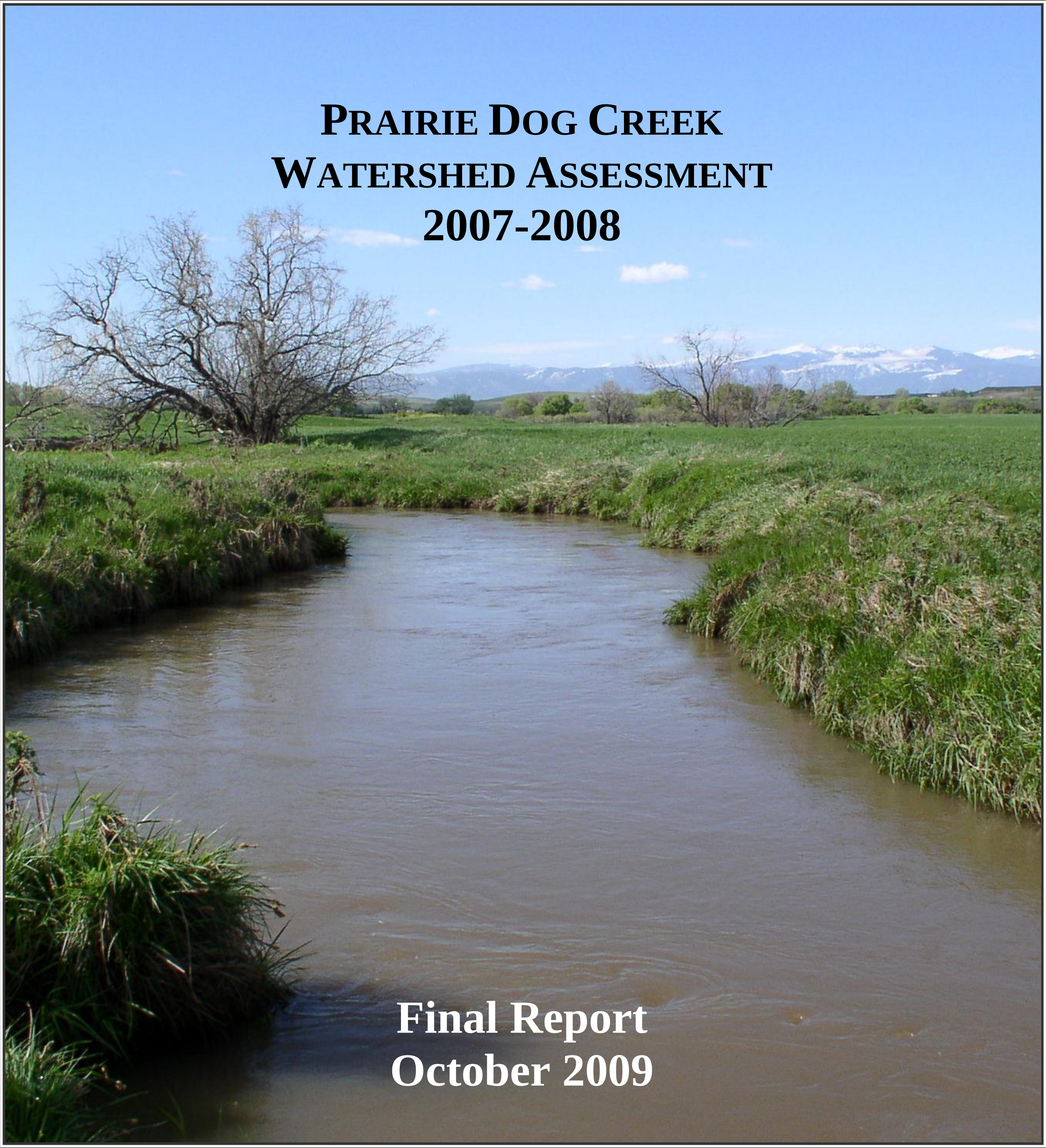
PRAIRIE DOG CREEK WATERSHED ASSESSMENT 2007-2008



Final Report
October 2009

SHERIDAN COUNTY
CONSERVATION DISTRICT

2007-2008

Prairie Dog Creek
Watershed Assessment

Final Report

<u>Prepared by:</u>
Sheridan County Conservation District
1949 Sugarland Drive, Suite 102
Sheridan, WY 82801
(307) 672-5820 x. 3

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1. INTRODUCTION

1.1 STATEMENT OF NEED

The Sheridan County Conservation District (SCCD), in partnership with the USDA Natural Resources Conservation Service (NRCS), has facilitated active watershed improvement efforts on the Tongue River and Goose Creek watersheds and sought to initiate a similar effort on the Prairie Dog Creek watershed. Both the Tongue River Watershed Assessment (SCCD, 2000) and the Goose Creek Watershed Assessment (SCCD, 2003) resulted in the development of watershed plans. Both plans were developed under the direction of local watershed steering committees and residents. The plans address watershed concerns through watershed improvement projects, information and education actives, and include provisions for continued water quality monitoring on a 3 year rotation (SCCD, 2007 and SCCD, 2004).

When the project was initiated, Prairie Dog Creek was listed on Table A of Wyoming's 303(d) List of Waters Requiring Total Maximum Daily Loads (TMDLs) for aesthetic drinking water impairments due to elevated Manganese concentrations and fecal coliform impairments related to recreational use (WDEQ, 2006). Manganese impairments, first identified in 2002, were determined to be related to natural geology and did not pose a human health risk (WDEQ, 2002). Previous monitoring was sufficient to have the streams identified as impaired; however, they were insufficient in frequency and duration to establish a baseline condition or to initiate a local watershed planning and improvement effort. The Prairie Dog Watershed Assessment (PDWA) served as the foundation for a local watershed planning and improvement effort and encouraged public participation in the process. The planning process adhered to the principles established in the <u>Watershed Strategic Plan</u> (WACD, 2000), which insists that "any watershed effort led by a conservation district should be landowner driven. . .[and] any participation on behalf of any landowner is strictly voluntary." The Draft Prairie Dog Creek Watershed Plan was submitted to WDEQ in September 2009 (SCCD, 2009).

1.2 PROJECT GOALS AND TASKS

The PDWA is part of a local watershed planning and improvement effort on the watershed. The PDWA and the development of a watershed plan are funded by a grant administered by the Wyoming Department of Environmental Quality (WDEQ), 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. The SCCD conducted the PDWA and used the information to facilitate the development of a watershed plan by watershed residents. As required by WDEQ and the US Environmental Protection Agency (USEPA) the watershed plan meets the nine essential elements of an USEPA Watershed-Based Plan. Specific project goals and tasks for this project were described in the January 2006 Project Implementation Plan (PIP) for the grant (SCCD, 2006). A final grant report will be submitted to the funding agencies to describe the activities for the items specific to each grant.

This report will summarize the activities and results related to the collection and analyses of water quality information for the 2007-2008 PDWA.

The goals and objectives fulfilled the guidelines outlined in the Wyoming Nonpoint Source Management Plan Update (WDEQ, 2000), which requires the Water Quality Division to "continue an ongoing assessment of the statewide condition of surface water…implement a proactive information and education program to enhance the public's knowledge of nonpoint source pollution,…[and to] achieve protection of the quality of Wyoming's water resources through the targeted application of regulatory and non-regulatory methods, but primarily through the organization and facilitation of local stakeholder groups which develop and implement watershed management plans (WDEQ, 2000)."

A Project specific Sampling Analysis Plan (SAP) was developed under the SCCD, Water Quality Monitoring Program *Quality Assurance Project Plan (QAPP),* Revision 2 (SCCD, 2007a) and the WDEQ, Water Quality Division, Watershed Program Quality Assurance Project Plan for *Beneficial Use Reconnaissance Program (BURP) Water Quality Monitoring* (WDEQ, 2001). The PDWA SAP (SCCD, 2007b) was approved by WDEQ in 2007, with adjustments made for monitoring in 2008. The SAP described the sample sites, parameters, methods used for monitoring, quality assurance/quality control (QA/QC) procedures, and other specifics related to the monitoring. This document ensured a seamless transition with changes in personnel.

The collection of data in the PDWA met the requirements of State law, Wyoming Statutes (W.S.) 35-11-103(b) and (c) and W.S. 35-11-302 and State of Wyoming Enrolled Act 47 (the Credible Data Bill), which requires the use of "scientifically valid, chemical, physical, and biological monitoring data collected under an accepted sampling and analysis plan, including quality control, quality assurance procedures and available historical data."

2. DESCRIPTION OF PROJECT AREA

2.1 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). The watershed is identified by hydrologic unit code (HUC) WYTR 10090101-020-2. 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. This is the lowest point in the watershed at 3,435 feet. The total elevation difference is 3,086 feet over a distance of approximately 26 miles (119 feet/mile, or 2.25%), sloping generally from south to north (EnTech, 2001).

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. Stream flow 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 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 recreational 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 diversion are suspected to be responsible for habitat and stream channel degradation (Entech, 2001).

EnTech, Inc. (2001) identified three Level I stream types using Rosgen’s stream classification methodology (Rosgen, 1996):

- <u>C-Type</u>: Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains. Typically associated with broad valleys containing terraces and slight entrenchment.
- <u>B_C-Type</u>: Steeper than a C-Type, riffle dominated with infrequently spaced pools. Associated with moderate entrenchment.
- <u>G-Type</u>: Entrenched “gully” step/pool on moderate gradients. Associated with narrow valleys or deeply incised alluvial/colluvial materials such as fans or deltas. Unstable, with grade control problems and high bank erosion rates.

The upper reaches of the watershed lie within Major Land Resource Area (MLRA) 46 – Northern Rocky Mountain Foothills (NRCS, 1986). The approximate lower two-thirds of the watershed lie within MLRA 58B – Northern Rolling High Plains (NRCS, 1986). Approximately 90% of the watershed is rangeland, with half in the 15”–19” Northern Plains Ecological Site group and half in the 10”–14” Northern Plains Ecological Site group (NRCS, 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) (NRCS, 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.

2.2 LAND USE

Land ownership within the watershed is approximately 77% privately owned, 20% owned by the State of Wyoming, and 3% federally administered by the Bureau of Land Management (EnTech, 2001 from 2001 Sheridan County Assessor records). 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.

There are approximately 15,300 acres of sprinkler and contour ditch irrigation on the watershed. The NRCS Sheridan Field Office estimates that ½ of the irrigation systems are operating at less than 70% of their potential efficiency; over half have the potential to be upgraded to higher efficiency systems. A few cash crops are grown, but most agricultural enterprises rely on hayland and cattle production.

Land use of privately owned lands is quite diverse. Small and large ranches constitute the majority of private lands. These ranches generally include pasture lands for cattle grazing, irrigated hay and crop lands, and corrals for short to long term feeding. Many private lands in rural areas continue to be sub-divided and developed as the Sheridan area continues to grow. 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 of the watershed. The area also provides year-round habitat for small and big game, furbearers, waterfowl, game birds, and song birds.

Streams and reservoirs within the watershed are highly appropriated and provide a crucial resource to ranches, subdivisions, and urban areas. Established diversions from these waterbodies to the end-users have created a complex web of water delivery systems where inter-drainage waters are often mixed and co-mingled. Many of the delivery and application systems operate at very low efficiencies losing much of the water to infiltration, seeps, and evaporation.

In recent years the watershed has been subject to increasing amounts of Coal Bed Methane (CBM) production. CBM development has the potential to affect surface and groundwater sources through increases in surface flow and drawdown of groundwater. Due to this increased type of development and at the request of watershed residents, SCCD included water quality parameters that may be affected by CBM development (i.e. Sodium Adsorption Ratio).

2.3 POINT SOURCE DISCHARGES

Prairie Dog Creek is somewhat unique for Sheridan County in that it has no municipal water uses or discharges. In 2007 there were two active Wyoming Pollutant Discharge Elimination System (WYPDES) storm water discharge permits within the Prairie Dog Creek watershed, in addition to one active temporary discharge permit. The vast majority of the WYPDES permits active in the Prairie Dog Creek watershed during 2007 were coal-bed methane (CBM) discharges, numbering 322 permits. Few of these discharge waters 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.

The point source discharges are monitored by WDEQ and operators of the facilities that discharge into Prairie Dog Creek and its tributaries. SCCD obtained and compiled the point source discharge monitoring data to compliment monitoring data collected during the PDWA. However, point source pollution within the Prairie Dog Creek watershed is currently regulated by WDEQ. The intention of SCCD's watershed efforts was to establish baseline watershed condition necessary to implement voluntary, incentive-based improvements. These improvements will be completed voluntarily at the landowner's request to eliminate and/or reduce non-point source pollution within the watershed.

3. STREAM LISTINGS, CLASSIFICATIONS, AND STANDARDS

3.1 STREAM 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. 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 their uses. A TMDL is the amount of a given pollutant a waterbody can receive and still meet water quality standards. WDEQ is required to develop TMDLs on waterbodies that do not meet water quality standards. While WDEQ supports and encourages local watershed planning and improvement efforts, they must also meet federal requirements for the development of TMDLs.

Wyoming's 305(b) report and 303(d) list is published every two years. The documents undergo a public comment period prior to being finalized. Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2007) describes the surface water classes and uses that each class is to be able to meet. In addition, Chapter 1 outlines the water quality standards that must be achieved for a Wyoming waterbody to support its designated uses (WDEQ, 2007). If a waterbody exceeds narrative or numeric water quality standards, it is considered to be "impaired" or not meeting its designated uses. These waterbodies were included on the Wyoming 303(d) list of Waters Requiring TMDLs (WDEQ, 2006). In 2008, WDEQ combined Tables A and C into a single 303(d) List of Waters Requiring TMDLs (WDEQ, 2008). Prior to 2008, the 303(d) lists published by WDEQ were organized as follows:

- Table A. Waterbodies requiring TMDL's, for which there are credible data that indicate the reach does not support all its designated uses. These are considered impaired.

- Table B. Waterbodies requiring Waste Load Allocations and/or TMDL's in the two years following publication due to the routine NPDES renewal process for permits containing Waste Load Allocations.

- Table C. Waterbodies requiring watershed plans or TMDL's, for which there are data indicating trends away from supporting beneficial use and where there are improvement plans or other corrective actions in progress. These are considered threatened.

- Table D. Waterbodies removed from the Table A, B, or C of the previous 303(d) lists of waterbodies requiring TMDL's.

In 1996, WDEQ listed Prairie Dog Creek on the 303(d) list of impaired water bodies as a result of information suggesting that the stream was only in partial support of its aquatic life use for siltation, nutrients, flow, habitat, and salinity/total dissolved solids/chlorides (WDEQ, 1996). However, in 1998, Prairie Dog Creek was among several waterbodies that were determined to have insufficient data. These waterbodies were included in the 1998 303(d) list on "Table E:

1996 303(d) Waters Requiring Further Monitoring" (WDEQ, 1998). Consequently the WDEQ included Prairie Dog Creek future monitoring efforts.

In 2002, Prairie Dog Creek was listed on Table A of Wyoming's 303(d) List of Waters Requiring TMDLs for aesthetic drinking water impairments (WDEQ, 2002). This was due primarily to elevated Manganese concentrations. This listing came as a result of monitoring done by the United States Geological Survey (USGS) at Station Number 06306250, Prairie Dog Creek Near Acme, and was assigned a low priority for TMDL development. While the concentrations indicated impairments for aesthetic drinking water use (discoloration), the Manganese concentrations were not believed to pose a human health risk (WDEQ, 2002). In 2004, WDEQ suspected the high Manganese concentrations resulted from the natural geology of the area and was considering site specific criteria (WDEQ, 2004).

In 2004, the entire Prairie Dog Creek watershed was placed on the 303 (d) List for fecal coliform impairments related to recreational uses (WDEQ, 2004). This came as a result of WDEQ monitoring in July 2003 (Collyard, 2003) and was assigned a high priority for TMDL development because no local group had committed to develop a watershed plan (WDEQ, 2004). In 2004, SCCD was denied 319 funding to initiate an assessment and planning effort on Prairie Dog Creek. SCCD addressed the concerns of the Non-Point Source Task Force and reapplied for funding in 2005. Once the SCCD effort was initiated, the priority for TMDL development for bacteria was changed to a low priority (WDEQ, 2006).

3.2 STREAM CLASSIFICATIONS AND BENEFICIAL USES

WDEQ is charged with implementing the policies of the Clean Water Act while also providing for the "highest possible water quality" for the designated uses on waterbody (WDEQ, 2007). Depending upon its classification, a waterbody is expected to be suitable for certain uses (Table 3-1).

As provided in the June 21, 2001 Wyoming Surface Water Classification List (WDEQ, 2001a), the stream classifications for the Prairie Dog Creek watershed are as follows:

- Prairie Dog Creek – Class 2AB;
- Coutant Creek – 3B;
- Dutch Creek – 3B;
- Dow Prong – 3B;
- Wildcat Creek – 3B;
- Meade Creek – 2AB;
- Murphy Gulch – 3B;
- Arkansas Creek – 3B;
- Wagner Prong – 3B; and
- Jenks Creek – 2AB.

Table 3-1. Surface Water Classes and Use Designations (WDEQ, 2007)

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	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3A	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3B	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3C	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4A	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4B	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4C	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

[1] Class 1 waters are not protected for all uses in all circumstances. For example, all waters in the National Parks and Wilderness areas are Class 1, however, all do not support fisheries or other aquatic life uses (e.g. hot springs, ephemeral waters, wet meadows, etc.).

[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 exotic species which are designated "undesirable" by the Wyoming Game and Fish Department or the U.S. Fish and Wildlife Service with 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 insect pests or exotic species which are designated "undesirable" by the Wyoming Game and Fish Department or the U.S. Fish and Wildlife Service with 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 in Class 2AB waters.

[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.

Class 2AB waters are

> those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. . .Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, aquatic life other that fish, recreation, wildlife, industry, agriculture and scenic value uses (WDEQ, 2007).

In 2001, Class 2AB waters were protected for "primary contact recreation," although primary contact recreation was not specifically defined. In 2007, a definition was added for primary contact recreation although the use designation implies protection for both primary and secondary contact recreation. The difference between primary and secondary contact recreation is related to the potential of the activity to result in "ingestion of the water or immersion" (WDEQ, 2007). In neither case does the protection address the quantity of water; rather it ensures that the quality of the water is "safe for human contact" (WDEQ, 2007). Of the 72 stream miles on Prairie Dog Creek, Meade Creek, and Jenks Creek, all but 1.5 miles are on private land and are not conducive to primary contact recreation by the public. However, the classification of 2AB requires these streams to be protected for both primary and secondary contact recreation. Where applicable, standards for both primary and secondary contact recreation are addressed in this report.

Class 3B waters are

> tributary waters including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna that inhabit waters of the state at some stage of their life cycles. In general, Class 3B waters are characterized by frequent linear wetland occurrences or impoundments within or adjacent to the stream channel over its entire length (WDEQ, 2007).

All Class 3 waters are expected to support aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value and must be protected for those uses (WDEQ, 2007).

3.3 WATER QUALITY STANDARDS

Wyoming's surface waters are protected through application of narrative (descriptive) and numeric water quality standards described in Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2007). For Class 2AB waters, the Human Health values for "Fish and Drinking Water" listed in Appendix B of Chapter 1 apply. The "acute" and "chronic" values for Aquatic Life apply to all Class 1, 2, and 3 waters. SCCD used the description of the narrative or numeric water quality standards applicable to the Prairie Dog Creek Watershed to determine attainment of beneficial uses of waterbodies within the project area (Table 3-2).

Table 3-2. Numeric and Narrative Quality Standards for Wyoming Surface Waters Applicable for Waters in the Prairie Dog Creek Watershed (From WDEQ, 2007)

NUMERIC STANDARDS				
Priority Pollutants[1]				
Parameter	**Reference**	**Standard / Description**		
		Human Health[2]	**Acute Aquatic Life[3]**	**Chronic Aquatic Life[3]**
Antimony	Section 18; Appendix B	5.6 ug/l		
Arsenic	Section 18 and 21; Appendix B	10 ug/l	340 ug/l	150 ug/l
Asbestos	Section 18; Appendix B	7000000 fibers/L		
Beryllium	Section 18; Appendix B	4 ug/l		
Cadmium	Section 18; Appendix B	5 ug/l	2.0 ug/l (calculated)	0.25 ug/l (calculated)
Chromium (III)	Section 18; Appendix B	100 ug/l	569.8 ug/l	74.1 ug/l
Chromium (VI)	Section 18; Appendix B	100 ug/l	16 ug/l	11 ug/l
Copper	Section 18; Appendix B	1000 ug/l	13.4 ug/l	9 ug/l
Cyanide (free)	Section 18; Appendix B	200 ug/l	22 ug/l	5.2 ug/l
Lead	Section 18; Appendix B	15 ug/l	64.6 ug/l	2.5 ug/l
Mercury	Section 18; Appendix B	0.050 ug/l	1.4 ug/l	0.77 ug.l
Nickel	Section 18; Appendix B	100 ug/l	468.2 ug/l	52.0 ug/l
Selenium	Section 18; Appendix B	50 ug/l	20 ug/l	5 ug/l
Silver	Section 18; Appendix B		3.4 ug/l	
Thallium	Section 18; Appendix B	2.4 ug/l		
Zinc	Section 18; Appendix B	5000 ug/l	117.2 ug/l	118.1 ug/l
Organics, priority	Section 18; Appendix B	Standards for organic priority pollutants are listed		
Non-Priority Pollutants[1]				
Parameter	**Reference**	**Standard / Description**		
		Human Health[2]	**Acute Aquatic Life[3]**	**Chronic Aquatic Life[3]**
Aluminum (pH 6.5-9.0)	Section 21; Appendix B		750 ug/l	87 ug/l
Barium	Section 18; Appendix B	2000 ug/l		
Carbofuran	Section 18; Appendix B	40 ug/l		

[1] Priority pollutants are those pollutants listed by USEPA under section 307(a) of the Clean Water Act (WDEQ, 2007); Non-priority pollutants are substances other than those listed by USEPA.
[2] The values that Class 1, 2AB, and 2A waters must meet; these are the "fish and drinking water" values (WDEQ, 2007). Because none of the waterbodies in the Prairie Dog Creek watershed are designated as Class 2B, 2C, or 2D, values for consumption of fish (or "fish only" values are not reported here.
[3] Aquatic Life protection values apply to Class 1, 2A, 2B, 2AB, 2C, 3A, 3B, and 3C. Chronic values are 4-day averages while acute values are 1-day averages (WDEQ, 2007). Neither shall be exceeded more than once every 3 years.

Table 3-2 (continued). Numeric and Narrative Quality Standards for Wyoming Surface Waters Applicable for Waters in the Prairie Dog Creek Watershed (From WDEQ, 2007)

Parameter	Reference	Standard / Description		
		Human Health[2]	**Acute Aquatic Life[3]**	**Chronic Aquatic Life[3]**
Chloride	Section 21; Appendix B		860000 ug/l	230000 ug/l
Chlorine (total residual)	Section 18; Appendix B		19 ug/l	11 ug/l
Chloropenoxy Herbicide 2,4-D	Section 18: Appendix B	70 ug/l		
Dissolved Gases	Sections 21 and 30; Appendix B			100% saturation 110% saturation below man-made dams
Iron	Section 18 and 21; Appendix B	300 ug/l	1000 ug/l	
Manganese	Section 18 and 21; Appendix B	50 ug/l	3110 ug/l	1462 ug/l
Nitrite (as N)	Section 18; Appendix B	1000 ug/l		
Nitrates (as N)	Section 18; Appendix B	10000 ug/l		
Nitrite + Nitrate (as N)	Section 18; Appendix B	10000 ug/l		
pH	Sections 21 and 26; Appendix B			6.5-9.0 standard units
Picloram	Section 18; Appendix B	500 ug/l		
Sulfide-Hydrogen Sulfide (S^{2-}, HS^-)	Section 21; Appendix B			2 ug/l
Ammonia	Section 21; Appendix C	In all Class 3 waters, concentrations shall not affect aquatic life or designated uses. In Class 1, 2A, 2B, 2AB, and 2C waters, Appendix C provides pH and temperature dependent numeric criteria		
Dissolved Oxygen	Sections 21 and 30 Appendix D	For Class 1, 2AB, 2B, and 2C waters 1 day minima Early life: 5.0 mg/L intergravel concentration (8.0 mg/L water column) Other life stages: 4.0 mg/L		
E. Coli	Section 27	Primary Contact Recreation: Geometric mean of 5 samples obtained during separate 24 hour periods within a 30 day period shall not exceed 126 organisms per 100 ml (May 1-Sept 30). Secondary Contact Recreation: Geometric mean of 5 samples obtained during separate 24 hour periods within a 30 day period shall not exceed 630 organisms per 100 ml.		

