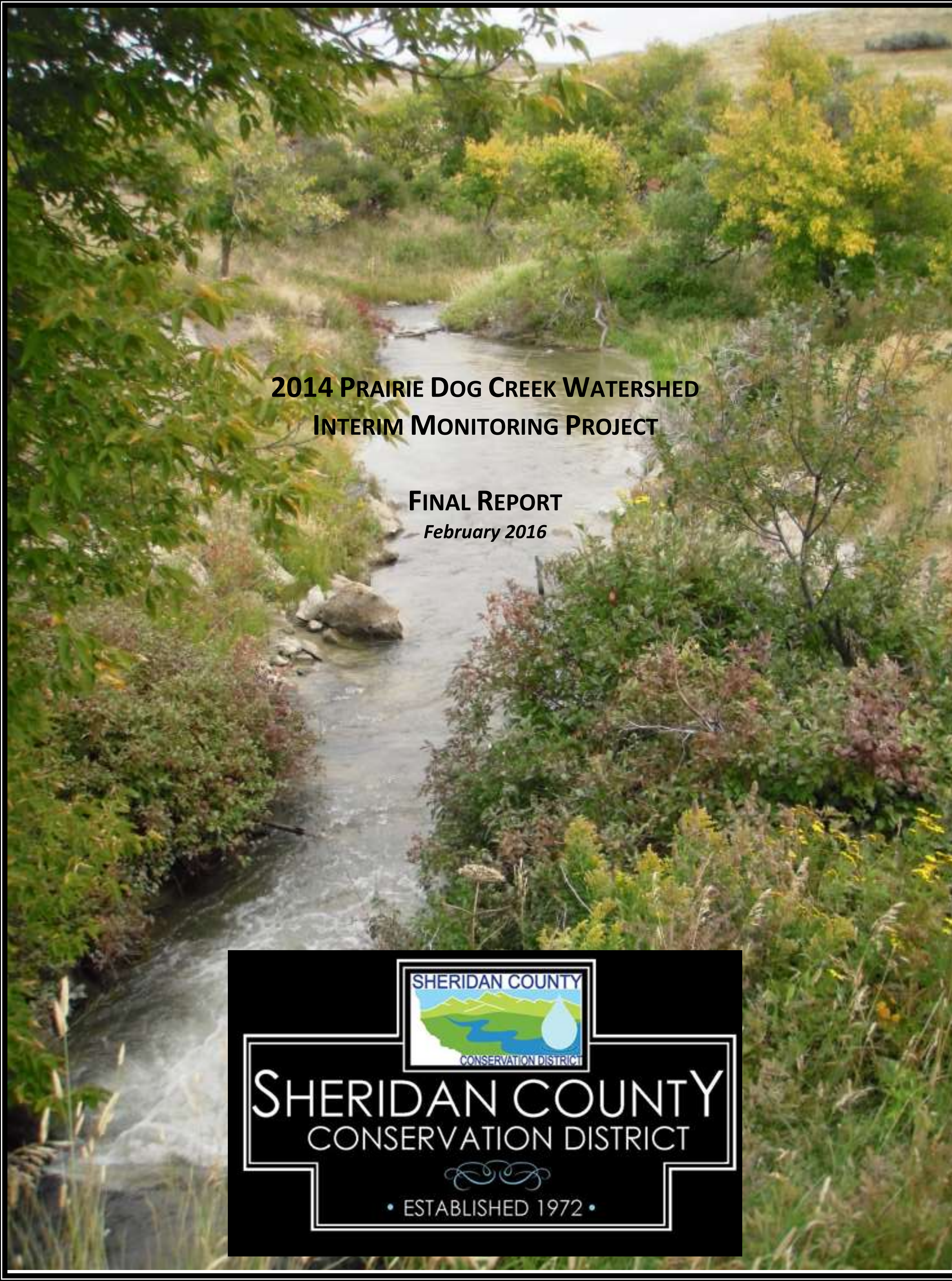

2014 Prairie Dog Creek Watershed Interim Monitoring Project

Final Report

February 2016

Sheridan County Conservation District

Established 1972

TABLE OF CONTENTS

Appendices

List of Figures

List of Tables

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 (cfs) can be diverted from the Piney Creek drainage into Prairie Dog Creek through these diversions.

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; in-stream recreation activities are minimal.

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 (NRCS), and the Wyoming Department of Environmental Quality (WDEQ), 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. There were *E. coli* bacteria concentrations 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.

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 make adjustments to 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.

Interim monitoring was completed in 2011 at the same 14 stations used in 2008. 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 for at least one sampling period. All but the uppermost station (PD10) recorded water temperatures in excess of 20°C.

Water quality parameters monitored in 2014 included: water temperature, pH, specific conductivity, dissolved oxygen, discharge, turbidity, and *E. coli* bacteria. Monitoring was performed at 14 stations; nine sites on the mainstem of the Prairie Dog Creek, four sites on the major tributaries, and one site on Prairie Dog Ditch. Samples were collected 5 times in May-June and 5 times in July-August. Continuous data loggers recorded water temperature at seven stations at 15 minute intervals from May through November. Macroinvertebrate sampling and habitat assessments were performed at four mainstem stations in October. All monitoring methods, standard operating procedures, and data management protocols used for this project were performed according to the WDEQ Manual of Standard Operating Procedures for Sample Collection and Analysis, the SCCD Water Quality Monitoring Program Quality Assurance Project Plan, Revision No. 4, and the Prairie Dog Creek Watershed 2014 Sampling Analysis Plan.

All instantaneous temperature samples during 2014 were below the maximum 20°C instream temperature standard; however, continuous temperature data loggers reported temperatures that exceeded the temperature standard of 20° C at all but the uppermost station (PD10) . Specific conductivity and pH were within the expected ranges during 2014. Turbidity values were considered normal for the watershed with occasional high values occurring during late-spring, early summer precipitation and run-off events. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages. Four tributary stations and eight mainstem stations had one or more samples that were below the water column concentration recommended to achieve the intergravel concentration for early life stages; however two of the tributaries are Class 3B streams and the DO standard did not apply. High flows in July-August correspond to above normal precipitation in the days preceding the sample collection.

Bacteria geometric mean concentrations in May-July were typically lower than in July-September, except at PD01, PD05, and in Prairie Dog Ditch. May-July and July-September geometric mean concentrations were above Wyoming Water Quality Standards at nearly all of the stations, with the exception of Dutch Creek and PD10 in May-July 2014. None of the individual samples collected on Prairie Dog Ditch were 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 decreased from 2011 to 2014 at a majority of the comparable sites in May-July and in July-September. May-July bacteria concentrations increased at the upper mainstem station (PD10), on Wildcat Creek, and Prairie Dog Ditch though geometric means at PD10 and on Prairie Dog Ditch continued to meet water quality standards in 2014. Increases from July-August 2011 to July-September 2014 were observed at two mainstem stations (PD3A and PD09) and on Dutch Creek and Meade Creek. Although bacteria decreases were observed at a majority of the sites from 2011-2014, all but one of the stations (PDDitch) continued to exceed Wyoming Water Quality standards in July-August 2014.

A total of two hundred twenty-seven (N=227) benthic macroinvertebrate taxa have been identified from streams in the Prairie Dog Creek watershed since historic sampling began in 1977. The caddisfly genus *Hydropsyche* and caddisfly species *Brachycentrus occidentalis* occurred most frequently. The worm genus *Tubifex* was identified in one historic sample and one sample during the current project. The presence of *Tubifex* 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. All other benthic macroinvertebrate taxa collected by SCCD during the current study have been previously identified from other waterbodies sampled in North-Central Wyoming.

Biological condition at the lower-most Prairie Dog Creek monitoring station PD01 was Partial/Non-Support during 2007, indeterminate during 2008 and 2011, then dropped to Partial/Non-Support during 2014. Biological condition at station PD6 has been relatively consistent since 2007 and was Partial/Non-Supporting during each year. Biological condition increased from station PD06 to the two upper-most monitoring stations PD8 and PD10. Biological condition at PD08 was Indeterminate during 2007, 2008, 2011 and 2014. The most upstream station PD10 exhibited Indeterminate biological condition during 2007, Full Support during 2008 and 2011, then dropped to Indeterminate Support in 2014.

The biological condition rating of Full-support indicates full support for narrative aquatic life use. The Indeterminate biological classification is a designation indicating the need for additional information or data to determine the proper narrative aquatic life use designation such as Full-support or Partial/Non-support. The Partial/Non-support classification indicates the aquatic community is stressed and water quality or habitat improvements are required to restore the stream to full support for narrative aquatic life use.

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.

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

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. SCCD will continue to monitor water quality in the Prairie Dog Creek Watershed on a three-year rotation, pending available funding sources. 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.

CHAPTER 1 PROJECT AREA DESCRIPTION

1.1 WATERSHED DESCRIPTION

The Prairie Dog Creek watershed consists of approximately 231,000 acres (360 square miles) located in central Sheridan County, in north-central Wyoming (Appendix A-1). The watershed is identified by hydrologic unit code (HUC) 100901-01-04. 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 elevation difference 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 elevation difference of Prairie Dog Creek is 956 feet over a distance of approximately 52.76 stream miles. The majority of the watershed is in the 14-16" precipitation zone (Appendix A-2). A small area of the upper portion of the watershed is in the 18-20" and 16-18" zones. Annual precipitation is 12-14" at the most downstream site of the watershed.

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 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 hayland and cattle production.

Urban areas within the watershed include the unincorporated towns of Banner, Wyarno, Verona, and Ulm. However, numerous rural subdivisions also exist within the watershed and tend to be most common in the western portion. 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. 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 or discharges. The watershed has had some energy development in the form of coal bed methane extraction. Most of this activity is located in the lower portions of the watershed. Few of these permits discharge directly into Prairie Dog Creek. Most of the permitted outfalls are first discharged into stockwater reservoirs, pits, or containment units, either on- or off-channel, then into one of the often unnamed draws or streams that feed the major Prairie Dog Creek tributaries. 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). Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2013) describes the surface water classes, and designated uses, and the water quality standards that must be achieved for a Wyoming waterbody to support its designated uses. Stream classifications are assigned by WDEQ and identified on the Wyoming Surface Water Classification List (WDEQ, 2013a) or in subsequent reports. 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, 2013a)

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.

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 and Use Designations

Stream Classifications	
Class 2AB	**Class 3B**
Prairie Dog Creek	Coutant Creek
Meade Creek	Dutch Creek
Jenks Creek	Dow Prong
	Wildcat Creek
	Murphy Gulch
	Arkansas Creek
	Wagner Prong

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, 2012). Once a TMDL is completed, a waterbody is moved from Category 5 to Category 4, which includes the list of waterbodies with TMDLs.

A 6.3 mile segment of Prairie Dog Creek from the confluence with Tongue River was listed in 2002 for aesthetic drinking water impairments caused by Manganese, which was determined to be from natural sources (WDEQ, 2012). The entire length of Prairie Dog Creek was listed in 2004 for bacteria related to recreational use (WDEQ, 2012). Subsequent monitoring resulted in additional impairment designations on Prairie Dog Creek and some tributaries (Table 1.3).

Table 1.3 Impairment Listings for Streams in the Prairie Dog Creek Watershed (WDEQ, 2012)

Name	Class	Location	Miles	Uses	Use Support	Causes	Sources
Prairie Dog Creek (tributary to Tongue River)	2AB	From the confluence of Tongue River to an undetermined point upstream	47.2	Recreation	Not supporting	Unknown	Fecal Coliform
Prairie Dog Creek (tributary to Tongue River)	2AB	From the confluence of Tongue River to an undetermined point upstream	47.2	Drinking Water	Not supporting	Natural Sources, Unknown	Manganese
Prairie Dog Creek (tributary to Tongue River)	2AB	From the confluence of Tongue River to an undetermined point upstream	47.2	Cold Water Fishery	Not supporting	Unknown	Temperature
Meade Creek (tributary to Prairie Dog)	2AB	From the confluence of Prairie Dog Creek to an unnamed tributary	1.1	Recreation	Not supporting	Unknown	*E. coli* bacteria
Meade Creek (tributary to Prairie Dog)	2AB	From the confluence of Prairie Dog Creek to an unnamed tributary	1.1	Drinking Water	Not supporting	Natural Sources, Unknown	Manganese
Wildcat Creek (tributary to Prairie Dog)	3B	From the confluence of Prairie Dog Creek to an undetermined point upstream	0.8	Recreation	Not supporting	Unknown	*E. coli* bacteria
Dutch Creek (tributary to Prairie Dog)	3B	From the confluence of Prairie Dog Creek to an undetermined point upstream	1.9	Recreation	Not supporting	Unknown	*E. coli* bacteria
Prairie Dog Creek (tributary to Tongue River)	2AB	From the confluence of Tongue River to an undetermined point upstream	6.7	Drinking Water	Not supporting	Natural Sources	Manganese
Prairie Dog Creek (tributary to Tongue River)	2AB	From the confluence of Tongue River to an undetermined point upstream	6.7	Recreation	Not supporting	Unknown	Fecal Coliform
Prairie Dog Creek (tributary to Tongue River)	2AB	From the confluence of Tongue River to an undetermined point upstream	6.7	Cold Water Game Fish	Not supporting	Unknown	Temperature

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CHAPTER 2 PROJECT BACKGROUND

2.1 PREVIOUS MONITORING AND PLANNING 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 in April – October. Discharge, turbidity, pH, specific 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 were collected for commonly used pesticides on 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). There were *E. coli* bacteria concentrations 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, 2012). Instantaneous water temperature, pH, specific 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 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 for 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. Action items in the plan address implementation of the plan, water quality improvement, and awareness and education.

2.2 WATERSHED PLAN IMPLEMENTATION

Activities that have been completed include interim water quality monitoring in 2011, development and distribution of an annual watershed newsletter, development and update of a Watershed Progress Register to document completed projects, and installation of improvement projects. As of 2014, 16 improvement projects have been completed on the watershed, including two livestock facility modifications, nine septic system replacements, two irrigation diversion replacements, and two riparian fencing project. These projects are documented on the Progress Register Map (Appendix A-6).

