*	*10*	*10*	*20*	*50 if >100 NA if <100*
5/18/22	DUP01	TR07	4.3	0.07	1.6	2.3	1.0	**52.8**	9.7
	DUP02	TR09	4.1	0.04	2.2	1.3	0.6	1.2	5.3
5/31/22	DUP01	TR08	1.7	0.03	0.5	1.29	1.0	0.0	13.3
	DUP02	LTR01	1.4	0.05	1.8	1.06	1.1	7.8	**89.7**
6/13/22	DUP01	PD01	0.6	0.01	0.1	0.1	0.1	**27.7**	25.7
	DUP02	WC01	1.0	0.13	0.6	1.0	0.7	13.3	0.9
6/28/22	DUP01	TR07	2.0	0.02	2.2	1.3	0.0	5.4	19.2
	DUP02	TR08	2.5	0.02	1.8	0.6	0.6	0.0	0.0
7/7/22	DUP01	TR08/GC01	0.0	0.02	0.8	1.0	0.9	8.0	21.6
	DUP02	FMC01	1.7	0.02	0.1	0.5	0.5	8.7	3.6
7/20/22	DUP01	FMC01	1.1	0.01	0.2	0.9	0.6	11.1	1.7
	DUP02	SC01	1.0	0.03	0.0	0.9	0.2	0.0	10.2
8/1/22	DUP01	LTR01	1.1	0.02	0.3	2.7	2.5	8.0	12.4
	DUP02	SC01	1.6	0.02	0.9	2.7	2.3	15.9	**51.4**
8/9/22	DUP01	TR01	1.4	0.00	0.8	0.1	0.0	0.0	14.0
	DUP02	TR03	0.0	0.02	4.5	1.1	1.1	2.2	11.1
8/24/22	DUP01	TR05	0.0	0.00	0.0	4.8	4.0	7.3	96.6
	DUP02	CC01	2.5	0.01	0.3	1.3	0.8	2.8	21.3
9/8/22	DUP01	TR01	0.0	0.00	3.1	4.5	4.6	9.5	27.8
	DUP02	PD01	0.6	0.01	0.5	0.5	0.6	**24.0**	15.0

*Bold values do not meet the Data Quality Objective.

Duplicate macroinvertebrate samples and habitat assessments were collected at greater than 10% of the total macroinvertebrate and habitat assessment sites (Table 5-6). The RPD for total macroinvertebrate abundance was 20 percent, which was within the DQO of 50 percent. The RPD for total macroinvertebrate taxa was 0 percent, which was within the DQO of 15 percent. The RPD for the duplicate habitat assessment was 8 percent (Appendix E), which was within the established DQO of 15 percent. The macroinvertebrate and habitat assessment data were determined to be valid and of known quality based upon the QA/QC criteria established for those parameters.

Table 5-6. Precision of 2022 Tongue River benthic macroinvertebrate and habitat data

Parameter	TR05 Duplicate 1	TR05 Duplicate 2	(% - RPD)	DQO (%)
Total Abundance	2668	3243	20	50
Total Taxa	35	35	0	15
Intra-Crew Habitat Assessment Score	123	133	8	15

5.5.8 Accuracy

Accuracy is the degree of agreement of a measured value with the true or actual value. For water quality parameters measured in the field, accuracy was assured by calibration of equipment to known standards. Conductivity and pH meters were calibrated on the morning of every sampling event. The dissolved oxygen meter was calibrated prior to each sampling event and re-calibrated with every 500-foot change in elevation. A crushed ice test was used to verify the accuracy of the continuous temperature data loggers. Proficiency tests are run twice annually by Pace Analytical for *E. coli* and turbidity. Accuracy cannot be determined for macroinvertebrate samples or habitat assessments because the true or actual values are unknown, therefore precision served as the primary QA check for these parameters.

5.5.9 Completeness

Completeness refers to the percentage of measurements determined to be valid and acceptable compared to the number of samples scheduled for collection. This DQO is achieved by avoiding loss of samples due to accidents, inadequate preservation, holding time exceedances, and proper access to sample sites for collection of samples as scheduled. DQOs for most parameters were met except for discharge (Table 5-7).

Staff gauges were submerged during high flows in May and June at several sites; additionally, there were two instances where staff gauges were out of water at the end of the season. Discharge values for Little Tongue River were outside of the calibrated range for the first four sampling days and were discarded. One conductivity reading was discarded as the value was not recorded correctly.

Table 5-7. Completeness of 2022 Tongue River water quality monitoring data

Parameter	# Samples Planned	# Samples Collected	% 2022 Completeness	DQO (%)
Water Temperature	130	130	100%	95%
pH	130	130	100%	95%
Conductivity	130	129	99%	95%
Dissolved Oxygen	130	130	100%	95%
Discharge	130	107	**82%**	95%
Turbidity	130	130	100%	95%
E. coli	130	130	100%	95%
Total Abundance of Macroinvertebrates	5	5	100%	95%
Total Taxa	5	5	100%	95%
Intra-Crew Habitat Assessments	5	5	100%	10%

*Bold values are below the Data Quality Objective.

5.6 DATA VALIDATION

Data generated by the contract laboratories was subject to the internal contract laboratory QA/QC process before it was released. Data are assumed to be valid because the laboratory adhered to its internal QA/QC plan. Field data generated by SCCD were considered valid and usable only after defined QA/QC procedures and processes were applied, evaluated, and determined acceptable. Questionable data were rechecked by the contract laboratory and either confirmed or corrected. Data determined to be invalid were rejected and not used in preparation of this report.

Low flow values and lab results reported below the detection limit were to be reported as ½ the detection limit for the purpose of summary statistics, as specified in the SAP for this project (Gilbert, 1987; SCCD, 2022a).

When *E. coli* samples are reported as less than 1 MPN/100 mL or greater than 2419 MPN/100 mL, the SAP requires that 1 MPN/100 mL or 2420 MPN/100 mL be used for summary statistics, respectively. *E. coli* samples collected from TR03, GC01, and TR05 on May 31 were reported by Pace Analytical as >2419.6 MPN/100 mL, therefore 2420 MPN/100 mL was use for the calculation of summary statistics. An *E. coli* sample collected from TR03 on September 8 was reported as ND (not detected), therefore 1 MPN/100 mL was used for statistics.

5.7 DOCUMENTATION AND RECORDS

All water quality field data were recorded on data sheets prepared for the appropriate waterbody and monitoring station. After each sampling day, water quality field data sheets were duplicated and maintained in a binder. Macroinvertebrate and habitat assessment data were recorded onto data sheets similar in format to those used by WDEQ in the past. WDEQ now uses a more comprehensive protocol for macroinvertebrate and habitat assessments, but SCCD has continued with their existing data sheets for consistency and simplicity. Field sheets are scanned and filed electronically after the monitoring season has ended. Equipment checklists, COC forms, and calibration logs were documented on the appropriate forms and are maintained on file and/or electronically in the SCCD office. Photographs and photograph descriptions were organized by station and are stored electronically in the SCCD office (Appendix F).

Water quality and supporting QA/QC data were received electronically from the contract laboratory. Printed hard copies are maintained on file in the SCCD office. Macroinvertebrate sample results were received from the contract laboratory electronically and printed. All electronic data are maintained in a database on the SCCD server in Sheridan, Wyoming.

5.8 DATABASE CONSTRUCTION AND DATA REDUCTION

The project database consists of a series of Excel© spreadsheets and computer files. Each project database was constructed with reportable data (accepted after QA/QC checks) by inputting into Microsoft Excel© spreadsheets. Electronic files for water quality, discharge, continuous water temperature, macroinvertebrate, and habitat data were constructed. All computer data entries were checked for possible mistakes made during data entry. If a mistake was suspected, the original field or laboratory data sheet was re-examined, and the

data entry corrected. SCCD also maintains an ACCESS© database for all reportable water quality data collected by SCCD; validated data are copied into the ACCESS© database and are considered provisional until approved by WDEQ.

After data validation and database construction, data were statistically summarized for the following calculations (Appendix C): Number of samples, maximum, minimum, median, mean, geometric mean, and coefficient of variation.

These statistics and analyses provided insight for temporal and spatial water quality changes within the watershed. Microsoft Excel© was used to generate the statistical tables, geometric means, and graphics for this report. Arithmetic means were calculated for all water quality parameters except for *E. coli* using the ten sampling dates and then separately for the five samples collected during the early, mid, and late seasons. Geometric means were calculated for *E. coli* for the same time periods. Summary statistics do not include discarded data or instances where the staff gauge was submerged or unreadable.

5.9 DATA RECONCILIATION

Data collected by SCCD were evaluated before being accepted and recorded into the project database. Obvious outliers were flagged after consideration of expected values based upon evaluation of historical and current data. Field data sheets were re-checked and if no calibration or field note anomalies were identified, the data were accepted as presented. Otherwise, data was discarded and noted as such in the data validation log.

5.10 DATA REPORTING

Data collected by SCCD for this project is presented in tabular, narrative, and graphical formats throughout this report. This report will be submitted to WDEQ, and other interested parties as requested. Copies of this report will be available through the SCCD office. Compact disks containing the Microsoft Excel®, Microsoft Word®, Adobe Reader X®, and Arc Map 10® files used to construct this document can be produced upon request.

In addition to this report, the SCCD will submit a separate data package to WDEQ. The complete data package will include copies of all field and laboratory data sheets, field and equipment calibration logs, survey notes, and QA/QC documentation. Other information may be submitted as requested by WDEQ.

CHAPTER 6 DISCUSSION OF RESULTS

6.1 WATER QUALITY STANDARDS

Wyoming's surface waters are protected through application of numeric and narrative (descriptive) water quality standards (WDEQ, 2018b). The applicable water quality standards and other recommendations were used in interpretation of results and included in this report (Table 6-1).

Table 6-1. Numeric and narrative water quality standards for Wyoming surface waters applicable for waters in the Tongue River watershed

NUMERIC STANDARDS FOR NON-PRIORITY POLLUTANTS		
Parameter	**Reference**	**Standard / Description**
Dissolved Oxygen	Chapter 1 Sections 24 and 30 & Appendix D	For Class 1, 2AB, 2B, and 2C waters 1-day minima Early life stages: 5.0 mg/L intergravel concentration 8.0 mg/L water column Other life stages: 4.0 mg/L
E. coli	Chapter 1 Section 27	Geometric mean within a 60-day period shall not exceed 126 organisms per 100 ml for primary contact recreation waters/seasons (May 1-Sept 30) and shall not exceed 630 organisms per 100 ml for secondary contact recreation waters/seasons.
pH	Chapter 1 Sections 21 and 26 & Appendix B	6.5-9.0 standard units
Temperature	Chapter 1 Section 25	Discharge shall not increase temperature by more than 2 degrees F; maximum allowable temperature is 68 degrees F/20 degrees C (cold water fisheries) except on Class 2D, 3 and 4 waters.
Turbidity	Chapter 1 Section 23	For cold water fisheries and drinking water supplies, discharge shall not create increase of 10 NTU's.
NARRATIVE STANDARDS FOR NON-PRIORITY POLLUTANTS		
Settleable Solids	Chapter 1 Section 15	Shall not be present in quantities that could degrade aquatic life habitat, affect public water supplies, agricultural or industrial use, or affect plant and wildlife.
Floating and Suspended Solids	Chapter 1 Section 16	Shall not be present in quantities that could degrade aquatic life habitat, affect public water supplies, agricultural or industrial use, or affect plant and wildlife.
Taste, Odor, Color	Chapter 1 Section 17	Substances shall not be present in quantities that would produce taste, odor, or color in fish flesh, skin, clothing, vessels, structures, or public water supplies.
Macroinvertebrates	Chapter 1 Section 32 Hargett (2011)	Score for Full, Indeterminate, or Partial/Non-Support *Sedimentary Mountains Bioregion: >52.3, 34.8-52.3; <34.8;* *High Valleys Bioregion: >48.8, 32.5-48.8, <32.5;* *Northeast Plains Bioregion: >58.4, 38.9-58.4, <38.9*
ADDITIONAL PARAMETERS AND RECOMMENDED STANDARDS		
Habitat	King (1993) Stribling et al. (2000)	Habitat condition no less than 50 percent of reference; total habitat score >100 to qualify as reference
Specific Conductivity	King (1990)	Concentrations greater than 6900 µmhos/cm may affect aquatic organisms in ponds in NE Wyoming.

6.2 FIELD WATER CHEMISTRY AND PHYSICAL PARAMETERS

Water quality data were collected from May 18 through September 8 at 13 sites (Appendix C). Summary statistics were calculated for all instantaneous monitoring parameters on accepted data. Geometric means for three 60-day periods were calculated for bacteria samples; arithmetic means for all other parameters were established for the same 60-day periods as well as for the season.

6.2.1 Instantaneous Water Temperature

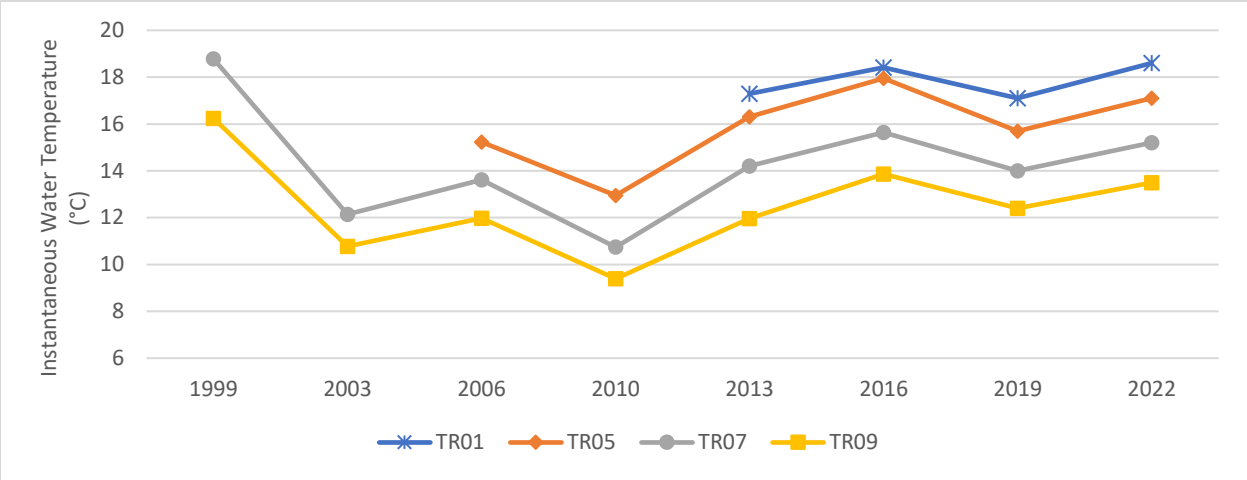
Instantaneous water temperature measurements were recorded above the maximum 20°C instream temperature standard at ten of the 13 sites on August 9 (Table 6-2). Exceedances were also recorded at Columbus Creek on June 28, five sites on July 7 and July 20, six sites on August 1, seven sites on August 24, and two sites on September 8. The highest instantaneous temperature of 25.0°C was recorded at TR01 on August 1. There were no instantaneous temperature exceedances measured at the Little Tongue River site (LTR01) or TR09. Instantaneous temperature measurements do not necessarily represent daily minimum, maximum, or average water temperatures.

Table 6-2. Instantaneous temperature measurements exceeding 20°C in 2022

Site	Instantaneous Water Temperature (°C)						
	6/28	7/7	7/20	8/1	8/9	8/24	9/8
TR01		20.7	21.6	25.0	21.3	22.9	
PD01		20.9					
TR03		20.5	22.6	24.6	24.0	23.5	20.8
GC01		20.8	22.4	24.5	25.0	22.5	20.2
TR05				23.6	23.0	22.8	
TR07					20.1	20.5	
WC01			20.8	23.8	22.6	20.7	
FMC01					20.4		
TR08					21.4		
CC01	21.1	23.6		20.2	21.3	20.0	
SC01			20.2		20.1		

Changes in seasonal average instantaneous water temperatures were relatively consistent among select mainstem sites (Figure 6-1). Seasonal average water temperatures decreased from 1999 to 2010, then increased from 2010 to 2016, decreasing again between 2016 and 2019, and increasing since the last sampling season in 2019. Temperatures in 2022 were most like those recorded in 2016. Average temperatures in 1999 remain the highest out of all years sampled at TR07 and TR09. Direct comparisons among years are difficult because of variations in water quantity and air temperatures.

Figure 6-1. Seasonal average instantaneous temperature at select Tongue River sites from 1999-2022



6.2.2 Continuous Water Temperature

Continuous temperature data loggers were deployed at five Tongue River sites (Appendix C). All loggers were deployed on May 18, apart from the logger at TR05, which could not be deployed until May 26 due to the gauge being submerged. All sites reported continuous water temperatures that exceeded the temperature standard of 20° C, except for the uppermost site in Tongue River Canyon (TR09). Exceedances shown on the TR09 chart were likely when the logger was out of water and these data were not included in statistical calculations.

Continuous water temperatures at TR01, TR03, and TR05 remained above the standard for extended periods of time in July and August, with exceedances continuing into early September. Exceedances were seen less often and for a shorter time at TR07, with temperatures dropping below the standard regularly during July and August. Temperatures at TR09 remained below the standard throughout the sampling season. The highest temperatures occurred from July-August at all sites (Table 6-3). The highest temperature, 29.2°C, was recorded on July 31 at TR01.

Water temperatures at TR07 in 2022 were generally higher than those in 2019, particularly later in the season (Appendix C). Temperatures in mid-August and a few periods in September were higher than those recorded in all previous years.

Table 6-3. Daily maximum, minimum and average continuous water temperature in 2022

Site	Max. Water Temperature (°C)		Min. Water Temperature (°C)		Seasonal Average Water Temp (°C)	# of Days Water Temp >20°C
	Temp	Date	Temp	Date		
TR01	29.2	7/31	8.5	5/22	19.0	72
TR03	29.0	8/13	8.6	5/21	19.1	69
TR05	27.1	8/12 & 8/15	6.1	6/1	18.1	65
TR07	24.7	8/15	3.2	5/21	15.5	59
TR09[1]	17.8	7/9	2.7	5/21	10.6	0

[1] The TR09 logger recorded unusually high temperatures on July 8, July 17, and September 3-8. The logger was likely out of water during these periods and this data was removed before statistical analysis.

6.2.3 pH

Ranging from 7.94 SU at Wolf Creek and Fivemile Creek to 8.72 SU at Goose Creek, all pH values were within the Wyoming water quality standard of 6.5-9.0 SU (Appendix C). Average pH values have remained relatively consistent among sites since 1999, ranging from 7.95-8.60 SU (**Error! Reference source not found.**).

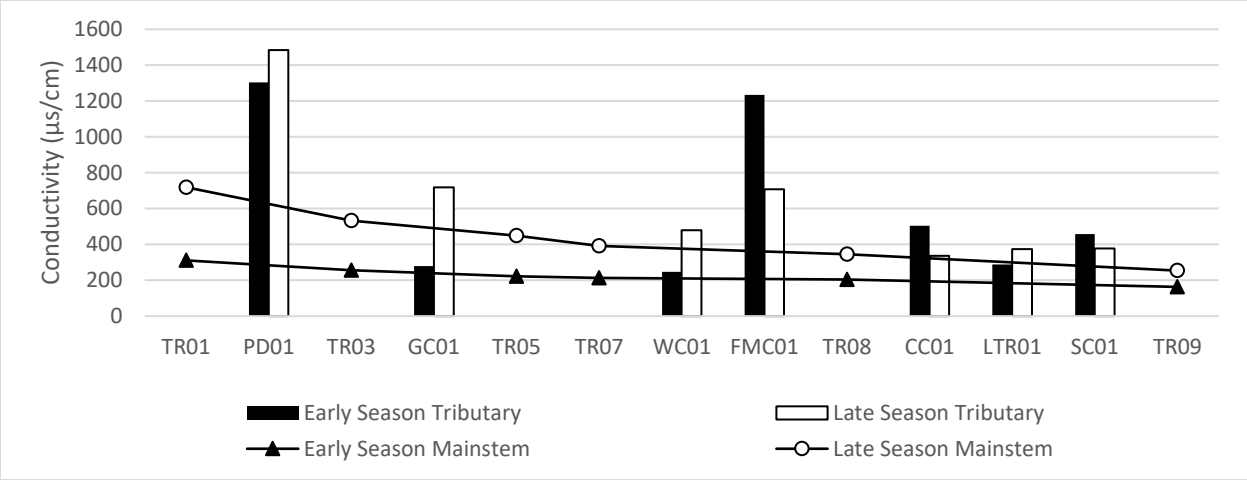
Table 6-4. Average seasonal pH within the Tongue River watershed from 1999-2022

Site/Year	1999	2003	2006	2010	2013	2016	2019	2022
TR01					8.35	8.34	8.23	8.28
PD01					8.14	8.33	8.16	8.15
TR03					8.36	8.43	8.26	8.35
GC01					8.31	8.36	8.2	8.35
TR05			8.13	8.17	8.38	8.43	8.16	8.27
TR07	8.31	8.09	8.06	8.26	8.33	8.34	8.25	8.24
WC01	8.09	8.08	8.05	8.17	8.24	8.33	8.15	8.23
FMC01	8.08	7.95	7.98	8.19	8.15	8.13	8.21	8.08
TR08	8.23	8.14	8.04	8.38	8.44	8.47	8.40	8.38
CC01	7.97	8.06	8.09	8.24	8.32	8.20	8.26	8.31
LTR01	8.28	8.16	8.15	8.35	8.41	8.48	8.23	8.39
SC01	8.18	8.27	8.29	8.32	8.52	8.44	8.39	8.51
TR09	8.36	8.30	8.27	8.60	8.58	8.49	8.37	8.47

6.2.4 Conductivity

Average conductivity increased from upstream to downstream at mainstem Tongue River sites in 2022 (Figure 6-2). Early season averages were higher at FMC01, CC01, and SC01, whereas late season averages were higher at GC01, WC01, and LTR01. Conductivity averages at tributary sites were generally higher than adjacent mainstem sites. The highest conductivity measurement (1739 µs/cm) was taken at PD01 on July 20. Eight out of the ten conductivity measurements from PD01 in 2022 were over 1000 µs/cm, which is typical for this site. All other sites reported values below 1000 µs/cm throughout the entire season (Appendix C).

Figure 6-2. Average conductivity in the Tongue River watershed by site and sample period in 2022



There is no standard for specific conductivity in the state of Wyoming; however, because conductivity is highly dependent on the number of dissolved solids, high values could be a concern for agricultural operations related to crop/hay production. Quality standards are established for Wyoming groundwater such that concentrations of total dissolved solids (TDS) for domestic, agricultural, or livestock use shall not exceed 500 mg/L, 2000 mg/L, or 5000 mg/L, respectively (WDEQ, 2005). Conductivity is not directly proportional to the TDS concentration, but it can be used to estimate the relative concentration of TDS.

With some exceptions, conductivity values were relatively consistent among years at most sites. Late season averages are generally higher than early season averages (Table 6-5). Conductivity averages at tributary sites are much more variable, making yearly comparisons more difficult.

Table 6-5. Average conductivity in the Tongue River watershed from 2003-2022

Site	May-July (Early Season)							
	1999	2003	2006	2010	2013	2016	2019	2022
TR01					595	431	414	311
PD01					1646	1651	1676	1304
TR03					369	313	311	256
GC01					436	432	277	279
TR05			224	349	314	273	292	222
TR07		275	206	336	287	239	269	214
WC01		354	268	383	373	358	281	248
FMC01		926	663	793	1080	647	855	1235
TR08		270	191	302	263	218	248	205
CC01		1030	586	655	561	338	574	504
LTR01		420	442	476	664	263	310	289
SC01		900	548	620	565	441	632	457
TR09		193	157	202	192	174	172	163

Site	July-September (Late Season)							
	1999	2003	2006	2010	2013	2016	2019	2022
TR01					831	739	704	719
PD01					2265	1575	1524	1484
TR03					577	532	534	532
GC01					718	729	647	718
TR05			548	426	505	420	441	449
TR07	327	372	433	375	407	364	403	392
WC01	490	616	661	573	628	491	565	479
FMC01	679	584	440	415	442	429	526	707
TR08	285	341	384	325	374	328	347	345
CC01	299	312	312	331	321	281	400	336
LTR01	454	330	407	426	412	289	413	374
SC01	495	619	567	621	506	479	529	377
TR09	219	224	237	252	245	230	246	254

6.2.5 Dissolved Oxygen

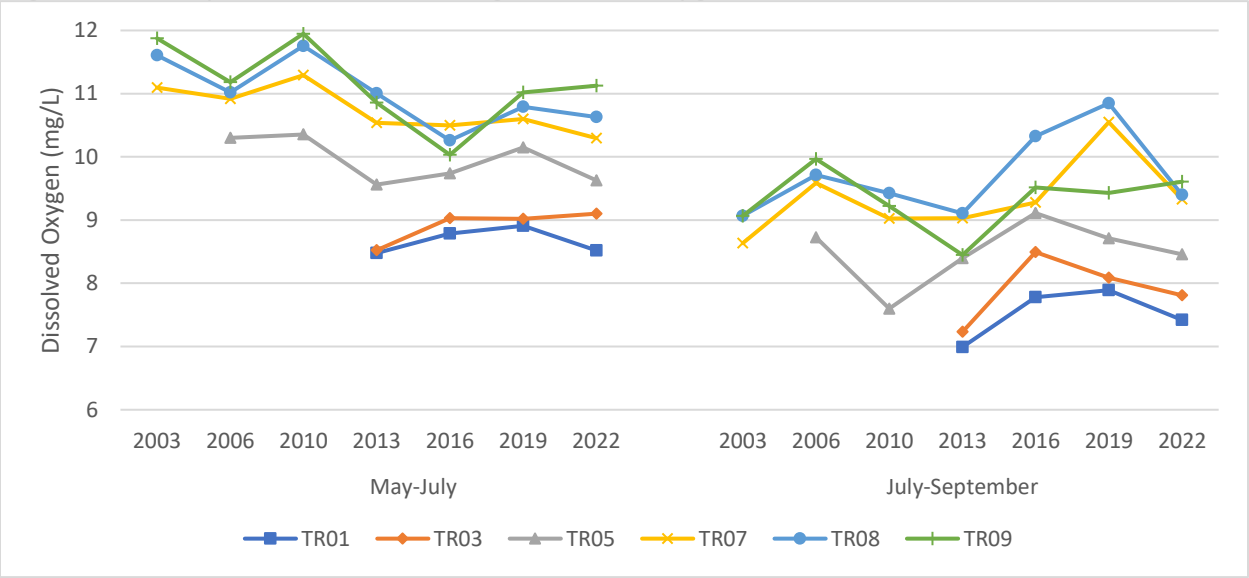
All sites met the minimum instantaneous dissolved oxygen concentration standard of 4.0 mg/L for other life stages and 5.0 mg/L for early life stages, apart from site FMC01, which had one measurement below 5.0 mg/L on July 20. Several samples at TR01, TR03, PD01, FMC01, and CC01 were below the 8.0 mg/L water column concentration recommended to achieve the 5.0 mg/L inter-gravel concentration for early life stages (Table 6-6). The uppermost mainstem sites and four tributary sites did not have any values below 8.0 mg/L. Dissolved oxygen values on mainstem sites ranged from 7.15 mg/L at TR01 to 12.21 mg/L at TR09. Tributary sites ranged from 4.66-13.19 mg/L, both of which were recorded at FMC01.

Table 6-6. Dissolved oxygen ranges and number of samples below 8.0 mg/L in 2022

Mainstem			Tributaries		
Site	**Samples below 8.0 mg/L**	**Range (mg/L)**	**Site**	**Samples below 8.0 mg/L**	**Range (mg/L)**
TR01	5	7.15-9.46	**PD01**	6	7.38-9.93
TR03	3	7.22-10.08	**GC01**	0	8.09-11.71
TR05	0	8.07-10.65	**WC01**	0	8.01-10.55
TR07	0	8.66-11.29	**FMC01**	7	4.66-13.19
TR08	0	9.02-11.68	**CC01**	5	7.71-9.23
TR09	0	8.90-12.21	**LTR01**	0	8.74-11.39
			SC01	0	8.40-10.57

Averages were above 4.0 mg/L and 5.0 mg/L at all sites during all years (Figure 6-3). There were no dissolved oxygen averages below 8.0 mg/L during the early season across all years at mainstem sites. Late season averages below 8.0 mg/L were observed across all years for TR01, in 2013 and 2022 at TR03, and in 2010 at TR05. Fluctuations at mainstem sites appear to follow a similar pattern across the seasons and years. Tributaries continue to be more variable among years and sites, particularly during the late season.

Figure 6-3. Yearly comparisons of average dissolved oxygen at mainstem sites from 2003-2022



6.3 DISCHARGE

SCCD used calibrated staff gauges to estimate discharge during water sampling events (Appendix C). SCCD used a USGS gauge and real-time flow information at TR09 (Station 06298000 Tongue River Near Dayton).

The highest flows occurred from May through June. Many staff gauges were submerged during this time and discharge was not calculated for those sites during those sampling days. The lowest flows were recorded in August and September.

Real-time flow data from the State Engineer's Office (SEO), corresponding with the USGS stations, was used to supplement SCCD's data at TR01, PD01, GC01 and TR09 (Appendix C). Average daily flows in June were higher than normal at TR01, GC01, and TR09. The opposite was true at PD01 where average daily flows were mostly below normal, with a few spikes above normal occurring throughout the season. Overall, SCCD discharge values corresponded with mean daily flow data from the USGS stations.

Figure 6-5. Discharge at TR01, PD01, TR03, and GC01 in 2022

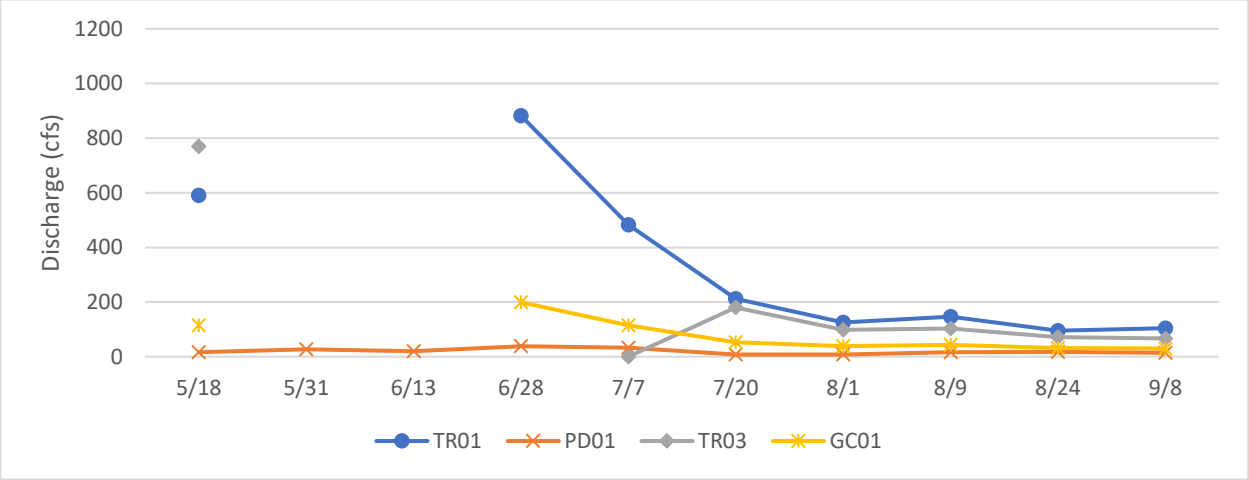


Figure 6-4. Discharge at TR05, TR07, WC01, and FMC01 in 2022

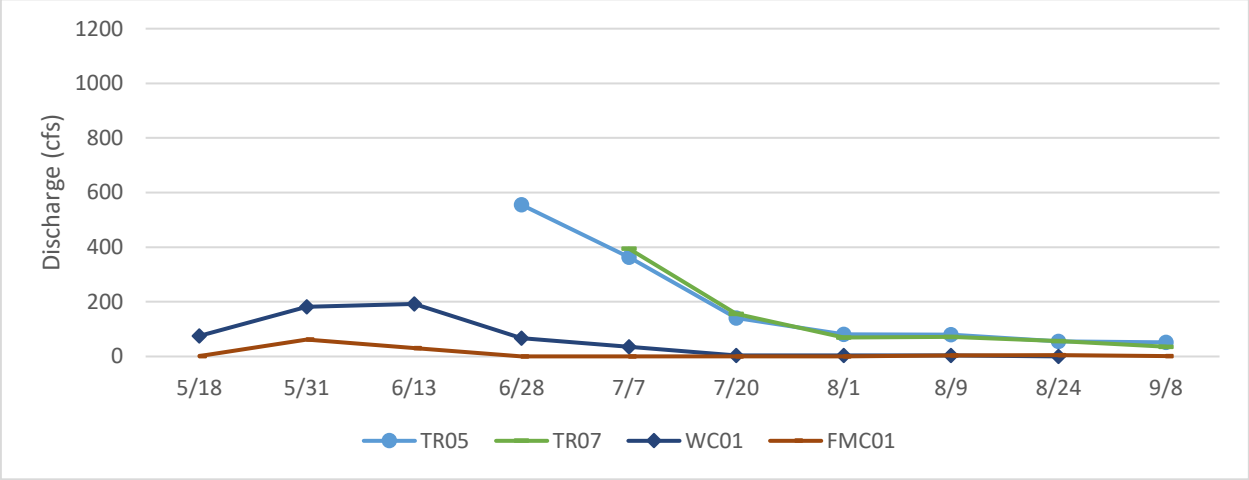
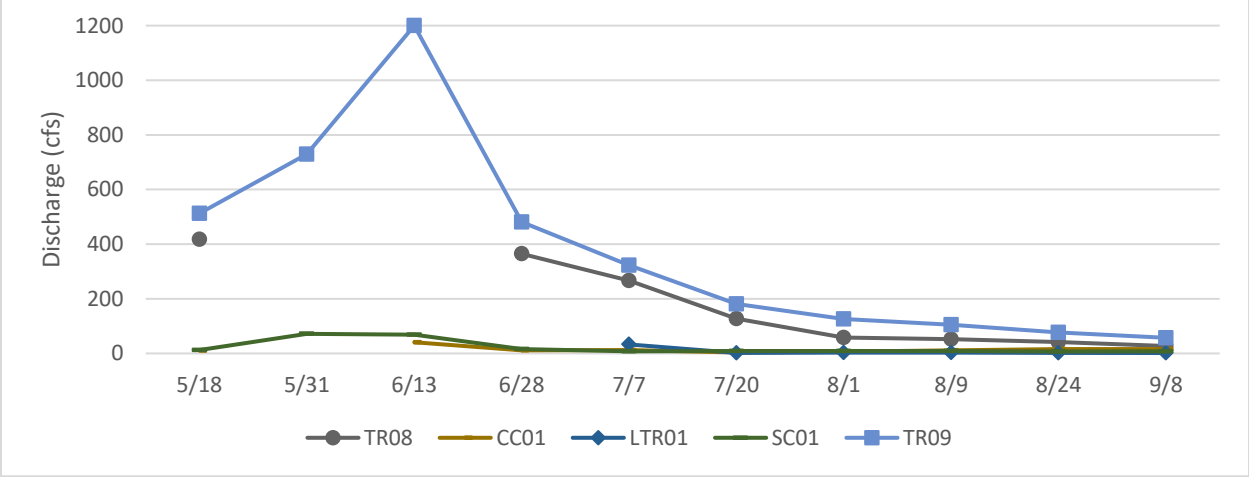


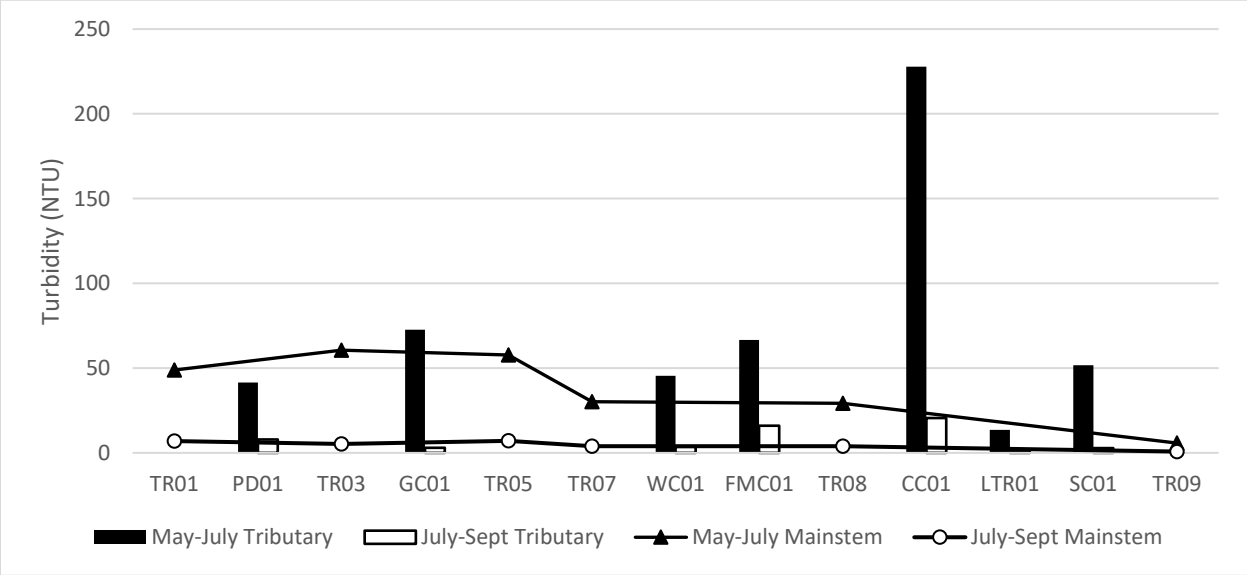
Figure 6-6. Discharge at TR08, CC01, LTR01, SC01, and TR09 in 2022



6.4 TURBIDITY

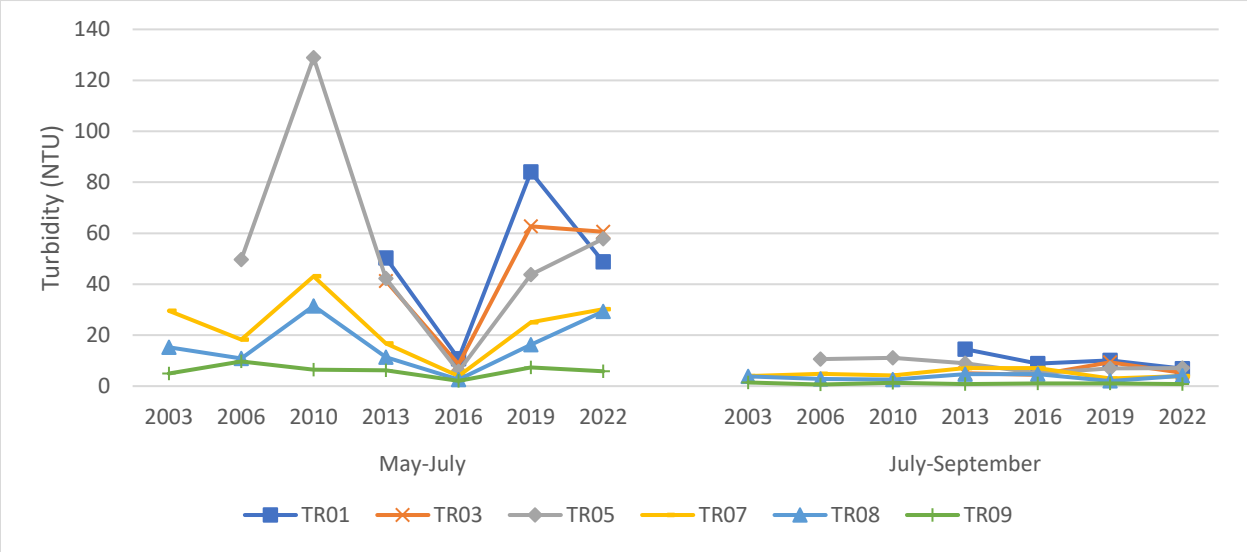
Average early season and late season turbidity generally increased from upstream to downstream at mainstem sites (Figure 6-7). Averages at tributary sites were more variable. Samples collected in the early season had higher average turbidity than samples collected later in the season at all sites.

Figure 6-7. Average turbidity in the Tongue River watershed by site and sample period in 2022



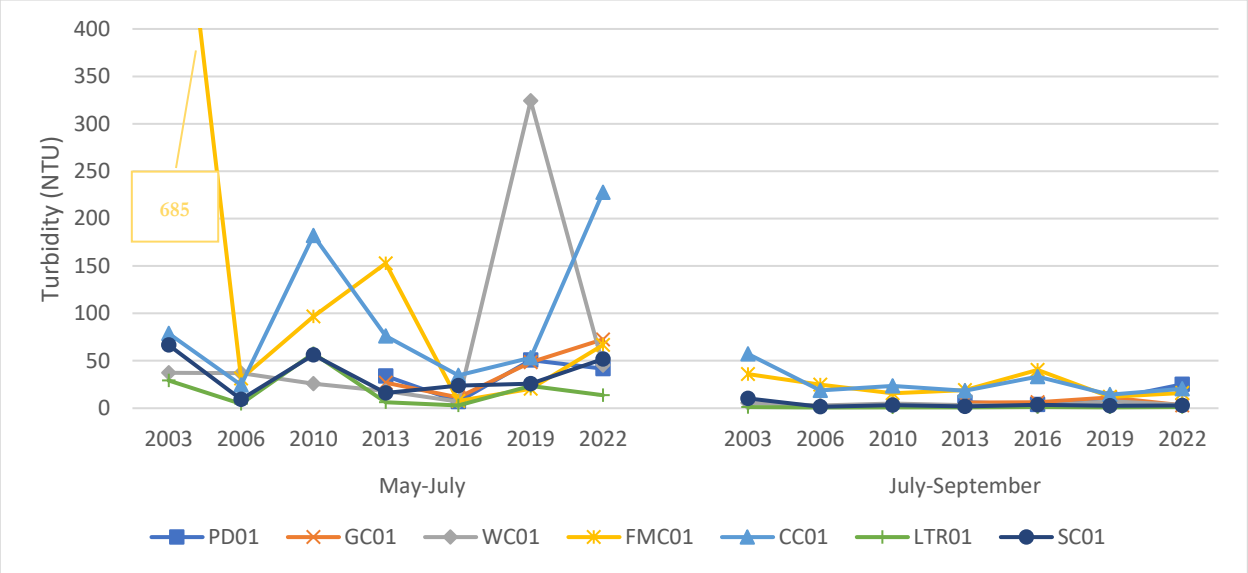
Average turbidity was higher at TR05, TR07, and TR08 during the early season of 2022 than in 2019 (Figure 6-8). Turbidity averages in 2019 and 2022 were similar but overall higher than all past years with a few exceptions. Less fluctuations were observed with late season turbidity averages, with a range of 0-20 NTU at all mainstem sites across all years.

Figure 6-8. Yearly comparisons of average turbidity at mainstem sites from 2003-2022



Early season turbidity averages in 2022 were higher than those in 2019 at all tributary sites, apart from WC01, CC01, and LTR01 (Figure 6-9). Late season turbidity averages were more variable from 2019 to 2022, with increases observed at tributary sites PD01, FMC01, CC01, LTR01, and SC01. Like mainstem sites, there is less variability during the late season across the years, with averages remaining below 60 NTU.