[1] Priority pollutants are those pollutants listed by USEPA under section 307(a) of the Clean Water Act (WDEQ, 2007); Non-priority pollutants are substances other than those listed by USEPA

[2] The values that Class 1, 2AB, and 2A waters must meet; these are the “fish and drinking water” values (WDEQ, 2007). Because none of the waterbodies in the Prairie Dog Creek watershed are designated as Class 2B, 2C, or 2D, values for consumption of fish (or “fish only” values are not reported here.

[3] Aquatic Life protection values apply to Class 1, 2A, 2B, 2AB, 2C, 3A, 3B, and 3C. Chronic values are 4-day averages while acute values are 1-day averages (WDEQ, 2007). Neither shall be exceeded more than once every 3 years.

Table 3-2 (continued). Numeric and Narrative Quality Standards for Wyoming Surface Waters Applicable for Waters in the Prairie Dog Creek Watershed (From WDEQ, 2007)

Parameter	Reference	Standard / Description		
		Human Health[2]	**Acute Aquatic Life[3]**	**Chronic Aquatic Life[3]**
Oil and Grease	Section 29	Shall not exceed 10 mg/L or cause visible deposits or sheen, or impair human, animal, plant, or aquatic life		
Radium 226	Section 22	Shall not exceed limits in Federal Primary Drinking water Standards published by USEPA (Class 1, 2AB, and 2A). Shall not exceed 60 pCi/l (Class 2b, 2C, 2D, 3, and 4)		
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.		
Organics, non-priority	Section 18; Appendix B	Standards for organic non-priority pollutants are listed		
NARRATIVE STANDARDS				
Parameter	**Reference**	**Standard / Description**		
Settleable Solids	Section 15	Shall not be present in quantities that could degrade aquatic life habitat, affect public water supplies, agricultural or industrial use, or affect plant and wildlife.		
Floating and Suspended Solids	Section 16	Shall not be present in quantities that could degrade aquatic life habitat, affect public water supplies, agricultural or industrial use, or affect plant and wildlife.		
Taste, Odor, Color	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 762.1 for full support; Score 41.4-62.1 for indeterminate support; and score <41.4 for partial/non-support.		

[1] Priority pollutants are those pollutants listed by USEPA under section 307(a) of the Clean Water Act (WDEQ, 2007); Non-priority pollutants are substances other than those listed by USEPA

[2] The values that Class 1, 2AB, and 2A waters must meet; these are the "fish and drinking water" values (WDEQ, 2007). Because none of the waterbodies in the Prairie Dog Creek watershed are designated as Class 2B, 2C, or 2D, values for consumption of fish (or "fish only" values are not reported here.

[3] Aquatic Life protection values apply to Class 1, 2A, 2B, 2AB, 2C, 3A, 3B, and 3C. Chronic values are 4-day averages while acute values are 1-day averages (WDEQ, 2007). Neither shall be exceeded more than once every 3 years.

Table 3-2 (continued). Numeric and Narrative Quality Standards for Wyoming Surface Waters Applicable for Waters in the Prairie Dog Creek Watershed (From WDEQ, 2007)

Parameter	Reference	Standard / Description
ADDITIONAL PARAMETERS AND RECOMMENDED STANDARDS		
Total Phosphorus	USEPA (1977); USGS (1999)	USEPA: Should not exceed 0.05 mg/L for a stream entering a lake or reservoir (i.e. Tongue River Reservoir); USGS: National background level in undisturbed watersheds is 0.10 mg/L
Total Sulfate	Winget and Magnum (1979) WDEQ (2005) USEPA (1986)	Recommended 150 mg/L for benthic macroinvertebrates Groundwater: 200 mg/L agriculture; 250 mg/L domestic use; 3000 mg/L livestock; 250 mg/L USEPA secondary drinking water
Alkalinity	USEPA (1986)	Minimum 20 mg/L; up to 400 mg/L as $CaCO_3$ for human health
Total Suspended Solids (TSS)	Refer to Sections 15 and 16	No recommended standard for use attainability. Narrative standards prohibit quantities of settleable, floating, or suspended solids that could cause significant degradation in aesthetics and/or habitat for aquatic life or adversely affect public water supplies, agricultural or industrial water use, plant life or wildlife.
Total Dissolved Solids	WDEQ (2005)	Groundwater: 500 mg/L domestic use; 2000 mg/L agriculture; 5000 mg/L livestock Groundwater Fish and Aquatic Life: 500 mg/L egg hatching; 1000 mg/L fish rearing; and 2000 mg/L fish and aquatic life
Hardness	Sawyer (1960) *in* USEPA (1986)	Concentrations greater than 300 mg/L may be considered very hard and possibly unsuitable for industrial use
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.
Chloride-Groundwater	WDEQ (2005)	Groundwater: 250 mg/L domestic use; 100 mg/L agriculture; 2000 mg/L livestock
Nitrite-Nitrate-N Groundwater	WDEQ (2005)	Groundwater: 100 mg/L livestock
Manganese-Groundwater	WDEQ (2005)	Groundwater: 0.05 mg/L domestic use; 0.2 mg/L agriculture; 1.0 mg/L aquatic life
SAR	WDEQ (2005)	Groundwater: 8 agriculture use

[1] Priority pollutants are those pollutants listed by USEPA under section 307(a) of the Clean Water Act (WDEQ, 2007); Non-priority pollutants are substances other than those listed by USEPA
[2] The values that Class 1, 2AB, and 2A waters must meet; these are the "fish and drinking water" values (WDEQ, 2007). Because none of the waterbodies in the Prairie Dog Creek watershed are designated as Class 2B, 2C, or 2D, values for consumption of fish (or "fish only" values are not reported here.
[3] Aquatic Life protection values apply to Class 1, 2A, 2B, 2AB, 2C, 3A, 3B, and 3C. Chronic values are 4-day averages while acute values are 1-day averages (WDEQ, 2007). Neither shall be exceeded more than once every 3 years.

4. HISTORICAL AND CURRENT DATA SOURCES

4.1 USE OF HISTORICAL AND CURRENT DATA

Collection, compilation, and evaluation of existing data provide a long-term perspective for water quality within the Project area. Available data were considered in the development of a cost-effective monitoring and assessment plan by providing information to:

- identify gaps in previous monitoring, sampling parameters, sampling frequency, and sampling locations;
- select representative sampling stations;
- select sampling parameters;
- allow comparison of data collected during the project to existing data; and
- assist development of post-project monitoring recommendations.

SCCD requested and reviewed available data from a variety of sources including, EnTech, WDEQ, USGS, Wyoming Game and Fish Department, Wyoming Water Resources Data System, and Prairie Dog Ditch Company. In some cases, there was little or no data available or the data were considered outside the scope of this project. This report does not include all of the available data for the watershed, but includes the data considered most relevant to the scope and purpose of the project.

Historical data for the purposes of this project were defined as data that were greater than five years from the start of this project. Since monitoring was initiated during 2007, data collected before January 1, 2002 were considered historical data; data collected after January 1, 2002 were considered current. However, some historical databases also contained some current data. For simplicity, these databases were left as a single historical data set (Appendix B).

4.2 HISTORICAL DATA AND DATA SOURCES

4.2.1 Entech Data

During 2000 and 2001, the SCCD sponsored a Level 1 Watershed Study through the Wyoming Water Development Commission (WWDC). WWDC contracted with Entech, Inc., who conducted water quality monitoring on Prairie Dog Creek and its tributary, Jenks Creek as a part of the study. Their analyses included measurements of flow, temperature, turbidity, total suspended solids (TSS), total dissolved solids (TDS), electrical conductivity (EC), iron, bicarbonate, sulfate, sodium adsorption ratio, and fecal coliform bacteria at 10 sites on Prairie Dog Creek and one Jenks Creek site. Fecal coliform bacteria were found to exceed water quality standards in some instances, though because WDEQ regulations require a geometric mean of five samples within a 30 day period; these data were insufficient to show a clear violation of the standard (Appendix Table B-1).

4.2.2 USGS Data

USGS began measuring stream flow on Prairie Dog Creek near the confluence with Tongue River in 1970. This was done at the gauging station on Prairie Dog Creek Near Acme (#06306250). Measurement continued through 1979, when it was terminated.

From 1986 through 1992, USGS (2001) conducted herbicide monitoring on Prairie Dog Creek Near Acme (#06306250) during the summer irrigation season (Appendix Table B-2). Their results showed occasional very low concentrations (<1 part per billion) of three commonly used broadleaf herbicides: picloram (Tordon), 2,4-D, and dicamba (Banvel, Clarity, Vanquish).

In 2000, USGS resumed stream flow measurement and began water quality monitoring at the gauging station on Prairie Dog Creek Near Acme (#06306250). The parameters measured regularly included Discharge, Water and Air Temperature, Specific Conductivity, Dissolved Oxygen, pH, Hardness, Alkalinity, Calcium, Magnesium, Sodium, Sodium Adsorption Ratio (SAR), Phosphorus, Chloride, Sulfate, Fluoride, Silica, Manganese, Barium, and Iron, as well as others at less frequent intervals. SCCD used the "real-time" data from this station to record Stage and Discharge measurements during sampling events. Because of its size, the complete set of USGS data is not included in this report. These data are available through the USGS website at http://waterdata.usgs.gov/wy/nwis.

USGS began collecting Manganese data at Prairie Dog Creek Near Acme (#06306250) in 2000. Data collected from this station in 2000 were used by WDEQ to list Prairie Dog Creek for aesthetic drinking water impairments in 2002. These data range from 49 ug/l (0.049 mg/L) to 157 ug/l (.157 mg/L). Additional data from this station was collected through 2009 (Appendix Table B-3). Manganese levels collected at this station range from 7.4 ug/L (0.007 mg/L) to 394 ug/L (0.394 mg/L).

4.2.3 WDEQ Data

WDEQ conducted water quality sampling at three Prairie Dog Creek sites and one site on Jenks Creek in 1992. Analyzed parameters included temperature, pH, electrical conductivity, dissolved oxygen, turbidity, total suspended solids (TSS), alkalinity, chlorides, sulfate, total hardness, phosphorus, and nitrates (Appendix Table B-4). Overall, no analyzed parameters indicated water quality impairments at that time, though Sulfate levels at the Jenks Creek site and the uppermost Prairie Dog Creek site were near or marginally above 150 mg/L, the level considered optimal for macroinvertebrates (Winget and Mangum, 1979). Macroinvertebrate samples were also collected by WDEQ in 1992 at three sites on Prairie Dog Creek with results either in the "Good" or "Very Good" category of the Wyoming Stream Integrity Index, though differing sampling methodology skews this data set slightly in favor of larger species (Appendix Table B-5).

WDEQ collected water quality data at 13 sites in the Prairie Dog Creek watershed on two dates in October and November 1998 (Appendix Tables B-6 and B-7). The sampled sites included 9 sites on Prairie Dog Creek and one each on Wildcat Creek, Meade Creek, Murphy Gulch, and Jenks Creek. WDEQ concluded that irrigation return water contributed to turbidity, nutrient, and sulfate concentrations (Collyard, 2003). Habitat quality assessment showed some reduction in habitat (Appendix Tables B-8 through B-11). Irrigation practices in the watershed were suspected to contribute to increased channelization, reduction in vegetative cover and bank stability, increased sedimentation, and reduction of the available aquatic habitat (Collyard, 2003). Macroinvertebrate sampling at these sites suggested that macroinvertebrate communities were in “Good” condition, with the exception of Meade Creek, which was in “Fair” condition.

4.3 CURRENT DATA AND DATA SOURCES

4.3.1 WDEQ Data

In July 2003 WDEQ conducted *E. coli* bacteria sampling at six sites on Prairie Dog Creek (Collyard, 2003). The 5-sample, 30-day geometric mean *E. coli* values exceeded the USEPA recommended water quality standard for primary recreational contact waters of 126 cfu/100 mL (Appendix Table B-12). These exceedences resulted in the addition of the entire Prairie Dog Creek watershed to the 303(d) list for fecal coliform bacteria in 2004. Concurrently, WDEQ’s review of biological, physical, chemical and habitat data on Prairie Dog Creek determined that Prairie Dog Creek was fully supporting its cold-water fishery, non-fishery aquatic life, drinking water, agricultural, industrial and aesthetic value uses, though was not supporting contact recreation water uses.

While not geographically part of the Prairie Dog Creek watershed, in July and August 2005 the community of Story was the subject of *E. coli* monitoring in response to a landowner complaint (WDEQ, 2005a). The community of Story lies within the Clear Creek watershed, but three cross-basin irrigation diversions carry Piney Creek water into the Prairie Dog Creek watershed for use in downstream irrigation. The Dalton Ditch was the primary focus of this investigation because it was the source of the original complaint. WDEQ’s results indicated geometric means well above the 126 cfu/100 mL water quality standard in the Dalton Ditch, as well as at their downstream North Piney Creek site, which was located above the confluence with South Piney Creek (Table B-13). While these exceedences are of significance for the community of Story, they show little concern for the Prairie Dog Creek watershed because the exceedences on North Piney Creek are below the diversions conveying water into the Prairie Dog Creek drainage.

In October 2003, WDEQ issued a report of <u>Whole Effluent Toxicity (WET) Testing of CBM Produced Water in Northeastern Wyoming</u> (WDEQ, 2003). The report included data from a CBM well in the lower Prairie Dog Creek watershed on the Anderson/Canney/Monarch coal seam. Water from this well was sampled on three days in June 2003 (Appendix Table B-14). Data from this testing is included in this report because there is a significant amount of CBM development in the lower portions of the Prairie Dog Creek watershed and in the Dutch Creek area. These CBM produced waters may have high sodium and other dissolved metals concentrations and have the potential to detrimentally affect surface water quality. These results were included in this report for informational purposes only; it is unknown if the quality of discharge water from this CBM well is representative of all CBM produced water in the Prairie Dog Creek watershed.

4.3.2 USGS Data

USGS continues to monitor physical and chemical water quality parameters on a more-or-less monthly schedule, in addition to real-time discharge, gauge height, temperature, specific conductivity, and sodium adsorption ratio at the Prairie Dog Near Acme gauging station near the confluence with Tongue River (#06306250). Regularly measured parameters included Dissolved Oxygen, pH, Hardness, Alkalinity, Calcium, Magnesium, Sodium, Phosphorus, Chloride, Sulfate, Fluoride, Silica, Manganese, Barium, Iron, trace metals, and others at less frequent intervals.

In 2003, USGS added the Prairie Dog Creek at Wakely Siding gauging station above the Wildcat Creek confluence (#06306200). This station includes real-time discharge and gauge-height measurements, as well as monthly water quality sampling for parameters similar to those at the Prairie Dog Creek Near Acme station. Up to date data from water quality monitoring at both Prairie Dog Creek USGS gauging stations, as well as real-time data are available through the USGS website at http://waterdata.usgs.gov/wy/nwis.

USGS collected Manganese data at the Prairie Dog Creek Wakely Siding gauging station above the Wildcat Creek confluence (#06306200) from 2003-2009 (Appendix Table B-3). Values at this station were typically lower than those collected at the Prairie Dog Creek Near Acme station (#06306250) ranging from 4.5 ug/L (0.004 mg/L) to 186 ug/L (0.186 mg/L).

5. MONITORING AND ASSESSMENT PLAN

5.1 MONITORING DESIGN

The PDWA was a reconnaissance level study to establish baseline watershed condition in respect to seasonal and spatial variations on Prairie Dog Creek and its major tributaries. Reconnaissance studies are typically used to determine the magnitude and extent of a water quality problem (NRCS, 2003). Samplers collected and analyzed chemical, physical, bacteriological, biological, and habitat data according to WDEQ sampling protocol (WDEQ, 2004a), modified as necessary in order to meet specific project goals and objectives.

The SAP described the sampling parameters, locations, and methods used to collect, manage, and validate results (SCCD, 2007b). Parameters include those required for BURP protocol and others necessary to meet project goals and objectives. Rationale for sampling each parameter is described below.

5.2 SAMPLING PARAMETERS

5.2.1 Field Water Chemistry and Physical Parameters

Water Temperature

Water Temperature affects the growth, distribution, and survival of aquatic organisms including trout. These organisms are cold-blooded and thus assume the Temperature of the water in which they reside. Water Temperature is affected by seasonal changes in air Temperature, solar radiation, and other factors. Physical factors may also affect stream Temperature through loss of vegetative cover caused by disruption of the riparian zone and variation in stream flow due to diversion and irrigation returns.

High summer Water Temperatures are most critical to trout. Trout are mobile and may migrate to cooler upstream reaches. However, low stream flow may prevent trout movement and result in death when lethal Temperatures of 25.6°C (78°F) are attained (Garside and Tait, 1958).

Except for Class 2D, 3, and 4 waters, Wyoming surface water quality standards prohibit Temperature increases that change natural Water Temperatures to levels deemed harmful to existing coldwater fish life, which is considered by WDEQ to be 68°F (20°C) (WDEQ, 2007). In addition, the standards prohibit activities that cause Temperature changes in excess of 2°F (1.1°C) from ambient Water Temperatures in Class 1, 2AB, and 2B cold water fisheries (WDEQ, 2007). There are no Temperature standards for Class 3B waters, which are not known to support fish populations.

Instantaneous grab samples for Water Temperature normally collected during routine water quality monitoring are insufficient to detect maximum daily Temperatures in streams (SCCD, 2000 and SCCD, 2003). Continuous Temperature recorders monitor Temperature ranges more effectively than the instantaneous grab samples. Grab samples collected during each sampling event allow for comparisons and correlations with other parameters.

pH

A low-cost measurement that is routinely conducted in water quality monitoring is the collection of pH data. Values for pH range from 0 to 14 standard units (SU). The pH of pure water at 24°C (75.2°F) is 7.0 SU, which is neutral. Water greater than 7.0 SU is considered basic and water with a pH below 7.0 SU is considered acidic. The pH for most mountain streams in northeast Wyoming ranges from near neutral to slightly basic while plains streams are usually basic.

Daily fluctuations in stream pH are common and may be quite pronounced when considerable instream plant growth is present. The pH usually rises during daylight hours in response to plant photosynthesis, which reduces the buffering capacity of water. Reduction in pH normally occurs during the night when plant photosynthesis is reduced.

USEPA has set a pH range from 6.5 SU to 9.0 SU to protect aquatic life (USEPA, 1986). Wyoming water quality standards also set limits from 6.5 SU to 9.0 SU (WDEQ, 2007).

Specific Conductivity

The primary purpose for measurement of Specific Conductivity is to estimate the relative concentration of Total Dissolved Solids (TDS). TDS is a measure of the amount of total substances that are dissolved in water and, although not entirely correct, has also been referred to as salinity. Specific Conductivity is not directly proportional to the TDS concentration; however, the higher the concentrations of dissolved substances present in water, the higher the conductivity measurement. Thus, Specific Conductivity is a reliable, inexpensive estimator of TDS. Conductivity is measured in the field whereas determinations of TDS concentration require more expensive laboratory analysis.

TDS may pollute streams due to irrigation delivery system seepage (Riggle and Kysar, 1985) and poor quality irrigation return flows (MacDonald et al., 1991). High Specific Conductivity may affect aquatic organisms. King (1990) reported that aquatic organisms in several northeast Wyoming ponds were affected when Conductivities were greater than 6900 µmhos/cm. USEPA (1988) found that high Conductivity and Chloride concentrations resulted in lower diversity of stream macroinvertebrate taxa. Lower diversity of stream macroinvertebrates used as a food source for stream fish may negatively affect fish populations.

There are no Wyoming surface water standards for Specific Conductivity or TDS since these parameters generally pose no significant threat to surface water supplies, beneficial use, fisheries, and aquatic organisms. However, quality standards are established for Wyoming groundwater such that TDS concentrations for domestic, agriculture, or livestock use shall not exceed 500 mg/L, 2000 mg/L, or 5000 mg/L, respectively (WDEQ, 2005).

Dissolved Oxygen

Dissolved oxygen (DO) is the amount of free oxygen available to fish and aquatic organisms. A minimum of 4 milligrams per liter (mg/L) is required for maintenance and survival of most aquatic organisms (WDEQ, 2007). One mg/L is equivalent to one part per million (ppm). Trout and other coldwater fish require a minimum of 5 mg/L DO.

Temperature and DO are inversely related. As water temperature rises, DO concentration decreases. DO depletion rarely occurs in shallow, well mixed, aerated streams (Hynes, 1970).

Wyoming surface water quality standards for DO in Class 1, 2AB, 2B, and 2C streams are designed to protect both the early life stages for coldwater fish (eggs, larvae and juveniles) and other life stages (adults). A 1 day minimum DO concentration of 5.0 mg/L is set to protect early life stages and a 1 day minimum DO concentration of 4.0 mg/L is set to protect adult coldwater fish (WDEQ, 2007). For early life stages, WDEQ recommends a 1 day minimum DO concentration in the water column of 8.0 mg/L to achieve intergravel DO concentrations of 5.0 mg/L (WDEQ, 2007).

Discharge

Discharge is the measure of the amount of water flowing in a water body and is usually expressed as cubic feet per second (cfs). Discharge is an important physical parameter monitored during water quality sampling because it may affect the quantities of pollutants present. For example, in most Wyoming streams TSS, Turbidity, Nitrate, and Phosphorus will normally increase with increasing stream discharge while Conductivity, Chlorides, Sulfates, and other ions will normally decrease with increasing stream discharge. Discharge may be used to estimate the load, or amount, of a pollutant by combining measured stream flow with the concentration of a pollutant. Estimates of pollutant loads assist to evaluate pollutant response to variable temporal and spatial stream flows and provide information to identify sources of pollutants.

Habitat Assessment

Evaluation of stream habitat is a necessary component of the total water quality monitoring program. Disruption of upland, riparian, and in-stream habitat can adversely affect stream water quality and biological communities. Good habitat quality is essential to sustainable fish populations and healthy aquatic biological communities. Soil compaction, loss of ground cover, and eroding stream banks can result in increased discharge, erosion, sedimentation, and water temperature in the stream. Trout spawning and rearing habitat may be lost and macroinvertebrate populations, which serve as food for trout, may be reduced. Habitat assessments may be quantitative (habitat parameters measured) or qualitative (subjective with no measurements).

There are no numeric standards for habitat quality in Wyoming water quality standards. However, Section 15 (Settleable Solids) and Section 16 (Floating and Suspended Solids) in Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2007) refer to narrative (non-numeric) standards for Settleable Solids and Floating and Suspended Solids, which shall not be present in quantities that could result in significant aesthetic degradation, significant degradation of habitat for aquatic life, or adversely affect other beneficial uses (WDEQ, 2007).

In addition to using the habitat assessment to address narrative Wyoming water quality standards, the habitat assessment will be used to determine if changes in benthic macroinvertebrate populations are due to changes in water quality or to changes in habitat quality.

Habitat Assessment data collected during the project will be compared to habitat assessment data collected from “reference” stream reaches identified during WDEQ Reference Stream Project monitoring at similar stream types in the Northwestern Great Plains ecoregion and Middle Rockies ecoregion of Wyoming.

5.2.2 Laboratory Analyzed Water Chemistry Parameters

Turbidity

Turbidity is a common parameter measured in water quality monitoring studies since analysis of samples is inexpensive and results may be used as an indicator of Suspended Sediment concentration. Turbidity is based on a comparison of the intensity of light scattered by a water sample with the intensity of light scattered by a standard reference solution under the same conditions (APHA, 1975).

A strong, direct correlation may exist between Turbidity and Suspended Sediment. Therefore, the higher the Turbidity values in a sample, the higher the Suspended Sediment concentration. High Turbidity values may be caused by substances other than sediment. Presence of natural water color due to high mineral content (i.e. Sulfates, Chlorides) or to significant amounts of algae entrained in water may affect Turbidity values.