The SCCD anticipates that voluntary, incentive based watershed planning and implementation efforts will eventually be successful; however, it may require several years to actually measure these achievements. Continued monitoring can provide information on water quality changes over the long-term.

The Prairie Dog Creek Watershed Plan (SCCD, 2011) includes interim monitoring to analyze trends of bacteria levels and changes in macroinvertebrate communities. Interim monitoring data collection occurs on a three year rotation in the Prairie Dog Creek watershed. The monitoring objectives for the 2014 interim monitoring were:

- to evaluate the effects of high and low flow regimes on bacteria loads, and
- to evaluate the effects land use and sediment have on stream habitat and macroinvertebrate communities.

CHAPTER 3 HISTORICAL AND CURRENT DATA

Historical data, for the purposes of this project, are defined as data greater than five years old from the start of the 2007-2008 Assessment. The 2007-2008 Prairie Dog Creek Watershed Assessment Final Report 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 various 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 report for the 2011 interim monitoring (SCCD, 2012). These summaries included data from USGS Station Numbers 06306250 (Prairie Dog Near Acme) and 06306200 (Prairie Dog at Wakely Siding). USGS collected water quality data from these two stations in 2014 (Table 3.1). USGS Station 06306200 (Wakely siding) was discontinued after July 2014.

Table 3.1. Active USGS Stations in the Prairie Dog Creek Watershed during 2014.

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-Current	Temperature Discharge Conductance SAR
06306200 Prairie Dog Creek at Wakely Siding	88.3 square miles	Discharge	10/22/2003-6/24/2014	Discharge

Among other things, the USGS collected temperature, pH, dissolved oxygen, specific conductivity, nutrients, and metals throughout the period (Appendix B). USGS did collect water quality samples for other parameters, but they are not included here. 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, the Wyoming Association of Conservation Districts (WACD), and other volunteers (Table 4.1). Initially, the District Manager served as the Project Coordinator with the Natural Resource Specialist serving as the Field Supervisor. The Natural Resource Specialist was responsible for the implementation of the Quality Assurance/Quality Control (QA/QC) procedures, training monitoring assistants, and for *E. coli* and turbidity field collections through mid-August 2014. After the Natural Resource Specialist left employment with the SCCD, the District Manager assumed the responsibility for field and QA/QC procedures. Progress updates were provided to the SCCD Board of Supervisors, steering committee, and cooperating stakeholders and landowners who provided site access for sampling and other information. WDEQ provided assistance and oversight as well as administration of the funds provided through Section 319 of the Clean Water Act.

Table 4.1 Key Personnel and Organizations Involved in the Project

Personnel/Organization	Project Role
Carrie Rogaczewski, District Manager	Project management/oversight; Field monitoring assistance; QA/QC oversight; Data review and validation; Reporting
Maria Burke Steyaart, Natural Resource Specialist	Field monitoring and supervision; QA/QC protocol; Data validation assistance; Reporting
Amy Doke, Program Specialist	Field monitoring assistance and data management
Liz Navas-Pacheco, NRCS State Office Intern	Field monitoring assistance
Karyn Rieger, Sheridan College Practicum Student	Field monitoring assistance
Cathy Rosenthal, WACD Watershed Coordinator	Field monitoring assistance
WDEQ Personnel	Project, QA/QC, and report review; funding administration
SCCD Board, Steering Committee, Landowners	Project and data review; sampling access
Beth Kelly, WWC Engineering	Field Audit Project Manager, under contract with WACD

4.2 MONITORING PARAMETERS

Water quality parameters monitored in 2014 included: water temperature, pH, specific conductivity, dissolved oxygen, discharge, turbidity, and *E. coli* bacteria. Monitoring was performed at 14 stations; nine sites on the mainstem of the Prairie Dog Creek, four sites on the major tributaries (Appendix A-1), and one site on Prairie Dog Ditch. Samples were collected 5 times in May-June and 5 times in July-August. Continuous data loggers recorded water temperature at seven stations at 15 minute intervals from May through November. Macroinvertebrate sampling and habitat assessments were performed at four mainstem stations in September.

4.3 SAMPLING AND ANALYSIS METHODS

Water quality samples, discharge measurements, macroinvertebrate collections, and habitat assessments monitoring were collected by the methods described in the Sampling Analysis Plan (SAP) according to accepted analytical methods (Table 4.2). Water quality and macroinvertebrate samples were obtained from representative sample riffles.

All monitoring methods, standard operating procedures, and data management protocols used for this project were performed according to the WDEQ Manual of Standard Operating Procedures for Sample Collection and Analysis (WDEQ, 2011), the SCCD Water Quality Monitoring Program Quality Assurance Project Plan, Revision No. 4 (SCCD, 2013), and the Prairie Dog Creek Watershed 2014 SAP (SCCD, 2014).

Table 4.2 Standard Field and Laboratory Methods Applicable to 2014 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	6 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; one sample site was equipped with USGS gauge (06306250 Prairie Dog Creek at Acme). During 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, 2011). 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, specific 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.

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. Benthic macroinvertebrates were collected and habitat assessments were performed at five stations in September. Macroinvertebrate samples were sorted by Aquatic Assessments, Inc. (AA) in Sheridan, Wyoming and analyzed by Aquatic Biology Associates, Inc. (ABA) in Corvallis, Oregon.

4.4 Site Descriptions

Sites were selected based on a review of the historical data, historical SCCD sampling sites, availability, and access (Table 4.3). During the initial site reconnaissance and site set-up SCCD identified land uses and other site characteristics. Considerations for site selection included the ability to reveal types and regions of non-point source pollution at a level that would optimize landowner participation in the watershed planning process and would allow SCCD to direct remediation assistance in the most cost-effective and environmentally sound ways.

All of the monitoring stations in 2014 had been monitored previously, with the exception of a site on Jenks Creek. To maintain consistency with other watershed monitoring, SCCD updated the site names of the tributary sites (Table 4.3). Sites include the waterbody initials numbered from downstream to upstream.

Historically, SCCD requested and documented verbal permission to collect water quality samples and publish the data. 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, subsequent discussions on trespass concerns, prompted SCCD to secure written permission for the collection of data at all sample sites. Signed consent forms were maintained for all sample sites; all sites were access using public highways/roads or private driveways/parking areas where consent forms had been received.

Table 4.3 Prairie Dog Creek Watershed 2014 Monitoring Sample Site Descriptions

Site ID	Previous Site Name	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	100901010407 Lower Prairie Dog Ck	3484	Horse grazing; CBM production and irrigated haylands upstream.
PD02	——	On Prairie Dog Creek upstream of County Road 114 bridge crossing.	4975920N 0353140E	44.92155N 106.860805W	100901010407 Lower Prairie Dog Ck	3,536	Irrigated haylands, wildlife habitat, and cattle grazing. CBM production present in area.
DC01	PD03	On Dutch Creek above Prairie Dog Creek confluence, downstream of culvert crossing.	4970648N 0354031E	44.874299N 106.848001W	100901010405 Lower Dutch Creek	3,621	Wildlife habitat, cattle grazing. CBM production present in area.
PD03A	——	On Prairie Dog Creek, upstream ranch road crossing ~ ¼ mile above Dutch Creek.	4969902N 0353648E	44.867508N 106.852632W	100901010402 Mid Prairie Dog Ck	3,635	Irrigated haylands, wildlife habitat, and cattle grazing. CBM production present in area.
WCC01	PD04	On Wildcat Creek upstream Highway 336 bridge crossing, upstream of culvert crossing.	4966405N 0352650E	44.835839N 106.864243W	100901010402 Mid 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	100901010402 Mid Prairie Dog Ck	3,742	Cattle grazing and irrigated haylands. Railroad and HWY 336 parallel east side of creek.
PD05A	——	On Prairie Dog Creek east of Peno Road, upstream private driveway bridge crossing.	4959487N 0349873E	44.773017N 106.897316W	100901010402 Mid Prairie Dog Ck	3,840	Rural residential, wildlife habitat, cattle grazing, and irrigated land.
PD06	——	On Prairie Dog Creek upstream Highway 14 bridge crossing.	4954698N 0351543E	44°.730277N 106.874827W	100901010402 Mid Prairie Dog Ck	3,969	Rural residential, wildlife habitat, cattle grazing, and irrigated land.
MC01	PD07	On Meade Creek adjacent to County Road 131, just upstream of culvert crossing.	4951421N 0352645E	44.701019N 106.859973W	100901010401 Upper Prairie Dog Ck	3,985	Wildlife habitat, cattle grazing, and irrigated land.
PD08	——	On Prairie Dog Creek downstream County Road 127, upstream of private bridge.	4946810N 0354334E	44.659875N 106.837352W	100901010401 Upper Prairie Dog Ck	4,160	Rural residential, cattle grazing, irrigated land, and wildlife habitat.
PD9	——	On Prairie Dog Creek upstream County Road 127 crossing downstream of Jenks Creek.	4942369N 0353743E	44.619796N 106.843537W	100901010401 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	100901010401 Upper Prairie Dog Ck	4375	Wildlife habitat, cattle grazing, pasture and irrigated hayland.
PD10	——	On Prairie Dog Creek upstream Highway 87 bridge crossing.	4941296N 0351759E	44.609735N 106.868222W	100901010401 Upper Prairie Dog Ck	4532	Wildlife habitat, grazing, irrigated land.
PDD01 (Ditch)	PD11	On Prairie Dog Ditch at flume downstream Piney Creek/Prairie Dog Ditch Diversion	4937789N 0350556E	44.577931N 106.882356W	100902060303 North Piney Ck	5024	Predominantly rural residential community.

Table 4.3 (continued). Prairie Doc Creek Watershed 2014 Sample Site Descriptions

Site ID	Previous Site Name	Sample Site Description	UTM Zone 13 (NAD83)	Latitude Longitude	HUC	Elevation (ft)	Land use(s)
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	100901010407 Lower Prairie Dog Ck	3484	Horse grazing; CBM production and irrigated haylands upstream.
PD06	____	On Prairie Dog Creek upstream Highway 14 bridge crossing.	4954698N 0351543E	44°.730277N 106.874827W	100901010402 Mid Prairie Dog Ck	3,969	Rural residential, wildlife habitat, cattle grazing, and irrigated land.
PD08	____	On Prairie Dog Creek downstream County Road 127, upstream of private bridge.	4946810N 0354334E	44.659875N 106.837352W	100901010401 Upper Prairie Dog Ck	4,160	Rural residential, cattle grazing, irrigated land, and wildlife habitat.
PD10	____	On Prairie Dog Creek upstream Highway 87 bridge crossing.	4941296N 0351759E	44.609735N 106.868222W	100901010401 Upper Prairie Dog Ck	4532	Wildlife habitat, grazing, irrigated land.

4.5 Monitoring Schedule

The 2014 monitoring schedule included sampling to determine the geometric means of *E. coli*, based on 5 samples collected within 60-day period in May-July and 5 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. Sample dates were based on random numbers generated for Tuesday, Wednesday, or Thursday due to lab availability and sampling holding times. Continuous temperature data loggers were deployed to measure instream temperatures from May 1st through October 31st. Macroinvertebrate collections and habitat assessments were completed in October.

Table 4.4 Sample Schedule for 2014 Prairie Dog Creek Watershed Monitoring

Date(s)	Sites	Parameters
May 1st – October 31st, 2014	PD01, PD02, PD05A, PD06, PD07, PD08, PD09	Continuous Temperature
May 8th	PD01, PD02, DC01, PD03A, WCC01, PD04, PD05A, PD06, MC01, PD07, PD08, JC01, PD09, PDD01	Instantaneous Temperature, pH, Conductivity, Dissolved Oxygen, Discharge, Turbidity, and *E. coli.* Upstream and downstream photos were taken once during the high flow period
May 20th		
June 4th		
June 18th		
July 1st		
July 31st	PD01, PD02, DC01, PD03A, WCC01, PD04, PD05A, PD06, MC01, PD07, PD08, JC01, PD09, PDD01	Instantaneous Temperature, pH, Conductivity, Dissolved Oxygen, Discharge, Turbidity, and *E. coli.* Upstream and downstream photos were taken once during the low flow period
August 14th		
August 28th		
September 9th		
September 24th		
October, 2014	PD01, PD06, PD08, PD10	Macroinvertebrates, Habitat, Photo

CHAPTER 5 QUALITY ASSURANCE/QUALITY CONTROL

5.1 FUNCTION OF QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance (QA) may be defined as an integrated system of management procedures designed to evaluate the quality of data and to verify that the quality control system is operating within acceptable limits (Friedman 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 Water Monitoring Program Quality Assurance Project Plan, Revision No. 4 (SCCD, 2013) and the Prairie Dog Creek Watershed SAP (SCCD, 2014).

5.2 SAMPLING PERSONNEL QUALIFICATIONS

SCCD personnel involved in the collection and analysis of samples had the proper training to implement this project through a combination of college studies, previous employment experiences, and on-the-job training (Table 5.1). Other personnel and SCCD staff that assisted with sampling and/or data management activities were trained prior to sampling and were under direct supervision of the Natural Resource Specialist and/or District Manager during sampling. SCCD sampling personnel participated in a field audit, which was performed by WWC Engineering under contract with WACD. The audit was successfully completed on July 31, 2014 (Appendix D). Recommendations were incorporated into future monitoring efforts; however, no changes were made to the 2014 monitoring in order to maintain consistency.

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; 15+ years of experience with the SCCD; WACD Water Quality training
Maria Burke, Natural Resource Specialist	B.S. University of Vermont in Environmental Science with a concentration in Ecological Design; 6-month water quality intern with WDEQ in Sheridan; 2+ year of experience with SCCD conducting watershed monitoring
Amy Doke Program Specialist	B.A. University of Wyoming in Environment and Natural Resources with an emphasis in international studies and ecology; 8+ years of experience with SCCD, assisting in other watershed efforts

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 sent an email confirmation of the samples appearance.

