SHERIDAN COUNTY
CONSERVATION DISTRICT
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2017 Prairie Dog Creek Watershed Interim Monitoring Project

Final Report

July 2018

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Executive Summary

The Prairie Dog Creek watershed consists of approximately 231,000 acres (360 square miles) located in central Sheridan County, which originates in the foothills of the Big Horn Mountains and flows into the Tongue River near the Montana border. Annual precipitation ranges from 20 inches in the headwaters to 12 inches at the confluence with Tongue River. From the abrupt, eastern slope of the Big Horn Mountains to the rolling, brushy draw prairies, the watershed provides exceptional wildlife habitat, scenic, and recreational values.

Major tributaries to Prairie Dog Creek include Meade, Jenks, SR, Jim, Arkansas, Coutant, Wildcat, and Dutch Creeks. Most of these streams are ephemeral throughout much of their length. Streamflow in Jenks and Meade Creek is augmented during the irrigation season by trans-basin diversions from the Piney Creek drainage. During the recreation season, as much as 100 cubic feet per second can be diverted from the Piney Creek drainage into Prairie Dog Creek.

The project area includes a combination of private, State, and Federal lands, with private lands dominating the watershed. Land use in the Prairie Dog Creek Watershed is predominately rangeland, with irrigated crop and hayland along Prairie Dog Creek and tributaries. Other land uses include small and large ranches, rural subdivisions and unincorporated communities, energy development, and wildlife habitat. There are no municipal water uses or discharges.

Prairie Dog Creek and Meade Creek are classified as 2AB waterbodies and are listed on the 303(d) list of waterbodies requiring TMDLs for *E. coli* bacteria impairments related to recreational use and for Manganese impairments for aesthetic drinking water use (discoloration, taste, etc.). Wildcat Creek and Dutch Creek, which are class 3B waterbodies, also have bacteria impairments. In addition, Prairie Dog Creek is listed for temperature impairments that affect its ability to support Cold Water Fisheries.

In 2007-2008, the Sheridan County Conservation District (SCCD), with support from the USDA Natural Resources Conservation Service, and the Wyoming Department of Environmental Quality, completed a watershed assessment and planning effort on the Prairie Dog Creek Watershed. In 2007, credible data (chemical, physical, and biological) was collected from a total of 11 locations on the mainstem, three tributaries and an irrigation ditch. In 2008, sampling was conducted at 14 locations (10 on the mainstem and 3 on the major tributaries, and one on Prairie Dog Ditch).

In the 2007-2008 Assessment, there were no issues with nutrients, pesticides, or concerns with urban run-off in the watershed. *E. coli* bacteria concentrations were found in excess of Wyoming Water Quality Standards for primary contact recreation. Water temperatures were also recorded in excess of the Wyoming water quality standard of 20°C in portions of the watershed. Dissolved manganese concentrations exceeded the aesthetic drinking water standard, though levels were not so high as to be of concern for human health or aquatic life.

Results from the 2007-2008 Prairie Dog Creek Watershed Assessment formed the basis for the development of the Prairie Dog Creek Watershed Plan, which was approved in 2011. The Prairie Dog

Creek Watershed Plan included a commitment to continue monitoring to evaluate changes in water quality over time and to adjust load and load reduction estimates as additional data are collected. The manganese impairments were attributed to natural sources and are not addressed in planning and improvement efforts.

There have been three rounds of interim water quality monitoring on the Prairie Dog Creek watershed since 2008; one in 2011, one in 2014, and the most recent in 2017. Interim monitoring includes water quality monitoring along with benthic macroinvertebrate populations and habitat assessments at a limited number of stations. Interim monitoring evaluates trends in bacteria and other water quality parameters. The water quality parameters include: water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, and *E. coli* bacteria.

Results from 2011 and 2014 interim monitoring were similar to the results from the 2007-2008 assessment. All stations had *E. coli* bacteria concentrations that exceeded Wyoming Water Quality Standards for primary contact recreation for at least one sampling period. All stations recorded continuous water temperatures in excess of 20°C, apart from the uppermost station (PD10), which remained below 20°C during both the 2011 and 2014 monitoring seasons.

Water quality monitoring in 2017 was performed at eight stations; five sites on the mainstem of the Prairie Dog Creek and three sites on the major tributaries; Wildcat Creek, Meade Creek and Jenks Creek. The landowner on Dutch Creek chose not to allow access in 2017; that site was not monitored nor included in the discussion of results. All stations monitored in 2017 were equipped with a SCCD calibrated staff gauge. Grab samples for bacteria and turbidity were collected five times in the early season (May-July) and five times in the late season (July-September). Instantaneous temperature, pH, conductivity, dissolved oxygen, and stream discharge were measured on-site during sampling events. Continuous data loggers recorded water temperature at four mainstem stations at 15-minute intervals from May through October. Macroinvertebrate sampling and habitat assessments were performed at three mainstem stations during October. All monitoring methods, standard operating procedures, and QA/QC protocols used for this project were described in the 2016 Quality Assurance Project Plan 2015 Update and the 2017 Prairie Dog Watershed Interim Monitoring Sampling and Analysis Plan.

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 few exceptions, all parameters met the DQOs and data were accepted. Staff measurements were very low at Jenks Creek and PD10 on May 31; it was likely the values were misread and not recorded accurately. As a result, staff measurements and the corresponding discharge values were discarded for Jenks Creek and PD10 on May 31. Parameters at Meade Creek were measured nine out of the ten scheduled sampling dates; access permission had not yet been renewed by the first sampling date.

All instantaneous temperature samples during 2017 were at or below the maximum 20°C instream temperature standard, except for PD01, which reported a temperature of 20.5°C on July 11. Continuous temperature data loggers reported temperatures that exceeded the temperature standard of 20°C at all but PD10, the uppermost station. Conductivity and pH were within the expected ranges during 2017. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages. One mainstem station, PD05, had a sample that was below the water column concentration recommended to achieve the intergravel concentration for early life stages. Turbidity values were considered normal for the watershed with occasional high values occurring during late-spring, early summer precipitation and run-off events.

Bacteria geometric mean concentrations in May-July were typically higher than in July-September, with the exception of Wildcat Creek and PD10. May-July and July-September concentrations were above Wyoming Water Quality Standards at nearly all stations in 2017, with the exception of PD10 in May-July, and PD09 and Jenks Creek in July-September. The highest bacteria concentration observed at a mainstem site was 875 cfu/mL or 86% above the standard. Bacteria concentrations at tributary stations did not appear to contribute significantly to bacteria increases on Prairie Dog Creek at adjacent downstream stations.

Bacteria concentrations increased from 2014 to 2017 at PD01, PD05 and PD06 in May-July and in July-September. PD10, the uppermost mainstem station, and Wildcat Creek, the lowermost tributary station, decreased from 2014 to 2017 in May-July and in July-September. Bacteria concentrations increased at Meade Creek and Jenks Creek from May-July 2014 to 2017, then decreased from July-September 2014 to 2017. In May-July 2017, all but one station (PD10) exceeded Wyoming Water Quality Standards. From July-September 2017, PD09 and Jenks Creek reported bacteria geometric mean concentrations below the standard; all other stations exceeded the standard during this time.

Biological condition based on the collection of benthic macroinvertebrate samples was determined at three mainstem Prairie Dog Creek stations. Biological condition at the lower-most Prairie Dog Creek monitoring station PD01 was Partial/Non-Support during each year. The Partial/Non-support classification indicated the aquatic community was stressed by anthropogenic stressors. Biological condition at station PD06 was Partial/Non-Supporting during 2007, 2008, 2011 and 2014, but improved to Indeterminate support during 2017**.** 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

Although station PD08 was not sampled during 2017, biological condition was determined for PD08 for the period from 2007 to 2014. Biological condition at station PD08 indicated Indeterminate support during each year. The most upstream station PD10 exhibited variable biological condition scores. Biological condition was Partial/Non-Support during 2007, then increased to Full support during 2008 and 2011, decreased to Partial/Non-Support during 2014, then increased to Indeterminate support in 2017.

Wyoming Game and Fish Department implemented a monitoring program throughout Wyoming to prevent the establishment of the zebra mussel and the quagga mussel in Wyoming waterbodies**.** No zebra or quagga mussels have been identified by SCCD sampling in the Prairie Dog Creek watershed. Further, other aquatic invasive species of significant concern including the New Zealand Mudsnail and the Asian clam have not identified the in the Prairie Dog Creek watershed or adjacent Tongue River, Little Goose Creek and Big Goose Creek watersheds.

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 be anticipated nor expected during monitoring, these varying conditions make water quality comparisons more difficult. Bacteria concentrations are known to vary in response to a number of different water quality and water quantity factors, including changes in water temperature, water quantity, and suspended sediment loads.

Like other watersheds in Sheridan County, the Prairie Dog Creek watershed serves as an important resource for agriculture, wildlife, and scenic value. The watershed, as it exists today, has been defined by irrigation practices and trans-basin diversions since the 1880s. While the system cannot be returned to its natural state, there are opportunities for improvement. Best management practices addressing bacteria and sediment sources, irrigation water conservation and management, and riparian management can be implemented to improve water quality and the overall health of the watershed.

The data provided by the 2007-2008 watershed assessment and subsequent interim monitoring indicate the need for additional improvement projects as well as additional future monitoring to 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 actually measure these achievements. Nonetheless, each improvement project that has been implemented or is currently being implemented on the watershed certainly promotes positive water quality changes, even if they are not immediately apparent.

SCCD will continue to monitor water quality in the Prairie Dog Creek Watershed on a three-year rotation, pending available funding sources. Planning and implementation of remedial measures to restore full aquatic life use support in the streams in the Prairie Dog Creek watershed should continue. Continued benthic macroinvertebrate sampling should be conducted at stations in the watershed to track potential changes in biological condition.

Chapter 1 Project Area Description

1.1 Watershed Description

The Prairie Dog Creek watershed consists of approximately 231,000 acres in central Sheridan County, in north-central Wyoming (Appendix A-1). Prairie Dog Creek originates in the foothills of the Big Horn Mountains near Moncreiffe Ridge, northwest of Story, Wyoming. This ridge is located in the southwest corner of the watershed, less than a ½ mile above the headwaters of Prairie Dog Creek. The stream flows east until the confluence with Jenks Creek, where it turns north until it enters the Tongue River near the Montana border.

The difference in elevation between the highest point and lowest point in the watershed is 3,086 feet over a distance of approximately 26 miles, sloping generally from south to north (EnTech, 2001). Stream elevation is 4,440 feet at the uppermost Prairie Dog Creek site (PD10) and drops to 3,484 feet just above the confluence with Prairie Dog Creek and Tongue River (PD01). Total difference in elevation of Prairie Dog Creek is 956 feet over a distance of approximately 52.76 stream miles. Annual precipitation at the uppermost monitoring stations (PD09, JC01 and PD10) is 16 to 18 inches (Appendix A-2). The majority of the watershed receives 14 to 16 inches of annual precipitation. The watershed transitions to a lower precipitation zone near the Wyoming-Montana state line, near station PD01, where annual precipitation is only 10 to 12 inches.

A small portion of the upper watershed lies within Major Land Resource Area (MLRA) 46 – Northern Rocky Mountain Foothills with the majority being within MLRA 58B – Northern Rolling High Plains (USDA, 1986). Most of the watershed is in the 15”–19” Northern Plains Ecological Site group (Appendix A-3) with the lowermost tip in the 10”–14” Northern Plains Ecological Site group (USDA, 1995). Soils range from very deep loamy and clayey soils on alluvial fans, terraces, and floodplains (Haverdad-Zigweid-Nuncho grouping) to shallow and very shallow loamy soils on slopes up to 90% with rock outcrops (Shingle-Kishona-Cambria grouping) (USDA, 1986a). From the abrupt, eastern slope of the Big Horn Mountains to the rolling, brushy draw prairies, the watershed provides exceptional wildlife habitat, scenic, and recreational values.

Major tributaries to Prairie Dog Creek include Meade, Jenks, SR, Jim, Arkansas, Coutant, Wildcat, and Dutch Creeks. Most of these streams are ephemeral throughout much of their length. Streamflow in Jenks and Meade Creek is augmented during the irrigation season by trans-basin diversions from the Piney Creek drainage. Jenks Creek was likely a steep ephemeral draw until the late 1800’s, at which time the trans-basin diversions were constructed to divert water from the North and South Forks of Piney Creek through three tunnels located on the northern side of the present community of Story. The ridge through which the tunnels were constructed is known as Tunnel Hill. During the recreation season, as much as 100 cubic feet per second (cfs) can be diverted from the Piney Creek drainage into Prairie Dog Creek. The additional flows resulting from the trans-basin diversions are suspected to be responsible for habitat and stream channel degradation (EnTech, 2001).

1.2 LAND OWNERSHIP AND USES

Land ownership within the watershed is approximately 80% privately owned, 19% owned by the State of Wyoming, and 1% federally administered by the Bureau of Land Management (Appendix A-4). In addition, the unincorporated Town of Story, Wyoming lies immediately adjacent to the watershed. While Story lies geographically in the Piney Creek/Powder River drainage, it is a significant hydrological part of the Prairie Dog Creek watershed due to the trans-basin diversions through Tunnel Hill.

Land use in the Prairie Dog Creek Watershed is predominately rangeland, with irrigated crop and hayland along Prairie Dog Creek and tributaries (Appendix A-5). Small and large ranches constitute the majority of private lands. These ranches generally include pasture lands for cattle grazing, irrigated and non-irrigated hay and crop lands, and corrals for short to long term feeding, with approximately 13,000 irrigated acres. A few cash crops are grown, but most agricultural enterprises rely on hay and cattle production.

Urban areas within the watershed include the unincorporated towns of Banner, Wyarno, Verona, and Ulm. However, numerous rural subdivisions also exist and tend to be most common in the western portion of the watershed. In addition, the unincorporated Town of Story, Wyoming lies immediately adjacent to the watershed. The area also provides year-round habitat for small and big game, furbearers, waterfowl, game birds, and song birds.

Prairie Dog Creek is somewhat unique for Sheridan County in that it has no municipal water uses and little to no direct discharges. The watershed has had some energy development in the form of coal bed methane extraction located in the lower portions of the watershed. Most of the permitted outfalls from coal bed methane facilities are first discharged into stockwater reservoirs, pits, or containment units, either on- or off-channel, then into one of the often-unnamed draws that feed the Prairie Dog Creek tributaries. Few of these permits discharge directly into Prairie Dog Creek. Thus, any effect as a result of these discharges is difficult to discern by the time it reaches Prairie Dog Creek.

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, 2013). 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, 2013)

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 based on value determinations rather than use support and are protected for all uses in existence at the time or after designation.

[2]The drinking water use involves maintaining a level of water quality that is suitable for potable water or intended to be suitable after receiving conventional drinking water treatment.

[3]The fisheries use includes water quality, habitat conditions, spawning and nursery areas, and food sources necessary to sustain populations of game and non-game fish. This does not include the protection of species considered "undesirable" by the Wyoming Game and Fish Department or the U.S. Fish and Wildlife Service within their appropriate jurisdictions.

[4]The fish consumption use involves maintaining a level of water quality that will prevent any unpalatable flavor and/or accumulation of harmful substances in fish tissue.

[5]Aquatic life other than fish includes water quality and habitat necessary to sustain populations of organisms other than fish in proportions which make up diverse aquatic communities common to waters of the state. This does not include the protection of organisms designated "undesirable" by the Wyoming Game and Fish Department or the U.S. Fish and Wildlife Service within their appropriate jurisdictions.

[6]Recreational use protection involves maintaining a level of water quality that is safe for human contact. It does not guarantee the availability of water for any recreational purpose. Both primary and secondary contact recreation are protected.

[7]The wildlife use designation involves protection of water quality to a level that is safe for contact and consumption by avian and terrestrial wildlife species.

[8]For purposes of water pollution control, agricultural uses include irrigation or stock watering.

[9]Industrial use protection involves maintaining a level of water quality useful for industrial purposes.

[10]Scenic value involves the aesthetics of the aquatic systems themselves (odor, color, taste, settleable solids, floating solids, suspended solids, and solid waste) and is not necessarily related to general landscape appearance.

Stream classifications are assigned by WDEQ and identified on the Wyoming Surface Water Classification List (WDEQ, 2013a) or in subsequent reports. Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2013) describes the surface water classes and designated uses, as well as the water quality standards that must be achieved for a Wyoming waterbody to support its designated uses (WDEQ, 2013).

Streams in the Prairie Dog Creek Watershed are classified as 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, 2013). Some tributaries and other draws, which are Class 3B surface waters, are not expected to support fish populations or drinking water supplies.

Table 1-2. Prairie Dog Creek Watershed Stream Classifications (WDEQ, 2013b)

Class 2AB Waterbodies	Class 3B Waterbodies
Prairie Dog Creek	Arkansas Creek
Jenks Creek	Coutant Creek
Meade Creek	Dow Prong
	Dutch Creek
	Jim Creek
	Murphy Gulch
	Pompey Creek
	SR Creek
	Stanley Creek
	Wagner Prong
	Wildcat Creek

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 to be “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, 2016). Once a TMDL is completed, a waterbody is moved from Category 5 to Category 4, which includes the list of waterbodies with TMDLs.

A 6.7-mile segment of Prairie Dog Creek from the confluence with Tongue River was listed in 2004 for aesthetic drinking water impairments caused by manganese, which was determined to be from natural sources (WDEQ, 2016). The entire length of Prairie Dog Creek was listed in 2004 for bacteria related to recreational use (WDEQ, 2016). Subsequent monitoring resulted in additional impairment designations on Prairie Dog Creek and some tributaries (Table 1-3).