Narrative water quality standards for Turbidity in Class 1, 2AB, 2A, and 2B water bodies prohibits discharge of substances attributable to or influenced by the activities of man to be present in quantities that would result in a Turbidity increase of more that 10 nephelometric turbidity units (NTU’s). The WDEQ may allow short-term increases in Turbidity subject to approval from the Administrator (WDEQ, 2007).

Total Suspended Solids (TSS)

TSS is the measure of suspended solid material in the water column. The majority of TSS present in streams within the project area is expected to consist of sediment. This is a valuable indicator parameter because it may be used to track and identify sources contributing sediment to a water body. TSS is highly variable and is correlated to stream discharge. Due to this variability, large numbers of samples may be required to adequately estimate annual TSS concentrations.

There is no Wyoming water quality standard for TSS. However, narrative standards in Section 15 (Settleable Solids) and Section 16 (Floating and Suspended Solids) in Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2007) address effects due to sediment deposition. These narrative standards prohibit quantities of settleable, floating, or suspended solids that could cause significant degradation in aesthetics and/or habitat for aquatic life or adversely affect public water supplies, agricultural or industrial water use, plant life or wildlife. These standards apply to substances that are “attributable or influenced by the activities of man.” Settleable solids are substances that will settle to form sludge, bank, or bottom deposits (WDEQ, 2007).

Alkalinity
Alkalinity is the sum total of components in the water that tend to elevate the pH of the water above a value of about 4.5 Standard Units (SU); it is a measure of the buffering capacity of the water. The buffering capacity is important to water quality because pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain other pollutants in the water (USEPA, 1986). Its measurement is also used in the evaluation and control of water and waste water treatment processes.

Dissolved substances such as Carbonates, Bicarbonates, Phosphates, Hydroxides (USEPA, 1986), Borates, and Silicates (APHA, 1975) can increase stream Alkalinity. Stream water high in Alkalinity can maintain ambient pH when exposed to acidic water better than water low in Alkalinity. Alkalinity is important for primary production (bacteria and algae) in streams, which directly affects benthic macroinvertebrate populations that serve as food for fish. Generally, as Alkalinity increases, stream productivity and density (total number of organisms) increases.

There is no water quality standard for Alkalinity in Wyoming surface waters. Naturally occurring maximum Alkalinity levels up to approximately 400 mg/L as Calcium Carbonate ($CaCo_3$) are not considered a problem to human health (National Academy of Sciences, 1974 *in* USEPA 1986). Without adequate Alkalinity levels, a water body may experience dramatic shifts in pH that can disrupt fish and other aquatic life. USEPA (1986) suggests a minimum of 20 mg/L Alkalinity for adequate productivity in streams.

Total Sulfate
Sulfate is a potential significant pollutant in Wyoming streams. It is naturally present in water with concentrations ranging from a few to several thousand mg/L (APHA, 1975). Higher Sulfate content is expected in groundwater close to deposits in sedimentary rocks. These deposits may include Sodium Chloride and other Chloride salts. Drinking water high in Sulfate (greater than 600 mg/L) may have laxative effects on individuals. Water high in Sulfate consumed by livestock may cause the “blind staggers” and eventual death. Increased sulfate concentrations in streams are a good indicator of anthropogenic (due to man) effects because irrigation return, industrial, oil field produced water, and other point source discharge effluents may artificially elevate ambient levels.

An increase in Sulfate appears to negatively affect aquatic life and benthic macroinvertebrates. Winget and Mangum (1979) studying streams in the Great Basin found that as Sulfate levels increased, macroinvertebrate community diversity decreased. They indicated that a Sulfate concentration below 150 mg/L was optimal for macroinvertebrates.

Wyoming has not established surface water quality standards for Sulfate. Sulfate concentration for Wyoming groundwater has been set at 250 mg/L, 200 mg/L, and 3000 mg/L for domestic, agricultural, and livestock use, respectively (WDEQ, 2005). The secondary drinking water standard for sulfate is set at 250 mg/L (USEPA, 2006). USEPA secondary drinking water regulations are federal guidelines regarding cosmetic or aesthetic effects of drinking water.

Total Chloride

Chloride naturally occurs in streams and is a principal component of salt (NaCl). Wyoming streams generally contain low Chloride concentrations (generally <25 mg/L). Streams draining through sedimentary deposits high in salts may result in high Chloride levels. Stream Chloride levels may increase due to oilfield produced water, industrial and municipal effluent, and irrigation returns.

Aquatic life is sensitive to Chlorides at higher concentrations. O'Neil et al. (1989) studying effects of coalbed methane produced water, found that Chloride concentrations at or below 565 mg/L produced no significant effects to the benthic macroinvertebrate community structure in study streams. Chloride values above 565 mg/L showed impairment to the community. Birge et al. (1985) found that benthic macroinvertebrate community structure was negatively affected by increasing Chloride concentration. They recommended that the average Chloride concentration should not exceed 600 mg/L over thirty consecutive days and a maximum instantaneous (one time sample) should not exceed 1,200 mg/L.

Plants are more sensitive than humans to high Chloride content. Thus, Wyoming groundwater standards set chloride content at 250 mg/L for domestic use, 100 mg/L for agricultural/irrigation water, and 2000 mg/L for livestock use (WDEQ, 2005). The Wyoming surface water quality standard for Chloride is 860 mg/L for protection of aquatic life (WDEQ, 2007).

Nitrite-Nitrate Nitrogen

Nitrate nitrogen in streams may originate from several possible sources including the atmosphere, plant debris, animal waste and sewage, nitrogen based fertilizers, and some industrial wastes. Nitrate is considered to be one of the primary nutrients (along with phosphorus) associated with non-point source pollution. Nitrate is the end product of the decomposition of organic material such as sewage and excrement, and can be responsible for nutrient enrichment and/or oxygen depletion. Bacteria acts on organic material changing it to ammonia (NH_3), then nitrite (NO_2), and finally nitrate (NO_3).

Nitrate generally has no direct effect on aquatic organisms. Indirect effects are manifest by stimulation of bacteria, periphyton, algae, and instream macrophyte (submerged and rooted plants) growth which, in turn, may stimulate macroinvertebrate and fish production. The benthic macroinvertebrate community structure may shift due to increased abundance of periphyton and algae used as food or refuge by different taxa. Thus, evaluation of the macroinvertebrate community change can indicate nitrate pollution.

Wyoming has adopted the USEPA drinking water human health standard of 10 mg/L for Class 1, 2AB, and 2A surface waters (WDEQ, 2007). USEPA has not established surface water standards for Nitrates since concentrations required for toxicity to cold or warm water fish rarely occur in natural waters (USEPA, 1986). USEPA established a standard of 10 mg/L for drinking water supplies to protect against toxic infant methemoglobinemia (blue baby syndrome) characterized by a bluish color of the skin (USEPA, 1986 and USEPA, 2006). High concentrations of Nitrate in livestock drinking water have resulted in abnormally high mortality rates in baby pigs and calves and abortion in brood animals. USGS (1999) reported that national background concentrations of Nitrate from streams in undeveloped areas (similar concept to

WDEQ Reference areas) were about 0.6 mg/L. However, they cautioned that the overall national background levels were higher than those concentrations measured from relatively undeveloped areas.

Total Phosphorus

Phosphorus, along with Nitrate, is one of the two most common nutrients associated with non-point source pollution. Phosphorus is an essential element for plant growth. However, generally low levels of Phosphorus (>0.2 mg/L) can stimulate primary production (bacteria, periphyton, algae) and plant growth when in the presence of sunlight. Strict control of Phosphorus is required in watersheds draining to lakes and reservoirs because aquatic organisms and plants rapidly assimilate phosphorus resulting in potential nuisance algae and plant populations, which create unfit conditions for human recreation. Bacterial breakdown of dense growth of algae and plants consumes DO, often resulting in oxygen depletion in lakes and reservoirs stressing or killing fish and aquatic organisms.

Naturally occurring Phosphorus enters streams primarily by soil erosion and sediment transport. Additional Phosphorus may enter streams through municipal and industrial point discharges, runoff containing animal wastes and phosphate fertilizers. Phosphorus creates fewer problems in streams than in lakes and reservoirs since Phosphorus is accumulated in bottom sediments. It is difficult to eliminate from standing water bodies because they serve as sediment traps and generally cannot be flushed of bottom sediments.

Wyoming has not established surface water quality standards for Phosphorus because problems associated with this pollutant are generally site-specific due to localized sources of Phosphorus affecting individual water bodies. USEPA (1977) recommended that the total Phosphorus concentration should not exceed 0.05 mg/L in a stream that enters a lake or reservoir to prevent development of nuisance algal and plant populations. Mackenthun (1973) suggested a target Phosphorus level of less than 0.10 mg/L for streams that did not directly enter lakes or reservoirs. Information provided by USGS (1999) from the National Water Quality Assessment (NAWQA) reported that national background concentrations for total phosphorus from streams in undeveloped (reference) areas was about 0.10 mg/L. USGS indicated that waters with concentrations of Total Phosphorus greater than the national background concentration were considered to have been affected by human activities. They found that enrichment of streams with nutrients generally occurred in small watersheds and or regions dominated by agricultural or urban land use.

Manganese

Manganese is an essential nutrient required by mammals and birds (USEPA, 1993 and USEPA, 2003). It occurs naturally in soil, air, water, and foods in low levels. Human exposure usually occurs through ingestion of foods, inhalation of Manganese dust, and drinking water contaminated with Manganese (USEPA, 2003). It is generally considered to be of low toxicity, though inhalation of high doses can be toxic (USEPA, 2003). Manganese toxicity affects the nervous system and can include dementia and anxiety and the elderly appear to be at greater risk (USEPA, 1993 and USEPA, 2003). There is limited data on toxicity levels for ingested Manganese; however there are several studies that identify safe dietary levels (USEPA, 2003).

At low levels in water, Manganese can result in discoloration and undesired taste (USEPA, 2003).

USEPA has set a secondary drinking water standard of 0.05 mg/L based on discoloration and taste (USEPA, 2006). The Wyoming surface water standard for Manganese for the protection of fish and drinking water is 0.05 mg/L; and for the protection of other aquatic life is 3.11 mg/L (WDEQ, 2007).

Total Hardness
Hardness is related to the concentration of metals (metallic ions) and is conventionally expressed as the concentration of calcium carbonate ($CaCo_3$) in mg/L. Hardness may be used as an indicator to determine suitability of water for industrial use (Industry Beneficial Use). The maximum acceptable Hardness concentration for industrial use varies according the type of industry (Table 5-1).

Table 5-1. Maximum Hardness Levels Accepted by Industry (after USEPA, 1986).

Industry	Maximum Concentration (mg/L) as $CaCO_3$
Electric Utilities	5,000
Textile	120
Pulp and Paper	475
Chemical	1,000
Petroleum	9000
Primary Metals	1,000

A commonly used classification for Hardness describes water as soft, moderately hard, hard, or very hard, according to the Hardness concentration (Table 5-2).

Table 5-2. Classification of Water by Hardness Content (mg/L as $CaCo_3$) in USEPA 1986, (after Sawyer, 1960).

Concentration	Description
0 – 75	Soft
75 – 150	Moderately Hard
150 – 300	Hard
300 +	Very Hard

Water that has come into contact with natural limestone formations is the primary source for Hardness in streams. Municipal and industrial (especially subsurface mines) point source effluents, storm drain discharge, and to a lesser extent, runoff from agricultural areas, may elevate Hardness concentrations.

Wyoming and USEPA have not established water quality standards for Hardness. Because Hardness in water can be removed with treatment by such processes as softening or ion exchange systems, a standard for industrial use or for public water supply is not practical. Moreover, the effects of Hardness on fish and aquatic life appear to be related to the specific ions causing the Hardness (i.e. Calcium, Magnesium, Manganese) rather than the Hardness itself (USEPA, 1986).

SAR (Sodium Adsorption Ratio)

The Sodium Adsorption Ratio (SAR) is a calculated value obtained by comparing the amount of Sodium in the water relative to the amount of Calcium and Magnesium. When Sodium levels are relatively higher than Calcium and Magnesium levels, the SAR value is high, indicating that the Sodium ions may adsorb into soil sites and in turn decrease soil permeability. If Calcium and Magnesium are available in the water, the SAR value drops. This is due to the effect of Calcium and Magnesium preventing the Sodium from adsorbing onto the soil and lowering water infiltration rates.

Wyoming has not established surface water quality standards for SAR, or the individual SAR constituents (Sodium, Calcium, Magnesium). Further, USEPA has not established national primary or secondary drinking water standards for SAR, or its constituents. USEPA (1986) reports SAR tolerance levels of 4 for sensitive fruits and 8-18 for general crops and forage, but cautions use of these figures without consideration of the specific soil and water conditions. The development of a standard for SAR to protect agricultural use would be highly variable since it depends upon the Specific Conductivity of the water and soil characteristics where the water is being applied. Both Specific Conductivity and soil characteristics are highly variable, not only in the Prairie Dog Creek watershed, but statewide. WDEQ issues permits for CBM discharges that limit SAR and specific conductivity discharge values to 10 and 2,000 µmhos/cm, respectively.

For industrial uses, USEPA (1986) recommends levels of Total Dissolved Solids (including Calcium, Magnesium, and Sodium) to be between 150 mg/L and 35,000 mg/L depending upon the industry. USEPA (1986) also recommends Total Dissolved Solids (including Calcium, Magnesium, Sodium, and others) to be between 10,000 and 15,000 mg/L for freshwater fish. Recommendations on Sodium limits are based on dietary restrictions on drinking water for some individuals and range between 270 mg/L for moderately restricted diets to 20 mg/L for very restricted diets (USEPA 1986).

Pesticides and Herbicides

Pesticides and herbicides may enter surface water bodies through surface runoff, ground water discharge, or direct application through accidental spillage or haphazard aerial and ground application. Once in water, many of these man-made compounds may persist and pose human health and safety risks. Pesticides and herbicides may work their way into the aquatic food chain by benthic and terrestrial organism uptake, consumption of the organisms by fish, and accumulation in fish tissue consumed by wildlife and humans. Contamination of drinking water supplies is a major concern because many of these compounds may be carcinogenic at low concentrations.

Based on interest from landowners within the watershed, SCCD consulted with the Sheridan County Weed and Pest for the most commonly used application times and chemicals used within the watershed (Table 5-3). The watershed has infestations of leafy spurge, thistle, and bindweed, which are controlled chemically with Tordon, Plateau, 2,4-D, Banvil, and Redeem. Furodan is used to control alfalfa weevil in several areas of the watershed.

Table 5-3.Pesticides and herbicides of interest in the Prairie Dog Creek Watershed

Pesticide / Herbicide Name	Common Trade Name(s)	Chemical Type
Carbofuran	Furodan	Pesticide
2,4-D	Weed-B-Gone, Demise, Agrotect, others	Herbicide
Picloram	Tordon	Herbicide
Dicamba	Banvel, Brush Buster, Weedmaster, others	Herbicide
Clopyralid-Triclopyr	Redeen	Herbicide
Imazadil	Plateau	Herbicide

WDEQ and USEPA have established drinking water standards for numerous pesticides and herbicides. Wyoming water quality standards for the protection of human health for Carbofuran, 24-D, and Picloram, are 40 ug/l, 70 ug/l, and 500 ug/l, respectively (WDEQ, 2007). The list of standards for other individual pesticides and herbicides is extensive and is not presented in its entirety here. However, the reader may refer to Chapter 1 of Wyoming <u>Water Quality Rules and Regulations</u> (WDEQ, 2007) for a more complete list.

5.2.3. Laboratory Analyzed Biological Parameters

Escherichia coli

Fecal coliform bacteria are present in the digestive tracts of humans and mammals. Sampling for fecal coliform bacteria may be considered as one of the most important tests conducted in water quality monitoring programs because of public health and safety concerns. Cholera, typhoid fever, bacterial dysentery, infectious hepatitis, and cryptosporidiosis are some of the well known diseases that spread through contact with contaminated water. Eye, ear, nose, and throat infections may also result from contact with contaminated water.

Presence of fecal coliform bacteria in water indicates that the water is contaminated with fecal material and suggests the possible presence of pathogenic organisms harmful to humans. Animals and humans may be carriers of these pathogens. Because of this, domestic sewage from wastewater treatment systems and runoff from land may contaminate water with pathogens.

Escherichia coli (*E. coli*) are a species of fecal coliform bacterium commonly used as an indicator of fecal contamination. This species comprises many different strains of which the vast majorities are not pathogenic to humans (Hinton, 1985). However, particular strains of *E. coli* (i.e. *E. coli* 0157:H7) and other very toxic strains may be responsible for haemorraghic colitis (severe diahhrea) and haemolytic uraemic syndrome (kidney failure) in humans, which may be fatal if left untreated. *E. coli* is considered to be a superior indicator of pathogens originating from fecal matter; the fecal coliform test may also detect non-fecal bacteria (USEPA, 1986). For this reason, WDEQ replaced fecal coliform with *E. coli* as the indicator species for Wyoming surface water quality standards (WDEQ, 2007). The *E. coli* standards are based on the seasonal use of surface waters and the degree of body contact likely occurring within these waters. Limits for primary contact recreation waters are set at 126 organisms per 100 mL and at 630 organisms per 100 mL for secondary contact (WDEQ, 2007).

E. coli bacteria concentrations are known to vary due to a number of different water quality and water quantity factors, including discharge, temperature, and turbidity. These variations are not well understood and may be affected by inputs from other sources, dilution from precipitation events, die-off or multiplications within the water column or sediments. Discharge information is necessary to estimate the load, or amount, of a pollutant by combining measured stream flow with the concentration of a pollutant. Estimates of pollutant loads assist to evaluate pollutant response to variable temporal and spatial stream flows and provide information to identify sources of pollutants.

Benthic Macroinvertebrates
Aquatic macroinvertebrates reside in and on the bottom substrate of streams and provide another valuable tool for assessment of water quality. They are small but visible to the naked eye and large enough to be retained in a U.S. Standard No. 30 sieve. Water chemistry sampling provides information for the quality of water at the time of sample collection. In contrast, macroinvertebrates serve as continuous monitors of stream water quality since they live in the water during the majority of their life cycle and are exposed to variable concentrations of pollutants over extended periods of time. This is an important concept because instantaneous water quality sampling may miss important changes in water quality due to normal seasonal and spatial variability, changes in land use, water management, or accidental pollutant spills that macroinvertebrates may detect.

Wyoming water quality standards established for chemical and physical water quality parameters are established to protect aquatic life and human health. Instead of using sampling results from individual chemical and physical water quality parameters, evaluation of benthic macroinvertebrate populations may serve as a direct measure for the attainment of the Aquatic Life beneficial use in addition to validating the effectiveness of individual numeric water quality chemical and physical standards. Benthic macroinvertebrates also serve to integrate water quality and habitat quality interaction, and evaluate potential synergistic effects from multiple chemical and physical water pollutants not measured during routine water quality monitoring.

Wyoming has developed biological criteria for streams statewide, but they have not been adopted as numeric, enforceable standards (Stribling et al., 2000). As such, they may be used as a narrative standard to determine beneficial use for protection and propagation of fish and wildlife, and aquatic life use.

5.2.4. Supporting Information

Precipitation and Air Temperature
Precipitation and air temperature are essential components in watershed scale monitoring projects. Both may be used to predict the timing and magnitude for water yield within the project area. The timing and magnitude of water yield will affect chemical, physical, biological, and habitat characteristics for water bodies. Precipitation and temperature must be factored into water quality data analyses because observed water quality changes among years may be related to normal annual fluctuation rather than anthropogenic (man-caused) effects.

5.3 SAMPLE SITE DESCRIPTIONS

Sites were selected based on a review of the historical data, historical sampling sites, availability, and access (Table 5-4). Previous water quality monitoring stations used by EnTech, WDEQ, and USGS were used where possible. 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.

Table 5-4. Types of Monitoring and Site Description

Site	Type(s) of Monitoring	Water Quality Sample Site Description
PD1	Cont. Water Temperature, Water Quality, and BURP	Located on Prairie Dog Creek above Tongue River confluence, approximately 100 yards upstream from County Rd 1211 crossing on State Trust land. At USGS monitoring station # 06306250.
PD2	Cont. Water Temperature, Water Quality, BURP and Pesticide/Herbicide	Located on Prairie Dog Creek upstream of County Rd. 114 crossing.
PD3	Water Quality	Located on Dutch Creek approximately 100 yards upstream of confluence.
PD3A	Water Quality	Located on Prairie Dog Creek, just upstream from crossing approximately ¼ mile from Dutch Creek confluence.
PD4	Water Quality	Located on Wildcat Creek approximately 100 yards downstream from Hwy 336.
PD5	Cont. Water Temperature, Water Quality, and BURP	Located on Prairie Dog Creek just south of the railroad crossing off of Hwy 336.
PD5A	Water Quality	Prairie Dog Creek East of Peno Road upstream of bridge on private driveway
PD6	Cont. Water Temperature, Water Quality, BURP and Pesticide/Herbicide	Located on Prairie Dog Creek upstream from the Hwy 14 crossing.
PD7	Water Quality	Located on Meade Creek approximately 50 yards south of confluence and 400 yards north of County Rd. 131.
PD 7A	Water Quality	Located on Prairie Dog Creek just upstream from confluence with Meade Creek.
PD8	Water Quality	Located on Prairie Dog Creek north of County Rd. 127
PD9	Water Quality	Located on Prairie Dog Creek approximately 200 yards upstream from County Rd. 127 crossing.
PD10	Cont. Water Temperature, Water Quality, and BURP	Located on Prairie Dog Creek approximately 100 yards upstream from Hwy 87 crossing.
PD11	Water Quality	Located approximately 50 yards downstream Piney Creek/Prairie Dog Ditch Diversion

In 2007, SCCD collected samples from 11 sites in the watershed. Of these 11 sites, 7 were located on Prairie Dog Creek, three were located on tributaries (Dutch, Wildcat, and Meade Creek), and one was located on Prairie Dog Ditch in Story, Wyoming. Based on analyses of first year monitoring data, three sites were added in 2008. These sites were added to fill geographical gaps along the mainstem. The sites added in 2008 include an "A" in the sample site identification code.

Each sampling site was equipped with a staff gauge for flow measurements. Staff gauges were calibrated to develop a stage-discharge relationship. The existing recording gauge operated by USGS at Prairie Dog Near Acme (#063062500) was utilized at site PD1. During site set-up, SCCD identified land use characteristics and other activities.

Table 5-5. Site Location and Land Uses

Site	Latitude / Longitude	Elevation (feet)	Land Use(s)
PD1	44°59.033' / 106°50.400'	3,477	Mainly horse grazing and irrigated haylands upstream. CBM production also located within area.
PD2	44°55.278' / 106°51.594'	3,536	Irrigated haylands, wildlife habitat, and cattle grazing. CBM production present in area.
PD3	44°52.455' / 106°50.868'	3,621	Wildlife habitat, pastureland for cattle grazing and CBM production.
PD3A	44°52.037' / 106°51.202'	3,635	Irrigated haylands, wildlife habitat, and cattle grazing. CBM production present in area.
PD4	44°50.356' / 106°51.607'	3,680	Irrigated agricultural land, CBM production, and cattle grazing.
PD5	44°49.184' / 106°54.054'	3,742	Cattle grazing, and irrigated haylands. Railroad and HWY 336 parallel east side of Prairie Dog Creek downstream of sample site.
PD5A	44°46.387' / 106°53.842'	3,840	Rural residential, wildlife habitat, cattle grazing, and irrigated haylands.
PD6	44°43.799' / 106°52.474'	3,969	Rural residential, wildlife habitat, cattle grazing, and irrigated haylands. Hwy 14 parallels on east and west side.
PD7	44°42.268' / 106°51.433'	3,955	Wildlife habitat, cattle grazing, and irrigated haylands.
PD7A	44°42.065' / 106°51.220'	4,035	Cattle grazing and irrigated haylands. County Road 342 is just upstream of the site.
PD8	44°39.594' / 106°50.190'	4,160	Rural residential, cattle grazing, irrigated haylands, and wildlife habitat.
PD9	44°37.199' / 106°50.624'	4,355	Wildlife habitat, cattle grazing, pasture and irrigated hayland.
PD10	44°36.552' / 106°52.102'	4,532	Wildlife habitat, cattle/horse grazing, pasture and irrigated hayland. Creek crosses Hwy 87 just downstream.
PD11	44°34.676' / 106°53.937'	5024	Predominantly rural residential community.