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 (DO) 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 DO meter, used throughout the project, did not require a calibration solution. The DO meter was calibrated by inserting the probe into the moist calibration chamber. The barometric pressure on the DO meter was cross referenced to the barometric pressure at the Sheridan County airport to check calibration accuracy. Calibration of each meter was documented on the corresponding instruments 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 May 2014. Onset Hobo data loggers, used for continuous temperature monitoring, were also factory calibrated and completely encapsulated. These loggers are considered disposable; when the enclosed battery is depleted, it cannot be replaced. A crushed-ice test was performed at the beginning and end of the season to validate the logger's accuracy.

Equipment maintenance, to include replacement of the DO meter membrane cap before each sampling day and battery replacement, was performed according to the SAP and manufacturer's instructions. 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. 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).

Table 5.2 Data Quality Objectives in 2014 Prairie Dog Creek Sampling Analysis Plan (SCCD, 2014)

Parameter	Precision (%)	Accuracy (%)*	Completeness (%)	Minimum Detection Limit
Temperature	10	10	95	0.2 ^{O}C
pH	5	5	95	0.01 S.U.
Conductivity	10	10	95	1 µmho/cm
Dissolved Oxygen	20	20	95	0.2 mg/L
Turbidity	20	10	95	0.1 NTU
E. coli	50	NA	95	1 CFU/100 mL
Macroinvertebrates	NA	NA	95	NA
Total Taxa	15	NA	95	NA
Habitat Assessment	NA	NA	95	NA
Intra-Crew	15	NA	10	NA
Discharge	NA	NA	90	NA
Stage-Discharge Relationships	NA	NA	90	Minimum r^2 = 0.90

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 assessment 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 5 samples collected within a 30 day period. SCCD collected other water quality parameters on the same schedule as the *E. coli* samples; 5 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 5 or more samples collected within a 60 day period (WDEQ, 2014). In anticipation of this change, SCCD incorporated 60 day geometric means into the 2014 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, PD02, PD05A, PD06, PD08, 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 4/29/2014 was reported to be between 0.01°C to 0.232°C, which was within the manufacturer's predicted range. The post-season ice bath temperature on 11/4/2014 also reported temperatures between 0.01°C to 0.232°C (Appendix D).

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 returned the expected results in the crushed ice tests. All of the temperature loggers were considered to have maintained their accuracy and have provided valid water temperature data for the 2014 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. A correlation coefficient (R^2 value) of at least 0.90 (90%) is desirable for proper calibration of the gauge. Stage-discharge relationships were established for all staff gauges installed by SCCD (Table 5.3). These relationships were developed by recording the stage height and measuring discharge using the mid-section method (WDEQ, 2011) on at least three occasions with varying flow conditions.

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 2014Gauge 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	NA-USGS GAUGE STATION			
PD02	9.10	9.25	0.15	0.9987
DC01	5.36	5.26	0.10	0.8533
PD3A	3.69	3.71	0.02	0.9894
WCC01	1.31	1.32	0.01	09934
PD05	0.96	1.99	1.03	0.9522
PD5A	8.06	7.98	0.08	0.9975
PD06	0.43	0.32	0.11	1.0000
MC01	0.37	0.34	0.03	0.9997
PD08	1.47	1.49	0.02	0.9894
PD09	2.63	2.55	0.08	0.9661
JC01	8.27	8.12	0.15	0.9528
PD10	1.69	1.66	0.03	0.7896
PDD01	NA-PRAIRIE DOG DITCH FLUME			

Gauges were not installed at PD01 and PD11; flow information was obtained from a USGS gauges at PD01 and the ditch flume at PDD01. Two sites had coefficient values below the DQO correlation coefficient minimum of 0.90. These occurred on DC01 (0.8533) and at PD10 (0.7896). Both of sites had low late season flows and instream vegetation growth, which could have impacted the flow measurements. Because the values represented the best, and in some cases the only, flow information available, the value was used in the calculation of summary statistics and in the development of load estimates, where appropriate.

One of the gauge surveys resulted in differences greater than 0.5 between the pre-season and post-season surveys. The difference between the pre-season and post-season survey for PD05 was 1.03. During the post-season survey, the location of the benchmark used during the pre-season survey could not be verified. However, the elevation difference between the staff gauge and the benchmark during the post-season survey was similar to differences in other years (<0.07 feet). Discharge measurements for this site were retained, because 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*; two samples had turbidity detections of 0.1 NTU (Table 5.4 and Appendix D). Because the reported values were very low, the data for those days were accepted.

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 two separate sites during all sampling days. At the designated sites, 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 0.2 NTU (Table 5.4 and Appendix D). Because the reported values were very low, the data for those days were accepted.

Lab blanks were prepared by the contract laboratory during lab analyses to determine whether samples might be contaminated by conditions within the laboratory. No lab blanks used during the project contained detectable levels of *E. coli*; two samples had turbidity detections of 0.1 NTU (Table 5.4 and Appendix D). Because the reported values were very low, the data for those days were accepted.

Table 5. 4 Turbidity Detections in Blanks for 2014 Prairie Dog Creek Watershed Monitoring

Field Blanks				Trip Blanks			Lab Blanks		
Sample ID	Site Prepared	Sample Date	Turbidity (NTU)	Sample ID	Sample Date	Turbidity (NTU)	Sample ID	Sample Date	Turbidity (NTU)
FB01	PD05	7/1/14	0.1	TB01	7/1/14	0.1	LB02	5/22/14	0.1
FB01	PD01	8/12/14	0.1	TB01	8/28/14	0.1	LB02	8/12/14	0.1
FB02	PD10	8/28/14	0.2						

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 eight *E. coli* samples were outside of the 6 hour holding time specified by the Project SAP (SCCD, 2014) and the WDEQ Manual of Operating Procedures (WDEQ, 2011). Three of these samples were at PD01 on 8/28, 9/9, and 9/24, two were on PD02 on 9/9 and 9/24, and three were on duplicate samples collected on 5/12, 9/9, 9/24.

The data for these two samples were retained for a couple of reasons. First, all of the samples exceeded the holding time by 45 minutes or less. Secondly, in 2012, the EPA issued a rule updating approved analytical methods. In this rule, the holding time for bacteria samples was extended to 8 hours (Federal Register, 2012).

All turbidity samples were analyzed within the required 48 hour holding time. All water quality field samples were analyzed on-site immediately following sample collection. Benthic macroinvertebrate samples were preserved immediately following 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 5.5).

Table 5.5 Summary of 2014 Prairie Dog Creek Watershed Duplicates

Parameter	No. of samples	No. of Duplicates	% Duplicated	DQO (%)
Water Quality Samples in 2014 (14 sites X 10 samples)	140	19	13.57	10
Macroinvertebrate Samples in 2014	4	1	25.0	10
Habitat Assessments in 2014	4	1	25.0	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. With few exceptions, all samples met the DQOs for precision (Table 5.6).

Table 5.6 Precision of 2014 Water Quality Monitoring Data for each sampled parameter

Date	Duplicate Sample ID	Site Duplicated	TEMP RPD (%)	pH RPD (%)	COND RPD (%)	DO mg/L RPD (%)	DO % RPD (%)	TURB RPD (%)	*E. coli* RPD (%)
Relative Percent Difference DQO:			***10***	***5***	***10***	***20***	***20***	***20***	***50***
5/12/14	Dup 1	PD01	1.2	5.8	4.4	0.1	0.5	18.8	33.1
	Dup2	PDDitch01	*NO SAMPLE; DITCH WAS DRY*						
5/22/14	Dup 1	PD02	0.6	0.5	2.0	2.2	2.4	6.1	19.0
	Dup2	PD10	1.8	3.3	1.9	0.3	0.4	1.5	50.6
6/4/14	Dup 1	DC01	0.0	0.9	2.8	2.7	2.7	ND	40.0
	Dup2	JC01	0.8	0.7	1.6	3.2	2.9	ND	23.2
6/18/14	Dup 1	PD03A	0.7	0.4	1.7	2.9	3.5	11.3	40.2
	Dup2	PD09	0.0	0.7	3.1	2.8	3.2	9.7	5.7
7/1/14	Dup 1	WCC01	0.0	0.4	1.7	0.7	0.6	12.6	25.3
	Dup2	PD08	1.3	0.2	1.3	1.5	0.7	11.1	19.8
7/31/14	Dup 1	PD05	1.1	0.7	1.3	4.3	5.2	0.9	50.2
	Dup2	MC01	1.1	1.1	1.5	16.1	15.9	3.0	0.0
8/12/14	Dup 1	PD5A	0.0	0.1	0.4	3.2	2.2	0.2	118.1
	Dup2	PD06	1.6	0.7	0.6	2.1	1.2	6.3	42.0
8/28/14	Dup 1	PD01	0.6	2.6	0.6	3.4	2.3	1.4	5.7
	Dup2	PDDitch01	0.0	0.2	3.3	5.9	8.2	15.4	23.3
9/9/14	Dup 1	PD02	0.7	0.9	0.0	0.2	0.2	5.8	38.9
	Dup2	PD10	0.0	0.6	1.2	0.5	0.4	13.3	24.6
9/24/14	Dup 1	DC01	0.7	0.1	0.0	16.1	14.2	2.0	86.3
	Dup2	JC01	1.3	1.1	0.4	6.5	5.6	0.0	9.8
AVERAGE RPD FOR ALL SAMPLES			**0.71**	**1.11**	**1.57**	**3.93**	**3.81**	**7.02**	**34.52**

One pH sample on 5/12/2014 exceeded the DQO for precision of 5.0%. The relative percent difference for that sample was 5.8%, which was only slightly above the DQO. Four *E. coli* samples exceeded the precision DQO of 50%. Two of the samples, occurring on 5/22/14 and 7/31/2014 had a relative percent difference of 50.6% and 50.2%, which was only slightly above the DQO. The relative percent difference of the other two samples was higher with one at 118.1% (8/12/14) and one at 86.3% (9/24/14). The relative percent difference for the other duplicate samples collected on those same days met the DQO. 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 (Appendix D). The RPD for total macroinvertebrate abundance was 7.5% and the RPD for total macroinvertebrate taxa was 2.4 %, which was within the established DQO. The RPD for the duplicate habitat assessment was 3.6%, which was within the DQO of 15%.

Table 5.7 Precision of 2014 Benthic Macroinvertebrate and Habitat Monitoring Data

Parameter	PD08 Duplicate 1	PD08 Duplicate 2	(% - RPD)	DQO (%)
Total Abundance	2712	2517	7.5	50
Total Taxa	41	42	2.4	15
Intra-Crew Habitat Assessment Score	135	140	3.6	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, DO, 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 most parameters were met with the exception of turbidity measurements (Table 5.8).

Table 5.8 Completeness of 2014 Monitoring Data

Parameter	% 2014 Completeness	DQO (%)
Water Temperature	99	95
pH	99	95
Conductivity	99	95
Dissolved Oxygen	99	95
Discharge	96	90
Turbidity	89	95
E. coli	99	95
Total Abundance of Marcroinvertebrates	100	95
Total Taxa	100	95
Intra-Crew Habitat Assessments	100	10

Completeness values for all parameters were affected by two sample days at the beginning of the season prior to water being let into Prairie Dog Ditch. Because there was no water in the ditch, no samples could be collected. Gauges that were submerged, emerged, or unusable affected completeness values for discharge. There was one instance where the water level was below the staff gauge (PD10 on 9/24/14), one instance where the staff gauge was submerged (PD02 on 7/1/14), and one instance when the gauge was deemed unusable and subsequently replaced (PD06 on 5/22/14).

All of the turbidity samples for 6/4/2014 were discarded because of a potential issue with the lab analyses. The laboratory re-ran the samples; however it was not until after the 48 hour holding time had expired. The loss of this set of samples combined with the lack of samples from the Ditch resulted in a completeness value below the DQO.

5.6 Data Validation

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

Low flow values and lab results reported below the detection limit were to be reported as ½ the detection limit for the purpose of summary statistics, as specified in the SAP for this project (Gilbert, 1987 and SCCD, 2014). No values were reported below the detection limits in 2014. One *E. coli* sample from DC01 on 9/9/14 was reported as >2419.6; SCCD used 2420 for calculation of 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. After each sampling day, water quality field data sheets are scanned and filed electronically on SCCD's computer; hard copies 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 existing data sheets 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 E).

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 database 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 of the monitoring report by WDEQ.

After data validation and database construction, data were statistically summarized for the following calculations (Appendix B):

- Number of samples;
- Maximum;
- Minimum;
- Median;
- Mean;
- Geometric mean; and
- Coefficient of variation.

These statistics and analyses provided insight for temporal and spatial water quality changes within the watershed. Microsoft Excel® was used to generate the statistical tables, geometric means, and graphics for this report. Geometric means were calculated for all of the water quality parameters using the ten sampling dates, and then separately for the months of May and August. Summary statistics did not include discarded data or instances where the staff gauge was submerged.

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. Other information may be submitted as requested by WDEQ.

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CHAPTER 6 WATER QUALITY STANDARDS AND DISCUSSION OF RESULTS

6.1 WATER QUALITY STANDARDS

Wyoming's narrative (descriptive) and numeric water quality standards (Table 6.1), applicable to the Prairie Dog Creek 2014 monitoring, were used in interpretation of results.

Table 6.1 Numeric and Narrative Water Quality Standards Applicable for Waters in the 2014 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 and Zumberge (2006)	Big Horn and Wind River Foothills Bioregion: Score 62.1 for full support; Score 41.4-62.1 for indeterminate support; and score <41.4 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
Specific Conductivity	King (1990)	Concentrations greater than 6900 µmhos/cm may affect aquatic organisms in ponds in NE Wyoming.

6.2 FIELD WATER CHEMISTRY AND PHYSICAL PARAMETERS

Water quality data were collected in May-July and July-September of 2014 at all 14 stations (Appendix B). Summary statistics and geometric mean values each period were calculated for instantaneous monitoring parameters on accepted data (Appendix B). Prior to 2014, geometric means were calculated on 5 samples collected within two separate 30 day periods (May-June and July-August). In 2014, SCCD calculated geometric means on 5 samples collected within two separate 60 day periods (WDEQ, 2014). Comparisons among years are still valuable for evaluating water quality trends; both the 30 day geometric means and the 60 day geometric means capture samples collected during early season (May-June/July) and late season (July-August/September) conditions.