Table 1-3. Impaired Listings for Streams in the Prairie Dog Creek Watershed (WDEQ, 2016)

Name	Class	Location	Miles	Uses	Impairment	List Date
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Recreation	Fecal Coliform	2004
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Drinking Water	Manganese	2012
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Cold Water Fishery	Temperature	2012
Prairie Dog Creek	2AB	From Tongue River to a point 6.7 miles upstream	6.7	Recreation	Fecal Coliform	2004
Prairie Dog Creek	2AB	From Tongue River a point 6.7 miles upstream	6.7	Drinking Water	Manganese	2004
Prairie Dog Creek	2AB	From Tongue River a point 6.7 miles upstream	6.7	Cold Water Fishery	Temperature	2012
Meade Creek	2AB	From confluence upstream to an unnamed tributary	1.1	Recreation	*E. coli* bacteria	2012
Meade Creek	2AB	From confluence upstream to an unnamed tributary	1.1	Drinking Water	Manganese	2012
Wildcat Creek	3B	From confluence to a point 0.8 miles upstream	0.8	Recreation	*E. coli* bacteria	2012
Dutch Creek	3B	From confluence upstream to an unnamed tributary	1.9	Recreation	*E. coli* bacteria	2012

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CHAPTER 2 PROJECT BACKGROUND

2.1 PREVIOUS SCCD MONITORING EFFORTS

The Sheridan County Conservation District (SCCD), with support from the USDA Natural Resources Conservation Service (NRCS) and the WDEQ, conducted the Prairie Dog Creek Watershed Assessment in 2007-2008 with a grant through Section 319 of the Clean Water Act. Non-federal cash and in-kind matching funds were provided by the Wyoming Department of Agriculture and other local sources. In 2007, credible data (chemical, physical, and biological) was collected from a total of 11 locations on the mainstem, three tributaries and Prairie Dog Ditch. In 2008, sampling was conducted at 14 locations (10 on the mainstem, three on the major tributaries, and one on Prairie Dog Ditch). SCCD added the three sites in 2008 to fill in geographical gaps within the watershed. *E*. *coli* bacteria samples were collected 5 times each within 30-day periods in April, May-June, July-August, and September-October. Total and dissolved manganese, total suspended solids (TSS), sodium adsorption ratio (SAR), including dissolved calcium, dissolved sodium, and dissolved magnesium, alkalinity, total sulfate, total chloride, hardness, nitrate-nitrite, and total phosphorus were measured once per month from April – October. Discharge, turbidity, pH, conductivity, dissolved oxygen, and instantaneous water temperature were measured at all sampling events. Continuous water temperature data loggers were deployed at select stations on Prairie Dog Creek and recorded water temperature information at 15-minute intervals. Sampling of aquatic macroinvertebrates and habitat assessments were performed at five stations in October of each year. Samples for commonly used pesticides were collected from two sites in September 2007 and July 2008.

Based on the 2007-2008 Assessment, there were no issues with nutrients, pesticides, or concerns with urban run-off in the watershed (SCCD, 2009). *E. coli* bacteria concentrations were found in excess of Wyoming Water Quality Standards for primary contact recreation. Water temperatures were recorded in excess of 20°C in portions of the watershed. Dissolved manganese concentrations exceeded the aesthetic drinking water standard, though levels were not so high as to be of concern for human health or aquatic life. Although there are no numeric standards for sediment and turbidity, Prairie Dog Creek does contain high levels of sediment, which may contribute to bacteria and temperature concerns. Increased flow from trans-basin diversions may contribute to channel instability.

Interim water quality monitoring was conducted from May-October 2011 at the same 14 stations used in 2008 (SCCD, 2009). Instantaneous water temperature, pH, conductivity, dissolved oxygen, discharge, *E. coli*, and turbidity were measured at all water quality sampling events. Continuous data loggers recorded water temperature at 15-minute intervals from six stations on Prairie Dog Creek. Aquatic macroinvertebrate samples were collected in conjunction with habitat assessments in October 2011 at five stations on Prairie Dog Creek. Results from 2011 were similar to the results from the 2007-2008 Assessment. All stations had *E. coli* bacteria concentrations that exceeded Wyoming Water Quality Standards for primary contact recreation during at least one sampling period. All but the uppermost station (PD10) recorded water temperatures in excess of 20°C.

The SCCD and steering committee worked with WDEQ to finalize the Prairie Dog Creek Watershed Plan, which was approved in February 2011 (SCCD, 2011). The plan was written to include the nine essential elements of an EPA Watershed Based Plan as described in the Thursday, October 23, 2003 Federal Register, Vol. 68, No. 205 (Federal Register, 2003). Action items address implementation of the plan, water quality improvement, and awareness and education.

Monitoring was conducted from May-October 2014 at the same 14 stations used in 2011 and an additional site on Jenks Creek. To maintain consistency with other watershed monitoring, SCCD updated the site names of the tributary sites (SCCD, 2014). Instantaneous water temperature, pH, conductivity, dissolved oxygen, discharge, *E. coli*, and turbidity were measured at all water quality sampling events. Continuous data loggers recorded water temperature at 15-minute intervals from seven stations on Prairie Dog Creek. Aquatic macroinvertebrate samples were collected in conjunction with habitat assessments in October 2014 at four stations on Prairie Dog Creek. Instantaneous temperature measurements in 2014 were lower than in all other years with all stations reporting temperatures below the maximum 20°C instream temperature standard; however, continuous temperature data loggers reported temperatures that exceeded the standard at all but the uppermost station (PD10). *E. coli* bacteria concentrations at all mainstem sites decreased between 2011 and 2014, apart from PD3A, PD09 and PD10. *E. coli* bacteria concentrations at four of the tributary sites increased from 2011 to 2014, while concentrations at the other four sites decreased from 2011 to 2014.

2.2 WATERSHED PLANNING AND IMPLEMENTATION

The 2007-2008 Prairie Dog Creek Watershed Assessment served as the foundation of a local watershed planning and implementation effort. The assessment allowed SCCD to administer and guide a public Prairie Dog Creek watershed planning process, develop a watershed plan, implement remediation projects, develop progress registers, and conduct interim water quality monitoring. Watershed planning occurred during 2010-2011, resulting in the Prairie Dog Creek Watershed Plan (SCCD, 2011). The plan outlined the goals, objectives, and action items for improving water quality within the Prairie Dog Creek Watershed, along with prioritizing best management practices, and providing future recommendations. The initial plan included recommendations for continued monitoring, information and education, and improvement projects.

Since the completion of the original Prairie Dog Creek Watershed Plan, there has been one update. The Prairie Dog Creek Watershed Plan, 2016 Update (SCCD, 2016a) recommended continuation of improvement efforts and monitoring. The 2016 Update 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. As part of the Prairie Dog Creek Watershed Plan, 2016 Update, SCCD/NRCS will implement the following recommendations:

- Maintain a viable watershed improvement program for the Prairie Dog Creek watershed
- Reduce direct bacteria contribution to waterbodies 10% by 2020
- Reduce sediment contributions and other indirect bacteria contributions
- Increase awareness of and participation in watershed improvement programs and activities through positive and consistent outreach strategies

As of 2017, there have been several improvement projects completed within the Prairie Dog Creek watershed, including: 11 septic system replacements, five livestock facility modifications, one irrigation diversion replacement, one erosion control project and one riparian fencing project. These projects are documented on a progress register map for the watershed (Appendix A-6).

The Prairie Dog Creek 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 2017 interim milestone in the Prairie Dog Creek Watershed Plan, 2016 Update (SCCD, 2016). The 2017 monitoring is within a three-year monitoring rotation currently conducted by SCCD on the Tongue River, Goose Creek, and Prairie Dog Creek watersheds and is 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, 2013b). 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 identify and prioritize areas affected by nonpoint source pollution, and
- to evaluate effectiveness of implementation of improvement projects and other activities.

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CHAPTER 3 HISTORICAL AND CURRENT DATA

Historical data, for the purposes of this project, is defined as data greater than five years old from the start of the 2007-2008 Assessment. The 2007-2008 Prairie Dog Creek Watershed Assessment included a comprehensive compilation of known water quality data for the watershed and contained historical and current data through 2008 (SCCD, 2009). Data collected by SCCD, government agencies, and other sources were provided in tabular form and are not repeated in this document.

Summaries of current water quality data collected after the 2007-2008 Assessment were provided in the reports for the 2011 and 2014 interim monitoring (SCCD, 2012). These summaries included data from USGS Station Numbers 06306250 (Prairie Dog Near Acme) and 06306200 (Prairie Dog at Wakeley Siding) (Table 3-1). Station 06306200 (Wakeley Siding) was discontinued in July 2014 and USGS Station 06306250 (Near Acme) was discontinued in July 2016.

Table 3-1. USGS Stations in the Prairie Dog Creek Watershed during 2017

Site ID	Drainage Area (miles^2)	Real-time: Current Observations	Field Lab Water Quality Samples	Daily/Monthly/Annual Statistics
06306250 Prairie Dog Creek, Near Acme, WY	358 square miles	Discharge Conductivity SAR	6/23/1986- 6/24/2016	Temperature Discharge Conductance SAR
06306200 Prairie Dog Creek at Wakeley Siding	88.3 square miles	Discharge	10/22/2003- 6/24/2014	Discharge

Among other things, the USGS collected temperature, pH, dissolved oxygen, conductivity, nutrients, and metals throughout the period (Appendix B). USGS collected water quality samples for other parameters, but they were not included in this report. It was not the purpose of the interim monitoring to conduct a comprehensive review of data from other sources

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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 served as the Project Coordinator and was responsible for the implementation of the Quality Assurance/Quality Control (QA/QC) procedures. The Program Assistant served as the Field Supervisor and implemented QA/QC procedures. WDEQ provided assistance and oversight as well as administration of the funds provided through Section 319 of the Clean Water Act. Progress updates were provided to the SCCD Board of Supervisors, steering committee, and cooperating stakeholders who provided site access for sampling and other information.

Table 4-1. Key Personnel and Organizations Involved in the Project

Personnel/Organization	Project Role
Carrie Rogaczewski, District Manager	Project management/oversight; field monitoring; QA/QC protocol and oversight; data validation; reporting
Jackie Carbert, Program Assistant	Field data collection, data management, QA/QC protocols, and reporting
Cat Winnop, Seasonal Intern	Assistance with field data collection, data management, QA/QC protocols, and reporting
SCCD Board of Supervisors	Project review; field monitoring assistance
NRCS Sheridan Field Office Staff	Field monitoring assistance
Wyoming Department of Environmental Quality	Project review; QA/QC review; report review, 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 2017 included water temperature, pH, conductivity, dissolved oxygen, stage height, discharge, turbidity, and *E. coli* bacteria. Monitoring was performed at eight stations; five sites on the mainstem of the Prairie Dog Creek and three sites on the major tributaries (Appendix A-1). Samples were collected five times from May-July, and five times from July-September. Continuous data loggers recorded water temperature at four stations at 15-minute intervals from May through November. Macroinvertebrate sampling and habitat assessments were performed at three mainstem stations in October.

4.3 Site Descriptions

Sites were selected based on a review of the historical data, historical SCCD sampling sites, availability, and access (Table 4-3). During the initial site reconnaissance and site selection, 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. These considerations would allow SCCD to direct remediation assistance in the most cost-effective and environmentally sound ways.

All sites chosen for this project were previously used in the 2007-2008 assessment and/or subsequent monitoring years. In 2017, water quality sampling occurred at eight sites; five stations on the mainstem of Prairie Dog Creek and three tributary stations (Appendix A-1). Tributary stations were located on Wildcat Creek, Meade Creek and Jenks Creek. The landowner on Dutch Creek chose not to allow access in 2017; that site was not monitored nor included in the discussion of results. Benthic macroinvertebrate collections and habitat assessments were performed at three stations in October.

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 (The Trespass Bill), 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 4-2. Sample Site Descriptions and Information for 2017 Prairie Dog Creek Watershed Interim Monitoring

Site ID	Sample Site Description	UTM Zone 13 (NAD83)	Latitude Longitude	HUC	Elevation (ft.)	Land use(s)
Water Quality Stations						
PD01	On Prairie Dog Creek above Tongue River confluence, near USGS Station #06306250 upstream County Road 1211 bridge crossing.	4982922N 0355001E	44.984931N 106.839249W	100901010307 Lower Prairie Dog Ck	3,484	Horse grazing; CBM production and irrigated haylands upstream.
WCC01	On Wildcat Creek upstream Highway 336 bridge crossing, upstream of culvert crossing.	4966405N 0352650E	44.835839N 106.864243W	100901010306 Middle Prairie Dog Ck	3,680	Irrigated agricultural land, CBM production, and cattle grazing.
PD05	On Prairie Dog Creek upstream of railroad and Highway 336 bridge crossings, upstream of ranch bridge.	4964763N 0349709E	44.820452N 106.900946W	100901010306 Middle Prairie Dog Ck	3,742	Cattle grazing and irrigated haylands. Railroad and HWY 336 parallel east side of creek.
PD06	On Prairie Dog Creek Upstream Highway 14 bridge crossing.	4954698N 0351543E	44.730277N 106.874827W	100901010306 Middle Prairie Dog Ck	3,969	Rural residential, wildlife habitat, cattle grazing, and irrigated land.
MC01	On Meade Creek adjacent to County Road 131, just upstream of culvert crossing.	4951421N 0352645E	44.701019N 106.859973W	100901010301 Upper Prairie Dog Ck	3,985	Wildlife habitat, cattle grazing and irrigated land.
PD9	On Prairie Dog Creek upstream County Road 127 crossing downstream of Jenks Creek.	4942369N 0353743E	44.619796N 106.843537W	100901010301 Upper Prairie Dog Ck	4,355	Wildlife habitat, cattle grazing, pasture and irrigated hayland.
JC01	Upstream Prairie Dog Creek downstream of Interstate-90 culvert crossing	4941847N 0353570E	44.615064N 106.845568W	100901010301 Upper Prairie Dog Ck	4,375	Wildlife habitat, cattle grazing, pasture and irrigated hayland.
PD10	On Prairie Dog Creek upstream Highway 87 bridge crossing.	4941296N 0351759E	44.609735N 106.868222W	100901010301 Upper Prairie Dog Ck	4,532	Wildlife habitat, grazing, irrigated land.
Macroinvertebrate Stations						
PD01	On Prairie Dog Creek above Tongue River confluence, near USGS Station #06306250 upstream County Road 1211 bridge crossing.	4982922N 0355001E	44.984931N 106.839249W	100901010307 Lower Prairie Dog Ck	3,484	Horse grazing; CBM production and irrigated haylands upstream.
PD06	On Prairie Dog Creek upstream Highway 14 bridge crossing.	4954698N 0351543E	44°.730277N 106.874827W	100901010306 Middle Prairie Dog Ck	3,969	Rural residential, wildlife habitat, cattle grazing, and irrigated land.
PD10	On Prairie Dog Creek upstream Highway 87 bridge crossing.	4941296N 0351759E	44.609735N 106.868222W	100901010301 Upper Prairie Dog Ck	4,532	Wildlife habitat, grazing, irrigated land.

4.4 SAMPLING AND ANALYSIS METHODS

Water quality samples, discharge measurements, macroinvertebrate collections, and habitat assessments were performed according to the methods described in the Sampling Analysis Plan (SCCD, 2017) and the SCCD Water Quality Monitoring Program Quality Assurance Project Plan, 2015 Update (SCCD, 2015a). These documents were developed according to the WDEQ Manual of Standard Operating Procedures for Sample Collection and Analysis (WDEQ, 2017a) and accepted analytical methods (Table 4-3). Samples were obtained from representative riffles.

Table 4-3. Standard Field and Laboratory Methods Applicable to 2017 Monitoring

Parameter	Units	Method / Reference[1]	Location of Analyses	Preservative	Holding Time
Temperature	°C	grab/USEPA 1983 170.1	On-site	n/a	n/a
Temperature	°C	continuous recorder	On-site	n/a	n/a
pH	SU	grab/USEPA 1983 150.1	On-site	n/a	n/a
Conductivity	µmhos/cm	grab/USEPA 1983 120.1	On-site	n/a	n/a
Dissolved Oxygen	mg/l	grab/USEPA 1983 360.1	On-site	n/a	n/a
Turbidity	NTU	grab/USEPA 1983 180.1	IML[2]	Ice; at or below 4ºC	48 hours
E. coli	col/100 ml	grab/SM 9222G[5]	IML[2]	Ice; at or below 4ºC	8 hours
Gauge Height	cfs	Calibrated staff gauge and/or USGS	On-site	n/a	n/a
Flow	cfs	Mid-Section Method	On-site	n/a	n/a
Macroinvertebrates	Metrics	King 1993	AA[3] ABA[4]	formalin	n/a
Habitat (Reach level)	n/a	King 1993	On-site	n/a	n/a

[1]Method references for laboratory analyses were provided by the contract laboratories and defined in their SOPs.
[2]IML refers to Inter-Mountain Laboratories in Sheridan, Wyoming
[3]AA refers to Aquatic Assessments, Inc. in Sheridan, Wyoming.
[4]ABA refers to Aquatic Biology Associates, Inc. in Corvallis, Oregon.
[5] SM refers to Eaton et. al., 1995. Standard Methods for the examination of water and wastewater.

Sample sites were equipped with a staff gauge for flow measurements. During annual site reconnaissance, staff gauges were inspected, surveyed, and replaced if needed. Upon installation and/or inspection, gauges were surveyed and compared with a permanent bench mark; this confirmed the stability of the gauge to ensure consistent measurement. Staff gauge calibrations were performed by measuring instantaneous discharge with a Marsh-McBirney 2000 current meter using the mid-section method (WDEQ, 2017a). 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 anchoring the data loggers to the bottom of the staff gauges and downloading the information. Benthic macroinvertebrates were collected, and habitat assessments were performed at three stations in October.

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 samples were 32 oz., 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 Inter-Mountain Laboratories (IML) 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.