5.4 SAMPLING AND ANALYSIS METHODS

5.4.1. Water Quality

Grab samples were collected for laboratory analyzed parameters. Method references, holding times, and preservation requirements for field and laboratory analyzed parameters were described in the SAP (Table 5-6). The goal was to collect samples that were representative of the site conditions at the time the sample was collected. Grab samples were taken in the middle of the stream at 0.6 the depth of the water column when discharge and adequate depth allowed (Ponce, 1980). Samplers entered the water downstream of the sampling location to minimize disturbance to stream substrate in order to prevent the introduction of bed load sediment into the sample container. The contract laboratory provided the necessary sample containers, coolers, and preservatives. Trip blanks were prepared by the contract laboratory and provided with each daily sample set. Samples requiring preservation were immediately preserved, placed on ice, and hand delivered to the contract laboratory with the appropriate forms (WDEQ, 2004a). The contract laboratory for parameters except benthic macroinvertebrates was Inter-Mountain Laboratories (IML) in Sheridan, Wyoming.

Water samples requiring filtration (i.e. dissolved metals) were collected following the accepted WDEQ SOP for Total and Dissolved Metals (WDEQ, 2004a). Samples for Dissolved Metals were collected in appropriate sample containers supplied by the contract laboratory, immediately placed on ice (unfiltered), and hand-delivered same-day to the contract laboratory. The contract laboratory immediately filtered the sample and either preserved, or analyzed the sample. This procedure conforms to the WDEQ SOP, which states, "For **dissolved metals** analysis, if samples are delivered to the Water Quality Division Laboratory within 48 hours there is no need to filter/preserve samples on site (WDEQ, 2004a)."

After collecting grab water quality samples, a five gallon plastic bucket was rinsed at least twice with ambient water. Facing upstream, the bucket was filled with stream water and field parameters were then immediately analyzed with portable monitoring instruments. Field parameters were: instantaneous water temperature, pH, specific conductivity, and dissolved oxygen. Water temperature and pH were measured with a Hanna Instruments meter Model No. HI 9025. Specific conductivity was measured with a Hanna Instruments conductivity meter Model No. HI 8733. Dissolved Oxygen was measured with a YSI Model 550A, which also measured temperature. All instrumentation was calibrated according to the manufacturer's instructions.

The SCCD sampled for pesticides on two sites on Prairie Dog Creek watershed in September 2007 and June 2008. These dates were selected to correspond to the most common application times within the watershed. Constituents monitored include 2,4-D, Picloram, Dicamba, Clopyralid-Triclopyr. Although used in the watershed, results were not provided for Carbofuran or Imazadil. The samples will provide some preliminary information that may be useful for future planning and monitoring efforts.

Table 5-6. Standard Field and Laboratory Methods for Monitoring

Parameter	Units	Method / Reference[1]	Analyses Location	Preservative	Holding Time
Water Temperature	°C	grab/EPA 1983 170.1	On-site	n/a	n/a
Water Temperature	°C	continuous recorder	On-site	n/a	n/a
pH	SU	grab/EPA 1983 150.1	On-site	n/a	n/a
Specific Conductivity	µmhos/cm	grab/EPA 1983 120.1	On-site	n/a	n/a
Dissolved Oxygen	mg/L	grab/EPA 1983 360.1	On-site	n/a	n/a
Turbidity	NTU	grab/EPA 1983 180.1	IML[2]	Ice; at or below 4ºC	48 hours
Hardness	mg/L	grab/EPA 1983 130.2 SM 2340B	IML[2]	Nitric Acid (HNO_3); cool to 4ºC	180 days
Alkalinity	mg/L	grab/SM 2320B	IML[2]	Ice; at or below 4ºC	14 days
Total Sulfate	mg/L	grab/EPA 1983 300.0	IML[2]	Ice; at or below 4ºC	28 days
Total Chloride	mg/L	grab/EPA 1983 300.0	IML[2]	Sulfuric Acid (H_2O4); cool to 4ºC	28 days
Dissolved Calcium	mg/L	grab/EPA 1983 200.7	IML[2]	Filtered; Nitric Acid (HNO_3); cool to 4ºC	180 days
Dissolved Manganese	mg/L	grab/EPA 1983 200.7	IML[2]	Filtered; Nitric Acid (HNO_3); cool to 4ºC	180 days
Total Manganese	mg/L	grab/EPA 1983 200.7	IML[2]	Nitric Acid (HNO_3); cool to 4ºC	180 days
Dissolved Magnesium	mg/L	grab/EPA 1983 200.7	IML[2]	Filtered; Nitric Acid (HNO_3); cool to 4ºC	180 days
Dissolved Sodium	mg/L	grab/EPA 1983 200.7	IML[2]	Filtered; Nitric Acid (HNO_3); cool to 4ºC	180 days
Nitrate-Nitrite	mg/L	grab/EPA 1983 353.2	IML[2]	Sulfuric Acid (H_2O4); cool to 4ºC	28 days
Total Phosphorus	mg/L	grab/EPA 1994 200.7	IML[2]	Sulfuric Acid (H_2O4); cool to 4ºC	28 days
Total Suspended Solids					
E. coli	col/100 ml	mColiBlue24	IML[2]	Ice; at or below 4ºC	6 hours
Discharge	cfs	Calibrated staff gauge	On-site	n/a	n/a
Discharge	cfs	Mid-Section Method	On-site	n/a	n/a
Macroinvertebrates	Metrics	King 1993	AA[3] ABA[4]	Formalin or formalin/ alcohol mixture	n/a
Habitat (Reach level)	n/a	King 1993	On-site	n/a	n/a

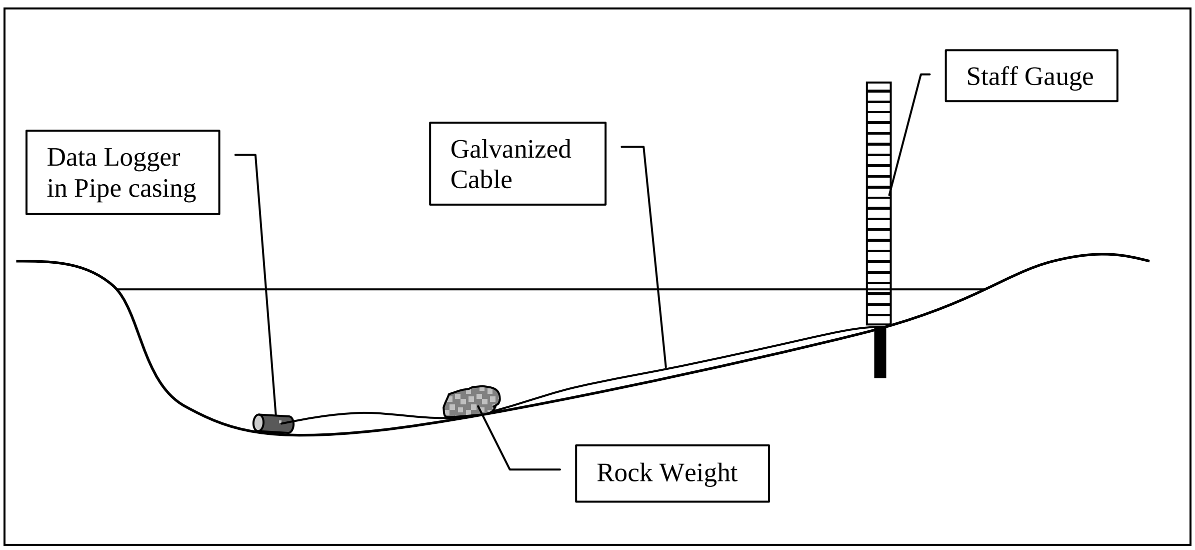
[1]Method references for laboratory analyses were provided by the contract laboratories and defined in their SOPs. Refer to Appendix B for SOPs for sample collection and on-site analyses.
[2]IML refers to Inter-Mountain Laboratories in Sheridan, Wyoming.
[3]AA refers to Aquatic Assessments, Inc. in Sheridan, 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.
Note: SCCD did not filter samples on site. They were delivered to the contract laboratory on the same day of collection and were filtered and preserved there.

5.4.2 Continuous Water Temperature

Instream temperatures were measured on a continuous basis at five sites in 2007 and 2008. Onset® Tidbit temperature loggers (model #TBI32-05+37) were programmed to measure temperature at 15 minute intervals. Data were electronically transferred in the field to a Shuttle. Once all logger data were collected, the Shuttle was used to transfer data to a computer.

To house the data loggers, each logger was placed inside a six inch piece of HDPE pipe with galvanized mesh at each end to allow water passage (Figure 5-1). The pipe was placed in a relatively deep portion of the channel, secured with a weight (if necessary), and cabled to the station's staff gauge.

Figure 5-1. Stream Cross-Section of a Typical Continuous Temperature Data Logger Arrangement



5.4.3 Discharge

Discharge was measured at each sampling event with a surveyed, calibrated staff gauge. In order to develop stage-discharge relationships, discharge measurements were made for each staff gauge at least three times to capture various flow regimes. Discharge was measured by reading the staff gauge and incorporating the recorded level into the stage-discharge equation to estimate discharge. Upon installation, gauges were surveyed and compared with a permanent bench mark to confirm stability and ensure consistent measurement. When flows were wadeable, samplers used the mid-section method (WDEQ, 2004a) and a Marsh-McBirney portable current velocity meter. Discharge was measured in a stable, straight channel section in areas where the flow was uniform and free of excess turbulence and obstructions. Samplers stretched a tape perpendicular to the channel. Ideally, samplers would be able to take at least 20 measurements across the width of the channel. However, samplers took between 12 and 20 measurements on some of the smaller tributaries and narrow reaches of Prairie Dog Creek. After determining and recording the depth of the water, velocity measurements were taken at each location. Where the depth of the water column was less than 3 feet, velocity measurements were taken at 0.6 of the depth. In situations where the depth of the water column exceeded 3 feet, samplers took two velocity measurements at 0.2 and 0.8 of the depth. The fixed gauge station operated by USGS at PD 1 provided discharge data for that site. Discharge for site PD11 was calculated with the formula:

$$Q= (3.6875\ W + 2.5)\ H_a^{\ 1.6}$$

where W is 10 feet for the throat width of the Parshall Flume and H_a is the water level or gauge height recorded by reading the staff gauge.

5.4.4. Benthic Macroinvertebrates

Macroinvertebrate sample collection and analysis followed WDEQ protocol (WDEQ, 2004a; King, 1993). For each site, eight individual Surber samples were collected from a representative maximum 100 foot riffle/run reach and composited into a single sample. Sampling began at the downstream portion of the riffle and proceeded upstream to prevent substrate disturbance and incidental sampling of drift. The Surber sampler with a 3 foot 500 micron extended net was used. A random number table was used to select individual square foot quadrants for sampling (SCCD, 2007b)

The Surber sampler was firmly seated on the stream bottom facing upstream into the streamflow. The Surber was positioned such that the flow would pass over the quadrant and through the net. Before disturbing the substrate within the frame of the Surber sampler, substrate composition and embeddedness were evaluated. After completion of substrate and embeddedness measurements, larger cobble and gravel within the Surber were scraped by hand and soft brush and were visually examined to ensure removal of all organisms, then discarded outside the sampler. Remaining substrate was thoroughly disturbed to a depth of approximately 2-3 inches (5-8 cm) to allow organisms to be transported into the net. Net contents were placed into a tub and rinsed into a U.S. Standard No. 35 (500um) sieve. Sieve contents were placed in plastic sample bottles with labels placed on the outside and on the inside of the bottle. Samples were preserved with sufficient formalin, or formalin/isopropyl alcohol mixture, to constitute approximately a 10% formalin mixture (WDEQ, 2004a; King, 1993). Stream current velocities were measured in feet per second (fps) at each Surber sample quadrant after macroinvertebrate collection to determine if differences in sediment deposition and embeddedness among stations were due to differences in current velocity. The portable current velocity meter was placed where the front of the Surber was located at 0.6 of the water depth.

Aquatic Assessments, Inc. in Sheridan Wyoming sorted the samples and analyzed the Chironomidae larvae. Samples received by Aquatic Assessments were evaluated for sample integrity and proper preservation. In the laboratory a minimum of 500 organisms (usually 500 to 550) were removed from randomly selected squares in a gridded tray as described by Caton (1991). When organism density was high (greater than 300 organisms per square), the next square or subsample was subdivided into quarters by placing an X-shaped frame over the sorting container. A random number from 1 to 4 was then selected and all organisms were removed from the corresponding quarter. The entire sample was analyzed if less than 500 organisms were present. After subsampling was completed and the representative 500 to 550 organisms removed, the sorter re-distributed the remaining sample within the gridded tray and spent approximately 5 minutes looking for Large and Rare organisms (Vinson and Hawkins, 1996).

Organisms removed during the Large and Rare search were placed in a separate vial and assigned an occurrence of one (1) for the correction factor, density and metric calculations. Organisms were then hand picked from preserved stream sediments with the aid of a binocular dissecting microscope at magnifications of 6 to 12X. No flotation methods were employed.

Vials containing organisms and the COC forms were then sealed inside a container and shipped to Aquatic Biology Associates, Inc. (ABA) in Corvallis, OR, for analysis. This was the same contract laboratory used by WDEQ and SCCD in the past and thus, the same analytical methods were used. Upon receipt of the samples, the analytical laboratory performed a visual check for the number and general condition of samples. The majority of organisms were identified to genus or species with the exception of taxonomically indistinct worms and certain difficult Dipteran taxa. The microcrustaceans Cladocera, Copepoda, and Ostracoda; microfauna such as rotifers and protozoa; semi-aquatic, water surface and water column macroinvertebrates; and vertebrates such as fish and amphibians were also noted, but were not included in taxa lists and metric calculations. A consistent Standard Level of Identification was used during the project to provide data comparable between years. Density estimates were expressed as number per square meter (No./m^2).

5.4.5 Habitat Assessment

Habitat assessments were conducted at the same riffle and stream reach where macroinvertebrates were collected <u>after</u> biological sampling was completed with the exception of the substrate composition. This was done prior to collection of benthic macroinvertebrate samples, which disturbed the substrate. The habitat assessment was conducted according to WDEQ protocols following methods found in Platts et al. (1983), Plafkin et al. (1989) and Hayslip (1993) compiled and modified by King (1993) for use in Wyoming and described in the SAP (SCCD, 2007b). The habitat assessment includes three components:

1. Semiquantitative substrate particle size composition and embeddedness (silt cover) evaluation;

2. Qualitative habitat assessment for the stream reach; and

3. Photopoints

Substrate Composition.

Evaluation of substrate was required because substrate particle size is an important factor controlling the composition and density of benthic macroinvertebrate populations. A station dominated by diverse cobble and gravel substrate will normally have a diverse benthic macroinvertebrate population (in the absence of water pollution). Stream reaches dominated by sand and silt substrate will exhibit different benthic community composition when compared to reaches dominated by cobble and gravel. Population density and diversity is usually reduced because favorable habitat for colonization of organisms has been reduced. Water quality monitoring programs must include evaluation of substrate to determine whether observed change in benthic macroinvertebrate populations are due to water pollution or merely to change in stream substrate. Evaluation of differences in substrate particle size among stations may reveal disruptions in the watershed often evidenced by increased sand and sediment deposition.

Immediately after the Surber sampler was seated and before substrate was disturbed, the percent area occupied by cobble, gravel, fine gravel, sand, and silt were estimated for each of the eight Surber sample quadrats (DeBrey and Lockwood, 1990; Platts et al., 1983). A piece of plexiglass was used to reduce surface glare to aid in observation of substrate.

Table 5-7. Embeddedness (Silt Cover) Rating Classification (Platts et al., 1983).

Rating	Description
5	Less than 5 percent of surface covered by silt
4	Between 5 to 25 percent of surface covered by silt
3	Between 25 to 50 percent of surface covered by silt
2	Between 50 to 75 percent of surface covered by silt
1	Greater than 75 percent of surface covered by silt

Qualitative Habitat Assessment.

The habitat assessment is a qualitative assessment comprised of thirteen (13) components. Because of the subjective nature of the assessment, results must be interpreted with caution. The majority of habitat assessment parameters are "discharge dependent". This means many habitat parameters rate higher during periods of higher discharge and rate lower during periods of low discharge.

The qualitative habitat assessment methods used are described in King (1993), which was based on compilation of methods presented in Plafkin et al. (1989), USEPA (1991), and Hayslip (1993). The length of stream reach assessed will be determined by multiplying the bankfull width times 20, or a minimum of 360 feet (WDEQ, 2004a; Burton, 1991).

Habitat parameters were weighted according to their influence on aquatic organisms. **Primary parameters** receive the greatest weight and describe microhabitat characteristics which have a direct influence on macroinvertebrates. **Secondary parameters** describe macrohabitat characteristics through stream channel morphology which indirectly influence macroinvertebrates. **Tertiary parameters** are weighted less than primary and secondary parameters. These parameters describe surrounding land use characteristics which affect streambank and riparian zone stability. The higher the individual or cumulative score, the better the habitat. The maximum habitat assessment score is 200 points.

Primary Parameters (each 20-0 points)

1. Bottom substrate / Percent fines (silt, sand): estimates the percent of combined sand and silt **only** within the riffle/run sampled.

2. In stream cover (for fish): estimates the amount of in stream features serving as habitat and cover for fish for the entire reach.

3. **Embeddedness (silt cover)**: estimates the degree to which cobble and gravel were covered or surrounded by silt **only** within the riffle/run sampled.

4. **Velocity / Depth**: estimates the relative contribution for four different velocity and depth regimes within the entire reach.

a. Fast and deep
b. Slow and deep
c. Fast and shallow
d. Slow and shallow

A stream reach with equal mixtures of each is desirable and would score high. A stream reach dominated by one velocity/depth regime (which may naturally occur in some stream types) would score low.

5. **Channel Flow Status**: estimates how much of the stream channel and in stream structures are covered by water within the entire reach. Complete inundation of the channel and in stream structures would rate highest.

Secondary Parameters (each 15-0 points)

6. **Channel shape** (at bankfull stage): evaluates the approximate shape of the stream channel at the bankfull stage for the entire reach. Four shapes may be selected and a stream channel may normally be comprised of an admixture of two shapes.

a. Trapezoidal (undercut banks) will rate highest.
b. Rectangular will rate high.
c. Triangular will rate lower.
d. Inverse trapezoidal (obvious deposition and bars in channel) will rate lowest.

7. **Channel alteration** (channelization): estimates the amount of man-caused channelization (straightening) and channel disruption (dredging) in the entire reach. The length of time in years since channelization will be an important element for assessing this parameter.

8. **Pool / Riffle Ratio**: estimates the approximate ratio for the distance between pools and riffles. A consistent pool and riffle sequence within the entire reach is desired. A variety of pool and riffle habitat would rate high. Lack of a pool and riffle sequence and dominance by all pool or all riffle would rate low.

9. **Width to Depth Ratio:** is the approximate average "wetted" channel width divided by average water depth within the entire reach. This provides an estimate for the amount of channel that may support fish and aquatic life. A low width to depth ratio, less than 7, is optimal and a high width to depth ratio, greater than 25, will rate low.

Tertiary Parameters (each 10-0 points)

10. **Bank Vegetation Protection**: estimates the amount of stream bank (at the bankfull stage) within the entire reach covered by vegetation, large cobble, boulder and larger woody debris serving to provide bank stability. The rating would increase as bank area covered by protective bank features increases.

11. Bank Stability: estimates the amount of bank erosion (at the bankfull stage) within the entire reach evidenced by raw, sloughing, or unstable banks. A low proportion of unstable bank areas would rate high. A stream reach dominated by unstable banks would rate low.

12. Disruptive Pressures: estimates the degree that vegetation was cropped or removed from the streambank immediately adjacent to the stream along the entire reach. Presence of all vegetation expected for the ecoregion, stream channel type and seasonal development would rate high. Significant removal of vegetation would rate lower.

13. Zone of Influence: estimates the width of the riparian zone within the entire reach. Consideration was given to the degree of human impact within the riparian zone. A wide riparian zone with negligible human impact provides an adequate buffer zone to filter water pollutants and would rate high. A narrow riparian zone impacted by man related activity would rate low.

5.5 SAMPLING FREQUENCY

Continuous water temperature recorders were deployed at five sites along the main stem of Prairie Dog Creek (Table 5-4). The continuous recorders monitored in-stream water temperatures from May 1 to October 31, 2007 and April 1 to October 27, 2008. Grab samples for turbidity, alkalinity, Manganese, TSS, SAR, Total Sulfate, Total Chloride, Total Hardness, Total Phosphorus, and Nitrite-Nitrate Nitrogen were collected once in May, June, July, August, and September in 2007 and in April, May, June, July, August, and October in 2008. Samples were transported to and analyzed by Inter-Mountain Laboratories in Sheridan, Wyoming. SAR involved sampling for Calcium, Sodium, and Magnesium. Samples were delivered to the lab on the same day of collection to eliminate the need for filtering the samples in the field (WDEQ, 2004a). Grab samples for bacteria and turbidity were collected 20 times each in 2007 and 2008 so geometric means for bacteria data could be established and compared to Wyoming water quality standards. Geometric means are necessary to account for the variability with bacteria sampling and are calculated on 5 samples collected on separate 24-hour periods within a 30 day period (WDEQ, 2007) The timing of these sampling events corresponded with recreation season high flows (May and June) and low flows (August) as well as the irrigation season. Water temperatures also differ considerably during these periods. Instantaneous water temperature, pH, specific conductivity, dissolved oxygen, and discharge were measured on-site during each water quality sampling event (bacteria and monthly samples). Upstream, downstream and panoramic photographs were taken at each station during May 2007, June 2008, and October 2008 along with various other photos during site set-up and sample collection.

Reach level habitat assessments were conducted in conjunction with benthic macroinvertebrate sampling (i.e. BURP monitoring) at five sites along the main stem of Prairie Dog creek (Table 5-4). This monitoring was conducted during late October during expected low flows after the end of the irrigation season. Macroinvertebrate samples are collected easier and more accurately during low flows because the collection net measures only 12 inches high. Moreover, representative macroinvertebrate communities are present during this time since populations have had adequate time to recover and stabilize following the disruptive effects related to spring runoff.

Supporting data, consisting of meteorological data, was gathered from the National Weather Service station located at the Sheridan County Airport in Sheridan, Wyoming.

6. QUALITY ASSURANCE QUALITY CONTROL

6.1 FUNCTION OF QUALITY ASSURANCE/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; USEPA1990). QA/QC should not be viewed as an obscure notion to be tolerated by monitoring and assessment personnel, but as a critical, deeply ingrained concept followed through each step of the monitoring process. Data quality must be assured before the results can be accepted with any scientific study. Project QA/QC is fully described in the SCCD QAPP (SCCD, 2007a) and in the SAP (SCCD, 2007b).

6.2 TRAINING

SCCD personnel had adequate training/experience for the proper implementation of the project. This was obtained through a combination of college studies, previous employment experiences, and on-the job training. The SCCD District Manager holds a M.S. University of Wyoming in Rangeland Ecology and Watershed Management with an emphasis in Water Resources. There were two separate technicians for the project, one in 2007 and one in 2008. The first held a B.S. Colorado State University in Natural Resource Management; the second has a M.A. from Chadron State College in Rangeland Management. The District Manager and the two technicians participated in the WACD water quality training program and had environmental and water quality assessment skills obtained through prior employment experiences. Kurt King, former WDEQ QA/QC officer provided annual training for all employees in conducting benthic macroinvertebrate sampling and reach level habitat assessments.

Other SCCD and USDA-NRCS personnel provided field and other assistance as needed. These personnel were trained to follow the necessary field protocols and were under the direct supervision of the District Manager and/or the technician supervising the sample collection.

6.3 SAMPLE COLLECTION, PRESERVATION, ANALYSIS AND CUSTODY

6.3.1 Collection, Preservation, and Analysis

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 site during each sampling event. Calibration logs were completed for each instrument every time a calibration was performed.