In addition, USGS collected water quality data from two stations from 2011-2014:

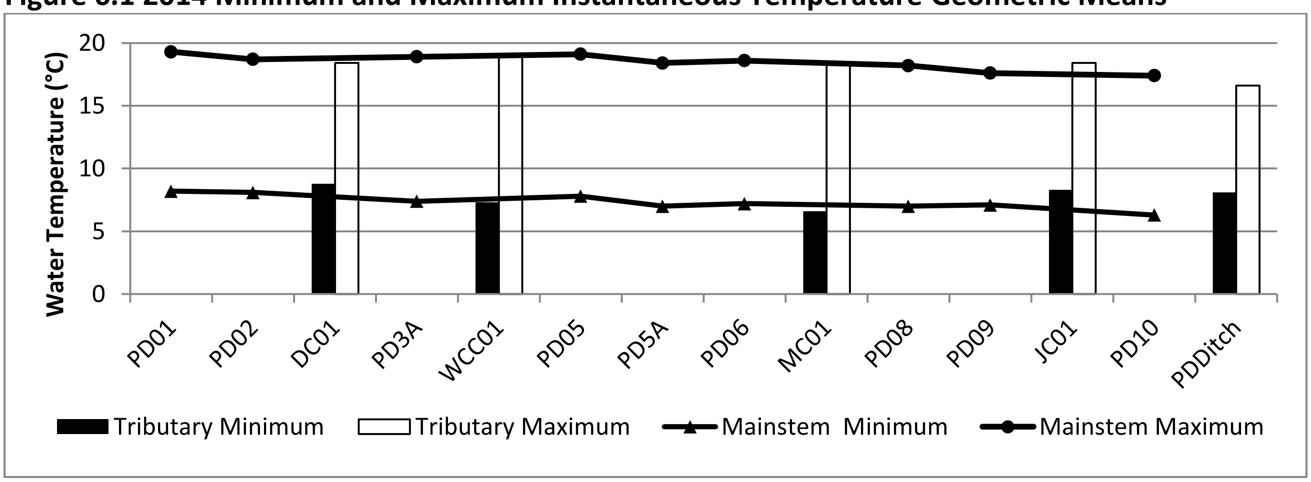
- Station 06306250 Prairie Dog Creek, Near Acme, WY and
- Station 06306200 Prairie Dog Creek Near Wakely Siding.

Among other things, the USGS collected temperature, pH, dissolved oxygen, specific conductivity, discharge, nutrients, and metals throughout the period. For these stations, only data similar in scope to the parameters collected by SCCD during 2014 are discussed.

6.2.1 INSTANTANEOUS WATER TEMPERATURE

All stations had higher temperatures in August than in May. All samples reported temperatures below the maximum 20°C instream temperature standard in 2014. The minimum temperature for all stations occurred on May 12, 2014 and all samples reported instantaneous temperatures below 9.0°C (Figure 6.1). Instantaneous temperatures were highest at all stations on August 12, 2014; Dutch Creek had the same temperature (18.4°C) on 8/12/14 and 5/22/14).

Figure 6.1 2014 Minimum and Maximum Instantaneous Temperature Geometric Means



Comparisons among years are difficult because of variations in water quantity and air temperatures. However, instantaneous water temperature measurements were lower in 2014 than in all other years. In 2011, instantaneous water temperatures were reported above 20°C at three stations (DC01, WCC01, and PD05) in August and one station (DC01) in June. All but the three uppermost stations (PD09, PD10, and PD Ditch) reported at least one measurement above 20°C in 2008 and on multiple occasions in 2007. The station at PD09 had one measurement above in 2007. Instantaneous temperature measurements do not necessarily represent daily minimum, maximum, or average water temperatures.

USGS Station 06306250 (Prairie Dog Near Acme) reported an instantaneous water temperature of 20.7°C in June 2014; no values above 20°C were reported from USGS Station 06306200 (Prairie Dog Near Wakely Siding) in 2014. Both USGS Stations reported instantaneous water temperatures that exceeded 20°C in April, June, and July in 2012 and 2013.

6.2.2 Continuous Water Temperature

Continuous temperature data loggers were deployed at seven Prairie Dog Creek stations. The logger at PD05A was lost and replaced during the season and is missing the data between June 4 and July 11. All but one station reported temperatures that exceeded the temperature standard of 20° C (Appendix B). The uppermost station on Prairie Dog Creek (PD10) was the only station that did not have any measurements above 20°C.

Temperatures at the lowest three stations (PD01, PD02, and PD5A) had extended periods in July-August where the daily maximum temperatures exceeded 20°C; with only a few exceptions, the daily minimums were below 20°C. Sites in the middle-upper part of the watershed (PD06, PD08, and PD09) also had temperatures above 20°C, but the periods were not as long and the maximum temperatures were not as high. All but the upper two stations (PD09 and PD10) had some temperatures above 20°C from May 22-28.

The three lower stations (PD01, PD02, and PD5A) reported maximum temperatures on 7/23/2014 (Table 6.2). Maximum temperatures at PD06, PD08, and PD09 occurred on 7/6/2014. The uppermost station (PD10) had a maximum temperature of 19.282, which occurred on 7/24/2014. The logger at PD05A did not have a full dataset; reported maximum temperatures may not represent the actual maximum daily temperature for that site.

Yearly comparisons from PD01 showed that daily mean temperatures for 2014 were similar to previous years with some exceptions. In mid-late May, daily mean temperatures were up to 5°C higher in 2014; however there were short periods in August, September, and October, where daily mean temperatures were lower in 2014.

Table 6.2 2014 Maximum Daily Temperatures Recorded by Continuous Data Loggers

Site	# of days Temperature was ≥ 20°C	Maximum Temperature (°C)		Maximum Temperature (°C) on Select Dates					
		Date	Temp	5/22	5/28	7/6	7/23	7/24	8/20
PD01	67	7/23	26.683	20.71	23.1	24.931	26.683	26.585	20.996
PD02	63	7/23	27.173	23.581	21.378	24.641	27.173	26.585	20.043
PD5A*	37*	7/23	24.255	20.329	21.664	*	24.255	24.158	19.092
PD06	43	7/6	24.255	22.238	22.333	24.255	24.062	23.581	19.187
PD08	37	7/6	24.062	21.951	20.615	24.062	23.292	23.1	19.472
PD09	20	7/6	22.812	17.855	18.236	22.812	22.333	22.238	18.331
PD10	0	7/24	19.282	14.421	15.282	18.616	18.806	19.282	16.713

*Logger was lost sometime after 6/4/14 and replaced on 7/11. There are no data for this period, which likely contained additional days with temperatures above 20°C.

6.2.3 pH

Ranging from 7.39 to 8.87, all pH values were within the Wyoming water quality standard of 6.5-9.0 SU. USGS stations reported similar pH values, which ranged from 7.6 to 8.5 from 2011 through 2014 (Appendix B). Geometric means for May-July/July and July-August/September periods were calculated for all sampling years so comparisons could be made (Table 6.3).

Table 6.3 Yearly Comparisons of pH Geometric Means from 2007-2014

Site	May-June /July				July-August/September			
	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)
PD01	8.11	8.12	8.39	8.02	8.2	8.1	8.58	7.84
PD02	8.08	8.11	8.23	8.26	8.16	8.05	8.51	8.11
DC01	8[A]	7.97	8.16[B]	8.15	7.7	7.88	8.12	8.05
PD3A		8.15	8.41	8.45		8.05	8.68	8.44
WCC01	8.01	8	8.25	8.42	8.04	7.9	8.58	8.39
PD05	8.1	8.09	8.43	8.44	8.1	7.98	8.52	8.31
PD5A		8.07	8.41	8.46		7.97	8.43	8.28
PD06	8.1	8.02	8.39	8.47	8.08	7.99	8.43	8.29
MC01	8.19	8.23	8.46	8.4	8.22	8.1	8.35	8.11
PD08	8.26	7.93	8.44	8.56	8.17	8.02	8.45	8.42
PD09	8.19	8.03	8.53	8.63	8.1	8.08	8.55	8.44
JC01				8.54				8.46
PD10	7.99	7.95	8.58	8.5	8.07	8.13	8.24	8.15
PDDitch	7.7	7.93	8.8[C]	8.82[D]	7.78	8.05	8.69	8.5

[A] May-July 2007 geometric mean was calculated on 4 samples; site was inaccessible for one sample event
[B] May-July 2011 geometric mean was calculated on 4 samples; site was inaccessible for one sample event
[C] May-July 2011 value is based on a single sample; there was no water during four sample events
[D] May-July 2014 geometric mean was calculated on 3 samples; there was no water during two sample events

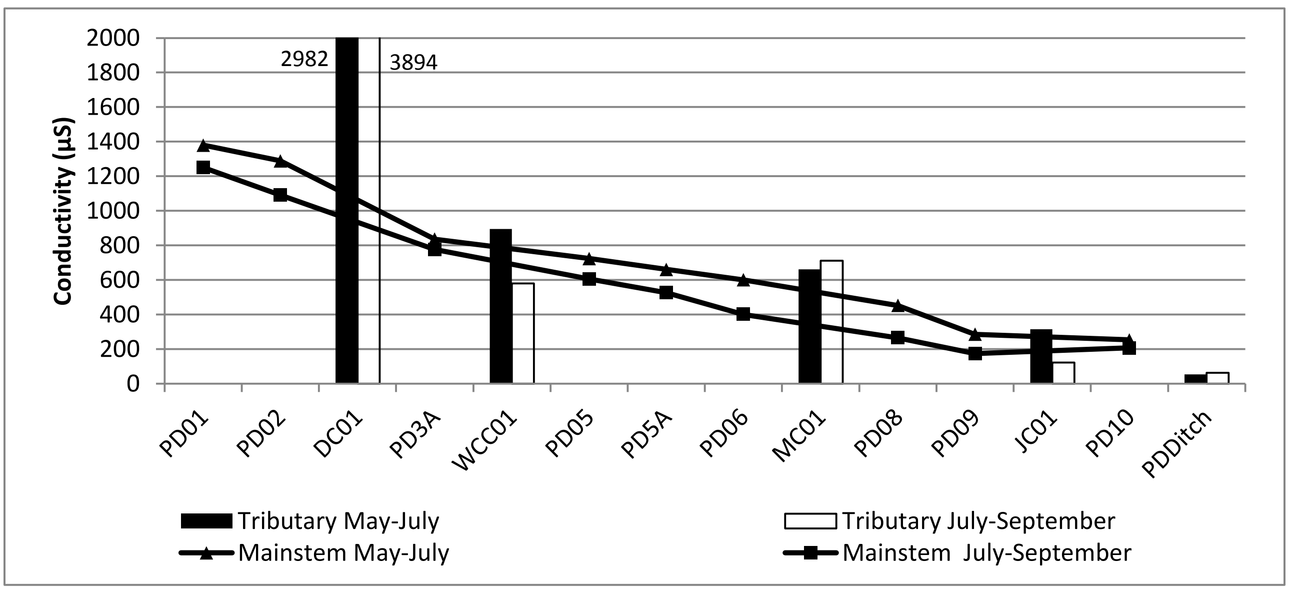
In 2014, July-September geometric means were lower than May-July geometric means for all stations. Geometric means for July-September 2014 were typically lower than previous years while May-July 2014 geometric means were typically higher than previous years (Figure 6.2).

6.2.4 *Specific Conductivity*

Specific Conductivity increased from upstream to downstream in May and August, with one exception (Figure 6.2). In August, station PD10 had a higher conductivity geometric mean (207µS) than PD09, just downstream (173 µS). Dutch Creek and Meade Creek stations were higher than the adjacent mainstem stations. This was also true for Wildcat Creek and Jenks Creek in May, but not in August. The highest conductivity was observed in Dutch Creek (DC01) with a May geometric mean of 2982 µS and an August geometric mean of 3894 µS. For mainstem sites, PD01 had the highest geometric mean in May and August with geometric means of 1380µS and 1250µS, respectively.

The same pattern was observed at USGS stations (Appendix B). Minimum and maximum conductivity values from 2011 to 2014 were highest at the most downstream station (USGS Station 06306250 Prairie Dog Near Acme), which ranged from 660 to 2380µS, and lowest in the station located above the confluence with Dutch Creek (USGS Station 06306200 Prairie Dog Near Wakely Siding), which ranged from 451 to 1200µS.

Figure 6.2. 2014 May-July and July-September Specific Conductivity Geometric Means



During the May-July 2014 period, all but one of the sites, had higher conductivity measurements in the first two sample dates (5/12 and 5/22) than in the last three sample dates (6/4, 6/18, and 7/1) of the period (Appendix B). The only site that did not follow this pattern was PD10, which does not convey water from Prairie Dog Ditch. The Ditch had not been turned on and was not flowing during the first two sample dates; it is unclear whether the higher conductivity in the first two samples was related to the lack of additional water from the Piney Creek drainage, which is brought into the Prairie Dog Creek watershed through a trans-basin diversion via Prairie Dog Ditch and Jenks Creek.

Geometric means for May-July 2014 were typically lower than in 2011 but higher than 2007 and 2008 for mainstem sites (Table 6.4). For site PD10, the highest May-July geometric mean was in 2007, although Conductivity geometric means were similar (±56µS) among all years. May-July 2014 geometric means were lower than other years on Meade Creek and Wildcat Creek; on Dutch Creek the May-July 2014 geometric mean was higher in 2014 than in 2011 but lower than in 2007 and 2008. The highest geometric means for most mainstem sites in July-September occurred in 2011; site PD09 had the highest July-September geometric mean in 2014, although all values were within ±50µS. The July-September 2014 geometric mean for Dutch Creek was higher than in 2011, but lower than 2007 and 2008; on Meade Creek, the July-September 2014 geometric mean was higher than in all of the other years. Conductivity geometric means on Prairie Dog Ditch were lower than 100µS for all sample periods with a range of 18µS.