Figure 6-9. Yearly comparisons of average turbidity at tributary sites in 2003-2022

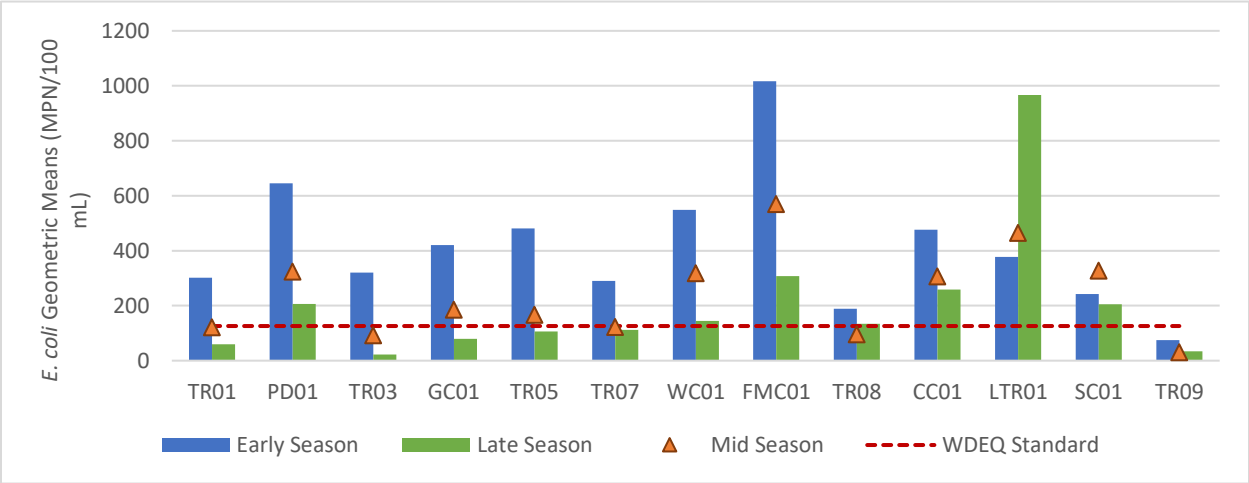


6.5 BACTERIA

In 2022, ten *E. coli* bacteria samples were obtained from 13 sites in the Tongue River watershed from May 18 to September 8 (Appendix C). Geometric means were calculated for each site from five early season samples (May 18-July 7) and five late season samples (July 20-September 8). A mid-season mean (June 13-August 1) was also calculated.

Bacteria geometric means exceeded the Wyoming water quality standard of 126 organisms/100 mL at all sites during the early season except for TR09 (Figure 6-10). Late season concentrations were generally lower; however, there were still exceedances at all the tributaries, except for GC01, and at TR08. Geometric means exceeded the standard during the mid-season at all tributary sites. The opposite was true for mainstem sites, except for TR05. Mainstem sites typically had lower bacteria concentrations than adjacent tributary sites.

Figure 6-10. *E. coli* geometric means by site and sample period in 2022



For samples collected from 1999-2013, geometric means were calculated on five samples collected within two separate 30-day periods. From 2016 onward, SCCD has collected samples within two separate 60-day periods to correspond to changes in WDEQ methodology (WDEQ, 2014). Comparisons among years are still valuable for evaluating water quality trends; both the 30-day geometric means and the 60-day geometric means capture samples collected during the early, mid, and late season conditions.

Comparisons among years could be made from 2003-2022 at the sites within and above the Town of Ranchester, which were within the original assessment boundary. The original assessment included sites TR07, TR08, and TR09 on the Tongue River. Tributary sites included Wolf Creek, Fivemile Creek, Columbus Creek, Little Tongue River, and Smith Creek. Comparisons between 2013, 2016, 2019, and 2022 could be made at all sites sampled in 2022.

Early season geometric means increased between 2019 and 2022 at most sites, apart from GC01, PD01, TR08, and SC01 (Figure 6-11 through Figure 6-13). During the late season, most sites decreased or increased only slightly between 2019 and 2022, apart from FMC01, CC01, TR08, and LTR01.

Geometric mean concentrations at the lowermost sites (Figure 6-11) were higher in 2022 than in 2013 during the early season, whereas late season concentrations in 2022 were mostly like those in 2013. Generally, trendlines show an increase since sampling began at these sites in 2013 during both the early and late seasons, apart from GC01, which appears to be decreasing slightly across the years during the late season.

Early and late season geometric means at sites located mid-watershed (Figure 6-12) in 2022 were like early and late season means in 2003, apart from FMC01. The early season geometric mean at FMC01 in 2022 was 1017 MPN/100 mL compared to 2713 MPN/100 mL in 2003; the late season geometric mean at FMC01 was 307 MPN/100 mL in 2022 compared to 689 MPN/100 mL in 2003. The linear trendline decreases at FMC01 during both the early and late season, whereas the trendline increases at TR05 and TR07 across the years for both seasons. The trendline for WC01 shows a slight increase during the early season across the years, with the opposite being true during the late season.

Early season geometric means at upper sites (Figure 6-13) were generally higher in 2022 than in 2003, apart from the geometric mean at SC01, which was over 500 MPN/100 mL less in 2022 than what it was in 2003. The opposite was true for these sites during the late season, apart from at TR08, which had a late season

geometric mean slightly higher in 2022 than in 2003. Early season trends show an increase in concentrations over the years at all sites but SC01. The opposite is true for late season trends, with all sites showing a decrease in concentrations over the years.

Bacteria concentrations vary in response to several water quality and water quantity factors, including changes in water temperature, water quantity, and suspended sediment loads. Higher *E. coli* bacteria concentrations during the early season are most likely associated with periods of increased precipitation and flooding events in the spring, including run-off from snowmelt, which may have contributed surface contaminants, increased sediment disturbance, and increased bacteria concentrations.

Figure 6-11. Early and late season *E. coli* geometric means at TR01, PD01, TR03, and GC01

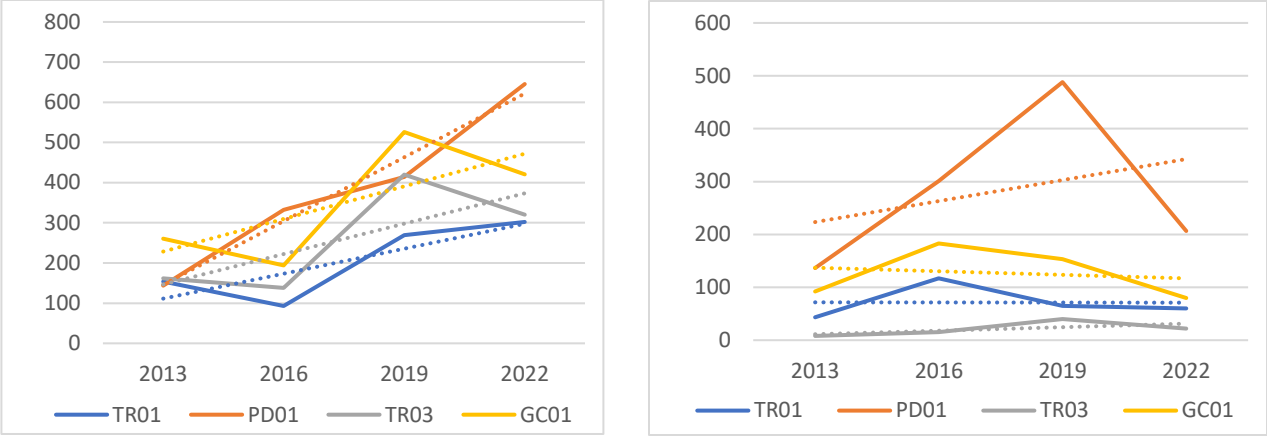


Figure 6-12. Early and late season *E. coli* geometric means at TR05, TR07, WC01, and FMC01

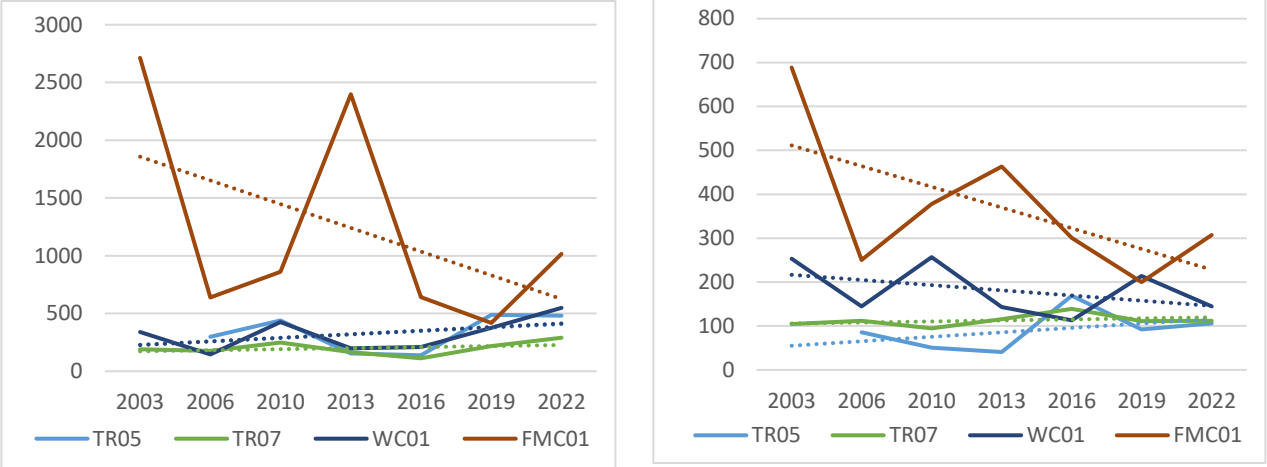
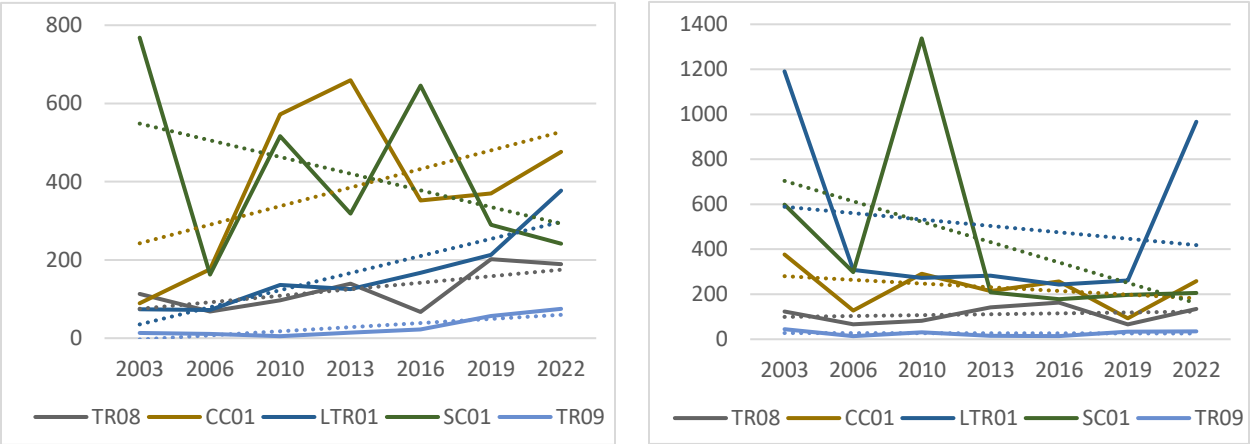


Figure 6-13. Early and late season E. coli geometric means at TR08, CC01, LTR01, SC01, and TR09



6.6 METEOROLOGICAL DATA AND SUPPORTING INFORMATION

Average daily air temperatures were just below normal in May, and 1-5°F above normal throughout the rest of the season (Table 6-7). Larger fluctuations from normal air temperatures were observed throughout April and May and again in September. Beginning in July, most daily average temperatures were above normal (Appendix C).

Cumulative precipitation through September was 11.6 inches, 0.3 inches higher than normal precipitation (Table 6-7). The increase in cumulative precipitation was likely due to periods of precipitation above normal in June and September (Appendix C).

Table 6-7. Air temperature and precipitation data collected by the National Weather Service from the Sheridan County Airport in 2022

	Average Monthly Air Temperature (°F)		Average Monthly Precipitation (inches)		
Months	**2022**	**Normal**	**2022**	**2022 Cumulative**	**Normal Cumulative**
May	52	53	0.11	5.0	5.5
June	63	62	0.05	8.5	8.0
July	74	71	0.01	9.3	9.4
August	74	69	0.02	9.9	10.2
September	64	59	0.07	11.6	11.3

6.7 BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates reside on and in the bottom substrate of streams and provide a valuable tool for the assessment of water quality in the Tongue River watershed. They are small but visible to the naked eye and large enough to be retained in a U.S. Standard Number 30 sieve.

Water chemistry sampling provides information for the quality of water at the time of sample collection. In contrast, macroinvertebrates serve as continuous monitors of stream water quality since they live in the water during most of their life cycle and are exposed to often variable concentrations of pollutants over extended periods of time. This is an important concept because water quality sampling may miss important changes in water quality due to normal seasonal and spatial variability, changes in land use, water management, or accidental pollutant spills. An optimal water quality monitoring program involves both water chemistry sampling and biological monitoring (Rosenberg & Resh, 1993).

Wyoming Water Quality Standards for chemical and physical water quality parameters (WDEQ, 2018b) were established to protect aquatic life and human health. Instead of using sampling results from individual chemical and physical water quality parameters, evaluation of benthic macroinvertebrate populations may serve as a direct measure for the attainment of the Aquatic Life beneficial use in addition to validating the effectiveness of individual numeric water quality chemical and physical standards. Benthic macroinvertebrates also serve to integrate water quality and habitat quality interaction and evaluate potential synergistic effects from multiple chemical and physical water pollutants not measured during routine water quality monitoring. Wyoming has developed biological criteria for streams statewide, but they have not been adopted as numeric, enforceable standards (Stribling, Jessup, & Gerritsen, 2000; Jessup & Stribling, 2002; Hargett, E.G.; ZumBerge, J.R., 2006; Hargett, 2011). As such, they may be used as narrative standards to determine

beneficial use for aquatic life and the protection and propagation of fish and wildlife. The Biological Criteria in Section 32 of the Wyoming Water Quality Standards provide a narrative standard for protection of indigenous or intentionally introduced aquatic communities (i.e., brown, brook, and rainbow trout species). In addition, Section 4 in the Wyoming Water Quality Standards relates the presence of food sources (e.g., benthic macroinvertebrates) for game and non-game fish as a criterion for Surface Water Classes and (beneficial) uses (WDEQ, 2018b).

6.7.1 Previous Benthic Macroinvertebrate Sampling

The historic benthic macroinvertebrate data for forty (N = 40) samples collected in the Tongue River watershed from 1993 through 1999 were presented and discussed in the Tongue River Watershed Assessment 1996-1999: Final Report (SCCD, 2000a). SCCD collected nine (N = 9) benthic macroinvertebrate samples from eight stations in 2003. The data from the 2003 sampling were presented and discussed in the 2003 Tongue River Monitoring Project report (SCCD, 2004). In 2006, a total of three benthic macroinvertebrate samples were collected by SCCD from two mainstem Tongue River monitoring stations (stations TRL (renamed TR07 in 2013) and TR1 (renamed TR05 in 2013). These data were presented and discussed in the 2006 Tongue River Monitoring Project report (SCCD, 2007a). No benthic macroinvertebrate samples were collected in the Tongue River watershed by SCCD from 2007 through 2009. SCCD then collected a total of eleven (N = 11) benthic macroinvertebrate samples in 2010 from ten stations. Six of the samples were collected from Tongue River mainstem stations and five of the samples were collected from tributaries to the Tongue River. These data were presented and discussed in the 2010 Tongue River Watershed Interim Monitoring Project report (SCCD, 2012a).

A total of six (N = 6) benthic macroinvertebrate samples were collected by SCCD in 2013 from five stations. Two of the monitoring stations were new and included TR03 near the Decker Highway bridge crossing, and TR01 near the Wyoming/Montana state line. These data were presented and discussed in the 2013 Tongue River Watershed Interim Monitoring Project report (SCCD, 2015). A total of six (N = 6) benthic macroinvertebrate samples were collected by SCCD in 2016 from five stations. All samples were collected from Tongue River mainstem stations TR09, TR07, TR05, TR03 and TR01. The data were presented and discussed in the 2016 Tongue River Watershed Interim Monitoring Project report (SCCD, 2017). The same five mainstem stations were sampled again in 2019 and were discussed in the 2019 Tongue River Watershed Interim Monitoring Project report (SCCD, 2020). WDEQ previously collected a total of two (N = 2) benthic macroinvertebrate samples at station TR03 in 1998 and 2004 (see Appendix Tables C-7 through C-8 in the 2013 Tongue River Watershed Interim Monitoring Report (SCCD, 2015). In addition, WDEQ collected a total of four (N = 4) samples from a location just downstream from SCCD station TR01 during 1998, 2003 and 2004 (see Appendix Tables C-9 through C-12 (SCCD, 2015)).

Field benthic macroinvertebrate sample collection methods and laboratory analytical methods employed by both SCCD and WDEQ have been the same since sampling began by WDEQ in 1993 and SCCD in 1996 (i.e., 8 random composite Surber samples with 500-micron net, 500-600 organisms identified in the laboratory, and similar Standard Taxonomic Effort). This resulted in comparable benthic macroinvertebrate data sets generated by SCCD and WDEQ and allowed all data to be used in the evaluation of biological condition for water bodies sampled within the project area.

6.7.2 Benthic Macroinvertebrate Sampling in 2022

A total of six (N = 6) benthic macroinvertebrate samples were collected by SCCD in 2019 from five stations (Appendix D). The samples were collected from Tongue River mainstem stations TR09, TR07, TR05, TR03 and TR01. No samples were collected from tributaries to the Tongue River. Included in the total number of samples was a duplicate benthic macroinvertebrate sample collected from station TR05. The duplicate sample was used only for QA/QC purposes, construction of taxa lists and for general discussion of macroinvertebrate results. The duplicate sample was not used for the determination of biological condition.

A series of metrics were calculated for each sample. A metric is a characteristic of the macroinvertebrate community that changes in a predictable way to increased human influence (Table 6-8). The change in certain macroinvertebrate metrics at a sample station over time, or between sample stations, can indicate change in water quality at or among stations. The metrics for macroinvertebrate samples collected in 2022 and for previous macroinvertebrate samples are presented in Appendix Tables D-7 through D-12.

Table 6-8. Definition of select macroinvertebrate metrics and expected response to perturbation including water quality and habitat change (King, K.W., 1993; Barbour, Gerritsen, Snyder, & Stribling, 1999)

Metric	Definition	Expected Response
Total Number Taxa	Measures the overall variety of the macroinvertebrate assemblage	Decrease
Total Number EPT Taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies, and Trichoptera (caddisflies)	Decrease
Total Number Ephemeroptera Taxa	Total Number of mayfly taxa	Decrease
% Ephemeroptera	Percent of mayfly nymphs	Decrease
Total Number Plecoptera Taxa	Total Number of stonefly taxa	Decrease
% Plecoptera	Percent of stonefly nymphs	Decrease
Total Number Insect Taxa	Total Number taxa in the Class Insecta	Decrease
Total Number Non - Insect Taxa	Total Number taxa not in the Class Insecta	Increase
% Non - Insects	Percent of Non - Insects	Increase
% Chironomidae	Percent of midge larvae	Increase
% Oligochaeta	Percent of worms	Increase
% 5 Dominant	Total Percent of the 5 most dominant taxa	Increase
% 10 Dominant	Total Percent of the 10 most dominant taxa	Increase
Number Predator Taxa	Number of taxa that feed upon other organisms or themselves in some instances	Variable, but appears to decrease in most regions of Wyoming
Total Number Scraper Taxa	Total Number of taxa that scrape periphyton for food	Decrease
% Scrapers	Percent organisms that scrape periphyton for food	Decrease
% Collector - Filterers	Percent organisms that filter Fine Particulate Organic Material from either the water column or sediment	Increase in most Wyoming ecoregions
% Collector - Gatherers	Percent organisms that either collect or gather food particles	Increase
Modified HBI	Uses tolerance values to weight abundance in an estimate of overall pollution. Originally designed to evaluate organic pollution.	Increase
BCI CTQa	Tolerance classification based on nonpoint source impact of sedimentation and velocity alteration	Increase
Shannon H (Log base 2)	Incorporates both richness and evenness in a measure of general diversity and composition	Decrease
% Multivoltine	Percent of organisms having short (several per year) life cycle	Increase
% Univoltine	Percent of organisms relatively long-lived (life cycles of 1 or more years)	Decrease

6.7.3 Benthic Macroinvertebrate Taxa

Taxa lists for Tongue River watershed benthic macroinvertebrate samples collected by SCCD in 2022 are presented in Appendix Tables D-1 through D-6. The list of benthic macroinvertebrate metrics for historic and current samples collected at stations TR09, TR07, TR05, TR03 and TR01 from 1993 to 2019 is presented in Appendix Tables D-7 through D-11.

The benthic community at Tongue River TR09 station was generally dominated by cool water taxa indicative of good water quality and good habitat. A mixture of cool water and warm water taxa were present at stations TR07 and TR05. A shift to primarily warm water taxa dominated the benthic community at stations TR03 and TR01. Worms, leeches, and other organisms indicating degraded water quality have comprised less than 1 percent of the macroinvertebrate community at TR09. Over the years, a higher frequency of occurrence and number of worm and leech taxa were observed at downstream stations TR07, TR05, TR03 and TR01.

No threatened or endangered benthic macroinvertebrate taxa or fish species (incidentally captured during macroinvertebrate sampling) have been identified since sampling began in the Tongue River watershed in 1993. One previously present, but recently reclassified mayfly taxon was identified during sampling in 2022. The mayfly genus *Anafroptilum* was identified at station TR01. This taxon previously classified in the genus *Centroptilum* is no longer represented in North America (Jacobus, L.M., Wiersema, N.A., 2014). The taxon in the mayfly family Baetidae (small minnow mayflies) previously identified in the Tongue River is now recognized as *Anafroptilum*.

The generally widespread occurrence of the freshwater shrimp genera *Gammarus* and *Hyalella*, and the freshwater shrimp species group *Hyalella azteca* (commonly used in laboratory toxicity tests) in the Tongue River watershed indicated that water in Tongue River contained no toxic substances in sufficient concentration to prevent the establishment and survival of these organisms.

The disappearance of stoneflies since the latter 1990's was noted at some mainstem Tongue River stations. Plecoptera (stoneflies) are considered one of the most pollution sensitive groups of aquatic organisms. At station TR07, from 3 to 5 Plecoptera taxa were collected each year from 1996 through 1999, but were absent from collections in 2003, 2004, 2006, 2013, and 2019. One immature stonefly in the family Perlidae was present in 2010 and one *Isoperla* was identified in the 2016 sample and 2022 sample, respectively.

No stoneflies have been collected at station TR05 since sampling began in 1995. The stonefly genus *Isoperla* was present at station TR03 in 1998 but has not been collected since then. At TR01, stonefly genera *Isoperla* and *Acroneuria* were present in 1998, but neither has been collected in samples since then. The general disappearance of stoneflies at Tongue River mainstem stations downstream of TR09 since the 1990's indicates that water quality and habitat change have negatively affected this pollution intolerant group of aquatic insects.

Whirling disease is caused by a destructive parasite that may decimate trout populations. Whirling disease has not been detected in the Tongue River watershed or nearby Little Goose Creek, Big Goose Creek, and Prairie Dog Creek watersheds. However, the disease has been detected at six locations in the Powder River watershed adjacent to the Prairie Dog Creek watershed. *Tubifex Tubifex* (a species of aquatic worm), is significantly involved in the whirling disease life cycle caused by a parasite (*Myxobolus cerebralis*) that penetrates the head and spinal cartilage of fingerling trout. Whirling disease may eventually cause death in trout. No *T. Tubifex* have been collected at Tongue River stations since monitoring began indicating a low probability for the occurrence of whirling disease. However, the presence of the genus *Tubifex* in a 2006 sample at TR07 and

the presence of immature Tubificid worms in samples collected at TR01 suggest the future potential occurrence of *T. Tubifex* at those locations.

Wyoming Game and Fish Department implemented an aquatic invasive species monitoring program throughout Wyoming including mandatory aquatic invasive species check stations. The program is designed to prevent the establishment of the zebra mussel (*Dreissena polymorpha*) and the quagga mussel (*Dreissena rostriformis bugensis*) in Wyoming waterbodies. The two clam species may produce serious negative impact to aquatic resources, ecological functions of waterbodies, drinking water intakes and water distribution systems. Although the mussels have been identified in Utah, Colorado, eastern South Dakota, and eastern Nebraska, they are not present in Wyoming to date. No zebra or quagga mussels have been identified by SCCD sampling in the Tongue River watershed or the nearby Goose Creek and Prairie Dog Creek watersheds.

Other aquatic invasive species of significant concern currently in Wyoming include the New Zealand Mudsnail species (*Potamopyrgus antipodarum*) and the Asian Clam species (*Corbicula fluminea*). The New Zealand Mudsnail is present in Yellowstone National Park, the Snake River, Shoshone River, and the Bighorn River. The distribution of the Asian Clam in Wyoming is restricted to a few locations in south-east Wyoming. Historic benthic macroinvertebrate sampling and current monitoring by SCCD have not identified the New Zealand Mudsnail or the Asian clam in the Tongue River watershed or the nearby Goose Creek and Prairie Dog Creek watersheds.

6.8 BIOLOGICAL CONDITION

The biological condition based on the benthic macroinvertebrate community was determined for each station sampled in 2022 and for those comparable stations sampled by WDEQ in 1998, 2003 and 2004. A total of fifty-four (N = 54) biological condition calculations were completed and listed in Table 6-10.

Biological condition scores were derived using the Wyoming Stream Integrity Index (WSII) initially developed by Jessup and Stribling (2002), updated by Hargett and ZumBerge (2006), and Hargett (2011). The WSII is based on the analysis of benthic macroinvertebrate monitoring data collected by WDEQ from 1993 through 2009 from 1,488 reference and non-reference quality streams statewide. The WSII identified eleven bioregions for Wyoming. Each bioregion used different scoring criteria because the biological communities naturally differ among bioregions. Based on classifications provided by Hargett (2011), biological condition scoring criteria for three bioregions were used to evaluate biological condition (Table 6-9) as follows:

- Sedimentary Mountains bioregion for Tongue River locations TR09
- High Valleys bioregion for Tongue River locations TR07 and TR05
- Northeastern Plains bioregion for Tongue River locations TR03 and TR01

Table 6-9. Wyoming Stream Integrity Index (WSII) metrics and scoring criteria for benthic macroinvertebrate communities in the Sedimentary Mountains, High Valleys, and Northeastern Plains bioregions (Hargett, 2011)

Sedimentary Mountains Bioregion (TR09)		
Macroinvertebrate Metric	**Metric Scoring Formulae**	**5th or 95th %ile (As per formula)**
No. of EPT Taxa (less Arctopsychidae and Hydropsychidae)	100*X / 95th%ile	24
% Ephemeroptera (less Baetidae and *Tricorythodes*)	100*X / 95th%ile	43.7
% Collector-gatherer	100*(88.3-X) / (88.3-5th%ile)	14
% Scraper	100*X / 95th%ile	71.5
Number of Scraper Taxa	100*X / 95th%ile	8
HBI	100*X / 95th%ile	100
High Valleys Bioregion (TR07 and TR05)		
Macroinvertebrate Metric	**Metric Scoring Formulae**	**5th or 95th %ile (As per formula)**
% Chironomidae Taxa of Total Taxa	100*(33.3-X) / (33.3-5th%ile)	0
% Ephemeroptera Taxa of Total Taxa	100*X / 95th%ile	24
No. EPT Taxa	100*X / 95th%ile	23
% EPT (less Arctopsychidae and Hydropsychidae)	100*X / 95th%ile	81.3
% Scraper	100*X / 95th%ile	52
BCICTQa	100*(79.9-X) / (79.9-5th%ile)	54.2
Northeastern Plains Bioregion (TR03 and TR01)		
Macroinvertebrate Metric	**Metric Scoring Formulae**	**25th or 75th %ile (As per formula)**
Number of Ephemeroptera Taxa	100*X / 75th%ile	4
Number of Univoltine Taxa	100*X / 75th%ile	16
HBI	100*(6.8-X) / (6.8-25th%ile)	5.7

Metric values for the sample benthic macroinvertebrate community were compared to optimal benthic macroinvertebrate metric values (WSII) and expressed as a percentage. The percentages were summed for each sample metric to provide a biological condition rating (Table 6-10).

Table 6-10. Assessment rating criteria for benthic macroinvertebrate communities based on the Wyoming Stream Integrity Index (WSII) (Hargett, 2011) in the Sedimentary Mountains, High Valleys, and Northeastern bioregions of Wyoming

Rating of Biological Condition (Aquatic Life Use Support)	Sedimentary Mountains bioregion	High Valleys bioregion	Northeastern Plains bioregion
Full Support	>52.25	>48.77	>58.42
Indeterminate Support	34.83-52.24	32.51 – 48.76	38.95-58.41
Partial/ (Non - Support)	0-34.82	0 – 32.50	0-38.94

The calculated biological condition rating was used to rate the biological community as Full-Support, Indeterminate, or Partial/Non-Support (Table 6-11). A biological condition rating of Full-support indicates full support for narrative aquatic life use. The Indeterminate biological classification is not an attainment category, but rather a designation requiring the use of ancillary information and/or additional data in a weight of evidence evaluation to determine a narrative assignment such as full support or partial/non-support (Hargett, 2011). The Partial/Non-support classification indicates the resident aquatic community is subjected to substantial anthropogenic stressors. Water quality and/or habitat improvements are required to restore the stream to full support for narrative aquatic life use.

Table 6-11. Biological condition score and rating for benthic macroinvertebrate samples collected from 1993 through 2022 from Tongue River based on Wyoming Stream Integrity Index (WSII) (Hargett, 2011)

Sampling Station and Year	Sedimentary Mountains Bioregion		High Valleys Bioregion		Northeastern Plains Bioregion	
	Score	Rating	Score	Rating	Score	Rating
Tongue River - TR09 - Canyon (1993)[A]	70.3	Full	NA[B]	NA	NA[B]	NA
Tongue River - TR09 - Canyon (1994)[A]	58.5	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1995)[A]	52.0	Indeterminate	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1996)[A]	64.3	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1997)[A]	61.9	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1998)[A]	56.9	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1999)[A]	62.9	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1999)[C]	63.1	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2000)[A]	55.2	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2001)[A]	66.5	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2002)[A]	72.5	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2003)	63.0	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2003)[A]	75.2	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2004)[A]	71.5	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2007)[A]	51.9	Indeterminate	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2009)[A]	59.4	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2010)	55.4	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2013)	71.6	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2016)	68.4	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2019)	62.2	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2022)	80.0	Full	NA	NA	NA	NA
Tongue River - TR07 - Co. Rd 67 (1996)	NA[B]	NA	46.6	Indeterminate	NA[B]	NA
Tongue River - TR07 - Co. Rd 67 (1997)	NA	NA	52.7	Full	NA	NA
Tongue River - TR07 - Co. Rd 67 (1998)	NA	NA	45.5	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (1999)	NA[B]	NA	48.2	Indeterminate	NA[B]	NA
Tongue River - TR07 - Co. Rd 67 (2003)	NA	NA	47.8	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2004)[A]	NA	NA	41.7	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2006)	NA	NA	44.0	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2013)	NA	NA	30.4	Partial or Non	NA	NA
Tongue River - TR07 - Co. Rd 67 (2016)	NA	NA	47.9	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2019)	NA	NA	40.0	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2022)	NA	NA	52.8	Full	NA	NA
Tongue River - TR05 - Kleenburn (1995)[A]	NA	NA	63.6	Full	NA	NA
Tongue River - TR05 - Kleenburn (1998)[A]	NA	NA	56.0	Full	NA	NA
Tongue River - TR05 - Kleenburn (2004)[A]	NA	NA	58.0	Full	NA	NA
Tongue River - TR05 - Kleenburn (2006)	NA	NA	46.2	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2010)	NA	NA	48.5	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2013)	NA	NA	46.0	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2016)	NA	NA	34.0	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2019)	NA	NA	44.7	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2022)	NA	NA	43.7	Indeterminate	NA	NA

[A] Sample collected by WDEQ.

[B] NA = WSII Score or Rating not applicable since sample was not collected in the bioregion.

Table 6-14. (Continued) Biological condition score and rating for benthic macroinvertebrate samples collected from 1993 through 2022 from Tongue River based on Wyoming Stream Integrity Index (WSII) (Hargett, 2011)

Sampling Station and Year	Sedimentary Mountains Bioregion		High Valleys Bioregion		Northeastern Plains Bioregion	
	Score	Rating	Score	Rating	Score	Rating
Tongue River - TR03 - Decker Hwy (1998)[A]	NA	NA	NA	NA	100.0	Full
Tongue River - TR03 - Decker Hwy (2004)[A]	NA	NA	NA	NA	66.7	Full
Tongue River - TR03 - Decker Hwy (2013)	NA	NA	NA	NA	73.2	Full
Tongue River - TR03 - Decker Hwy (2016)	NA	NA	NA	NA	62.7	Full
Tongue River - TR03 - Decker Hwy (2019)	NA	NA	NA	NA	68.5	Full
Tongue River - TR03 - Decker Hwy (2022)	NA	NA	NA	NA	81.3	Full
Tongue River - TR01 - State Line (1998)[A]	NA	NA	NA	NA	97.0	Full
Tongue River - TR01 - State Line (2003)[A]	NA[B]	NA	NA	NA	75.9	Full
Tongue River - TR01 - State Line (2004)[A]	NA	NA	NA	NA	70.4	Full
Tongue River - TR01 - State Line (2013)	NA	NA	NA	NA	87.1	Full
Tongue River - TR01 - State Line (2016)	NA	NA	NA	NA	79.4	Full
Tongue River - TR01 - State Line (2019)	NA	NA	NA	NA	77.0	Full
Tongue River - TR01 - State Line (2022)	NA	NA	NA	NA	67.5	Full

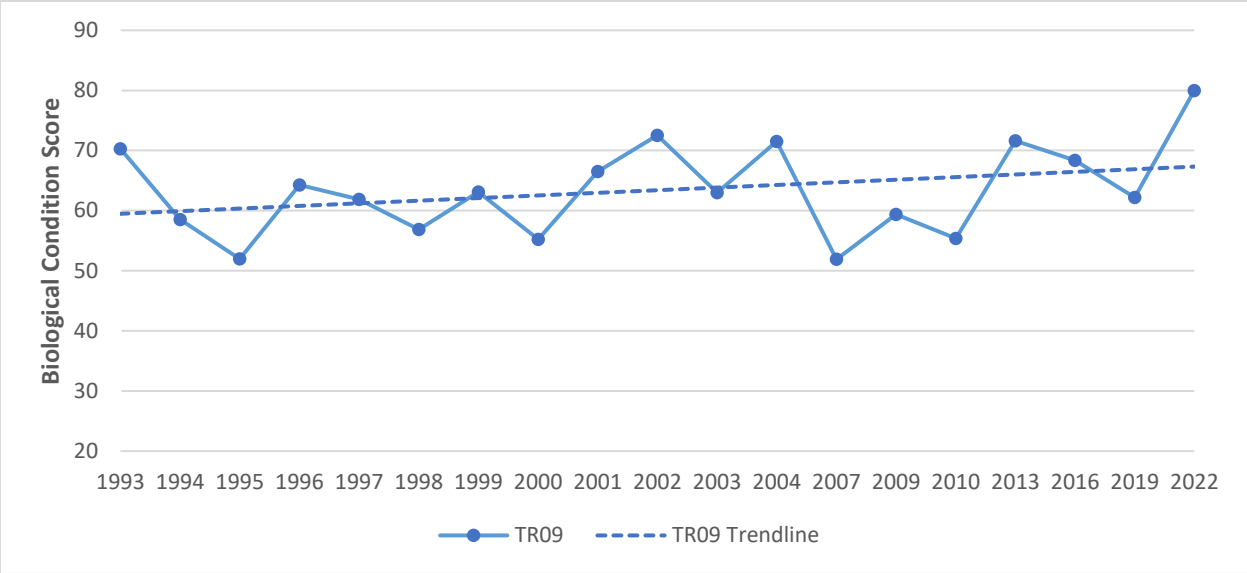
[A] Sample collected by WDEQ.
[B] NA = WSII Score or Rating not applicable since sample was not collected in the bioregion.

6.8.1 Tongue River TR09

The Tongue River station TR09 represents the most upstream monitoring site on the mainstem Tongue River and is in the Sedimentary Mountains bioregion. The station is identified as the reference, or control station, for macroinvertebrate monitoring on the mainstem Tongue River. The Tongue River TR09 station has been sampled annually for benthic macroinvertebrates from 1993 through 2004, and in 2007, 2009, 2010, 2013, 2016, 2019, and 2022 (Table 6-11). This station has been sampled by SCCD, WDEQ, USGS and EPA over the years and represents the most frequently sampled benthic macroinvertebrate station in north central Wyoming. It should be noted that data collected by EPA was not used to determine biological condition for this report since sampling and analysis methods were not directly comparable to those methods used by SCCD, WDEQ and USGS.

Biological condition scores have varied little over the years ranging from a score of 80.0 in the recent 2022 sampling to a score of 51.9 in 2007 (Table 6-11;). The high biological score of 80.0 was due to the dominance of pollution intolerant mayfly, stonefly and caddisfly taxa which comprised 78 percent of the total organisms (Appendix D). With the exception of 1995 and 2007, the biological condition scores consistently indicated full support for aquatic life use. It should be noted that the biological condition scores in 1995 (52.0) and 2007 (51.9) were very close to achieving the full support score of 52.2. The slightly positive trendline shown in Figure 6-14 for biological condition indicates stability in the biological community and confirms that station TR09 is a representative reference station. The general stability in biological condition over the years indicated that despite variable stream flows and likely variable water temperature and environmental conditions among years, water quality and habitat remained good.

Figure 6-14. Biological condition at Tongue River Station TR09



The benthic community at Tongue River TR09 station was generally dominated by cool water taxa indicative of good water quality and good habitat. Worms, leeches, and other organisms indicating degraded water quality comprised less than 1 percent of the macroinvertebrate community over the years. No *Tubifex tubifex* (a species of worm) have been collected at Tongue River TR09 since monitoring began in 1993 indicating a low probability for the occurrence of whirling disease.

The benthic macroinvertebrate data indicated that land use occurring upstream in the Bighorn National Forest (BNF) had no consistent measurable effect on the Tongue River TR09 benthic macroinvertebrate community. Potential pollutants that may enter the Tongue River from BNF are apparently removed by natural stream processes resulting in good year-round water quality and healthy biological communities. The high biological condition scores confirmed the overall good water quality shown through water quality sampling, habitat assessment, and the resultant general full support for aquatic life use.

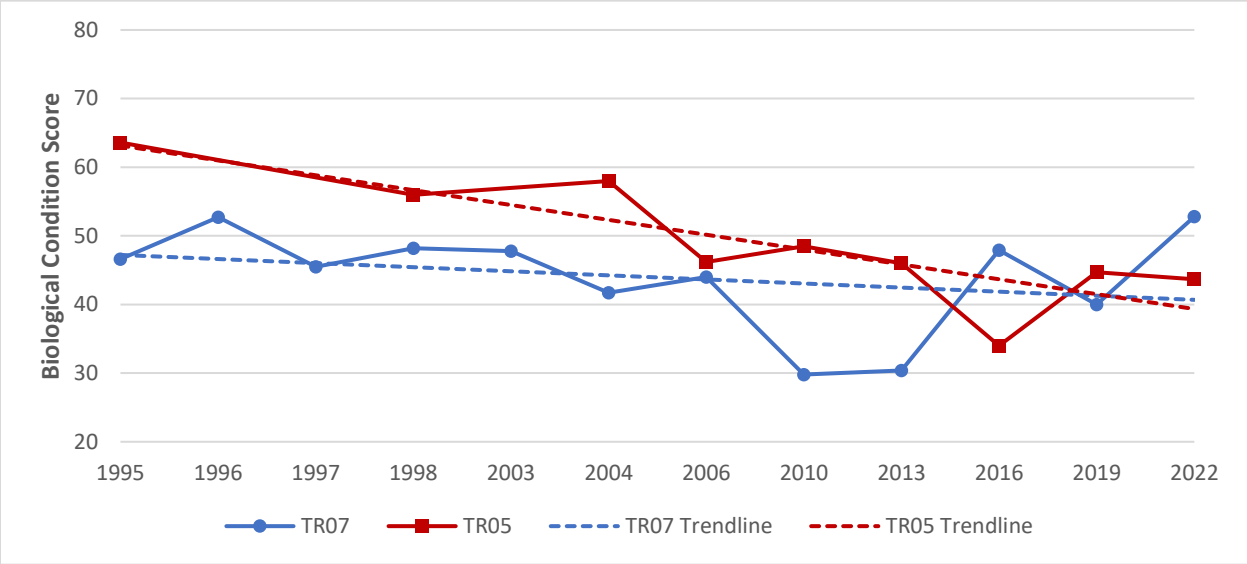
6.8.2 Tongue River TR07

The Tongue River TR07 station is located just upstream of the County Road 67 bridge near Ranchester, WY and is placed in the High Valleys bioregion near the lower boundary of the Sedimentary Mountains bioregion. The Tongue River TR07 station has been sampled annually for benthic macroinvertebrates from 1996 through 1999, and in 2003, 2004, 2006, 2010, 2013, 2016, 2019, and 2022 (Table 6-11). The sample collected by WDEQ in 2004 was comparable to samples collected by SCCD at TR07 since the WDEQ sampled in Connor Battlefield about 250 yards downstream of SCCD location TR07.

The biological condition of the benthic macroinvertebrate community at Tongue River TR07 station varied little from the period of 1996 through 1999 (Table 6-11; Figure 6-15). Biological condition scores ranged from 46.6 in 1996 to 52.0 in 1997. The biological condition scores indicated indeterminate or full support for aquatic life use each year.

In 2003, the biological condition score dropped to 47.8 with further declines to 41.7 in 2004, 29.8 in 2010 and 30.4 in 2013 (Figure 6-15). The biological condition increased to 47.9 in 2016 and then dropped to 40.0 in 2019. Aquatic life use dropped from full support in 1997 to indeterminate or partial or non-support during subsequent years (Table 6-11). Although the slight improvement in biological condition from 2016 to 2019 and 2022 was encouraging, the negative trendline shown in Figure 6-15 indicated a general decline in the biological condition since sampling began in 1996.

Figure 6-15. Biological condition at Tongue River Stations TR07 and TR05



The decline in biological condition was due to an increase in pollution tolerant organisms and a decrease in organisms sensitive to pollution. The total number of Non-Insect Taxa (generally more tolerant of pollution than Insect Taxa) and the HBI value (general community measure of pollution tolerant organisms) has been relatively high (Appendix D). Further, the number of Chironomidae taxa has generally increased since 1996. As previously noted was the near disappearance of Plecoptera (stoneflies) at Tongue River TR07 after 1999. Plecoptera are considered to be the most pollution sensitive group of aquatic organisms. 3 to 5 Plecoptera taxa were collected each year from 1996 through 1999, but were absent from collections in 2003, 2004, and 2006, 2013, and 2019. One immature stonefly in the family Perlidae was present in 2010 and one *Isoperla* was present in 2016 and 2022. Some Ephemeroptera (mayfly) taxa including the genera *Drunella* and *Ephemerella* (both indicative of good water quality and cooler water temperature) have nearly disappeared at Tongue River TR07 station since 1999.

The highest number of worm and leech taxa (N = 8 taxa) comprising 2.48% of the total benthic community occurred at Tongue River TR07 during 2006. In 2013 there were 5 worm and leech taxa comprising 4.19% of the total benthic community. Increase in the density of worms may be associated with organic pollution (Klemm, D.J., 1985), pollution from feedlots (Prophet, W.W.; Edwards, N.L., 1973) , and pollutants contained in urban storm water runoff (Lenat, D.R.; Penrose, D.L.; Eagleson, K.W., 1979; Lenat, D.R.; Eagleson, K.W., 1981). The number of worm taxa and percent contribution of worms in 2006 and 2013 did

not indicate a severe pollution problem, but rather a moderate amount of pollution indicative of animal waste from agricultural, wildlife or urban sources.

Tubifex Tubifex (a species of worm) has not been collected at Tongue River TR07 station since monitoring began in 1996. However, the presence of the genus *Tubifex* in the 2006 sample suggests the future potential occurrence of *T. Tubifex* at Tongue River TR07. The reasons for the general reduction in biological condition and the loss of cool water macroinvertebrate taxa at Tongue River TR07 since 1999 are unknown. An increase in the amount of sand in the stream substrate and relatively high embeddedness (amount of silt covering cobble and gravel) noted during 2006 in Section 7.6 in SCCD (2007a) may produce adverse effects on the river benthic macroinvertebrate community and other aquatic organisms including fish. However, the combined amount of sand and silt at Tongue River TR07 station was low (1%) in 2010 suggesting that the lower biological condition rating in 2010 was not due to combined silt and sand or embeddedness. The combined amount of sand and silt in the substrate increased in 2013 (10%).