4.5 MONITORING SCHEDULE

The 2017 monitoring schedule included sampling to determine the geometric means of *E. coli*, based on five samples collected within a 60-day period in May-July and five samples collected within a 60-day period in July-September (Table 4-4). A total of ten water quality samples were collected at each site, with the exception of Meade Creek which had nine water quality samples collected due to a delay in renewing permission to access the site.

Sample dates were chosen at random from Monday-Thursday due to lab availability and sampling holding times. Continuous temperature data loggers were deployed to measure instream temperatures from May 15 through October 25. Macroinvertebrate collections and habitat assessments were completed in October.

Table 4-4. Sample Schedule for 2017 Prairie Dog Creek Watershed Monitoring

Date(s)	Sites	Parameters
May 15 – October 24, 2017	PD01, PD06, PD09, PD10	Continuous Temperature
May 15th	PD01, WCC01, PD05, PD06, MC01, PD09, JC01, PD10	Instantaneous temperature, pH, Conductivity, Dissolved Oxygen, Stage Height/Discharge, Turbidity, and *E. coli.* *Early season upstream and downstream photos taken on 6/29/2017
May 31st		
June 13th		
June 29th		
July 11th		
July 26th	PD01, WCC01, PD05, PD06, MC01, PD09, JC01, PD10	Instantaneous temperature, pH, Conductivity, Dissolved Oxygen, Stage Height/Discharge, Turbidity, and *E. coli.* *Late season upstream/downstream photos taken on 9/9/2017
August 8th		
August 22ndA		
September 7th		
September 20th		
October	PD01, PD06, PD10	Macroinvertebrates, Habitat, Photo

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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 and 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 (SCCD, 2015), and the project SAP (SCCD, 2017).

5.2 SAMPLING PERSONNEL QUALIFICATIONS

Water quality monitoring, data management, and reporting were performed by SCCD personnel, who had the appropriate training and qualifications to implement the project (Table 5-1). SCCD Supervisors and NRCS field office staff assisted with site set-up, surveys, discharge measurements, water quality monitoring, and macroinvertebrate collection. 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; 17+ years of experience with the SCCD; WACD Water Quality training
Jackie Carbert Program Assistant	B.S. University of Wyoming in Geography, Environment and Natural Resources with concentrations in GIS and Natural Resource Management; Minor in Journalism; joined SCCD in May 2017 and under supervision of District Manager

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 log book 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 (if required), 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, laboratory internal procedures were implemented according to their Quality Assurance Plans.

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 then shipped to the contract laboratory for analyses. Upon receipt, the laboratory performed a visual check for the number and general condition of samples and signed the COC form. The completed COC was then returned to SCCD.

5.4 Calibration and Operation of Field Equipment

The project SAP outlined requirements for calibration and maintenance of field equipment; calibration instructions and manuals were carried on sampling days. On every sampling day, before leaving the office, the pH meter, conductivity meter, and dissolved oxygen meter 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 conductivity meter was calibrated using a 1413 µmhos/cm calibration standard. All calibration solutions were discarded after each use. The YSI Pro20 dissolved oxygen meter did not require a calibration solution; 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. Calibration of each meter was documented in the corresponding calibration logbook.

The Marsh-McBirney flow meter was factory calibrated and did not require field calibration; however, SCCD performed a "zero" test (or bucket test) in November 2017. Onset Hobo data loggers, used for continuous temperature monitoring, were also factory calibrated and completely encapsulated. A crushed-ice test was performed at the beginning and end of the season to validate the logger's accuracy.

Equipment used for benthic macroinvertebrate sample collection and reach level habitat assessments did not require calibration; however, surber sampler nets and other equipment were checked for damage prior to entering the field. Equipment maintenance, to include battery replacement and monthly replacement of the dissolved oxygen meter membrane cap, was performed according to the SAP and manufacturer's instructions. All maintenance activities were documented on the maintenance log.

5.5 Summary of Quality Assurance/Quality Control

Data quality objectives (DQO's) are qualitative and quantitative specifications used by water quality monitoring programs to limit data uncertainty to an acceptable level. DQO's 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 DQO's in the SAP (SCCD, 2017) and WDEQ protocols (WDEQ, 2017a).

Table 5-2. Data Quality Objectives for 2017 Prairie Dog Creek watershed monitoring (SCCD, 2017)

Parameter	Precision (%)		Accuracy** (%)	Completeness (%)	Minimum Detection Limit
	SCCD*	WDEQ*			
Temperature	10	10	10	95	0.2 ^{O}C
pH	5	±0.3 SU	5	95	0.01 S.U.
Conductivity	10	10	10	95	1 µS/cm
Dissolved Oxygen	20	10	20	95	0.2 mg/L
Turbidity	20	20	10	95	0.1 NTU
E. coli	50	50 if >100 NA if <100	NA	95	1 CFU/100 mL
Macroinvertebrates	NA		NA	95	NA
Total Taxa	15		NA	95	NA
Total Abundance	50		NA	95	NA
Habitat Assessment	NA		NA	95	NA
Intra-Crew	15		NA	10	NA
Discharge	NA		NA	95	NA
Stage-Discharge Relationships	NA		NA	95	Minimum r^2 = 0.95

** SCCD Precision DQOs were from the Prairie Dog Creek 2017 Sampling Analysis Plan and the SCCD Quality Assurance Project Plan, 2015 update; WDEQ precision DQOs were from the 2017 Manual of Standard Operating Procedures.*
*** Accuracy values shown are acceptable departures from 100% accuracy. A 10 percent accuracy value means accuracy values of 90-110% are acceptable.*

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. This was an important factor because future water quality monitoring will occur within the watershed and current project data must be comparable to future data in order 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); and
- 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. 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 other water quality parameters on the same schedule as the *E. coli* samples; five sample geometric means were calculated for all parameters for the 30-day periods. During 2014 revisions to water quality standards and methods, the 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 the 2017 monitoring schedule. 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-June/July) and late season (July-August/September) conditions.

5.5.2 Continuous Temperature Data Loggers

The continuous temperature data loggers, Onset's HOBO Pendent Temperature 64 Data Logger, were used at PD01, PD06, PD09, and PD10 to record water temperature. These loggers were factory calibrated, encapsulated devices that cannot be re-calibrated.

To verify the accuracy of the factory calibration before and after the sampling season, SCCD personnel performed a crushed-ice test. 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 should read the temperature of the ice bath as 0°C ±0.232°C. The pre-season ice bath temperature on May 12th was reported to be between 0.01°C to 0.232°C, which was within the manufacturer's predicted range (Appendix B-3). The post-season ice bath temperature on November 18th also reported temperatures between 0.01°C to 0.232°C, with the exception of one pendant logger. The initial test on this logger resulted in a temperature of 0.674°C, and the second test resulted in a temperature of 0.573°C. These results may have occurred because the logger was not submersed fully within the ice bath. On the third ice bath, the pendant logger read 0.232°C, which was within the predicted range.

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 data loggers were used outside of this range and all returned the expected results in the crushed ice tests, apart from the pendant logger that may not have been fully submersed in the initial tests. All the temperature loggers were considered to have maintained their accuracy and have provided valid water temperature data for the 2017 monitoring project.

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, 2017) on at least three occasions with varying flow conditions. A correlation coefficient (R^2 value) of at least 0.95 (95%) is desirable for proper calibration of the gauge.

Staff gauges installed by SCCD were surveyed against established benchmarks upon installation and at the end of the season. The difference between the height of the gauge and the height of the benchmark were compared to verify gauge stability (Table 5-3).

Table 5-3. Summary of 2017 Gauge Surveys and R^2 Values for Stage-Discharge Relationships

Site	Pre-Season Survey	Post-Season Survey	Pre/Post Season Survey Difference	Stage-Discharge Relationship R^2 Value
PD01	8.99	8.96	0.03	0.9961
WCC01	2.71	2.71	0.00	1.0000
PD05	0.89	0.88	0.01	0.9994
PD06	0.86	0.87	0.01	0.9788
MC01	0.14	0.20	**0.06**	0.9951
PD09	2.56	2.56	0.00	1.0000
JC01	0.66	0.68	0.02	0.9696
PD10	0.70	0.70	0.00	0.9973

One of the gauge surveys resulted in a difference greater than 0.05 between the pre-season and post-season surveys; a difference of 0.06 feet was recorded at the Meade Creek site. Field notes indicated windy conditions during the time of the post survey at this site, which may have affected survey measurements. Discharge measurements for this site were retained as the gauge appeared stable and the flow data is used only for pollutant load comparisons and not for regulatory decision making.

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. *E. coli* and turbidity trip blanks were prepared for every sampling event. Prior to sampling, the contract laboratory filled sample containers with laboratory de-ionized water and the appropriate preservative. The trip blanks were maintained in the cooler with the collected samples and returned to the laboratory for the analysis. No trip blanks used during the project contained detectable levels of *E. coli* or turbidity (Appendix B-4).

Field blanks were prepared to determine whether samples might be contaminated by conditions associated with sample collection procedures. *E. coli* and turbidity field blanks were prepared at one site during all sampling days. At the designated site, sample bottles were labeled, rinsed (if turbidity), and filled with de-ionized 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 used during the project contained detectable levels of *E. coli*; two samples had turbidity detections of 0.1 NTU and one had a value of 0.4 NTU (Appendix B-4). Because the reported values were very low, the data for those days were accepted.

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 and all turbidity samples were analyzed within their 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. Duplicate habitat assessments were performed by two field samplers 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 2017 Prairie Dog Creek Watershed Duplicates

Parameter	No. of samples	No. of Duplicates	% Duplicated	DQO (%)
Water Quality Samples in 2017 (7 sites x 10 samples, 1 site x 9 samples)	79	10	12.6	10
Macroinvertebrate Samples in 2017	3	1	33.0	10
Habitat Assessments in 2017	3	1	33.0	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 10 percent of the sample sites. RPD is calculated by the following formula: RPD = (|Number 1 - Number 2|/((Number 1 + Number 2)/2)) x 100**.** Precision was determined for water quality samples by conducting samples at 10 percent of sample sites. With few exceptions, all samples met the DQOs for precision (Table 5-5).

Table 5-5. Precision of 2017 Water Quality Monitoring Data

Date	Duplicate Sample ID	Site Duplicated	TEMP	pH	COND	DO mg/L	DO %	TURB	*E. coli*
			RPD (%)	RPD (%)	RPD (%)	RPD (%)	RPD (%)	RPD (%)	RPD (%)
SCCD DQO Relative Percent Difference:			*10*	*5*	*10*	*20*	*20*	*20*	*50*
WDEQ DQO Relative Percent Difference or Other:			*10*	*±0.3SU*	*10*	*10*	*10*	*20*	*50 if >100 NA if <100*
5/15/2017	Dup 1	PD01	0.6	0.0	0.2	1.0	0.6	14.9	2.8
5/31/2017	Dup 1	WCC01	2.1	0.2	0.0	1.1	2.0	**21.8**	23.1
6/13/2017	Dup 1	PD05	0.6	0.2	0.7	1.0	0.8	1.2	42.8
6/29/2017	Dup 1	PD05	0.6	0.0	0.7	0.2	0.3	0.7	14.9
7/11/2017	Dup 1	PD06	0.5	0.1	3.8	0.7	0.5	1.3	**68.7**
7/26/2017	Dup 1	MC01	1.1	0.0	0.6	0.2	0.1	3.7	**56.1**
8/8/2017	Dup 1	PD09	0.0	0.1	5.1	0.3	2.5	6.5	5.5
8/22/2017	Dup 1	JC01	1.9	0.5	0.7	0.1	0.6	9.9	14.6
9/7/2017	Dup 1	PD01	0.8	0.2	0.3	0.8	0.8	5.6	15.1
9/20/2017	Dup 1	PD10	1.0	0.1	0.6	1.7	1.9	0.0	14.2
AVERAGE RPD FOR ALL SAMPLES			**0.93**	**0.16**	**1.27**	**0.73**	**1.01**	**6.57**	**25.77**

All temperature, pH, conductivity and dissolved oxygen samples met the appropriate DQO for precision. One turbidity sample on May 31 exceeded the DQO for precision of 20%. The relative percent difference for that sample was 21.8% which was only slightly above the DQO. Because turbidity values can be relatively low, small variations can result in high RPDs. Two *E. coli* samples exceeded the precision DQO of 50%. The samples occurred on July 11 and 26 and had a relative percent difference of 68.7% and 56.1%, respectively. All other RPDs for the duplicates on these dates were within the DQOs, thus all of the data for these days were accepted.

Duplicate samples were collected at 10% of the macroinvertebrate and habitat assessment sites. Intra-crew habitat duplicates were conducted simultaneously by each observer conducting the assessment without communication. The RPD for total macroinvertebrate abundance was 6.1% and the RPD for total macroinvertebrate taxa was 9.3% which was within the established DQO. The RPD for the duplicate habitat assessment was 0.0%, which was within the DQO of 15%.

Table 5-6. Precision of 2017 Benthic Macroinvertebrate and Habitat Monitoring Data

Parameter	PD06 Duplicate 1	PD06 Duplicate 2	(% - RPD)	DQO (%)
Total Abundance	7749	7290	6	50
Total Taxa	41	45	9	15
Intra-Crew Habitat Assessment Score	134	134	0	15

5.5.8 *ACCURACY*

Accuracy is the degree of agreement of a measured value with the true or actual value. Accuracy for water quality parameters measured in the field was assured by calibration of equipment to known standards. Conductivity, dissolved oxygen, and pH meters were calibrated on the morning of every sampling event. A "crushed ice test" was used to verify the accuracy of the continuous temperature data loggers. There are no current laboratory methods to determine the accuracy of biological samples; therefore, the accuracy of *E. coli* samples could not be determined. Accuracy for macroinvertebrate sampling and habitat assessment could not be determined since the true or actual value for macroinvertebrate populations or habitat parameters was unknown. Precision served as the primary QA check for *E. coli* bacteria, macroinvertebrates, and habitat 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 all parameters were met (Table 5-8).

Due to a delay in obtaining access permission, the Meade Creek site was not surveyed on the first scheduled sampling day; only nine out of ten sample days were completed at this site, resulting in a lower completeness value for all water quality parameters. Discharge values on May 31st at Jenks Creek and PD10 were discarded as a result of misread gauge heights, resulting in a lower discharge completeness value.

Table 5-7. Completeness of 2017 Monitoring Data

Parameter	% 2017 Completeness	DQO (%)
Water Temperature	99	95
pH	99	95
Conductivity	99	95
Dissolved Oxygen	99	95
Discharge	96	90
Turbidity	99	95
E. coli	99	95
Total Abundance of Macroinvertebrates	100	95
Total Taxa	100	95
Intra-Crew Habitat Assessments	100	100

5.6 Data Validation

Data generated by the contract laboratories was subject to the internal QA/QC procedures 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 summary statistics, as specified in the SAP for this project (Gilbert, 1987 and SCCD, 2017). No values were reported below the detection limits in 2017. One *E. coli* sample from Meade Creek on June 13 was reported as >2419.6; SCCD used 2420 for calculation of relative percent difference for precision and for calculation of geometric means and summary statistics.

5.7 DOCUMENTATION AND RECORDS

All water quality field data were recorded on data sheets prepared for the appropriate waterbody and monitoring station. Hard copies of the data sheets were maintained in a binder. Macroinvertebrate and habitat assessment data were recorded onto data sheets that were in a similar format to those used by WDEQ in the past. WDEQ now uses a more comprehensive protocol for macroinvertebrate and habitat assessments, but SCCD decided to continue with their methods for consistency and simplicity. Equipment checklists, COC forms, and calibration and maintenance 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, maintained in digital and print format 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 electronic computer files. Each project workbook file was constructed with reportable data (accepted after QA/QC checks) by entering 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 only after approval 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, arithmetic means, geometric means, and graphics for this report. 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 (May 15-July 11, June 13-August 8 and July 26-September 20). Summary statistics did not include discarded data.

5.9 DATA RECONCILIATION

Data collected by SCCD were evaluated before being accepted and entered 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 or excursions were identified, the data were accepted as presented. Otherwise, data were rejected and not included in the project database.

5.10 DATA REPORTING

Data collected by SCCD for this project are presented in tabular, narrative, and graphical formats throughout this report. This report will be submitted to WDEQ and other interested parties as necessary. 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 will also be available.

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. WDEQ also now provides datasheet templates for monitoring site information and water quality sampling data. After these templates have been completed with the appropriate reportable data, they are saved electronically and submitted to WDEQ with the final report. 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. 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. Standards Applicable for 2017 Prairie Dog Creek Watershed Monitoring (WDEQ, 2013)

NUMERIC STANDARDS		
Parameter	**Reference**	**Standard / Description**
Dissolved Oxygen	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	Section 27	Geometric mean of a consecutive 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	Sections 26; Appendix B	6.5-9.0 standard units
Temperature	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	Section 23	For cold water fisheries and drinking water supplies, discharge shall not create increase of 10 NTU's.
NARRATIVE STANDARDS		
Settleable Solids	Section 15	Shall not be present in quantities that degrade aesthetics, aquatic life habitat, public water supplies, agricultural or industrial use, or plants and wildlife.
Floating and Suspended Solids	Section 16	Shall not be present in quantities that degrade aesthetics, aquatic life habitat, public water supplies, agricultural or industrial use, or plants and wildlife.
Taste, Odor, Color	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	Section 32 Hargett (2011)	High Valleys Bioregion: Score >48.77 for full support; Score 32.51-48.76 for indeterminate support; and score ≤32.50 for partial/non-support.
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
Conductivity	King (1990)	Concentrations greater than 6900 µmhos/cm may affect aquatic organisms in ponds in NE Wyoming.