Table 6.4 Yearly Comparisons for Specific Conductivity (µS) Geometric Means 2007-2014

	May-June/July				July-August/September			
Site	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)
PD01	1117	1137	1746	1380	1388	1158	1809	1250
PD02	1041	1034	1583	1289	1066	886	1572	1092
DC01	3663[A]	3592	2770[B]	2982	4516	4150	3814	3894
PD3A		783	1104	836		640	952	776
WCC01	1431	1118	1820	895	632	541	802	580
PD05	671	653	1028	724	567	465	678	606
PD5A		521	1023	661		405	609	527
PD06	552	415	972	601	345	331	438	401
MC01	869	904	863	661	526	415	539	712
PD08	428	289[C]	783	453	206	228	270	265
PD09	244	181[C]	447	286	123	136	158	173
JC01				315				123
PD10	284	236[C]	228	253	369	381[C]	367	207
PDDitch	66	72	54[D]	54[E]	57	72	59	63

[A] May-July 2007 geometric mean was calculated on 4 samples; site was inaccessible for one sample event
[B] May-July 2011 geometric mean was calculated on 4 samples; site was inaccessible for one sample event
[C] May-July and July-September 2008 geometric means calculated on 4 samples; meter malfunction
[D] May-July 2011 value is based on a single sample; there was no water during four sample events
[E] May-July 2014 geometric mean was calculated on 3 samples; there was no water during two sample events

6.2.5 *Dissolved Oxygen*

All sites met the minimum instantaneous DO concentration standard of 4.0 mg/L for other life stages and the 5.0 mg/L for early life stages. Four tributary stations and eight mainstem stations had one or more samples that were 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). As Class 3B streams, the DO standard does not apply to Dutch Creek and Wildcat Creek.

Table 6.5 Dissolved Oxygen Ranges and Number of Samples Below 8.0 mg/L in 2014

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	2	7.47-10.58	DC01	7	5.13-8.92
PD02	4	7.32-10.17	WCC01	2	7.82-11.78
PD3A	1	7.8-11.28	MC01	2	7.48-11.68
PD05	4	7.48-10.83	JC01	1	7.44-10.01
PD5A	2	7.54-10.85	PDDitch	0	8.16-10.16
PD06	2	7.14-12.15			
PD08	1	7.85-11.22			
PD09	0	8.10-11.85			
PD10	1	7.07-10.22			

Dutch Creek had the lowest overall Dissolved Oxygen, ranging from 5.13 to 8.92. The lowest Dissolved Oxygen on a mainstem site was 7.07, which occurred on 9/24/2014 at site PD10. It should be noted that the flow at PD10 on that day was below the staff gauge. All of the sample sites reported the highest Dissolved Oxygen value on 5/12/2014. The only exception is the site on Prairie Dog Ditch (PDDitch), which did not have any water until after 5/22/14.

Dissolved Oxygen concentrations at USGS stations were above the recommended water column concentration from 2011-2014, with the lowest value (8.0 mg/L) reported at USGS Station 06306200 (Prairie Dog Near Wakely Siding) in June and July of 2012 and June of 2013.

Geometric means for May-June/July and July-August/September sampling periods were calculated for all sampling years so comparisons could be made among years (Table 6.6). Geometric means for May-July 2014 were lower than in 2007 and 2008 but similar to 2011 at most stations. July-September 2014 geometric means were typically similar to 2011 but higher than 2007 and 2008.

Table 6.6 Yearly Comparisons of Dissolved Oxygen (mg/L) Geometric Means from 2007-2014

Site	May-June/July				July-August/September			
	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)
PD01	9.18	8.68	8.35	8.55	8.19	7.05	8.69	8.69
PD02	9.32	8.63	8.16	8.32	7.78	6.8	8.16	8.13
DC01	8.48[A]	7.53	7.86[B]	6.83	6.6	6.34	6.73	7.32
PD3A		10.23	8.85	9.02		7.17	8.34	8.5
WCC01	9.78	10.55	9.16	8.9	7.34	6.72	8.35	8.45
PD05	9.46	10.14	8.97	8.56	8.05	7.11	8.53	8.17
PD5A		9.21[C]	8.85	8.68		7.17	8.35	8.42
PD06	10.11	9.51[C]	9.51	9.2	8.7	7.58	8.9	8.31
MC01	10.14	9.26[C]	9.35	9.06	8.67	7.41	8.3	8.06
PD08	10.32	10.44[C]	9.6	9.35	8.6	7.64	8.95	8.77
PD09	10.12	9.9[C]	9.78	9.77	8.38	7.78	9.01	8.84
JC01				9.08				8.51
PD10	9.56	9.64[C]	9.94	9.05	8.01	7.39	8.18	8.37
PDDitch	10.85	10.79[C]	10.29[D]	9.79[E]	8.42	7.51	8.97	8.8

[A] May-July 2007 geometric mean was calculated on 4 samples; site was inaccessible for one sample event
[B] May-July 2011 geometric mean was calculated on 4 samples; site was inaccessible for one sample event
[C] May-July 2008 geometric mean calculated on 4 samples; meter calibration issue
[D] May-July 2011 value is based on a single sample; there was no water during four sample events
[E] May-July 2014 geometric mean was calculated on 3 samples; there was no water during two sample events

6.3 DISCHARGE

SCCD installed and used calibrated staff gauges to estimate discharge during water sampling events (Appendix B). SCCD used USGS "real-time" flow information at PD01 (Station 06306250 Prairie Dog Creek, Near Acme, WY) and the staff gauge for the flume on Prairie Dog Ditch; no staff gauges were installed at those locations.

On lower mainstem sites (PD01-PD06), the highest flows occurred on 7/1 or 8/28 (Table 6.7). The gauge at PD02 was submerged on 7/1. The lowest flows were on 7/31 from PD01-PD05 and on 5/22 from PD5A to PD09. High and low instantaneous discharge at tributary stations was more variable and occurred at different times.

Table 6.7 2014 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	7/1	72.00	8/28	60.00	7/31	6.6	8/12&9/4	28.00
PD02	7/1	Sub	8/28	72.12	7/31	9.62	9/4	25.02
PD03A	8/28	70.92	7/1	61.14	7/31	5.39	5/22	16.08
PD05	8/28	31.63	7/1	28.47	7/31	14.88	5/22	15.61
PD05A	8/28	44.70	7/1	36.52	5/22	17.35	9/4	17.96
PD06	8/28	73.06	7/1	45.90	5/22	OUT	9/4	14.75
PD08	8/12	72.18	8/28	60.55	5/22	15.04	9/4	16.45
PD09	8/12	56.05	7/31	55.35	5/22	12.43	5/12	13.20
PD10	5/12	6.13	5/22	5.93	9/4	OUT	7/1	4.07
TRIBUTARY SITES								
DC01	7/1	15.8	8/28	7.47	7/31	0.65	9/4	1.28
WCC01	8/12	11.43	6/18	11.31	5/12	1.92	9/9	3.24
MC01	7/1	14.12	6/4	9.46	7/31	1.14	8/12	1.7
JC01	7/31	149.72	8/12	60.97	5/12	4.21	5/22	4.21
PDDitch	8/12	52.01	7/31	51.31	5/12	No Water	5/22	No Water

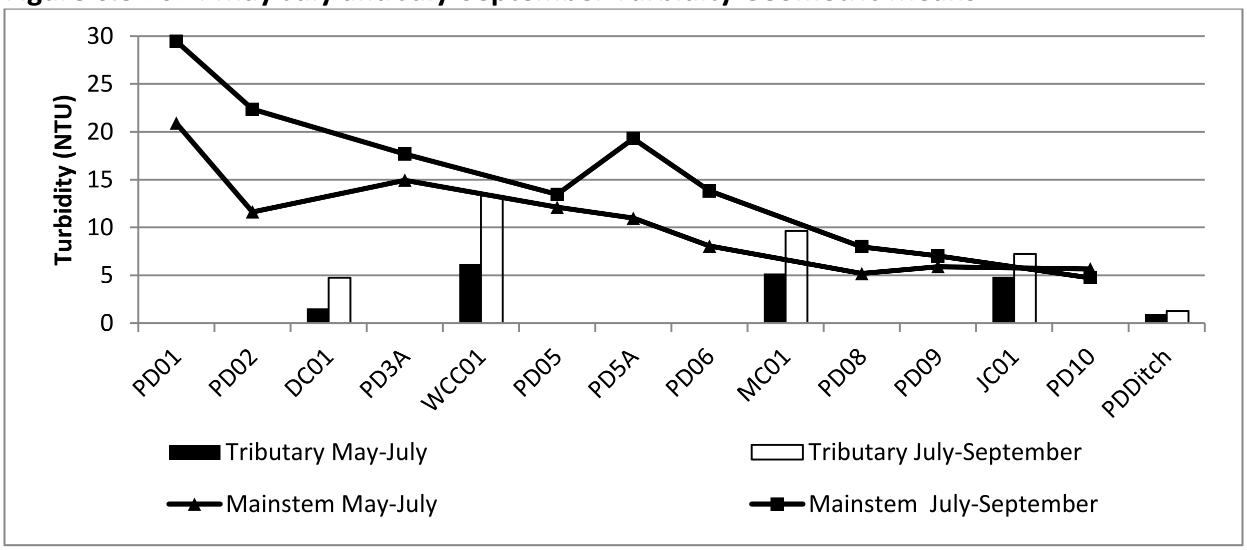
High flow values in 2014 measured on the lower portion of the watershed correspond to high instantaneous discharge measurements reported by the USGS on 6/24 at Station 06306200 (Prairie Dog at Wakely Siding) and on 6/24 and 8/26 at Station 06306250 (Prairie Dog Near Acme), which occur less than one week prior to the SCCD sample days (Appendix B). Low instantaneous discharge measurements were reported by USGS on 7/23 at Station 06306250 (Prairie Dog Creek Near Acme); no instantaneous measurements were collected at Station 06306200 (Prairie Dog at Wakely Siding) after 6/24/14.

USGS Station 06306250 (Prairie Dog Creek Near Acme) reported the highest mean daily discharge of 89 cfs on 6/27 and the lowest of 6 cfs on 7/30 and 7/31. The highest mean daily discharge reported from USGS Station 06306200 (Prairie Dog at Wakely Siding) was 65 cfs on 6/29; the lowest mean daily discharge was 4.4 cfs on 7/30. USGS mean daily flows within the watershed for 2014 were typically below the normal mean daily flow from May through mid-June and higher than normal in late June and late August (Appendix Figures B-8 and B-9).

6.4 TURBIDITY

Turbidity generally increased from upstream to downstream (Figure 6.3). Samples collected in May-July 2014 had lower turbidity geometric means than samples collected in July-August at all stations, except PD10. PD10 is the only station that is not affected by additional flow from Prairie Dog Ditch. Tributary sites were typically lower than adjacent mainstem stations; however, turbidity on Jenks Creek was slightly higher than PD09 and PD10 in July-September.

Figure 6.3 2014 May-July and July-September Turbidity Geometric Means



Geometric means for May and August sampling periods were calculated for all sampling years so comparisons could be made among years (Table 6.8). Turbidity geometric means for May-July were lower in 2014 than in all other years at all stations. For the most part, geometric means for turbidity in July-September 2014 were lower than in 2007, but not necessarily lower than in 2011.

Table 6.8 Yearly Comparisons of Turbidity (NTU) Geometric Means from 2007-2014

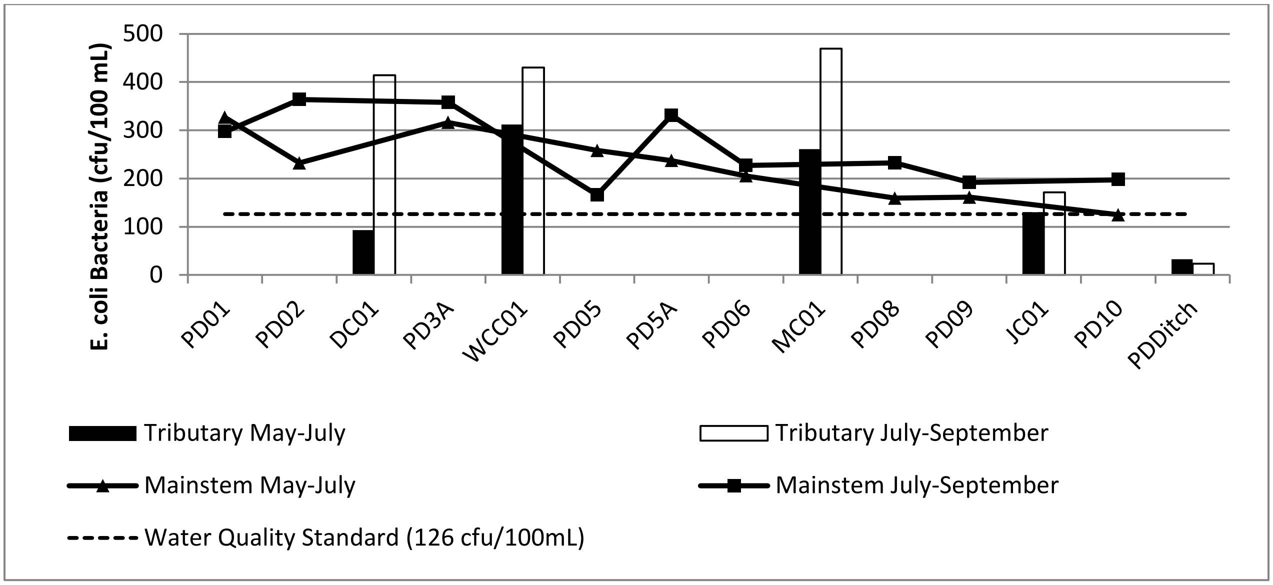
Site	May-June/July				July-August/September			
	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)	2007 (30 day)	2008 (30 day)	2011 (30 day)	2014 (60 day)
PD01	140.3	52.8	129.3	20.9[A]	11.6	31.2	9.5	29.5
PD02	105.7	54.9	75.9	11.6[A]	31.2	44.4	14.3	22.4
DC01	4.3[B]	5.2	5.2[C]	1.6[A]	12.3	11.0	12.9	4.8
PD3A		41.9	103.5	15.0[A]		41.7	16.8	17.7
WCC01	6.7	13.7	8.9	6.2[A]	25.7	31.7	18.6	13.3
PD05	74.6	31.0	53.3	12.1[A]	33.6	43.4	10.5	13.5
PD5A		67.7	37.2	11.0[A]		37.6	11.2	19.3
PD06	26.2	96.6	21.3	8.1[A]	25.9	24.9	10.7	13.8
MC01	13.3	10.6	27.9	5.2[A]	9.3	22.0	9.9	9.7
PD08	18.7	66.6	18.9	5.2[A]	21.2	19.3	18.2	8.0
PD09	28.2	56.2	19.1	5.9[A]	19.2	17.1	13.0	7.0
JC01				4.9[A]				7.2
PD10	6.1	12.3	13.5	5.7[A]	9.4	5.5	3.8	4.7
PDDitch	3.5	3.8	6.6[D]	1.0[E]	1.5	1.1	1.1	1.3