6.8.3 Tongue River TR05

The Tongue River TR05 station at the Kleenburn County Park was formerly known as Tongue River TR1 station. SCCD sampled TR05 for benthic macroinvertebrates in 2006, 2010, 2013, 2016, 2019, and 2022. WDEQ previously established a site identified as Tongue River at Kleenburn in 1995. WDEQ sampled this site in 1995, 1998 and 2004. The station is in the High Valleys bioregion.

The biological condition scores at station TR05 ranged from a low of 34.0 in 2016 to a high of 63.6 in 1995 (Table 6-11). Sampling in 1995, 1998 and 2004 indicated full support for aquatic life use. Sampling in 2006, 2010, 2013, 2016, 2019, and 2022 indicated indeterminate support for aquatic life use. The trendline shown in Figure 6-15 indicates a gradual downward trend in biological condition since sampling in 1995. The downward trend in biological condition was primarily due to a reduction in the percentage of mayfly taxa to the total number of taxa in the benthic community, a reduction in the number of EPT taxa and a reduction in the percentage of scrapers.

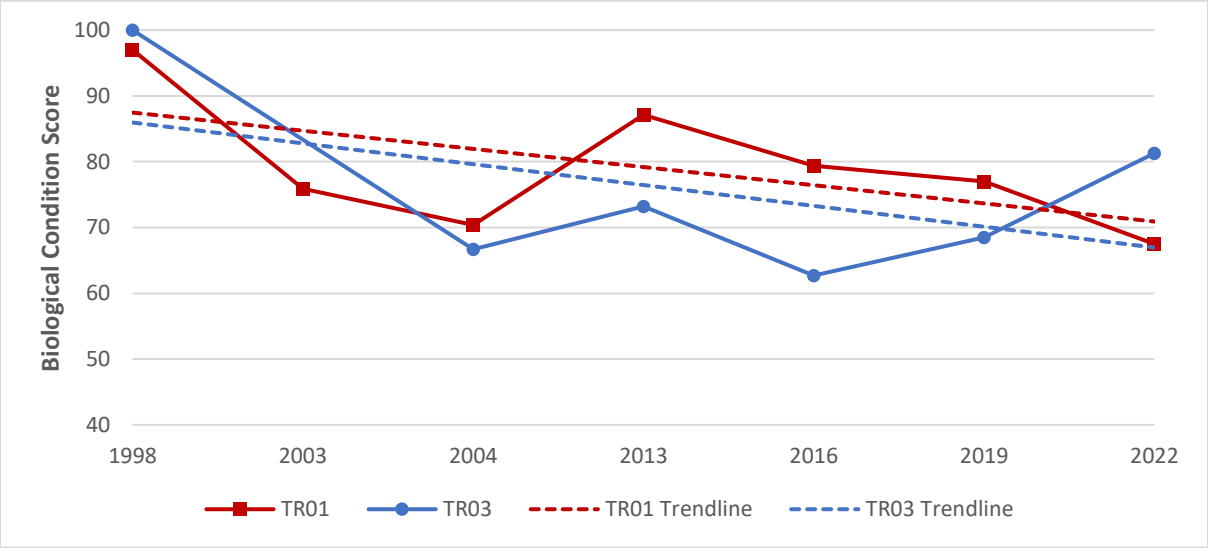
The benthic macroinvertebrate community was dominated by warm water taxa each year. The mayfly genus *Tricorythodes* dominated the community in 1998, 2006 and 2016, and was the second most dominant taxon in the community in 1995. The riffle beetle genus *Microcylloepus* co-dominated the community in 2006 and was the second most dominant taxon in the community in 2010. Trichoptera (caddisflies) were well represented in the benthic community each year. The genera *Helicopsyche*, *Hydropsyche* and *Cheumatopsyche* were the most common caddisfly taxa. *Helicopsyche* dominated the benthic community in 2004 and 2013. Several specimens in the stonefly genus *Isoperla* and one immature stonefly in the family Capniidae were present in 1998, but no stoneflies have been collected in samples since then. The disappearance of stoneflies since the latter 1990's was noted at other lower mainstem Tongue River stations.

6.8.4 Tongue River TR03

The Tongue River TR03 station located upstream of the Decker Highway bridge crossing was established by SCCD in 2013. WDEQ previously established a site identified as Tongue River at Decker Highway in 1998. WDEQ sampled that site in 1998 and 2004. The station is in the Northeastern Plains bioregion. The biological condition scores ranged from a low of 62.7 in 2016 to a high of 100.0 in 1998 (Table 6-14).

Sampling in 1998, 2004, 2013, 2016, 2019, and 2022 indicated full support for aquatic life use. However, Figure 6-16 shows that there has been a downward trend in biological condition since the high biological condition value of 100 in 1998 appeared to skew the trendline.

Figure 6-16. Biological condition at Tongue River Stations TR03 and TR01



The benthic macroinvertebrate community was dominated by warm water taxa each year. The mayfly genus *Tricorythodes* dominated the community in 1998 and 2016 and was the second most dominant taxon in the community in 2004 and 2013. The riffle beetle genus *Microcylloepus* dominated the community in 2004 and 2013 and was the second most dominant taxon in the community in 1998 and 2016. Trichoptera (caddisflies) were well represented in the benthic community each year. The genera *Hydropsyche*, *Helicopsyche* and *Oecetis* were the most common caddisfly taxa in 1998, 2004, 2013 and 2014. The stonefly genus *Isoperla* was present in 1998 but has not been collected in samples since then. The disappearance of stoneflies since the latter 1990's was noted at other mainstem Tongue River stations.

6.8.5 Tongue River TR01

The Tongue River TR01 station near the Wyoming – Montana border in the Northeastern Plains bioregion is the lowermost sampling station on the mainstem Tongue River within the project area. SCCD established this station in 2013. WDEQ previously established a site identified as Tongue River – State Line in 1998. WDEQ sampled that site in 1998, 2003 and 2004. The WDEQ station is located near U.S. Geological Survey Station 06306300 just downstream of SCCD station TR01. Biological condition at Tongue River TR01 dropped from 1998 to 2004, increased in 2013, and declined slightly from 2013 to 2019 (Figure 6-16).

The biological condition scores ranged from a low of 70.4 in 2004 to a high of 97.0 in 1998 (Table 6-11). Sampling during each year indicated full support for aquatic life use. WDEQ concurred with this finding but added that effects due to stressors such as temperature, sulfates, nutrients, and sediment were present (WDEQ, 2002). These stressors appeared to affect the mainstem Tongue River system below the confluence

with Goose Creek (between Tongue River stations TR05 and TR03). The biological condition trendline shown in Figure 6-16 indicated that biological condition has declined over time. Full support for aquatic life use could change should the decline in biological condition continue.

The benthic macroinvertebrate community was dominated by warm water taxa each year. No one taxon has consistently dominated the benthic community over the years. The mayfly genera *Tricorythodes* and *Fallceon* were abundant at times along with the caddisfly genera *Hydroptila*, *Oecetis*, *Cheumatopsyche*, and the chironomid genus *Rheotanytarsus*. The riffle beetle genus *Microcylloepus* was the second most abundant taxon in 2016. Immature Tubificid worms were abundant in 1998. The stonefly genera *Isoperla* and *Acroneuria* were present in 1998 but have not been collected in samples since then. The disappearance of stoneflies since 1998 was noted at other mainstem Tongue River stations upstream of TR01.

Tubifex Tubifex (a species of worm) has not been collected at Tongue River TR01 station since monitoring began in 1998. However, the presence of immature Tubificid worms in all samples collected over the years with the exception of 2019 and 2022 suggests the potential occurrence of *T. Tubifex* at Tongue River TR01.

6.8.6 Summary of Biological Condition

The collection and analysis of stream benthic macroinvertebrate samples during 2022 revealed similar trends in biological condition observed during previous monitoring at Tongue River mainstem stations. No Tongue River tributary stations were sampled during this 2022 report period.

Biological condition scores at reference station TR09 varied little over the years. With the exception of 1995 and 2007, the biological condition scores consistently indicated full support for aquatic life use. It should be noted that the biological condition scores in 1995 (52.0) and 2007 (51.9) were very close to achieving the full support score of 52.2. The slightly positive trendline at station TR09 for biological condition indicated stability in the biological community and confirmed that station TR09 was a representative reference station.

The biological condition of the benthic macroinvertebrate community at Tongue River TR07 station varied little from the period of 1996 through 1999. Biological condition scores ranged from 46.6 in 1996 to 52.0 in 1997. The biological condition scores indicated indeterminate or full support for aquatic life use each year. There was an improvement in biological condition from 2013 to 2016 with a slight reduction in 2019 and the highest biological condition in 2022; however, a negative trendline indicated a general decline in the biological condition since sampling began in 1996.

The biological condition scores at station TR05 in 1995, 1998 and 2004 indicated full support for aquatic life use. Sampling in 2006, 2010, 2013, 2016, 2019, and 2022 indicated indeterminate support for aquatic life use. The negative trendline graph for biological condition indicated a gradual downward trend in biological condition since sampling in 1995.

Biological condition scores at station TR03 generally indicated full support for aquatic life use. However, an apparent downward trend in biological condition was due to the high biological condition value of 100 in 1998 that appeared to skew the trend line. The stonefly genus *Isoperla* was present in 1998 but has not been collected in samples since then. The disappearance of stoneflies since the latter 1990's was noted at other mainstem Tongue River stations.

Biological condition scores at the most downstream station TR01 located near the Montana border indicated full support for aquatic life use during each year since 1998. However, a graph of biological condition scores

indicated that biological condition has declined over time. Full support for aquatic life use could change should the decline in biological condition continue.

Those stations that have the partial or non-support classification for biological condition indicated the aquatic communities were stressed and water quality or habitat improvements were required to restore the stream to full support for the narrative WDEQ standard for aquatic life use. Stations exhibiting the Indeterminate biological classification require the use of ancillary information and/or additional data in a weight of evidence evaluation to determine full support or partial/non-support (Hargett, 2011). Planning and implementation of remedial measures must continue to restore full aquatic life use support in the streams in the Tongue River watershed. Continued benthic macroinvertebrate sampling should be conducted at stations in the watershed to track changes in biological condition.

No threatened or endangered benthic macroinvertebrate taxa or fish species have been identified since sampling began in the Tongue River watershed within the project area in 1993. The generally widespread occurrence of freshwater shrimp genera indicated that water in Tongue River contained no toxic substances in sufficient concentration to prevent the establishment and survival of these organisms.

The disappearance of stoneflies since the latter 1990's noted at some mainstem Tongue River stations continued. The general disappearance of stoneflies at Tongue River stations downstream of TR09 since the 1990's indicates that water quality and habitat change have negatively affected this pollution intolerant group of aquatic insects.

Historic and current monitoring by SCCD and WDEQ of aquatic benthic macroinvertebrate communities in the Tongue River watershed have not identified the presence of aquatic invasive species of concern to the WGFD. No zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena rostriformis bugensis*), New Zealand Mudsnail (*Potamopyrgus antipodarum)* and the Asian Clam (*Corbicula fluminea*) have been identified in the Tongue River watershed or adjacent Little Goose Creek and Big Goose Creek watersheds. Recommended future benthic macroinvertebrate monitoring by SCCD will be attentive to the presence of aquatic invasive species.

Tubifex Tubifex, a species of aquatic worm, involved in the whirling disease life cycle that may decimate trout populations, have not been collected at Tongue River stations since monitoring began in 1993 indicating a low probability for the occurrence of whirling disease. However, the presence of the genus *Tubifex* and immature Tubificid worms in samples collected in the Tongue River watershed suggest the future potential occurrence of *T. Tubifex*. Whirling disease has not been detected in the Tongue River watershed or nearby Little Goose Creek and Big Goose Creek watersheds. However, the disease has been detected at six locations in the adjacent Powder River watershed to the east. *Tubifex Tubifex* (a species of aquatic worm), is significantly involved in the whirling disease life cycle caused by a parasite (*Myxobolus cerebralis*) that penetrates the head and spinal cartilage of fingerling trout. Whirling disease may eventually cause death in trout.

6.9 HABITAT ASSESSMENTS

Qualitative habitat assessments were conducted by SCCD during 2022 at mainstem Tongue River stations TR09, TR07, TR05, TR03 and TR01. WDEQ used the same habitat assessment method as that used by SCCD through 2004. WDEQ changed their habitat assessment methods after 2004, thus no habitat data are presented for WDEQ assessments after that time. Habitat assessment data, substrate data, and embeddedness (silt cover) data for Tongue River mainstem stations are presented in Appendix E Tables 1-5. Because habitat assessments were subjective, SCCD used caution by providing a conservative interpretation of data.

The average habitat score at reference station Tongue River TR09 from 1993 through 2004, 2010, 2013, 2016, 2019, and 2022 was 168 (Appendix E Table 2). The range in annual habitat scores at Tongue River TR09 station was from 149 in 2019 to 184 in 2003. Although assessments were generally conducted on sampling dates within + two (2) weeks of one another each year, differences in annual discharge affected scoring for some habitat parameters because they were flow dependent. Scores for instream cover, velocity / depth, channel flow status and width depth ratio will normally score higher when discharge is increased but will score lower when discharge is decreased.

The average habitat score at Tongue River TR07 station from 1996 through 1999, 2003, 2004, 2006, 2010, 2013, 2016, 2019, and 2022 was 137 (Appendix E Table 3). Scores at TR07 ranged from 108 in 2006 to 163 in 2016. Variation in habitat scores between years appeared to be primarily related to difference in stream discharge at the time that the habitat assessment was conducted.

The reduction in habitat score from the reference upstream station TR09 to the downstream Tongue River TR07 station was generally due to lower scores for embeddedness (silt cover on or surrounding cobble and gravel), channel flow status, channel shape, channelization, width depth ratio and bank stability. Reduced scores for some of these parameters were related not only to current land use practices, but to lingering effects from the period of extensive channelization that apparently occurred in the late 1950's to early 1960's. Effects of channelization from that period continue to affect the Tongue River stream channel to this day requiring patch work repair and bank stabilization projects. Despite the lower habitat score at Tongue River TR07 station, this station ranked high when compared to habitat scores at other Wyoming streams in the High Valleys bioregion. This observation indicated that although Tongue River in-stream and riparian habitat have been altered due to channelization, habitat was still in better condition when compared to most Wyoming streams in the High Valleys bioregion.

The semi-quantitative stream substrate particle size distribution varied little between the Tongue River TR09 and TR07 stations. Cobble dominated the stream substrate at each station. Average percent cobble was 67 percent at station TR09 and 54 percent at station TR07 (Appendix E Tables 2 and 3). Average percent coarse gravel ranged from 16 percent at Tongue River TR09 to 26 percent at TR07. Silt deposition was minimal at both TR09 and TR07. The Tongue River TR09 station averaged less than 1 percent silt in the stream substrate and the TR07 station averaged 1 percent. Sand comprised 7 percent of the average total substrate at TR09 and 6 percent at station TR07. The amount of silt and sand in the stream substrate is important since silt and sand are detrimental to trout egg survival and maintenance of healthy benthic macroinvertebrate populations that provide food for trout (Chutter, F.M., 1969). The dominance of cobble and coarse gravel at each station allowed comparison of macroinvertebrate communities between stations because the variability caused by potential differences in the stream substrate was minimal.

Embeddedness (silt covering on or surrounding cobble and gravel) was low at the upstream reference Tongue River TR09 station. Average weighted embeddedness at TR09 from 1996 through 1999, 2003, 2004, 2006, 2010, 2013, 2016, 2019, and 2022 was 94.7. The higher the weighted embeddedness value, the lower the embeddedness or amount of silt deposited on cobble and gravel. The weighted embeddedness value of 94.7 indicated that about 94 percent of the surface of cobble and gravels were free of silt. The average weighted embeddedness at Tongue River TR07 station for the period of 1996 through 1999, 2003, 2004, 2006, 2010, 2013, 2016, 2019, and 2022 was 50.4 indicating that about 37.5 percent of the surface of cobble and gravels were free of silt. The decrease in weighted embeddedness from Tongue River TR09 station to downstream TR07 station indicated increased deposition of silt on cobble and gravel stream substrate between stations.

Deposition of silt is controlled by the amount of silt contained in the water column and by the current velocity. Silt deposition will normally increase as current velocity decreases.

The average current velocity measured at Tongue River TR09 station was 1.90 feet per second (fps) and 2.19 fps at the TR07 station. Because average water current velocity was slightly higher at the Tongue River TR07 station when compared to the upstream TR09 station, the apparent increased silt deposition at TR07 station was probably not related to difference in current velocity but was likely due to increased amount of silt contained in the water column.

The general decrease in substrate particle size from the Tongue River TR09 to the Tongue River TR07 station was normal because particle size generally decreases as stream size and stream order increase (Rosgen, D.L., 1996). The observed increase in embeddedness from the TR09 station to the TR07 station was likewise considered normal for the size and stream order of the Tongue River. Embeddedness at the TR07 station should be considered moderate when compared to weighted embeddedness values at other comparable streams in the High Valleys bioregion.

The habitat assessments conducted at Tongue River TR05 station at the Kleenburn Park indicated similar habitat characteristics to the upstream Tongue River TR07 station. The average habitat score at the Tongue River TR05 station for sampling years 1995, 1998, 2004, 2006, 2010, 2013, 2016, 2019, and 2022 was 137 (Appendix E Table 4). Total habitat assessment scores at Tongue River TR05 ranged from 147 in 1998 to 127 in 2004. Although the Tongue River TR05 station was several miles downstream of TR07, the habitat quality was similar at both stations.

The semi-quantitative stream substrate particle size distribution indicated that Tongue River TR05 was dominated by cobble (43 percent of substrate) and coarse gravel (27 percent of substrate) (Appendix E Table 4). Silt deposition was minimal and comprised an average of 2 percent of the stream substrate. Sand accounted for about 14 percent of the substrate. The average embeddedness was 54.8 indicating that about 50 percent of the surface of cobble and gravels were free of silt. The average measured current velocity was 1.40 fps.

Tongue River monitoring station TR03, located just upstream of the Decker Highway bridge crossing, was established by SCCD in 2013. WDEQ conducted sampling at this station in 1998 and 2004.

The total habitat scores at Tongue River TR03 station in 1998, 2004, 2013, 2016 and 2019 were 114, 133, 131, 134 and 134, respectively (Appendix Table E-4). The average total habitat score was 131. The lower total habitat assessment score when compared to upstream stations was due to high embeddedness (the amount of silt covering cobble and gravel), low pool to riffle ratio, low width to depth ratio, high disruptive pressures, and low riparian width.

The semi-quantitative stream substrate particle size distribution at Tongue River station TR03 showed a reduction in cobble to more coarse and fine gravel when compared to upstream stations TR09, TR07 and TR05. Cobble comprised an average of 30 percent, coarse gravel 31 percent and fine gravel 23 percent of substrate since 1998 (Appendix Table E-4). Silt deposition was minimal and comprised an average of 2 percent of the stream substrate. Sand accounted for about 15 percent of the substrate. The average embeddedness value was 57.1 indicating that about 50 percent of the surface of cobble and gravels were free of silt. The average measured current velocity was 1.40 fps.

The Tongue River monitoring station TR01 located near the Wyoming – Montana border was established and sampled by SCCD in 2013. WDEQ previously sampled a site downstream of Tongue River TR01 in

1998. The WDEQ station was identified as Tongue River – State Line and was sampled in 1998, 2003 and 2004.

The average total habitat assessment score at TR01 was 135 with a range from 126 in 2022 to 152 in 2019 (Appendix E Table 5). The stream substrate was dominated by cobble (average 49 percent) followed by coarse gravel (average 26 percent), fine gravel (average 15 percent), sand (average 10 percent) and silt (average 1 percent). The average embeddedness score was 48.5 indicating that about 70 percent of the surface of cobble and gravels were covered or surrounded by silt. The average measured current velocity was 1.70 fps.

The riparian indicator parameters including bank vegetation, bank stability, disruptive pressures and riparian zone width scored relatively high indicating that the stream banks were stable, well vegetated, and utilization of bank vegetation was low.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

Water quality monitoring was performed at 13 sites from May 18 through September 8, including six sites on the mainstem of the Tongue River, and seven sites on the major tributaries that flow into the Tongue River. These seven tributaries include Smith Creek, Little Tongue River, Columbus Creek, Fivemile Creek, Wolf Creek, Goose Creek, and Prairie Dog Creek. Sites were equipped with a SCCD calibrated staff gauge, except for TR09, which was located at a USGS gauging station.

Instantaneous water temperature measurements were recorded above the maximum 20°C instream temperature standard at ten of the 13 sites on at least one occasion; Little Tongue River and the uppermost mainstem, TR09, did not have any temperature measurements above 20°C. Continuous temperature loggers recorded temperatures above 20°C at all but the uppermost site in Tongue River Canyon.

Conductivity and pH were within the expected ranges. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages, apart from one measurement taken at Fivemile Creek (FMC01) on July 20. Two mainstem sites and three tributary sites had one or more samples that were below the 8.0 mg/L water column concentration recommended to achieve the inter-gravel concentrations for early life stages. Early season turbidity averages were higher at all sites than late season averages.

Bacteria geometric mean concentrations were higher during the early season than in the late season at all mainstem sites and all but one of the tributary sites. All sites, apart from TR09, had early season concentrations in exceedance of the Wyoming water quality standard of 126 organisms/100 mL. Late season concentrations were lower; however, there were still exceedances at all but one of the tributaries, and at mainstem site TR08. Geometric means exceeded the standard during the mid-season at all tributary sites. The opposite was true for all mainstem sites apart from TR05. Mainstem sites typically had lower bacteria concentrations than adjacent tributary sites. The highest geometric mean concentration, over 1000 MPN/100 mL, was from Fivemile Creek (FMC01) during the early season.

Early season geometric means increased between 2019 and 2022 at most sites, apart from GC01, PD01, TR08, and SC01. During the late season, most sites decreased or increased only slightly between 2019 and 2022, apart from FMC01, CC01, TR08, and LTR01.

Early season geometric mean concentrations at the lowermost sites (TR01, PD01, TR03, and GC01) were higher in 2022 than in 2013, whereas late season concentrations in 2022 were like those in 2013. Generally, trendlines show an increase since sampling began at these sites in 2013 during both the early and late seasons, apart from GC01, which appears to be decreasing slightly across the years during the late season.

Early and late season geometric means at sites located mid-watershed (TR05, TR07, WC01, and FMC01) in 2022 were like early and late season means when sampling began in 2003, apart from FMC01. The linear trendline decreases at FMC01 during both the early and late season, whereas the trendline increases at TR05 and TR07 across the years for both seasons. The trendline for WC01 shows a slight increase during the early season across the years, with the opposite being true during the late season.

Early season geometric means at upper sites (TR08, CC01, LTR01, SC01, and TR09) were generally higher in 2022 than in 2003. The opposite was true for these sites during the late season, apart from at TR08, which had a late season geometric mean slightly higher in 2022 than in 2003. Early season trends show an increase in concentrations over the years at all sites but SC01. The opposite is true for late season trends, with all sites showing a decrease in concentrations over the years.

With the exception of upstream reference station TR09, biological condition has trended lower since the 1990's at downstream stations TR07, TR05, TR03 and TR01. No threatened or endangered benthic macroinvertebrate taxa or fish species have been identified since sampling began in 1993. The general disappearance of stoneflies at Tongue River stations downstream of TR09 since the 1990's indicates that water quality and habitat change have negatively affected this pollution intolerant group of aquatic insects.

Monitoring of aquatic benthic macroinvertebrate communities in the Tongue River watershed since 1993 have not identified the presence of aquatic invasive species of concern to the WGFD including zebra mussel, quagga mussel, New Zealand mudsnail, and the Asian Clam. Recommended future benthic macroinvertebrate monitoring by SCCD will be attentive to the presence of aquatic invasive species.

Tubifex tubifex, a species of aquatic worm, involved in the whirling disease life cycle that may decimate trout populations, has not been collected at Tongue River stations since monitoring began indicating a low probability for the occurrence of whirling disease. However, the presence of the genus *Tubifex* and immature Tubificid worms at some stations suggest the future potential occurrence of *T. Tubifex*. Whirling disease has not been detected in the Tongue River watershed or nearby Little Goose Creek and Big Goose Creek watersheds.

Continued benthic macroinvertebrate sampling should be conducted at stations in the Tongue River watershed to track the health of aquatic communities, changes in biological condition, potential occurrence of aquatic invasive species and presence of indicator species associated with whirling disease.

Attempts to determine if improvements in overall water quality have been achieved are often difficult, especially when comparing water quality data that has been collected during seasons with different hydrological and meteorological conditions. Although normal flow conditions cannot always be anticipated nor expected during monitoring, these varying conditions do make water quality comparisons more difficult. Bacteria concentrations are known to vary in response to several different water quality and quantity factors, including changes in water temperature, water quantity, and suspended sediment loads. Elevated concentrations during the early season may be associated with high precipitation and flooding, which contribute bacteria and other surface contaminants into the waterways. In addition, deeper, faster moving water can scour and suspend sediment that has been previously deposited on the channel bottom. These bed sediments have been found to contain elevated levels of bacteria. Rangeland studies in Idaho have shown that *E. coli* concentrations can be two to 760 times greater in bottom sediment than in the water column (Stephenson & Rhychert, 1982). A similar study in the Goose Creek watershed showed up to 3-fold increases of fecal coliform bacteria when disturbing the bed sediment (SCCD, 2003). The approximate duration for which sediment dwelling bacteria populations can remain viable is unknown.

From 2000 through 2006, the local area was in a prolonged drought and below average stream discharge conditions were experienced. The years 2001 and 2002 lacked adequate peak flows during May and June, which normally flush stream channel sediment accumulated during the previous year. During 2003 and 2010, the Tongue River experienced higher than normal peak flows, which may have had the ability to flush streambed sediment that had accumulated during the several previous drought years. Flows in 2013 and 2016 were generally below normal at most stations, especially during the early season. High water in the spring of 2019 and 2022 may have had a similar effect as observed in 2003 and 2010.

The positive effects that improvement projects have on water quality may not be immediately apparent due to factors such as the bacteria storage capacity of bed sediment, which is normally suspended during bankfull flows. This bacteria storage in bed sediments and their annual release during high flows may cause a delay in

observing quantifiable changes in bacteria currently entering the system. The data provided by the 1996 – 1999 watershed assessment and subsequent interim monitoring indicate the need for additional improvement projects as well as additional future monitoring to create and measure positive water quality changes.

The SCCD anticipates that voluntary, incentive-based watershed planning and implementation will be successful; however, it may require several years to accurately measure these achievements. Nonetheless, each improvement project that has been implemented or is currently being implemented on the watershed certainly induces positive water quality changes, whether they are immediately apparent or not. SCCD will continue to monitor water quality in the Tongue River watershed on a three-year rotation, pending available funding sources.

CHAPTER 8 REFERENCES

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APPENDIX A

2022 TONGUE RIVER WATERSHED MAPS

FIGURE A-1. PROJECT AREA WITH SAMPLE SITES

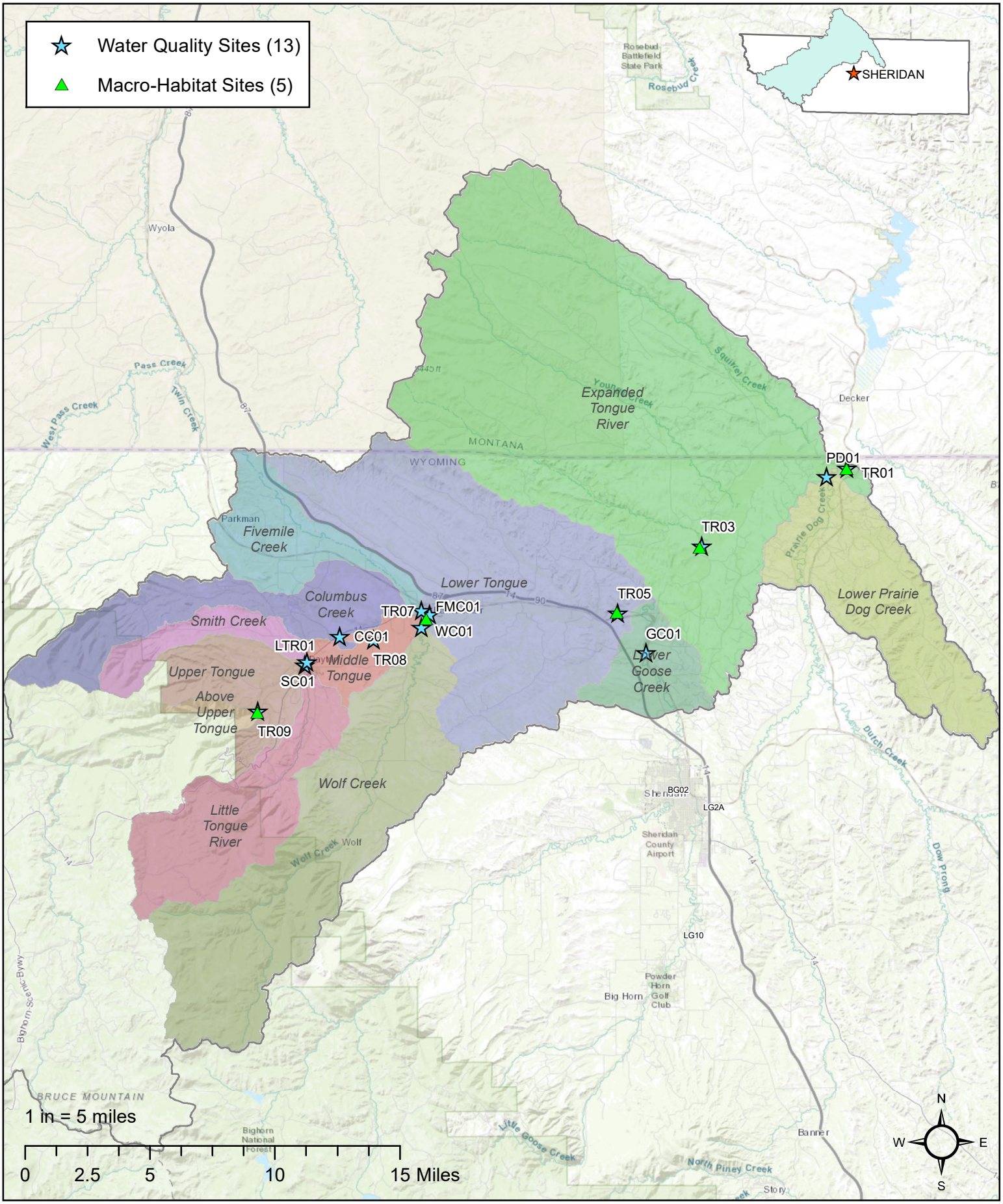


FIGURE A-2. PRECIPITATION ZONES (INCHES)