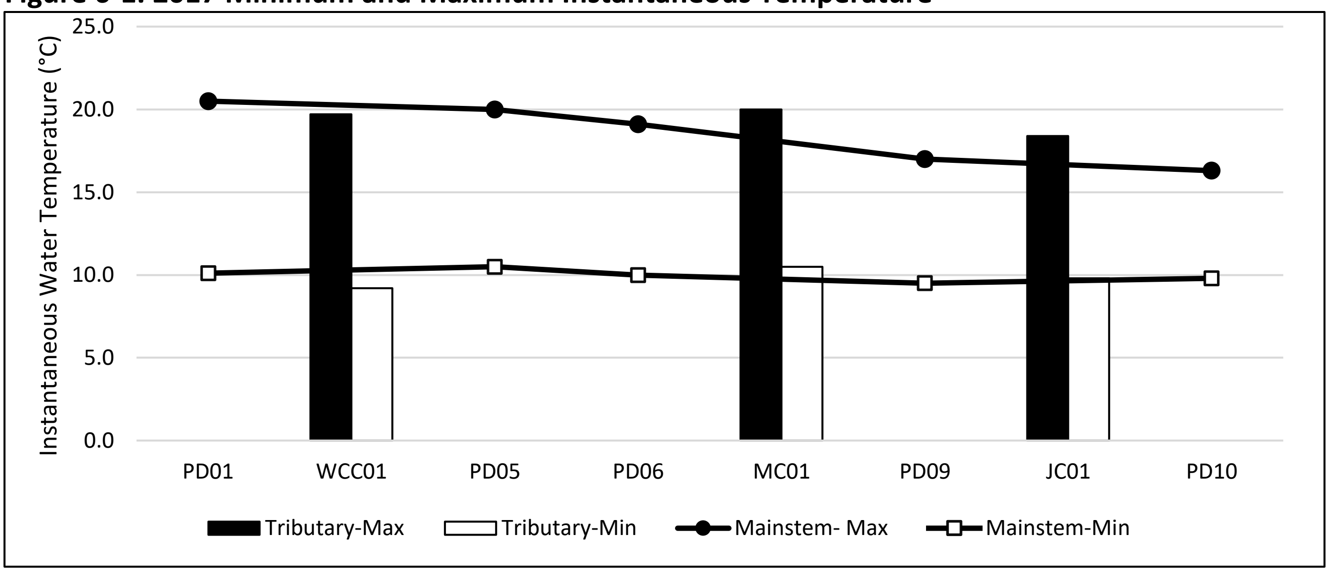
6.2 FIELD WATER CHEMISTRY AND PHYSICAL PARAMETERS

Water quality data were collected from May 15 to September 20, 2017 at eight stations (Appendix Tables C3 through C10). Summary statistics were calculated for all instantaneous monitoring parameters on accepted data (Appendix C-11). 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.

6.2.1 INSTANTANEOUS WATER TEMPERATURE

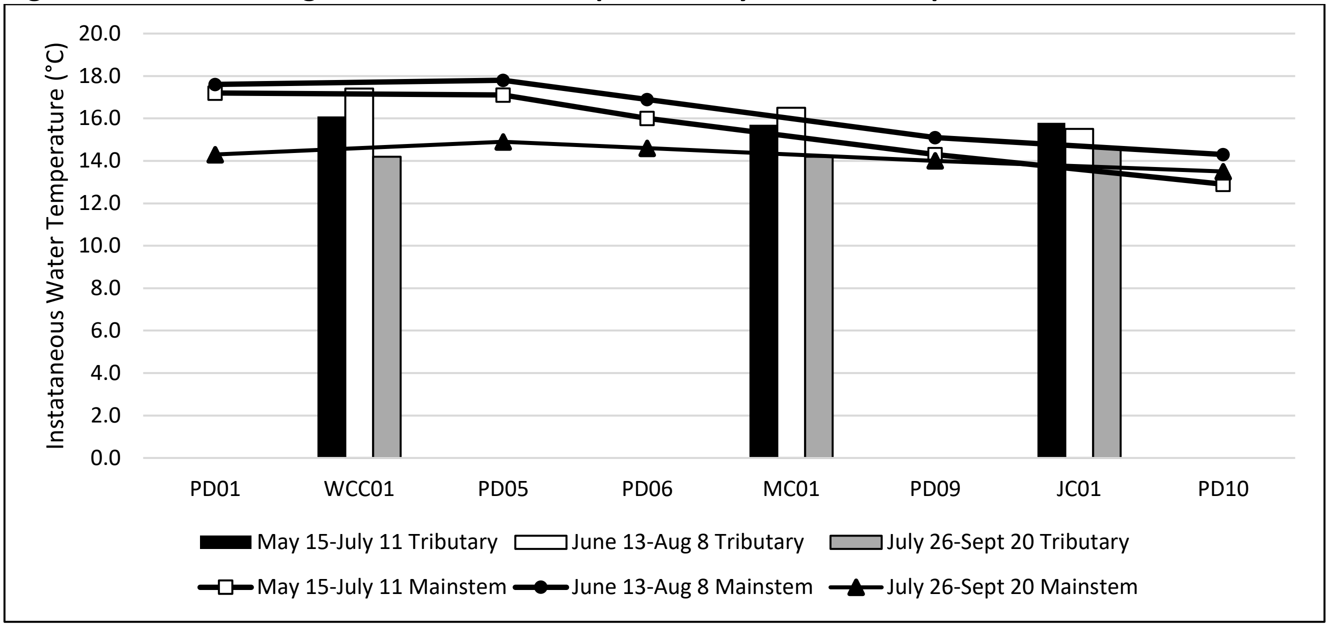
Instantaneous water temperatures were recorded at or above the maximum 20°C instream temperature standard at two stations on July 11. Site PD01 reported a temperature of 20.5°C and site PD05 reported a temperature of 20.0°C. All other stations reported instantaneous water temperatures below the maximum 20°C temperature standard during the 2017 monitoring season (Figure 6-1). Instantaneous temperature measurements do not necessarily represent daily minimum, maximum, or average water temperatures.

Figure 6-1. 2017 Minimum and Maximum Instantaneous Temperature



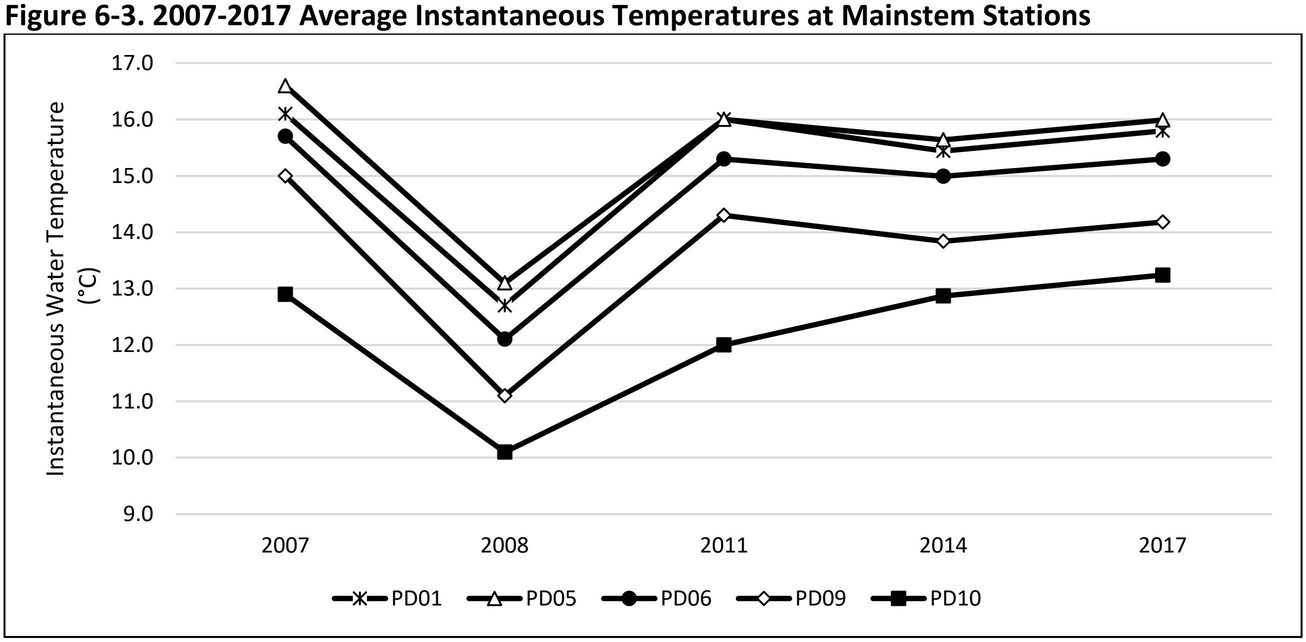
Average instantaneous temperature measurements were highest during the June 13-August 8 period at most stations, including all mainstem sites (Figure 6-2). Jenks Creek reported temperatures from May 15-July 11 that were higher than June 13-August 8. Average instantaneous temperature measurements were lowest during July 26-September 20 at all stations, apart from PD10, which had lower averages during May 15-July 11. Average instantaneous temperatures generally increased from upstream to downstream at mainstem sites.

Figure 6-2. 2017 Average Instantaneous Temperature by Site and Sample Period



Changes in seasonal average instantaneous water temperatures were relatively consistent among mainstem stations from 2007-2017. Average instantaneous water temperatures decreased at all stations from 2007 to 2008, increased from 2008 to 2011, and decreased from 2011 to 2014, with the exception of PD10 (Figure 6-3). Average instantaneous water temperature increased slightly at PD10 from 2011 to 2014. Average instantaneous water temperature measurements at all stations increased from 2014 to 2017. Direct comparisons among years are difficult because of variations in water quantity and air temperatures.

Figure 6-3. 2007-2017 Average Instantaneous Temperatures at Mainstem Stations



6.2.2 *Continuous Water Temperature*

Continuous temperature data loggers were deployed at four Prairie Dog Creek stations. The logger at PD09 was found on the bank at time of retrieval on October 24. Abnormally high temperatures were recorded after October 2 and have been discarded, as this is most likely when the pendant at PD09 was no longer in the water. All but one station reported temperatures that exceeded the temperature standard of 20° C (Appendix Figures C1 through C4). The uppermost station on Prairie Dog Creek, PD10, did not have any measurements above 20°C.

The lowest station, PD01, had extended periods from June through August where the daily maximum temperatures exceeded 20°C; with only a few exceptions, the daily minimums were below 20°C. Sites PD06 and PD09, located mid-watershed, also had temperatures above 20°C, but the periods were not as long, and the maximum temperatures were not as high. Temperatures at PD10 increased throughout June and August, but did not exceed 20°C.

PD01 and PD10 reported maximum temperatures on July 13 (Table 6-2). Maximum temperatures at PD06 and PD09 occurred on July 5 and July 20, respectively. The highest continuous temperature reported overall, 27°C, occurred at PD01. The logger at PD09 did not have a full dataset; reported minimum temperatures may not represent the actual minimum daily temperature for that site.

Table 6-2. 2017 Daily Average, Maximum and Minimum Continuous Temperatures

Site	Maximum Temperature (°C)		Minimum Temperature (°C)		Average Temp (°C)	# of Days Maximum Temp >20°C	# of Days Minimum Temp >20°C	# of Days Average Temp >20°C
	Temp (°C)	Date	Temp (°C)	Date				
PD01	26.98	7/13	4.1	10/15	16.3	66.0	6.0	38.0
PD06	22.8	7/5	4.9	10/15	14.9	35.0	0.0	8.0
PD09[A]	21.7	7/20	3.9	10/2	13.9	17.0	0.0	0.0
PD10	19.5	7/13	4.6	5/20	12.7	0.0	0.0	0.0

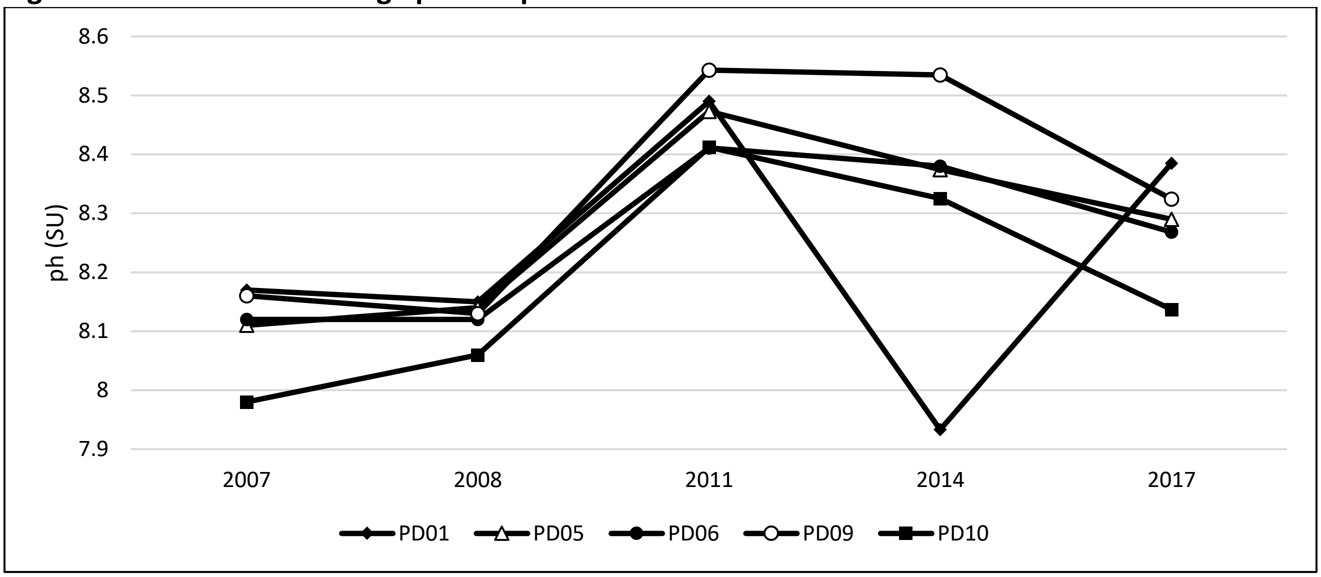
[A] Logger found on bank; data discarded after 10/2/2017

Yearly comparisons for 2007, 2008, 2011, 2014 and 2017 at PD01 showed that daily temperatures for 2017 were most similar in pattern to 2011 (Appendix Figure C-5). Average daily water temperatures during the first half of June 2017 were generally higher than those in all other years, whereas average daily water temperatures from July 25-August 8, 2017 were lower than those in all other years. Overall, mid-summer averages in 2017 were similar to other monitored years.

6.2.3 pH

Ranging from 7.73 to 8.65, all pH values were within the Wyoming Water Quality Standard of 6.5-9.0 SU during the 2017 season. Average pH values at mainstem sites have remained relatively consistent since 2007, with the exception of site PD01 (Figure 6-4). From 2011 to 2014, average pH at PD01 decreased somewhat drastically in comparison to changes at other sites. Similarly, from 2014 to 2017, while all other stations reported decreases in average pH, an increase was reported at PD01.

Figure 6-4. 2007-2017 Average pH Comparisons at Mainstem Stations



Average pH for all stations was higher in 2017 than the average pH for all stations in 2007 and 2008, but slightly lower than the average pH at all stations in 2011 and 2014, apart from PD01 (Table 6-3). Average pH at PD01 was lowest in 2014 than in all other monitored years.

Table 6-3. 2007-2017 Average pH for stations within the Prairie Dog Creek watershed

Site	2007	2008	2011	2014	2017
PD01	8.17	8.15	8.49	7.93	8.39
WCC01	8.04	8.01	8.41	8.40	8.29
PD05	8.11	8.14	8.47	8.37	8.29
PD06	8.12	8.12	8.41	8.38	8.27
MC01	8.17	8.15	8.40	8.26	8.21[A]
PD09	8.16	8.13	8.54	8.54	8.32
JC01				8.50	8.17
PD10	7.98	8.06	8.4	8.3	8.1

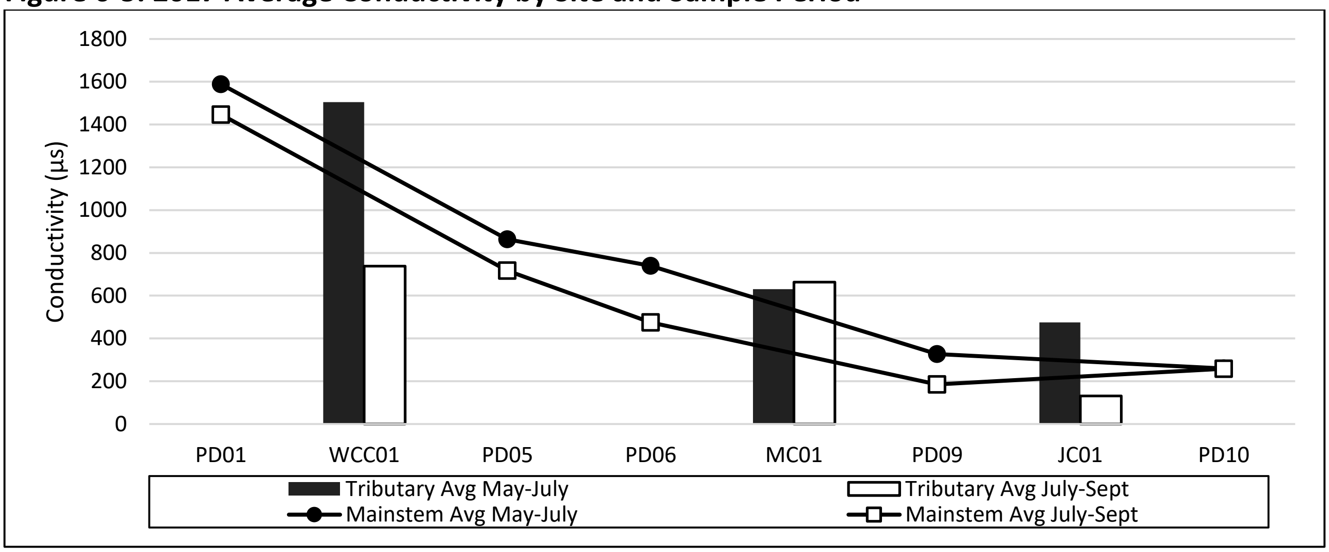
[A] MC01 2017 arithmetic mean was calculated on 4 samples; site was not sampled on May 15

6.2.4 *Conductivity*

Conductivity averages at all mainstem stations increased from upstream to downstream through May to September, with one exception (Figure 6-5). PD10 had a higher conductivity average (259 µS) than PD09, just downstream (257 µS). Conductivity averages also increased from upstream to downstream at the three tributary stations. Averages at the tributary stations were generally higher than their adjacent mainstem stations. The highest conductivity, 2500 µS, was observed at Wildcat Creek on May 15. The lowest conductivity, 104 µS, was observed at Jenks Creek on July 26.