6.3.2 Sample Custody

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. After samples changed custody, laboratory internal COC procedures were implemented according to their Quality Assurance Plan.

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 sealed inside a cooler and shipped to the contract analytical laboratory. Upon receipt, the analytical laboratory opened the coolers, performed a visual check for the number and general condition of samples, and then signed the COC form. The completed original COC form was returned to SCCD by the analytical laboratory after completion of analyses.

6.4 CALIBRATION AND OPERATION OF FIELD EQUIPMENT

The sampler was responsible for the proper and consistent calibration and maintenance of instrumentation. The SAP outlined the calibration and maintenance requirements for field equipment (SCCD, 2007b). On every sampling event, before leaving the office, the pH meter, conductivity meter, and DO meter were calibrated according to the manufacturer's instructions as described in the SAP. A calibration and maintenance log was completed by the Field Supervisor for all equipment used.

6.5 SUMMARY OF QA/QC RESULTS

This section provides a summary of the QA/QC procedures and results as described in the SAP (SCCD, 2007b). 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

6.5.1 Duplicates

Duplicate chemical, physical, biological, and habitat samples were obtained for all field and laboratory analyzed samples (Table 6-1). Duplicate water quality samples were obtained by collecting consecutive water quality and duplicate 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. In 2007, 9.2% of the water quality samples were duplicated, which was slightly below the target DQO) of 10%. However, when considered with the 2008 samples (of which 12.1 % were duplicated) 10.65% of the water quality samples for the two years were duplicated.

Table 6-1. Summary of Duplicates Collected for the 2007-2008 PDWA

Parameter	No. of Samples	No. of Duplicates	% Duplicated	DQO (%)
Water Quality Samples 2007	218	20	9.2	10
Water Quality Samples 2008	280	34	12.1	10
Macroinvertebrate Samples 2007	5	1	20.0	10
Macroinvertebrate Samples 2008	5	1	20.0	10
Habitat Assessments 2007	5	1	20.0	10
Habitat Assessments 2008	5	1	20.0	10

6.5.2 Accuracy

Accuracy is the degree of agreement between a measured value and the true or actual value. Accuracy for water quality parameters measured in the field was assured by calibration of equipment to known standards. Conductivity and pH meters were calibrated on the morning of every sampling event. The dissolved oxygen meter was calibrated at every 300' change in elevation. 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. In this instance, precision served as the primary QA check for benthic macroinvertebrate sampling and habitat assessment.

6.5.3 Precision

Precision is 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 was affected by changes in relative concentration for certain chemical parameters. Precision was determined for chemical, physical, biological, and habitat measurements by conducting duplicate samples at 10 percent of the collected samples. With few exceptions, all parameters met the DQO's for precision (Table 6-2). Precision for Turbidity was slightly above the DQO of 10% in both 2007 (14.3) and 2008 (12.0). Because Turbidity values can be relatively low, small variations can result in higher RPDs. Calculated precision values for TSS, Total Chloride, Nitrate-Nitrite, Dissolved Manganese, and Total Phosphorous consider were determined to be zero for values less than the detected limits, rather than assigning a random number as in the calculation for summary statistics.

Table 6-2. Precision Results for the 2007 and 2008 Prairie Dog Creek Monitoring Data

Parameter	2007 Precision (% - RPD)	2008 Precision (% - RPD)	Average	DQO (%)
Water Temperature-Hanna	0.6	0.5	0.7	10
Water Temperature-YSI	0.4	0.2	0.3	10
pH	0.2	0.5	0.4	5
Specific Conductivity	1.4	0.8	1.1	10
Dissolved Oxygen	0.2	0.4	0.3	20
Turbidity	14.3	11.7	13.0	10
E. coli	29.8	31.4	30.6	50
TSS	29.1	21.1	25.1	
Total Alkalinity	0.5	1.1	0.8	10
Total Hardness	1.7	2.5	2.1	10
SAR	5.0	1.5	3.3	
Alk Bicarb	1.3	1.3	1.3	
Total Chloride	8.0	0.0	4.0	10
Nitrate-Nitrite	9.5	7.1	8.3	20
Total Sulfate	4.7	7.7	6.2	20
Calcium-mg/L	1.5	3.4	2.5	10
Magnesium-mg/L	3.3	2.0	2.7	10
Sodium-mg/L	5.4	2.3	3.9	10
Calcium-milliequivalents	2.1	2.1	2.1	
Magnesium-milliequivalents	2.1	2.5	2.3	
Sodium-milliequivalents	7.2	3.0	5.1	
Dissolved Manganese	15.1	2.8	9.0	10
Total Manganese	7.9	3.7	5.8	10
Total Phosphorous	0.0	0.00	0.0	20

6.5.4 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 exceedences, and proper access to sample sites for collection of samples as scheduled. Overall, completeness results were above or slightly below the DQOs (Table 6-3). With the exception of discharge, all field parameters, macroinvertebrates, bacteria, and turbidity met the completeness DQOs. All of the monthly lab parameters were slightly below the DQOs.

Employee illness resulted in one suite of monthly samples not being collected in 2007. This illness was at the end of the season and the sampling event could not be rescheduled. Because there were only a total of six monthly sampling events in 2007, the result of even one missed day resulted in 83.3 % completeness for 2007 and an overall completeness of 92.7% for 2007 and 2008. In addition, there were two occasions during the 2007 bacteria/turbidity sample collection where conditions prevented access to site PD3, which resulted in 94.4% completion for those parameters in 2007 and 97.5% for 2007 and 2008. For the September 2007 monthly samples, the lab neglected to analyze/report a value for alkalinity at site PD1. This resulted in 81.8% completeness for 2007 and an overall completeness of 92.0% for 2007 and 2008. Completeness for discharge was affected in 2007 and 2008 by gauges being submerged, sites being inaccessible, or discharge calculations being outside of the calibrated range. In addition, low water levels prior to irrigation season in PD11 resulted in 5 instances where the gauge was out of water.

Table 6-3. Completeness of 2007 and 2008 Prairie Dog Creek Monitoring Data

Parameter	% 2007 Completeness	% 2008 Completeness	2007-2008 Total (%)	DQO (%)
Water Temperature	94.4	100.0	97.5	95
pH	94.4	100.0	97.5	95
Conductivity	94.4	98.2	96.5	95
Dissolved Oxygen	94.4	97.1	95.9	95
Discharge	92.2	95.7	94.1	95
Turbidity	94.4	100.0	97.5	95
E. coli	94.4	100.0	97.5	95
TSS	83.3	100.0	92.7	95
Total Alkalinity	81.8	100.0	92.0	95
Total Hardness	83.3	100.0	92.7	95
SAR	83.3	100.0	92.7	95
Total Chloride	83.3	100.0	92.7	95
Nitrate-Nitrite	83.3	100.0	92.7	95
Total Sulfate	83.3	100.0	92.7	95
Calcium	83.3	100.0	92.7	95
Magnesium	83.3	100.0	92.7	95
Sodium	83.3	100.0	92.7	95
Dissolved Manganese	83.3	100.0	92.7	95
Total Manganese	83.3	100.0	92.7	95
Total Phosphorous	83.3	100.0	92.7	95
Macroinvertebrates	100.0	100.0	100.0	95

6.5.5 Trip Blanks

Trip blanks were prepared to determine whether samples might be contaminated by the sample container, preservative, or during transport and storage conditions. These trip blanks were prepared by the analytical laboratory, Inter-Mountain Laboratories (IML), on sampling days. IML prepared trip blanks by filling preserved bottles with laboratory de-ionized water. In 2007, there were 10 blanks with values reported for turbidity (Appendix Table E-4). All of these were at or below 0.5 NTU. In 2008, there was one trip blank with a value reported for *E. Coli* and 10 with values reported for Turbidity. With the exception of one Turbidity value of 0.7 NTU, all of the Turbidity values were reported at or below 0.5 NTU. The Turbidity data were considered acceptable because they were low Turbidity values and were at, or approached, the minimum detection limit value of 0.1 NTU.

6.5.6 Sample Holding Times

All IML prepared laboratory data sheets were reviewed to ensure all samples were analyzed before their holding times had expired. This review found that all *E. coli* samples were analyzed within their required 6 hour holding time, with the exception of seven samples from PD1 on 5/15/07, 6/05/07, 8/22/07, 5/29/08, 6/4/08, 6/10/08, and 7/24/08 and four samples from PD2 on 5/15/07, 5/29/08, 6/10/08, and 7/24/08. The holding time exceedences were within 55 minutes and samples were preserved on ice in a cooler. As a result, data from these samples were used in the summary statistics and the calculation of the geometric means. All turbidity samples were analyzed within the required 48 hour holding time, with the exception of samples collected on 9/26/07 on sites PD1-PD9. The holding time exceedences were within 3 hours and samples were preserved on ice. Data from these samples were used. Other laboratory parameters were analyzed within recommended holding times. 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.

6.5.7 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. 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 (i.e. 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.

6.5.8 Stage-Discharge Relationships

Stage-discharge relationships were established for all staff gauges installed by SCCD. These relationships were developed by recording the stage height and measuring discharge using the mid-section method (WDEQ, 2004a) on at least three occasions with varying flow conditions. When regressions of stage height and discharge are performed, a correlation coefficient (R^2 value) is determined for each site (Table 6-4). Correlation coefficient values for PD4, PD5, PD5A and PD8 were slightly below the DQO of 0.95. Site conditions at PD 2 and PD9 resulted in the placement of staff gauges in less than optimal locations, which may have affected the stage-discharge relationship. Because these presented the best and in some cases only, flow information available, the values were used in the calculation of summary statistics and will be used to establish load estimates for other parameters, where appropriate.

Table 6-4. Summary of R^2 Values for 2007-2008 Stage-Discharge Relationships for the Prairie Dog Creek Watershed

Site	Actual R^2 Value	DQO Minimum R^2 Value
PD1	N/A	N/A
PD2	0.788	0.95
PD3	0.999	0.95
PD3A	0.987	0.95
PD4	0.925	0.95
PD5	0.918	0.95
PD5A	0.927	0.95
PD6	0.993	0.95
PD7	0.998	0.95
PD7A	0.992	0.95
PD8	0.917	0.95
PD9	0.861	0.95
PD10	0.976	0.95
PD11	N/A	N/A

*PD1 & PD11 site staff gauges were not calibrated by SCCD. USGS mean daily discharge data for Station No. 06306250 was used for PD1. Calculations for PD11 were based on the throat width and gauge height of the Parshall flume at that location, in addition to information provided by the Board of Control.

6.5.9 Continuous Temperature Data Loggers

SCCD used Onset Tidbit Model #TBI32-05+37 continuous temperature loggers. These loggers are factory calibrated, encapsulated devices that cannot be re-calibrated. Onset suggests these loggers should maintain their accuracy unless they have been utilized outside their range of intended use (-20°C to 50°C). To test a data logger's accuracy, Onset recommends performing a crushed ice test. The manufacturer's instructions for this test were adhered to and were followed accordingly. A seven pound bag of crushed ice was emptied into a 2.5 gallon bucket. Distilled water was then added to just below the level of the ice. The mixture was then stirred. The data loggers were submerged in the ice bath and the bucket was then 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 ±0.23°C.

On March 9, 2007, January 31, 2008, and May 4, 2009, SCCD performed the crushed ice test on the data loggers (Appendix Table E-5). The results show the data loggers' environmental response as they were transferred from room temperature conditions to the crushed ice bath mixture, and then removed from the ice bath. Each data logger started the test near 22°C in room temperature conditions, and cooled to below 0°C, before stopping the test (Table 6-5).

Variations in response times shown in the data are due to variations in the times that loggers were submerged and removed from the ice bath.

Table 6-5. Minimum temperatures observed during crushed ice tests.

Logger #	Site	3/9/07 Temp °C	1/31/08 Temp °C	5/4/09 Temp °C
415504	PD1	-0.11 & -0.27	-0.11 & -0.27	-0.11
415512	PD2	-0.24	-0.24	-0.08 & -0.24
415505	PD5	-0.19	-0.19	-0.19
415509	PD6-1 (2007)	-0.15	-0.15	0.01
415506	PD6-2	-0.16	-0.16	-0.16
415508	PD9	-0.26 & -0.42	-0.26	
415513	PD10	-0.14	-0.14	-0.14

The loggers used at stations PD 5, PD6-1, PD6-2, and PD10 recorded ice bath Temperatures as low as -0.19°C, -0.15°C, -0.16°C, and -0.14°C, respectively. The PD1 and PD2 data logger recorded the ice bath Temperature as -0.27°C and -0.24°C, respectively, which were slightly colder than the Temperatures Onset predicted. The logger used for PD9 recorded Temperatures as low as -0.42, which was well outside of the predicted range. Despite being outside of the predicted range, the Temperatures recorded in the ice baths were consistent in different years. Because the loggers were not used outside of their normal operating range and there was no other indication that the loggers were functioning improperly, the Temperature loggers are considered to have maintained their accuracy and have provided valid Water Temperature data.

6.6 DATA VALIDATION

Data generated by the contract laboratories was subject to the internal contract laboratory QA/QC process before it was released. Except in cases where holding times were exceeded, data were assumed 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. Data determined to be invalid were rejected and not used in preparation of this report. Seven discharge calculations were rejected because the stage reading was outside of the calibrated range and unreasonably high for the site and conditions (Table 6-6). These include one measurement at PD3 (5/29/2008), two measurements at PD4 (5/31/07 and 6/4/2008), two measurements at PD6 (5/7/07 and 5/29/208), and two measurements at PD7 (5/7/07 and 5/29/08).

Where there were a small number of low flow values and lab results reported as below the detection limit, these were reported as ½ the detection limit for the purpose of summary statistics, as specified in the SAP (SCCD, 2007b from Gilbert 1987). These included six TSS values, four Nitrate-Nitrite Nitrogen values, five Dissolved Manganese values, five *E. Coli* values, one value each for Total Chloride, Total Manganese, SAR, and Discharge (site PD11). For those parameters in which greater than 20% of the samples for a given site and year were below the detection limit, a random number was generated (SCCD, 2007b from Gilbert 1987). These included 17 TSS values, 102 Total Phosphorous values, 66 Dissolved Manganese, 19 Total Manganese, 76 Nitrate-Nitrite Nitrogen values, 41 Total Chloride values, and 10 SAR values and four Discharge measurements (PD11). In addition, 14 E. Coli results that were >2419 were reported as 2420 and one conductivity measurement of >1999 was reported as 1999.

There were some instances where the conductivity meter and the DO meter did not appear to be functioning properly and readings were erratic. These data were discarded and not used in the development of summary statistics. There were some instances where no gauge height could be established, because the gauge was either submerged or inaccessible. In addition, some of the gauge height measurements were determined to be outside of the calibrated range of the developed stage-discharge relationship (Table 6-6). These discharge measurements were discarded and not used in the development of summary statistics.

Table 6-6. Samples for which no discharge measurement was established.

Site	out of range	submerged	inaccessible
PD2		5/7/07; 5/29/08	
PD3	5/29/08		5/7/07; 9/18/07
PD3A		5/29/08	
PD4	5/31/07; 6/4/08		
PD5		5/7/07	
PD5A		5/29/08	
PD6	5/7/07; 5/29/08		
PD7	5/7/07; 5/29/08		

6.7 DOCUMENTATION AND RECORDS

All water quality field data were recorded on data sheets prepared for the appropriate waterbody and monitoring station. Macroinvertebrate and habitat assessment data were recorded onto data sheets that are very similar in format to those used by WDEQ. Equipment checklists, COC forms, and calibration and maintenance logs were documented on the appropriate forms and are maintained on file in the SCCD office.

6.8 DATABASE CONSTRUCTION AND DATA REDUCTION

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

After data validation and database construction, data were statistically summarized to determine the:

- 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 (Appendix Table C-18). Microsoft Excel® and Arc Map 9.2® were used to generate the statistical tables and graphics for this report. Where there were a small number of low flow values and lab results reported as below the detection limit, these were reported as ½ the detection limit for the purpose of summary statistics (SCCD, 2007b from Gilbert 1987). For those parameters in which greater than 20% of the samples for a given site and year were below the detection limit, a random number was generated (SCCD, 2007b and Gilbert 1987). Discharge measurements outside the calibrated range of the staff gauge or instances where the staff gauge was submerged were not used in the calculation of summary statistics.

6.9 DATA RECONCILIATION

Data collected by SCCD were evaluated before being accepted and entered into the 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 database.

6.10 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.

7 RESULTS AND DISCUSSION

7.1 GENERAL WATER QUALITY DISCUSSION

Overall, water quality data from the PDWA, indicated that water quality in the Prairie Dog Creek watershed is good (Appendix Tables C-3 through C-17). There were no issues with nutrients, pesticides, or concerns with urban run-off in the watershed. The primary regulatory concern is *E. coli* bacteria concentrations in excess of Wyoming water quality standards for primary contact recreation. Water temperatures were recorded in excess of 20^{o} C in portions of the watershed. Dissolved Manganese concentrations also 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 contains high levels of sediment, which may contribute to bacteria concerns. Increased flow from the Tunnel Hill trans-basin diversions that have augmented flow in Prairie Dog Creek since the late 1880s, has contributed to channel instability, concerns with sand and sediment, and may increase Water Temperature.

7.2 CONTINUOUS TEMPERATURE LOGGER DATA

Onset Tidbit data loggers were used to gather in-stream continuous Water Temperature data at six samples sites in the Prairie Dog Creek Watershed (Appendix Figures C-1 through C-12). Loggers were programmed to record Water Temperature at 15 minute intervals and were deployed on Prairie Dog Creek. Initially, recorders were installed on sites PD1, PD2, PD5, and PD6 and PD10 to begin recording on May 1, 2007. In June 2007, a second logger was added at PD6 to verify irregular readings. SCCD determined the previous logger was, in fact, recording correctly. An additional logger was installed at the PD9 site in June of 2007. In 2008, temperature loggers were redeployed at all of the sites used in 2007 and began recording on April 1. The logger at site PD9 was lost sometime between June and September 2008 during high flows. Because this was discovered late in the season (September 2008), SCCD decided to not redeploy a logger at that site. The logger at the PD5 site was buried in stream bottom sediment from approximately May 21 to June 18, 2008.

Water Temperature data reflected numerous exceedences of the Wyoming water quality standard for coldwater fisheries of 20^{o} C (WDEQ, 2007). The majority of the exceedences occurred at the lower Prairie Dog Creek sites, with the number of exceedences decreasing further up the watershed (Table 7-1). Sustained exceedences include those periods where the measurement did not drop below 20^{o} C, even at night. These occurred at lower stations (PD1, PD2, and PD5), typically in July and/or August.

In 2007, higher Temperatures were typically observed in late June through early August. These higher Water Temperatures correspond to the 2007 Mean Daily Air Temperatures and Normal Mean Daily Air Temperatures measured at the Sheridan County Airport by the National Weather Service (Appendix Figure C-17). A similar pattern is observed for 2008 Water and Air

Temperatures, with a small peak in May in both Water Temperature and 2007 Mean Daily Air Temperature (Appendix Figure C-18).

Table 7-1. 2007-2008 Prairie Dog Creek Watershed Water Temperature Exceedences

	2007 Temperature Exceedences			2008 Temperature Exceedences		
Site	**# of Days Exceeded**	**Percent of Days Exceeded**	**Periods of Sustained Exceedences**	**# of Days Exceeded**	**Percent of Days Exceeded**	**Periods of Sustained Exceedences**
PD1	May- 1 June- 8 July- 31 August- 23 September- 4	24.4%	6/30-7/10 7/15-7/27 7/31-8/2 8/2-8/4	May- 3 June- 15 July- 31 August- 18 September- 0	17.8%	7/4-7/7 7/22-7/27 8/8-8/11
PD2	May-0 June-11 July- 31 August- 24 September- 5	22.7%	7/1-7/4 7/16-7/18 7/18-7/20 7/24-7/26	May- 3 June- 13 July- 31 August- 24 September- 0	17.4%	7/4-7/7 7/23-7/25
PD5	May-2 June- 11 July- 31 August- 20 September- 4	17.4%	7/1-7/4 7/4-7/6	May- 1 June- 0 July- 18 August- 11 September- 0	6.9%	7/24-7/29 8/9-8/11
PD 6	May-0 June-10 July-31 August- 15 September- 4	12.5%	None	May-1 June- 0 July- 22 August- 14 September- 0	4.5%	None
PD 9	**Deployed June 28, 2007**			**Lost between June-September 2008**		
	May- N/A June- 1 July- 9 August- 1 September- 0	1.0%	None	May-0 June-0	0%	None
PD10	None	0%	None	None	0%	None

In 2007, the logger at the PD1 site recorded 18,344 measurements, of which 4,475 or 24.4% were greater than 20^o C. Sustained exceedences of the standard, when the Water Temperature did not drop below 20^o C for more than 24 hours, were recorded on four instances in 2007; June 30-July 10, July 15-July 27, July 31-August 2, and August 2-August 4. In 2008, the logger at the PD1 site recorded 20,069 measurements, including 3,571 readings in excess of 20^o C, or 17.8% of the total Temperature records. Sustained exceedences of the standard were recorded at three periods in 2008; July 4-July 7, July 22-July 27, and August 8-August 11.

The logger at the PD2 site recorded 18,345 measurements in 2007, of which 4,166 recorded Water Temperatures greater than 20^o C, equaling 22.7% of the total readings. Sustained exceedences were recorded at four intervals in 2007; July 1-4, July 16-18, July 18-20, and July 24-26. In 2008, the PD2 logger recorded 20,071 Water Temperature readings, with 3,493 or 17.4% in excess of 20^o C. Sustained exceedences were recorded over two periods in 2008; July 4-7, and July 23-25.

The PD5 logger recorded 18,352 measurements in 2007, of which 3,202 were greater than 20^o C, equaling 17.4%. Sustained exceedences were recorded at two periods in 2007; July 1-4, and July 4-6. In 2008, the PD5 logger recorded 20,073 readings, including 1,377 or 6.9% in excess of 20^o C. Sustained exceedences were recorded at two intervals in 2008; July 24-29, and August 9-11.

The logger deployed at site PD6 recorded 18,355 measurements in 2007, of which 2,298 or 12.5% were greater than 20^o C. In 2008, the PD6 logger recorded 20,076 measurements, including 911 with Water Temperatures greater than 20^o C, equivalent to 4.5% of the total number of readings. No sustained exceedences of were recorded at the PD6 site in 2007 or 2008.

The PD9 logger recorded 12,776 measurements in 2007, including 128 greater than 20^o C, or 1.0% of the total readings. In 2008, the PD9 logger was lost when the retaining cable broke during a high water period sometime after June 16. Thus, only 7,292 measurements were retrieved prior to the loss of the logger. These readings were early (April-June) in the year and there were no Temperature readings in excess of 20^o C. No sustained standard exceedences were recorded at the PD9 site in either 2007 or 2008 (prior to June 16).

The logger deployed at the PD10 sample site recorded 18,363 measurements in 2007, none of which exceeded 20^o C. In 2008, the logger recorded 20,143 measurements, with no Temperatures greater than 20^o C. Correspondingly, there were no sustained exceedances in either year.

7.3 *E. COLI* BACTERIA

E. coli samples were taken over seven 30 day periods in 2007 and 2008. Geometric means were calculated for each 5 sample-30 day period (Table 7-2). All sampled sites had at least one 30 day geometric mean that exceeded the Wyoming water quality standard of 126 colony forming units (cfu) per 100 mL (WDEQ, 2007), except the Piney Creek/Prairie Dog Ditch Diversion (PD11) site in Story. Overall, *E. coli* geometric means were highest during July and August when air temperatures were highest. April 2008 resulted in the lowest geometric means at all sites, with the exception of Meade Creek (PD7) and Prairie Dog Creek below Jenks Creek (PD9). This could be attributed to lower water temperatures than later in the season.

While there was much variability in the *E. coli* geometric means both between sample sites and between 30-day geometric mean sample periods, the highest geometric means for each sample period were generally recorded in the middle areas of the watershed. Geometric means for the sample sites in the lower areas of Prairie Dog Creek typically had higher geometric means than those sites in the upper reaches of the watershed (Figures 7-1 and 7-2). Four of the seven 30 day sample periods showed the highest geometric mean values at the sample sites in the middle reaches of Prairie Dog Creek. The PD10 Prairie Dog Creek site had the greatest number of 30 day geometric means below 126 cfu/100 mL.