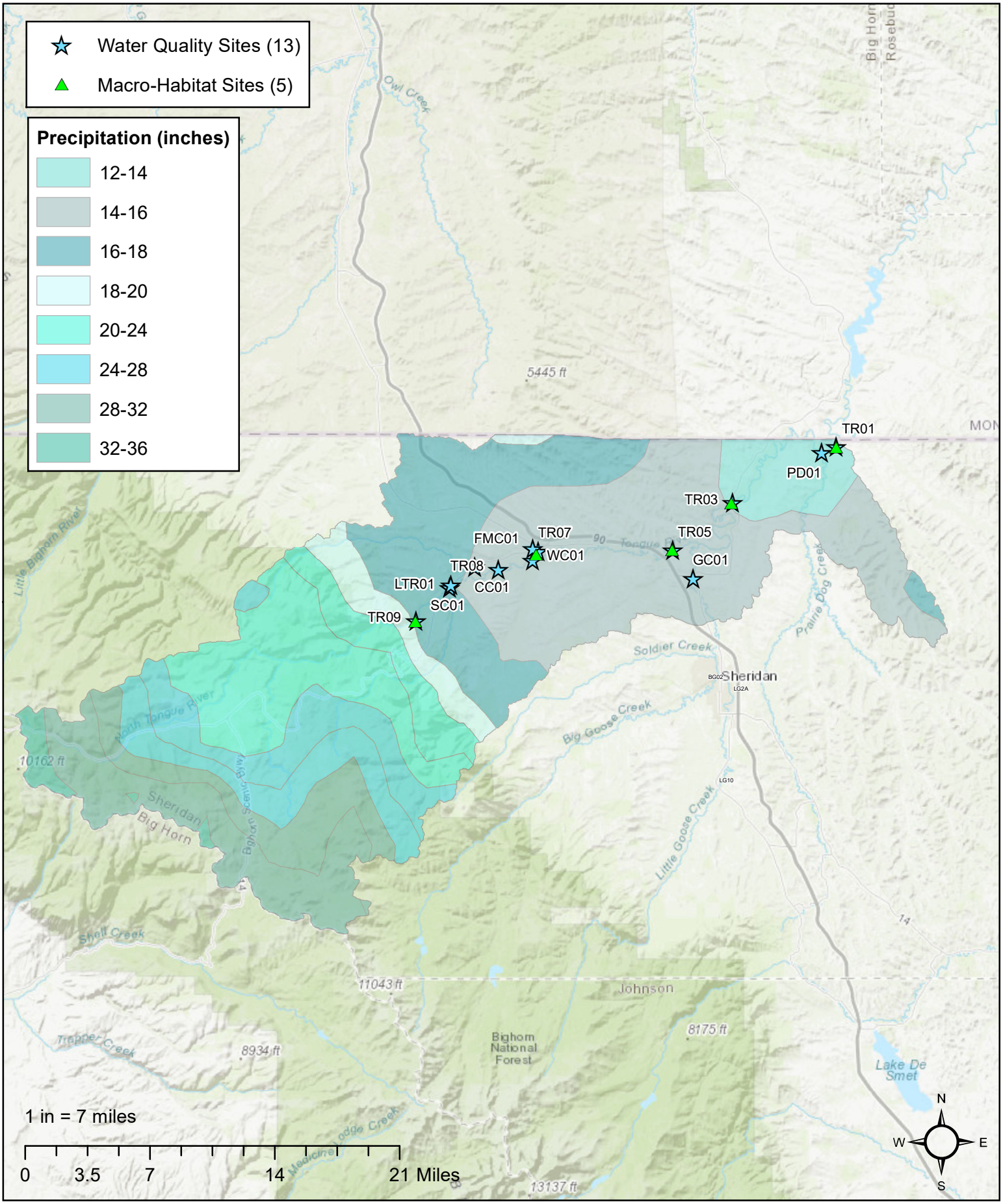


FIGURE A-3. ECOSITES

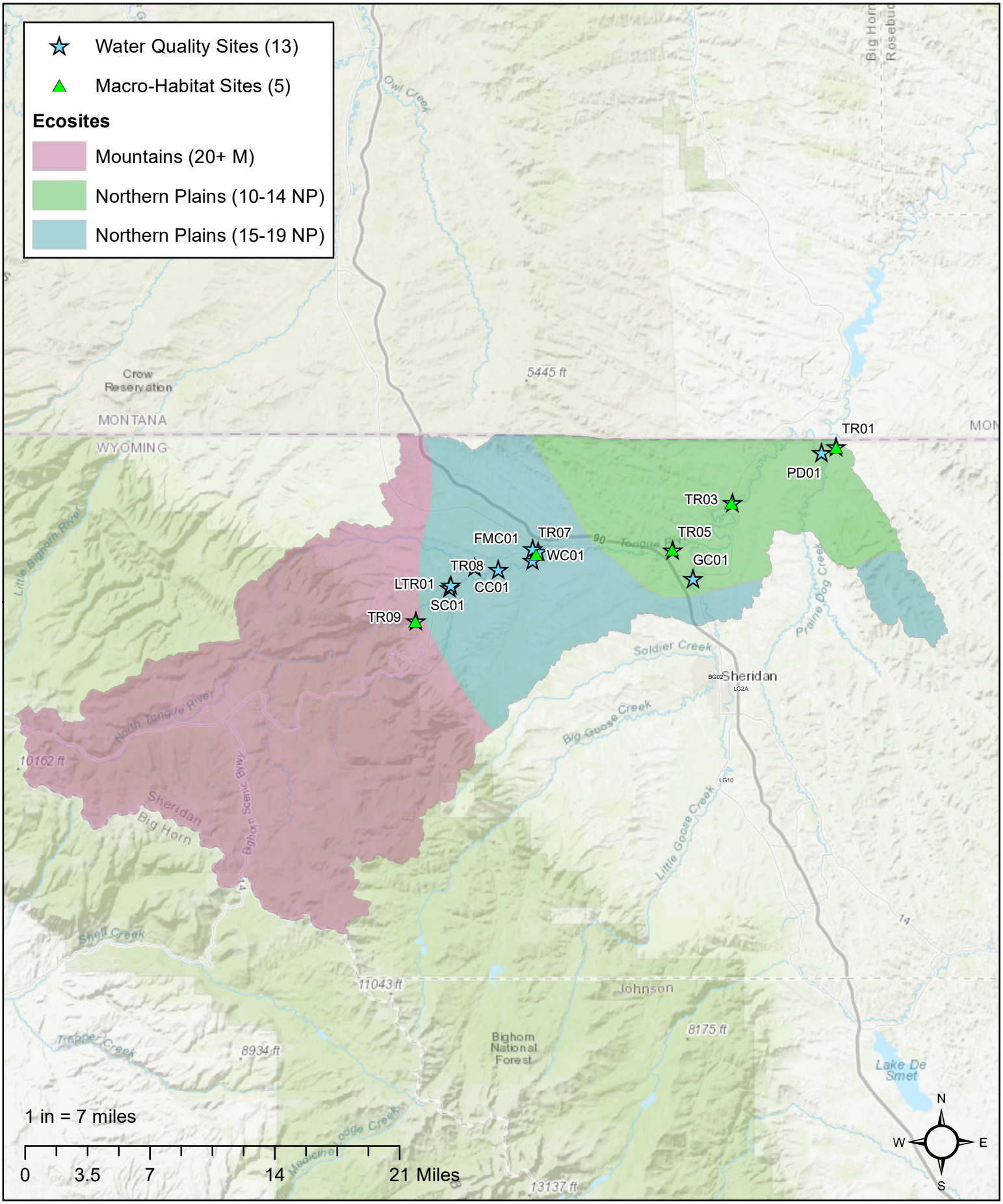


FIGURE A-4. LAND OWNERSHIP

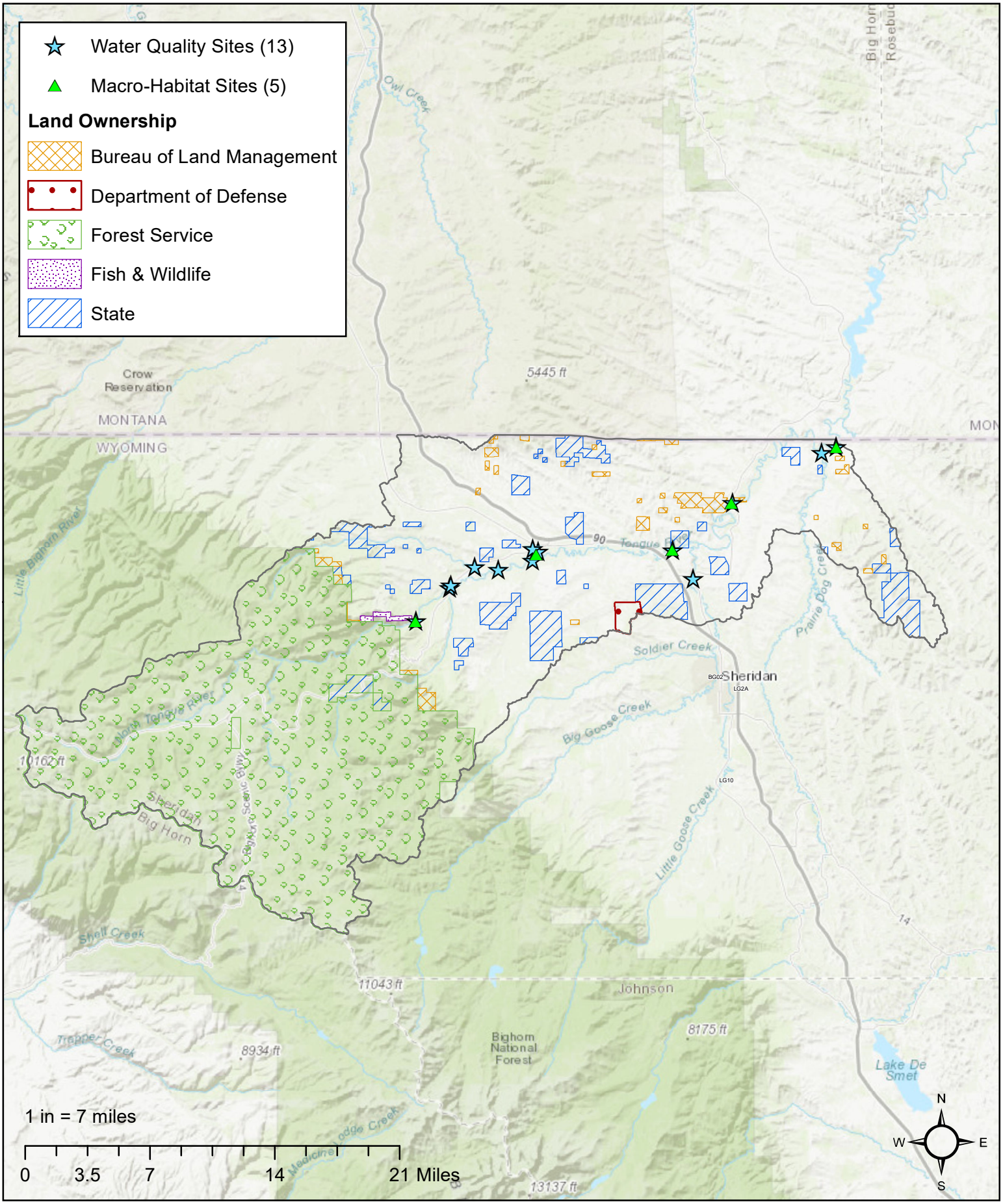


FIGURE A-5. LAND USE

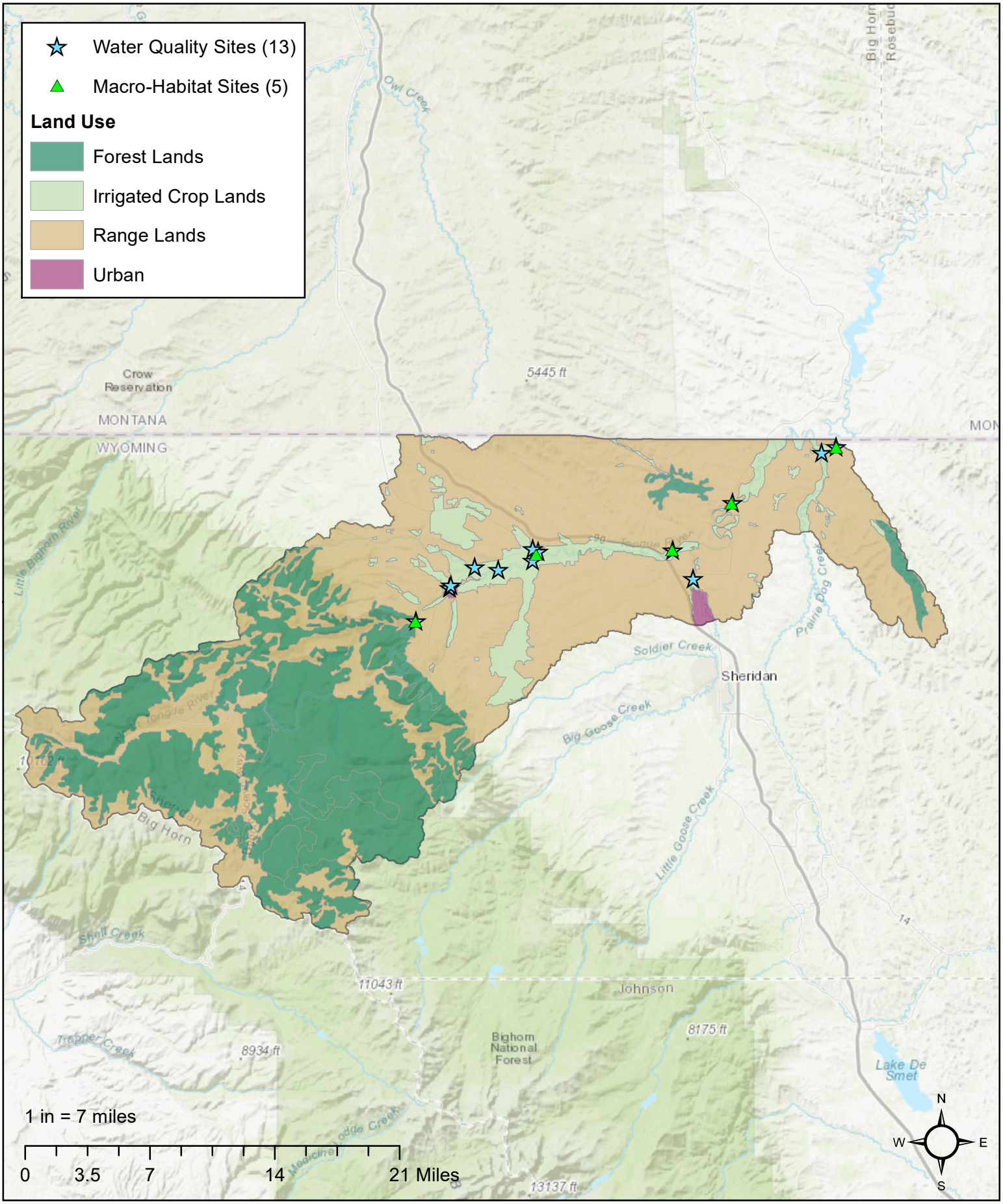


FIGURE A-6. PROGRESS REGISTER

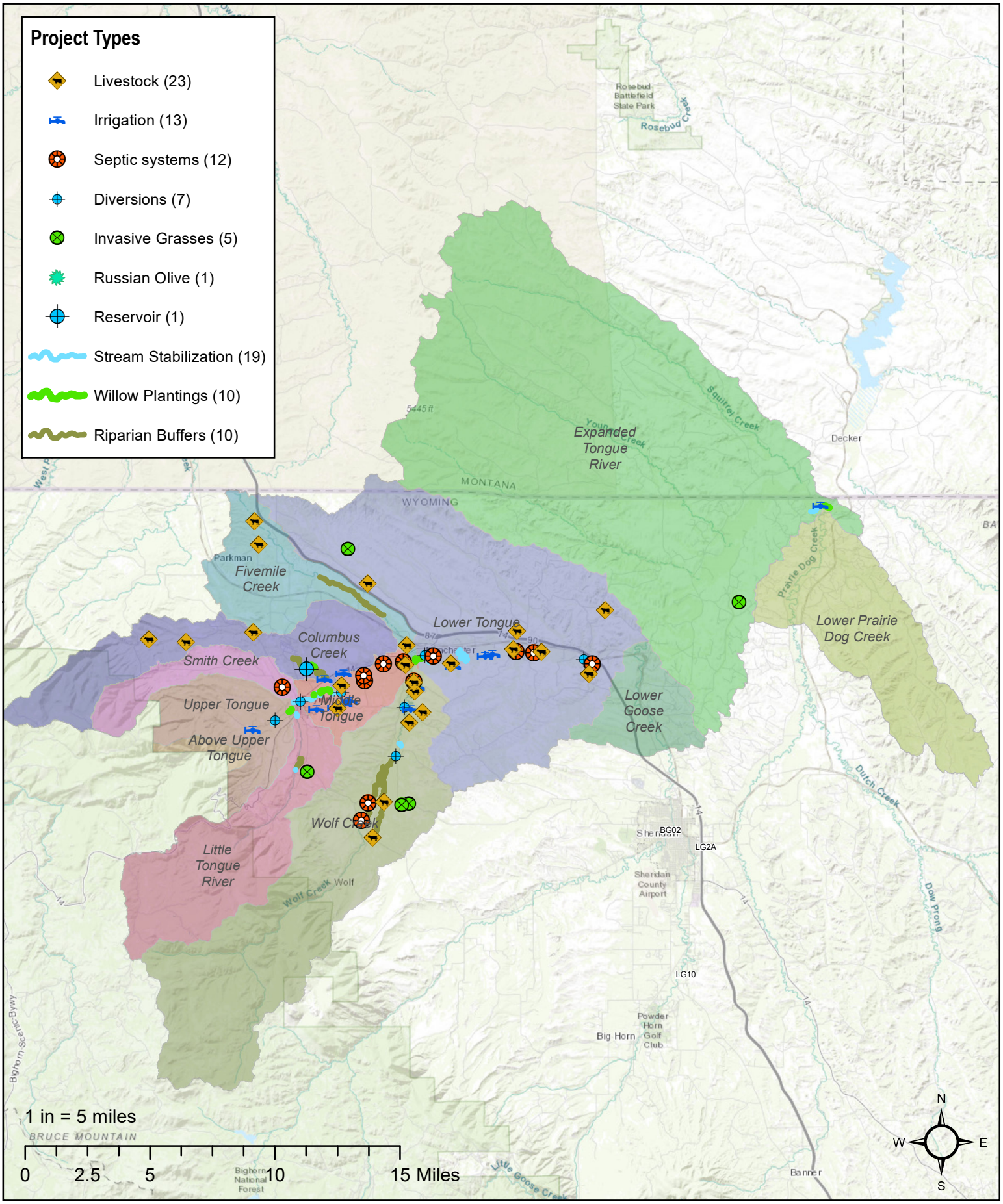
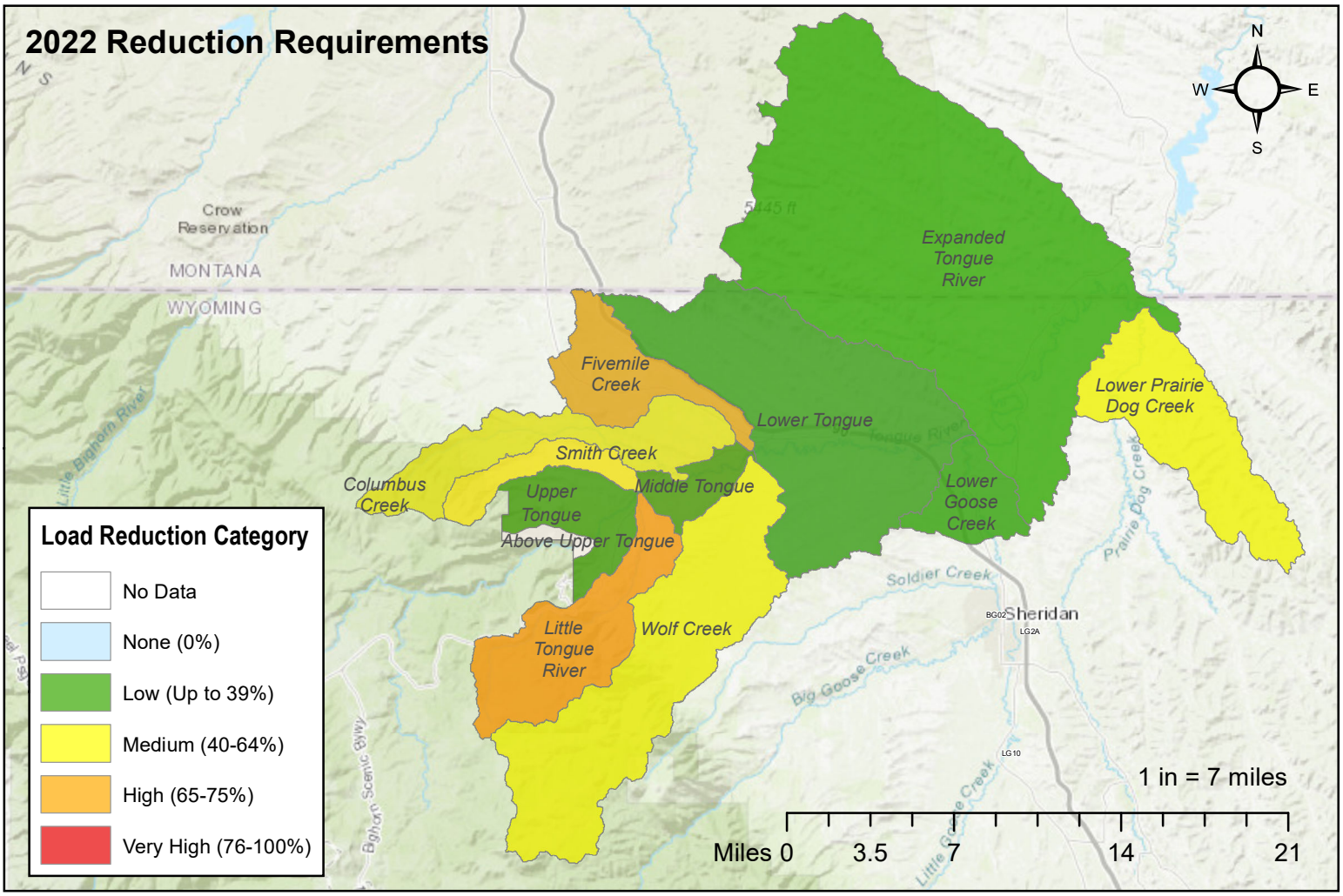
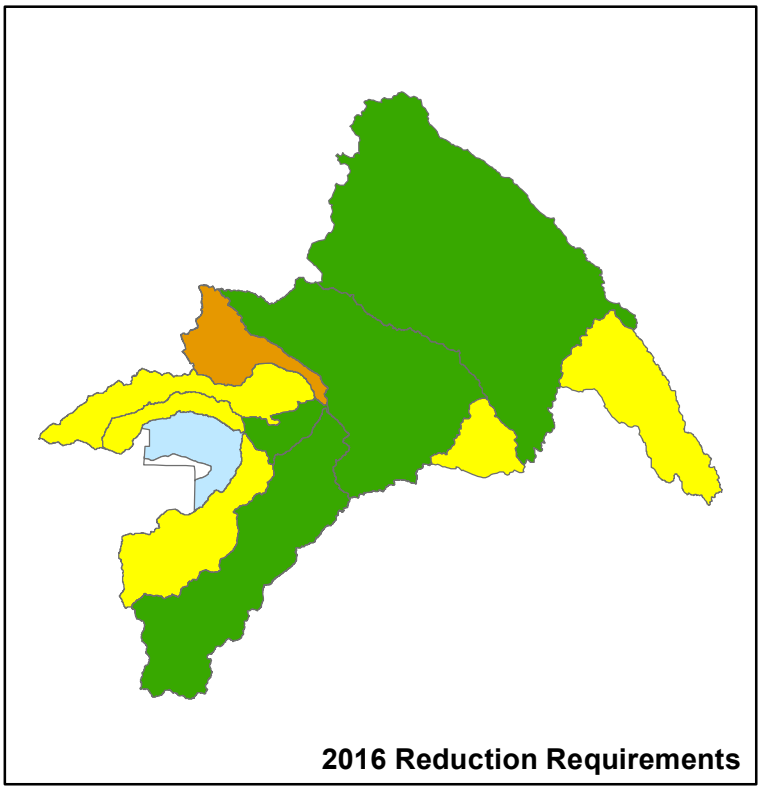
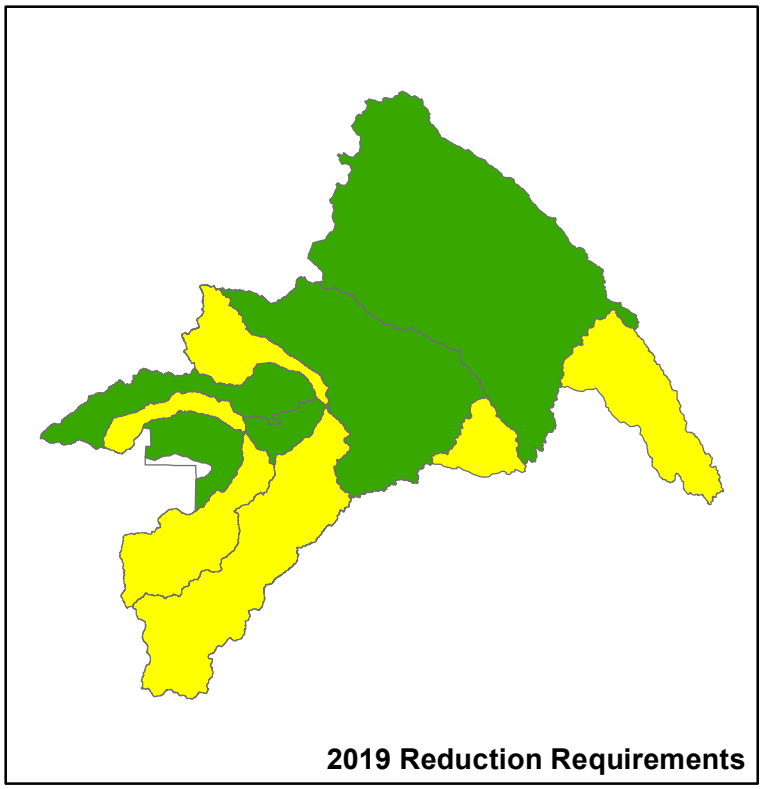


FIGURE A-7. LOAD REDUCTION COMPARISONS







APPENDIX B

2022 TONGUE RIVER WATERSHED
QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION

APPENDIX TABLE B-1. TONGUE RIVER WATERSHED 2022 CODES

Water Quality Data Codes	Parameter	Unit
DATE	Collection Date	Year, Month, Day
TIME	Collection Time	Military Time
TEMP	Water Temperature	Degrees Centigrade
PH	pH	Standard Units
COND	Specific Conductivity	µmho/cm
DO	Dissolved Oxygen	mg/L
DO %	Dissolved Oxygen % Saturation	%
STAFF	Staff Gauge Height	Feet
DISCH	Stream Flow	CFS
TURB	Turbidity	NTU
E.COLI	*Escherichia coli*	MPN/100ml
QAQC	QA/QC Validation Complete	Initials

APPENDIX TABLE B-2. TONGUE RIVER WATERSHED 2022 DATA QUALIFIERS

Data Qualifier Codes	Definition
CG	Sample result reported as greater than 1 µmho/cm.
DIS	Sample results rejected due to inability to meet quality control critiera.
DO	100 percent air saturation exceeded.
EG	Sample result reported as greater than 2419 MPN/100 mL.
EL	Sample result reported as less than 1 MPN/100 mL.
FB	Field blank exceeds the reporting limit for that analyte.
FD	Field duplicate results not within control limits.
H	The EPA recommended holding time was exceeded.
LE	Lab reporting error, correct value listed. See lab sheets for initial value reported.
ND	Not detectable at reporting limits.
NS	Not sampled.
SA	Staff height adjusted.
SO-OUT	Gauge out of water; unable to take reading.
SO-SUB	Gauge fully submerged; unable to take reading.
TB	Trip blank exceeds the reporting limit for that analyte.

Agency Abbreviations	Agency
SCCD	Sheridan County Conservation District
USFS	United States Forest Service
USGS	United States Geological Survey
WDEQ	Wyoming Department Environmental Quality
WGFD	Wyoming Game and Fish Department
WWRC	Wyoming Water Resources Center

APPENDIX TABLE B-3. RESULTS OF PRE- AND POST-SEASON ICE TESTS

TR01 S/N: 9927127				TR03 S/N: 9775391				TR05 S/N: 10484455				TR07 S/N: 9927129				TR09 S/N: 10612497			
Pre 5/8/2022		Post 11/10/2022		Pre 4/29/2022		Post 11/10/2022		Pre 4/29/2022		Post 11/10/2022		Pre 4/29/2022		11/10/2022		Pre 4/29/2022		Post 11/10/2022	
Time	Temp, °C	Time	Temp, °C	Time	Temp, °C	Time	Temp, °C	Time	Temp, °C	Time	Temp, °C	Time	Temp, °C	Time	Temp, °C	Time	Temp, °C	Time	Temp, °C
12:45	0.232	9:00	0.232	12:45	0.121	9:00	0.121	12:45	0.01	9:00	0.121	12:45	0.121	9:00	0.121	12:45	0.01	9:00	0.121
12:46	0.232	9:01	0.232	12:46	0.121	9:01	0.121	12:46	0.01	9:01	0.01	12:46	0.121	9:01	0.121	12:46	0.121	9:01	0.121
12:47	0.232	9:02	0.232	12:47	0.121	9:02	0.121	12:47	0.01	9:02	0.01	12:47	0.121	9:02	0.121	12:47	0.01	9:02	0.121
12:48	0.232	9:03	0.232	12:48	0.121	9:03	0.121	12:48	0.01	9:03	0.01	12:48	0.121	9:03	0.121	12:48	0.01	9:03	0.01
12:49	0.232	9:04	0.232	12:49	0.121	9:04	0.121	12:49	0.01	9:04	0.01	12:49	0.121	9:04	0.121	12:49	0.121	9:04	0.01
12:50	0.232	9:05	0.232	12:50	0.121	9:05	0.121	12:50	0.01	9:05	0.01	12:50	0.121	9:05	0.121	12:50	0.121	9:05	0.01
12:51	0.232	9:06	0.232	12:51	0.121	9:06	0.121	12:51	0.01	9:06	0.01	12:51	0.121	9:06	0.121	12:51	0.01	9:06	0.01
12:52	0.232	9:07	0.232	12:52	0.121	9:07	0.121	12:52	0.01	9:07	0.01	12:52	0.121	9:07	0.121	12:52	0.121	9:07	0.01
12:53	0.232	9:08	0.232	12:53	0.121	9:08	0.121	12:53	0.01	9:08	0.01	12:53	0.121	9:08	0.121	12:53	0.01	9:08	0.01
12:54	0.232	9:09	0.232	12:54	0.121	9:09	0.121	12:54	0.01	9:09	0.01	12:54	0.121	9:09	0.121	12:54	0.01	9:09	0.121
12:55	0.232	9:10	0.232	12:55	0.121	9:10	0.121	12:55	0.01	9:10	0.01	12:55	0.121	9:10	0.121	12:55	0.01	9:10	0.121
12:56	0.232	9:11	0.232	12:56	0.121	9:11	0.121	12:56	0.01	9:11	0.01	12:56	0.121	9:11	0.121	12:56	0.121	9:11	0.01
12:57	0.232	9:12	0.232	12:57	0.121	9:12	0.121	12:57	0.01	9:12	0.01	12:57	0.121	9:12	0.121	12:57	0.121	9:12	0.121
12:58	0.232	9:13	0.232	12:58	0.121	9:13	0.121	12:58	0.01	9:13	0.01	12:58	0.121	9:13	0.121	12:58	0.121	9:13	0.01
12:59	0.232	9:14	0.232	12:59	0.121	9:14	0.121	12:59	0.01	9:14	0.01	12:59	0.121	9:14	0.121	12:59	0.01	9:14	0.01
1:00	0.232	9:15	0.232	1:00	0.121	9:15	0.121	1:00	0.01	9:15	0.01	1:00	0.121	9:15	0.121	1:00	0.01	9:15	0.01
1:01	0.232	9:16	0.232	1:01	0.121	9:16	0.121	1:01	0.01	9:16	0.01	1:01	0.121	9:16	0.121	1:01	0.121	9:16	0.01
1:02	0.232	9:17	0.232	1:02	0.121	9:17	0.121	1:02	0.01	9:17	0.01	1:02	0.121	9:17	0.121	1:02	0.01	9:17	0.01
1:03	0.232	9:18	0.121	1:03	0.121	9:18	0.121	1:03	0.01	9:18	0.01	1:03	0.121	9:18	0.121	1:03	0.01	9:18	0.01
1:04	0.232	9:19	0.232	1:04	0.121	9:19	0.121	1:04	0.01	9:19	0.01	1:04	0.121	9:19	0.121	1:04	0.01	9:19	0.01
1:05	0.232	9:20	0.232	1:05	0.121	9:20	0.121	1:05	0.01	9:20	0.01	1:05	0.121	9:20	0.121	1:05	0.01	9:20	0.01
1:06	0.232	9:21	0.232	1:06	0.121	9:21	0.121	1:06	0.01	9:21	0.01	1:06	0.121	9:21	0.121	1:06	0.01	9:21	0.01
1:07	0.232	9:22	0.232	1:07	0.121	9:22	0.121	1:07	0.01	9:22	0.01	1:07	0.121	9:22	0.121	1:07	0.121	9:22	0.01
1:08	0.232	9:23	0.232	1:08	0.121	9:23	0.121	1:08	0.01	9:23	0.01	1:08	0.121	9:23	0.121	1:08	0.01	9:23	0.01
1:09	0.232	9:24	0.232	1:09	0.121	9:24	0.121	1:09	0.01	9:24	0.01	1:09	0.121	9:24	0.121	1:09	0.01	9:24	0.01
1:10	0.232	9:25	0.232	1:10	0.121	9:25	0.121	1:10	0.01	9:25	0.01	1:10	0.121	9:25	0.121	1:10	0.01	9:25	0.01
1:11	0.232	9:26	0.121	1:11	0.121	9:26	0.121	1:11	0.01	9:26	0.01	1:11	0.121	9:26	0.121	1:11	0.01	9:26	0.01
1:12	0.232	9:27	0.121	1:12	0.121	9:27	0.121	1:12	0.01	9:27	0.01	1:12	0.121	9:27	0.121	1:12	0.01	9:27	0.01
1:13	0.232	9:28	0.232	1:13	0.121	9:28	0.121	1:13	0.01	9:28	0.01	1:13	0.121	9:28	0.121	1:13	0.01	9:28	0.01
1:14	0.232	9:29	0.232	1:14	0.121	9:29	0.121	1:14	0.01	9:29	0.01	1:14	0.121	9:29	0.121	1:14	0.01	9:29	0.121
1:15	0.232	9:30	0.232	1:15	0.121	9:30	0.121	1:15	0.01	9:30	0.01	1:15	0.121	9:30	0.121	1:15	0.01	9:30	0.01
1:16	0.232	9:31	0.121	1:16	0.121	9:31	0.121	1:16	0.01	9:31	0.01	1:16	0.121	9:31	0.121	1:16	0.01	9:31	0.01
1:17	0.232	9:32	0.232	1:17	0.121	9:32	0.121	1:17	0.01	9:32	0.01	1:17	0.121	9:32	0.121	1:17	0.121	9:32	0.01
1:18	0.232	9:33	0.232	1:18	0.121	9:33	0.121	1:18	0.01	9:33	0.01	1:18	0.121	9:33	0.121	1:18	0.01	9:33	0.01
1:19	0.232	9:34	0.232	1:19	0.121	9:34	0.121	1:19	0.01	9:34	0.01	1:19	0.121	9:34	0.121	1:19	0.01	9:34	0.01
1:20	0.232	9:35	0.232	1:20	0.121	9:35	0.121	1:20	0.01	9:35	0.01	1:20	0.121	9:35	0.121	1:20	0.01	9:35	0.01
1:21	0.121	9:36	0.232	1:21	0.121	9:36	0.121	1:21	0.01	9:36	0.01	1:21	0.121	9:36	0.121	1:21	0.01	9:36	0.01
1:22	0.232	9:37	0.232	1:22	0.121	9:37	0.121	1:22	0.01	9:37	0.01	1:22	0.121	9:37	0.121	1:22	0.01	9:37	0.01
1:23	0.232	9:38	0.121	1:23	0.121	9:38	0.121	1:23	0.01	9:38	0.01	1:23	0.121	9:38	0.121	1:23	0.01	9:38	0.01
1:24	0.232	9:39	0.232	1:24	0.121	9:39	0.121	1:24	0.01	9:39	0.01	1:24	0.121	9:39	0.121	1:24	0.01	9:39	0.121
1:25	0.232	9:40	0.232	1:25	0.121	9:40	0.121	1:25	0.01	9:40	0.01	1:25	0.121	9:40	0.121	1:25	0.01	9:40	0.01
1:26	0.232	9:41	0.232	1:26	0.121	9:41	0.121	1:26	0.01	9:41	0.01	1:26	0.121	9:41	0.121	1:26	0.01	9:41	0.01
1:27	0.232	9:42	0.232	1:27	0.121	9:42	0.121	1:27	0.01	9:42	0.01	1:27	0.121	9:42	0.121	1:27	0.01	9:42	0.01
1:28	0.232	9:43	0.121	1:28	0.121	9:43	0.121	1:28	0.01	9:43	0.01	1:28	0.121	9:43	0.121	1:28	0.01	9:43	0.01
1:29	0.232	9:44	0.232	1:29	0.121	9:44	0.121	1:29	0.01	9:44	0.01	1:29	0.121	9:44	0.121	1:29	0.01	9:44	0.01
1:30	0.232	9:45	0.121	1:30	0.121	9:45	0.121	1:30	0.01	9:45	0.01	1:30	0.121	9:45	0.121	1:30	0.01	9:45	0.01
1:31	0.232	9:46	0.121	1:31	0.121	9:46	0.121	1:31	0.01	9:46	0.01	1:31	0.121	9:46	0.121	1:31	0.121	9:46	0.01
1:32	0.121	9:47	0.232	1:32	0.121	9:47	0.121	1:32	0.01	9:47	0.01	1:32	0.121	9:47	0.121	1:32	0.01	9:47	0.01
1:33	0.121	9:48	0.232	1:33	0.121	9:48	0.121	1:33	0.01	9:48	0.01	1:33	0.121	9:48	0.121	1:33	0.01	9:48	0.01
1:34	0.232	9:49	0.121	1:34	0.121	9:49	0.121	1:34	0.01	9:49	0.01	1:34	0.121	9:49	0.121	1:34	0.01	9:49	0.01
1:35	0.232	9:50	0.232	1:35	0.121	9:50	0.121	1:35	0.01	9:50	0.01	1:35	0.121	9:50	0.121	1:35	0.01	9:50	0.01
1:36	0.121	9:51	0.232	1:36	0.121	9:51	0.121	1:36	0.01	9:51	0.01	1:36	0.121	9:51	0.121	1:36	0.01	9:51	0.01
1:37	0.232	9:52	0.232	1:37	0.121	9:52	0.121	1:37	0.01	9:52	0.01	1:37	0.121	9:52	0.121	1:37	0.01	9:52	0.01
1:38	0.121	9:53	0.232	1:38	0.121	9:53	0.121	1:38	0.01	9:53	0.01	1:38	0.121	9:53	0.121	1:38	0.01	9:53	0.01
1:39	0.232	9:54	0.121	1:39	0.121	9:54	0.121	1:39	0.01	9:54	0.01	1:39	0.121	9:54	0.121	1:39	0.01	9:54	0.01
1:40	0.232	9:55	0.232	1:40	0.121	9:55	0.121	1:40	0.01	9:55	0.01	1:40	0.121	9:55	0.121	1:40	0.01	9:55	0.01
1:41	0.232	9:56	0.232	1:41	0.121	9:56	0.121	1:41	0.01	9:56	0.01	1:41	0.121	9:56	0.121	1:41	0.01	9:56	0.01
1:42	0.232	9:57	0.232	1:42	0.121	9:57	0.121	1:42	0.01	9:57	0.01	1:42	0.121	9:57	0.121	1:42	0.01	9:57	0.01
1:43	0.232	9:58	0.121	1:43	0.121	9:58	0.121	1:43	0.01	9:58	0.01	1:43	0.121	9:58	0.121	1:43	0.121	9:58	0.01
1:44	0.121	9:59	0.121	1:44	0.121	9:59	0.121	1:44	0.01	9:59	0.01	1:44	0.121	9:59	0.121	1:44	0.01	9:59	0.01
1:45	0.232	10:00	0.121	1:45	0.121	10:00	0.121	1:45	0.01	10:00	0.01	1:45	0.121	10:00	0.121	1:45	0.01	10:00	0.01
1:46	0.232	10:01	0.121	1:46	0.121	10:01	0.121	1:46	0.01	10:01	0.01	1:46	0.121	10:01	0.121	1:46	0.01	10:01	0.01
1:47	0.232	10:02	0.232	1:47	0.121	10:02	0.121	1:47	0.01	10:02	0.01	1:47	0.121	10:02	0.121	1:47	0.01	10:02	0.01
1:48	0.232	10:03	0.121	1:48	0.121	10:03	0.121	1:48	0.01	10:03	0.01	1:48	0.121	10:03	0.121	1:48	0.01	10:03	0.01
1:49	0.232	10:04	0.121	1:49	0.121	10:04	0.121	1:49	0.01	10:04	0.01	1:49	0.121	10:04	0.121	1:49	0.01	10:04	0.01
1:50	0.121	10:05	0.121	1:50	0.121	10:05	0.121	1:50	0.01	10:05	0.01	1:50	0.121	10:05	0.121	1:50	0.01	10:05	0.01
1:51	0.232	10:06	0.232	1:51	0.121	10:06	0.121	1:51	0.01	10:06	0.01	1:51	0.121	10:06	0.121	1:51	0.01	10:06	0.121
1:52	0.232	10:07	0.232	1:52	0.121	10:07	0.121	1:52	0.01	10:07	0.01	1:52	0.121	10:07	0.121	1:52	0.01	10:07	0.01
1:53	0.121	10:08	0.121	1:53	0.121	10:08	0.121	1:53	0.01	10:08	0.01	1:53	0.121	10:08	0.121	1:53	0.01	10:08	0.01
1:54	0.121	10:09	0.121	1:54	0.121	10:09	0.121	1:54	0.01	10:09	0.01	1:54	0.121	10:09	0.121	1:54	0.01	10:09	0.01
1:55	0.232	10:10	0.121	1:55	0.121	10:10	0.121	1:55	0.01	10:10	0.01	1:55	0.121	10:10	0.121	1:55	0.01	10:10	0.01
1:56	0.121	10:11	0.232	1:56	0.121	10:11	0.121	1:56	0.01	10:11	0.01	1:56	0.121	10:11	0.121	1:56	0.01	10:11	0.01
1:57	0.232	10:12	0.232	1:57	0.121	10:12	0.121	1:57	0.01	10:12	0.01	1:57	0.121	10:12	0.121	1:57	0.01	10:12	0.01
1:58	0.232	10:13	0.121	1:58	0.121	10:13	0.121	1:58	0.01	10:13	0.01	1:58	0.121	10:13	0.121	1:58	0.01	10:13	0.01
1:59	0.232	10:14	0.121	1:59	0.121	10:14	0.121	1:59	0.01	10:14	0.01	1:59	0.121	10:14	0.121	1:59	0.01	10:14	0.121

APPENDIX TABLE B-3 (CONTINUED). RESULTS OF PRE- AND POST-SEASON ICE TESTS

TR01 S/N: 9927127				TR03 S/N: 9775391				TR05 S/N: 10484455				TR07 S/N: 9927129				TR09 S/N: 10612497			
Pre 4/29/2022		Post 11/10/2022		Pre 4/29/2022		11/10/2022		Pre 4/29/2022		11/10/2022		Pre 4/29/2022		Post 11/10/2022		Pre 4/29/2022		Post 11/10/2022	
Time	**Temp, °C**	**Time**	**Temp, °C**	**Time**	**Temp, °C**	**Time**	**Temp, °C**	**Time**	**Temp, °C**	**Time**	**Temp, °C**	**Time**	**Temp, °C**	**Time**	**Temp, °C**	**Time**	**Temp, °C**	**Time**	**Temp, °C**
2:00	0.121	10:15	0.121	2:00	0.121	10:15	0.121	2:00	0.01	10:15	0.01	2:00	0.121	10:15	0.121	2:00	0.01	10:15	0.01
2:01	0.232	10:16	0.121	2:01	0.121	10:16	0.121	2:01	0.01	10:16	0.01	2:01	0.121	10:16	0.121	2:01	0.01	10:16	0.121
2:02	0.232	10:17	0.121	2:02	0.121	10:17	0.121	2:02	0.01	10:17	0.01	2:02	0.121	10:17	0.121	2:02	0.01	10:17	0.121
2:03	0.232	10:18	0.232	2:03	0.121	10:18	0.121	2:03	0.01	10:18	0.01	2:03	0.121	10:18	0.121	2:03	0.01	10:18	0.01
2:04	0.232	10:19	0.121	2:04	0.121	10:19	0.121	2:04	0.01	10:19	0.01	2:04	0.121	10:19	0.121	2:04	0.01	10:19	0.121
2:05	0.232	10:20	0.121	2:05	0.121	10:20	0.121	2:05	0.01	10:20	0.01	2:05	0.121	10:20	0.121	2:05	0.01	10:20	0.01
2:06	0.232	10:21	0.121	2:06	0.121	10:21	0.121	2:06	0.01	10:21	0.01	2:06	0.121	10:21	0.121	2:06	0.01	10:21	0.01
2:07	0.232	10:22	0.232	2:07	0.121	10:22	0.121	2:07	0.01	10:22	0.01	2:07	0.121	10:22	0.121	2:07	0.01	10:22	0.01
2:08	0.232	10:23	0.232	2:08	0.121	10:23	0.121	2:08	0.01	10:23	0.01	2:08	0.121	10:23	0.121	2:08	0.01	10:23	0.01
2:09	0.232	10:24	0.121	2:09	0.121	10:24	0.121	2:09	0.01	10:24	0.01	2:09	0.121	10:24	0.121	2:09	0.01	10:24	0.01
2:10	0.232	10:25	0.121	2:10	0.121	10:25	0.121	2:10	0.01	10:25	0.01	2:10	0.121	10:25	0.121	2:10	0.121	10:25	0.01
2:11	0.232	10:26	0.121	2:11	0.121	10:26	0.121	2:11	0.01	10:26	0.01	2:11	0.121	10:26	0.121	2:11	0.01	10:26	0.121
2:12	0.232	10:27	0.232	2:12	0.121	10:27	0.121	2:12	0.01	10:27	0.01	2:12	0.121	10:27	0.121	2:12	0.01	10:27	0.01
2:13	0.232	10:28	0.121	2:13	0.121	10:28	0.121	2:13	0.01	10:28	0.01	2:13	0.121	10:28	0.121	2:13	0.01	10:28	0.121
2:14	0.232	10:29	0.232	2:14	0.121	10:29	0.121	2:14	0.01	10:29	0.01	2:14	0.121	10:29	0.121	2:14	0.01	10:29	0.01
2:15	0.232	10:30	0.121	2:15	0.121	10:30	0.121	2:15	0.01	10:30	0.01	2:15	0.121	10:30	0.121	2:15	0.01	10:30	0.01

APPENDIX TABLE B-4. SUMMARY OF 2022 WATER QUALITY SAMPLE BLANK DATA FOR THE TONGUE RIVER WATERSHED

Sample Date	Sample ID	Trip Blank Data		Field Blank Data			
		TURB (NTU)	*E. COLI* (MPN/100mL)	Location of Field Blank	Collection Time	TURB (NTU)	*E. COLI* (MPN/100mL)
5/18/2022	01	0.1[TB]	ND	TR01	9:05	0.2[FB]	ND
5/31/2022	01	ND	ND	FMC01	11:30	0.1[FB]	ND
6/13/2022	01	ND	ND	TR01	9:05	ND	ND
6/28/2022	01	ND	ND	PD01	9:25	0.2[FB]	ND
7/7/2022	01	ND	ND	TR03	10:15	0.1[FB]	ND
7/20/2022	01	ND	ND	TR05	10:55	0.1[FB]	ND
8/1/2022	01	ND	ND	TR07	11:15	0.1[FB]	ND
8/9/2022	01	ND	ND	FMC01	12:10	0.1[FB]	ND
8/24/2022	01	ND	ND	GC01	10:10	0.3[FB]	ND
9/8/2022	01	0.1[TB]	ND	TR05	10:20	0.1[FB]	ND

[FB] Field blank exceeds the reporting limit for analyte.

[ND] Not detectable at reporting limits.

[TB] Trip blank exceeds the reporting limit for that analyte.

APPENDIX TABLE B-5. SUMMARY OF 2022 DUPLICATE WATER SAMPLES FOR THE TONGUE RIVER WATERSHED

				Field Data						Laboratory Data	
Site	Duplicate of Site	Agency	Date (mmddyy)	Hanna Temp (*C)	YSI Temp (*C)	PH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	TURB (NTU)	*E.coli* (MPN/100mL)
Precision DQO's				10%	10%	0.3 SU	10%	10%	10%	20%	50% if >100; NA if <100
TR07		SCCD	5/18/2022	9.2	8.7	8.15	181	10.95	93.5	9.9	260
TRDup01	TR07	SCCD	5/18/2022	9.6	8.9	8.22	184	10.70	92.6	17.0	236
Relative Percent Difference				***4.3***	***2.3***	***0.07***	***1.6***	***2.3***	***1.0***	***52.8[FD]***	***9.7***
TR08		SCCD	5/31/2022	5.8	5.2	8.02	218	11.68	92.0	120.0	1120
TRDup01	TR08	SCCD	5/31/2022	5.9	5.3	8.05	219	11.53	91.1	120.0	980
Relative Percent Difference				***1.7***	***1.9***	***0.03***	***0.5***	***1.29***	***1.0***	***0.0***	***13.3***
PD01		SCCD	6/13/2022	17.4	16.8	8.14	1714	7.70	79.4	37.0	435
TRDup01	PD01	SCCD	6/13/2022	17.5	16.9	8.15	1715	7.69	79.3	28.0	336
Relative Percent Difference				***0.6***	***0.6***	***0.01***	***0.1***	***0.1***	***0.1***	***27.7[FD]***	***25.7***
TR07		SCCD	6/28/2022	14.5	14.0	8.29	225	9.65	93.0	3.8	132
TRDup01	TR07	SCCD	6/28/2022	14.8	14.3	8.31	230	9.53	93.0	3.6	160
Relative Percent Difference				***2.0***	***2.1***	***0.02***	***2.2***	***1.3***	***0.0***	***5.4***	***19.2***
TR08 (Meters) GC01 (Lab)		SCCD	7/7/2022	16.3	15.7	8.52	250	9.59	96.6	13.0	441
TRDup01	TR08 & GC01	SCCD	7/7/2022	16.3	16.0	8.50	248	9.49	95.7	12.0	355
Relative Percent Difference				***0.0***	***1.9***	***0.02***	***0.8***	***1.0***	***0.9***	***8.0***	***21.6***
FMC01		SCCD	7/20/2022	17.5	17.4	7.94	1161	4.66	48.1	17.0	404
TRDup01	FMC01	SCCD	7/20/2022	17.7	17.3	7.95	1159	4.62	47.8	19.0	397
Relative Percent Difference				***1.1***	***0.6***	***0.01***	***0.2***	***0.9***	***0.6***	***11.1***	***1.7***
LTR01		SCCD	8/1/2022	18.8	18.3	8.43	368	8.75	92.8	1.3	8660
TRDup01	LTR01	SCCD	8/1/2022	19.0	18.3	8.45	367	8.52	90.5	1.2	9800
Relative Percent Difference				***1.1***	***0.0***	***0.02***	***0.3***	***2.7***	***2.5***	***8.0***	***12.4***
TR01		SCCD	8/9/2022	21.3	20.8	8.29	715	7.23	80.7	11.0	84
TRDup01	TR01	SCCD	8/9/2022	21.6	20.8	8.29	721	7.22	80.7	11.0	73
Relative Percent Difference				***1.4***	***0.0***	***0.00***	***0.8***	***0.1***	***0.0***	***0.0***	***14.0***
TR05		SCCD	8/24/2022	22.8	22.6	8.35	543	8.15	93.5	9.9	86
TRDup01	TR05	SCCD	8/24/2022	22.8	22.3	8.35	543	7.77	89.8	9.2	30
Relative Percent Difference				***0.0***	***1.3***	***0.00***	***0.0***	***4.8***	***4.0***	***7.3***	***96.6***
TR01		SCCD	9/8/2022	19.8	19.2	8.35	824	7.33	79.3	6.6	31
TRDup01	TR01	SCCD	9/8/2022	19.8	19.2	8.35	799	7.01	75.7	6.0	41
Relative Percent Difference				***0.0***	***0.0***	***0.00***	***3.1***	***4.5***	***4.6***	***9.5***	***27.8***

[FD] Field duplicate results not within the control limits.

APPENDIX TABLE B-6. SUMMARY OF 2022 WATER QUALITY SAMPLE BLANK DATA FOR THE TONGUE RIVER WATERSHED

Sample Date	Sample ID	Trip Blank Data		Field Blank Data			
		TURB (NTU)	*E. COLI* (MPN/100mL)	Location of Field Blank	Collection Time	TURB (NTU)	*E. COLI* (MPN/100mL)
5/18/2022	02	ND	ND	CC01	12:30	0.2[FB]	ND
5/31/2022	02	0.1[TB]	ND	TR09	12:55	0.1[FB]	ND
6/13/2022	02	ND	ND	GC01	10:15	ND	ND
6/28/2022	02	ND	ND	TR09	14:30	ND	ND
7/7/2022	02	ND	ND	LTR01	12:50	0.2[FB]	ND
7/20/2022	02	ND	ND	WC01	11:40	0.1[FB]	ND
8/1/2022	02	ND	ND	TR08	11:50	1.6[FB]	ND
8/9/2022	02	ND	ND	SC01	13:45	0.2[FB]	ND
8/24/2022	02	ND	ND	WC01	11:30	0.1[FB]	ND
9/8/2022	02	0.1[DIS]	ND[DIS]	TR07	10:45	0.2[FB]	ND

[DIS] Sample results rejected due to inability to meet quality control criteria.

[FB] Field blank exceeds the reporting limit for analyte.

[ND] Not detectable at reporting limits.

[TB] Trip blank exceeds the reporting limit for that analyte.

APPENDIX TABLE B-7. SUMMARY OF 2022 DUPLICATE WATER SAMPLES FOR THE TONGUE RIVER WATERSHED

				Field Data						Laboratory Data	
Site	Duplicate of Site	Agency	Date (mmddyy)	Hanna Temp (*C)	YSI Temp (*C)	PH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	TURB (NTU)	*E.coli* (MPN/100mL)
Precision DQO's				10%	10%	0.3 SU	10%	10%	10%	20%	50% if >100; NA if <100
TR09		SCCD	5/18/2022	7.1	6.9	8.26	133	12.20	99.4	8.3	55
TRDup02	TR09	SCCD	5/18/2022	7.4	6.8	8.3	136	12.04	98.8	8.4	58
			Relative Percent Difference	***4.1***	***1.5***	***0.04***	***2.2***	***1.3***	***0.6***	***1.2***	***5.3***
LTR01		SCCD	5/31/2022	7.3	6.7	8.03	223	11.39	93.2	40.0	2420
TRDup02	LTR01	SCCD	5/31/2022	7.4	6.8	7.98	219	11.27	92.2	37.0	921
			Relative Percent Difference	***1.4***	***1.5***	***0.05***	***1.8***	***1.06***	***1.1***	***7.8***	***89.7[FD]***
WC01		SCCD	6/13/2022	10.3	9.7	7.97	162	9.83	86.4	24.0	794
TRDup02	WC01	SCCD	6/13/2022	10.4	9.8	7.84	161	9.73	85.8	21.0	801
			Relative Percent Difference	***1.0***	***1.0***	***0.13***	***0.6***	***1.0***	***0.7***	***13.3***	***0.9***
TR08		SCCD	6/28/2022	15.6	15.0	8.49	227	9.59	95.3	2.3	74
TRDup02	TR08	SCCD	6/28/2022	16.0	15.1	8.47	223	9.53	94.70	2.3	74
			Relative Percent Difference	***2.5***	***0.7***	***0.02***	***1.8***	***0.6***	***0.6***	***0.0***	***0.0***
FMC01		SCCD	7/7/2022	18.3	17.4	7.97	1687	5.48	57.2	11.0	754
TRDup02	FMC01	SCCD	7/7/2022	18.0	17.5	7.99	1686	5.51	57.5	12.0	727
			Relative Percent Difference	***1.7***	***0.6***	***0.02***	***0.1***	***0.5***	***0.5***	***8.7***	***3.6***
SC01		SCCD	7/20/2022	20.2	19.2	8.68	350	8.67	93.5	2.8	309
TRDup02	SC01	SCCD	7/20/2022	20.0	19.3	8.71	350	8.59	93.3	2.8	279
			Relative Percent Difference	***1.0***	***0.5***	***0.03***	***0.0***	***0.9***	***0.2***	***0.0***	***10.2***
SC01		SCCD	8/1/2022	19.0	18.0	8.54	332	8.40	88.9	2.9	185
TRDup02	SC01	SCCD	8/1/2022	19.3	18.3	8.56	335	8.18	86.9	3.4	313
			Relative Percent Difference	***1.6***	***1.7***	***0.02***	***0.9***	***2.7***	***2.3***	***15.9***	***51.4[FD]***
TR03		SCCD	8/9/2022	24.0	22.9	8.44	571	8.00	93.1	4.6	85
TRDup02	TR03	SCCD	8/9/2022	24.0	22.9	8.46	546	7.91	92.1	4.5	95
			Relative Percent Difference	***0.0***	***0.0***	***0.02***	***4.5***	***1.1***	***1.1***	***2.2***	***11.1***
CC01		SCCD	8/24/2022	20.0	19.2	8.34	308	7.97	85.6	36.0	471
TRDup02	CC01	SCCD	8/24/2022	20.5	18.9	8.35	307	7.87	84.9	35.0	583
			Relative Percent Difference	***2.5***	***1.6***	***0.01***	***0.3***	***1.3***	***0.8***	***2.8***	***21.3***
PD01		SCCD	9/8/2022	16.9	16.3	8.11	1512	7.96	81.1	11.0	173
TRDup02	PD01	SCCD	9/8/2022	16.8	16.3	8.10	1505	7.92	80.6	14.0	201
			Relative Percent Difference	***0.6***	***0.0***	***0.01***	***0.5***	***0.5***	***0.6***	***24.0[FD]***	***15.0***

[FD] Field duplicate results not within the control limits.