At mainstem stations, conductivity averages were higher from May-July at all stations, apart from PD10. Conductivity averages at PD10 remained in the same range throughout the season; 260 µS in May-July and 259 µS in July-September. Tributary stations at Wildcat and Jenks Creek were higher from May-July than July-September. Meade Creek reported similar conductivity averages throughout the monitoring season; 631 µS in May-July and 664 µS in July-September.

Figure 6-5. 2017 Average Conductivity by Site and Sample Period



With some exceptions, conductivity values were relatively consistent among years at most stations (Table 6-4). Average conductivity values at most stations were highest during the early season of 2011, apart from Meade Creek and PD10. In general, yearly variability has been greater in the downstream sites.

Table 6-4. 2007-2017 Average Conductivity (µS) Comparisons by Site and Sample Period

Site	May-June/July					July-August/September				
	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2017 (60 day)	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2017 (60 day)
PD01	1131	1180	1801	1419	1589	1446	1173	1845	1393	1447
WCC01	1478	1173	1897	936	1505	637	543	846	603	738
PD05	683	679	1030	758	864	572	472	680	619	717
PD06	567	430	975	643	740	350	334	440	413	475
MC01	881	905	869	685	631[A]	528	417	556	722	664
PD09	261	187	455	310	328	125	145	158	183	185
JC01				466	475				131	132
PD10	284	238	232	253	260	370	381	367	218	259

[A] May-July 2017 arithmetic mean was calculated on 4 samples; site was not sampled on May 15

There is no standard for 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) shall not exceed 500 mg/L for domestic use, 2000 mg/L for agricultural use, and 5000 mg/L for livestock use (WDEQ, 2005). Conductivity is not directly proportional to the TDS concentration, but it can be used to estimate the relative concentration of TDS.

6.2.5 Dissolved Oxygen

All sites met the minimum instantaneous dissolved oxygen concentration standard of 5.0 mg/L for early life stages and 4.0 mg/L for other life stages. PD05 had one sample that was below the 8.0 mg/L water column concentration recommended to achieve the 5.0 mg/L intergravel concentration for early life stages (Table 6-5).

Table 6-5. 2017 Dissolved Oxygen Ranges and Number of Samples Below 8.0 mg/L

Mainstem Sites			Tributary Sites		
Site	# of samples below 8.0 mg/L	Range (mg/L)	Site	# of samples below 8.0 mg/L	Range (mg/L)
PD01	0	8.42 - 10.06	WCC01	0	8.17 -11.61
PD05	1	7.90 - 9.64	MC01	0	8.84 - 9.43
PD06	0	8.10 - 11.30	JC01	0	8.74 -10.27
PD09	0	8.78 - 11.40			
PD10	0	8.32 - 9.88			

PD05 had the lowest overall dissolved oxygen, ranging from 7.90 to 9.64 mg/L. The highest dissolved oxygen was observed at Wildcat Creek, at 11.61 mg/L, on May 15. Wildcat Creek also had the lowest dissolved oxygen for tributaries of 8.17, on June 13.

Early and late season averages were above 4.0 mg/L and 5.0 mg/L for all sites during all sampling years (Table 6-6). Dissolved oxygen averages were below 8.0 mg/L at all sites in the late season of 2008 as well as at Wildcat Creek during the late season of 2007. Average dissolved oxygen values were highest during late season 2017 than all other late season averages.

Table 6-6. 2007-2017 Average Dissolved Oxygen (mg/L) Comparisons

Site	May-June/July					July-August/September				
	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2017 (60 day)	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2017 (60 day)
PD01	9.20	8.71	8.36	8.62	8.83	8.20	7.07	8.74	8.70	9.29
WCC01	9.88	11.05	9.18	9.00	9.36	7.35	6.76	8.36	8.46	9.16
PD05	9.48	10.43	8.98	8.63	8.79	8.06	7.14	8.59	8.17	9.13
PD06	10.12	9.52	9.52	9.35	9.49	8.71	7.63	8.92	8.32	9.45
MC01	10.20	9.27	9.35	9.15	8.56[A]	8.68	7.46	8.31	8.08	9.19
PD09	10.13	9.95	9.78	9.84	10.15	8.39	7.82	9.02	8.85	9.40
JC01				9.11	9.25				8.53	9.25
PD10	9.57	9.64	9.95	9.08	9.48	8.02	7.46	8.19	8.40	8.69

[A] May-July 2017 arithmetic mean was calculated on 4 samples; site was not sampled on May 15

6.3 Discharge

SCCD installed and used calibrated staff gauges to estimate discharge during water sampling events (Appendix Tables C3-C10). Previously, SCCD used USGS "real-time" flow information from USGS Station 06306200 (Prairie Dog Creek near Wakeley Siding); however, data collection at this USGS station was discontinued in June 2016. Historical hydrological information was available from Station 06306250 (Prairie Dog Creek near Acme), which corresponds to site PD01 (Appendix Figure C-6). Flows at PD01 in 2017 were typically lower than USGS normal mean daily flows apart from one flow value at the beginning of the season and two additional flow values at the end of the season.

On mainstem sites PD01, PD05 and PD10, the highest flows occurred on May 15 (Table 6-7). For PD06 and PD09, the highest flows occurred on June 13, and July 11 and 26, respectively. The lowest flows for PD05, PD06 and PD10 occurred on September 7. The lowest flows for PD01 were on July 26; for PD09 on May 31. High and low instantaneous discharge values at tributary stations were more variable and occurred at different times.

Table 6-7. 2017 Highest and Lowest Instantaneous Discharge Measurements

Site	Highest Discharge		2nd Highest Discharge		Lowest Discharge		2nd Lowest Discharge	
	Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)
MAINSTEM SITES								
PD01	5/15	66.89	9/20	48.78	7/26	7.95	8/8	11.15
PD05	5/15	44.31	9/20	40.81	9/7	14.54	7/26	17.27
PD06	6/13	65.88	5/15	43.11	9/7	16.76	6/29	22.03
PD09	7/11 & 7/26	51.95	8/8	43.61	5/31	10.24	5/15	12.11
PD10[A]	5/15	6.49	6/13	5.05	9/7 & 9/20	1.56	8/22	2.18
TRIBUTARY SITES								
WCC01	8/22	12.12	6/13	11.88	6/29	0.78	5/15 & 5/31	1.09
MC01[B]	5/31	12.74	6/13	11.24	9/7	2.86	8/22	4.79
JC01[C]	7/26	65.11	7/11	62.08	5/15	1.22	9/20	14.51

[A] Inaccurate staff reading; staff and discharge values discarded for May 31
[B] Site was not sampled on May 15; no discharge data for this date
[C] Inaccurate staff reading; staff and discharge values discarded for May 31

Average flows were generally higher during the early season across all years (Table 6-8). Higher flows in the early season may correspond with trans-basin diversions from the Piney Creek drainage. The highest overall flows were observed during the early season of 2011, which corresponds with high precipitation events during the beginning of the 2011 monitoring season. The majority of the sites reported higher average discharge values during early season 2017 than in 2014; whereas the majority of the sites during late season 2017 reported lower average discharge values than in 2014. Typically, average discharge values were more variable across years during the early season than the late season.

Table 6-8. 2007-2017 Average Instantaneous Discharge (cfs) Yearly Comparisons

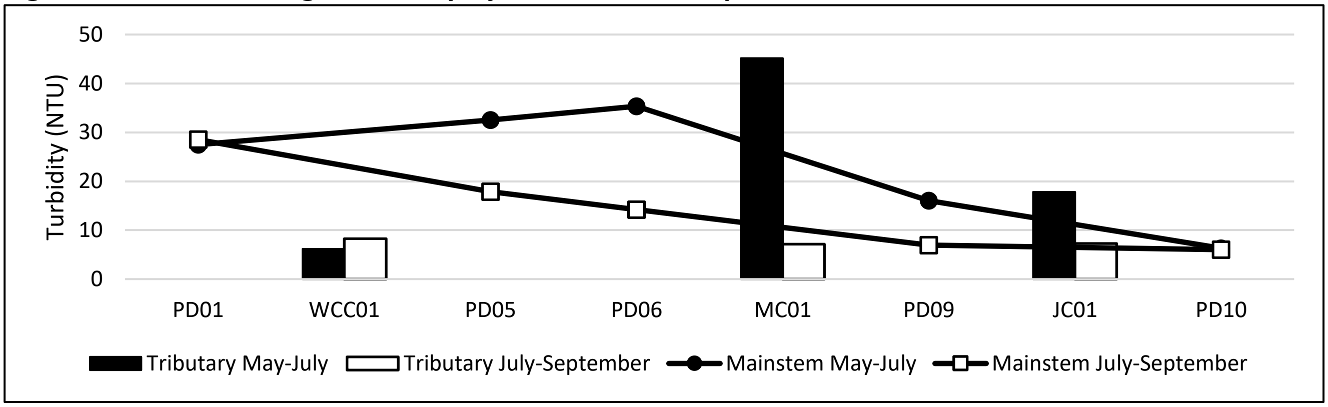
Site	May-June/July					July-August/September				
	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2017 (60 day)	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2017 (60 day)
PD01	111.00	69.20	198.60	45.00	34.81	14.70	20.58	19.00	33.92	23.22
WCC01	2.13	2.09	1.63	6.58	3.47	2.53	1.29	1.97	6.37	7.10
PD05	43.68	54.95	54.10	23.17	30.05	26.68	31.05	22.96	22.75	23.68
PD06	42.64	100.42	99.80	37.54	37.76	28.26	37.01	20.23	38.33	27.59
MC01	7.76	2.32	98.33	8.82	9.35[A]	1.06	1.05	38.59	3.45	5.69
PD09	28.84	61.94	16.21	24.57	28.04	43.61	53.67	34.58	40.45	39.11
JC01				17.85	28.56				55.68	42.29
PD10	9.18	8.42	7.70	5.21	4.73	1.81	0.45	0.00	4.56	2.23

[A] May-July 2017 arithmetic mean was calculated on 4 samples; site was not sampled on May 15

6.4 TURBIDITY

Most samples collected in May-July had higher turbidity arithmetic means than samples collected in July-August (Figure 6.8). However, stations PD01 and Wildcat Creek increased from May to September. Average turbidity at PD10 decreased slightly from May-September. These three stations remained within a range of 2.5 NTU between all months. Mainstem sites typically had higher average turbidity values than tributary sites, apart from Meade Creek and Jenks Creek. Meade Creek was higher than all stations in May-July. Average turbidity at Jenks Creek was higher than PD09 and PD10 across all months.

Figure 6-6. 2017 Average Turbidity by Station and Sample Period



Average turbidity was higher in the early season of 2017 than in the early season of 2014 at all sites with the exception of PD01 and Wildcat Creek (Table 6-9). During the late season, average turbidity was lower at all sites in 2017 than in 2014. Overall, turbidity was lower in 2017 during both the late and early seasons than the average turbidity values in 2007. Changes in turbidity at other stations and other years were more variable.

Table 6-9. 2007-2017 Average Turbidity (NTU) Yearly Comparisons

Site	May-June/July					July-August/September				
	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014[A] (60 day)	2017 (60 day)	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2017 (60 day)
PD01	217.40	90.26	246.24	29.53	27.50	18.70	49.00	12.60	41.44	28.52
WCC01	7.32	19.00	9.90	7.13	6.18	26.08	32.74	20.48	15.08	8.28
PD05	120.94	69.94	128.16	20.63	32.52	35.72	44.82	18.12	21.20	17.90
PD06	42.18	125.46	38.78	13.20	35.34	27.22	25.50	12.90	19.68	14.18
MC01	46.38	48.40	31.58	7.13	45.13	9.38	23.40	12.24	10.28	7.12
PD09	34.98	77.44	75.26	7.05	16.02	19.90	17.36	16.00	11.32	6.98
JC01				7.65	17.78				12.10	7.30
PD10	6.72	13.24	15.66	6.10	6.32	9.54	5.60	3.84	5.70	6.02

[A] 2014 arithmetic mean was calculated on 4 samples; lab error for one set of samples

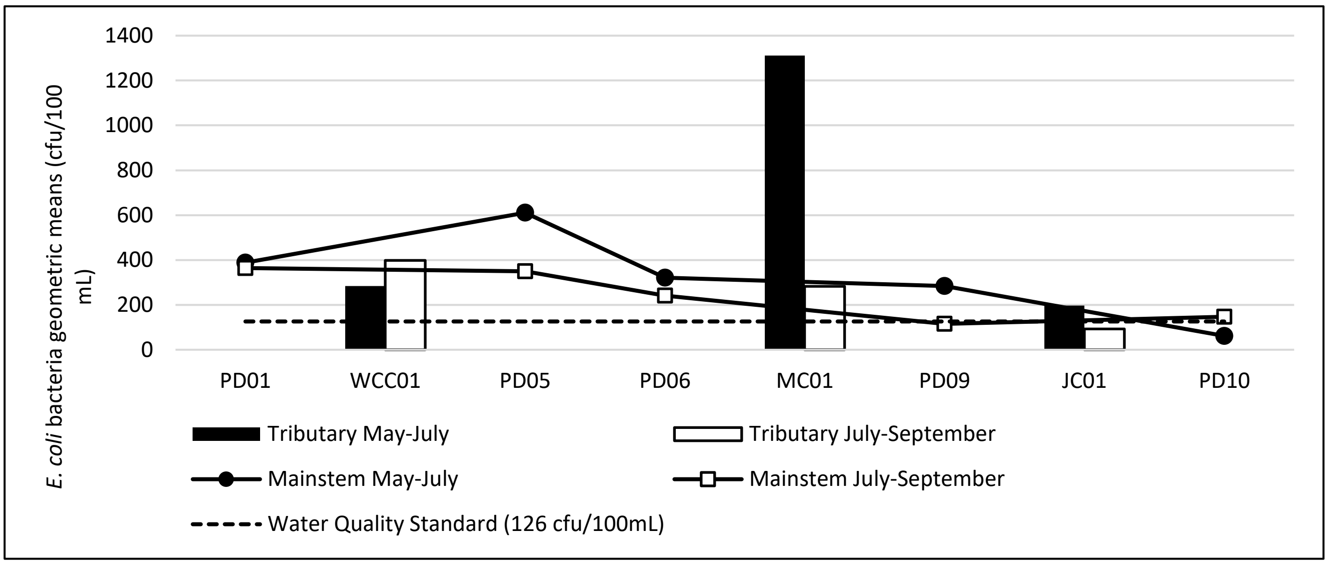
[B] May-July 2017 arithmetic mean was calculated on 4 samples; site was not sampled on May 1

6.5 BACTERIA

Ten *E. coli* bacteria samples were obtained from seven of the eight monitoring stations in May-September 2017 (Appendix Tables C3-C10). Approval for sampling at the Meade Creek site had not been received prior to the first sampling on May 15; thus, bacteria geometric means for 2017 were based on nine samples.

Bacteria geometric mean concentrations from May-July were typically higher than from July-September, except at Wildcat Creek and PD10 (Figure 6-7). May-July geometric means on mainstem sites were highest at PD05 (610 cfu/100 mL) and Meade Creek (1311 cfu/100mL). Bacteria concentrations at tributary stations did not appear to contribute significantly to bacteria increases on Prairie Dog Creek at adjacent downstream stations. May-July and July-September geometric mean concentrations were above Wyoming Water Quality Standards at nearly all stations, with the exception of PD10 (62 cfu/100mL) from May-July, and PD09 (115 cfu/100mL) and Jenks Creek (93 cfu/100mL) from July-September.

Figure 6-7. 2017 *E. coli* Bacteria Geometric Means by Site and Sample Period



Bacteria concentrations increased within a range of 19-403% from 2014 to 2017 at most sites in May-July (Table 6-10). PD10 and Wildcat Creek decreased during this time, by 50% and 9%, respectively. From July-September 2014 to 2017, PD01, PD05 and PD06 increased, whereas all remaining sites decreased. PD05 experienced the largest increase in geometric means, 111%, during this time. The largest decrease was at Jenks Creek, which dropped 45% between the late seasons of 2014 and 2017. Geometric means at mainstem stations typically dropped as the season progressed during 2017, apart from PD10, which nearly tripled by the end of the season. Tributaries Meade Creek and Jenks Creek also reported lower concentrations later in the season, while Wildcat Creek reported higher concentrations during this time.