Table 7-2. 2007-2008 Prairie Dog Creek Watershed *E. Coli* Geometric Means

Site	2007 May 7-June 5	2007 July 11-August 8	2007 August 22-September 20	2008 April 2-April 30	2008 May 15-June 10	2008 July 15-Aug. 13	2008 Sept. 18-Oct. 15
Mainstem Sites							
PD1	746.3	299.4	190.1	7.6	178.0	799.4	213.1
PD2	775.5	467.7	174.3	30.5	224.3	625.7	217.6
PD3A				27.3	227.0	743.2	256.4
PD5	486.5	429.9	165.8	41.7	237.5	664.9	133.8
PD5A				134.9	565.2	781.4	270.6
PD6	563.3	449.2	639.1	35.5	673.3	505.0	451.5
PD7A				252.2	661.6	381.7	192.5
PD8	156.4	350.9	527.7	28.9	337.3	357.4	107.0
PD9	444.7	184.5	163.7	641.6	153.6	235.8	110.6
PD10	51.5	236.1	196.3	2.9	21.4	363.0	47.6
Tributary Sites							
PD3	192.9	85.4	42.7	29.1	338.0	533.1	70.7
PD4	237.1	495.4	380.0	13.5	148.0	737.3	228.6
PD7	1411.1	469.4	326.6	1265.2	556.8	665.0	551.0
PD11	14.4	55.5	62.6	2.9	13.6	27.2	37.9

Geometric means at the sampled tributary sites were mixed in comparison to those of the nearby mainstem Prairie Dog Creek sites, with geometric means being either higher or lower than the nearby mainstem sample sites (Figure 7-3 and 7-4). Dutch Creek (PD3) returned the lowest geometric means of any tributary sample site, with four of seven 30 day geometric means below 126 cfu/100mL. The Piney Creek/Prairie Dog Ditch Diversion (PD11) had the lowest 30 day geometric means of any sampled site, with no geometric means exceeding Wyoming water quality standards.

Figure 7-1. 2007 Prairie Dog Creek Mainstem *E. Coli* Geometric Means

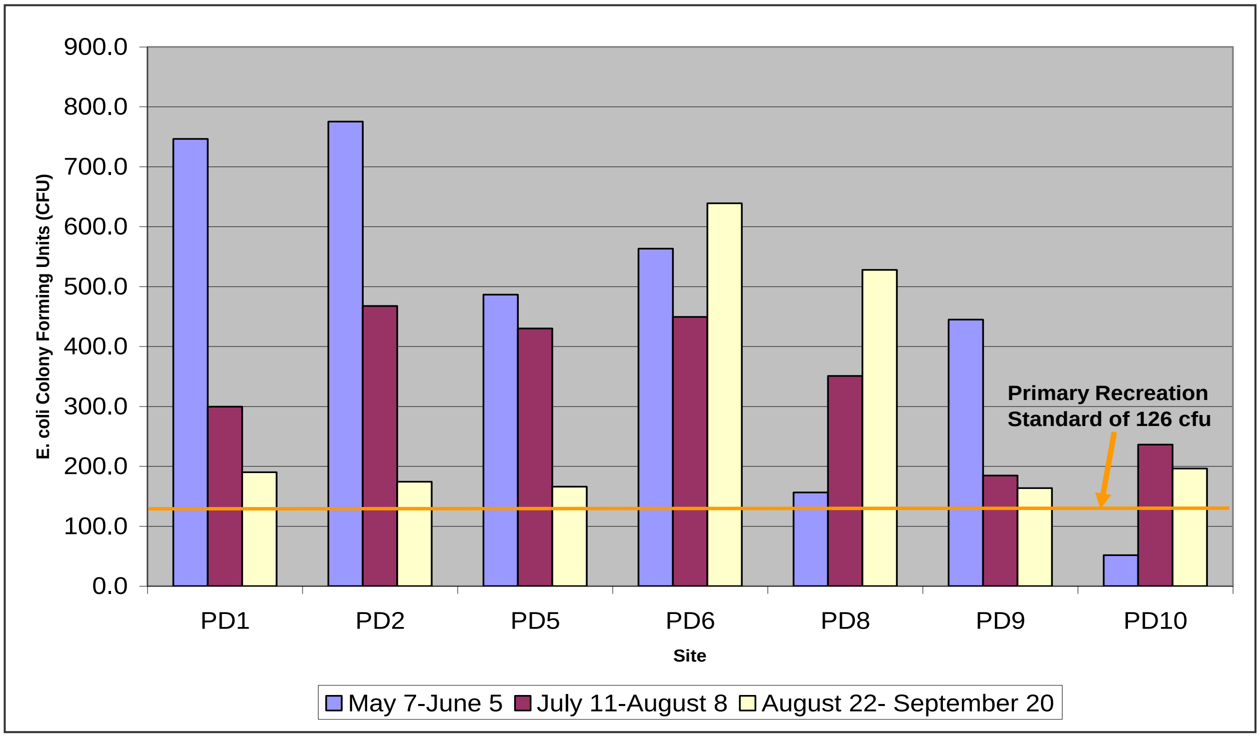


Figure 7-2. 2008 Prairie Dog Creek Mainstem *E. Coli* Geometric Means

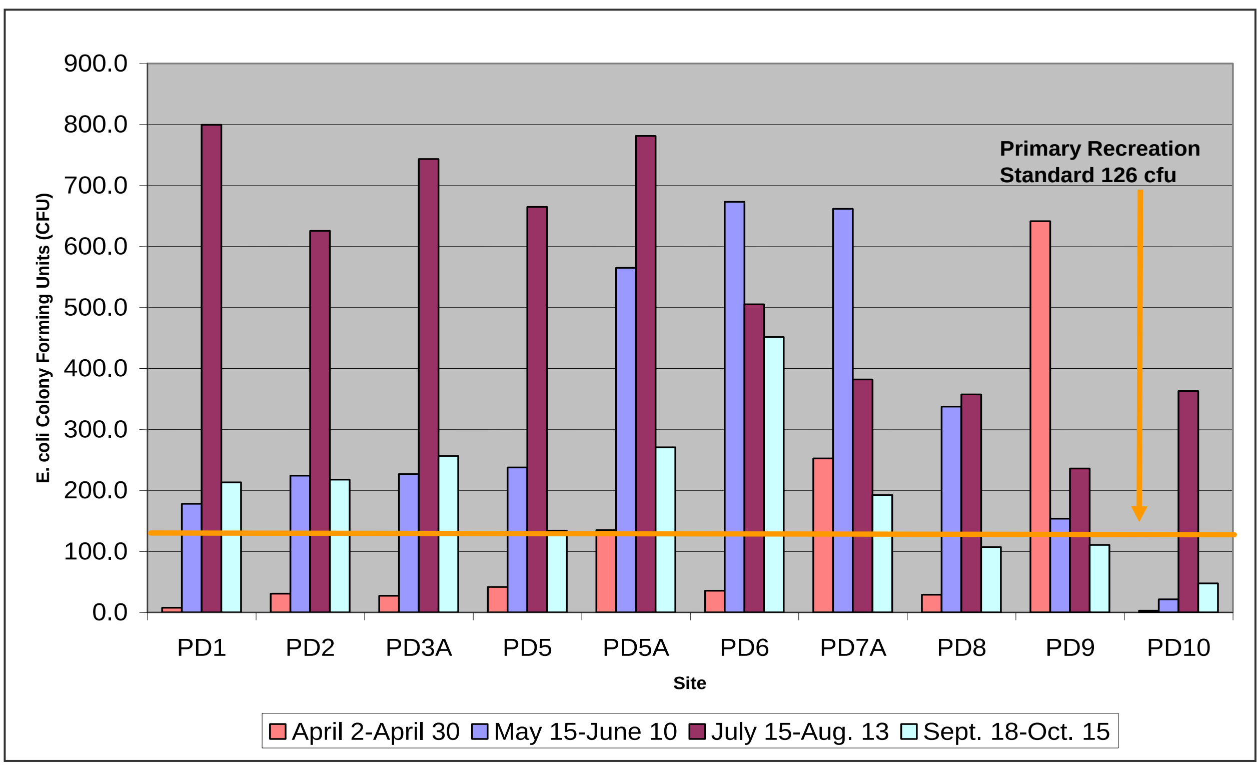


Figure 7-3. 2007 Prairie Dog Creek Tributary *E. Coli* Geometric Means

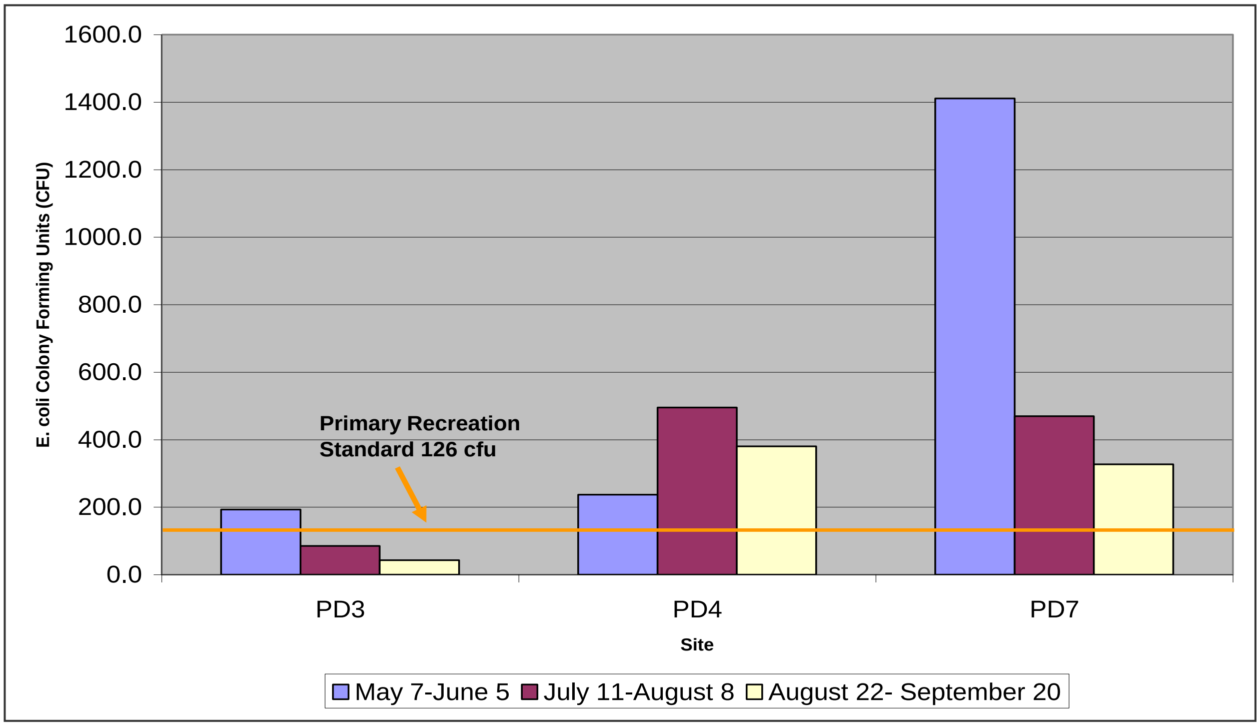
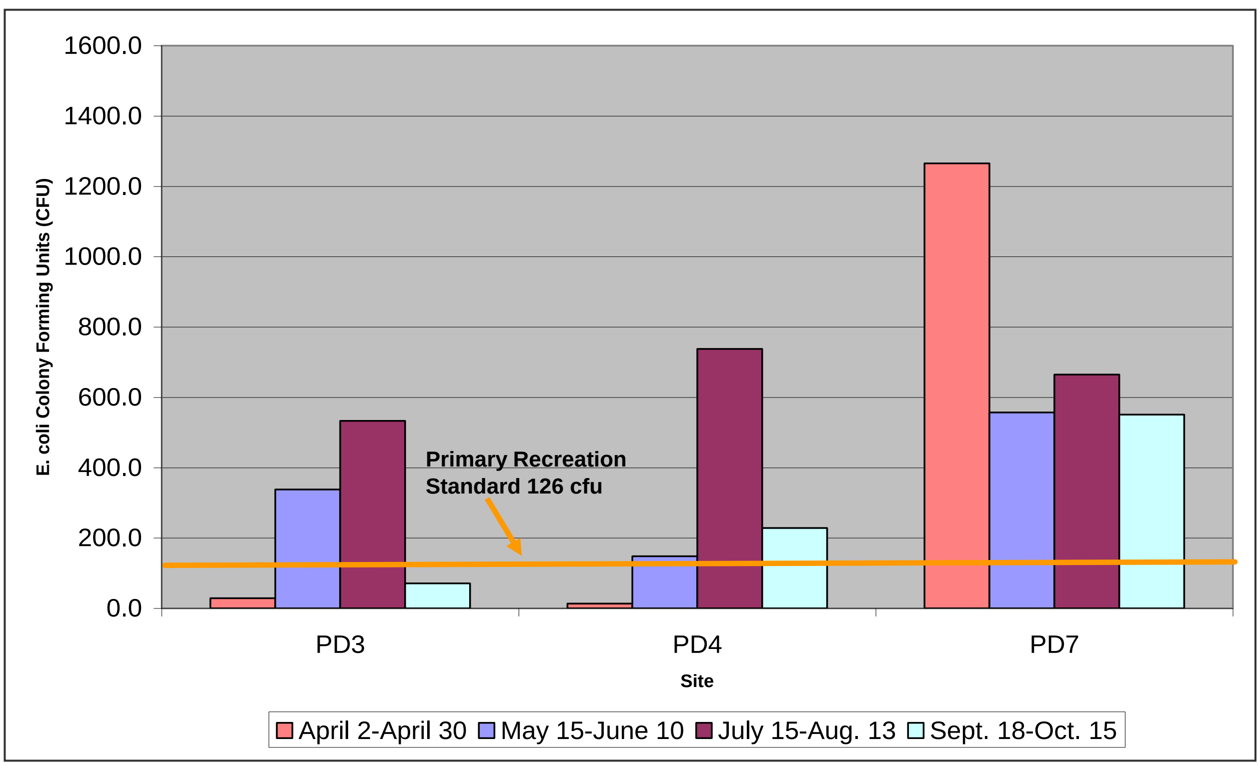


Figure 7-4. 2008 Prairie Dog Creek Tributary *E. Coli* Geometric Means



7.4 pH

All observed instantaneous pH values were within expected values (Appendix Tables C-3 through C-16). Generally, the observed instantaneous pH values measured on the Prairie Dog Creek mainstem showed little variability, only ranging from 7.67 to 8.51 SU. The sampled Prairie Dog Creek tributary sites also showed little variability in observed instantaneous pH values, though the values were slightly lower than those of the Prairie Dog Creek mainstem, ranging from 7.46 to 8.33 SU.

The maximum pH value observed was 8.83 SU at the PD11 Piney Creek/Prairie Dog Ditch Diversion flume in Story during 2008, which lies outside the Prairie Dog Creek watershed but is the source of significant flow augmentation in the form of a trans-basin irrigation diversion. This site also had the lowest instantaneous pH value of 7.10 SU, which was observed on two dates in 2008. The highest instantaneous pH measurement on Prairie Dog Creek was 8.51 SU below the mouth of Murphy Gulch (PD8) in 2007. The lowest instantaneous pH reading on Prairie Dog Creek was 7.67 SU, measured above Jenks Creek (PD10) in 2007. Of the sampled tributaries, the highest instantaneous pH measurement was 8.33 SU on Meade Creek (PD7) during 2007. The lowest instantaneous pH on a sampled tributary was 7.46 SU on Dutch Creek (PD3) in 2007.

7.5 SPECIFIC CONDUCTIVITY

Specific Conductivity values increased from upstream sites to downstream sites (Appendix Tables C-3 through C-16). The highest Specific Conductivity of 4800 µmhos/cm was observed in 2007 on Dutch Creek (PD3). The lowest observed Specific Conductivity value was 32 µmhos/cm, which was measured in 2007 at the Piney Creek/Prairie Dog Ditch Diversion flume in Story (PD11). This station lies outside the Prairie Dog Creek watershed but is the source of significant flow augmentation in the form of a trans-basin irrigation diversion. The lowest observed Specific Conductivity value from within the Prairie Dog Creek watershed was 81 µmhos/cm on Prairie Dog Creek below Jenks Creek (PD9) in 2007.

Specific Conductivity measurements within the Prairie Dog Creek watershed are likely influenced both upward and downward by activities inside and outside the watershed. Specific Conductivity may be influenced downward by the water from the Piney Creek/Prairie Dog Ditch trans-basin diversion that through Jenks Creek into Prairie Dog Creek. The water coming from the Piney Creek/Prairie Dog Ditch diversion was generally of low Specific Conductivity, with a maximum of 162 µmhos/cm recorded in 2008 and a minimum of 32 µmhos/cm in 2007. Conversely, Specific Conductivity is likely influenced upward by the addition of dissolved minerals and other solids as water moves down the watershed.

The observed Specific Conductivity on Prairie Dog Creek increased from upstream to downstream with the highest Specific Conductivity observed above the confluence with Tongue River (PD1) at 2140 µmhos/cm in 2007. The lowest Specific Conductivity on Prairie Dog Creek was 81µmhos/cm observed below the mouth of Jenks Creek (PD9) in 2007. This low Specific Conductivity reading may be the result of dilution from the Piney Creek trans-basin diversion water which had low observed Specific Conductivity. The Prairie Dog Creek site upstream of the Jenks Creek confluence (PD10) site had a minimum observed Specific Conductivity of 207 µmhos/cm recorded in 2008.

The sampled tributaries had Specific Conductivity values that were generally higher than those of the mainstem Prairie Dog Creek sites. Dutch Creek (PD3) had Specific Conductivity values that were consistently much higher than any other sample site within the watershed ranging from 1124 µmhos/cm to 4800 µmhos/cm. This may be the result of the larger drainage area and generally dryer climate of that portion of the watershed. Wildcat Creek (PD4) had Specific Conductivity values that were somewhat higher than those of Prairie Dog Creek, with values that ranged from 472 µmhos/cm to 2500 µmhos/cm. Meade Creek (PD7) also had Specific Conductivity values that were slightly higher than the nearby sites on Prairie Dog Creek with values that ranged from 374 µmhos/cm to 1141 µmhos/cm.

There is no surface water quality standard for Specific Conductivity in Wyoming. USDA (1993) identifies salt tolerance levels and irrigation water requirements for various crops, including grass and forage crops. Salt tolerance for typical crops grown in the Prairie Dog Creek watershed would range from Moderately Sensitive (~2000 µmhos/cm) to Tolerant (>5000 µmhos/cm).

7.6 DISSOLVED OXYGEN (DO)

Overall, observed instantaneous DO concentrations were relatively consistent for all sites, with lowest and highest concentrations being similar among sample sites (Appendix Tables C-3 through C-16). With the exception of Dutch Creek (PD3), all sites met the minimum instantaneous DO concentration standard of 5.0 mg/L for early life stages and in most cases, the 8.0 mg/L water column concentration recommended to achieve the 5.0 mg/L intergravel concentrations (WDEQ, 2007). As a class 3B stream, Dutch Creek is not protected for fish populations, and the DO standard does not apply.

The lowest observed instantaneous DO concentration was 3.6 mg/L on Dutch Creek (PD3) in 2007. The highest observed instantaneous DO concentration was 16.9 mg/L, recorded in 2008, on Wildcat Creek (PD4). DO concentrations on Prairie Dog Creek ranged from 6.0 mg/L (PD2) to 15.7 mg/L (PD5).

7.7 TURBIDITY

Turbidity values ranged widely throughout the watershed, though observed highest and lowest values generally increase from upstream to downstream (Appendix Tables C-3 through C-16). The highest Turbidity value was 709 NTU observed in 2007 on Prairie Dog Creek above the Tongue River confluence (PD1). The lowest value was 0.4 NTU observed on Prairie Dog Creek above the confluence with Jenks Creek (PD10) in 2008.

Turbidity values on sampled tributaries were somewhat lower than the values on Prairie Dog Creek. The highest and lowest Turbidity values on the sampled tributaries were observed on Meade Creek (PD7), at 221.0 NTU and 1.9 NTU, respectively. Turbidity values on Dutch Creek

(PD3) ranged from 2.2 NTU and 22.2 NTU. Wildcat Creek (PD4) Turbidity values ranged from 4.0 NTU to 46.2 NTU.

It is not possible to make a determination of whether waters in the Prairie Dog Creek watershed meet the standard because there were no documented discharges or disturbance activities that would increase Turbidity. Data from the PDWA could be used as a baseline for future determinations of whether streams within the Prairie Dog Creek watershed are meeting narrative water quality standards. Narrative standards would only apply to Prairie Dog Creek, Meade Creek, and Jenks Creek, as the other tributaries are classified as Class 3B waterbodies.

7.8 TOTAL SUSPENDED SOLIDS (TSS)

TSS varied widely during the project (Appendix Tables C-3 through C-16). Values ranged from undetectable levels, <5mg/L, recorded on at least one sample date at half of the sample sites, to 354 mg/L, which was recorded in 2008 on Prairie Dog Creek above the Meade Creek confluence (PD7A).

The highest observed TSS values of the sampled tributaries were generally lower than those of the Prairie Dog Creek mainstem, which is likely a result of the greater flow volume of the Prairie Dog Creek mainstem and the corresponding capacity to suspend solids within the water column. Additional water from trans-basin diversions into Prairie Dog Creek and the associated bank instability may also contribute to a higher sediment load in the water column.   Sampled tributaries had a range of TSS values that were fairly similar despite the differences in position within the watershed and flow characteristics. The highest observed TSS value on the sampled tributaries was 50 mg/L recorded on Wildcat Creek (PD4) in 2007 and on Meade Creek (PD7) in 2008. The highest observed TSS value on Dutch Creek (PD3) was 23 mg/L, recorded in 2008. The lowest observed TSS value on all of the sampled tributaries was <5 mg/L.

As with Turbidity, there is no definitive way to determine whether streams in the Prairie Dog Creek watershed met the narrative standards related to TSS because no discharges or activities increasing the potential load of suspended solids were documented.

7.9 TOTAL HARDNESS

Values for Total Hardness generally increased from upstream sites to downstream sites (Appendix Tables C-3 through C-16). This is expected for streams flowing through geologic substrates containing carbonate minerals. Recorded Total Hardness values ranged from soft to very hard (see Table 5-2). The lowest observed value for Total Hardness was 21 mg/L, recorded in 2008 at the Piney Creek/Prairie Dog Ditch Diversion flume site in Story (PD11). The highest observed total hardness value was 1990 mg/L recorded in 2008 on Dutch Creek (PD3).

The lowest observed Total Hardness value was 46 mg/L, recorded in 2008 on Prairie Dog Creek below the Jenks Creek confluence (PD9). This low value may be a result of the addition of water from the Piney Creek/Prairie Dog Ditch trans-basin diversion through Jenks Creek. The lowest value from above the Jenks Creek confluence (PD10) was 137 mg/L in 2007. The highest observed Total Hardness value on Prairie Dog Creek site was 881 mg/L just above the Tongue

River confluence (PD1). This is consistent with the trend that Total Hardness increases downstream as the stream flows over substrates containing carbonates.

Overall, Total Hardness values on the sampled tributaries were higher than on Prairie Dog Creek. The highest observed Total Hardness value was recorded in 2008 on Dutch Creek (PD3) at 1990 mg/L. The highest observed Total Hardness value on Wildcat Creek (PD4) was 1210 mg/L, recorded in 2008. Total Hardness values on Meade Creek (PD7) were closer to those of the Prairie Dog Creek sites, with a highest observed Total Hardness of 548 mg/L recorded in 2007. The lowest observed Total Hardness on the sampled tributaries was 185 mg/L, recorded on Meade Creek (PD7) in 2008.

WDEQ has not established water quality standards for Total Hardness, though specific uses may have associated requirements (see Table 5-1). There is no indication that Total Hardness is adversely affecting designated uses of the sampled waterbodies within the Prairie Dog Creek watershed.