APPENDIX C

2022 TONGUE RIVER WATERSHED
WATER QUALITY DATA

APPENDIX TABLE C-1. TONGUE RIVER WATERSHED 2022 CODES

Water Quality Data Codes	Parameter	Unit
DATE	Collection Date	Year, Month, Day
TIME	Collection Time	Military Time
TEMP	Water Temperature	Degrees Centigrade
PH	pH	Standard Units
COND	Specific Conductivity	µmho/cm
DO	Dissolved Oxygen	mg/L
DO %	Dissolved Oxygen % Saturation	%
STAFF	Staff Gauge Height	Feet
DISCH	Stream Flow	CFS
TURB	Turbidity	NTU
E.COLI	*Escherichia coli*	MPN/100ml
QAQC	QA/QC Validation Complete	Initials

APPENDIX TABLE C-2. TONGUE RIVER WATERSHED 2022 DATA QUALIFIERS

Data Qualifier Codes	Definition
CG	Sample result reported as greater than 1 µmho/cm.
DIS	Sample results rejected due to inability to meet quality control critiera.
DO	100 percent air saturation exceeded.
EG	Sample result reported as greater than 2419 MPN/100 mL.
EL	Sample result reported as less than 1 MPN/100 mL.
FB	Field blank exceeds the reporting limit for that analyte.
FD	Field duplicate results not within control limits.
H	The EPA recommended holding time was exceeded.
LE	Lab reporting error, correct value listed. See lab sheets for initial value reported.
ND	Not detectable at reporting limits.
NS	Not sampled.
SA	Staff height adjusted.
SO-OUT	Gauge out of water; unable to take reading.
SO-SUB	Gauge fully submerged; unable to take reading.
TB	Trip blank exceeds the reporting limit for that analyte.

APPENDIX TABLE C-3. TONGUE RIVER WATERSHED 2022 AGENCY ABBREVIATIONS

Agency Abbreviations	Agency
SCCD	Sheridan County Conservation District
USFS	United States Forest Service
USGS	United States Geological Survey
WDEQ	Wyoming Department Environmental Quality
WGFD	Wyoming Game and Fish Department
WWRC	Wyoming Water Resources Center

APPENDIX TABLE C-4. SCCD 2022 WATER QUALITY DATA AT SITE TR01

			Field Data										Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	pH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	*TURB* (NTU)	E_COLI (cfu/100mL)
Tongue River	TR01	SCCD	5/18/2022	9:05	14.7	14.2	8.25	DIS	8.45	82.2	2.54	590.73	45.0	108
Tongue River	TR01	SCCD	5/31/2022	9:15	10.0	9.5	8.08	332	9.46	82.8	SO-SUB	SO-SUB	100.0	2420
Tongue River	TR01	SCCD	6/13/2022	9:05	12.7	12.1	8.07	212	8.80	82.0	SO-SUB	SO-SUB	50.0	1270
Tongue River	TR01	SCCD	6/28/2022	9:15	17.4	16.2	8.25	301	8.22	83.5	3.32	882.11	24.0	41[H]
Tongue River	TR01	SCCD	7/7/2022	9:25	20.7	19.9	8.29	400	7.67	84.2	2.22	482.87	25.0	185
Tongue River	TR01	SCCD	7/20/2022	9:05	21.6	20.7	8.56	541	8.20	91.5	1.28	211.73	4.9	20
Tongue River	TR01	SCCD	8/1/2022	9:10	25.0	22.2	8.31	673	7.15	82.0	0.90	124.96	5.8	135
Tongue River	TR01	SCCD	8/9/2022	9:05	21.3	20.8	8.29	715	7.23	80.7	1.00	146.31	11.0	84
Tongue River	TR01	SCCD	8/24/2022	8:55	22.9	21.4	8.37	841	7.18	80.8	0.75	95.11	6.1	110
Tongue River	TR01	SCCD	9/8/2022	9:05	19.8	19.2	8.35	824	7.33	79.3	0.80	104.76	6.6	31

Arithmetic Averages (means)									Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	15.1	14.4	8.19	311	8.52	82.9	2.69	651.90	48.8	302
June 13-August 1	19.5	18.2	8.30	425	8.01	84.6	1.93	425.42	21.9	121
July 20-September 8	22.1	20.9	8.38	719	7.42	82.9	0.95	136.57	6.9	60
Annual	18.6	17.6	8.28	538	7.97	82.9	1.60	329.82	27.8	

APPENDIX TABLE C-5. SCCD 2022 WATER QUALITY DATA AT SITE PD01

			Field Data										Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	pH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	*TURB* (NTU)	E_COLI (cfu/100mL)
Prairie Dog Creek	PD01	SCCD	5/18/2022	9:45	16.2	15.6	8.17	1591	8.88	89.1	0.60	16.79	9.9	727
Prairie Dog Creek	PD01	SCCD	5/31/2022	9:45	12.4	11.1	8.19	1465	9.23	83.9	0.85	27.29	21.0	2420
Prairie Dog Creek	PD01	SCCD	6/13/2022	9:35	17.4	16.8	8.14	1714	7.70	79.4	0.68	19.99	37[FD]	435
Prairie Dog Creek	PD01	SCCD	6/28/2022	9:25	18.0	17.3	8.22	883	7.94	82.7	1.08	38.10	65.0	295
Prairie Dog Creek	PD01	SCCD	7/7/2022	9:50	20.9	20.1	8.18	865	7.57	83.0	0.96	32.33	75.0	496
Prairie Dog Creek	PD01	SCCD	7/20/2022	10:00	19.3	18.6	8.29	1739	9.93	104.3[DO]	0.35	7.92	3.5	417
Prairie Dog Creek	PD01	SCCD	8/1/2022	10:00	19.6	18.8	8.17	1605	8.48	91.1	0.35	7.92	5.1	135
Prairie Dog Creek	PD01	SCCD	8/9/2022	9:55	19.0	18.4	8.05	1232	7.93	84.5	0.60	16.79	12.0	134
Prairie Dog Creek	PD01	SCCD	8/24/2022	9:15	19.7	18.1	8.00	1331	7.38	78.1	0.61	17.18	13.0	287
Prairie Dog Creek	PD01	SCCD	9/8/2022	9:30	16.9	16.3	8.11	1512	7.96	81.1	0.52	13.75	11[FD]	173

Arithmetic Averages (means)									Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	17.0	16.2	8.18	1304	8.26	83.6	0.83	26.90	41.6	645
June 13-August 1	19.0	18.3	8.20	1361	8.32	88.1	0.68	21.25	37.1	324
July 20-September 8	18.9	18.0	8.12	1484	8.34	87.8	0.49	12.71	8.9	206
Annual	17.9	17.1	8.15	1394	8.30	85.7	0.66	19.81	25.3	

APPENDIX TABLE C-6. SCCD 2022 WATER QUALITY DATA AT SITE TR03

			Field Data										Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	pH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	*TURB* (NTU)	E_COLI (cfu/100mL)
Tongue River	TR03	SCCD	5/18/2022	10:10	13.5	13.0	8.16	236	8.98	85.8	3.30	769.67	50.0	435
Tongue River	TR03	SCCD	5/31/2022	10:05	8.7	8.4	8.09	306	10.08	85.5	SO-SUB	SO-SUB	190.0	>2419.6[EG]
Tongue River	TR03	SCCD	6/13/2022	9:55	12.3	11.6	8.04	177	9.37	86.2	SO-SUB	SO-SUB	33.0	495
Tongue River	TR03	SCCD	6/28/2022	10:20	16.6	16.5	8.20	230	8.56	86.4	SO-SUB	SO-SUB	17.0	75
Tongue River	TR03	SCCD	7/7/2022	10:15	20.5	19.7	8.39	330	8.52	93.2	NS	NS	13.0	86
Tongue River	TR03	SCCD	7/20/2022	10:25	22.6	21.9	8.56	414	8.52	95.3	1.38	179.92	4.1	41
Tongue River	TR03	SCCD	8/1/2022	10:25	24.6	23.8	8.54	500	7.22	85.4	0.96	98.25	6.2	52
Tongue River	TR03	SCCD	8/9/2022	10:40	24.0	22.9	8.44	571	8.00	93.1	0.99	103.42	4.6	85
Tongue River	TR03	SCCD	8/24/2022	9:55	23.5	23.1	8.57	620	7.95	92.4	0.79	70.99	5.8	31
Tongue River	TR03	SCCD	9/8/2022	9:55	20.8	20.3	8.46	555	7.36	81.5	0.76	66.56	5.1	<1[EL]

Arithmetic Averages (means)									Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	14.3	13.8	8.18	256	9.10	87.4	3.30	769.67	60.6	320
June 13-August 1	19.3	18.7	8.35	330	8.44	89.3	1.17	139.09	14.7	93
July 20-September 8	23.1	22.4	8.51	532	7.81	89.5	0.98	103.83	5.2	22
Annual	18.7	18.1	8.35	394	8.46	88.5	1.36	214.80	32.9	

Data Qualifiers	
DIS	Results rejected due to inability to meet quality control critiera.
DO	100 percent air saturation exceeded.
EG	Sample result reported as greater than 2419 MPN/100 mL.
EL	Sample result reported as less than 1 MPN/100 mL.
FB	Field blank exceeds the reporting limit for that analyte.
FD	Field duplicate results not within control limits.
H	The EPA recommended holding time was exceeded.
NS	Not sampled.
SO-OUT	Gauge out of water; unable to take reading.
SO-SUB	Gauge fully submerged; unable to take reading.
TB	Trip blank exceeds the reporting limit for that analyte.

APPENDIX TABLE C-7. SCCD 2022 WATER QUALITY DATA AT SITE CG01

			Field Data										Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (°C)	YSI Temp (°C)	pH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	*TURB* (NTU)	E_COLI (cfu/100mL)
Goose Creek	GC01	SCCD	5/18/2022	10:35	15.6	15.1	8.36	310	9.72	96.7	1.02	114.29	13.0	62
Goose Creek	GC01	SCCD	5/31/2022	10:25	8.8	8.4	7.97	315	9.62	81.8	SO-SUB	SO-SUB	300.0	>2419.6[EG]
Goose Creek	GC01	SCCD	6/13/2022	10:15	12.2	11.4	8.02	132	9.56	87.6	SO-SUB	SO-SUB	26.0	1480
Goose Creek	GC01	SCCD	6/28/2022	10:35	16.5	15.9	8.08	206	8.56	86.3	1.92	199.13	11.0	134
Goose Creek	GC01	SCCD	7/7/2022	10:35	20.8	19.7	8.25	430	8.10	88.8	1.03	115.27	13.0	441
Goose Creek	GC01	SCCD	7/20/2022	10:40	22.4	21.3	8.72	678	11.71	131.6[DO]	0.42	52.45	2.0	84
Goose Creek	GC01	SCCD	8/1/2022	10:40	24.5	23.4	8.63	721	10.12	118.9[DO]	0.30	39.04	2.8	30
Goose Creek	GC01	SCCD	8/9/2022	11:20	25.0	23.0	8.53	662	9.82	114.5[DO]	0.34	43.57	3.9	52
Goose Creek	GC01	SCCD	8/24/2022	10:10	22.5	21.9	8.47	759	8.09	92.5	0.24	32.09	4.5	183
Goose Creek	GC01	SCCD	9/8/2022	10:10	20.2	19.6	8.42	771	8.38	91.5	0.22	29.73	2.2	135

Arithmetic Averages (means)										Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	14.8	14.1	8.14	279	9.11	88.2	1.32	142.90	72.6	420
June 13-August 1	19.3	18.3	8.34	433	9.61	102.6	0.92	101.47	11.0	186
July 20-September 8	22.9	21.8	8.55	718	9.62	109.8	0.30	39.38	3.1	80
Annual	18.9	18.0	8.35	498	9.37	99.0	0.69	78.20	37.8	

APPENDIX TABLE C-8. SCCD 2022 WATER QUALITY DATA AT SITE TR05

			Field Data										Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (°C)	YSI Temp (°C)	pH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	*TURB* (NTU)	E_COLI (cfu/100mL)
Tongue River	TR05	SCCD	5/18/2022	10:50	10.4	9.9	8.06	175	9.90	87.6	SO-SUB	SO-SUB	55.0	816
Tongue River	TR05	SCCD	5/31/2022	10:40	7.2	6.6	8.01	240	10.65	86.9	SO-SUB	SO-SUB	190.0	>2419.6[EG]
Tongue River	TR05	SCCD	6/13/2022	10:25	11.8	11.2	7.98	178	9.50	86.5	SO-SUB	SO-SUB	22.0	450
Tongue River	TR05	SCCD	6/28/2022	10:50	15.2	14.4	8.21	237	9.31	90.6	3.32	555.23	10.0	120
Tongue River	TR05	SCCD	7/7/2022	10:50	18.0	17.6	8.27	282	8.79	92.1	2.58	363.22	12.0	241
Tongue River	TR05	SCCD	7/20/2022	10:55	19.9	19.4	8.49	352	9.02	98.1	1.47	140.94	5.3	75
Tongue River	TR05	SCCD	8/1/2022	10:55	23.6	22.8	8.44	421	8.07	93.7	1.06	81.29	5.3	134
Tongue River	TR05	SCCD	8/9/2022	11:35	23.0	22.2	8.45	461	8.72	100.2[DO]	1.05	80.00	7.0	132
Tongue River	TR05	SCCD	8/24/2022	10:40	22.8	22.6	8.35	543	8.15	93.5	0.84	54.96	9.9	86
Tongue River	TR05	SCCD	9/8/2022	10:20	19.5	18.9	8.42	469	8.32	89.5	0.81	51.69	8.1	118

Arithmetic Averages (means)										Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	12.5	11.9	8.11	222	9.63	88.7	2.95	459.22	57.8	481
June 13-August 1	17.7	17.1	8.28	294	8.94	92.2	2.11	285.17	10.9	167
July 20-September 8	21.8	21.2	8.43	449	8.46	95.0	1.05	81.78	7.1	106
Annual	17.1	16.6	8.27	336	9.04	91.9	1.59	189.62	32.5	

APPENDIX TABLE C-9. SCCD 2022 WATER QUALITY DATA AT SITE TR07

			Field Data										Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (°C)	YSI Temp (°C)	pH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	*TURB* (NTU)	E_COLI (cfu/100mL)
Tongue River	TR07	SCCD	5/18/2022	11:20	9.2	8.7	8.15	181	10.95	93.5	SO-SUB	SO-SUB	9.9[FD]	260
Tongue River	TR07	SCCD	5/31/2022	11:10	6.3	5.8	8.04	232	11.29	90.2	SO-SUB	SO-SUB	120.0	1990
Tongue River	TR07	SCCD	6/13/2022	10:50	10.6	10.0	8.01	172	10.03	88.9	SO-SUB	SO-SUB	13.0	246
Tongue River	TR07	SCCD	6/28/2022	11:20	14.5	14.0	8.29	225	9.65	93.0	SO-SUB	SO-SUB	3.8	132
Tongue River	TR07	SCCD	7/7/2022	11:20	16.5	15.7	8.29	258	9.57	96.2	3.20	394.70	4.5	122
Tongue River	TR07	SCCD	7/20/2022	11:25	17.3	17.5	8.40	318	9.69	99.7	2.66	156.40	1.8	52
Tongue River	TR07	SCCD	8/1/2022	11:15	19.7	19.0	8.33	376	9.19	99.0	2.26	69.15	3.5	134
Tongue River	TR07	SCCD	8/9/2022	11:55	20.1	19.6	8.26	413	10.19	111[DO]	2.28	72.27	4.3	86
Tongue River	TR07	SCCD	8/24/2022	11:15	20.5	19.9	8.30	436	8.91	97.0	2.17	56.41	5.8	226
Tongue River	TR07	SCCD	9/8/2022	10:45	17.5	17.0	8.29	415	8.66	89.50	1.98	35.65	4.6	131

Arithmetic Averages (means)										Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	11.4	10.8	8.16	214	10.30	92.4	3.20	394.70	30.2	290
June 13-August 1	15.7	15.2	8.26	270	9.63	95.4	2.71	206.75	5.3	123
July 20-September 8	19.0	18.6	8.32	392	9.33	99.2	2.27	77.97	4.0	112
Annual	15.2	14.7	8.24	303	9.81	95.8	2.43	130.76	17.1	

Data Qualifiers	
DIS	Results rejected due to inability to meet quality control critiera.
DO	100 percent air saturation exceeded.
EG	Sample result reported as greater than 2419 MPN/100 mL.
EL	Sample result reported as less than 1 MPN/100 mL.
FB	Field blank exceeds the reporting limit for that analyte.
FD	Field duplicate results not within control limits.
H	The EPA recommended holding time was exceeded.
NS	Not sampled.
SO-OUT	Gauge out of water; unable to take reading.
SO-SUB	Gauge fully submerged; unable to take reading.
TB	Trip blank exceeds the reporting limit for that analyte.

APPENDIX TABLE C-10. SCCD 2022 WATER QUALITY DATA AT SITE WC01

			Field Data										Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	pH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	*TURB* (NTU)	E_COLI (cfu/100mL)
Wolf Creek	WC01	SCCD	5/18/2022	11:40	15.3	14.8	8.27	321	9.14	90.2	1.45	75.06	26.0	435
Wolf Creek	WC01	SCCD	5/31/2022	11:20	7.4	6.8	7.94	282	10.55	86.6	2.76	181.38	160.0	1990
Wolf Creek	WC01	SCCD	6/13/2022	11:00	10.3	9.7	7.97	162	9.83	86.4	2.88	192.28	24.0	794
Wolf Creek	WC01	SCCD	6/28/2022	11:35	15.2	14.3	8.11	204	9.42	92.0	1.34	67.36	9.5	231
Wolf Creek	WC01	SCCD	7/7/2022	11:30	19.1	18.5	8.33	271	8.82	94.1	0.84	35.51	7.3	313
Wolf Creek	WC01	SCCD	7/20/2022	11:40	20.8	20.3	8.50	378	9.86	107[DO]	0.18	4.30	3.3	173
Wolf Creek	WC01	SCCD	8/1/2022	11:30	23.8	20.8	8.25	433	8.77	98.1	0.16	3.66	2.6	331
Wolf Creek	WC01	SCCD	8/9/2022	12:10	22.6	20.4	8.38	461	10.04	111.4[DO]	0.18	4.30	2.3	134
Wolf Creek	WC01	SCCD	8/24/2022	11:30	20.7	20.5	8.33	520	8.87	98.1	0.02	0.21	5.0	75
Wolf Creek	WC01	SCCD	9/8/2022	11:00	18.0	17.4	8.22	602	8.01	83.5	SO-OUT	SO-OUT	4.7	110

Arithmetic Averages (means)										Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	13.5	12.8	8.12	248	9.55	89.9	1.85	110.32	45.4	549
June 13-August 1	17.8	16.7	8.23	290	9.34	95.5	1.08	60.62	9.3	319
July 20-September 8	21.2	19.9	8.34	479	9.11	99.6	0.14	3.12	3.6	145
Annual	17.3	16.4	8.23	363	9.33	94.7	1.09	62.67	24.5	

APPENDIX TABLE C-11. SCCD 2022 WATER QUALITY DATA AT SITE FMC01

			Field Data										Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	pH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	*TURB* (NTU)	E_COLI (cfu/100mL)
Fivemile Creek	FMC01	SCCD	5/18/2022	11:50	15.4	14.9	8.46	1357	13.19	130.4[DO]	0.86	1.35	8.9	1990
Fivemile Creek	FMC01	SCCD	5/31/2022	11:30	11.4	10.6	8.05	697	8.97	80.6	1.94	61.88	270.0	2420
Fivemile Creek	FMC01	SCCD	6/13/2022	11:15	17.0	16.4	8.09	719	7.64	78.0	1.67	30.58	36.0	605
Fivemile Creek	FMC01	SCCD	6/28/2022	12:50	18.0	16.9	8.15	1714	9.22	95.1	0.74	0.66	7.0	495
Fivemile Creek	FMC01	SCCD	7/7/2022	11:45	18.3	17.4	7.97	1687	5.48	57.2	0.70	0.51	11.0	754
Fivemile Creek	FMC01	SCCD	7/20/2022	11:55	17.5	17.4	7.94	1161	4.66	48.1	0.65	0.36	17.0	404
Fivemile Creek	FMC01	SCCD	8/1/2022	11:40	19.7	18.2	7.97	693	6.86	72.8	0.71	0.55	18.0	657
Fivemile Creek	FMC01	SCCD	8/9/2022	12:20	20.4	18.9	7.95	415	7.33	78.9	1.10	4.29	19.0	323
Fivemile Creek	FMC01	SCCD	8/24/2022	11:40	19.5	19.3	8.01	457	7.20	77.7	1.13	4.87	13.0	175
Fivemile Creek	FMC01	SCCD	9/8/2022	11:10	17.3	16.7	8.23	808	7.84	80.6	0.87	1.42	13.0	183

Arithmetic Averages (means)										Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	16.0	15.2	8.14	1235	8.90	88.3	1.18	19.00	66.6	1017
June 13-August 1	18.1	17.3	8.02	1195	6.77	70.2	0.89	6.53	17.8	570
July 20-September 8	18.9	18.1	8.02	707	6.78	71.6	0.89	2.30	16.0	307
Annual	17.5	16.7	8.08	971	7.84	79.9	1.04	10.65	41.3	

APPENDIX TABLE C-12. SCCD 2022 WATER QUALITY DATA AT SITE TR08

					Field Data								Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	PH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	TURB (NTU)	E_COLI (cfu/100mL)
Tongue River	TR08	SCCD	5/18/2022	12:20	8.6	8.0	8.31	173	11.62	98.3	2.88	417.42	12.0	138
Tongue River	TR08	SCCD	5/31/2022	12:00	5.8	5.2	8.02	218	11.68	92.0	SO-SUB	SO-SUB	120.0	1120
Tongue River	TR08	SCCD	6/13/2022	11:55	10.4	9.7	8.16	159	10.67	93.8	SO-SUB	SO-SUB	8.9	161
Tongue River	TR08	SCCD	6/28/2022	13:40	15.6	15.0	8.49	227	9.59	95.3	2.58	364.72	2.3	74
Tongue River	TR08	SCCD	7/7/2022	12:15	16.3	15.7	8.52	250	9.59	96.6	2.00	266.86	3.5	132
Tongue River	TR08	SCCD	7/20/2022	12:30	18.2	18.2	8.56	293	9.73	101.5[DO]	1.09	126.72	1.0	98
Tongue River	TR08	SCCD	8/1/2022	11:50	18.7	18.2	8.38	337	9.27	98.3	0.58	58.44	3.1[FB]	52
Tongue River	TR08	SCCD	8/9/2022	12:50	21.4	19.1	8.44	351	9.36	101.1[DO]	0.53	52.32	5.1	146
Tongue River	TR08	SCCD	8/24/2022	12:05	19.0	18.8	8.50	369	9.62	102.5	0.44	41.64	6.6	187
Tongue River	TR08	SCCD	9/8/2022	11:40	17.6	16.9	8.37	376	9.02	93.2	0.31	27.10	4.4	313

Arithmetic Averages (means)										Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	11.3	10.7	8.30	205	10.63	95.2	2.49	349.66	29.3	189
June 13-August 1	15.8	15.4	8.42	253	9.77	97.1	1.56	204.18	3.8	96
July 20-September 8	19.0	18.2	8.45	345	9.40	99.3	0.59	61.24	4.0	134
Annual	15.2	14.5	8.38	275	10.02	97.3	1.30	169.40	16.7	

Data Qualifiers	
DIS	Results rejected due to inability to meet quality control critiera.
DO	100 percent air saturation exceeded.
EG	Sample result reported as greater than 2419 MPN/100 mL.
EL	Sample result reported as less than 1 MPN/100 mL.
FB	Field blank exceeds the reporting limit for that analyte.
FD	Field duplicate results not within control limits.
H	The EPA recommended holding time was exceeded.
NS	Not sampled.
SO-OUT	Gauge out of water; unable to take reading.
SO-SUB	Gauge fully submerged; unable to take reading.
TB	Trip blank exceeds the reporting limit for that analyte.

APPENDIX TABLE C-13. SCCD 2022 WATER QUALITY DATA AT SITE CC01

					Field Data								Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	PH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	TURB (NTU)	E_COLI (cfu/100mL)
Columbus Creek	CC01	SCCD	5/18/2022	12:30	15.3	14.8	8.38	620	9.23	91.0	1.08	9.67	55.0	687
Columbus Creek	CC01	SCCD	5/31/2022	12:15	8.7	8.1	7.97	468	8.27	69.9	SO-SUB	SO-SUB	1000.0	770
Columbus Creek	CC01	SCCD	6/13/2022	12:05	16.1	15.4	8.28	507	8.77	87.7	1.84	40.85	34.0	389
Columbus Creek	CC01	SCCD	6/28/2022	13:55	21.1	20.4	8.37	517	7.93	88.0	1.16	11.73	18.0	158
Columbus Creek	CC01	SCCD	7/7/2022	12:40	23.6	20.5	8.31	406	7.71	85.6	1.20	12.85	32.0	754
Columbus Creek	CC01	SCCD	7/20/2022	13:10	19.6	19.2	8.31	378	8.55	92.2	0.73	3.35	14.0	292
Columbus Creek	CC01	SCCD	8/1/2022	12:05	20.2	19.4	8.32	369	7.92	86.2	0.95	6.83	18.0	201
Columbus Creek	CC01	SCCD	8/9/2022	13:25	21.3	20.7	8.34	324	7.96	88.8	1.14	11.19	23.0	223
Columbus Creek	CC01	SCCD	8/24/2022	12:40	20.0	19.2	8.34	308	7.97	85.6	1.31	16.30	36.0	471
Columbus Creek	CC01	SCCD	9/8/2022	11:50	17.5	16.9	8.45	302	8.37	86.3	1.30	15.96	12.0	187

Arithmetic Averages (means)										Geometric Means
Period	TEMP	TEMP	PH	COND	DO (mg/L)	DO (%)	STAFF	Discharge	Turbidity	E.coli
May 18-July 7	17.0	15.8	8.26	504	8.38	84.4	1.32	18.77	227.8	476
June 13-August 1	20.1	19.0	8.32	435	8.18	87.9	1.18	15.12	23.2	307
July 20-September 8	19.7	19.1	8.35	336	8.15	87.8	1.09	10.73	20.6	258
Annual	18.3	17.5	8.31	420	8.27	86.1	1.19	14.30	124.2	

APPENDIX TABLE C-14. SCCD 2022 WATER QUALITY DATA AT SITE LTR01

					Field Data								Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	PH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	TURB (NTU)	E_COLI (cfu/100mL)
Little Tongue River	LTR01	SCCD	5/18/2022	12:50	12.2	11.7	8.28	318	10.04	92.6	1.30	DIS	16.0	921
Little Tongue River	LTR01	SCCD	5/31/2022	12:25	7.3	6.7	8.03	223	11.39	93.2	1.96	DIS	40.0	2420[FD]
Little Tongue River	LTR01	SCCD	6/13/2022	12:15	11.7	11.5	8.29	243	10.18	91.8	1.70	DIS	6.0	479
Little Tongue River	LTR01	SCCD	6/28/2022	14:05	16.2	15.5	8.43	284	9.29	93.0	1.10	DIS	3.9	73
Little Tongue River	LTR01	SCCD	7/7/2022	12:50	17.2	16.5	8.42	377	9.00	92.2	0.66	32.90	2.2	98
Little Tongue River	LTR01	SCCD	7/20/2022	13:40	19.3	18.8	8.46	355	8.74	93.2	0.33	1.80	1.1	712
Little Tongue River	LTR01	SCCD	8/1/2022	12:15	18.8	18.3	8.43	368	8.75	92.8	0.36	2.59	1.3	8860
Little Tongue River	LTR01	SCCD	8/9/2022	13:35	19.9	19.3	8.51	386	8.99	97.4	0.36	2.59	1.8	557
Little Tongue River	LTR01	SCCD	8/24/2022	13:10	18.6	18.6	8.48	379	9.08	95.5	0.34	2.04	1.1	331
Little Tongue River	LTR01	SCCD	9/8/2022	12:00	16.6	16.1	8.54	382	9.24	93.7	0.32	1.58	0.9	727

Arithmetic Averages (means)										Geometric Means
Period	TEMP	TEMP	PH	COND	DO (mg/L)	DO (%)	STAFF	Discharge	Turbidity	E.coli
May 18-July 7	12.9	12.4	8.29	289	9.98	92.6	1.34	32.90	13.6	377
June 13-August 1	16.6	16.1	8.41	325	9.19	92.6	0.83	12.43	2.9	464
July 20-September 8	18.6	18.2	8.48	374	8.96	94.5	0.34	2.12	1.2	967
Annual	15.8	15.3	8.39	332	9.47	93.5	0.84	7.25	7.4	

APPENDIX TABLE C-15. SCCD 2022 WATER QUALITY DATA AT SITE SC01

					Field Data								Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	PH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	TURB (NTU)	E_COLI (cfu/100mL)
Smith Creek	SC01	SCCD	5/18/2022	12:55	13.7	13.2	8.45	499	9.47	90.5	0.94	12.62	23.0	162
Smith Creek	SC01	SCCD	5/31/2022	12:35	8.9	8.2	8.27	508	10.57	89.7	1.62	71.61	200.0	78
Smith Creek	SC01	SCCD	6/13/2022	12:25	14.2	13.6	8.36	499	9.28	89.2	1.60	68.83	18.0	512
Smith Creek	SC01	SCCD	6/28/2022	14:15	18.8	18.0	8.50	393	8.55	90.5	1.02	16.38	5.5	201
Smith Creek	SC01	SCCD	7/7/2022	13:00	18.2	17.4	8.53	385	8.63	89.9	0.80	7.55	12.0	637
Smith Creek	SC01	SCCD	7/20/2022	14:05	20.2	19.2	8.68	350	8.67	93.5	0.85	9.15	2.8	309
Smith Creek	SC01	SCCD	8/1/2022	12:25	19.0	18.0	8.54	332	8.40	88.9	0.83	8.49	2.9	185[FD]
Smith Creek	SC01	SCCD	8/9/2022	13:45	20.1	19.4	8.71	381	8.50	92.5	0.84	8.82	3.3	173
Smith Creek	SC01	SCCD	8/24/2022	13:40	18.1	17.5	8.55	427	8.52	89.0	0.78	6.96	2.7	231
Smith Creek	SC01	SCCD	9/8/2022	12:10	16.1	15.5	8.53	396	9.02	90.4	0.81	7.85	2.2	161

Arithmetic Averages (means)										Geometric Means
Period	TEMP	TEMP	PH	COND	DO (mg/L)	DO (%)	STAFF	Discharge	Turbidity	E.coli
May 18-July 7	14.8	14.1	8.42	457	9.30	90.0	1.20	35.40	51.7	242
June 13-August 1	18.1	17.2	8.52	392	8.71	90.4	1.02	22.08	8.2	327
July 20-September 8	18.7	17.9	8.60	377	8.62	90.9	0.82	8.25	2.8	206
Annual	16.7	16.0	8.51	417	8.96	90.4	1.01	21.82	27.2	

Data Qualifiers	
DIS	Results rejected due to inability to meet quality control critiera.
DO	100 percent air saturation exceeded.
EG	Sample result reported as greater than 2419 MPN/100 mL.
EL	Sample result reported as less than 1 MPN/100 mL.
FB	Field blank exceeds the reporting limit for that analyte.
FD	Field duplicate results not within control limits.
H	The EPA recommended holding time was exceeded.
NS	Not sampled.
SO-OUT	Gauge out of water; unable to take reading.
SO-SUB	Gauge fully submerged; unable to take reading.
TB	Trip blank exceeds the reporting limit for that analyte.

APPENDIX TABLE C-16. SCCD 2022 WATER QUALITY DATA AT SITE TR09

					Field Data								Laboratory Data	
Waterbody	Site	Agency	Date (mmddyy)	Time (military)	Hanna Temp (*C)	YSI Temp (*C)	PH (SU)	COND (umho/cm)	DO (mg/L)	DO (%)	STAFF	DISCH (cfs)	TURB (NTU)	E_COLI (cfu/100mL)
Tongue River	TR09	SCCD	5/18/2022	13:20	7.1	6.9	8.26	133	12.20	99.4	3.24	512	8.3	55
Tongue River	TR09	SCCD	5/31/2022	12:55	4.5	4.0	8.17	155	12.21	93.2	3.58	729	10.0	1990
Tongue River	TR09	SCCD	6/13/2022	12:45	9.4	8.8	8.18	136	10.87	93.5	4.20	1200	6.3	20
Tongue River	TR09	SCCD	6/28/2022	14:30	13.8	12.9	8.51	187	10.04	95.0	3.16	481	2.2	10
Tongue River	TR09	SCCD	7/7/2022	13:20	14.8	13.7	8.47	203	10.30	99.2	2.86	323	2.1	108
Tongue River	TR09	SCCD	7/20/2022	14:35	16.5	16.0	8.59	238	10.12	102.2[DO]	2.45	181	1.0	31
Tongue River	TR09	SCCD	8/1/2022	12:40	17.8	16.6	8.55	244	9.65	99.1	2.25	126	0.9	41
Tongue River	TR09	SCCD	8/9/2022	14:15	19.6	17.2	8.64	249	9.61	100.0	2.14	105	1.1	52
Tongue River	TR09	SCCD	8/24/2022	14:10	16.1	16.0	8.67	263	8.90	89.3	1.97	76.5	0.8	10
Tongue River	TR09	SCCD	9/8/2022	12:25	15.7	15.2	8.68	276	9.75	97.0	SO-OUT	57.2	0.4	74

	Arithmetic Averages (means)								Geometric Means
Period	**TEMP**	**TEMP**	**PH**	**COND**	**DO (mg/L)**	**DO (%)**	**STAFF**	**Discharge**	**Turbidity**	**E.coli**
May 18-July 7	9.9	9.3	8.32	163	11.12	96.1	3.41	649.00	5.8	75
June 13-August 1	14.5	13.6	8.46	202	10.20	97.8	2.98	462.20	2.5	31
July 20-September 8	17.1	16.2	8.63	254	9.61	97.5	2.20	109.14	0.8	35
Annual	13.5	12.7	8.47	208	10.37	96.8	2.87	379.07	3.3	

Data Qualifiers	
DIS	Results rejected due to inability to meet quality control critiera.
DO	100 percent air saturation exceeded.
EG	Sample result reported as greater than 2419 MPN/100 mL.
EL	Sample result reported as less than 1 MPN/100 mL.
FB	Field blank exceeds the reporting limit for that analyte.
FD	Field duplicate results not within control limits.
H	The EPA recommended holding time was exceeded.
NS	Not sampled.
SO-OUT	Gauge out of water; unable to take reading.
SO-SUB	Gauge fully submerged; unable to take reading.
TB	Trip blank exceeds the reporting limit for that analyte.

APPENDIX TABLE C-17. 2022 WATER QUALITY DATA SUMMARY STATISTICS

Site	Statistic	Hanna	YSI	PH	COND	DO	DO	STAFF	DISCH	TURB	*E. Coli*
		Temp (°C)	Temp (°C)	(SU)	(uS/cm)	(mg/L)	(%)		(cfs)	(NTU)	(cfu/100mL)
TR01	COUNT	10.0	10.0	10.0	9.0	10.0	10.0	8.0	8.0	10.0	10.0
	MAXIMUM	25.0	22.2	8.56	841	9.46	91.5	3.32	882.11	100.0	2420.0
	MINIMUM	10.0	9.5	8.07	212	7.15	79.3	0.75	95.11	4.9	20.0
	MEDIAN	20.3	19.6	8.29	541	7.94	82.1	1.14	179.02	17.5	109.0
	MEAN	18.6	17.6	8.28	538	7.97	82.9	1.60	329.82	27.8	440.4
	GEOMETRIC MEAN	18.0	17.0	8.28	487	7.93	82.8	1.38	236.25	16.7	134.6
	COEFFICIENT OF VARIATION	25.77	24.86	1.70	43.97	9.90	4.03	60.37	88.16	108.7	179.37
PD01	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	MAXIMUM	20.9	20.1	8.29	1739	9.93	104.3	1.08	38.10	75.0	2420.0
	MINIMUM	12.4	11.1	8.00	865	7.38	78.1	0.35	7.92	3.5	134.0
	MEDIAN	18.5	17.7	8.17	1489	7.95	83.5	0.61	16.98	12.5	356.0
	MEAN	17.9	17.1	8.15	1394	8.30	85.7	0.66	19.81	25.3	551.9
	GEOMETRIC MEAN	17.8	16.9	8.15	1357	8.27	85.4	0.62	17.57	16.1	365.0
	COEFFICIENT OF VARIATION	13.49	14.56	1.02	22.63	9.85	8.92	36.57	50.27	101.0	123.54
TR03	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	6.0	6.0	10.0	10.0
	MAXIMUM	24.6	23.8	8.57	620	10.08	95.3	3.30	769.67	190.0	2420.0
	MINIMUM	8.7	8.4	8.04	177	7.22	81.5	0.76	66.56	4.1	1.0
	MEDIAN	20.7	20.0	8.42	372	8.52	86.3	0.98	100.84	9.6	80.0
	MEAN	18.7	18.1	8.35	394	8.46	88.5	1.36	214.80	32.9	372.1
	GEOMETRIC MEAN	17.8	17.2	8.34	363	8.42	88.4	1.17	137.13	13.7	84.6
	COEFFICIENT OF VARIATION	29.88	30.07	2.44	40.65	10.40	5.18	71.46	127.96	174.0	198.94
GC01	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	8.0	8.0	10.0	10.0
	MAXIMUM	25.0	23.4	8.72	771	11.71	131.6	1.92	199.13	300.0	2420.0
	MINIMUM	8.8	8.4	7.97	132	8.09	81.8	0.22	29.73	2.0	30.0
	MEDIAN	20.5	19.7	8.39	546	9.59	92.0	0.38	48.01	7.8	134.5
	MEAN	18.9	18.0	8.35	498	9.37	99.0	0.69	78.20	37.8	502.1
	GEOMETRIC MEAN	18.0	17.2	8.34	430	9.31	97.9	0.51	62.17	8.9	183.2
	COEFFICIENT OF VARIATION	28.66	28.39	3.10	49.34	11.99	16.81	87.23	76.69	244.2	159.94
TR05	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	7.0	7.0	10.0	10.0
	MAXIMUM	23.6	22.8	8.49	543	10.65	100.2	3.32	555.23	190.0	2420.0
	MINIMUM	7.2	6.6	7.98	175	8.07	86.5	0.81	51.69	5.3	75.0
	MEDIAN	18.8	18.3	8.31	317	8.91	91.4	1.06	81.29	10.0	133.0
	MEAN	17.1	16.6	8.27	336	9.04	91.9	1.59	189.62	32.5	459.2
	GEOMETRIC MEAN	16.1	15.5	8.27	312	9.01	91.8	1.38	126.73	14.6	225.9
	COEFFICIENT OF VARIATION	33.60	34.79	2.34	39.26	9.05	5.04	61.47	102.60	176.6	158.22
TR07	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	6.0	6.0	10.0	10.0
	MAXIMUM	20.5	19.9	8.40	436	11.29	111.0	3.20	394.70	120.0	1990.0
	MINIMUM	6.3	5.8	8.01	172	8.66	88.9	1.98	35.65	1.8	52.0
	MEDIAN	16.9	16.4	8.29	288	9.67	94.9	2.27	70.71	4.6	133.0
	MEAN	15.2	14.7	8.24	303	9.81	95.8	2.43	130.76	17.1	337.9
	GEOMETRIC MEAN	14.3	13.8	8.24	287	9.78	95.6	2.39	92.35	6.7	180.3
	COEFFICIENT OF VARIATION	32.53	33.70	1.55	33.61	8.52	6.87	18.14	103.80	212.0	172.99
WC01	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	9.0	9.0	10.0	10.0
	MAXIMUM	23.8	20.8	8.50	602	10.55	111.4	2.88	192.28	160.0	1990.0
	MINIMUM	7.4	6.8	7.94	162	8.01	83.5	0.02	0.21	2.3	75.0
	MEDIAN	18.6	18.0	8.26	350	9.28	93.1	0.84	35.51	6.2	272.0
	MEAN	17.3	16.4	8.23	363	9.33	94.7	1.09	62.67	24.5	458.6
	GEOMETRIC MEAN	16.4	15.5	8.23	337	9.30	94.4	0.48	16.48	8.9	281.7
	COEFFICIENT OF VARIATION	30.63	30.02	2.16	38.80	8.06	9.58	102.13	120.99	197.8	125.96
FMC01	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	MAXIMUM	20.4	19.3	8.46	1714	13.19	130.4	1.94	61.88	270.0	2420.0
	MINIMUM	11.4	10.6	7.94	415	4.66	48.1	0.65	0.36	7.0	175.0
	MEDIAN	17.8	17.2	8.03	764	7.49	78.5	0.87	1.39	15.0	550.0
	MEAN	17.5	16.7	8.08	971	7.84	79.9	1.04	10.65	41.3	800.6
	GEOMETRIC MEAN	17.2	16.5	8.08	868	7.55	77.4	0.97	2.35	19.1	559.1
	COEFFICIENT OF VARIATION	14.80	14.88	2.01	49.35	29.81	27.56	42.48	189.85	195.6	96.30
TR08	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	8.0	8.0	10.0	10.0
	MAXIMUM	21.4	19.1	8.56	376	11.68	102.5	2.88	417.42	120.0	1120.0
	MINIMUM	5.8	5.2	8.02	159	9.02	92.0	0.31	27.10	1.0	52.0
	MEDIAN	17.0	16.3	8.41	272	9.61	97.5	0.84	92.58	4.8	142.0
	MEAN	15.2	14.5	8.38	275	10.02	97.3	1.30	169.40	16.7	242.1
	GEOMETRIC MEAN	14.1	13.4	8.37	264	9.98	97.2	0.95	107.44	5.9	159.4
	COEFFICIENT OF VARIATION	33.79	34.63	2.05	29.41	9.62	3.80	79.55	92.96	218.4	130.81
CC01	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	9.0	9.0	10.0	10.0
	MAXIMUM	23.6	20.7	8.45	620	9.23	92.2	1.84	40.85	1000.0	770.0
	MINIMUM	8.7	8.1	7.97	302	7.71	69.9	0.73	3.35	12.0	158.0
	MEDIAN	19.8	19.2	8.33	392	8.12	87.0	1.16	11.73	27.5	340.5
	MEAN	18.3	17.5	8.31	420	8.27	86.1	1.19	14.30	124.2	413.2
	GEOMETRIC MEAN	17.8	16.9	8.31	409	8.26	85.9	1.16	11.65	34.9	350.8
	COEFFICIENT OF VARIATION	22.97	22.38	1.54	25.04	5.70	7.11	25.45	75.26	248.0	58.98