Table 6-10. 2007-2017 Bacteria Geometric Means and Change by Site and Sample Period

Site		May-June/July					Percent Change			
		2007 (30-day)	2008 (30-day)	2011[A] (30-day)	2014 (60-day)	2017 (60-day)	2007-2008	2008-2011	2011-2014	2014-2017
Mainstem Stations	PD01	746	178	777	327	388	-76%	337%	-58%	19%
	PD05	486	238	502	258	611	-51%	111%	-49%	137%
	PD06	563	673	345	205	321	20%	-49%	-40%	56%
	PD09	445	154	403	161	284	-65%	162%	-60%	76%
	PD10	52	21	62	125	62	-59%	190%	101%	-50%
Tributary Stations	WCC01	237	148	260	312	283	-38%	76%	20%	-9%
	MC01	1411	557	479	261	1311[B]	-61%	-14%	-46%	403%
	JC01				130	197				51%
Site		**July-August/September**					**Percent Change**			
		2007 (30-day)	**2008 (30-day)**	**2011 (30-day)**	**2014 (60-day)**	**2017 (60-day)**	**2007-2008**	**2008-2011**	**2011-2014**	**2014-2017**
Mainstem Stations	PD01	299	799	398	297	364	167%	-50%	-25%	23%
	PD05	430	665	284	166	350	55%	-57%	-41%	111%
	PD06	449	505	395	227	242	12%	-22%	-42%	6%
	PD09	185	236	122	192	115	28%	-48%	57%	-40%
	PD10	236	363	244	197	147	54%	-33%	-19%	-26%
Tributary Stations	WCC01	495	737	592	430	398	49%	-20%	-27%	-7%
	MC01	469	665	396	469	283	42%	-40%	19%	-40%
	JC01				171	93				-45%

[A] May-July 2011 geometric mean was calculated on 4 samples; lab error for one set of samples
[B] May-July 2017 MC01 geometric mean was calculated on 4 samples; site was not sampled on May 15

Overall, early season bacteria concentrations generally decreased from 2007 to 2008, increased from 2008 to 2011, decreased from 2011 to 2014, and increased again from 2014 to 2017. Late season bacteria concentrations typically increased from 2007 to 2008, decreased from 2008 to 2011 and decreased again from 2011 to 2014. Changes in late season concentrations were more variable from 2014 to 2017. In 2014, all sites from both the early and late seasons had bacteria geometric means exceeding Wyoming Water Quality Standards. In 2017, seven sites from May-June and six sites from June-September exceeded Wyoming Water Quality Standards.

Early season bacteria concentrations decreased at mainstem sites PD01 and PD05 from 2007 to 2008, whereas early season concentrations increased from 2007 to 2008 at PD06 (Figure 6-8). Changes in concentrations were more consistent among sites from 2008-2017. Early bacteria concentrations at PD01, PD05 and PD06 increased from 2008 to 2011, decreased from 2011 to 2014, and increased from 2014 to 2017. Late season bacteria concentrations at PD01, PD05 and PD06 increased from 2007 to 2008, decreased from 2008 to 2011, decreased again from 2011 to 2014, and increased from 2014 to 2017. All three sites reported bacteria concentrations across all years that exceeded Wyoming Water Quality Standards.

Bacteria concentrations at sites PD09 and PD10 were more variable across the years (Figure 6-9). PD09 early season concentrations decreased from 2007 to 2008, increased from 2008 to 2011, decreased from 2011 to 2014 and increased from 2014 to 2017. The opposite pattern was observed during the late season at PD09. Early season concentrations at PD10 decreased from 2007 to 2008, increased from 2008 to 2014, and decreased from 2014 to 2017. Late season concentrations at PD10 increased from 2007 to 2008 and then decreased across all monitored years from 2008-2017. PD09 bacteria concentrations were above the Wyoming Water Quality Standards for both seasons across all years, apart from late season concentrations in 2011 and 2017, where the concentrations fell slightly below 126 cfu/mL. PD10 reported concentrations below the Wyoming Water Quality Standards during the early season across all years but exceeded the standard during the late season across all years.

Bacteria concentrations exceeded Wyoming Water Quality Standards at all tributaries, apart from Jenks Creek, which reported concentrations below the standard during the late season of 2017 (Figure 6-10). Jenks Creek early season bacteria concentrations increased from 2014 to 2017; whereas late season concentrations decreased from 2014 to 2017. Overall concentrations at Jenks Creek remained in the same range. Wildcat Creek and Meade Creek experienced more variable bacteria concentrations. Early season concentrations at Meade Creek decreased markedly from 2007 to 2008, and continued to decrease from 2008 to 2014, then increasing notably again from 2014 to 2017. Fluctuations in late season concentrations at Meade Creek were less drastic; increasing from 2007 to 2008, decreasing from 2008 to 2011, increasing from 2011 to 2014 and decreasing from 2014 to 2017. Early season concentrations at Wildcat Creek decreased from 2007 to 2008, increased from 2008 to 2014, and decreased slightly from 2014 to 2017. Late season concentrations at Wildcat Creek increased from 2007 to 2008 and decreased across the remaining monitored years from 2008 to 2017. Late season concentrations at Wildcat Creek were generally higher than early season concentrations.

Bacteria deposits from livestock, humans, wildlife, and other sources can be transported from upland areas to streams through overland run-off. Increased flow from the Tunnel Hill trans-basin diversions, which has augmented flow in Prairie Dog Creek since the late 1880s, has contributed to channel instability, concerns with sand and sediment, and may affect bacteria concentrations, water temperature, and other parameters. Deeper, faster moving water within the stream channels 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 2 to 760 times greater in bottom sediment than in the water column (Stephenson and Rychert, 1982). A similar study on 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.

Figure 6-8. 2007-2017 *E. coli* Bacteria Geometric Means at Mainstem Sites (PD01, PD05, and PD06)

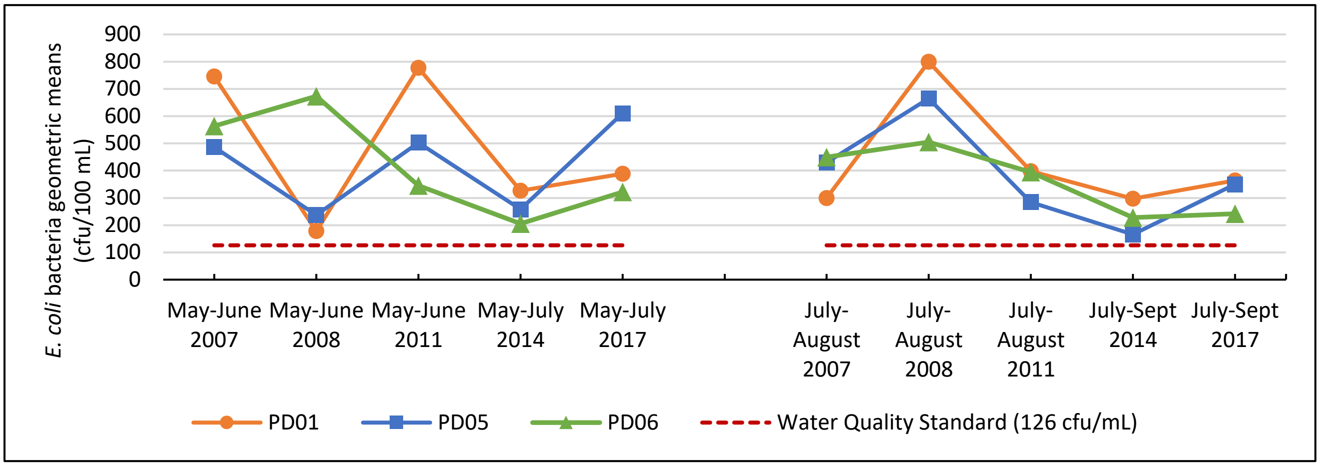


Figure 6-9. 2007-2017 *E. coli* Bacteria Geometric Means at Mainstem Sites (PD09 and PD10)

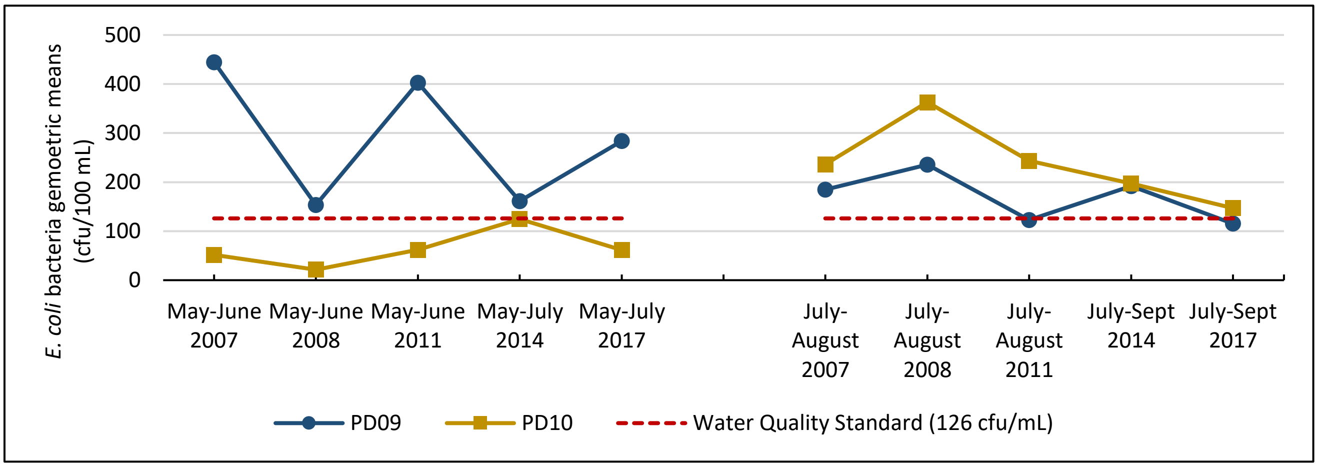
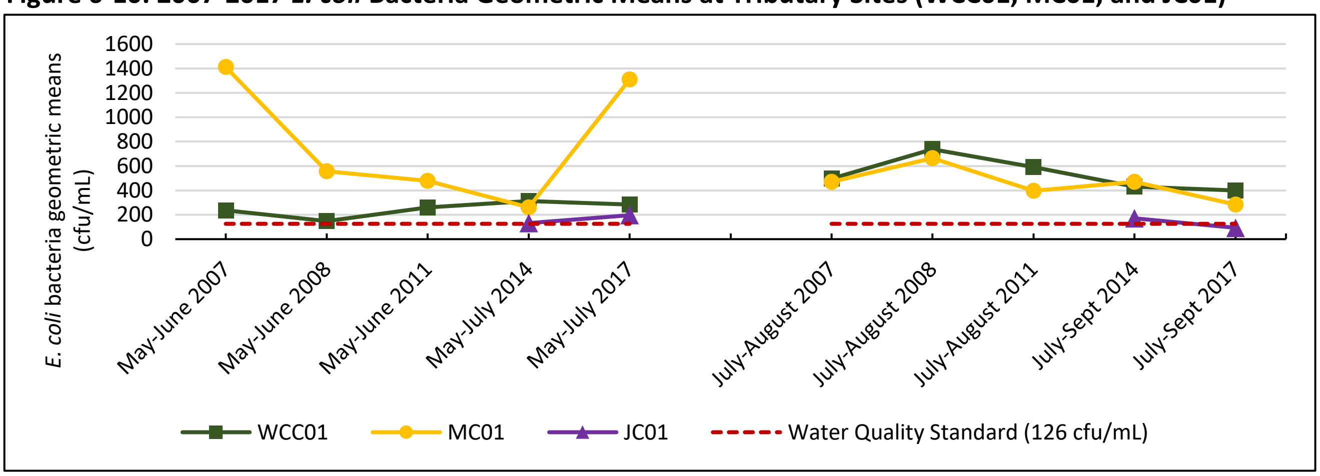


Figure 6-10. 2007-2017 *E. coli* Bacteria Geometric Means at Tributary Sites (WCC01, MC01, and JC01)



6.6 METEOROLOGICAL DATA AND SUPPORTING INFORMATION

Mean daily air temperatures were above normal for most of May-July 2017 and below normal from August-October 2017 (Table 6-11 and Appendix Figure C-7). National Weather Service data at the Sheridan County Airport show normal mean daily air temperatures from May through October average 59.40°F while 2017 temperatures during this time averaged 60.41°F.

Cumulative precipitation through October 2017 was 15.92 inches, which was 3.36 inches higher than normal precipitation (Table 6-11 and Appendix Figure C-8). Winter precipitation in 2017 was 6.10 inches higher than normal, partially contributing to the overall higher cumulative values in 2017. Cumulative precipitation throughout 2017 was higher than normal across all months.

Table 6-11. 2017 Air Temperature and Precipitation data collected by the National Weather Service from the Sheridan County Airport

Months	Average Monthly Air Temperature (°F)		Average Monthly Precipitation (inches)			
	2017	Normal	2017	Normal	2017 Cumulative	Normal Cumulative
January-April					9.73	3.68
May	53.71	52.45	0.07	0.08	10.85	4.89
June	64.03	61.55	0.04	0.07	12.60	7.24
July	74.52	70.05	0.01	0.04	13.30	8.78
August	67.81	68.94	0.01	0.02	13.72	9.70
September	57.33	57.90	0.06	0.05	14.74	10.73
October	45.10	45.50	0.01	0.05	15.92	12.29

6.7 BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates reside in and on the bottom substrate of streams and provide a valuable tool for the assessment of water quality. 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 the majority 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 and Resh, 1993).

Wyoming Water Quality Standards for chemical and physical water quality parameters (WDEQ, 2013) 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 et al., 2000; Jessup and Stribling, 2002; Hargett and ZumBerge, 2006; Hargett, 2011). As such, they may be used as a narrative standard 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, 2013).

6.7.1 Previous Benthic Macroinvertebrate Sampling

Several monitoring groups have collected benthic macroinvertebrate samples in the Prairie Dog Creek watershed since 1977 (Table 6-12). United States Geological Survey (USGS) collected a total of four (N=4) samples from a single sample station located near the current SCCD sample station PD01 during 1977, 2005 and 2006. Bureau of Land Management (BLM) collected a total of four (N=4) samples from two stations in 2004. WDEQ has monitored the watershed intermittently since 1992 and has collected the most historic benthic macroinvertebrate samples (N=20) from thirteen different stations.

The WDEQ benthic macroinvertebrate data was incorporated into this report to provide additional information for biological condition to determine potential change in biological condition of Prairie Dog Creek over time. The WDEQ data could be included in this report since the data was directly comparable to SCCD data. WDEQ and SCCD used the same benthic macroinvertebrate sampling and analytical methods (i.e. 8 random composite Surber samples with 500-micron net, 500-600 organisms identified in the laboratory; similar Standard Taxonomic Effort). Other benthic macroinvertebrate data collected by other monitoring groups was not used to determine biological condition since the sample collection or sample analytical methods differed from those used by SCCD.

SCCD began benthic macroinvertebrate sampling in the watershed in 2007. A total of six (N=6) benthic macroinvertebrate samples were collected each year during October 2007, 2008, and 2011 from five (N=5) monitoring stations on the mainstem Prairie Dog Creek. A total of five (N=5) benthic macroinvertebrate samples were collected in 2014 from four (N=4) monitoring stations. Sampling at Prairie Dog Creek station PD05 was discontinued in 2014 because comparable representative samples could not be collected due to the dominance of sand in the stream substrate. One (N=1) duplicate benthic macroinvertebrate sample was collected each year at a single sample station.

Taxa lists for all historic and current benthic macroinvertebrate samples collected in the Prairie Dog Creek watershed through 2008 were presented in Appendix D, Tables D-1 through D-40 *in* SCCD (2009). Table 7.1 *in* SCCD (2009) cross-referenced the taxa list and the location of the sample station to the taxa summary tables in Appendix D (SCCD, 2009).

6.7.2 Benthic Macroinvertebrate Sampling in 2017

A total of four (N=4) benthic macroinvertebrate samples were collected in October 2017 from three (N=3) monitoring stations on Prairie Dog Creek. Prairie Dog Creek station PD08 was not sampled in 2017. One (N=1) duplicate benthic macroinvertebrate sample was collected at Station PD06. The duplicate sample was used for QA/QC purposes, construction of taxa lists and for general discussion of results. The duplicate sample was not used for the determination of biological condition. No benthic macroinvertebrate samples were collected from tributaries to Prairie Dog Creek.

Table 6-12. Historic and Current Benthic Macroinvertebrate Sampling Stations in the Prairie Dog Creek Watershed – 1977 to 2017. Stations Sampled by Sheridan County Conservation District (SCCD) are Shown in Bold.