7.10 TOTAL ALKALINITY (AS $CaCO_3$)

Total Alkalinity values varied somewhat among sample sites within the Prairie Dog Creek watershed (Appendix Tables C-3 through C-16). The lowest observed values were generally in the upper reaches of the watershed, while sites in the lower portions of the watershed had somewhat higher values for Total Alkalinity.

The highest observed Total Alkalinity value was 594 mg/L, recorded on Dutch Creek (PD3) in 2007. On Prairie Dog Creek, the highest Total Alkalinity of 378 mg/L was observed in 2007 above the Tongue River confluence (PD1). The lowest Total Alkalinity value of 25 mg/L was observed at the Piney Creek/Prairie Dog Ditch Diversion flume in Story (PD11) in 2008. The lowest observed value from within the Prairie Dog Creek watershed was 50 mg/L, recorded in 2008 on Prairie Dog Creek below the Jenks Creek confluence (PD9). This may be the result of the diluting effects from the addition of water from the Piney Creek/Prairie Dog Ditch Diversion. The lowest observed value from Prairie Dog Creek above the Jenks Creek confluence (PD10) was 138 mg/L.

Total Alkalinity values on the sampled tributaries were generally higher than those on Prairie Dog Creek. Wildcat Creek (PD4) had the lowest observed Total Alkalinity on a sampled tributary at 150 mg/L. Dutch Creek (PD3) consistently had the highest Total Alkalinity values of any sample site, with the highest observed Total Alkalinity at 594 mg/L.

All of the sample sites on Prairie Dog Creek were within the 400 mg/L maximum recommended for human health and the 20 mg/L minimum recommended for productive aquatic life (USEPA, 1986).

Meade Creek (PD7) had a value of 404 mg/L, measured on a single occasion in 2007. Dutch Creek (PD3) returned only one value below 400 mg/L. However, there is no indication that Total Alkalinity in the sampled waterbodies was adversely affecting their designated uses.

7.11 SODIUM ADSORPTION RATIO (SAR)

SAR values were generally low, with a few exceptions (Appendix Tables C-3 through C-16). The majority of the sample sites had a highest observed SAR value less than 1.0, and all sites except one had a highest observed SAR value less than 3.0. The lowest observed SAR values were <0.1, recorded in both 2007 and 2008 on Prairie Dog Creek above the Jenks Creek confluence (PD10) and the Piney Creek/Prairie Dog Ditch Diversion flume (PD11). Prairie Dog Creek had a highest observed SAR value of 2.6, recorded in 2007 on Prairie Dog Creek above the Tongue River confluence (PD1).

Dutch Creek had SAR values that were consistently higher than the other sample sites, with the lowest observed SAR value at the site being 1.7 recorded in 2007. The highest observed SAR value of 5.1 was also recorded on Dutch Creek (PD3) in 2008. The other sampled tributaries had SAR values that were closer to those of the Prairie Dog Creek sites, though Wildcat Creek (PD4) had slightly higher SAR values than the nearby Prairie Dog Creek sites.

All of the SAR values reported in the Prairie Dog Creek watershed were within the USEPA (1986) recommended tolerance levels of 8-18 for general crops and forage. That being said, it is important to consider specific soil and water conditions of an area. While there was no indication that designated uses were adversely affected by SAR, there is not enough site specific information to make any definitive determinations.

7.12 TOTAL CHLORIDE

Total Chloride concentrations were quite low at all sample sites, with the highest observed total chloride concentration being 13 mg/L, recorded on Dutch Creek (PD3) in 2008 (Appendix Tables C-3 through C-16). The lowest observed Total Chloride value was <1mg/L, recorded at approximately half the sample sites on at least one occasion. Generally, Total Chloride levels increased from upstream to downstream sample sites. Sites on Prairie Dog Creek had values that ranges from <1.0 mg/L to 5 mg/L.

The sampled tributaries had higher Total Chloride levels than the mainstem Prairie Dog Creek sites ranging from 1.0 mg/L to 13 mg/L. Wildcat Creek (PD4) and Meade Creek (PD7) had Total Chloride values only marginally higher than the nearby Prairie Dog Creek sites, with values ranging from 1.0 mg/L to 6.0 mg/L. Dutch Creek (PD3) had Total Chloride levels that ranged from 2.0 mg/L to 13 mg/L, with only two of the values below 5 mg/L.

Total Chloride levels on Prairie Dog Creek and sampled tributaries were well below the Wyoming water quality standard of 860 mg/L (WDEQ, 2007). In addition, values were lower than Wyoming groundwater standards of 250 mg/L for domestic use, 100 mg/L for agricultural/irrigation water, and 2000 mg/L for livestock use (WDEQ, 2005).

7.13 NITRITE-NITRATE NITROGEN

Generally, Nitrite-Nitrate Nitrogen levels were quite low, with nearly all sample sites having at least one sample at <0.05 mg/L. The highest observed Nitrite-Nitrate Nitrogen concentration of

1.93 mg/L was recorded on the Prairie Dog Creek PD2 site in 2007. This concentration was almost three times higher than the next highest observed Nitrite-Nitrate Nitrogen level of 0.74 mg/L recorded in 2007 on Meade Creek (PD7).

Wildcat Creek (PD4) and Meade Creek (PD7) had Nitrite-Nitrate Nitrogen levels that were somewhat higher than the nearby Prairie Dog Creek mainstem sites. Dutch Creek (PD3) was the only site to never have a detectable concentration of Nitrite-Nitrate Nitrogen, with all samples <0.05 mg/L.

All samples from the Prairie Dog Creek watershed were within 10mg/L, the Wyoming water quality standard for Nitrite-Nitrate Nitrogen for Class 1, 2ab, and 2a waterbodies (WDEQ, 2007). Despite this, Nitrite-Nitrate Nitrogen concentrations in the Prairie Dog Creek watershed may be of interest as a nutrient that is frequently associated with nonpoint source pollution.

7.14 TOTAL SULFATE

Total Sulfate concentrations varied widely throughout the watershed and increased from upstream to downstream (Appendix Tables C-3 through C-16). The lowest Total Sulfate concentration was 1 mg/L, observed at the Piney Creek/Prairie Dog Ditch Diversion flume in Story (PD11). This was lower than the lowest observed value from within the Prairie Dog Creek watershed of 4 mg/L, observed on Prairie Dog Creek above and below the Jenks Creek confluence (PD9 and PD10). The highest observed Total Sulfate value on Prairie Dog Creek of 819 mg/L was recorded above the confluence with Tongue River (PD1).

The highest observed Total Sulfate in the watershed was on Dutch Creek (PD3) at 2500 mg/L. With the exception of one value reported at 502 mg/L, values on Dutch Creek ranged between 1580 and 2500 mg/L. On Wildcat Creek (PD4), the highest observed Total Sulfate concentration was 1050 mg/L; remaining values ranged from 100 to 739 mg/L. Meade Creek (PD7) had the lowest Total Sulfate levels of any of the sampled tributaries, though the levels were higher than the nearby Prairie Dog Creek sites. Total Sulfate levels on Meade Creek ranged from 45 to 249 mg/L.

Wyoming does not have established surface water quality standards for Total Sulfate. However, Total Sulfate values on the lower Prairie Dog Creek sites (PD1 and PD2) approached or exceeded the USEPA (2006) secondary drinking water standard of 250 mg/L and Wyoming groundwater standards for domestic and agricultural use, which are 250 mg/L and 200 mg/L, respectively (WDEQ, 2005). For the most part, other Prairie Dog Creek sites and Meade Creek were within 200 mg/L. Dutch Creek (PD3) and Wildcat Creek (PD4) had Total Sulfate values that approached or exceeded 250 mg/L; Dutch Creek values also approached the groundwater standards for livestock use of 3000 mg/L. While not truly applicable, these standards suggest that Dutch Creek, Wildcat Creek, and lower Prairie Dog Creek have total sulfate concentrations may be of some concern. It is entirely unknown whether theses Total Sulfate concentrations are naturally occurring, anthropogenic, or a combination thereof. Lower and Middle portions of Prairie Dog Creek (PD1, PD2, PD3A, PD5, PD5A), Dutch Creek, and Wildcat Creek Total Sulfate values also exceed the 150 mg/L shown to be optimal for Macroinvertebrate communities. It is unknown whether total sulfate concentrations in the Prairie Dog Creek watershed are adversely affecting macroinvertebrate populations and other aquatic life.

7.15 DISSOLVED MANGANESE

Dissolved Manganese concentrations were between <0.02 mg/L to 1.84 mg/L (Appendix Tables C-3 through C-16). The highest observed Dissolved Manganese concentration on Prairie Dog Creek was 0.07 mg/L, recorded in 2007 above the Tongue River confluence (PD1).

The sampled tributaries had variable Dissolved Manganese concentrations. Meade Creek (PD7) had Dissolved Manganese values ranging from <0.02 mg/L to 0.08 mg/L. Dissolved Manganese concentrations were slightly higher on Wildcat Creek, ranging from 0.03 to 0.53 mg/L. Dutch Creek had the highest observed concentrations of Dissolved Manganese on the watershed, with 1.84 mg/L recorded in 2007. The lowest observed Dissolved Manganese concentration on Dutch Creek (PD3) was 0.06 mg/L.

All samples on Dutch Creek (PD3) exceeded Wyoming water quality standards for Manganese, for the protection of fish and drinking water, which is 0.05 mg/L (WDEQ, 2007). Occasional exceedences were recorded on the lower Prairie Dog Creek sites (PD1 and PD2) and on Wildcat Creek (PD4) and Meade Creek (PD7). There were no exceedences of the 3.11 mg/L standard set for the protection of other aquatic life (WDEQ, 2007). The source of the Manganese concentrations in the Prairie Dog Creek watershed is expected to be natural geologic formations.

7.16 TOTAL PHOSPHORUS

Total Phosphorus concentrations showed little variability throughout the Prairie Dog Creek watershed (Appendix Tables C-3 through C-16). Total Phosphorous values observed on Prairie Dog Creek were between <0.1 to 0.4 mg/L; tributary values ranged from <0.1-0.3 mg/L. All values for Prairie Dog Creek above Jenks Creek and the Piney Creek/Prairie Dog Ditch Diversion flume were <0.01 mg/L. The highest Total Phosphorus concentrations of 0.4 mg/L were recorded on Prairie Dog Creek above the Meade Creek confluence (PD7A) and twice on Prairie Dog Creek below the Murphy Gulch confluence (PD8). All of the samples collected from Meade Creek (PD7) had Total Phosphorous levels <0.1 mg/L. With the exception of one value reported as 0.1 mg/L, all of the values on Wildcat Creek (PD4) were also <0.1 mg/L. Dutch Creek (PD3) had one value of 0.3 mg/L; the remaining values were 0.1 or <0.1 mg/L.

While Wyoming has not established surface water quality standards for Total Phosphorus, there were occasions where the recommended target level of <0.01 mg/L for streams that do not directly enter lakes or reservoirs was exceeded (Mackenthun, 1973). Additionally, Total Phosphorus concentrations in the Prairie Dog Creek watershed may be of interest as a nutrient frequently associated with nonpoint source pollution.

7.17 PESTICIDES/HERBICIDES

SCCD sampled for commonly used pesticides/herbicides on two sites in September 2007 and July of 2008 (Appendix Table C-17). The sampled pesticides/herbicides included: 2,4-D, Clopyralid, Dicama, Picloram, Triclopyr, and Carbofuran on sites PD2 and PD6. All of the samples were below the detection thresholds, although no results were reported by the lab for Carbofuran in 2008.

7.18 DISCHARGE

With the exception of site PD1 and PD11, the SCCD installed and used calibrated staff gauges to determine discharge at all sampling events (Appendix Tables C-3 through C-16). SCCD used real-time data from USGS station 06306250 (Prairie Dog Near Acme) for stage and discharge information at site PD1 and calculated discharge based on height and flume width for PD11.

On May 7 of 2007, discharge was very high at most sites (Figures 7-5 and 7-6). The USGS station reported a discharge of 351 cfs; staff gauge heights at sites PD2-PD8 were either submerged or outside of the calibrated range. While discharge was also high on the upper portions of the watershed, PD9 and PD10, it was not as pronounced. Discharges could not be calculated for Dutch Creek and Meade Creek. The gauge height at Meade Creek was outside of the calibrated range. Dutch Creek was inaccessible due to flood flows over a Prairie Dog Creek bridge crossing, which made it impossible to access the site. Discharge on Wildcat Creek (PD4) was somewhat higher than other parts of the year, but not as much so. These high discharges correspond to heavy precipitation recorded by the National Weather Service at the Sheridan County Airport (Appendix Figure C-15). Another precipitation even in late May-early June of 2007, resulted in a peak in Discharge at all stations, with the exception of Wildcat Creek (PD4).

Discharge in 2008 was somewhat different than in 2007 (Figures 7-7 and 7-8); high Discharges were not observed until early June. With the exception of PD10, all Prairie Dog Creek and tributary sites had a peak discharge in early June. This corresponds to an increase in precipitation measured at the Sheridan County airport by the National Weather Service (Appendix Figure C-16).

Figure 7-5. 2007 Prairie Dog Creek Discharge

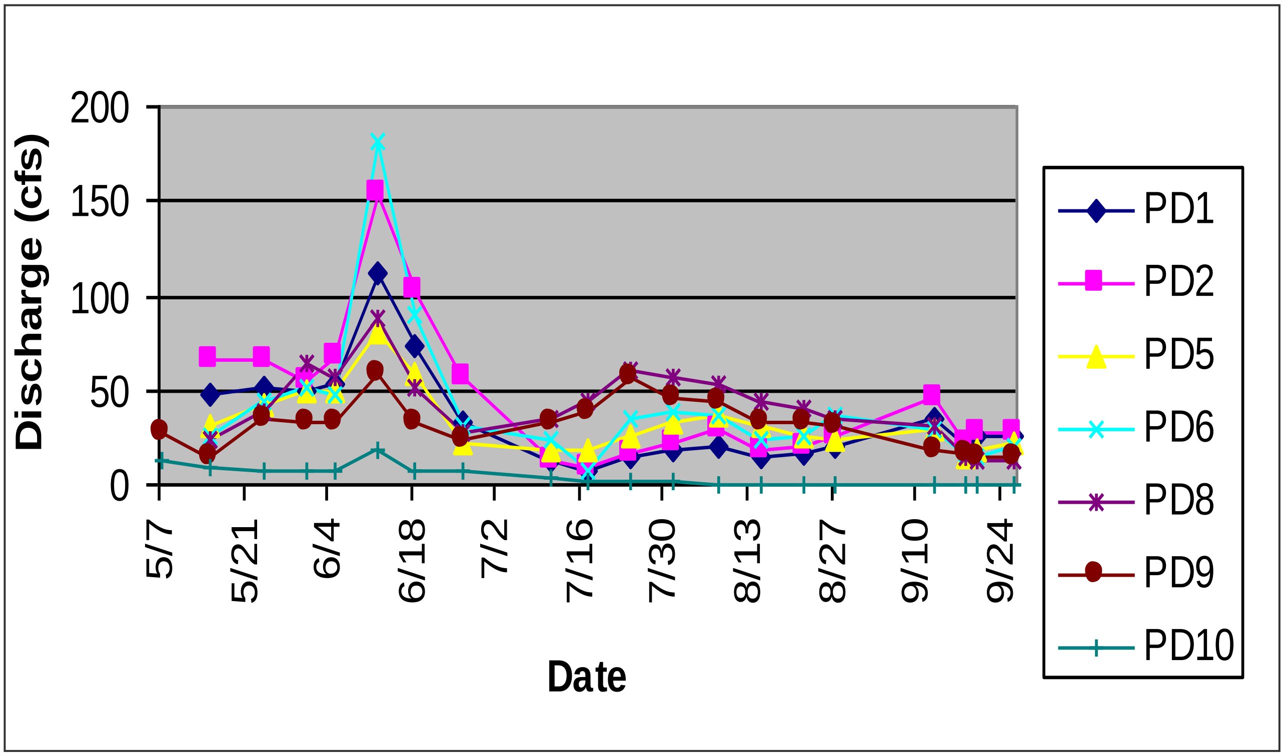


Figure 7-6. 2007 Tributary Discharge

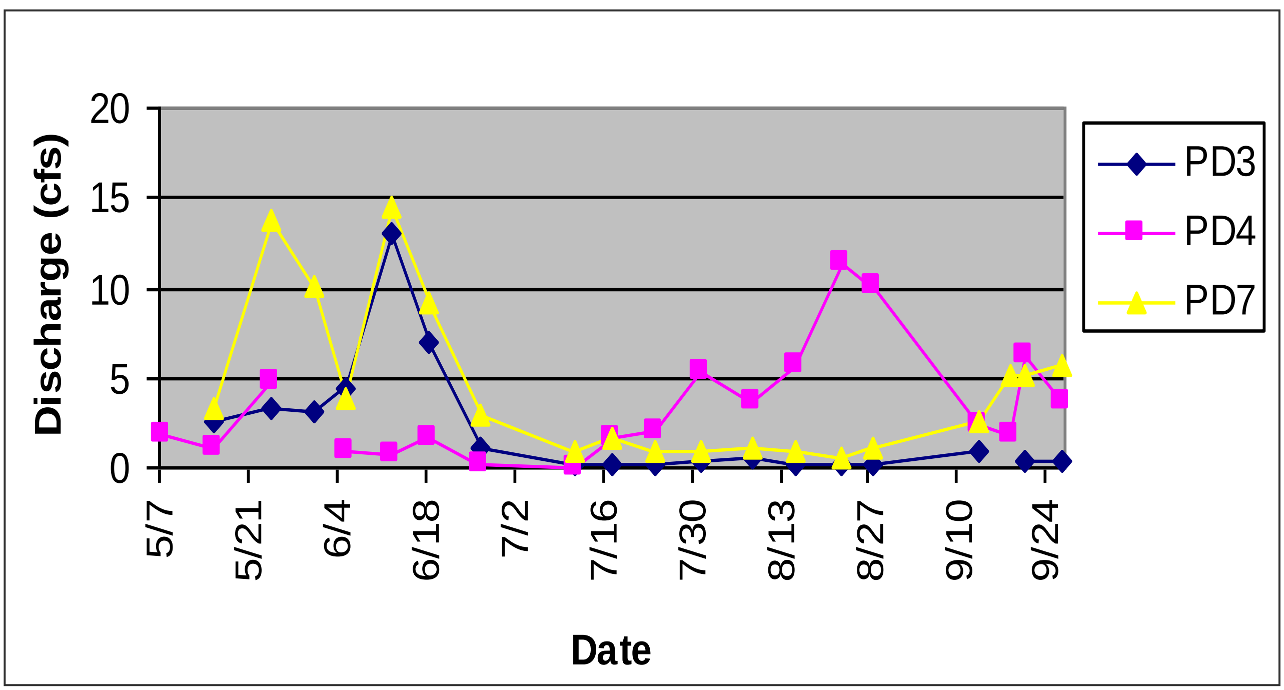


Figure 7-7. 2008 Prairie Dog Creek Discharge

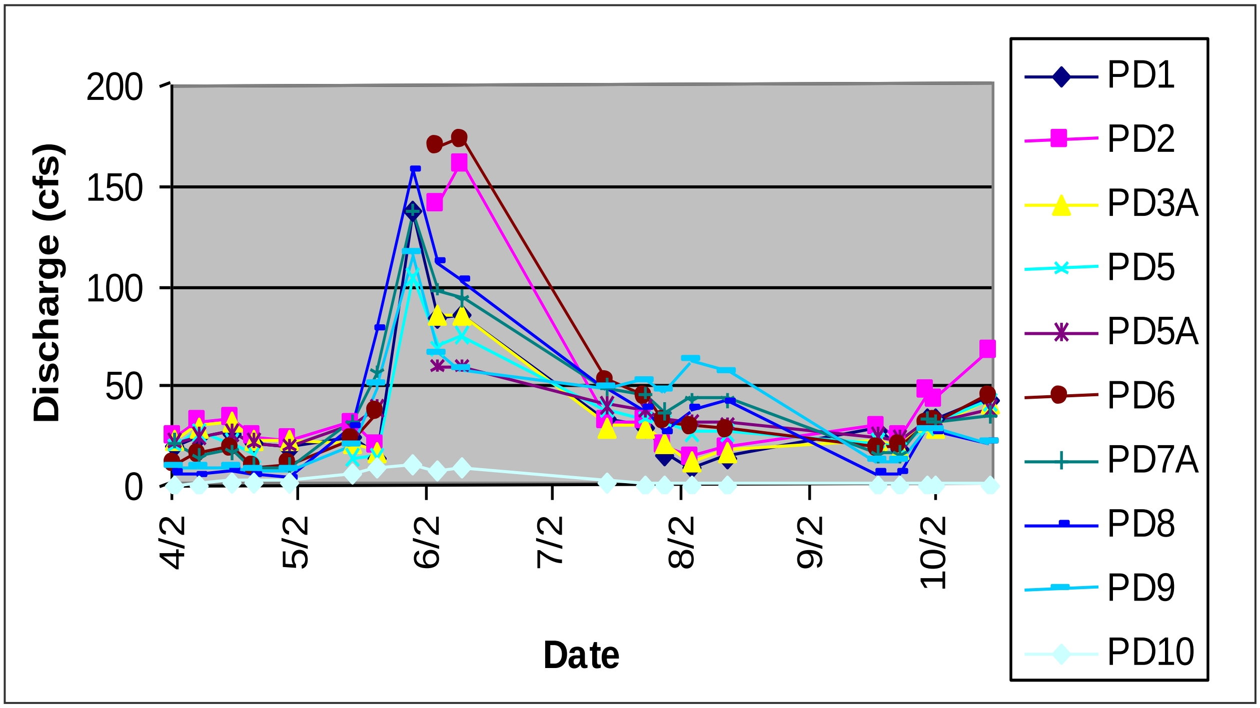
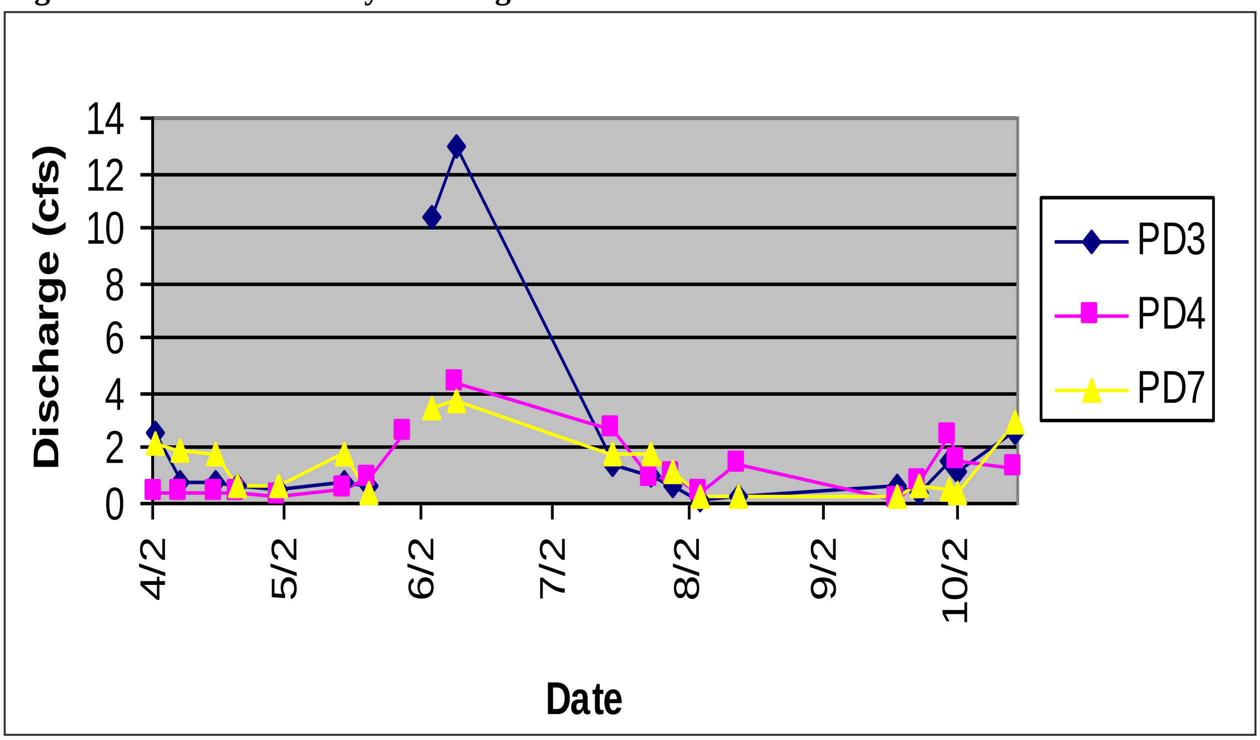


Figure 7-8. 2008 Tributary Discharge



7.19 BENTHIC MACROINVERTEBRATES

A total of six (N = 6) benthic macroinvertebrate samples were collected each year during October 2007 and October 2008 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. The duplicate sample was used for QA/QC purposes, construction of taxa lists and for general discussion of macroinvertebrate results. The duplicate sample was not used for the determination of biological condition. No benthic macroinvertebrate samples were collected from tributaries to Prairie Dog Creek.