APPENDIX TABLE C-17 (continued). 2022 WATER QUALITY DATA SUMMARY STATISTICS

Site	Statistic	Hanna	YSI	PH	COND	DO	DO	STAFF	DISCH	TURB	E. Coli
		Temp (°C)	Temp (°C)	(SU)	(uS/cm)	(mg/L)	(%)		(cfs)	(NTU)	(cfu/100mL)
LTR01	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	6.0	10.0	10.0
	MAXIMUM	19.9	19.3	8.54	386	11.39	97.4	1.96	32.90	40.0	8860.0
	MINIMUM	7.3	6.7	8.03	223	8.74	91.8	0.32	1.58	0.9	73.0
	MEDIAN	16.9	16.3	8.43	362	9.16	93.1	0.51	2.31	2.0	634.5
	MEAN	15.8	15.3	8.39	332	9.47	93.5	0.84	7.25	7.4	1517.8
	GEOMETRIC MEAN	15.2	14.7	8.39	326	9.44	93.5	0.66	3.29	3.1	604.0
	COEFFICIENT OF VARIATION	25.93	26.83	1.80	18.48	8.80	1.80	74.47	173.51	165.9	175.51
SC01	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	MAXIMUM	20.2	19.4	8.71	508	10.57	93.5	1.62	71.61	200.0	637.0
	MINIMUM	8.9	8.2	8.27	332	8.40	88.9	0.78	6.96	2.2	78.0
	MEDIAN	18.2	17.5	8.53	395	8.65	90.2	0.85	8.99	4.4	193.0
	MEAN	16.7	16.0	8.51	417	8.96	90.4	1.01	21.82	27.2	264.9
	GEOMETRIC MEAN	16.3	15.6	8.51	413	8.94	90.4	0.97	13.99	7.8	223.0
	COEFFICIENT OF VARIATION	21.29	21.72	1.55	15.35	7.47	1.67	32.18	117.62	224.5	66.33
TR09	COUNT	10.0	10.0	10.0	10.0	10.0	10.0	9.0	10.0	10.0	10.0
	MAXIMUM	19.6	17.2	8.68	276	12.21	102.2	4.20	1200.00	10.0	1990.0
	MINIMUM	4.5	4.0	8.17	133	8.90	89.3	1.97	57.20	0.4	10.0
	MEDIAN	15.3	14.5	8.53	221	10.08	98.1	2.86	252.00	1.6	46.5
	MEAN	13.5	12.7	8.47	208	10.37	96.8	2.87	379.07	3.3	239.1
	GEOMETRIC MEAN	12.4	11.7	8.47	202	10.32	96.7	2.79	243.38	1.9	50.9
	COEFFICIENT OF VARIATION	36.28	36.00	2.34	25.60	10.57	4.08	25.81	96.37	106.6	257.61

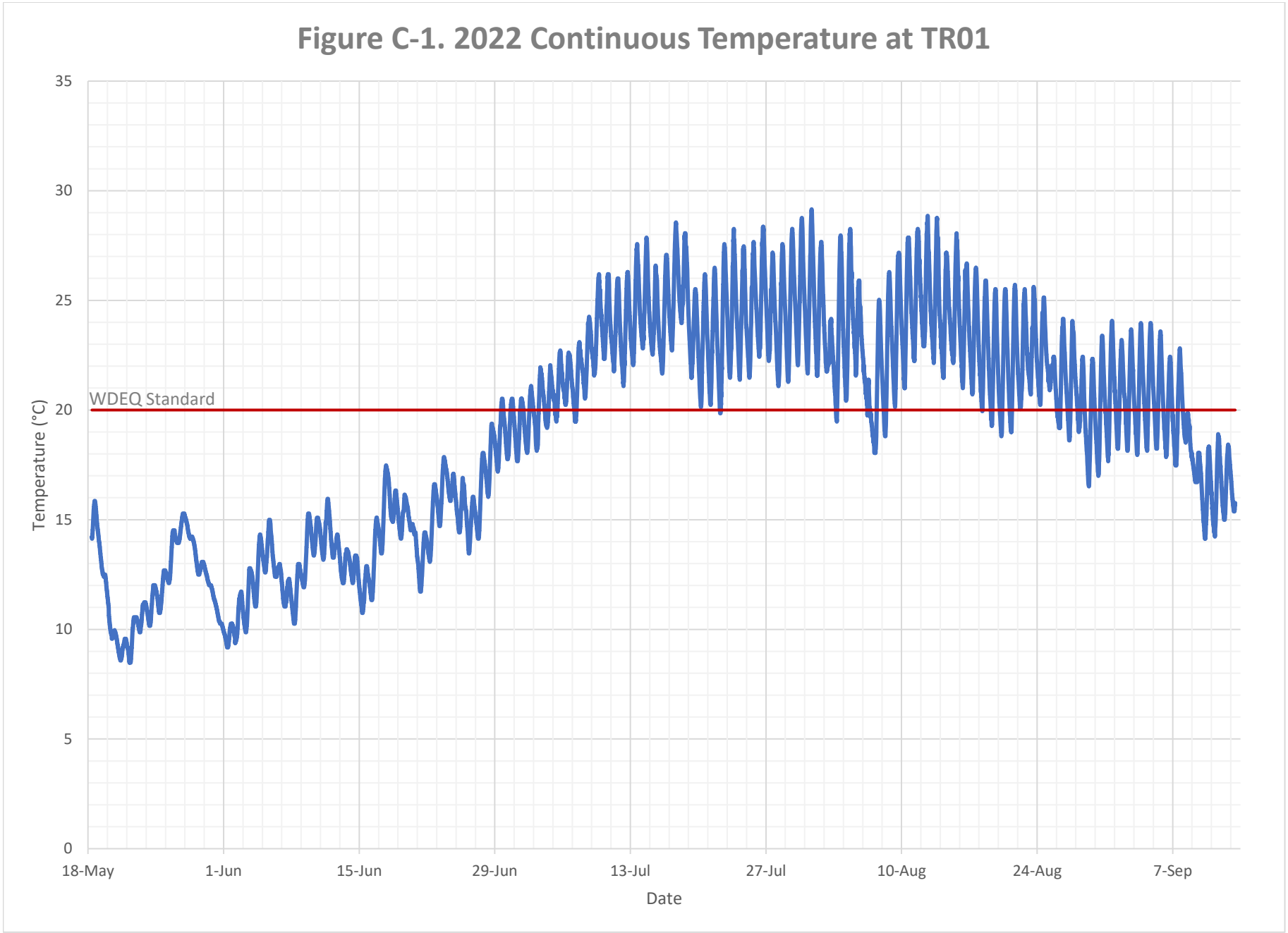


Figure C-1. 2022 Continuous Temperature at TR01
35
30
25
20
15
10
5
0
Temperature (°C)
WDEQ Standard
18-May
1-Jun
15-Jun
29-Jun
13-Jul
27-Jul
10-Aug
24-Aug
7-Sep
Date

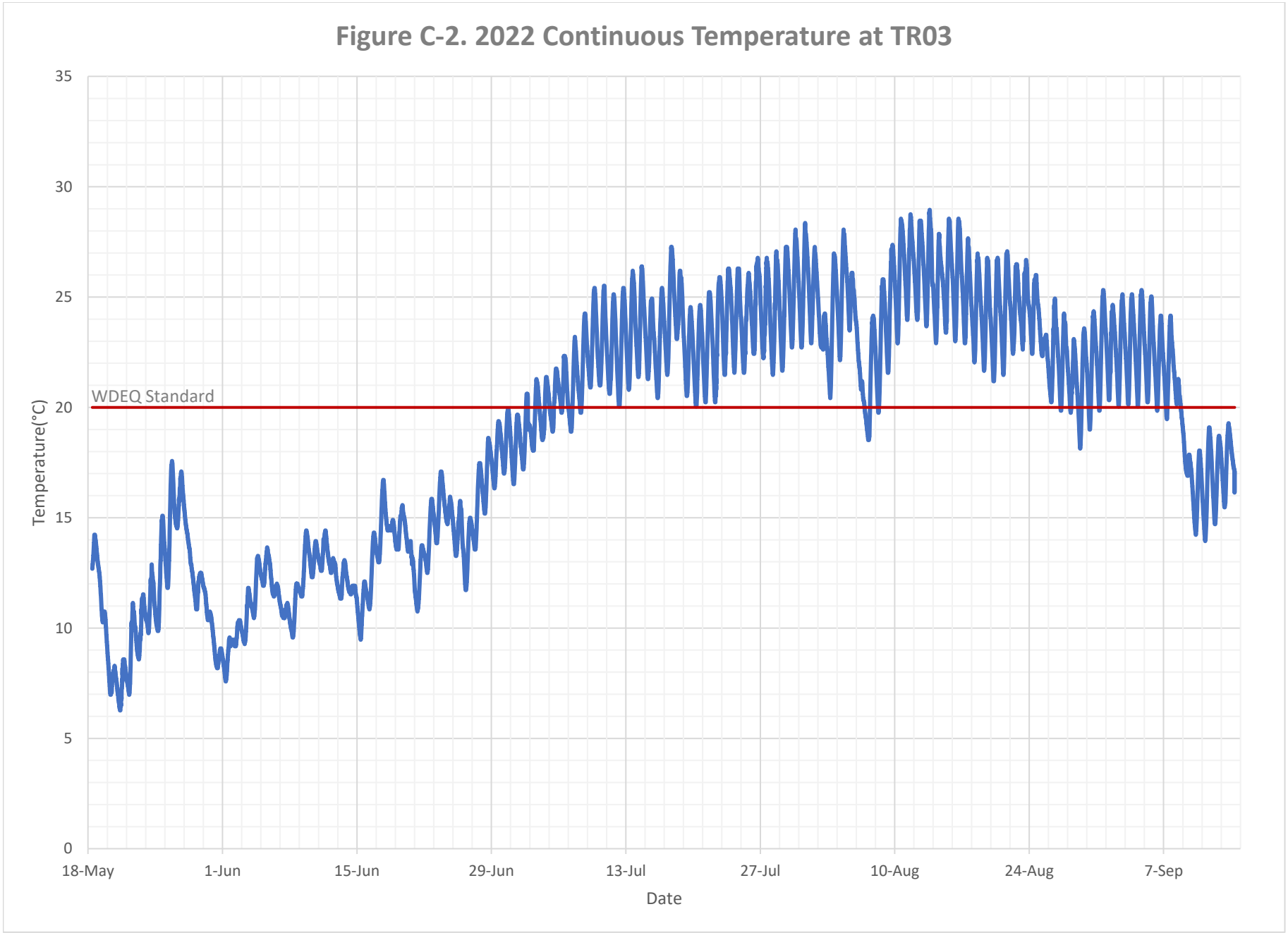


Figure C-2. 2022 Continuous Temperature at TR03
35
30
25
20
15
10
5
0
Temperature(°C)
WDEQ Standard
18-May
1-Jun
15-Jun
29-Jun
13-Jul
27-Jul
10-Aug
24-Aug
7-Sep
Date

Figure C-3. 2022 Continuous Temperature TR05

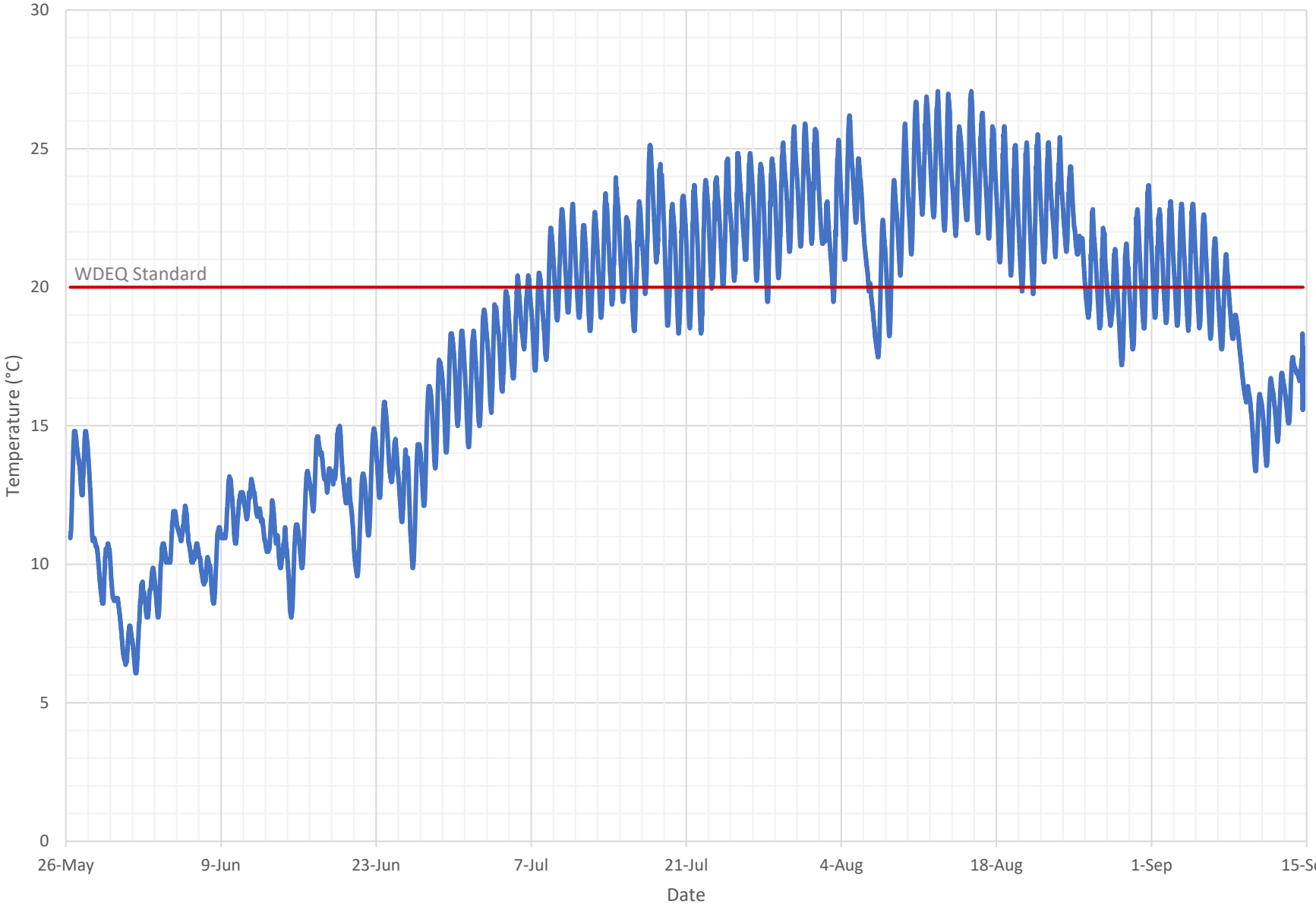


Figure C-4. 2022 Continuous Temperature TR07

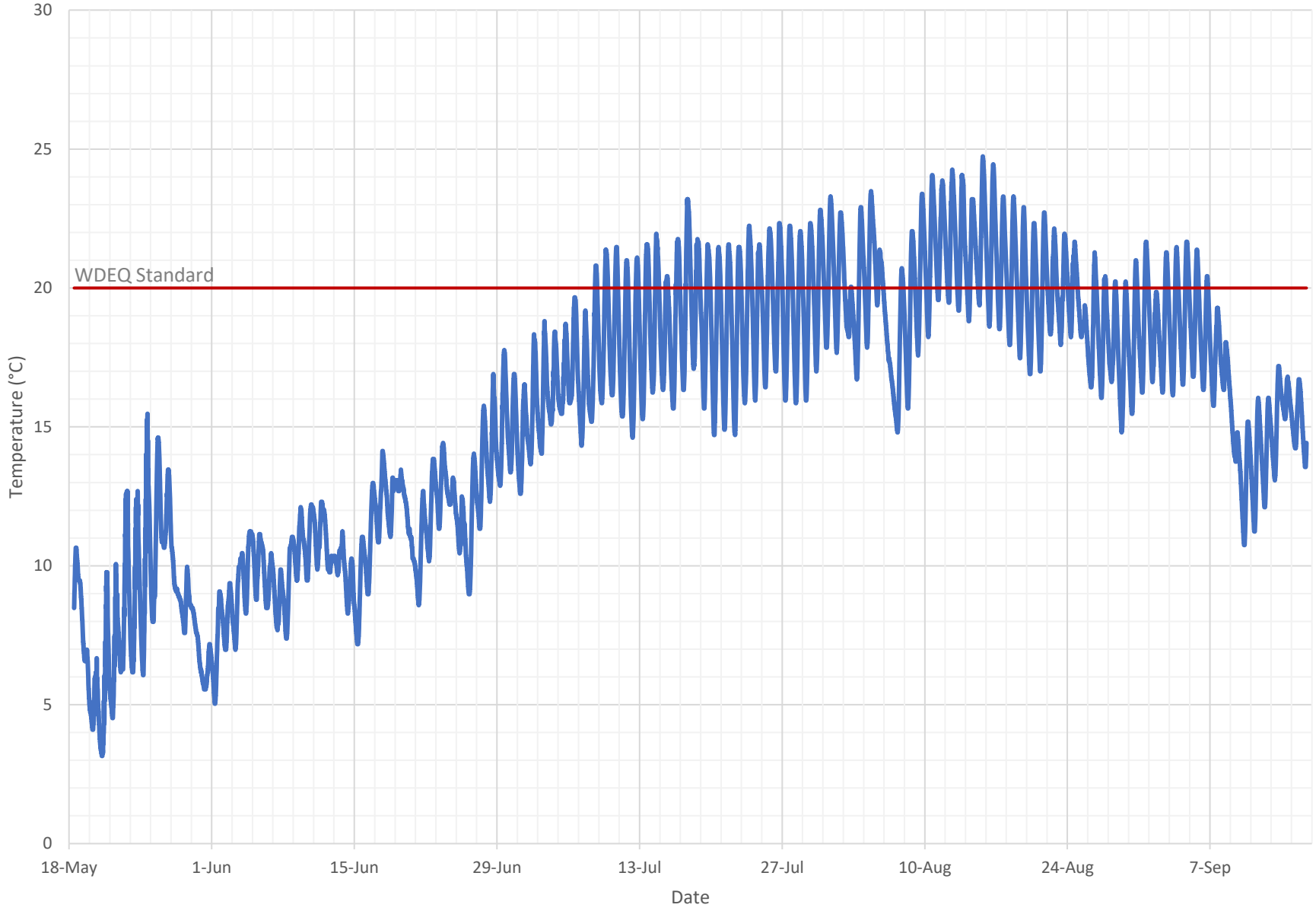


Figure C-5. 2022 Continuous Temperature at TR09

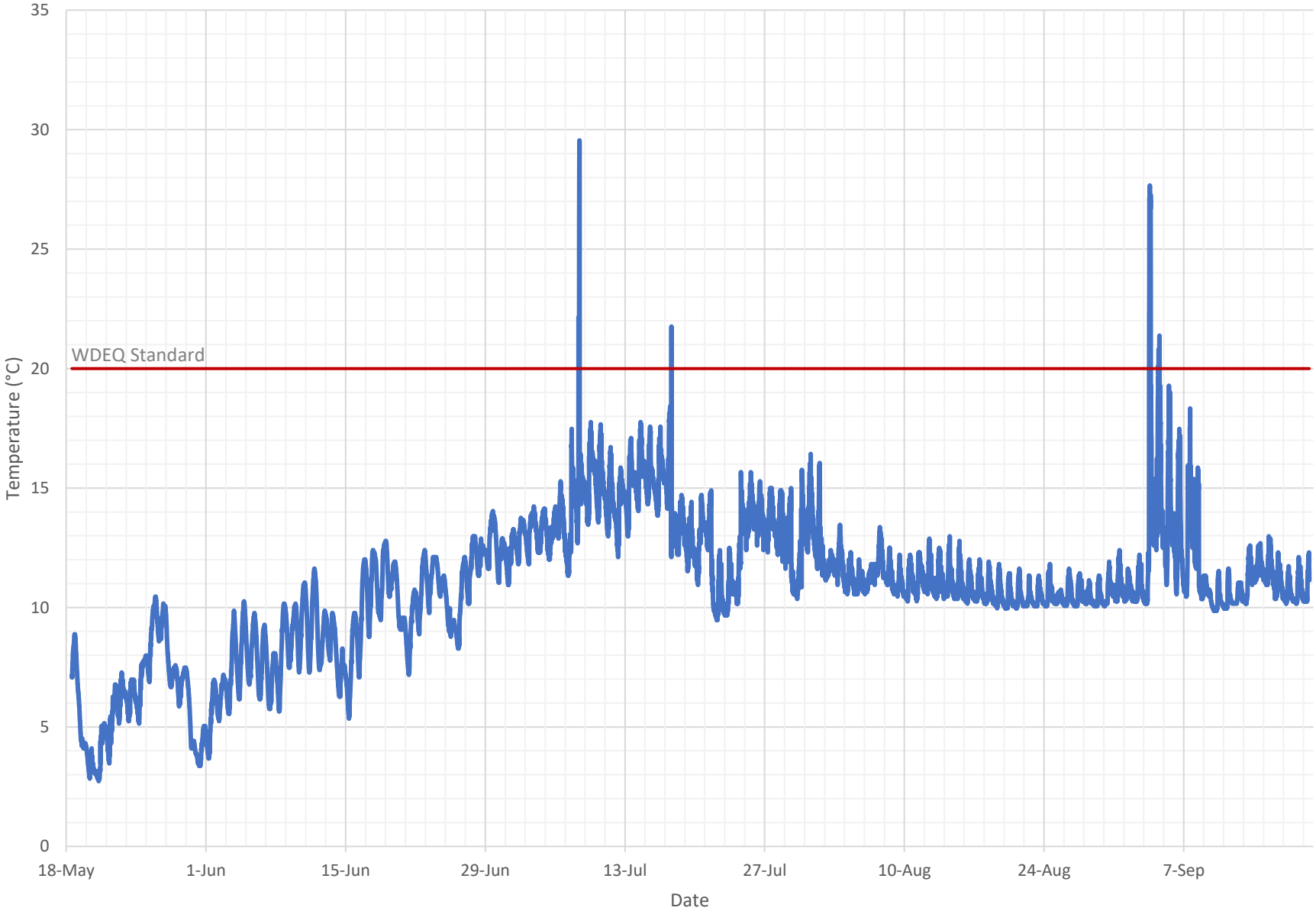


Figure C-6. Yearly Mean Daily Water Temperature Comparison at TR07

Figure C-7. 2022 Mean Daily Flow and Normal Flow at USGS Station 06306300 Tongue River near Decker, MT with 2022 Instantaneous Discharge at TR01

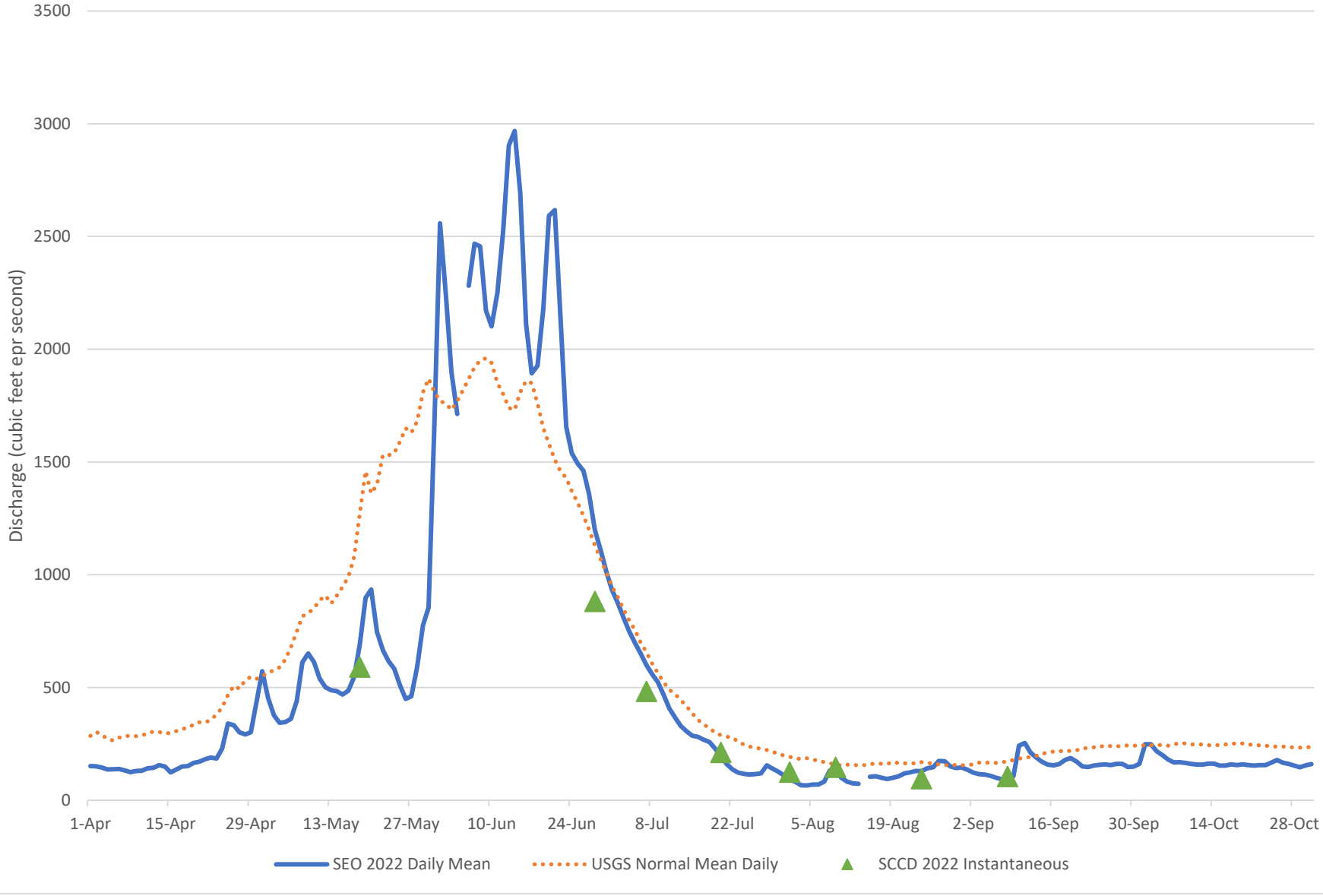


Figure C-8. 2022 Mean Daily Flow and Normal Flow at USGS Station 06306250 Prairie Dog Creek near Acme with 2022 Instantaneous Discharge at PD01

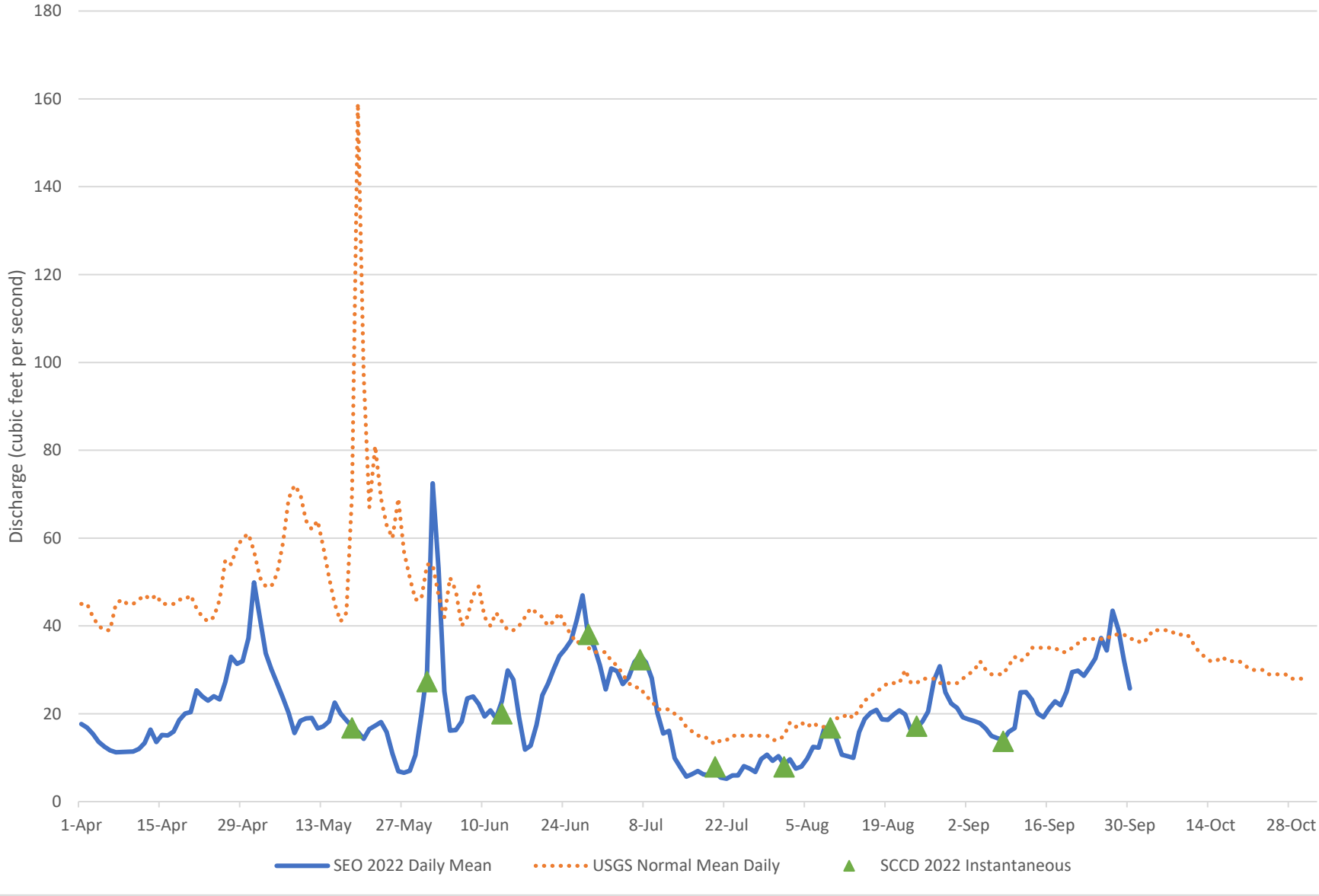


Figure C-9. 2022 Mean Daily Flow and Normal Flow at USGS Station 06305700 Goose Creek near Acme with 2022 Instantaneous Discharge at GC01

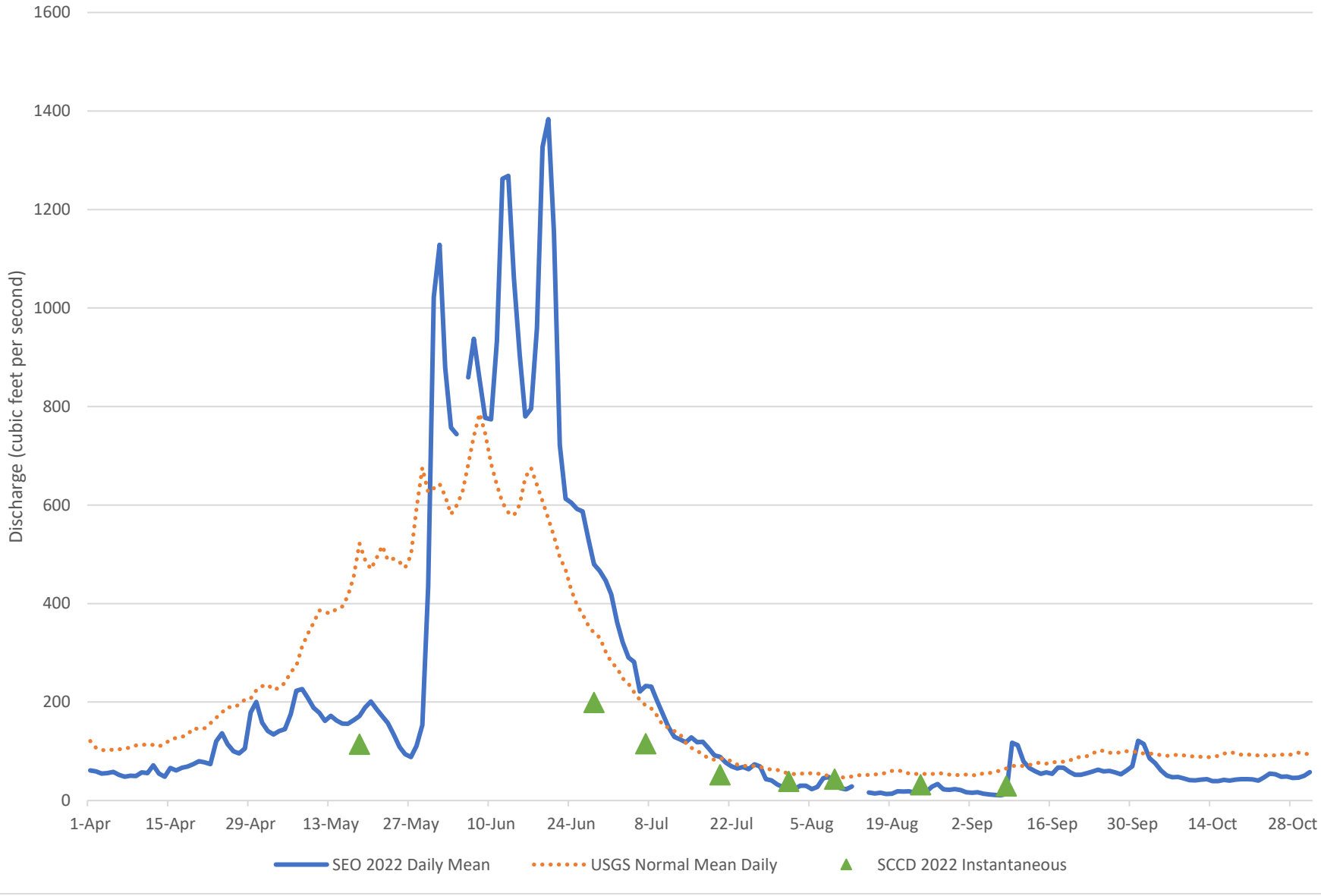


Figure C-10. 2022 Mean Daily Flow and Normal Flow at USGS Station 06298000 Tongue River near Dayton (TR09)

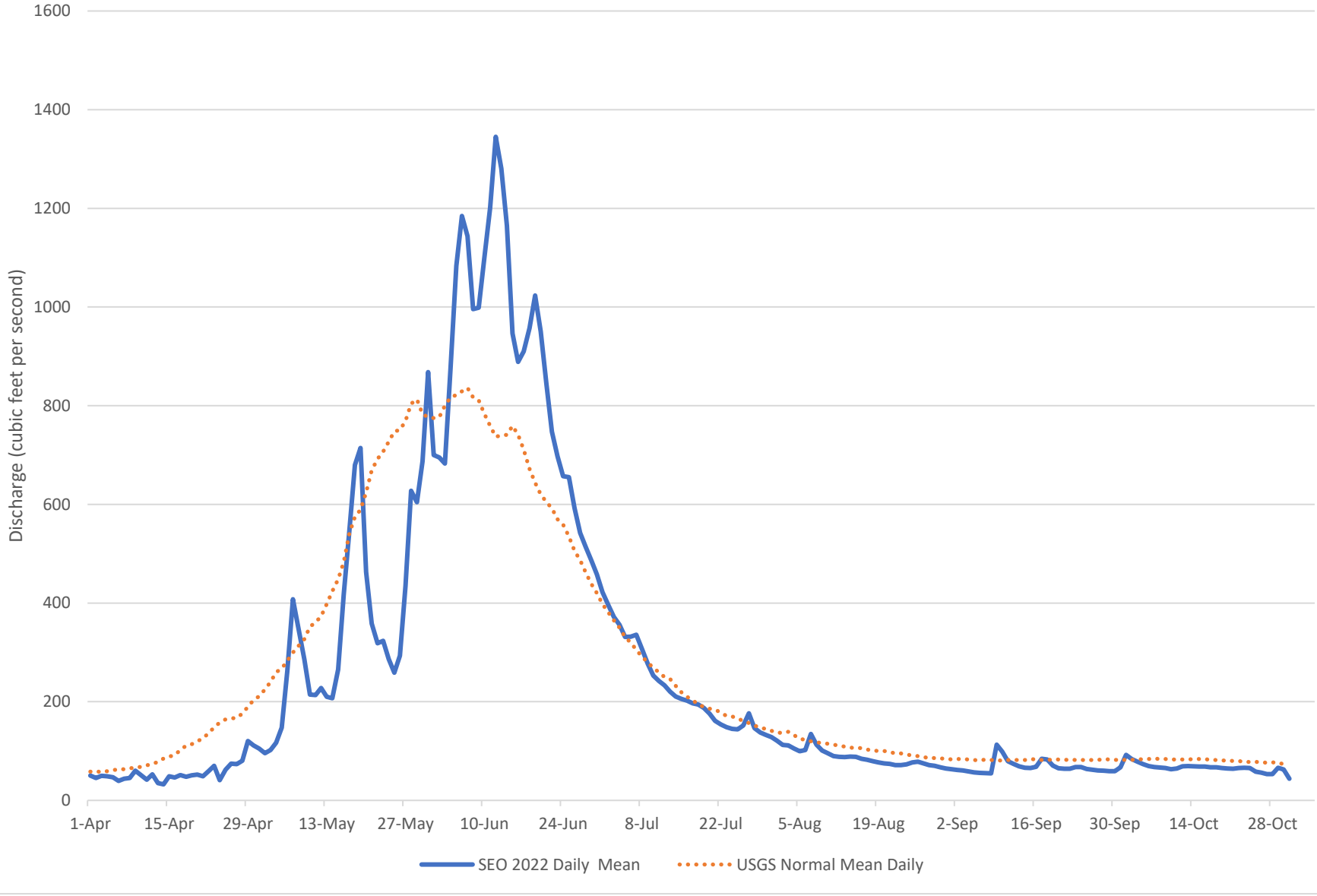


Figure C-11. 2022 Average Daily Air Temperature and Normal Average Daily Air Temperature from the National Weather Service at the Sheridan County Airport

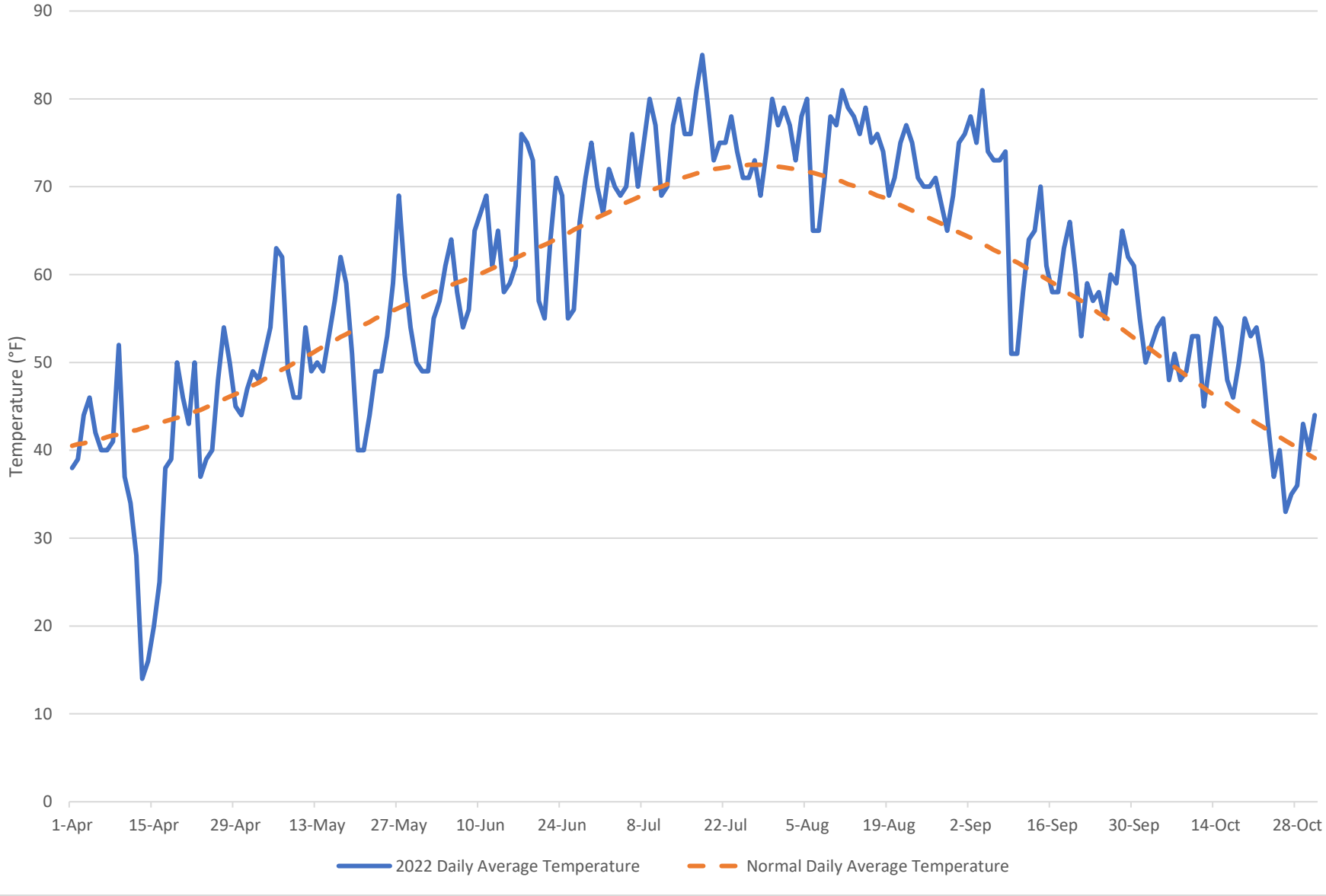
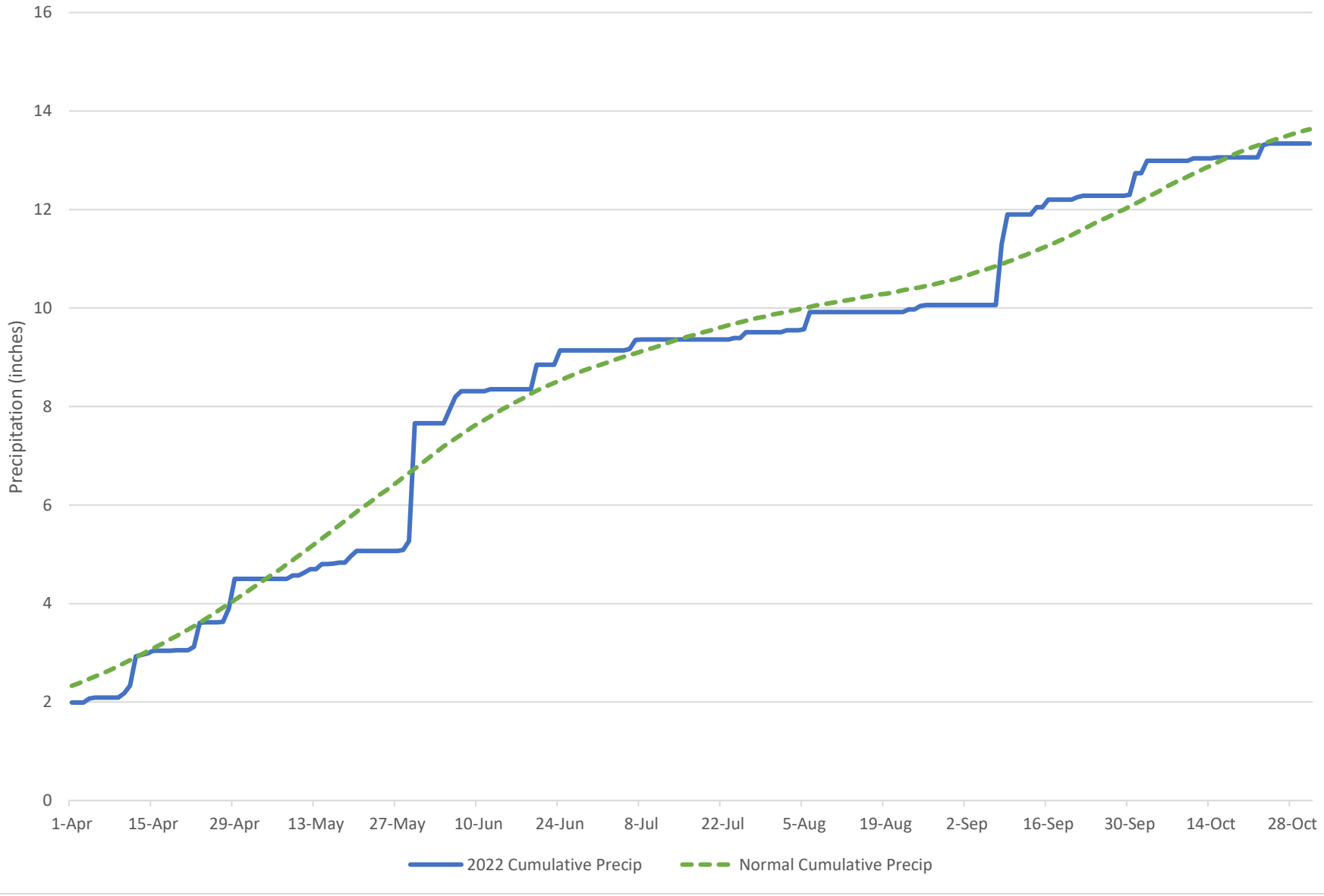


Figure C-12. 2022 Average Daily Precipitation and Normal Average Daily Precipitation from the National Weather Service at Sheridan County Airport



APPENDIX D

2022 TONGUE RIVER WATERSHED
BENTHIC MACROINVERTEBRATE DATA

APPENDIX TABLE D-1. 2022 MACROINVERTEBRATE DATA COLLECTED AT TR09

Tongue R. Canyon, u/s USGS gauge, TR09 (formerly TRU), September 19, 2022.
WY: Sheridan County Conservation District. WY DEQ protocols.
Riffle habitat, composite 8 Surber, 8 square feet total area, 500 micron.
Abundances= full sample and 1 m2 basis. ABA, Inc.