Stream Name	Station Name	Latitude / Longitude	Elevation (feet)	Sampling Group	Year(s) Sampled	Station Description
Prairie Dog Creek	**PD01**	**44°59'01" / 106°50'24"**	**3477**	**SCCD**	**2007, 08, 11, 14, 17**	**About 150 yards downstream USGS station 06306250**
Prairie Dog Creek	06306250	44°59'02" / 106°50'21"	3480	USGS	1977, 2005, 06	Near USGS Gage Station No. 06306250
Prairie Dog Creek	Lower – Prairie- 02	44°59'01" / 106°50'24"	3480	BLM	2004	Just downstream of USGS Gage Station No. 06306250
Prairie Dog Creek	NGP30	44°50'55" / 106°51'49"	3650	WDEQ	1998	Below Wildcat Creek
Prairie Dog Creek	NGP28	44°50'52" / 106°51'50"	3650	WDEQ	1998	Above Wildcat Creek
Prairie Dog Creek	**PD05**	**44°49'11" / 106°54'03"**	**3740**	**SCCD**	**2007, 08, 11**	**Upstream Highway 336 and Railroad Line**
Prairie Dog Creek	NGP31	44°44'20" / 106°52'43"	3920	WDEQ	1998	About ½ mile below Highway 14
Prairie Dog Creek	Upper Prairie- 01	44°43'56" / 106°52'29"	3950	BLM	2004	Downstream Highway 14
Prairie Dog Creek	**PD06**	**44°43'48"/ 106°52'29"**	**3960**	**SCCD**	**2007, 08, 11, 14, 17**	**About 100 yards upstream Highway 14 crossing**
Prairie Dog Creek	NGP32	44°42'19" / 106°51'30"	4030	WDEQ	1998	Below confluence w/Meade Creek
Prairie Dog Creek	NGPI13	44°42'16" / 106°51'28"	4050	WDEQ	1992, 98	About 0.7 mile above confluence w/Meade Creek
Prairie Dog Creek	NGP33	44°39'35" / 106°50'12"	4150	WDEQ	1998	About 0.3 mile below confluence w/Murphy Gulch
Prairie Dog Creek	**PD08**	**44°39'36" / 106°50'11"**	**4160**	**SCCD**	**2007, 08, 11, 14**	**About 0.1 mile below confluence w/Murphy Gulch**
Prairie Dog Creek	NGP29	44°37'48" / 106°50'06"	4260	WDEQ	1998	About 2.0 mile above confluence w/Murphy Gulch
Prairie Dog Creek	NGPI12	44°37'12" / 106°50'37"	4340	WDEQ	1992, 98	About 100 yards below confluence w/Jenks Creek
Prairie Dog Creek	NGPI11	44°37'08" / 106°50'35"	4360	WDEQ	1992, 98	About 50 yards upstream confluence w/ Jenks Creek
Prairie Dog Creek	**PD10**	**44°36'33" / 106°52'06"**	**4520**	**SCCD**	**2007, 08, 11, 14, 17**	**About 150 yards upstream Highway 87**
Jenks Creek	NGPI10	44°37'01" / 106°50'33"	4360	WDEQ	1992, 98	About 0.1 mile above confluence w/ Prairie Dog Creek
Jenks Creek	MRC91	44°35'20" / 106°50'57"	4480	WDEQ	2000	About 0.4 mile below confluence w/ Peno Creek
Jenks Creek	MRC90	44°35'04" / 106°51'20"	4520	WDEQ	2000	About 0.15 mile upstream confluence w/ Peno Creek
Meade Creek	NGP19	44°42'16" / 106°51'28"	4030	WDEQ	1998	Near confluence w/Prairie Dog Creek

6.7.3 *Benthic Macroinvertebrate Taxa*

A total of two hundred thirty-three (N=233) benthic macroinvertebrate taxa have been identified from streams in the Prairie Dog Creek watershed since 1977 (Appendix D, Table D-5). The family Chironomidae (midge flies) comprised the largest number of taxa (N=53) followed by the order Trichoptera (caddisflies) (N=37) taxa, the order Ephemeroptera (mayflies) (N=36) taxa, the order Coleoptera (beetles) with twenty (N=20) taxa, and the order Plecoptera (stoneflies) with sixteen (N=16) taxa.

Seven new taxa were identified during 2017 including the water mite genera *Lebertia, Sperchon and Wandesia*, the dipteran genus *Meringodixa*, the mayfly genus *Neoleptophlebia*, the mayfly species *Tricorythodes explicatus* and the worm genus *Bothrioneurum*.

The identification of *Lebertia, Sperchon* and *Wandesia* was due to enhanced taxonomic resolution since water mites were previously identified only to subclass. Water mites are common in the Prairie Dog Creek watershed streams occurring in 89 percent of samples collected since 2007 (Appendix D, Table D-5). The three water mite genera are common in Wyoming streams.

Meringodixa was identified at Prairie Dog Creek station PD10. This genus is uncommon in North-Central Wyoming streams occurring only in the Big Horn Mountains at Cross Creek, a wilderness stream, and at a high elevation unnamed tributary to the East Fork of the South Tongue River. Arnett (2000) reported that the family Dixidae in which *Meringodixa* is included, is mostly northern in distribution and not widespread. Courtney and Merritt (2008) indicated that *Meringodixa* was distributed only in the western United States.

The occurrence of the mayfly genus *Neoleptophlebia* was due to a change in nomenclature from the genus *Paraleptophebia* (Tiunova and Kluge, 2016). *Paraleptophebia* frequently occurred in about 30 percent of previous Prairie Dog Creek samples. Accordingly, previous taxa lists containing *Paraleptophebia* will be replaced with *Neoleptophlebia.* A similar situation existed with the occurrence of *Tricorythodes explicates. Tricorythodes minutus* was synonymized with *Tricorythodes explicates* by Baumgardner (2009). *Tricorythodes minutus* occurred in 30 percent of Prairie Dog Creek samples collected since 2007. As such, previous taxa lists containing *Tricorythodes minutus* will be replaced with *Tricorythodes explicates*.

The worm genus *Bothrioneurum* was identified in both samples collected at station PD06 during 2017. *Bothrioneurum* is a widespread genus that is generally most abundant in large rivers in coarse sand substrates (Stimpson et al. 1985). Kathman and Brinkhurst (1998) reported that *Bothrioneurum* was widespread in sand substrates and Brinkhurst (1986) found the genus was widespread, especially in sandy situations.

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 Prairie Dog Creek watershed.

Other aquatic invasive species of significant concern 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 Prairie Dog Creek watershed or adjacent Tongue River, Little Goose Creek and Big Goose Creek watersheds.

The caddisfly genus *Hydropsyche* and caddisfly species *Brachycentrus occidentalis* occurred most frequently in samples collected in the Prairie Dog Creek watershed (Appendix D, Table D-5). *Hydropsyche* occurred in 93% of the historic samples collected from 1977-2006, and in 85% of samples collected by SCCD during the current study. *B. occidentalis* occurred in 88% of the historic samples, and in 74% of samples collected by SCCD during the current study. Trombidiformes (water mites) were common in samples occurring in 80% of all historic samples and in 89 of samples collected during the current study. The mayfly species *Baetis tricaudatus complex* occurred in 68% of the historic samples and in 81% of samples collected during the current study. The Chironomidae genera *Cricotopus*, *Rheotanytarsus, Eukiefferiella, Micropsectra and Polypedilum* occurred in 89%, 70%, 67%, 67% and 67%, respectively, of samples collected during the current study. The riffle beetle genera *Microcylloepus, Optioservus* and *Dubiraphia* were common and occurred in 59%, 44%, and 44%, respectively, of samples collected during the current study. The stonefly genera *Isoperla and Taenionema* were the most common stonefly genera and occurred in 59% and 48%, respectively, of samples collected during the current study.

All benthic macroinvertebrate taxa collected by SCCD during the current study have been previously identified from other waterbodies sampled in North-Central Wyoming.

6.8 BIOLOGICAL CONDITION

Biological condition scores were determined using the Wyoming Stream Integrity Index (WSII) initially developed by Jessup and Stribling (2002), updated by Hargett and ZumBerge (2006) and revised by Hargett (2011). The WSII is based on the analysis of 1,488 benthic macroinvertebrate samples collected by WDEQ from 1993 through 2009 from multiple 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 between bioregions.

Biological condition scoring criteria developed for the High Valleys bioregion were used to evaluate biological condition for streams in the Prairie Dog Creek watershed based on stream classifications in Hargett (2011). Table 6-13 lists the WSII metrics and metric formulae used to determine biological condition for benthic macroinvertebrate communities in the High Valleys bioregion.

Table 6-13. Wyoming Stream Integrity Index (WSII) metrics and scoring criteria for benthic macroinvertebrate communities in the High Valleys bioregion (from Hargett, 2011)

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

Table 6-14. Assessment rating criteria for benthic macroinvertebrate communities based on the Wyoming Stream Integrity Index (WSII); (from Hargett, 2011) in the High Valleys bioregion of Wyoming

Rating of Biological Condition (Aquatic Life Use Support)	High Valleys bioregion
Full Support	>48.77
Indeterminate Support	32.51 – 48.76
Partial/ (Non - Support)	0 – 32.50

Metric values for the sample benthic macroinvertebrate community were compared to optimal benthic macroinvertebrate values and expressed as a percent. The percentages were summed for each sample metric to provide a biological condition rating. The calculated biological condition rating was then used to rate the biological community as Full-support, Indeterminate, or Partial/Non-support (Table 6-14). 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 aquatic community is stressed by anthropogenic stressors. Water quality and/or habitat improvements are required to restore the stream to full support for narrative aquatic life use.

The benthic macroinvertebrate metric values used in the determination of biological condition for sample stations in the Prairie Dog Creek watershed are shown in in Table 6-15. Biological condition is presented in Table 6-16 and illustrated in Figure 6-11.

Table 6-15. Benthic macroinvertebrate metric values used in the determination of biological condition for sample stations in the Prairie Dog Creek watershed, 2007, 2008, 2011, 2014 and 2017.

Macroinvertebrate Metric	PD01	PD01	PD01	PD01	PD01	PD06	PD06	PD06	PD06	PD06	PD08	PD08	PD08	PD08
	2007	2008	2011	2014	2017	2007	2008	2011	2014	2017	2007	2008	2011	2014
% Chironomidae Taxa of Total Taxa	30.8	27.6	29.6	28.6	18.2	42.1	39.6	34.5	38.8	34.1	29.3	28.6	31.8	31.7
% Ephemeroptera Taxa of Total Taxa	19.2	13.8	11.1	10.7	13.6	10.5	7.5	9.0	12.2	14.6	14.6	11.9	11.4	12.2
Number of EPT Taxa	10	11	11	9	9	7	15	15	13	14	19	21	17	17
% EPT (less Arctopsychidae and	2.91	20.80	14.62	14.77	5.89	27.14	43.14	39.01	46.95	63.18	38.41	28.80	36.71	36.04
% Scraper	12.71	14.12	1.76	3.19	1.85	0.21	2.99	2.41	1.97	1.04	11.18	15.04	22.40	30.29
BCICTQa	94.58	92.07	89.00	92.63	94.05	99.97	90.32	92.04	93.45	87.00	76.76	75.00	79.48	80.39

Table 6-15. (cont.) Benthic macroinvertebrate metric values used in the determination of biological condition for sample stations in the Prairie Dog Creek watershed, 2007, 2008, 2011, 2014 and 2017

Macroinvertebrate Metric	PD10	PD10	PD10	PD10	PD10
	2007	2008	2011	2014	2017
% Chironomidae Taxa of Total Taxa	27.2	22.0	20.4	34.2	38.3
% Ephemeroptera Taxa of Total Taxa	6.1	12.0	8.2	5.3	8.5
Number of EPT Taxa	11	24	20	11	15
% EPT (less Arctopsychidae and Hydropsychidae	42.86	38.52	61.23	37.38	58.96
% Scraper	3.32	17.49	19.21	0.87	11.56
BCICTQa	79.56	72.51	71.69	79.21	81.32

Table 6-16. Biological condition score and rating for benthic macroinvertebrate samples collected from the Prairie Dog Creek Watershed based on the Wyoming Stream Integrity Index (WSII) for the High Valleys Bioregion (Hargett, 2011).

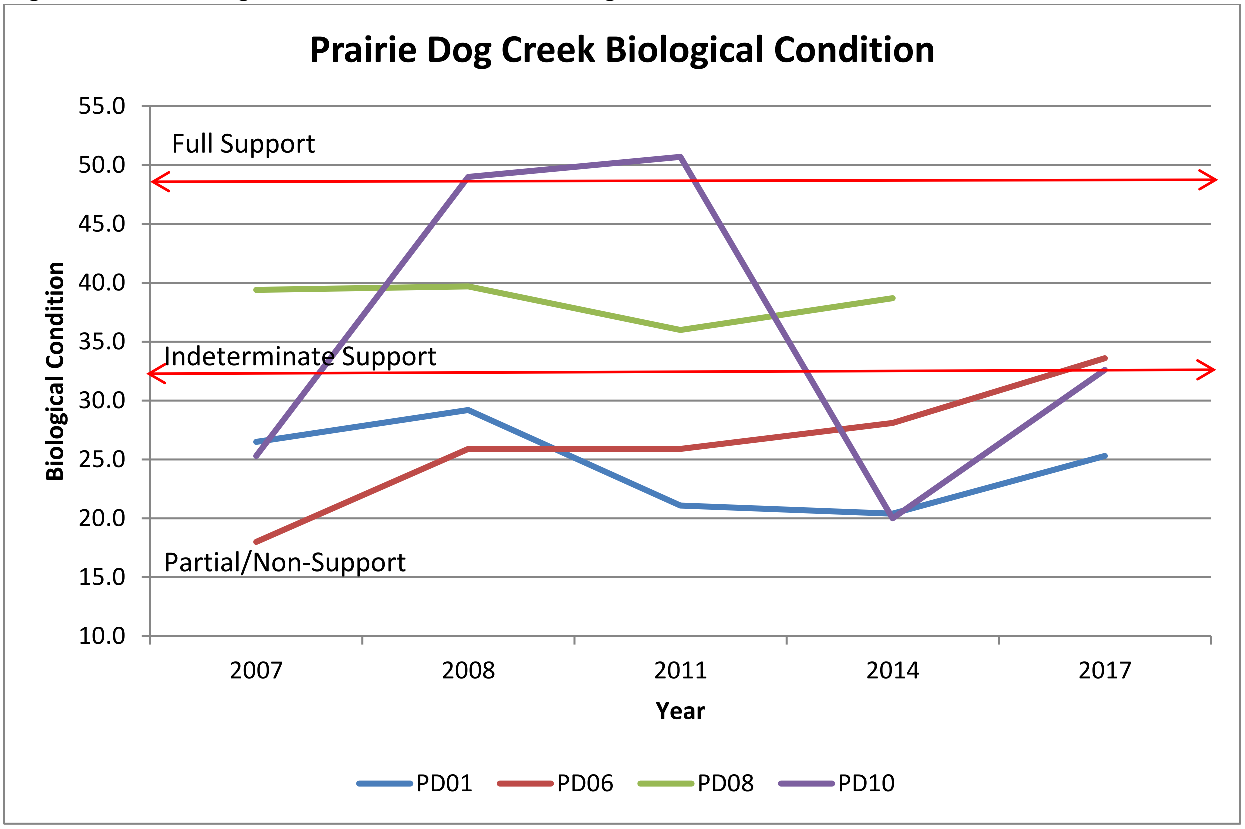
Stream Name	Station Name	Sampling Group	Year	Score	Rating
Prairie Dog Creek	**PD01**	**SCCD**	**2007**	**26.5**	**Partial/ Non-Support**
Prairie Dog Creek	**PD01**	**SCCD**	**2008**	**29.2**	**Partial/ Non-Support**
Prairie Dog Creek	**PD01**	**SCCD**	**2011**	**21.1**	**Partial/ Non-Support**
Prairie Dog Creek	**PD01**	**SCCD**	**2014**	**20.4**	**Partial/ Non-Support**
Prairie Dog Creek	**PD01**	**SCCD**	**2017**	**25.3**	**Partial/ Non-Support**
Prairie Dog Creek	NGP30	WDEQ	1998	52.8	Full
Prairie Dog Creek	NGP28	WDEQ	1998	40.4	Indeterminate
Prairie Dog Creek	PD05	SCCD	2007	0.0	Partial/ Non-Support
Prairie Dog Creek	PD05	SCCD	2008	9.1	Partial/ Non-Support
Prairie Dog Creek	PD05	SCCD	2011	13.9	Partial/ Non-Support
Prairie Dog Creek	NGP31	WDEQ	1998	35.6	Indeterminate
Prairie Dog Creek	**PD06**	**SCCD**	**2007**	**18.0**	**Partial/ Non-Support**
Prairie Dog Creek	**PD06**	**SCCD**	**2008**	**25.9**	**Partial/ Non-Support**
Prairie Dog Creek	**PD06**	**SCCD**	**2011**	**25.9**	**Partial/ Non-Support**
Prairie Dog Creek	**PD06**	**SCCD**	**2014**	**28.1**	**Partial/ Non-Support**
Prairie Dog Creek	**PD06**	**SCCD**	**2017**	**33.6**	**Indeterminate**
Prairie Dog Creek	NGP32	WDEQ	1998	50.5	Full
Prairie Dog Creek	NGPI13	WDEQ	1992	22.3	Partial/ Non-Support
Prairie Dog Creek	NGPI13	WDEQ	1998	40.5	Indeterminate
Prairie Dog Creek	NGP33	WDEQ	1998	41.8	Indeterminate
Prairie Dog Creek	**PD08**	**SCCD**	**2007**	**39.4**	**Indeterminate**
Prairie Dog Creek	**PD08**	**SCCD**	**2008**	**39.7**	**Indeterminate**
Prairie Dog Creek	**PD08**	**SCCD**	**2011**	**36.0**	**Indeterminate**
Prairie Dog Creek	**PD08**	**SCCD**	**2014**	**38.7**	**Indeterminate**
Prairie Dog Creek	NGP29	WDEQ	1998	41.8	Indeterminate
Prairie Dog Creek	NGPI12	WDEQ	1992	32.6	Indeterminate
Prairie Dog Creek	NGPI12	WDEQ	1998	63.7	Full
Prairie Dog Creek	NGPI11	WDEQ	1992	55.1	Full
Prairie Dog Creek	NGPI11	WDEQ	1998	63.7	Indeterminate

Table 6-16. (cont.) Biological condition score and rating for benthic macroinvertebrate samples collected from the Prairie Dog Creek Watershed based on the Wyoming Stream Integrity Index (WSII) for the High Valleys Bioregion (Hargett, 2011).