[A] May-July 2014 geometric mean was calculated on 4 samples; lab error for one set of samples
[B] May-July 2007 geometric mean was calculated on 4 samples; site was inaccessible for one sample event
[C] May-July 2011 geometric mean was calculated on 4 samples; site was inaccessible for one sample event
[D] May-July 2011 value is based on a single sample; there was no water during four sample events
[E] May-July 2014 geometric mean was calculated on 2 samples; no water for two and lab error for one

6.5 BACTERIA

Ten *E. coli* bacteria samples were obtained from 13 of the 14 monitoring stations in May-July and July-September 2014 (Appendix B). Prairie Dog Ditch had not been turned on and had no water to sample on 5/12 and 5/22; thus bacteria geometric means for 2014 were based on three samples for Prairie Dog Ditch. Bacteria geometric mean concentrations in May-July were typically lower than in July-September, except at PD01, PD05 and in Prairie Dog Ditch (Figure 6.4). May-July geometric means on mainstem sites were highest at PD01 (327) and PD3A (316). 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 of the stations, with the exception of Dutch Creek (93cfu/100mL) and PD10 (125 cfu/100mL) in May-July 2014. None of the samples collected on Prairie Dog Ditch were above the standard; in fact, all of the individual samples were below 55 cfu/100mL.

Figure 6.4. 2014 May-July and July-September *E. coli* Bacteria Geometric Means



Prior to 2014, geometric means were calculated on 5 samples collected within two separate 30 day periods (May-June and July-August). In 2014, SCCD calculated geometric means on 5 samples collected within two separate 60 day periods (WDEQ, 2014). Comparisons among years are still valuable for evaluating water quality trends; both the 30 day geometric means and the 60 day geometric means capture samples collected during early season (May-June/July) and late season (July-August/September) conditions. Comparisons among years could be made at all stations with the exception of Jenks Creek, which was a new site in 2014 (Table 6.9).

Bacteria concentrations decreased by 13-84% from 2011 to 2014 at a majority of the comparable sites in May-July and in July-September (Table 6.9). May-July bacteria concentrations increased at the upper mainstem station (PD10), on Wildcat Creek, and Prairie Dog Ditch by 101%, 20%, and 263%, respectively, though geometric means at PD10 and on Prairie Dog Ditch continued to meet water quality standards (Table 6.9 and Figure 6.5). The large percent increase on Prairie Dog Ditch in May-July represents a change from only 9 cfu/100 mL to 33 cfu/100 mL. Increases from July-August 2011 to July-September 2014 were observed at two mainstem stations (PD3A and PD09) and on Dutch Creek and Meade Creek.

Table 6.9. Bacteria Geometric Means and Percent Change Among Years at Comparable Stations in the Prairie Dog Creek Watershed.

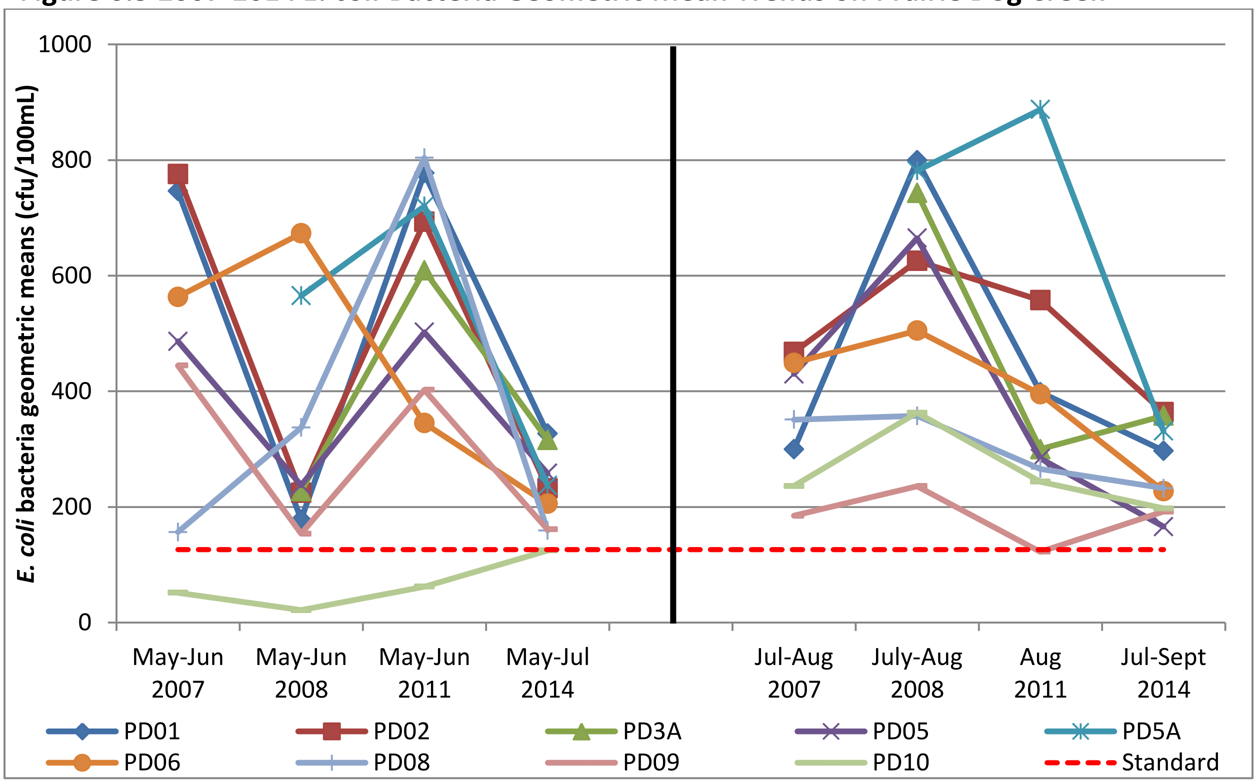
	Site	May-June/July *E. Coli* geometric means (cfu/100 mL)				Percent Change		
		2007 30-day	2008 30-day	2011 30-day	2014 60-day	2007-2014	2008-2014	2011-2014
Mainstem Stations	PD01	746	178	777[A]	327	-56.20%	84%	-57.94%
	PD02	776	224	693[A]	232	-70.05%	4%	-66.48%
	PD3A		227	609[A]	316	39.17%	39%	-48.11%
	PD05	486	238	502[A]	258	-46.95%	9%	-48.61%
	PD05A		565	720[A]	237	-58.06%	-58%	-67.10%
	PD06	563	673	345[A]	205	-63.52%	-69%	-40.42%
	PD08	156	337	804[A]	159	1.74%	-53%	-80.21%
	PD09	445	154	403[A]	161	-63.74%	5%	-59.95%
	PD10	52	21	62[A]	125	141.94%	483%	100.98%
Tributary Stations	Dutch Creek (DC01)	193[B]	338	152[C]	93	-51.69%	-72%	-38.71%
	Wildcat Creek (WCC01)	237	148	260	312	31.7%	110.9%	19.87%
	Meade Creek (MC01)	1411	557	479	261	-81.52%	-53.2%	-45.5%
	Jenks Creek (JC01)				130			
	Prairie Dog Ditch (PDDitch)	14	14	9[D]	33[E]	126.82%	140.2%	262.67%

	Site	July-August/September *E. Coli* geometric means (cfu/100 mL)				Percent Change		
		2007 30-day	2008 30-day	2011 30-day	2014 60-day	2007-2014	2008-2014	2011-2014
Mainstem Stations	PD01	299	799	398	297	-0.84%	-62.9%	-25%
	PD02	468	626	557	364	-22.20%	-41.8%	-35%
	PD3A		743	300	358	-51.88%	-51.9%	19%
	PD05	430	665	284	166	-61.40%	-75.0%	-41%
	PD05A		781	887	331	-57.63%	-57.6%	-63%
	PD06	449	505	395	227	-49.39%	-55.0%	-42%
	PD08	351	357	266	232	-33.78%	-35.0%	-13%
	PD09	185	236	122	192	4.03%	-18.6%	57%
	PD10	236	363	244	197	-16.39%	-45.6%	-19%
Tributary Stations	Dutch Creek (DC01)	85	533	164	414	385.07%	-22.3%	153%
	Wildcat Creek (WCC01)	495	737	592	430	-13.14%	-41.6%	-27%
	Meade Creek (MC01)	469	665	396	469	-0.01%	-29.4%	19%
	Jenks Creek (JC01)				171			
	Prairie Dog Ditch (PDDitch)	56	27	142	23	-58.36%	-15.1%	-84%

[A] May-July 2011 geometric mean was calculated on 4 samples; lab error for one set of samples
[B] May-July 2007 geometric mean was calculated on 4 samples; site was inaccessible for one sample event
[C] May-July 2011 geometric mean was calculated on 3 samples; site was inaccessible for one and lab error for one
[D] May-July 2011 value is based on a single sample; there was no water during four sample events
[E] May-July 2014 geometric mean was calculated on 3 samples; there was no water during two sample events

At mainstem sites, bacteria concentrations decreased from May-June 2007 to May-June 2008, except at PD06 and PD08. These decreases were followed by increases in May-June 2011, except at PD06, which decreased. May-July 2014 concentrations were similar to May-June 2008 at all mainstem stations except PD06, which continued to decrease, and PD10, which increased from May-June 2008 through May-July 2014. Bacteria concentrations at all mainstem sites increased from July-August 2007 to July-August 2008, which was followed by a decrease in August 2011 at all but one station (PD5A). Concentrations continued to decrease in July-September 2014 at most stations, but remained above Wyoming Water Quality Standards. Two mainstem sites, PD3A and PD09 had bacteria concentrations that increased from August 2011 to July-September 2014.

Figure 6.5 2007-2014 *E. coli* Bacteria Geometric Mean Trends on Prairie Dog Creek

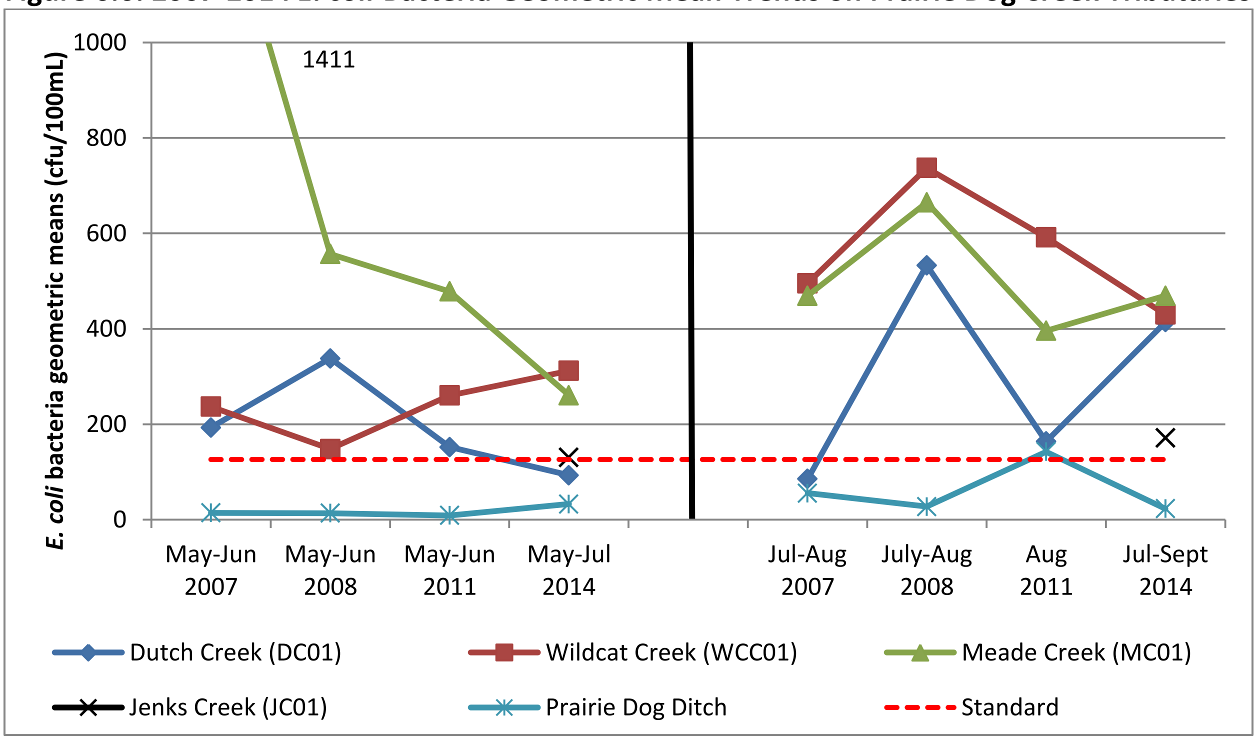


Early season bacteria concentrations on Meade Creek have decreased steadily since May-June 2007 (Table 6.9 and Figure 6.6). The station on Meade Creek was moved upstream between 2008 and 2011 to address accessibility issues. This could contribute to the decrease observed between 2008 and 2011, but would not be a factor in the decreases observed from 2007 to 2008 and from 2011-2014. Bacteria concentrations have also decreased since May-June 2008 in Dutch Creek, while early season bacteria concentrations in Wildcat Creek have increased.