IDENTIFICATION CODE	Not Listed
CORRECTION FACTOR	1.875

Taxon	Abundance	%
Polycelis	3	0.19
Nemata	3	0.19
Pisidium	5	0.38
Trombidiformes	3	0.19
TOTAL: NON INSECTS	13	0.96
Ameletus	23	1.73
Baetis tricaudatus complex	8	0.58
Diphetor hageni	3	0.19
Drunella doddsii	149	11.32
Drunella grandis	68	5.18
Ephemerella excrucians group	48	3.65
Ephemerella tibialis	18	1.34
Rhithrogena	58	4.41
Neoleptophlebia	5	0.38
TOTAL: EPHEMEROPTERA	378	28.79
Sweltsa	35	2.69
Claassenia sabulosa	5	0.38
Pteronarcella	5	0.38
Pteronarcys californica	25	1.92
TOTAL: PLECOPTERA	71	5.37
Brachycentrus americanus	5	0.38
Brachycentrus occidentalis	63	4.80
Agapetus	28	2.13
Glossosoma	184	14.00
Hydropsyche	71	5.37
Lepidostoma (Neodinarthrum)	25	1.92
Rhyacophila hyalinata group	10	0.77
Oligophlebodes	189	14.39
TOTAL: TRICHOPTERA	575	43.77
Optioservus	131	9.97
Zaitzevia	38	2.89
TOTAL: COLEOPTERA	169	12.86
Atherix	10	0.77
Simulium	3	0.19
Antocha	5	0.38
Hexatoma	3	0.19
TOTAL: DIPTERA	20	1.54
Chironomidae pupae	18	1.34
Cladotanytarsus	10	0.77
Cricotopus	5	0.38
Eukiefferiella	13	0.96
Lopescladius	15	1.15
Micropsectra	20	1.54
Orthocladius	5	0.38
Rheocricotopus	3	0.19
TOTAL: CHIRONOMIDAE	88	6.72
GRAND TOTAL	1314	100.00

APPENDIX TABLE D-2. 2022 MACROINVERTEBRATE DATA COLLECTED AT TR07

Tongue R. u/s County Rd 67, TR07 (formerly TRL), Sept 9, 2022.
WY: Sheridan County Conservation District. WY DEQ protocols.
Riffle habitat, composite 8 Surber, 8 square feet total area, 500 micron.
Abundances= full sample and 1 m2 basis. ABA, Inc.

IDENTIFICATION CODE	Not Listed
CORRECTION FACTOR	3.33

Taxon	Abundance	%
Trepaxonemata	22	0.84
Hyalella	4	0.17
Hygrobates	4	0.17
Sperchon	13	0.50
TOTAL: NON INSECTS	45	1.68
Acentrella	4	0.17
Baetis tricaudatus complex	264	9.92
Fallceon	4	0.17
Iswaeon	40	1.51
Drunella grandis	9	0.34
Ephemera simulans	9	0.34
Maccaffertium	4	0.17
Tricorythodes explicatus	452	16.98
TOTAL: EPHEMEROPTERA	788	29.59
Isoperla	4	0.17
TOTAL: PLECOPTERA	4	0.17
Brachycentrus occidentalis	4	0.17
Glossosoma	4	0.17
Helicopsyche	255	9.58
Cheumatopsyche	717	26.90
Hydropsyche	390	14.63
Ochrotrichia	4	0.17
Oecetis avara group	54	2.02
Marilia	9	0.34
Chimarra	13	0.50
Neureclipsis	4	0.17
TOTAL: TRICOPTERA	1456	54.64
Petrophila	58	2.19
TOTAL: LEPIDOPTERA	58	2.19
Cleptelmis addenda	17	0.64
Dubiraphia	22	0.83
Microcylloepus	22	0.84
Optioservus	18	0.67
Zaitzevia	45	1.69
TOTAL: COLEOPTERA	124	4.67
Simulium	72	2.69
Tipula	4	0.17
TOTAL: DIPTERA	76	2.86
Chironomidae pupae	4	0.17
Cricotopus bicinctus group	9	0.34
Cricotopus trifascia group	18	0.67
Eukiefferiella	9	0.34
Microtendipes	9	0.34
Rheocricotopus	27	1.01
Thienemanniella	4	0.17
Thienemannimyia group	4	0.17
Tvetenia vitracies group	27	1.01
TOTAL: CHIRONOMIDAE	112	4.20
GRAND TOTAL	2664	100.00

APPENDIX TABLE D-3. 2022 MACROINVERTEBRATE DATA COLLECTED AT TR05

Tongue R. u/s Acme Road (at Kleenburn Park), TR05, September 14, 2022.
WY: Sheridan County Conservation District. WY DEQ protocols.
Riffle habitat, composite 8 Surber, 8 square feet total area, 500 micron.
Abundances= full sample and 1 m2 basis. ABA, Inc.

IDENTIFICATION CODE	Not Listed
CORRECTION FACTOR	3.75

Taxon	Abundance	%
Trepaxonemata	20	0.76
Naididae (Tubificinae) without cap	10	0.38
Physella	5	0.19
Pisidium	5	0.19
Sperchon	10	0.38
TOTAL: NON INSECTS	50	1.89
Ophiogomphus	5	0.19
Argia	5	0.19
TOTAL: ODONATA	10	0.38
Acentrella insignificans complex	76	2.84
Baetis tricaudatus complex	10	0.38
Fallceon	76	2.84
Iswaeon	20	0.76
Ephemera simulans	136	5.10
Maccaffertium	76	2.84
Tricorythodes explicatus	414	15.50
Neochoroterpes	5	0.19
TOTAL: EPHEMEROPTERA	812	30.44
Brachycentrus occidentalis	10	0.38
Helicopsyche	45	1.70
Arctopsyche	0	0.00
Cheumatopsyche	741	27.79
Hydropsyche	499	18.72
Nectopsyche	20	0.76
Oecetis avara group	30	1.13
Marilia	86	3.21
Chimarra	91	3.40
TOTAL: TRICOPTERA	1523	57.09
Petrophila	20	0.76
TOTAL: LEPIDOPTERA	20	0.76
Dubiraphia	50	1.89
Microcylloepus	35	1.32
Stenelmis	40	1.51
Zaitzevia	40	1.51
TOTAL: COEOPTERA	166	6.24
Simulium	45	1.70
TOTAL: DIPTERA	45	1.70
Cricotopus trifascia group	5	0.19
Eukiefferiella	5	0.19
Pentaneura	10	0.38
Rheocricotopus	5	0.19
Rheotanytarsus	5	0.19
Thienemannimyia group	10	0.38
TOTAL: CHIRONOMIDAE	40	1.51
GRAND TOTAL	2668	100.00

APPENDIX TABLE D-4. 2022 MACROINVERTEBRATE DATA COLLECTED AT TR05

Tongue R. u/s Acme Road (at Kleenburn Park), TR05 Dup. 2, September 14, 2022.
WY: Sheridan County Conservation District. WY DEQ protocols.
Riffle habitat, composite 8 Surber, 8 square feet total area, 500 micron.
Abundances= full sample and 1 m2 basis. ABA, Inc.

IDENTIFICATION CODE	Not Listed
CORRECTION FACTOR	4.29

Taxon	Abundance	%
Trepaxonemata	23	0.71
Naididae (Tubificinae) without cap	23	0.71
Physella	6	0.18
Pisidium	6	0.18
Hyalella	6	0.18
Sperchon	12	0.36
TOTAL: NON INSECTS	75	2.31
Acentrella insignificans complex	110	3.38
Baetis tricaudatus complex	6	0.18
Fallceon	162	4.98
Iswaeon	87	2.67
Ephemera simulans	58	1.78
Maccaffertium	196	6.05
Rhithrogena	6	0.18
Tricorythodes explicatus	877	27.04
TOTAL: EPHEMEROPTERA	1500	46.26
Helicopsyche	87	2.67
Cheumatopsyche	716	22.08
Hydropsyche	312	9.61
Nectopsyche	23	0.71
Oecetis avara group	52	1.60
Marilia	46	1.42
Chimarra	92	2.85
TOTAL: TRICHOPTERA	1328	40.94
Petrophila	58	1.78
TOTAL: LEPIDOPTERA	58	1.78
Dubiraphia	17	0.53
Microcylloepus	58	1.78
Stenelmis	58	1.78
Zaitzevia	12	0.36
TOTAL: COLEOPTERA	144	4.45
Simulium	75	2.31
Dicranota	6	0.18
TOTAL: DIPTERA	81	2.49
Cricotopus trifascia group	6	0.18
Epoicocladius	6	0.18
Eukiefferiella	6	0.18
Rheocricotopus	6	0.18
Rheotanytarsus	23	0.71
Thienemanniella	6	0.18
Tvetenia vitracies group	6	0.18
TOTAL: CHIRONOMIDAE	58	1.78
GRAND TOTAL	3243	100.00

APPENDIX TABLE D-5. 2022 MACROINVERTEBRATE DATA COLLECTED AT TR03

Tongue R. u/s Decker Highway, TR03, Sept 14, 2022.
WY: Sheridan County Conservation District. WY DEQ protocols.
Riffle habitat, composite 8 Surber, 8 square feet total area, 500 micron.
Abundances= full sample and 1 m2 basis. ABA, Inc.

IDENTIFICATION CODE	Not Listed
CORRECTION FACTOR	3.75

Taxon	Abundance	%
Trepaxonemata	20	0.63
Nais variabilis	5	0.16
Physella	61	1.89
Pisidium	5	0.16
Orconectes	1	0.04
TOTAL: NON INSECTS	92	2.88
Acentrella insignificans complex	76	2.36
Baetis tricaudatus complex	10	0.31
Fallceon	837	26.13
Iswaeon	35	1.10
Ephemera simulans	20	0.63
Heptageniidae	5	0.16
Maccaffertium	358	11.18
Tricorythodes explicatus	358	11.18
Neochoroterpes	625	19.52
TOTAL: EPHEMEROPTERA	2325	72.57
Helicopsyche	40	1.26
Cheumatopsyche	25	0.79
Hydropsyche	45	1.42
Hydroptila	15	0.47
Marilia	50	1.57
Chimarra	5	0.16
TOTAL: TRICHOPTERA	181	5.66
Petrophila	25	0.79
TOTAL: LEPIDOPTERA	25	0.79
Ambrysus	5	0.16
TOTAL: HEMIPTERA	5	0.16
Simulium	35	1.10
TOTAL: DIPTERA	35	1.10
Chironomidae pupae	50	1.57
Cricotopus	277	8.66
Cricotopus bicinctus group	55	1.73
Cricotopus trifascia group	61	1.89
Eukiefferiella	5	0.16
Orthocladius complex	5	0.16
Parametriocnemus	5	0.16
Pentaneura	5	0.16
Polypedilum	25	0.79
Rheotanytarsus	10	0.31
Thienemanniella	40	1.26
TOTAL: CHIRONOMIDAE	540	16.84
GRAND TOTAL	3204	100.00

APPENDIX TABLE D-6. 2022 MACROINVERTEBRATE DATA COLLECTED AT TR01

Tongue R. u/s Montana Border, TR01, Sept 13, 2022.
WY: Sheridan County Conservation District. WY DEQ protocols.
Riffle habitat, composite 8 Surber, 8 square feet total area, 500 micron.
Abundances= full sample and 1 m2 basis. ABA, Inc.

IDENTIFICATION CODE	Not Listed
CORRECTION FACTOR	3.00

Taxon	Abundance	%
Naididae (Tubificinae) without cap	8	0.36
Erpobdellidae	1	0.06
Physella	12	0.54
Sphaerium	4	0.18
Hyalella	161	7.25
TOTAL: NON INSECTS	187	8.40
Anafroptilum	8	0.36
Baetis tricaudatus complex	8	0.36
Fallceon	16	0.73
Iswaeon	28	1.27
Ephemera simulans	8	0.36
Maccaffertium	16	0.73
Tricorythodes explicatus	141	6.35
Choroterpes	8	0.36
TOTAL: EPHEMEROPTERA	234	10.52
Ophiogomphus	1	0.06
Argia	4	0.18
TOTAL: ODONATA	5	0.24
Sialis	8	0.36
TOTAL: MEGALOPTERA	8	0.36
Helicopsyche	141	6.35
Cheumatopsyche	311	13.96
Hydropsyche	186	8.36
Hydroptila	56	2.52
Oecetis avara group	32	1.45
Chimarra	8	0.36
TOTAL: TRICHOPTERA	734	33.00
Petrophila	169	7.62
TOTAL: LEPIDOPTERA	169	7.62
Dubiraphia	504	22.65
Microcylloepus	125	5.62
Stenelmis	64	2.88
TOTAL: COLEOPTERA	693	31.15
Ceratopogoninae	8	0.36
Simulium	8	0.36
Dicranota	12	0.54
TOTAL: DIPTERA	28	1.27
Chironomidae pupae	32	1.45
Ablabesmyia	4	0.18
Cricotopus	12	0.54
Cricotopus bicinctus group	12	0.54
Cricotopus trifascia group	4	0.18
Nanocladius	16	0.73
Paralauterborniella	4	0.18
Paraphaenocladius	4	0.18
Pentaneura	32	1.45
Polypedilum	4	0.18
Rheocricotopus	4	0.18
Rheotanytarsus	16	0.73
Tanytarsus	20	0.91
TOTAL: CHIRONOMIDAE	165	7.44
GRAND TOTAL	2225	100.00

APPENDIX TABLE D-7. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR09 (FORMERLY KNOWN AS TRU - UPPER CANYON STATION); 1993-2022

METRIC	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon
	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	USGS	WDEQ	WDEQ	WDEQ
	1993	1994	1995	1996	1997	1998	1999	1999	2000	2001 D.1	2001 D.2
No. Oligochaete Taxa	1	1	0	0	0	0	0	1	0	0	0
% Oligochaete Density	0.16	0.08	0	0	0	0	0	1.37	0	0	0
% Turbellaria Density	0	0	0.14	0	0	0	0	0	0	0	0
% C.Nostococladius Density	0	0	0	0	0	0	0	0	0	0.14	0.29
Density (No./ m2)	1001	3024	4679	2656	6376	4729	3637	4511	281	9725	4977
EPT Density (No./ m2)	819	2335	3652	2379	6030	4447	3120	2768	204	6421	3832
Total Taxa	33	48	41	27	26	31	27	43	24	44	33
No. EPT Taxa	23	26	22	17	20	20	17	23	15	25	21
HBI	1.89	3.20	3.65	2.09	2.38	2.54	2.23	2.92	4.40	4.40	4.45
Brillouin Diversity	2.51	2.67	2.39	2.46	2.29	2.55	2.33	2.94	2.44	2.78	2.68
No. Non-Insect Taxa	1	3	2	1	1	2	1	2	1	2	1
% Non-Insect Density	0.16	0.36	1.54	0.19	0.18	0.51	0.89	1.70	0.96	3.32	1.62
No. Odonata Taxa	0	0	0	0	0	0	0	0	0	0	0
% Odonata Density	0	0	0	0	0	0	0	0	0	0	0
No. Ephemeroptera Taxa	6	7	8	8	7	7	5	8	6	9	7
% Ephemeroptera Density	43.14	45.16	61.27	57.88	47.01	45.05	38.55	36.17	33.65	30.17	30.96
No. Plecoptera Taxa	10	10	8	5	7	7	7	5	6	9	6
% Plecoptera Density	13.25	8.17	4.8	7.03	9.93	15	8.18	3.12	6.72	10.52	7.52
No. Hemiptera Taxa	0	0	0	0	0	0	0	0	0	0	0
% Hemiptera Density	0	0	0	0	0	0	0	0	0	0	0
No. Megaloptera Taxa	0	0	0	0	0	0	0	0	0	0	0
% Megaloptera Density	0	0	0	0	0	0	0	0	0	0	0
No. Trichoptera Taxa	7	9	6	4	6	6	5	10	3	7	8
% Trichoptera Density	25.51	23.89	11.99	24.67	37.61	33.95	39.09	22.05	32.21	25.46	38.5
No. Lepidoptera Density	0	0	0	0	0	0	0	0	0	0	0
% Lepidoptera Density	0	0	0	0	0	0	0	0	0	0	0
No.Coleoptera Taxa	2	3	3	2	1	3	3	5	3	4	3
% Coleoptera Density	13.25	9.64	9.94	6.64	3.44	2.9	9.77	16.75	15.86	26.69	19.32
No. Misc. Diptera Taxa	5	5	6	3	3	3	4	4	3	7	6
% Misc. Diptera Density	3.38	2.97	3.7	1.9	1.62	1.36	2.49	7.96	9.14	1.81	1.32
No. Chironomidae Taxa	2	11	8	4	1	3	2	9	2	6	2
% Chironomidae Density	1.29	9.87	6.81	1.71	0.18	1.19	1.07	12.21	1.44	2.08	0.73
No. Predator Taxa	12	12	8	4	7	6	9	8	6	13	8
% Predator Density	6.93	6.44	3.91	6.08	5.59	5.45	7.13	4.66	9.13	9.13	5.02
No. Parasite Taxa	0	0	1	1	1	2	1	1	1	1	1
% Parasite Density	0	0	1.4	0.19	0.18	0.51	0.89	0.33	0.96	2.77	1.62
No. Collector Gatherer Taxa	10	18	18	12	8	10	10	18	7	13	7
% Collector Gatherer Density	33.92	50.74	64.78	45.36	40.32	44.02	31.81	50.14	26.92	23.67	25.21
No. Collector Filterer Taxa	1	2	2	2	1	2	1	2	2	2	3
% Collector Filterer Density	14.22	6.63	7.93	11.77	14.83	13.99	7.82	8.31	18.27	3.60	5.90

APPENDIX TABLE D-7. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR09 (FORMERLY KNOWN AS TRU - UPPER CANYON STATION); 1993-2022 (CON'T)

METRIC	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon
	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	USGS	WDEQ	WDEQ	WDEQ
	1993	1994	1995	1996	1997	1998	1999	1999	2000	2001 D.1	2001 D.2
No. Macrophyte Herbivore Taxa	1	1	1	0	0	0	0	1	0	1	1
% Macrophyte Herbivore Density	0.16	0.08	0.45	0	0	0	0	1.02	0	0.14	1.18
No. Piercer Herbivore Taxa	0	0	0	0	0	1	0	0	1	1	1
% Piercer Herbivore Density	0	0	0	0	0	0.17	0	0	0.96	0.14	0.29
No. Scraper Taxa	3	5	3	3	4	4	3	7	4	6	7
% Scraper Density	36.03	30.35	16.83	32.63	31.83	23.38	47.24	28.65	41.82	51.46	52.94
No. Shredder Taxa	1	3	1	2	2	2	1	1	0	3	2
% Shredder Density	0.16	0.63	0.08	0.57	1.08	1.19	1.6	0.02	0	5.26	4.42
No. Xylophage Taxa	0	0	0	0	0	0	0	0	0	0	0
% Xylophage Density	0	0	0	0	0	0	0	0	0	0	0
No. Omnivore Taxa	4	6	6	2	3	3	2	3	2	2	2
% Omnivore Density	8.24	3.81	3.53	2.85	6.14	10.91	3.55	2.4	1.44	3.6	2.95
No. Unknown Taxa	1	1	1	1	0	1	0	2	1	2	1
% Unknown Density	0.32	1.38	1.14	0.57	0	0.34	0	4.43	0.48	0.28	0.44
Percent 1 Dominant	16.64	24.99	34.90	15.56	20.80	20.99	28.95	16.36	17.79	22.96	18.29
Percent 5 Dominant	66.89	63.96	72.45	66.98	74.51	67.06	70.87	51.24	65.86	57.82	60.03
Percent 10 Dominant	88.71	81.37	86.88	90.14	94.03	87.54	91.48	73.39	86.54	80.37	83.93
Ratio EPT/Chironomidae Density	63	7.83	11.49	52.44	52.98	78.71	80.5	5.02	50.33	31.87	104.40
Ratio Hydropsych./Tot. Trichopter	0.55	0.27	0.65	0.46	0.39	0.41	0.2	0.38	0.57	0.14	0.14
Ratio Baetidae/Tot. Ephemeropter	0.14	0.55	0.57	0.24	0.41	0.47	0.35	0.29	0.17	0.22	0.29
Ratio Scraper/Collector Filterers	2.54	4.58	2.12	2.77	2.15	1.67	6.05	3.45	2.29	14.31	8.97
Ratio Scraper/Scrap.+Coll. Filter.	0.72	0.82	0.68	0.74	0.68	0.63	0.86	0.78	0.70	0.93	0.90
Ratio Shredders/Tot. Density	0.002	0.01	0	0.01	0.01	0.01	0.02	0	0.00	0.05	0.04
BCI	117	84	82	92	129	95	109	83	93	90	100
BCI Predicted	50	50	50	50	50	50	50	50	50	50	50
BCI CTQA	42.79	59.73	61.34	54.56	38.81	52.68	45.81	60.36	53.79	55.43	49.76
BCI CTQD	83	58	58	50.73	40.42	48.14	47.61	64.55	52.09	54.72	50.25
Diversity LOGe	2.56	2.71	2.42	2.48	2.3	2.56	2.35	2.96	2.58	2.79	2.70
Diversity LOG2	3.69	3.91	3.49	3.58	3.32	3.7	3.4	4.27	3.72	4.03	3.89
Evenness	0.73	0.70	0.65	0.75	0.71	0.75	0.71	0.79	0.81	0.74	0.77
Simpson D	0.10	0.11	0.16	0.11	0.13	0.11	0.14	0.08	0.10	0.10	0.09
% Multivoltine	9.02	27.90	34.93	14.85	18.40	20.61	13.90	19.50	11.78	14.35	14.38
% Univoltine	67.81	58.67	51.71	73.96	71.20	64.29	71.72	61.73	68.27	54.04	61.21
% Semivoltine	23.18	13.43	13.36	11.20	10.40	15.10	14.39	18.77	19.95	31.61	24.41

APPENDIX TABLE D-8. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR09 (FORMERLY KNOWN AS TRU - UPPER CANYON STATION); 1993-2022

METRIC	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon
	WDEQ	SCCD	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	SCCD	SCCD	SCCD	SCCD	SCCD
	2002	2003	2003	2004	2007 D.1	2007 D.2	2009	2010	2013	2016 D.1	2016 D.2	2019
No. Oligochaete Taxa	0	1	0	0	0	0	1	1	0	0	1	1
% Oligochaete Density	0	0.38	0	0	0	0	2.51	0.75	0	0	0.19	0.42
% Turbellaria Density	0	0	0	0.35	1.00	0	0	0.19	0	0	1	0.63
% C.Nostococladius Density	0.93	6.00	1.47	0	0.18	0	0	0.19	0	0	0	0
Density (No./ m2)	3327	2995	7317	15252	Not Reported	Not Reported	Not Reported	1132	1049	997	924	639
EPT Density (No./ m2)	2620	1976	6322	13612	Not Reported	Not Reported	Not Reported	825	748	740	630	327
Total Taxa	40	47	33	33	38	31	30	43	34	31	41	51
No. EPT Taxa	24	25	19	20	23	19	17	20	19	16	16	20
HBI	2.16	5.06	1.86	2.44	3.32	3.46	2.62	4.39	2.69	1.98	2.19	3.57
Brillouin Diversity	Not Reported	3.00	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	2.86	Not Reported	Not Reported	Not Reported	Not Reported
No. Non-Insect Taxa	1	3	2	4	2	1	4	5	3	3	6	6
% Non-Insect Density	0.56	1.73	0.55	1.59	0.36	0.20	3.86	4.88	2.12	1.16	3.80	5.05
No. Odonata Taxa	0	0	0	0	0	0	0	0	0	0	0	0
% Odonata Density	0	0	0	0	0	0	0	0	0	0	0	0
No. Ephemeroptera Taxa	9	9	7	7	9	9	6	8	8	9	9	8
% Ephemeroptera Density	21.83	19.99	21.32	19.22	59.93	57.29	48.07	21.17	35.58	17.16	17.84	14.95
No. Plecoptera Taxa	7	6	2	6	6	5	5	3	4	1	2	4
% Plecoptera Density	2.61	2.49	1.10	2.47	4.92	3.99	2.70	1.32	3.85	1.54	0.38	2.74
No. Hemiptera Taxa	0	0	0	0	0	0	0	0	0	0	1	0
% Hemiptera Density	0	0	0	0	0	0	0	0	0	0	0.38	0
No. Megaloptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0
% Megaloptera Density	0	0	0	0	0	0	0	0	0	0	0	0
No. Trichoptera Taxa	8	10	10	7	8	5	8	9	7	6	5	8
% Trichoptera Density	54.29	43.45	63.97	687.55	21.13	27.74	27.61	50.39	31.92	55.52	49.91	33.47
No. Lepidoptera Density	0	0	0	0	0	0	0	0	0	0	0	0
% Lepidoptera Density	0	0	0	0	0	0	0	0	0	0	0	0
No.Coleoptera Taxa	5	3	3	3	2	2	2	3	3	3	3	2
% Coleoptera Density	16.04	15.19	4.41	7.76	5.28	4.59	10.04	8.05	11.73	19.66	16.51	6.11
No. Misc. Diptera Taxa	3	6	6	3	5	6	6	4	4	3	5	3
% Misc. Diptera Density	1.87	5.76	4.78	0.53	3.1	3.79	7.72	3.75	6.88	1.57	3.23	10.05
No. Chironomidae Taxa	8	10	3	3	6	3	3	11	5	6	10	20
% Chironomidae Density	2.8	11.35	3.86	0.88	4.37	2.4	2.7	10.49	7.88	3.47	7.97	35.79
No. Predator Taxa	10	10	6	8	7	Not Reported	4	6	9	5	10	11
% Predator Density	4.1	4.80	1.65	2.82	3.28	Not Reported	3.86	3.95	18.85	14.21	17.65	7.79
No. Parasite Taxa	0	2	0	1	Not Reported	Not Reported	Not Reported	2	2	3	2	3
% Parasite Density	0	1.35	0	0.53	Not Reported	Not Reported	Not Reported	3.75	1.92	1.16	1.14	0.84
No. Collector Gatherer Taxa	18	16	11	12	14	Not Reported	12	19	12	13	16	22
% Collector Gatherer Density	22.01	28.06	21.14	19.40	62.30	64.70	50.97	29.22	17.31	23.52	27.32	25.05
No. Collector Filterer Taxa	2	2	2	1	3	Not Reported	3	3	2	2	4	5
% Collector Filterer Density	4.85	13.65	7.35	4.59	6.74	Not Reported	11.2	6	16.92	3.085	4.175	11.58

APPENDIX TABLE D-8. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR09 (FORMERLY KNOWN AS TRU - UPPER CANYON STATION); 1993-2022 (CON'T)

METRIC	Tongue R. TR09 Canyon WDEQ 2002	Tongue R. TR09 Canyon SCCD 2003	Tongue R. TR09 Canyon WDEQ 2003	Tongue R. TR09 Canyon WDEQ 2004	Tongue R. TR09 Canyon WDEQ 2007 D.1	Tongue R. TR09 Canyon WDEQ 2007 D.2	Tongue R. TR09 Canyon WDEQ 2009	Tongue R. TR09 Canyon SCCD 2010	Tongue R. TR09 Canyon SCCD 2013	Tongue R. TR09 Canyon SCCD 2016 D.1	Tongue R. TR09 Canyon SCCD 2016 D.2	Tongue R. TR09 Canyon SCCD 2019
No. Macrophyte Herbivore Taxa	1	1	2	0	1	0	0	0	0	1	1	1
% Macrophyte Herbivore Density	0.93	0.19	1.65	0	0.18	0	0	0	0	0.96	0.38	13.26
No. Piercer Herbivore Taxa	0	1	0	0	Not Reported	Not Reported	Not Reported	1	0	0	1	0
% Piercer Herbivore Density	0	0.19	0	0	Not Reported	Not Reported	Not Reported	0.19	0	0	0.38	0
No. Scraper Taxa	5	8	6	5	4	4	5	5	6	6	7	8
% Scraper Density	63.06	47.50	63.79	69.31	23.86	22.71	29.15	40.44	34.62	45.31	41.37	30.32
No. Shredder Taxa	1	1	2	1	2	Not Reported	3	2	3	0	0	1
% Shredder Density	3.54	1.15	2.76	2.47	0.81	Not Reported	1.93	3.94	8.27	0	0	1.68
No. Xylophage Taxa	Not Reported	0	Not Reported	0	Not Reported	Not Reported	Not Reported	0	Not Reported	Not Reported	Not Reported	Not Reported
% Xylophage Density	Not Reported	0.00	Not Reported	0	Not Reported	Not Reported	Not Reported	0	Not Reported	Not Reported	Not Reported	Not Reported
No. Omnivore Taxa	2	4	3	3	Not Reported	Not Reported	Not Reported	4	1	2	1	1
% Omnivore Density	0.75	1.92	1.29	0.53	Not Reported	Not Reported	Not Reported	11.81	2.12	11.76	7.59	9.47
No. Unknown Taxa	2	2	1	1	Not Reported	Not Reported	Not Reported	1	0	0	0	0
% Unknown Density	0.75	1.15	0.37	0.18	Not Reported	Not Reported	Not Reported	0.75	0	0	0	0
Percent 1 Dominant	31.72	20.77	52.94	56.79	31.15	28.54	16.41	21.72	16.54	22.56	18.79	13.26
Percent 5 Dominant	70.52	52.89	75.18	82.36	46.99	78.84	61.00	54.87	61.15	76.54	68.12	48.21
Percent 10 Dominant	86.38	70.38	89.52	93.65	56.65	89.22	82.43	73.61	75.19	89.65	85.01	67.58
Ratio EPT/Chironomidae Density	28.13	5.81	22.42	101.58	19.67	14.39	29.00	6.95	9.01	6.61	3.69	1.43
Ratio Hydropsych./Tot. Trichopter	0.08	0.24	0.06	0.07	0.25	0.10	0.40	0.11	0.476	0.05	0.03	0.16
Ratio Baetidae/Tot. Ephemeropter	0.36	0.23	0.25	0.41	0.53	0.51	0.29	0.15	0.075	0.012	0.012	0.04
Ratio Scraper/Collector Filterers	13.00	3.48	8.68	15.12	Not Reported	Not Reported	Not Reported	6.75	2.04	14.58	9.79	2.62
Ratio Scraper/Scrap.+Coll. Filter.	0.93	0.78	0.90	0.94	Not Reported	Not Reported	Not Reported	0.87	0.67	0.94	0.91	0.73
Ratio Shredders/Tot. Density	Not Reported	0.01	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	0.04	0.005	0.00	0.00	0.017
BCI	73	79	90	98	82	Not Reported	80	75	82	78	66	67
BCI Predicted	50	50	50	50	50	50	50	50	50	50	50	50
BCI CTQA	68.59	63.64	55.83	51.00	60.66	No Report	62.61	67.02	60.71	64.48	75.15	74.96
BCI CTQD	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	62.31	57.72	57.16	68.27	69.88
Diversity LOGe	3.61	3.04	2.91	1.81	2.29	Not Reported	2.74	2.94	2.85	2.39	2.63	3.19
Diversity LOG2	2.51	4.39	2.02	2.60	3.31	Not Reported	3.95	4.24	4.11	3.45	3.8	4.6
Evenness	0.06	0.79	0.06	0.07	Not Reported	Not Reported	Not Reported	0.78	0.81	0.7	0.71	0.81
Simpson D	0.15	0.08	0.29	0.34	Not Reported	Not Reported	Not Reported	0.09	Not Reported	Not Reported	Not Reported	Not Reported
% Multivoltine	11.19	19.42	9.38	Not Reported	Not Reported	Not Reported	Not Reported	15.78	21.54	29.11	31.5	40.00
% Univoltine	71.08	60.39	84.74	Not Reported	Not Reported	Not Reported	Not Reported	66.43	59.04	48.78	49.15	44.21
% Semivoltine	17.72	20.19	5.88	Not Reported	Not Reported	Not Reported	Not Reported	17.79	19.42	22.11	19.35	15.79

APPENDIX TABLE D-9. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR09 (FORMERLY KNOWN AS TRU - UPPER CANYON STATION), AND TONGUE RIVER STATION TR07; 1996-2022

METRIC	Tongue R. @	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
	TR09 Canyon	TR07	TR07	TR07	TR07	TR07	TR07	TR07	TR07	TR07	TR07	TR07
	SCCD	WDEQ	WDEQ	WDEQ	SCCD	SCCD	SCCD	SCCD	SCCD	SCCD	SCCD	SCCD
	2022	1996	1997	1998	1999	2003 D. 1	2003 D. 2	2004	2006	2010	2013	2016
No. Oligochaete Taxa	0	3	4	0	0	4	4	1	7	3	3	2
% Oligochaete Density	0	3.65	1.42	0	0	3.08	1.41	1.44	2.28	0.54	4.12	1.81
% Turbellaria Density	0.19	0.58	1.06	0	0.37	3.42	4.77	4.87	2.15	0.71	3.44	1.63
% C.Nostococladius Density	0	0	0	0	0	0	0	0	0	2.49	0	0
Density (No./ m2)	1314	41965	18304	17529	22072	18852	22839	25178	4606	1742	2938	1586
EPT Density (No./ m2)	1024	33895	16303	14140	18037	12687	15011	15387	2359	1076	2123	1151
Total Taxa	38	37	37	36	40	39	35	39	52	37	43	48
No. EPT Taxa	21	19	20	19	21	15	12	12	18	11	13	20
HBI	2.03	3.88	3.33	4.24	3.79	6.39	6.48	6.13	6.62	6.70	6.38	5.97
Brillouin Diversity	Not Reported	2.31	2.34	1.94	2.36	2.82	2.75	Not Reported	2.97	2.29	Not Reported	Not Reported
No. Non-Insect Taxa	4	4	5	1	2	8	8	4	13	6	10	7
% Non-Insect Density	0.96	4.23	2.48	0.37	0.74	9.58	6.72	16.88	11.07	3.92	11.25	9.07
No. Odonata Taxa	0	0	0	0	0	0	0	0	0	0	0	0
% Odonata Density	0	0	0	0	0	0	0	0	0	0	0	0
No. Ephemeroptera Taxa	9	7	7	7	9	5	5	4	8	5	6	10
% Ephemeroptera Density	28.79	26.53	39.33	13.99	45.71	27.4	23.31	14.85	32.81	40.05	31.93	38.66
No. Plecoptera Taxa	4	4	3	4	5	0	0	0	0	1	0	1
% Plecoptera Density	5.37	1.72	1.06	1.46	1.28	0	0	0	0	0.18	0	2.88
No. Hemiptera Taxa	0	0	0	0	0	1	0	0	0	0	0	1
% Hemiptera Density	0	0	0	0	0	0.17	0	0	0	0	0	4.719
No. Megaloptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0
% Megaloptera Density	0	0	0	0	0	0	0	0	0	0	0	0
No. Trichoptera Taxa	8	8	10	8	7	10	7	8	10	5	7	9
% Trichoptera Density	43.76	52.49	48.69	65.18	34.73	39.9	42.4	46.26	18.44	21.53	40.34	33.76
No. Lepidoptera Density	0	1	1	1	1	1	1	1	1	1	1	1
% Lepidoptera Density	0.00	0.19	0.71	0.55	0.55	0.68	0.71	0.32	0.18	0.53	0.52	4.90
No.Coleoptera Taxa	2	3	3	4	3	6	6	7	5	5	5	4
% Coleoptera Density	12.86	7.11	4.58	5.52	4.21	17.81	20.31	9.08	18.78	6.24	2.06	2.54
No. Misc. Diptera Taxa	11	2	1	4	1	3	2	4	4	3	3	6
% Misc. Diptera Density	8.25	0.77	0.18	4.22	2.93	1.54	0.71	0.96	4.04	14.77	0.49	2.36
No. Chironomidae Taxa	7	8	7	7	12	5	6	9	11	11	11	9
% Chironomidae Density	6.72	6.91	3.01	8.65	9.89	2.9	5.83	11.65	14.75	12.81	9.61	3.81
No. Predator Taxa	7	5	3	6	6	6	2	5	5	2	8	6
% Predator Density	10.17	1.14	1.06	1.64	2.19	1.02	0.36	1.92	1.24	0.89	8.16	3.99
No. Parasite Taxa	2	0	0	1	1	2	0	0	2	2	2	1
% Parasite Density	0.38	0	0	0.37	0.37	2.91	0	0	3.86	2.67	3.26	3.45
No. Collector Gatherer Taxa	15	16	15	13	17	13	16	15	25	17	21	25
% Collector Gatherer Density	18.81	35.56	42.52	21.72	53.42	35.44	33.2	33.01	53.54	48.07	45.49	46.82
No. Collector Filterer Taxa	4	4	4	3	3	4	5	5	5	3	6	5
% Collector Filterer Density	6.72	47.12	36.34	64.64	34.74	25.35	20.85	19.66	17.89	31.68	41.2	29.4

APPENDIX TABLE D-9. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR09 (FORMERLY KNOWN AS TRU - UPPER CANYON STATION), AND TONGUE RIVER STATION TR007; 1996-2022

METRIC	Tongue R. @ TR09 Canyon SCCD 2022	Tongue R. TR07 WDEQ 1996	Tongue R. TR07 WDEQ 1997	Tongue R. TR07 WDEQ 1998	Tongue R. TR07 SCCD 1999	Tongue R. TR07 SCCD 2003 D.1	Tongue R. TR07 SCCD 2003 D.2	Tongue R. TR07 SCCD 2004	Tongue R. TR07 SCCD 2006	Tongue R. TR07 SCCD 2010	Tongue R. TR07 SCCD 2013	Tongue R. TR07 SCCD 2016
No. Macrophyte Herbivore Taxa	0	0	0	0	0	0	0	0	0	0	1	1
% Macrophyte Herbivore Density	0.00	0	0	0	0	0	0	0	0	0	0.34	0.73
No. Piercer Herbivore Taxa	0	0	0	0	0	1	1	0	1	2	1	2
% Piercer Herbivore Density	0.00	0	0	0	0	0.17	0.35	0	0.35	2.67	0.34	4.9
No. Scraper Taxa	7	6	8	7	7	7	6	5	7	3	2	5
% Scraper Density	56.43	10.38	9.35	7.35	6.21	25.17	35.35	35.58	18.26	5.16	0.69	7.62
No. Shredder Taxa	0	1	2	1	1	0	0	3	1	1	2	2
% Shredder Density	0.00	0.38	8.12	0.55	0.18	0	0	0.32	0.18	3.02	0.52	0.73
No. Xylophage Taxa	Not Reported	0	0	0	0	0	0	0	0	0	Not Reported	Not Reported
% Xylophage Density	Not Reported	0	0	0	0	0	0	0	0	0	Not Reported	Not Reported
No. Omnivore Taxa	4	4	4	4	4	5	4	4	5	5	0	1
% Omnivore Density	7.49	4.99	2.12	2.57	2.75	9.41	9.36	4.49	4.57	4.80	0	2.36
No. Unknown Taxa	0	1	1	1	1	1	1	1	1	2	0	0
% Unknown Density	0.00	0.38	0.53	1.1	0.18	0.51	0.53	4.91	0.18	1.07	0	0
Percent 1 Dominant	14.4	43.65	35.1	58.93	30.71	14.04	15.55	23.08	24.04	37.9	29.35	32.67
Percent 5 Dominant	55.09	68.65	75.31	75.13	74.41	56	58.65	56.73	55.09	72.96	66.26	70.05
Percent 10 Dominant	76.01	80.77	87.3	85.25	84.66	81	83.73	78.63	70.52	85.24	81.54	80.94
Ratio EPT/Chironomidae Density	11.60	11.67	29.71	9.32	8.28	23.12	11.27	5.25	3.48	4.82	7.53	19.18
Ratio Hydropsych./Tot. Trichopter	0.12	0.87	0.74	0.94	0.92	0.5	0.41	0.36	0.58	0.83	0.92	0.82
Ratio Baetidae/Tot. Ephemeropter	0.027	0.14	0.24	0.49	0.29	0.71	0.67	0.67	0.21	0.96	0.64	0.11
Ratio Scraper/Collector Filterers	8.400	0.22	0.26	0.11	0.18	0.99	1.69	1.81	1.02	0.16	0.016	0.26
Ratio Scraper/Scrap.+Coll. Filter.	0.893	0.18	0.2	0.1	0.15	0.5	0.63	0.64	0.5	0.14	0.47	0.21
Ratio Shredders/Tot. Density	0.000	0	0.08	0.01	0	0	0	Not Reported	0	0.03	0.08	0.01
BCI	83	71	72	73	71	62	59	59	57	57	57	61
BCI Predicted	50	53	53	53	53	53	53	53	53	53	53	53
BCI CTQA	60.34	74.7	73.76	72.33	74.53	85.54	92.06	89.171	92.6	93.49	93.44	87.29
BCI CTQD	54.82	75.32	71.33	75.08	76.41	86.12	89.93	Not Reported	92.73	94.99	93.17	88.23
Diversity LOGe	2.92	2.31	2.35	1.94	2.37	2.82	2.75	2.61	3.00	2.34	2.63	2.55
Diversity LOG2	4.21	3.33	3.39	2.81	3.42	4.07	3.97	3.77	4.33	3.37	3.80	3.67
Evenness	0.8	0.64	0.65	0.54	0.64	0.77	0.77	0.58	0.76	0.65	0.70	0.66
Simpson D	Not Reported	0.22	0.17	0.36	0.18	0.08	0.09	0.11	0.09	0.19	Not Reported	Not Reported
% Multivoltine	22.26	20.05	19.44	27.21	25.96	28.25	25.44	Not Reported	26.54	46.4	74.5	62.98
% Univoltine	46.07	69.76	74.38	65.05	68.01	53.25	53.71	Not Reported	53.99	47.2	22.32	34.48
% Semivoltine	31.67	10.19	6.17	7.73	6.03	18.49	20.85	Not Reported	19.47	6.41	3.18	2.54