Stream Name	Station Name	Sampling Group	Year	Score	Rating
Prairie Dog Creek	**PD10**	**SCCD**	**2007**	**25.3**	**Partial/ Non-Support**
Prairie Dog Creek	**PD10**	**SCCD**	**2008**	**49.0**	**Full**
Prairie Dog Creek	**PD10**	**SCCD**	**2011**	**50.7**	**Full**
Prairie Dog Creek	**PD10**	**SCCD**	**2014**	**20.0**	**Partial/ Non-Support**
Prairie Dog Creek	**PD10**	**SCCD**	**2017**	**32.6**	**Indeterminate**
Jenks Creek	NGPI10	WDEQ	1992	33.6	Indeterminate
Jenks Creek	NGPI10	WDEQ	1998	62.4	Full
Jenks Creek	MRC91	WDEQ	2000	71.3	Full
Jenks Creek	MRC90	WDEQ	2000	80.3	Full
Meade Creek	NGP19	WDEQ	1998	37.3	Indeterminate

Biological condition at the lower-most Prairie Dog Creek monitoring station PD01 was Partial/Non-Support during each year (Table 6-16 and Figure 6-11). Biological condition at station PD06 was Partial/Non-Supporting during 2007, 2008, 2011 and 2014. Biological condition improved to Indeterminate during 2017. Biological condition was Indeterminate at station PD08 during 2007, 2008, 2011 and 2014. PD08 was not sampled during 2017. The range in biological condition scores at PD08 among years was narrow and ranged from a score of 36.0 in 2011 to a score of 39.7 in 2008. The most upstream station PD10 exhibited variable biological condition scores. Biological condition was Partial/Non-Support during 2007, then increased to Full support during 2008 and 2011, decreased to Partial/Non-Support during 2014 then increased to Indeterminate support in 2017 (Table 6.16 and Figure 6.11). The degree of variability in biological condition at station PD10 has not been observed at other stations monitored by SCCD in the nearby Tongue River, Little Goose Creek and Big Goose Creek watersheds. The high variability is likely related to unknown changes in water quality, variable stream flow during the irrigation season, percent sand in the stream substrate, or other unknown factors.

Figure 6-11. Biological condition at Prairie Dog Creek stations, 2007, 2008, 2011, 2014 and 2017.



A general improvement was observed in biological condition from the lower-most station PD01 upstream to station PD06, and from station PD06 to station PD08 (Figure 6-11). An increase in biological condition occurred from station PD08 to the most upstream station PD10 during 2008 and 2011, but not during the other years (Figure 6-11). The general improvement in biological condition from station PD01 to station PD10 was related to the increased number of the generally pollution intolerant organisms including Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa, an increase in % scrapers, and a decrease in the BCICTQa metric (Table 6-16). This observation indicated that the benthic macroinvertebrate communities at the downstream monitoring stations were comprised of more pollution tolerant organisms than at the upstream monitoring stations. Benthic macroinvertebrate monitoring conducted by WDEQ in 1992 and 1998 (Table 6-16) showed a similar trend where biological condition improved from downstream to upstream Prairie Dog Creek monitoring stations (WDEQ, 2003).

The highest number of worm taxa and percent composition of worms to the total benthic macroinvertebrate community occurred at station PD06 in 2007 and 2008 (see Appendix D, Tables D-18 and D-19 *in* SCCD, 2009), during 2011 (see Appendix C, Table C-4 *in* SCCD, 2012), 2014 (Appendix C, Table C-2 *in* SCCD, 2016) and during 2017. This observation suggests a source of organic material entering Prairie Dog Creek between station PD06 and upstream stations. Increased density of worms may be associated with organic pollution (Klemm, 1985), pollution from feedlots (Prophet and

Edwards, 1973), and pollutants contained in urban storm water runoff (Lenat et al., 1979; Lenat and Eagleson, 1981). The number of worm taxa at station PD06 in 2007 (N=8), 2008 (N=6), 2011 (N=5), 2014 (N=3), and 2017 (N=3), and the percent contribution of worms in 2007 (16.5%), 2008 (14.4%), 2011 (9.51%), 2014 (5.3%) and 2017 (1.04%) showed a general decline in the number and percent contribution of worms since 2007. This observation did not indicate a severe organic pollution problem, but rather a moderate amount of pollution indicative of animal waste from agricultural, wildlife or urban sources.

Worms comprised 17.8% of the benthic macroinvertebrate community at station PD10 in 2007, but only 0.38% of the community in 2008 (Appendix D, Tables D-32 and D-33 *in* SCCD 2009), 0.13% in 2011 (Appendix C, Table C-6 *in* SCCD 2012), 0.34% (Appendix C, Table C-5 *in* SCCD, 2016) and 0.19% in this report. Although only three (N=3) worm taxa were identified at station PD10 in 2007, the worm genus *Rhyacodrilus* accounted for 8.9% of total organisms and immature Naididae comprised 7.9% of total organisms. The worm species *Aulodrilus pluriseta* was present, but in low abundance (N=7 organisms per square meter). Station PD10 should continue to be monitored to evaluate the reduction in worms since 2007.

The worm genus *Tubifex* was identified in one historic sample and one sample during the current project (station PD6 in 2008). *Tubifex* occurred in only 3% of the total 67 macroinvertebrate samples collected in the Prairie Dog Creek watershed since 1977. However, it should be noted that the frequency of occurrence for *Tubifex* is probably higher in the watershed than indicated since many sampling groups did not identify worms to the generic or species level. The presence of *Tubifex* in streams is of concern since T*ubifex tubifex* (a species of worm) is implicated in the occurrence of whirling disease. Whirling disease is caused by a destructive parasite that may decimate trout populations. *T. tubifex* 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. Although the genus *Tubifex* has been infrequently collected in the watershed, at this time no mature *T. tubifex* have been collected. The presence of the genus *Tubifex* suggests the potential occurrence of *T. tubifex* in the Prairie Dog Creek watershed. Continued monitoring for this organism is suggested not only as an environmental indicator, but as an indicator of future health of trout populations in the Prairie Dog Creek watershed.

Although leeches are likely present in the Prairie Dog Creek watershed, none have been collected since sampling began in 1977.

6.8 HABITAT ASSESSMENTS

Previous qualitative habitat assessments were conducted in conjunction with benthic macroinvertebrate sampling at mainstem Prairie Dog Creek monitoring stations PD01, PD05, PD06, PD08 and PD10 during October 2007, October 2008 and October 2011. As indicated in Section 6.7.1 in this report, Prairie Dog Creek station PD05 was not sampled in 2014 because a comparable representative benthic macroinvertebrate sample could not be collected due to the dominance of sand in the stream substrate. Station PD05 was deleted as a sample station. Habitat assessments were conducted at monitoring stations PD01, PD06, PD08 and PD10 during 2014. Station PD08 was not sampled during 2017, thus stations PD01, PD06, and PD10 were sampled during 2017.

Habitat assessment data, embeddedness values and current velocity data are presented in Table 6-17. The mean percent substrate composition is presented in Table 6-18. The total habitat score could not be determined for station PD10 in 2007 and 2008 because embeddedness (one of the habitat parameters) could not be estimated since the stream substrate was dominated by sand. Because habitat assessments were subjective, SCCD used caution by providing a conservative interpretation of data.

The habitat scores at the Prairie Dog Creek stations during 2017 ranged from lows of 134 at station PD06 and 139 at station PD01, to a high of 154 at station PD10 (Table 6-17). The habitat scores were considered good compared to habitat scores at other comparable streams assessed in North-Central Wyoming.

The riparian zone indicator parameters including bank vegetation protection, bank stability, and disruptive pressures scored moderately high at station PD06 and high at stations PD01 and PD10 indicating that the riparian zone immediately adjacent to the stream channel was in moderate to good condition. Conversely, the riparian zone width parameter scored low at each station. The low rating for this parameter was related to the fact that the stream channel at most monitoring stations was incised and lowered thereby cutting off critical moisture from the stream to the riparian zone for establishment of riparian vegetation.

The semi-quantitative stream substrate particle size distribution indicated that stream substrate varied among the sampling stations (Table 6-18). Station PD01 was dominated by cobble (42% of total substrate) and sand (37% of total substrate). PD06 was intermediate to stream substrate at the other Prairie Dog Creek monitoring stations. Station PD06 during 2017 was dominated by coarse gravel (32% of total substrate) followed closely by cobble (28% of total substrate), sand (26% of total substrate) and fine gravel (14% of total substrate). Station PD10 was dominated by coarse gravel (47% of total substrate), sand (38% of total substrate) and fine gravel (14% of total substrate) with only 1% cobble. Stream substrate comprised of a mixture of cobble, coarse and fine gravel, with minimal sand and silt provides the ideal habitat for benthic macroinvertebrate populations, which serve as an important food source for fish.

Table 6-17. Habitat assessment scores, weighted embeddedness values and current velocities for Prairie Dog Creek stations, 2007, 2008, 2011, 2014 and 2017.

Habitat Parameter	PD01	PD01	PD01	PD01	PD01	PD06	PD06	PD06	PD06	PD06	PD10	PD10	PD10	PD10	PD10
	2007	2008	2011	2014	2017	2007	2008	2011	2014	2017	2007	2008	2011	2014	2017
Substrate / Percent Fines	4	13	18	8	4	3	10	7	5	9	1	1	3	10	7
Instream Cover	15	14	16	12	15	8	13	16	14	14	15	19	18	16	13
Embeddedness	6	20	2	3	6	8	16	12	2	9	ND	ND	17	20	2
Velocity / Depth	11	7	12	8	11	16	16	17	14	16	9	19	15	10	16
Channel Flow Status	20	19	20	19	20	14	19	17	19	18	17	19	18	15	19
Channel Shape	15	14	14	14	15	11	12	13	13	12	12	19	15	13	14
Pool Riffle Ratio	7	6	3	6	7	10	12	13	6	7	6	15	7	12	6
Channelization	14	14	14	13	14	11	11	12	10	11	14	15	14	14	14
Width Depth Ratio	15	12	10	11	15	8	9	12	13	13	14	15	10	13	13
Bank Vegetation Protection	10	9	10	9	10	8	7	8	8	6	10	10	10	9	10
Bank Stability	10	9	10	9	10	8	7	8	8	6	10	10	10	9	10
Disruptive Pressures	10	9	10	9	10	10	7	10	10	9	10	10	10	9	10
Riparian Zone Width	2	3	8	4	2	2	7	8	2	4	4	7	5	4	2
TOTAL SCORE	139	149	147	125	139	117	146	153	124	134	NC	NC	152	154	136
Weighted Embeddedness	43	98	29	30	43	50	82	69	27	54	ND	ND	88	99	81
Current Velocity (ft. per second)	2.69	1.87	2.28	2.20	2.69	1.12	1.81	1.32	1.53	2.08	0.57	0.71	0.69	0.96	0.40

Note: ND = embeddedness values, and thus total habitat scores, were not determined for station PD10 in 2007 and 2008 since substrate was dominated by sand.

NC = Total habitat score was not calculated since the embeddedness value could not be determined.

Table 6-18. Mean percent substrate composition for Prairie Dog Creek stations, 2007, 2008, 2011, 2014 and 2017.

Substrate Type	PD01	PD01	PD01	PD01	PD01	PD06	PD06	PD06	PD06	PD06	PD10	PD10	PD10	PD10	PD10
	2007	2008	2011	2014	2017	2007	2008	2011	2014	2017	2007	2008	2011	2014	2017
% Cobble	42	47	66	61	42	2	1	5	8	28	0	0	0	0	1
% Coarse Gravel	4	18	12	3	4	20	18	20	20	32	1	0	0	1	47
% Fine Gravel	13	8	1	1	13	29	23	20	16	14	0	4	34	75	14
% Silt	1	0	21	0	1	4	0	0	0	0	5	15	5	7	0
% Sand	37	26	0	35	37	46	58	55	56	26	94	81	61	18	38

The large amount of sand at station PD06 since 2007 appeared to be responsible for the reduction in biological condition observed at this station when compared to biological condition at the other monitoring stations. 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, 1969). The increase in sand at this station suggested upstream disruption occurred in the watershed resulting in the increased contribution of sand to the stream channel. The amount of sand in the stream substrate at the Prairie Dog Creek stations should continue to be tracked to determine if the sand deposition increases.

Embeddedness (the amount of silt covering cobble and gravel) was not determined for Station PD10 in 2007 and 2008 since substrate was dominated by sand. The Weighted Embeddedness values may range from 20 (silt covering all cobble and gravel) to 100 (no silt covering cobble and gravel). Thus, the higher the Weighted Embeddedness value, the lower the amount of silt covering cobble and gravel substrate. The mean Weighted Embeddedness value at station PD01 was 49 and 56 at station PD06. The mean of three Weighted Embeddedness values at the upper-most monitoring station PD10 in 2011, 2014 and 2017 was 89. This observation indicated that approximately 5% of cobble and gravel were covered by silt.

The reduction in silt cover on stream substrate appears to promote the production of certain benthic macroinvertebrate groups, especially organisms in the scraper functional feeding group that scrape and ingest food from the surface of cobble and gravel. The deposition of silt covers the surface of cobble and gravel resulting in reduced food for the scrapers. Scrapers accounted for a mean 7% of the benthic macroinvertebrate community at station PD01, 2% at station PD06 and 10% at station PD10.

The mean current velocity during 2007, 2008, 2011, 2014 and 2017 measured at station PD01 was 2.3 feet per second (FPS), 1.6 FPS at station PD06 and 0.7 FPS at station PD10. Current velocity is important because the higher the current velocity, the less silt entrained in the water column will settle out and deposit on the stream substrate. Excess silt present in and on the stream substrate negatively affects the establishment and production of many benthic macroinvertebrates important as a food source for fish.

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CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

Water quality monitoring for 2017 was performed at eight stations; five sites on the mainstem of Prairie Dog Creek, and three sites on tributaries that flow into Prairie Dog Creek; Wildcat Creek, Meade Creek and Jenks Creek. Stations were equipped with a SCCD calibrated staff gauge.

All instantaneous water temperature samples during 2017 were at or below the maximum 20°C instream temperature standard, except for PD01, which reported a temperature of 20.5°C on July 11. Continuous water temperature data loggers reported temperatures that exceeded the temperature standard of 20°C at all but PD10, the uppermost station. Conductivity and pH were within the expected ranges during 2017. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages. One mainstem station, PD05, had a sample that was below the water column concentration recommended to achieve the intergravel concentration for early life stages. Turbidity values were considered normal for the watershed with occasional high values occurring during late-spring, early summer precipitation and run-off events.

Bacteria concentrations in May-July were typically higher than in July-September, except at Wildcat Creek and PD10. May-July and July-September concentrations were above Wyoming Water Quality Standards at nearly all stations in 2017, with the exception of PD10 in May-July, and PD09 and Jenks Creek in July-September. Bacteria concentrations at tributary stations did not appear to contribute significantly to bacteria increases on Prairie Dog Creek at adjacent downstream stations.

Bacteria concentrations increased from 2014 to 2017 at PD01, PD05 and PD06 in May-July and in July-September. PD10, the uppermost mainstem station, and Wildcat Creek, the lowermost tributary station, decreased from 2014 to 2017 in May-July and in July-September. Bacteria concentrations increased at Meade Creek and Jenks Creek from May-July 2014 to 2017, then decreased from July-September 2014 to 2017. In May-July 2017, all but one station (PD10) exceeded Wyoming Water Quality Standards. From July-September 2017, PD09 and Jenks Creek reported bacteria geometric mean concentrations below the standard; all other stations exceeded the standard during this time.

Biological condition based on the collection of benthic macroinvertebrate samples was determined at three mainstem Prairie Dog Creek stations during 2017. No Prairie Dog Creek tributaries were sampled. Biological condition at the lower-most Prairie Dog Creek monitoring station PD01 was Partial/Non-Support during each year. The Partial/Non-support classification indicated the aquatic community was stressed by anthropogenic stressors. Water quality and/or habitat improvements are required to restore the stream to Full support for the narrative aquatic life use. Biological condition at station PD06 was Partial/Non-Supporting during 2007, 2008, 2011 and 2014, but improved to Indeterminate support during 2017**.** 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

Although station PD08 was not sampled during 2017, biological condition was determined for PD08 for the period from 2007 to 2014. Biological condition at station PD08 indicated Indeterminate support during each year. The range in biological condition scores at PD08 among years was narrow and ranged from a score of 36.0 in 2011 to a score of 39.7 in 2008. The most upstream station PD10 exhibited variable biological condition scores. Biological condition was Partial/Non-Support during 2007, then increased to Full support during 2008 and 2011, decreased to Partial/Non-Support during 2014 then increased to Indeterminate support in 2017.

Wyoming Game and Fish Department implemented a monitoring program throughout Wyoming to prevent the establishment of the zebra mussel and the quagga mussel in Wyoming waterbodies**.** No zebra or quagga mussels have been identified by SCCD sampling in the Prairie Dog Creek watershed. Further, other aquatic invasive species of significant concern including the New Zealand Mudsnail and the Asian clam have not identified the in the Prairie Dog Creek watershed or adjacent Tongue River, Little Goose Creek and Big Goose Creek watersheds.

Continued benthic macroinvertebrate sampling is recommended at current Prairie Dog Creek watershed stations including station PD08 as funding allows, to track changes in biological condition. Planning and implementation of remedial measures should continue to restore full aquatic life use support in streams in the Prairie Dog Creek watershed.

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 be anticipated nor expected during monitoring, these varying conditions do make water quality comparisons more difficult. Bacteria concentrations, in particular, are known to vary in response to a number of different water quality and water quantity factors, including changes in water temperature, water quantity, and suspended sediment loads.

Like other watersheds in Sheridan County, the Prairie Dog Creek watershed serves as an important resource for agriculture, wildlife, and scenic value. The watershed, as it exists today, has been defined by irrigation practices and trans-basin diversions since the 1880s. While the system cannot be returned to its natural state, there are opportunities for improvement. Best management practices addressing bacteria and sediment sources, irrigation water conservation and management, and riparian management, can be implemented to improve water quality and the overall health of the watershed.

The data provided by the 2007-2008 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 actually 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 Prairie Dog Creek Watershed on a three-year rotation, pending available funding sources. Planning and implementation of remedial measures to restore full aquatic life use support in the streams in the Prairie Dog Creek watershed should continue. Continued benthic macroinvertebrate sampling should be conducted at stations in the watershed to track potential changes in biological condition.

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APPENDICES

APPENDIX A

2017 Prairie Dog Creek Watershed Maps

APPENDIX B

2017 Prairie Dog Creek Watershed Quality Assurance/Quality Control Documentation

APPENDIX C

2017 Prairie Dog Creek Watershed Water Quality Data

APPENDIX D

2017 Prairie Dog Creek Watershed Benthic Macroinvertebrate Data

APPENDIX E

2017 Prairie Dog Creek Watershed Photos