All three of the tributary stations had an increase in late season bacteria concentrations from July-August 2007 to July-August 2008 followed by a decrease to August 2011 (Table 6.9 and Figure 6.6). Late season bacteria concentrations continued to decrease in Wildcat Creek for July-September 2014; however, July-September 2014 concentrations in Meade Creek and Dutch Creek increased from August 2011.

Bacteria concentrations on Prairie Dog Ditch have remained well-below Wyoming Water Quality standards for all sample periods except for August 2011 (Table 6.9 and Figure 6.6). Early season bacteria concentrations on Prairie Dog Ditch increased from May-June 2011 to May-July 2014. July-August 2008 bacteria concentrations were lower than July-August 2007, but increased in August 2011. Bacteria concentrations in July-September 2014 were similar to concentrations in July-August 2008.

Figure 6.6. 2007-2014 *E. coli* Bacteria Geometric Mean Trends on Prairie Dog Creek Tributaries



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.

6.6 METEOROLOGICAL DATA AND SUPPORTING INFORMATION

Mean daily air temperatures were below normal for most of June through September 2014 and above normal during late May and late September through October 2014 (Table 6.10 and Appendix Figure B-10). National Weather Service data at the Sheridan County Airport show normal mean daily air temperatures from May through October average 59.5°F while 2014 temperatures averaged 60.0°F. Monthly averages for air temperature were 1.3°F and 5.0°F higher than normal in May and October, respectively.

Cumulative precipitation through October 2014 was 12.86 inches, which was 0.03 inches lower than normal precipitation (Table 6.10 and Appendix Figure B-11). However, through September 2014 cumulative precipitation in 2014 was higher than normal. Monthly precipitation in 2014 was 0.62 inches, 0.17 inches, and 1.25 inches below normal in May, July, and October, respectively.

Table 6.10 2014 Air Temperature and Precipitation data collected by the National Weather Service from the Sheridan County Airport

	Average Daily Air Temperature (°F)		Precipitation (inches)			
	2014	Normal	2014	Normal	2014 Cumulative	Normal Cumulative
January-April					5.08	3.75
May	53.8	52.5	1.73	2.35	6.81	6.03
June	59.2	61.5	2.20	2.12	9.01	8.15
July	70.4	70.2	1.01	1.18	10.02	9.33
August	67.8	69.0	1.05	0.72	11.07	10.05
September	58.3	58.0	1.63	1.43	12.70	11.48
October	50.5	45.5	0.16	1.41	12.86	12.89

6.7 BENTHIC MACROINVERTEBRATES

6.7.1 PREVIOUS BENTHIC MACROINVERTEBRATE SAMPLING

Several monitoring groups have collected benthic macroinvertebrate samples in the Prairie Dog Creek watershed since 1977 (Table 6.11). 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. 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 2014

A total of five (N=5) benthic macroinvertebrate samples were collected in October 2014 from four (N=4) monitoring stations on Prairie Dog Creek. Prairie Dog Creek station PD05 was not sampled in 2014 because a comparable representative sample could not be collected due to the dominance of sand in the stream substrate. One (N=1) duplicate benthic macroinvertebrate sample was collected at Station PD08. 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 6.11 Historic and Current Benthic Macroinvertebrate Sampling Stations in the Prairie Dog Creek Watershed – 1977 to 2014. 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**	**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**	**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**	**About 150 yards upstream Highway 87**
Jenks Creek	NGPI10	44°37'01" / 106°50'33"	4360	WDEQ	1992, 98	About 0.1 mile upstream 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 twenty-seven (N=227) benthic macroinvertebrate taxa have been identified from streams in the Prairie Dog Creek watershed since 1977 (Appendix Table C-6). The family Chironomidae (midge flies) comprised the largest number of taxa (N=53) followed by the order Trichoptera (caddisflies) with thirty-seven (N=37) taxa, the order Ephemeroptera (mayflies) with thirty-five (N=35) taxa, the order Coleoptera (beetles) with twenty (N=20) taxa, and the order Plecoptera (stoneflies) with sixteen (N=16) taxa.

The caddisfly genus *Hydropsyche* and caddisfly species *Brachycentrus occidentalis* occurred most frequently in samples collected in the Prairie Dog Creek watershed (Appendix Table C-6). *Hydropsyche* occurred in 93% of the historic samples collected from 1977-2006, and in 83% 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. Acari (water mites) were common in samples occurring in 80% of all historic samples and in 87% of samples collected during the current study. The mayfly species *Baetis tricaudatus* occurred in 68% of the historic samples and in 78% of samples collected during the current study. The Chironomidae genera *Cricotopus*, *Diamesa, Eukiefferiella* and *Rheotanytarsus* occurred in 87%, 74%, 70%, and 70%, respectively, of samples collected during the current study. The riffle beetle genera *Microcylloepus, Optioservus* and *Dubiraphia* were common and occurred in 57%, 48%, and 43%, respectively, of samples collected during the current study. The stonefly genera Isoperla and Taenionema were the most common stonefly genera and occurred in 57% and 52%, 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) and revised by Hargett and ZumBerge (2006). The WSII is based on the analysis of benthic macroinvertebrate monitoring data collected by WDEQ from 1993 through 2001 from multiple reference and non-reference quality streams statewide. The WSII identified seven bioregions for Wyoming. Each bioregion used different scoring criteria because the biological communities naturally differ between bioregions.

Biological condition scoring criteria developed for the Bighorn and Wind River Foothills bioregion were used to evaluate biological condition for streams in the Prairie Dog Creek watershed. Table 6.12 lists the WSII metrics and metric formulae used to determine biological condition for benthic macroinvertebrate communities in the Bighorn and Wind River Foothills bioregion.

Table 6.12 Wyoming Stream Integrity Index (WSII) metrics and scoring criteria for benthic macroinvertebrate communities in the Bighorn and Wind River Foothills bioregion (from Hargett and ZumBerg, 2006).

Macroinvertebrate Metric	Metric Scoring Formulae	5^{th} or 95^{th} %ile (as per formula)
No. Ephemeroptera Taxa	100*X / 95^{th}%ile	9
No. Trichoptera Taxa	100*X / 95^{th}%ile	11
No. Plecoptera Taxa	100*X / 95^{th}%ile	7
% Non-insect	100*(74-X) / (74-5^{th}%ile)	0.3
% Plecoptera	100*X / 95^{th}%ile	19
% Trichoptera (w/o Hydropsychidae) (% within the Trichoptera)	100*X / 95^{th}%ile	100
% Collector-gatherer	100*(91.4-X) / (91.4-5^{th}%ile)	16.5
% Scraper	100*X / 95^{th}%ile	50.3
HBI	100*(8-X) / (8-5^{th}%ile)	1.8
No. Semivoltine Taxa (less semivoltine Coleoptera)	100*X / 95^{th}%ile	5

Metric values for the sample benthic macroinvertebrate community were compared to optimal benthic macroinvertebrate values (WSII) and expressed as a percent. The percentages were summed for each sample metric to provide a biological condition rating. The calculated biological condition value was then used to rate the biological community as Full-support, Indeterminate, or Partial/Non-support (Table 6-13).

Table 6.13 Assessment rating criteria for benthic macroinvertebrate communities based on the Wyoming Stream Integrity Index (WSII; from Hargett and ZumBerg, 2006) in the Bighorn and Wind River Foothills bioregion of Wyoming.

Rating of Biological Condition (Aquatic Life Use Support)	Bighorn and Wind River Foothills Bioregion
Full Support	>62.1
Indeterminate Support	41.4 – 62.1
Partial/ (Non - Support)	0-41.3

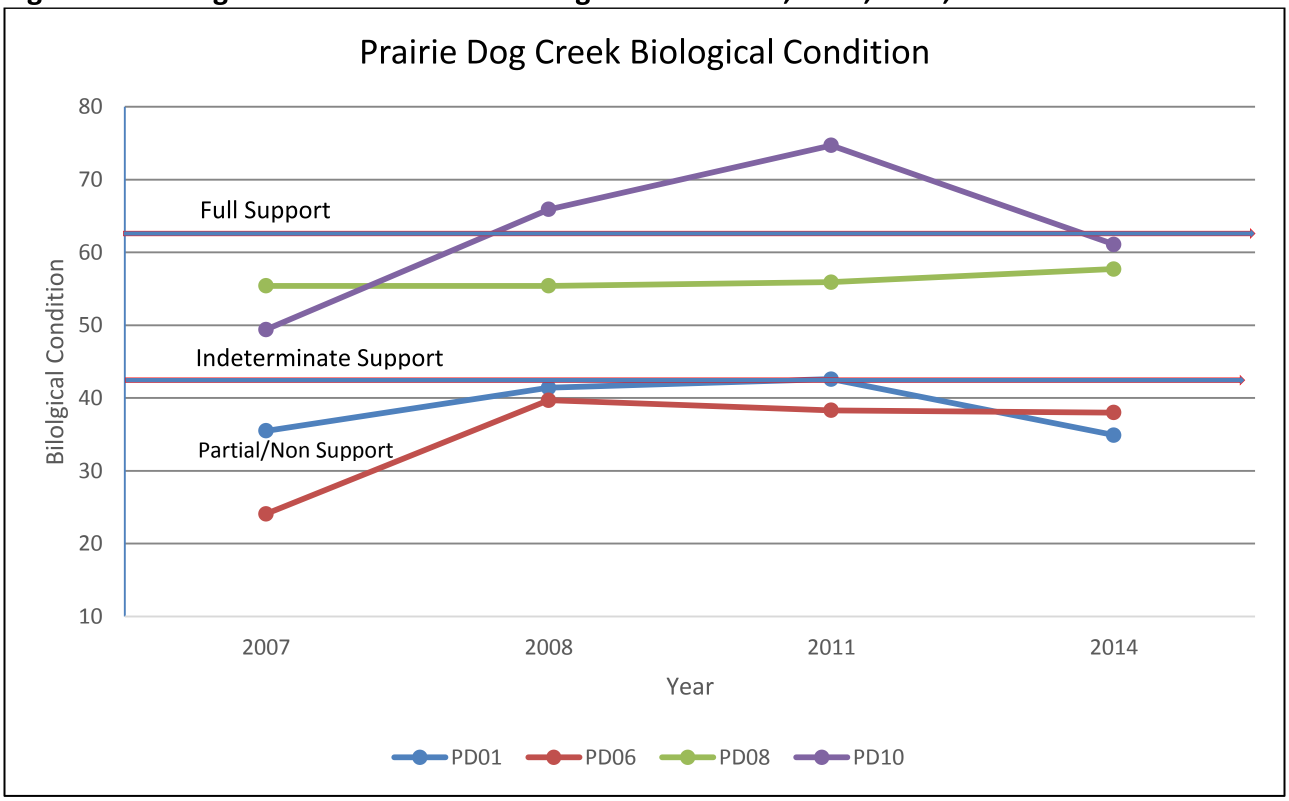
A biological condition rating of Full-support indicates full support for narrative aquatic life use. The Indeterminate biological classification is not an attainment category in itself, but is a designation indicating the need for additional information or data to determine the proper narrative aquatic life use designation such as Full-support or Partial/Non-support (Hargett and ZumBerge, 2006). The Partial/Non-support classification indicates the aquatic community is stressed and water quality or habitat improvements are required to restore the stream to full support for narrative aquatic life use. Biological condition for each station is presented in Table 6.14 and illustrated in Figure 6.7.

Table 6.14 Biological condition score and rating for benthic macroinvertebrate samples collected from the Prairie Dog Creek Watershed based on the Wyoming Stream Integrity Index for the Bighorn and Wind River Foothills Bioregion (WSII; from Hargett and ZumBerge, 2006).