APPENDIX TABLE D-10. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR07, AND TONGUE RIVER STATION TR05; 1995-2022

METRIC	Tongue R.	Tongue R. @	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R. @
	TR07	TR07	TR05	TR05	TR05	TR05	TR05	TR05	TR05	TR05	TR05	TR05
	SCCD	SCCD	WDEQ	WDEQ	WDEQ	SCCD	SCCD	SCCD	SCCD	SCCD	SCCD	SCCD
	2019	2022	1995	1998	2004	2006 D. 1	2006 D. 2	2010	2013	2016	2019	2022 D.1
No. Oligochaete Taxa	2	0	1	4	2	1	2	1	3	4	3	1
% Oligochaete Density	0.34	0	0.59	4.47	5.66	1.43	1.88	0.17	1.18	3.41	0.85	0.38
% Turbellaria Density	0	0.84	1.91	1.30	0.90	2.15	2.92	3.67	0.36	2.73	0.17	0.76
% C.Nostococladius Density	0	**0**	0	0	0	0	0	0	0	0	0	0
Density (No./ m2)	5871	2665	6852	8668	20928	3762	3364	1611	3372	2625	4729	2668
EPT Density (No./ m2)	4741	2248	5510	5698	9980	2046	1944	1009	2242	1165	4317	2335
Total Taxa	34	39	44	50	32	36	38	36	40	56	33	35
No. EPT Taxa	13	19	24	21	14	15	15	16	15	17	17	16
HBI	5.96	6.38	4.77	4.64	6.56	6.59	6.46	7.00	6.31	6.37	6.06	5.98
Brillouin Diversity	Not Reported	Not Reported	2.64	3.09	Not Reported	2.87	2.72	2.68	Not Reported	Not Reported	Not Reported	Not Reported
No. Non-Insect Taxa	4	4	5	8	8	5	7	6	9	9	5	5
% Non-Insect Density	0.86	1.68	3.82	7.81	14.40	6.98	7.03	4.68	3.76	22.70	1.20	1.89
No. Odonata Taxa	0	0	1	1	1	0	0	1	1	0	0	2
% Odonata Density	0	0	0.29	0.19	0.13	0	0	0.83	0.17	0	0	0.38
No. Ephemeroptera Taxa	6	8	12	12	6	7	7	8	7	8	10	8
% Ephemeroptera Density	41.75	29.58	64.36	36.88	7.71	22.36	16.64	23.7	14.87	33.79	60.41	30.43
No. Plecoptera Taxa	0	1	2	2	0	0	0	0	0	0	0	0
% Plecoptera Density	0	0.17	0.3	3.17	0	0	0	0	0	0	0	0
No. Hemiptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0
% Hemiptera Density	0	0	0	0	0	0	0	0	0	0	0	0
No. Megaloptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0
% Megaloptera Density	0	0	0	0	0	0	0	0	0	0	0	0
No. Trichoptera Taxa	7	10	10	7	8	8	8	8	8	9	7	8
% Trichoptera Density	39.00	54.62	15.76	25.69	39.97	32.03	41.15	38.88	51.62	10.58	30.89	57.09
No. Lepidoptera Density	1	1	1	1	0	1	0	1	1	1	1	1
% Lepidoptera Density	1.38	2.19	0.29	2.61	0	0.18	0	0.33	1.54	1.20	0.34	0.76
No.Coleoptera Taxa	5	5	5	3	4	5	5	5	5	4	1	4
% Coleoptera Density	2.41	4.71	11.19	11.74	32.26	24.86	22.48	27.04	14.02	5.97	0.17	6.24
No. Misc. Diptera Taxa	2	10	1	5	1	2	1	1	1	5	1	7
% Misc. Diptera Density	0.74	7.06	0.59	6.9	0.26	3.04	0.34	2.67	8.89	5.46	0.77	3.21
No. Chironomidae Taxa	9	8	7	11	4	8	10	6	8	20	8	6
% Chironomidae Density	6.36	4.20	3.39	5.04	5.27	10.55	12.35	1.83	5.13	20.31	2.56	1.51
No. Predator Taxa	1	5	4	7	3	1	1	2	5	6	2	6
% Predator Density	0.17	3.53	0.88	5.97	2.57	1.43	0.69	1.00	5.30	6.66	0.34	3.03
No. Parasite Taxa	1	2	2	1	1	1	1	1	2	1	1	1
% Parasite Density	0.17	0.67	1.03	0.37	0.39	1.79	0.86	0.17	0.68	4.44	0.17	0.38
No. Collector Gatherer Taxa	20	17	19	25	12	15	18	14	19	33	15	16
% Collector Gatherer Density	48.80	36.97	58.47	47.49	24.81	34.88	29.16	28.89	31.28	67.06	56.48	34.97
No. Collector Filterer Taxa	5	6	3	4	4	5	5	6	6	7	5	6
% Collector Filterer Density	44.85	45.21	10.16	16.94	6.17	22.54	26.40	16.18	36.07	7.85	33.28	51.98

APPENDIX TABLE D-10. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR07, AND TONGUE RIVER STATION TR05; 1995-2022 (CON'T)

METRIC	Tongue R.	Tongue R. @	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R. @
	TR07	TR07	TR05	TR05	TR05	TR05	TR05	TR05	TR05	TR05	TR05	TR05
	SCCD	SCCD	WDEQ	WDEQ	WDEQ	SCCD	SCCD	SCCD	SCCD	SCCD	SCCD	SCCD
	2019	2022	1995	1998	2004	2006 D. 1	2006 D. 2	2010	2013	2016	2019	2022 D.1
No. Macrophyte Herbivore Taxa	1	0	0	0	0	0	0	0	1	0	1	0
% Macrophyte Herbivore Density	0.69	0.00	0	0	0	0	0	0	0.34	0	0.51	0.00
No. Piercer Herbivore Taxa	1	1	2	0	0	1	1	0	1	1	1	0
% Piercer Herbivore Density	0.69	0.17	0.3	0	0	0.36	0.17	0	1.37	0.5119	0.34	0.00
No. Scraper Taxa	3	5	7	7	5	8	7	6	4	4	5	3
% Scraper Density	4.12	12.77	22.08	18.26	58.87	33.45	33.62	47.39	21.54	10.75	7.85	5.29
No. Shredder Taxa	1	2	0	1	0	0	0	1	1	3	2	1
% Shredder Density	0.34	0.50	0	0.19	0	0	0	0.17	1.88	1.20	0.85	3.21
No. Xylophage Taxa	Not Reported	Not Reported	0	0	0	0	0	0	Not Reported	Not Reported	Not Reported	Not Reported
% Xylophage Density	Not Reported	Not Reported	0	0	0	0	0	0	Not Reported	Not Reported	Not Reported	Not Reported
No. Omnivore Taxa	1	1	4	5	4	5	5	5	1	1	1	2
% Omnivore Density	0.17	0.17	5.6	10.81	4.37	5.55	9.09	5.83	1.54	1.536	0.17	1.13
No. Unknown Taxa	0	0	3	0	1	0	0	1	0	0	0	0
% Unknown Density	0.00	0.00	1.47	0	1.41	0	0	0.33	0	0	0.00	0.00
Percent 1 Dominant	21.82	26.89	26.07	20.86	29.56	13.95	18.52	20.53	18.29	25.94	20.48	27.79
Percent 5 Dominant	82.47	77.98	66.13	49.92	68.38	57.24	64.15	57.91	59.15	47.27	75.26	70.51
Percent 10 Dominant	91.24	88.07	83.5	67.61	82.78	75.48	79.76	79.61	78.80	62.63	91.47	84.12
Ratio EPT/Chironomidae Density	12.70	20.07	23.74	13.07	9.05	5.15	4.68	34.09	12.96	2.19	35.67	58.38
Ratio Hydropsych./Tot. Trichopter	0.92	0.76	0.61	0.45	0.06	0.17	0.15	0.21	0.398	0.351	0.91	0.81
Ratio Baetidae/Tot. Ephemeropter	0.50	0.398	0.54	0.14	0.13	0.15	0.15	0.46	0.345	0.212	0.64	0.224
Ratio Scraper/Collector Filterers	0.09	0.282	2.17	1.08	9.54	1.48	1.27	2.93	0.597	1.37	0.24	0.102
Ratio Scraper/Scrap.+Coll. Filter.	0.084	0.220	0.68	0.52	0.90	0.60	0.56	0.75	0.374	0.58	0.191	0.092
Ratio Shredders/Tot. Density	0.003	0.005	0	0	0	0	0	0	0.019	0.012	0.008	0.032
BCI	59	64	63	68	61	60	59	65	58	57	62	62
BCI Predicted	53	53	50	53	53	53	53	53	53	53	53	53
BCI CTQA	90.12	83.16	79.98	77.52	87.38	87.61	89.63	81.36	90.55	93.2	86.03	85.47
BCI CTQD	91.34	85.85	79.22	76.54	Not Reported	87.95	88.13	77.87	87.23	93.83	83.89	83.25
Diversity LOGe	2.27	2.41	2.66	3.11	2.38	2.90	2.75	2.73	2.83	3.16	2.39	2.47
Diversity LOG2	3.27	3.48	3.84	4.49	3.43	4.18	3.96	3.94	4.09	4.55	3.45	3.56
Evenness	0.64	0.66	0.70	0.80	0.07	0.81	0.76	0.76	0.77	0.78	0.68	0.69
Simpson D	Not Reported	Not Reported	0.12	0.08	0.17	0.08	0.10	0.10	Not Reported	Not Reported	Not Reported	Not Reported
% Multivoltine	72.68	74.12	34.42	12.10	Not Reported	16.01	16.64	14.44	71.97	78.16	85.49	61.81
% Univoltine	24.57	21.51	52.62	68.34	Not Reported	58.59	60.55	56.59	13.83	16.04	14.16	28.36
% Semivoltine	2.75	4.37	12.96	19.55	Not Reported	25.40	22.81	27.96	14.19	5.80	0.34	9.83

APPENDIX TABLE D-11. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR05, TONGUE RIVER STATION TR03, AND TONGUE RIVER STATION TR01; 1998-2022

METRIC	Tongue R. @ TR05 SCCD 2022 D.2	Tongue R. TR03 WDEQ 1998	Tongue R. TR03 WDEQ 2004	Tongue R. TR03 SCCD 2013	Tongue R. TR03 SCCD 2016	Tongue R. TR03 SCCD 2019 Dup. 1	Tongue R. TR03 SCCD 2019 Dup. 2	Tongue R. TR03 SCCD 2022	Tongue R. TR01 WDEQ 1998 Dup. 1	Tongue R. TR01 WDEQ 1998 Dup. 2	Tongue R. TR01 WDEQ 2003	Tongue R. TR01 WDEQ 2004
No. Oligochaete Taxa	1	3	4	2	2	1	0	1	4	4	2	2
% Oligochaete Density	0.71	4.02	3.16	2.3	0.87	0.38	0	0.16	21.08	4.75	3.93	6.81
% Turbellaria Density	0.71	0	3.33	1.41	1.05	0.19	0.74	0.63	0.35	1.71	0.94	0.24
% C.Nostococladius Density	0	0	0	0	0	0	0	0	0	0	0	0.24
Density (No./ m2)	3243	12047	11500	2835	4616	4199	3627	3204	15306	14851	7182	22515
EPT Density (No./ m2)	2827	9404	2804	1170	2348	3632	3087	2507	7693	9062	Not Reported	11756
Total Taxa	35	39	38	43	37	38	37	33	45	43	33	43
No. EPT Taxa	15	17	12	15	12	14	16	15	19	20	14	14
HBI	6.24	4.62	7.28	6.24	6.52	6.19	6.29	5.63	5.80	5.24	6.29	6.47
Brillouin Diversity	Not Reported	1.89	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	2.69	2.73	Not Reported	Not Reported
No. Non-Insect Taxa	6	6	13	7	8	5	4	5	9	9	7	12
% Non-Insect Density	2.31	4.53	35.09	9.08	8.92	1.03	1.74	2.88	22.85	17.72	7.68	11.35
No. Odonata Taxa	0	0	1	1	1	1	0	0	2	1	0	1
% Odonata Density	0.00	0	0.18	0.18	0.35	0.19	0	0.00	0.53	0.16	0	0.12
No. Ephemeroptera Taxa	8	10	4	8	7	9	10	9	8	10	5	7
% Ephemeroptera Density	46.26	68.53	19.12	29.54	39.34	34.21	29.66	72.57	39.89	48.93	18.54	31.42
No. Plecoptera Taxa	0	1	0	0	0	0	0	0	2	2	0	0
% Plecoptera Density	0	0.67	0	0	0	0	0	0	0.36	0.63	0	0
No. Hemiptera Taxa	0	1	0	1	0	0	0	1	1	0	0	0
% Hemiptera Density	0	0.17	0	0.18	0	0	0	0.16	0.18	0	0	0
No. Megaloptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0
% Megaloptera Density	0	0	0	0	0	0	0	0	0	0	0	0
No. Trichoptera Taxa	7	6	8	7	5	5	6	6	9	8	9	7
% Trichoptera Density	40.93	8.9	5.26	11.74	11.54	52.27	55.43	5.67	10.02	11.52	41.2	20.79
No. Lepidoptera Density	1	1	0	1	1	1	1	1	0	0	1	1
% Lepidoptera Density	1.78	1.01	0	0.53	0.52	1.15	1.11	0.79	0	0	2.25	0.84
No.Coleoptera Taxa	4	3	4	4	4	3	3	0	4	3	5	3
% Coleoptera Density	4.45	7.71	32.63	33.63	31.29	2.69	2.78	0.00	11.6	9.16	16.48	10.63
No. Misc. Diptera Taxa	9	3	3	2	1	1	2	11	1	3	1	2
% Misc. Diptera Density	4.27	1.35	3.16	2.48	0.35	8.25	4.44	17.95	0.18	0.63	8.43	5.73
No. Chironomidae Taxa	7	8	5	12	10	13	11	10	9	7	6	10
% Chironomidae Density	1.78	7.23	4.56	10.85	7.69	7.69	8.53	16.84	14.43	11.34	5.43	19.12
No. Predator Taxa	3	6	4	6	5	4	4	3	10	7	3	5
% Predator Density	2.49	2.53	3.86	8.9	6.29	1.35	1.48	0.94	3.02	1.89	1.5	1.19
No. Parasite Taxa	1	1	1	0	1	0	1	0	0	1	1	1
% Parasite Density	0.36	0.17	0.35	0	0.87	0	0.56	0.00	0	0.16	0.75	1.55
No. Collector Gatherer Taxa	19	18	11	23	22	23	21	16	23	21	14	17
% Collector Gatherer Density	46.62	77.42	34.91	72.06	80.42	35.17	31.52	78.86	69.25	68.66	29.03	46.95
No. Collector Filterer Taxa	6	2	6	7	6	5	4	6	2	3	5	5
% Collector Filterer Density	37.72	6.54	3.16	11.57	5.94	51.89	55.99	3.94	2.81	4.35	20.41	27.12

APPENDIX TABLE D-11. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR05, TONGUE RIVER STATION TR03, AND TONGUE RIVER STATION TR01; 1998-2022 (CON'T)

METRIC	Tongue R. @ TR05 SCCD 2022 D.2	Tongue R. TR03 WDEQ 1998	Tongue R. TR03 WDEQ 2004	Tongue R. TR03 SCCD 2013	Tongue R. TR03 SCCD 2016	Tongue R. TR03 SCCD 2019 Dup. 1	Tongue R. TR03 SCCD 2019 Dup. 2	Tongue R. TR03 SCCD 2022	Tongue R. TR01 WDEQ 1998 Dup. 1	Tongue R. TR01 WDEQ 1998 Dup. 2	Tongue R. TR01 WDEQ 2003	Tongue R. TR01 WDEQ 2004
No. Macrophyte Herbivore Taxa	0	0	0	1	0	1	1	1	0	0	1	0
% Macrophyte Herbivore Density	0	0	0	0.71	0	1.15	2.97	0.79	0	0	15.73	0
No. Piercer Herbivore Taxa	0	1	0	1	0	1	0	1	1	1	0	0
% Piercer Herbivore Density	0	0.17	0	2.85	0	0.58	0	0.47	3.69	3.11	0	0
No. Scraper Taxa	4	5	7	4	2	3	3	4	5	5	6	8
% Scraper Density	10.68	7.55	55.09	3.74	5.77	9.80	7.05	13.38	10.37	15.07	18.35	8.96
No. Shredder Taxa	1	0	1	1	1	0	1	1	0	0	0	0
% Shredder Density	1.42	0	0.18	0.18	0.70	0	0.19	1.57	0	0	0	0
No. Xylophage Taxa	Not Reported	0	0	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	0	0	Not Reported	0
% Xylophage Density	Not Reported	0	0	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	0	0	Not Reported	0
No. Omnivore Taxa	1	5	2	0	0	1	2	1	3	4	4	3
% Omnivore Density	0.71	2.87	0.53	0	0	0.06	0.26	0.04	1.76	1.57	14.23	2.75
No. Unknown Taxa	0	1	2	0	0	0	0	0	1	1	0	0
% Unknown Density	0.00	2.85	0.35	0	0	0	0	0.00	9.14	5.28	0	0
Percent 1 Dominant	27.05	59.97	24.74	21.89	27.10	32.48	35.04	26.13	27.59	34.16	15.73	22.82
Percent 5 Dominant	69.75	76.73	75.44	58.54	65.38	73.8	75.45	76.66	64.14	58.38	58.05	59.26
Percent 10 Dominant	83.63	86.62	87.54	73.67	80.42	85.14	88.62	86.11	79.95	74.69	76.03	79.81
Ratio EPT/Chironomidae Density	49.51	10.84	5.35	3.80	6.61	11.25	9.98	4.64	3.49	5.38	11	1.46
Ratio Hydropsych./Tot. Trichopter	0.77	0.72	0.133	0.213	0.287	0.97	0.98	0.39	0.28	0.35	0.18	0.351
Ratio Baetidae/Tot. Ephemeropter	0.242	0.08	0.073	0.391	0.2	0.43	0.37	0.412	0.05	0.06	0.14	0.259
Ratio Scraper/Collector Filterers	0.283	1.15	17.44	0.323	0.97	0.19	0.13	3.400	3.69	3.46	0.9	0.33
Ratio Scraper/Scrap.+Coll. Filter.	0.221	0.54	0.946	0.244	0.493	0.159	0.112	0.772	0.79	0.78	0.47	0.248
Ratio Shredders/Tot. Density	0.014	0	0.002	0.002	0.012	0.000	0.002	0.016	0	0	0	0
BCI	62	79	72	71	69	71	75	74	66	69	64	60
BCI Predicted	53	65	65	65	65	65	65	65	55	**55**	**55**	**55**
BCI CTQA	85.03	81.95	90.879	91.49	94.43	91.89	86.67	87.56	83.82	79.36	86.56	91.85
BCI CTQD	82.89	82.56	Not Reported	91.85	92.82	89.74	87.76	85.79	85.33	82.35	Not Reported	Not Reported
Diversity LOGe	2.49	1.90	2.39	2.89	2.59	2.44	2.31	2.41	2.70	2.74	4.67	2.74
Diversity LOG2	3.59	2.75	3.45	4.17	3.73	3.52	3.33	3.48	3.90	3.95	3.24	3.96
Evenness	0.70	0.52	0.07	0.77	0.72	0.67	0.64	0.69	0.71	0.73	0.10	0.05
Simpson D	Not Reported	0.37	0.141	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	0.13	0.14	0.08	0.102
% Multivoltine	76.69	11.43	Not Reported	52.49	56.12	72.26	71.00	74.93	16.7	16.11	25.84	Not Reported
% Univoltine	17.44	80.11	Not Reported	12.10	14.34	22.10	23.54	24.24	70.56	74.26	57.68	Not Reported
% Semivoltine	5.872	8.46	Not Reported	35.41	29.55	5.64	5.45	0.829	12.74	9.63	16.48	Not Reported

APPENDIX TABLE D-12. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR01; 1998-2022

METRIC	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
	TR01 - Dup. 1	TR01 - Dup. 2	TR01	TR01	TR01
	SCCD	SCCD	SCCD	SCCD	SCCD
	2013	2013	2016	2019	2022
No. Oligochaete Taxa	2	2	1	1	1
% Oligochaete Density	0.88	1.83	0.18	0.53	0.36
% Turbellaria Density	1.07	1.00	0	0.18	0.00
% C.Nostococladius Density	0	0	0	0	**0**
Density (No./ m2)	5701	4810	3766	5720	2226
EPT Density (No./ m2)	3268	2018	2058	4217	968
Total Taxa	32	33	31	27	41
No. EPT Taxa	13	12	13	12	14
HBI	5.92	5.96	5.90	5.77	6.29
Brillouin Diversity	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported
No. Non-Insect Taxa	5	7	5	3	5
% Non-Insect Density	2.83	5.37	6.61	1.06	8.40
No. Odonata Taxa	1	0	2	0	2
% Odonata Density	0.02	0	0.71	0.00	0.24
No. Ephemeroptera Taxa	5	6	6	7	8
% Ephemeroptera Density	35.92	27.01	40.54	32.80	10.51
No. Plecoptera Taxa	0	0	0	0	0
% Plecoptera Density	0	0	0	0	0
No. Hemiptera Taxa	0	0	0	0	0
% Hemiptera Density	0	0	0	0	0
No. Megaloptera Taxa	0	0	0	0	1
% Megaloptera Density	0	0	0	0	0.36
No. Trichoptera Taxa	8	6	7	5	6
% Trichoptera Density	21.41	14.93	14.11	40.92	32.99
No. Lepidoptera Density	1	1	1	1	1
% Lepidoptera Density	0.35	0.17	0.89	1.24	7.61
No.Coleoptera Taxa	3	3	3	2	3
% Coleoptera Density	20.00	23.15	21.79	5.64	31.18
No. Misc. Diptera Taxa	2	1	1	2	15
% Misc. Diptera Density	11.50	20.47	0.53	1.89	8.70
No. Chironomidae Taxa	7	9	6	7	12
% Chironomidae Density	7.96	8.89	14.82	8.29	7.43
No. Predator Taxa	7	5	5	2	9
% Predator Density	10.29	10.40	8.93	0.35	4.65
No. Parasite Taxa	1	2	2	1	0
% Parasite Density	0.18	0.34	0.36	0.35	0.00
No. Collector Gatherer Taxa	11	13	13	15	20
% Collector Gatherer Density	56.80	52.68	75.54	45.50	53.11
No. Collector Filterer Taxa	6	7	6	5	7
% Collector Filterer Density	27.60	31.54	11.43	49.91	24.83

APPENDIX TABLE D-12. BENTHIC MACROINVERTEBRATE METRICS AT TONGUE RIVER STATION TR01; 1998-2022 (CON'T)

METRIC	Tongue R. TR01 - Dup. 1 SCCD 2013	Tongue R. TR01 - Dup. 2 SCCD 2013	Tongue R. TR01 SCCD 2016	Tongue R. TR01 SCCD 2019	Tongue R. TR01 SCCD 2022
No. Macrophyte Herbivore Taxa	0	1	0	1	1
% Macrophyte Herbivore Density	0	0.17	0	1.24	0.18
No. Piercer Herbivore Taxa	2	1	0	1	1
% Piercer Herbivore Density	3.18	2.35	0	0.88	2.54
No. Scraper Taxa	3	3	4	2	3
% Scraper Density	1.24	2.18	3.57	1.76	14.68
No. Shredder Taxa	1	1	1	0	0
% Shredder Density	0.35	0.34	0.18	0	0
No. Xylophage Taxa	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported
% Xylophage Density	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported
No. Omnivore Taxa	1	0	0	0	0
% Omnivore Density	0.35	0	0	0	0
No. Unknown Taxa	0	0	0	0	0
% Unknown Density	0	0	0	0	0
Percent 1 Dominant	27.60	20.47	14.64	21.16	22.66
Percent 5 Dominant	73.96	64.09	59.11	70.900	59.82
Percent 10 Dominant	89.54	82.55	82.50	90.12	83.56
Ratio EPT/Chironomidae Density	7.2	4.71	3.69	8.89	5.76
Ratio Hydropsych./Tot. Trichopter	0.695	0.259	0.38	0.97	0.68
Ratio Baetidae/Tot. Ephemeropter	0.768	0.658	0.652	0.935	0.259
Ratio Scraper/Collector Filterers	0.045	0.069	0.310	0.035	0.591
Ratio Scraper/Scrap.+Coll. Filter.	0.043	0.065	0.251	0.034	0.371
Ratio Shredders/Tot. Density	0.004	0.003	0.002	0	0
BCI	63	60	64	60	61.80
BCI Predicted	**55**	**55**	55	55	55
BCI CTQA	87.56	92.18	86.47	91.04	88.98
BCI CTQD	89.13	92.32	87.79	92.4	89.03
Diversity LOGe	2.39	2.66	2.73	2.45	2.73
Diversity LOG2	3.46	3.83	3.94	3.53	3.95
Evenness	0.69	0.76	0.79	0.74	0.74
Simpson D	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported
% Multivoltine	66.89	59.56	60.71	73.54	48.58
% Univoltine	13.29	18.12	14.11	20.81	41.87
% Semivoltine	19.82	22.32	25.18	5.64	9.547

APPENDIX E

2022 TONGUE RIVER WATERSHED
HABITAT ASSESSMENT DATA

APPENDIX TABLE E-1. HABITAT ASSESSMENT METRIC SCORES AT TONGUE RIVER STATION TR09 (FORMERLY KNOWN AS TRU - UPPER CANYON STATION); 1993-2003

Stream Name	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
Location	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon
Sampler	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	WDEQ	SCCD	WDEQ
Date	10/19/1993	10/20/1994	10/16/1995	9/26/1996	10/13/1997	10/13/1998	10/12/1999	9/20/2000	10/10/2001	9/19/2002	9/24/2003	9/30/2003
Habitat Parameter												
Percent Fines	19	16	18	18	17	19	19	19	18	20	17	18
Instream Cover	16	18	18	19	18	19	19	18	19	18	17	19
Embeddedness	18	19	17	19	20	20	20	18	18	20	20	20
Velocity/Depth	18	18	18	18	18	19	16	17	18	15	16	20
Channel Flow	18	18	18	19	19	18	19	18	17	18	14	20
Channel Shape	9	11	11	11	11	9	9	10	11	6	8	7
Pool/Riffle	11	14	14	13	12	13	14	14	14	12	12	15
Channel Alteration	15	15	15	14	14	15	15	15	15	15	11	15
Width/Depth	7	9	13	13	11	11	6	1	2	3	4	10
Bank Vegetation	8	9	9	9	9	9	10	10	10	15	8.5	10
Bank Stability	10	9	9	9	9	9	10	10	10	10	10	10
Disruptive Pressures	10	10	10	10	10	10	10	10	10	10	9	10
Riparian Width	6	7	8	9	9	2	6	7	10	10	8.5	10
Total Score	*165*	*173*	*178*	*181*	*177*	*173*	*173*	*167*	*172*	*172*	*155*	*184*
Substrate												
Mean % Cobble	72	64	68	83	81	82	62	58	37	49	74	68
Mean % Coarse Gravel	15	18	11	7	9	10	16	27	25	34	11	22
Mean % Fine Gravel	7	10	7	4	3	4	19	12	15	17	8	6
Mean % Silt	0	1	0	0	0	0	0	0	1	0	0	0
Mean % Sand	6	8	4	5	7	3	3	3	9	0	7	4
Mean % Clay	0	0	0	0	0	0	0	0	0	0	0	0
Mean % Organic	0	0	0	0	0	0	0	0	0	0	0	0
Mean % Precipitate	0	0	0	0	0	0	0	0	0	0	0	0
Weighted Embeddedness	*92.0*	*95.0*	*92.2*	*95.4*	*99.0*	*99.0*	*98.6*	*88.8*	*96.8*	*100.0*	*97.0*	*100.0*
Stream Velocity												
Mean (Ft. per Second)	2.40	1.70	2.00	2.30	1.72	2.45	1.88	1.82	1.54	5.58	1.50	2.00

APPENDIX TABLE E-2. HABITAT ASSESSMENT METRIC SCORES AT TONGUE RIVER STATION TR09 (FORMERLY KNOWN AS TRU - UPPER CANYON STATION); 2004-2022 AND STATION TR07 1996-1999

Stream Name	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
Location	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR09 Canyon	TR07	TR07	TR07	TR07
Sampler	WDEQ	WDEQ	WDEQ	SCCD	SCCD	SCCD	SCCD	SCCD	Average	WDEQ	WDEQ	WDEQ	SCCD
Date	10/11/2004	10/10/2007	10/15/2009	9/9/2010	9/9/2013	10/4/2016	9/12/2019	9/19/2022	All Years	10/11/1996	10/14/1997	10/12/1998	10/26/1999
Habitat Parameter													
Percent Fines	19	N	N	12	17	14	11	17	17	20	19	20	20
Instream Cover	20	O	O	17	19	16	19	17	18	12	13	19	16
Embeddedness	20	T	T	20	19	15	19	16	19	1	7	4	2
Velocity/Depth	20			15	19	16	17	18	18	14	16	17	19
Channel Flow	17	R	R	18	16	19	19	18	18	15	16	15	15
Channel Shape	7	E	E	10	7	7	8	11	9	8	8	10	9
Pool/Riffle	15	P	P	9	14	13	14	13	13	12	13	14	14
Channel Alteration	15	O	O	14	12	11	11	12	14	11	9	9	11
Width/Depth	3	R	R	3	4	6	3	3	6	5	2	2	3
Bank Vegetation	10	T	T	9	10	8	9	8	9	8	7	8	7
Bank Stability	10	E	E	9	10	8	9	8	9	6	8	6	8
Disruptive Pressures	10	D	D	10	10	9	8	10	10	6	10	9	8
Riparian Width	10			4	9	8	2	8	7	9	9	2	2
Total Score	*176*			*150*	*166*	*150*	*149*	*159*	*168*	*127*	*137*	*135*	*134*
Substrate													
Mean % Cobble	45			63	83	65	72	74	67	72	66	42	69
Mean % Coarse Gravel	44			12	4	14	6	8	16	18	24	51	18
Mean % Fine Gravel	10			9	7	9	3	7	9	9	7	7	14
Mean % Silt	0			0	0	0	0	0	0	0	1	0	0
Mean % Sand	1			18	6	12	18	11	7	1	2	0	0
Mean % Clay	0			0	0	0	0	0	0	0	0	0	0
Mean % Organic	0			0	0	0	0	0	0	0	0	0	0
Mean % Precipitate	0			0	0	0	0	0	0	0	0	0	0
Weighted Embeddedness	*100.0*			*97.5*	*94.6*	*77.5*	*96.4*	*84.5*	*94.7*	*21.8*	*47.6*	*33.0*	*25.4*
Stream Velocity													
Mean (Ft. per Second)	1.59			1.23	1.12	1.49	1.15	0.74	1.90	3.20	2.31	2.26	2.60

APPENDIX TABLE E-3. HABITAT ASSESSMENT METRIC SCORES AT TONGUE RIVER STATION TR07, 2003-2022 AND STATION TR05 1995-2006

Stream Name	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
Location	TR07	TR07	TR07	TR07	TR07	TR07	TR07	TR07	TR07	TR05	TR05	TR05	TR05
Sampler	SCCD	WDEQ	SCCD	SCCD	SCCD	SCCD	SCCD	SCCD	Average	WDEQ	WDEQ	WDEQ	SCCD
Date	9/22/2003	10/13/2004	9/19/2006	9/7/2010	9/7/2013	9/26/2016	9/10/2019	9/16/2022	All Years	9/12/1995	10/15/1998	10/13/2004	9/19/2006
Habitat Parameter													
Percent Fines	18	18	13	19	16	20	11	14	17	19	17	13	14
Instream Cover	16	19	6	10	16	16	16	11	14	10	16	10	7
Embeddedness	10	18	5	12	10	14	9	9	8	11	8	7	15
Velocity/Depth	12	20	16	15	16	18	16	16	16	14	15	15	14
Channel Flow	19	15	16	18	15	19	18	15	16	19	18	17	19
Channel Shape	11	11	3	10	10	12	12	11	10	11	10	10	12
Pool/Riffle	13	15	8	11	14	13	8	12	12	8	11	10	2
Channel Alteration	11	7	7	6	8	11	11	10	9	11	15	10	10
Width/Depth	2	3	2	2	5	9	5	4	4	5	4	1	2
Bank Vegetation	9	9	8.5	10	8	8	9	9	8	9	9	10	10
Bank Stability	9	9	8.5	10	8	9	9	8	8	8	8	10	8
Disruptive Pressures	8	9	7.5	8	8	8	10	8	8	9	10	6	10
Riparian Width	9	8	7.5	8	8	6	7	8	7	10	6	8	5
Total Score	*146*	*161*	*108*	*139*	*142*	*163*	*141*	*135*	*139*	*144*	*147*	*127*	*128*
Substrate													
Mean % Cobble	54	36	38	40	66	64	52	51	54	73	24	32	78
Mean % Coarse Gravel	29	45	11	35	12	24	18	31	26	18	41	38	9
Mean % Fine Gravel	12	11	17	24	11	12	11	12	12	7	29	11	7
Mean % Silt	1	0	0	0	4	0	4	5	1	1	0	10	0
Mean % Sand	4	8	34	1	6	0	14	0	6	2	6	7	5
Mean % Clay	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean % Organic	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean % Precipitate	0	0	0	0	0	0	0	0	0	0	0	0	0
Weighted Embeddedness	*59.1*	*84.0*	*31.8*	*65.0*	*58.0*	*73.4*	*53.3*	*53.0*	*50.4*	*62.6*	*49.0*	*42.0*	*55.0*
Stream Velocity													
Mean (Ft. per Second)	1.90	1.60	1.70	2.25	1.76	2.05	2.27	2.37	2.19	2.58	1.56	1.72	1.82

APPENDIX TABLE E-4. HABITAT ASSESSMENT METRIC SCORES AT TONGUE RIVER STATION TR05, 2010-2022, STATION TR03, 1998-2022 AND STATION TR01, 1998

Data Collection by Sheridan County Conservation District and Wyoming Department Environmental Quality

Data Type: Habitat, Stream Substrate, Embeddedness and Stream Velocity (Feet per Second)

Stream Name	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
Location	TR05	TR05	TR05	TR05	TR05	TR05	TR03	TR03	TR03	TR03	TR03	TR03	TR03	TR01
Sampler	SCCD	SCCD	SCCD	SCCD	SCCD	Average	WDEQ	WDEQ	SCCD	SCCD	SCCD	SCCD	Average	WDEQ
Date	9/23/2010	9/5/2013	10/4/2016	9/11/2019	9/14/2022	All Years	10/15/1998	10/12/2004	9/3/2013	9/22/2016	9/11/2019	9/14/2022	All Years	10/15/1998
Habitat Parameter														
Percent Fines	18	17	16	7	15	15	12	17	14	11	9	15	13	14
Instream Cover	14	15	17	17	12	13	17	12	9	15	15	12	13	16
Embeddedness	9	7	6	11	3	9	4	7	14	8	17	6	9	2
Velocity/Depth	16	17	16	16	12	15	15	17	12	16	16	16	15	14
Channel Flow	19	14	16	18	17	17	18	19	16	15	18	15	17	18
Channel Shape	11	11	13	12	12	11	10	8	11	12	14	12	11	11
Pool/Riffle	11	13	12	6	10	9	8	12	5	13	8	9	9	11
Channel Alteration	5	7	14	13	7	10	13	13	11	11	13	14	13	14
Width/Depth	2	4	2	3	3	3	1	2	1	3	4	2	2	2
Bank Vegetation	8	8	9	8	8	9	6	8	10	9	8	8	8	8
Bank Stability	8	8	9	8	8	8	6	8	8	8	8	8	8	8
Disruptive Pressures	10	10	9	9	9	9	3	4	10	9	9	9	7	8
Riparian Width	8	8	7	8	7	7	1	6	10	4	6	7	6	5
Total Score	*139*	*139*	*146*	*136*	*123*	*137*	*114*	*133*	*131*	*134*	*145*	*133*	*132*	*131*
Substrate														
Mean % Cobble	30	64	30	27	32	43	11	26	45	41	25	35	31	59
Mean % Coarse Gravel	40	16	32	17	34	27	39	44	29	17	24	30	31	17
Mean % Fine Gravel	25	14	29	14	24	18	33	19	14	22	26	24	23	12
Mean % Silt	0	0	0	19	1	3	0	9	0	0	0	0	2	1
Mean % Sand	5	6	8	23	9	8	16	2	12	19	26	11	14	11
Mean % Clay	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean % Organic	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean % Precipitate	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Weighted Embeddedness	*54.5*	*48.4*	*43.8*	*64*	*28.9*	*49.8*	*35.0*	*35.6*	*75.8*	*51.9*	*87.2*	*43.0*	*54.8*	*25.0*
Stream Velocity														
Mean (Ft. per Second)	1.64	1.85	2.86	1.08	1.28	1.82	1.28	1.12	1.21	1.54	1.87	1.37	1.40	1.81

APPENDIX TABLE E-5. HABITAT ASSESSMENT METRIC SCORES AT TONGUE RIVER STATION TR01, 2003-2022

Data Collection by Sheridan County Conservation District and Wyoming Department Environmental Quality

Data Type: Habitat, Stream Substrate, Embeddedness and Stream Velocity (Feet per Second)

Stream Name	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.	Tongue R.
Location	TR01	TR01	TR01	TR01	TR01	TR01	TR01
Sampler	WDEQ	WDEQ	SCCD	SCCD	SCCD	SCCD	Average
Date	10/22/2003	10/20/2004	9/3/2013	9/22/2016	9/10/2019	9/13/2022	All Years
Habitat Parameter							
Percent Fines	20	17	16	9	20	12	15
Instream Cover	9	10	13	14	15	10	12
Embeddedness	2	4	7	8	20	11	8
Velocity/Depth	14	16	13	17	16	11	14
Channel Flow	16	15	16	18	19	16	17
Channel Shape	11	10	11	11	12	12	11
Pool/Riffle	8	8	7	12	5	5	8
Channel Alteration	15	15	14	13	14	14	14
Width/Depth	0	2	3	7	2	3	3
Bank Vegetation	10	10	8	8	8	8	9
Bank Stability	10	10	7	8	8	8	8
Disruptive Pressures	10	10	8	9	8	9	9
Riparian Width	9	10	4	7	5	7	7
Total Score	*134*	*137*	*127*	*141*	*152*	*126*	*135*
Substrate							
Mean % Cobble	30	17	60	36	79	59	49
Mean % Coarse Gravel	58	49	24	17	12	8	26
Mean % Fine Gravel	12	26	8	19	8	18	15
Mean % Silt	0	1	1	0	0	0	0
Mean % Sand	0	6	8	28	0	16	10
Mean % Clay	0	0	0	0	0	0	0
Mean % Organic	0	0	0	0	0	0	0
Mean % Precipitate	0	0	0	0	0	0	0
Weighted Embeddedness	*23.6*	*35.8*	*42.4*	*51.8*	*98.4*	*62.2*	*48.5*
Stream Velocity							
Mean (Ft. per Second)	1.72	1.70	0.82	1.41	3.32	1.14	1.70

APPENDIX TABLE E-6. 2022 DUPLICATE QA/QC HABITAT ASSESSMENT METRIC SCORES AT TONGUE RIVER STATION TR05

Stream Name	Tongue R.	Tongue R.
Location	TR03	TR03
Sampler	SCCD	SCCD
Date	9/14/2022	9/14/2022
Assessor Name	Assessor 1	Assessor 2
Habitat Parameter		
Percent Fines	15	14
Instream Cover	12	12
Embeddedness	3	2
Velocity/Depth	12	17
Channel Flow	17	17
Channel Shape	12	12
Pool/Riffle	10	9
Channel Alteration	7	11
Width/Depth	3	3
Bank Vegetation	8	9
Bank Stability	8	9
Disruptive Pressures	9	9
Riparian Width	7	9
Total Score	*123*	*133*
RPD**	7.81	

RPD** = Relative Percent Difference is calculated by the formula: RPD = [(A-B) / (A+B)] X 200

APPENDIX F

2022 TONGUE RIVER WATERSHED PHOTOS

Tongue River Site TR01 Photopoints

Early Season
Upstream

Site TR01 Facing Upstream
5/18/2022

Late Season
Upstream

Site TR01 Facing Upstream
8/24/2022

Early Season
Downstream

Site TR01 Facing Downstream
5/18/2022

Late Season
Downstream

Site TR01 Facing Downstream
8/24/2022

Prairie Dog Site PD01 Photopoints

Early Season
Upstream

Site PD01 Facing Upstream
5/18/2022

Late Season
Upstream

Site PD01 Facing Upstream
8/24/2022

Early Season
Downstream

Site PD01 Facing Downstream
5/18/2022

Late Season
Downstream

Site PD01 Facing Downstream
8/24/2022

Tongue River Site TR03 Photopoints

Early Season
Upstream

Site TR03 Facing Upstream
5/18/2022

Late Season
Upstream

Site TR03 Facing Upstream
8/24/2022

Early Season
Downstream

Site TR03 Facing Downstream
5/18/2022

Late Season
Downstream

Site TR03 Facing Downstream
8/24/2022

Goose Creek Site GC01 Photopoints

Early Season
Upstream

Site GC01 Facing Upstream
5/18/2022

Late Season
Upstream

Site GC01 Facing Upstream
8/24/2022

Early Season
Downstream

Site GC01 Facing Downstream
5/18/2022

Late Season
Downstream

Site GC01 Facing Downstream
8/24/2022

Tongue River Site TR05 Photopoints

Early Season
Upstream

Site TR05 Facing Upstream
5/18/2022

Late Season
Upstream

Site TR05 Facing Upstream
8/24/2022

Early Season
Downstream

Site TR05 Facing Downstream
5/18/2022

Late Season
Downstream

Site TR05 Facing Downstream
8/24/2022

Tongue River Site TR07 Photopoints

Early Season
Upstream

Site TR07 Facing Upstream
5/18/2022

Late Season
Upstream

Site TR07 Facing Upstream
8/24/2022

Early Season
Downstream

Site TR07 Facing Downstream
5/18/2022

Late Season
Downstream

Site TR07 Facing Downstream
8/24/2022

Wolf Creek Site WC01 Photopoints

Early Season
Upstream

Site WC01 Facing Upstream
5/18/2022

Late Season
Upstream

Site WC01 Facing Upstream
8/24/2022

Early Season
Downstream

Site WC01 Facing Downstream
5/18/2022

Late Season
Downstream

Site WC01 Facing Downstream
8/24/2022

Five Mile Creek Site FMC01 Photopoints

Early Season
Upstream

Site FMC01 Facing Upstream
5/18/2022

Late Season
Upstream

Site FMC01 Facing Upstream
8/24/2022

Early Season
Downstream

Site FMC01 Facing Downstream
5/18/2022

Late Season
Downstream

Site FMC01 Facing Downstream
8/24/2022

Tongue River Site TR08 Photopoints

Early Season
Upstream

Site TR08 Facing Upstream
5/18/2022

Late Season
Upstream

Site TR08 Facing Upstream
8/24/2022

Early Season
Downstream

Site TR08 Facing Downstream
5/18/2022

Late Season
Downstream

Site TR08 Facing Downstream
8/24/2022

Columbus Creek Site CC01 Photopoints

Early Season
Upstream

Site CC01 Facing Upstream
5/18/2022

Late Season
Upstream

Site CC01 Facing Upstream
8/24/2022

Early Season
Downstream

Site CC01 Facing Downstream
5/18/2022

Late Season
Downstream

Site CC01 Facing Downstream
8/24/2022

Little Tongue River Site LTR01 Photopoints

Early Season
Upstream

Site LTR01 Facing Upstream
5/18/2022

Late Season
Upstream

Site LTR01 Facing Upstream
8/24/2022

Early Season
Downstream

Site LTR01 Facing Downstream
5/18/2022

Late Season
Downstream

Site LTR01 Facing Downstream
8/24/2022

Smith Creek Site SC01 Photopoints

Early Season
Upstream

Site SC01 Facing Upstream
5/18/2022

Late Season
Upstream

Site SC01 Facing Upstream
8/24/2022

Early Season
Downstream

Site SC01 Facing Downstream
5/18/2022

Late Season
Downstream

Site SC01 Facing Downstream
8/24/2022

Tongue River Site TR09 Photopoints

Early Season
Upstream

Site TR09 Facing Upstream
5/18/2022

Late Season
Upstream

Site TR09 Facing Upstream
8/24/2022

Early Season
Downstream

Site TR09 Facing Downstream
5/18/2022

Late Season
Downstream

Site TR09 Facing Downstream
8/24/2022

Tongue River Site TR01 Reach Assessment Photos

Upstream

Site TR01 Bottom of Riffle Facing Upstream
9/14/2022 7:17

Downstream

Site TR01 Top of Riffle Facing Downstream
9/14/2022 7:18

Panorama of Riffle

Site TR01 Panorama from River Right
9/14/2022 7:15

Tongue River Site TR03 Reach Assessment Photos

Upstream

Site TR03 Bottom of Riffle Facing Upstream
9/14/2022 9:30

Downstream

Site TR03 Top of Riffle Facing Downstream
9/14/2022 9:32

Panorama of Riffle

Site TR03 Panorama from River Right
9/14/2022 9:33

Tongue River Site TR05 Assessment Photos

Upstream

Site TR05 Bottom of Riffle Facing Upstream
9/14/2022 13:27

Downstream

Site TR05 Top of Riffle Facing Downstream
9/14/2022 13:27

Panorama of Riffle

Site TR05 Panorama from River Right
9/14/2022 13:28

Tongue River Site TR07 Reach Assessment Photos

Upstream

Site TR07 Bottom of Riffle Looking Upstream
9/16/2022 8:23

Downstream

Site TR07 Bottom of Riffle Facing Downstream
9/16/2022 8:57

Panorama of Riffle

Site TR07 Panorama from River Right
9/16/2022 8:34

Tongue River Site TR09 Reach Assessment Photos

Upstream

Site TR09 Base of Riffle Facing Upstream
9/19/22 12:22

Downstream

Site TR09 Base of Riffle Facing Downstream
9/19/2022 12:49

Panorama of Riffle

Site TR09 Panorama from River Right
9/19/2022 12:44