Stream Name	Station Name	Sampling Group	Year	Score	Rating
Prairie Dog Creek	**PD01**	**SCCD**	**2007**	**35.5**	**Partial/ Non Support**
Prairie Dog Creek	**PD01**	**SCCD**	**2008**	**41.4**	**Indeterminate**
Prairie Dog Creek	**PD01**	**SCCD**	**2011**	**42.6**	**Indeterminate**
Prairie Dog Creek	**PD01**	**SCCD**	**2014**	**34.9**	**Partial/ Non Support**
Prairie Dog Creek	NGP30	WDEQ	1998	47.9	Indeterminate
Prairie Dog Creek	NGP28	WDEQ	1998	48.5	Indeterminate
Prairie Dog Creek	**PD05**	**SCCD**	**2007**	**15.0**	**Partial/ Non Support**
Prairie Dog Creek	**PD05**	**SCCD**	**2008**	**26.0**	**Partial/ Non Support**
Prairie Dog Creek	**PD05**	**SCCD**	**2011**	**13.1**	**Partial/ Non Support**
Prairie Dog Creek	NGP31	WDEQ	1998	49.1	Indeterminate
Prairie Dog Creek	**PD06**	**SCCD**	**2007**	**24.1**	**Partial/ Non Support**
Prairie Dog Creek	**PD06**	**SCCD**	**2008**	**39.7**	**Partial/ Non Support**
Prairie Dog Creek	**PD06**	**SCCD**	**2011**	**38.3**	**Partial/ Non Support**
Prairie Dog Creek	**PD06**	**SCCD**	**2014**	**38.0**	**Partial/ Non Support**
Prairie Dog Creek	NGP32	WDEQ	1998	60.5	Indeterminate
Prairie Dog Creek	NGPI13	WDEQ	1992	51.8	Indeterminate
Prairie Dog Creek	NGPI13	WDEQ	1998	54.5	Indeterminate
Prairie Dog Creek	NGP33	WDEQ	1998	57.5	Indeterminate
Prairie Dog Creek	**PD08**	**SCCD**	**2007**	**55.4**	**Indeterminate**
Prairie Dog Creek	**PD08**	**SCCD**	**2008**	**55.4**	**Indeterminate**
Prairie Dog Creek	**PD08**	**SCCD**	**2011**	**55.9**	**Indeterminate**
Prairie Dog Creek	**PD08**	**SCCD**	**2014**	**57.7**	**Indeterminate**
Prairie Dog Creek	NGP29	WDEQ	1998	59.7	Indeterminate
Prairie Dog Creek	NGPI12	WDEQ	1992	53.8	Indeterminate
Prairie Dog Creek	NGPI12	WDEQ	1998	64.3	Full
Prairie Dog Creek	NGPI11	WDEQ	1992	63.7	Full
Prairie Dog Creek	NGPI11	WDEQ	1998	57.2	Indeterminate
Prairie Dog Creek	**PD10**	**SCCD**	**2007**	**49.4**	**Indeterminate**
Prairie Dog Creek	**PD10**	**SCCD**	**2008**	**65.9**	**Full**
Prairie Dog Creek	**PD10**	**SCCD**	**2011**	**74.7**	**Full**
Prairie Dog Creek	**PD10**	**SCCD**	**2014**	**61.1**	**Indeterminate**
Jenks Creek	NGPI10	WDEQ	1992	50.5	Indeterminate
Jenks Creek	NGPI10	WDEQ	1998	62.3	Full
Jenks Creek	MRC91	WDEQ	2000	68.1	Full
Jenks Creek	MRC90	WDEQ	2000	59.2	Indeterminate
Meade Creek	NGP19	WDEQ	1998	41.9	Indeterminate

Biological condition at the lower-most Prairie Dog Creek monitoring station PD01 was Partial/Non-Support during 2007, indeterminate during 2008 and 2011, then dropped to Partial/Non-Support during 2014 (Table 6.14 and Figure 6.7). Biological condition at station PD06 has been Partial/Non-Supporting during each year. Biological condition increased from station PD06 to the two upper-most monitoring stations PD08 and PD10. Biological condition at PD08 was Indeterminate during 2007, 2008, 2011 and 2014. The range in biological condition scores among years was narrow and ranged from a score of 55.4 in both 2007 and 2008, to a score of 57.7 in 2014. The most upstream station PD10 exhibited Indeterminate biological condition during 2007, Full Support during 2008 and 2011, then dropped to Indeterminate support in 2014 (Figure 6.7).

Figure 6.7 Biological condition at Prairie Dog Creek stations, 2007, 2008, 2011 and 2014.



An improvement was observed in biological condition from stations PD001 and PD06 to station PD08, and generally from station PD08 to the most upstream station PD10 (Figure 6.7). The general improvement in biological condition from stations PD01 and PD06 to upstream stations PD08 and PD10 was related to the increased number of the generally pollution intolerant organisms including ephemeroptera, trichoptera, and plecoptera taxa and a normally lower percent of non-insects in the benthic community (Table 6.15). Further, the HBI value, which provides a general index of community pollution tolerance, generally decreased from the downstream monitoring stations to the upstream monitoring stations. 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, 1998 (Table 6.14) 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 Tables D-18 and D-19 *in* SCCD, 2009), during 2011 (see Appendix Table C-4 *in* SCCD, 2012) and during sampling in 2014 (Appendix Table C-2). This observation suggests a source of organic material entering Prairie Dog Creek between station PD06 and station PD08. 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., 1981; Lenat and Eagleson, 1981a). The number of worm taxa at station PD06 in 2007 (N=8), 2008 (N=6), 2011 (N=5), 2014 (N=3) and the percent contribution of worms in 2007 (16.5%), 2008 (14.4%), 2011 (9.51%) and 2014 (5.3%) 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 Tables D-32 and D-33 *in* SCCD 2009), 0.13% in 2011 (Appendix Table C-6 *in* SCCD 2012) and 0.34% 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 63 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.

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 and 2014.

	PD01	PD01	PD01	PD01	PD06	PD06	PD06	PD06	PD08	PD08	PD08	PD08	PD10	PD10	PD10	PD10
Macroinvertebrate Metric	**2007**	**2008**	**2011**	**2014**	**2007**	**2008**	**2011**	**2014**	**2007**	**2008**	**2011**	**2014**	**2007**	**2008**	**2011**	**2014**
Ephemeroptera taxa	5	4	3	3	4	4	5	6	6	5	5	5	2	6	4	2
Trichoptera taxa	4	5	5	5	3	3	8	6	9	12	9	8	6	12	11	5
Plecoptera taxa	1	2	3	1	0	2	2	1	4	4	3	4	3	6	5	4
% non-insects	0.91	5.15	0.88	8.05	18.59	16.85	15.17	6.90	2.88	2.33	7.37	2.79	30.02	1.54	3.89	1.56
% Plecoptera	0.73	4.58	3.73	2.68	0	2.41	0.86	0.20	4.06	1.62	3.14	1.45	14.70	6.80	27.09	18.51
% Trichoptera (less Hydropsychidae)	1.59	16.77	8.47	20.47	18.75	46.67	25.30	47.89	31.11	21.26	42.57	46.53	98.16	28.44	87.78	94.22
% collector-gatherers	33.03	27.66	41.62	55.2	80.39	69.07	62.93	74.77	28.95	22.37	24.14	29.92	44.30	21.16	27.14	19.20
% scrapers	12.71	14.12	1.76	3.19	0.21	2.99	2.411	1.97	11.18	15.04	22.36	30.29	3.32	17.49	19.21	0.87
HBI	6.72	6.23	5.07	5.69	6.76	6.20	5.922	5.63	5.88	6.03	4.57	4.40	6.17	5.80	2.75	4.38
Semi-voltine taxa (less semivoltine Coleoptera)	1	1	3	2	2	2	2	2	1	1	2	2	0	2	2	2

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 6.7.2 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. Consequently, habitat assessments were conducted at monitoring stations PD01, PD06, P0D8 and PD10 during 2014.

Habitat assessment data, embeddedness values and current velocity data are presented in Table 6.16. The mean percent substrate composition is presented in Table 6.17. 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 score at the Prairie Dog Creek stations during 2014 ranged from lows of 124 at station PD06 and 125 at station PD01, to a high of 154 at station PD10 (Table 6.16).

The riparian zone indicator parameters including bank vegetation protection, bank stability, and disruptive pressures scored high at each monitoring station indicating that the riparian zone immediately adjacent to the stream channel was in 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 greatly among the sampling stations (Table 6.17). Stations PD01 and PD08 were similar since each was dominated by cobble and coarse gravel. Station PD10 was dominated by sand and fine gravel with no cobble and little coarse gravel. Stream substrate at station PD06 was intermediate to stream substrate at the other Prairie Dog Creek monitoring stations. Station PD06 during 2014 was dominated by sand (56% of total substrate) with coarse gravel (20% of total substrate), fine gravel (16% of total substrate) and cobble (8% of total substrate) also present. 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 6.16 Habitat assessment scores, weighted embeddedness values and current velocities for Prairie Dog Creek stations, 2007, 2008, 2011 and 2014.

	PD01	PD01	PD01	PD01	PD06	PD06	PD06	PD06	PD08	PD08	PD08	PD08	PD10	PD10	PD10	PD10
Habitat Parameter	**2007**	**2008**	**2011**	**2014**	**2007**	**2008**	**2011**	**2014**	**2007**	**2008**	**2011**	**2014**	**2007**	**2008**	**2011**	**2014**
Substrate / Percent Fines	4	13	18	8	3	10	7	5	11	15	10	15	1	1	3	10
Instream Cover	15	14	16	12	8	13	16	14	13	10	13	15	15	19	18	16
Embeddedness	6	20	2	3	8	16	12	2	10	6	12	8	ND	ND	17	20
Velocity / Depth	11	7	12	8	16	16	17	14	15	16	16	14	9	19	15	10
Channel Flow Status	20	19	20	19	14	19	17	19	17	19	16	16	17	19	18	15
Channel Shape	15	14	14	14	11	12	13	13	12	12	12	12	12	19	15	13
Pool Riffle Ratio	7	6	3	6	10	12	13	6	13	13	13	13	6	15	7	12
Channelization	14	14	14	13	11	11	12	10	11	8	8	9	14	15	14	14
Width Depth Ratio	15	12	10	11	8	9	12	13	9	10	10	11	14	15	10	13
Bank Vegetation Protection	10	9	10	9	8	7	8	8	8	8	8	8	10	10	10	9
Bank Stability	10	9	10	9	8	7	8	8	8	9	8	8	10	10	10	9
Disruptive Pressures	10	9	10	9	10	7	10	10	6	8	6	7	10	10	10	9
Riparian Zone Width	2	3	8	4	2	7	8	2	1	4	2	2	4	7	5	4
TOTAL SCORE	139	149	147	125	117	146	153	124	134	138	134	138	NC	NC	152	154
Weighted Embeddedness	43	98	29	30	50	82.5	68.6	27.1	57	43.3	65.4	48.6	ND	ND	87.5	99.2
Current Velocity (ft. per second)	2.69	1.87	2.28	2.20	1.12	1.81	1.32	1.53	2.14	2.87	1.62	1.50	0.57	0.71	0.69	0.96

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

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

Table 6.17 Mean percent substrate composition for Prairie Dog Creek stations, 2007, 2008, 2011 and 2014.

Substrate Type	PD01 2007	PD01 2008	PD01 2011	PD01 2014	PD06 2007	PD06 2008	PD06 2011	PD06 2014	PD08 2007	PD08 2008	PD08 2011	PD08 2014	PD10 2007	PD10 2008	PD10 2011	PD10 2014
% Cobble	42	47	66	61	2	1	5	8	51	71	59	72	0	0	0	0
% Coarse Gravel	4	18	12	3	20	18	20	20	25	7	8	11	1	0	0	1
% Fine Gravel	13	8	1	1	29	23	20	16	0	4	11	6	0	4	34	75
% Silt	1	0	21	0	4	0	0	0	0	0	0	0	5	15	5	7
% Sand	37	26	0	35	46	58	55	56	24	18	23	11	94	81	61	18

The dominance of sand at station PD06 was responsible for the reduction in biological condition observed at this station when compared to biological condition at the other monitoring stations. 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 values were similar among stations PD01 (mean=50), PD06 (mean=57) and PD08 (mean=54). The mean of two Weighted Embeddedness values at the upper-most monitoring station PD10 in 2011 and 2014 was 93. This observation indicated that approximately 7% to 8% 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 8% of the benthic macroinvertebrate community at station PD01 and means of 2% at station PD06, 20% at station PD08 and 10% at station PD10 (Table 6.15).

The mean current velocity during 2007, 2008, 2011 and 2014 measured at station PD01 was 2.3 feet per second (FPS), 1.4 FPS at station PD06, 2.0 FPS at station PD08, and 0.7 FPS at station PD10 (Table 6.16). 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.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

All instantaneous temperature samples during 2014 were below the maximum 20°C instream temperature standard; however, continuous temperature data loggers reported temperatures that exceeded the temperature standard of 20° C at all but the uppermost station (PD10) . Specific conductivity and pH were within the expected ranges during 2014. Turbidity values were considered normal for the watershed with occasional high values occurring during late-spring, early summer precipitation and run-off events. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages. Four tributary stations and eight mainstem stations had one or more samples that were below the water column concentration recommended to achieve the intergravel concentration for early life stages; however two of the tributaries are Class 3B streams and the DO standard did not apply. High flows in July-August correspond to above normal precipitation in the days preceding the sample collection.

Bacteria geometric mean concentrations in May-July were typically lower than in July-September, except at PD01, PD05, and in Prairie Dog Ditch. May-July and July-September geometric mean concentrations were above Wyoming Water Quality Standards at nearly all of the stations, with the exception of Dutch Creek and PD10 in May-July 2014. None of the individual samples collected on Prairie Dog Ditch were 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 decreased from 2011 to 2014 at a majority of the comparable sites in May-July and in July-September. May-July bacteria concentrations increased at the upper mainstem station (PD10), on Wildcat Creek, and Prairie Dog Ditch though geometric means at PD10 and on Prairie Dog Ditch continued to meet water quality standards in 2014. Increases from July-August 2011 to July-September 2014 were observed at two mainstem stations (PD3A and PD09) and on Dutch Creek and Meade Creek. Although bacteria decreases were observed at a majority of the sites from 2011-2014, all but one of the stations (PDDitch) continued to exceed Wyoming Water Quality standards in July-August 2014.

Biological condition at the lower-most Prairie Dog Creek monitoring station PD01 was Partial/Non-Support during 2007, indeterminate during 2008 and 2011, then dropped to Partial/Non-Support during 2014. Biological condition at station PD06 has been relatively consistent since 2007 and was Partial/Non-Supporting each year. The Partial/Non-support classification at stations PD01 and PD06 indicates the aquatic community is stressed and water quality or habitat improvements are required to restore the stream to full support for narrative aquatic life use.

Biological condition increased from station PD06 to the two upper-most monitoring stations PD08 and PD10. Biological condition at PD08 was Indeterminate during 2007, 2008, 2011 and

2014. The most upstream station PD10 exhibited Indeterminate biological condition during 2007, Full Support during 2008 and 2011, then dropped to Indeterminate Support in 2014. The Indeterminate biological classification is a designation indicating the need for additional information or data to determine the proper narrative aquatic life use designation such as Full-support or Partial/Non-support. The biological condition rating of Full-support at station PD10 during 2008 and 2011 indicates full support for narrative aquatic life use.

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.

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

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. SCCD will continue to monitor water quality in the Prairie Dog Creek Watershed on a three-year rotation, pending available funding sources. 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.

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APPENDICES

APPENDIX A

Prairie Dog Creek Watershed
2014 Watershed Maps

APPENDIX B

Prairie Dog Creek Watershed
2014 Water Quality Data

APPENDIX C

Prairie Dog Creek Watershed
Benthic Macroinvertebrate Data

APPENDIX D

Prairie Dog Creek Watershed
2014 Quality Assurance Quality Control Documentation

APPENDIX E

Prairie Dog Creek Watershed
2014 Photos