Several monitoring groups have collected benthic macroinvertebrate samples in the Prairie Dog Creek watershed since 1977. Table 7-3 lists the sampling group, station name and location of the sampling station for all known benthic macroinvertebrate samples collected in the Prairie Dog Creek watershed. 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 PD1 during 1977, 2005 and 2006. Bureau of Land Management (BLM) collected a total of four (N = 4) samples from two stations in 2004. The two BLM stations were identified as Upper and Lower. The BLM – Lower station was located near the current SCCD sample station PD1, and the Upper station was located near the current SCCD sample station PD6. WDEQ has monitored the watershed intermittently since 1992 and has collected the most benthic macroinvertebrate samples (N = 20) from thirteen different stations. WDEQ monitored both Prairie Dog Creek mainstem stations and tributaries including Jenks Creek and Meade Creek.

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 was 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.

Taxa lists for all historic and current benthic macroinvertebrate samples collected in the Prairie Dog Creek watershed are presented in Appendix D, Tables D-1 through D-40. Table 7-3 cross-references the taxa list and the location of the sample station to the taxa summary tables in Appendix D.

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 7-4 lists the WSII metrics and metric formulae used to determine biological condition for benthic macroinvertebrate communities in the Bighorn and Wind River Foothills bioregion. The calculated biological condition value was then used to rate the biological community as Full-support, Indeterminate, or Partial/Non-support (Table 7.5). 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 7-6 and illustrated in Figure 7-9.

A total of two hundred one (N = 201) benthic macroinvertebrate taxa have been identified from streams in the Prairie Dog Creek watershed since 1977 (Appendix Table D-41). Chironomidae (midge flies) comprised the largest number of taxa (N = 46 taxa) followed by Ephemeroptera (mayflies) with thirty-two (N = 32) taxa, Trichoptera (caddisflies) with thirty (N = 30) taxa, Coleoptera (beetles) with seventeen (N = 17) taxa, and Plecoptera (stoneflies) with fifteen (N = 15) taxa.

The caddisfly genus *Hydropsyche* and caddisfly species *Brachycentrus occidentalis* occurred most frequently in samples collected in the Prairie Dog Creek watershed (Appendix Table D-41). *Hydropsyche* occurred in 93 percent of the samples collected since 1977, and in 75 percent of samples collected by SCCD during the current study. Acari (water mites) were common in samples occurring in 80 percent of all samples collected since 1997, and in 83 percent of samples collected by SCCD during the current study. The mayfly species *Baetis tricaudatus* occurred in 68 percent of the samples collected since 1977 and in 67 percent of samples collected by SCCD.

Biological condition at the lower-most Prairie Dog Creek monitoring stations PD1, PD5 and PD 6 was Partial/Non-Support during both 2007 and 2008 (Table 7-6 and Figure 7-9). Biological condition improved and was highest at the two upper-most monitoring stations PD8 and PD10. Biological condition at PD8 was Indeterminate during 2007 and 2008. The most upstream station PD10 exhibited Indeterminate biological condition during 2007 and Full Support during 2008.

The lowest biological condition was observed at station PD5. The low biological condition was due to the absence of ephemeroptera (mayfly) taxa, plecoptera (stonefly) taxa, organisms in the scraper functional feeding group, and semi-voltine taxa (Table 7-7). There were only eight (N = 8) total macroinvertebrate taxa present at station PD5 in 2007 (Appendix Table D-12). In addition, there were only three (N = 3) and six (N = 6) total macroinvertebrate taxa present in duplicate sample 1 and duplicate sample 2, respectively, collected during 2008 (Appendix Tables D-13 and D-14). The low number of macroinvertebrate taxa appeared to be due to the dominance of sand in the stream substrate and not to poor water quality. Sand accounted for approximately 99 percent of the stream substrate at station PD5 (Table 7-8). The presence of sand in the stream channel is inversely related to benthic macroinvertebrate community production because sand is unstable and its movement produces grating and destructive action on macroinvertebrates (Chutter, 1969). Benthic macroinvertebrates cannot effectively establish themselves or successfully reproduce in a shifting sand environment. The increase in sand at station PD5 when compared to the percentage of sand at other monitoring stations indicated the occurrence of unknown disruption(s) in the watershed upstream of PD5 resulting in the increased contribution of sand to the stream channel. The cause(s) of this disturbance should be determined and corrected to prevent introductions of sand into the system.

Biological condition improved from station PD5 to station PD6, from station PD6 to station PD8, and generally from station PD8 to the most upstream station PD10 (Figure 7-9). The general improvement in biological condition from station PD5 to upstream stations PD6, PD8 and PD10 was related to the increased number of the generally pollution intolerant organisms including ephemeroptera, trichoptera, and plecoptera taxa. 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 and 1998 (Table 7-6) showed a similar trend where biological condition generally improved from downstream to upstream Prairie Dog Creek monitoring stations (Collyard, 2003).

The highest number of worm taxa and percent composition of worms to the total benthic macroinvertebrate community occurred at station PD6 in 2007 and 2008 (Appendix Tables D-18 and D-19), and at station PD10 in 2007 (Appendix Table D-10). Increase in the 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 PD 6 in 2007 (N =8) and 2008 (N = 6) and the percent contribution of worms in 2007 (16.5%) and 2008 (14.4%) 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). 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 Tubificidae comprised 7.9% of total organisms. The worm species *Aulodrilus pluriseta* was present, but in low abundance (N = 7 organisms per square meter).

The worm genus *Tubifex* was identified only at station PD6 in 2008 during the current study. *Tubifex* occurred in only 3% of macroinvertebrate samples collected in the Prairie Dog Creek watershed since 1977 (Appendix Table D-41). However, it should be noted that the frequency of occurrence for *Tubifex* is likely higher in the watershed than indicated since many sampling groups did not identify worms to the generic 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.

In summary, biological condition was Partial/Non-Support during both 2007 and 2008 at the lower-most Prairie Dog Creek monitoring stations PD1, PD5 and PD 6. This observation indicated that the aquatic communities were stressed and water quality or habitat improvements were required to restore the stream to full support for narrative aquatic life use. The dominance of sand in the stream substrate at stations PD5 and PD6 appeared to be related to the low biological condition. In addition, the benthic macroinvertebrate communities at stations PD1, PD5 and PD 6 were comprised primarily of warmer water taxa that were adapted to warmer water temperatures. The benthic macroinvertebrate community at upstream station PD8 was comprised of an admixture of both warmer water taxa and colder water taxa. Several colder water taxa including *Atherix* (snipe fly), the caddisfly genera *Glossosoma* and *Lepidostoma*, the mayfly taxa *Paraleptophlebia* and *Rhithrogena*, and the stonefly genus *Pteronarcella* disappeared from Prairie Dog Creek downstream of station PD8. This observation suggested that change in water temperature was also a likely factor related to the reduced biological condition observed at stations PD1, PD5 and PD 6. Collyard (2003) stated that Prairie Dog Creek was fully supporting the protection and propagation of cold water fish. He added that some previous water temperature data suggested temperature exceedences could occur but it was unclear to the extent of the problem. Additional temperature monitoring may be required.

Collyard (2003) concluded that "A review of chemical, biological, and physical data collected on Prairie Dog Creek suggest that Prairie Dog Creek is fully supporting non-fishery aquatic life use. Although Prairie Dog Creek is clearly impacted by anthropogenic activities the macroinvertebrate community appears to be adapted and healthy."

7.20 FISHERIES

Although no fish sampling occurred during this current study, WDEQ conducted a review of fisheries data and fisheries information collected in the Prairie Dog Creek watershed (Collyard, 2003). Collyard (2003) in the WDEQ summary report for Prairie Dog Creek stated "Historically, [brown] trout have been observed in Prairie Dog Creek as far back as 1959, and are the dominant trout species found in the creek. Records show that between 1959 and 1999 brown trout were collected and identified below Jenks Creek, with an estimated density of 281 fish per mile. In 1968, brown trout were introduced above Meade Creek, with a density estimate of 420 trout per mile. In 1969, brown trout were again introduced above Meade Creek, but the estimated number of trout per mile had dropped to 215. Brown trout population estimates dropped considerably in 1970 above Meade Creek where only 22 Brown Trout per mile were observed. In 1999, 257 Brown Trout per mile were reported at the Below Highway 14 crossing site on the Baccari property. Of the 257 trout collected, 117 were between one and six inches long and 70 were greater than six inches long. According to Wyoming Game and Fish Biologists, trout do not migrate during their first year and the large number of fish less than one year old (117) suggests that spawning was successful. Other common fish species found in Prairie Dog Creek include the Mountain Sucker, White Sucker, and Longnose Sucker (WGFD, 1999)." In addition, "Wyoming Game and Fish data indicates successful Brown Trout spawning."

Collyard (2003) concluded that "…Prairie Dog Creek is fully supporting protection and propagation of cold water fish." However, he added that review of the data suggested that high water temperatures can occur during the summer, but it was unclear as to the extent of the problem.

7.21 HABITAT

Qualitative habitat assessments were conducted in conjunction with benthic macroinvertebrate sampling at the five (N = 5) monitoring stations on the mainstem Prairie Dog Creek during October 2007 and October 2008.

Habitat assessment data, embeddedness values and current velocity data are presented in Table 7-8. The mean percent substrate composition is presented in Table 7-9, and Table 7-10 compares the habitat at the Prairie Dog Creek stations to habitat at 129 other plains stream stations in the Northwestern Great Plains ecoregion of Wyoming. The total habitat score could not be determined for stations PD5 and PD10 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 mean habitat score at the Prairie Dog Creek stations ranged from a low of 128 at station PD6 to a high of 135 at station PD1 (Table 7-10). The habitat at the Prairie Dog Creek stations should be considered average when compared to habitat assessed at 129 other plains streams stations in northeast Wyoming. The habitat assessment score at station PD6 fell within the 40-50th percentile indicating that habitat was worse at approximately 40 percent of the other plains streams and that habitat was better at approximately 50 percent of the other plains streams in northeastern Wyoming (Table 7-10). The average habitat assessment score at station PD1 fell within the 60 to 70th percentile indicating that habitat was worse at approximately 60 percent of the other plains streams and that habitat was better at approximately 30 percent of other plains streams in northeastern Wyoming (Table 7-10).

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 7-9). Stations PD1 and PD8 were similar since each was dominated by cobble and coarse gravel. Stations PD5 and PD10 were dominated by sand with no cobble and little coarse gravel. Stream substrate at station PD6 was intermediate to stream substrate at the other Prairie Dog Creek monitoring stations. Station PD6 was dominated by sand (52% of total substrate) with coarse gravel (18% of total substrate) and fine gravel (26% 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.

The dominance of sand at station PD5 was responsible for the reduction in biological condition observed at this station when compared to biological condition at the other monitoring stations (see Section 7.18). 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 increased sand deposition continues.

Embeddedness (the amount of silt covering cobble and gravel) was not determined for stations PD5 and PD10 since substrate was dominated by sand at these two stations. Embeddedness may range from a value of 20 (no silt covering cobble and gravel) to a value of 100 (silt covering all cobble and gravel). Embeddedness was highest at the lower-most monitoring station PD1 (embeddedness value = 70) and lowest at the more upper monitoring station (PD8). This observation indicated that deposition of silt on stream substrate increased from upstream to downstream monitoring stations.

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 about 13% of the benthic macroinvertebrate community at station PD1, 0% at station PD5, 2% at station PD6, 13% at station PD8 and 10% at station PD10 (Table 7-7).

The mean current velocity measured at station PD1 was 2.28 feet per second (FPS), 1.15 FPS at station PD5, 1.46 FPS at station PD6, 2.50 FPS at station PD8, and 0.64 FPS at station PD10. Current velocity is important because the higher the current velocity, the less silt entrained in the water column will settle out and deposit on the stream substrate. Excess silt present in and on the stream substrate negatively affects the establishment and production of many benthic macroinvertebrates important as a food source for fish.

Table 7-3. Historic and Current Benthic Macroinvertebrate Sampling Stations in the Prairie Dog Creek Watershed – 1977 to 2008. 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	Appendix Table
Prairie Dog Creek	**PD1**	**44°59'01" / 106°50'24"**	**3477**	**SCCD**	**2007, 08**	**About 150 yards downstream from USGS station No. 06306250.**	**D-1; D-2; D-3**
Prairie Dog Creek	06306250	44°59'02" / 106°50'21"	3480	USGS	1977, 2005, 06	Near USGS Gage Station No. 0630625	D-4; D-5; D-6; D-7
Prairie Dog Creek	Lower – Prairie-02	44°59'01" / 106°50'24"	3480	BLM	2004	Just downstream of USGS Gage Station No. 0630625	D-8; D-9
Prairie Dog Creek	NGP30	44°50'55" / 106°51'49"	3650	WDEQ	1998	Below Wildcat Creek	D-10
Prairie Dog Creek	NGP28	44°50'52" / 106°51'50"	3650	WDEQ	1998	Above Wildcat Creek	D-11
Prairie Dog Creek	**PD5**	**44°49'11" / 106°54'03"**	**3740**	**SCCD**	**2007, 08**	**Upstream Highway 336 and Railroad Line**	**D-12; D-13; D-14**
Prairie Dog Creek	NGP31	44°44'20" / 106°52'43"	3920	WDEQ	1998	About ½ mile below Highway 14	D-15
Prairie Dog Creek	Upper – Prairie-01	44°43'56" / 106°52'29"	3950	BLM	2004	Downstream Highway 14	D-16; D-17
Prairie Dog Creek	**PD6**	**44°43'48"/ 106°52'29"**	**3960**	**SCCD**	**2007, 08**	**About 100 yards upstream Highway 14 crossing**	**D-18; D-19**
Prairie Dog Creek	NGP32	44°42'19" / 106°51'30"	4030	WDEQ	1998	Prairie Dog Creek Below Confluence w/Meade Creek	D-20
Prairie Dog Creek	NGPI13	44°42'16" / 106°51'28"	4050	WDEQ	1992, 98	Prairie Dog Creek About 0.7 mile Above Confluence w/Meade Creek	D-21; D-22
Prairie Dog Creek	NGP33	44°39'35" / 106°50'12"	4150	WDEQ	1998	Prairie Dog Creek About 0.3 mile below Confluence w/Murphy Gulch	D-23
Prairie Dog Creek	**PD8**	**44°39'36" / 106°50'11"**	**4160**	**SCCD**	**2007, 08**	**Prairie Dog Creek About 0.1 mile below Confluence w/Murphy Gulch**	**D-24; D-25**
Prairie Dog Creek	NGP29	44°37'48" / 106°50'06"	4260	WDEQ	1998	Prairie Dog Creek About 2.0 mile above Confluence w/Murphy Gulch	D-26; D-27

Table 7-3. (con't) **Historic and Current Benthic Macroinvertebrate Sampling Stations in the Prairie Dog Creek Watershed – 1977 to 2008.**

Stream Name	Station Name	Latitude / Longitude	Elevation (feet)	Sampling Group	Year(s) Sampled	Station Description	Appendix Table Data
Prairie Dog Creek	NGPI12	44°37'12" / 106°50'37"	4340	WDEQ	1992, 98	Prairie Dog Creek About 100 yards below Confluence w/Jenks Creek	D-28; D-29
Prairie Dog Creek	NGPI11	44°37'08" / 106°50'35"	4360	WDEQ	1992, 98	Prairie Dog Creek About 50 yards upstream Confluence w/ Jenks Creek	D-30; D-31
Prairie Dog Creek	**PD10**	**44°36'33" / 106°52'06"**	**4520**	**SCCD**	**2007, 08**	**About 150 yards upstream Highway 87**	**D-32; D-33**
Jenks Creek	NGPI10	44°37'01" / 106°50'33"	4360	WDEQ	1992, 98	Jenks Creek about 0.1 mile upstream confluence w/ Prairie Dog Creek	D-34; D-35; D-36
Jenks Creek	MRC91	44°35'20" / 106°50'57"	4480	WDEQ	2000	Jenks Creek about 0.4 mile below confluence w/ Peno Creek	D-37
Jenks Creek	MRC90	44°35'04" / 106°51'20"	4520	WDEQ	2000	Jenks Creek about 0.15 mile upstream confluence w/ Peno Creek	D-38; D-39
Meade Creek	NGP19	44°42'16" / 106°51'28"	4030	WDEQ	1998	Meade Creek near Confluence w/Prairie Dog Creek	D-40

Table 7-4. **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

Table 7-5. **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

Table 7-6. Biological condition score and rating for benthic macroinvertebrate samples collected from the Prairie Dog Creek Watershed based on the Wyoming Stream Integrity Index (WSII; from Hargett and ZumBerge, 2006).

				Bighorn and Wind River Foothills Bioregion	
Stream Name	**Station Name**	**Sampling Group**	**Year**	**Score**	**Rating**
Prairie Dog Creek	**PD1**	**SCCD**	**2007**	**35.5**	**Partial/ Non Support**
Prairie Dog Creek	**PD1**	**SCCD**	**2008**	**41.4**	**Partial/ Non Support**
Prairie Dog Creek	NGP30	WDEQ	1998	47.9	Indeterminate
Prairie Dog Creek	NGP28	WDEQ	1998	48.5	Indeterminate
Prairie Dog Creek	**PD5**	**SCCD**	**2007**	**15.0**	**Partial/ Non Support**
Prairie Dog Creek	**PD5**	**SCCD**	**2008**	**26.0**	**Partial/ Non Support**
Prairie Dog Creek	NGP31	WDEQ	1998	49.1	Indeterminate
Prairie Dog Creek	**PD6**	**SCCD**	**2007**	**24.1**	**Partial/ Non Support**
Prairie Dog Creek	**PD6**	**SCCD**	**2008**	**39.7**	**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	**PD8**	**SCCD**	**2007**	**55.4**	**Indeterminate**
Prairie Dog Creek	**PD8**	**SCCD**	**2008**	**55.4**	**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**
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

Table 7-7. Benthic macroinvertebrate metric values used in the determination of biological condition for sample stations in the Prairie Dog Creek watershed, 2007 and 2008.

	Sampling Station									
	PD1	**PD1**	**PD5**	**PD5**	**PD6**	**PD6**	**PD8**	**PD8**	**PD10**	**PD10**
Macroinvertebrate Metric	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**
Ephemeroptera taxa	5	4	0	0	4	4	6	5	2	6
Trichoptera taxa	4	5	0	1	3	3	9	12	6	12
Plecoptera taxa	1	2	0	0	0	2	4	4	3	6
% non-insects	0.91	5.15	10.00	11.11	18.59	16.85	2.88	2.33	30.02	1.54
% Plecoptera	0.73	4.58	0	0	0	2.41	4.06	1.62	14.70	6.80
% Trichoptera (less Hydropsychidae)	16.00	16.77	0	100.00	18.75	46.67	31.11	21.26	98.16	28.44
(% within Trichoptera)										
% collector-gatherers	33.03	27.66	45.00	55.55	80.39	69.07	28.95	22.37	44.30	21.16
% scrapers	12.71	14.12	0	0	0.21	2.99	11.18	15.04	3.32	17.49
HBI	6.72	6.23	5.42	6.89	6.76	6.20	5.88	6.03	6.17	5.80
Semi-voltine taxa (less semivoltine Coleoptera	1	1	0	0	2	2	3	3	2	4

Table 7-8. Mean habitat assessment score, weighted embeddedness value and current velocity for Prairie Dog Creek stations, 2007 and 2008.

Habitat Parameter	**PD1**	**PD5**	**PD6**	**PD8**	**PD10**
Substrate / Percent Fines	8	1	4	10	1
Instream Cover	11	9	10	12	17
Embeddedness	13	ND*	12	8	ND*
Velocity / Depth	6	9	16	16	14
Channel Flow Status	19	18	16	18	18
Channel Shape	14	14	12	12	16
Pool Riffle Ratio	6	6	11	13	10
Channelization	14	14	11	10	14
Width Depth Ratio	12	10	8	10	14
Bank Vegetation Protection	10	10	8	8	10
Bank Stability	10	10	8	8	10
Disruptive Pressures	10	10	8	6	10
Riparian Zone Width	2	2	4	2	6
TOTAL SCORE	135	ND*	128	133	ND*
Weighted Embeddedness	70	ND*	66	50	ND*
Current Velocity (ft. per second)	2.28	1.15	1.46	2.50	0.64

Note: * ND = embeddedness values, and thus total habitat scores, were not determined for stations PD5 and PD10 since substrate was dominated by sand at these two stations.

Table 7-9. Mean percent substrate composition for Prairie Dog Creek stations, 2007 and 2008.

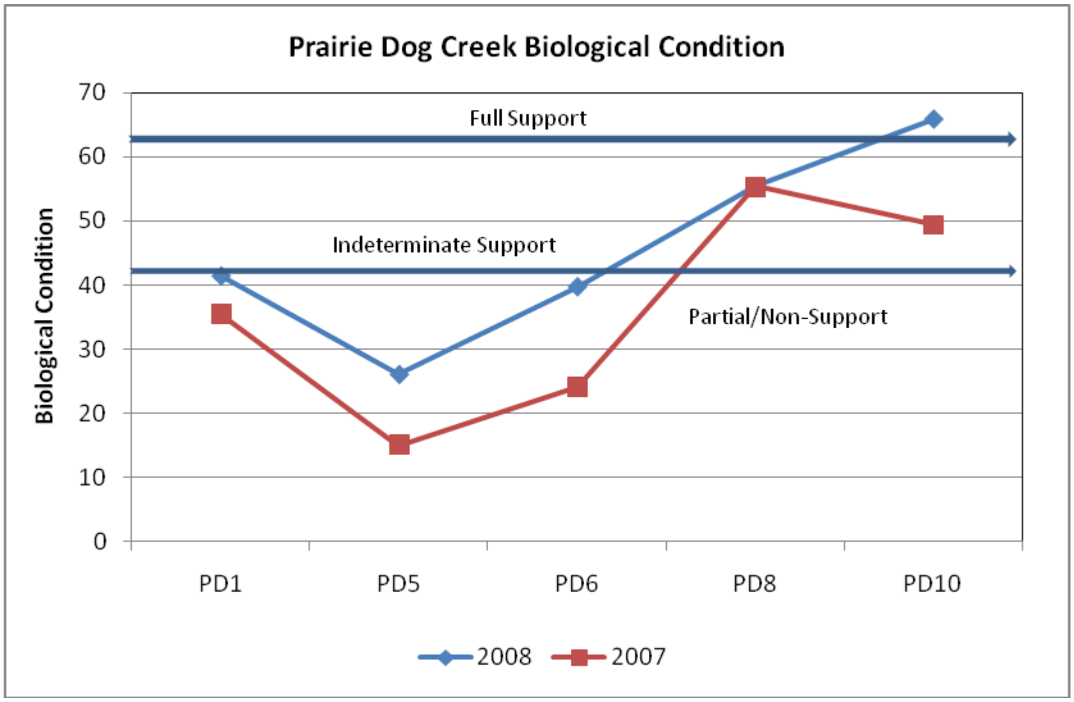
Substrate Type	**PD1**	**PD5**	**PD6**	**PD8**	**PD10**
% Cobble	44	0	2	61	0
% Coarse Gravel	12	0	18	16	1
% Fine Gravel	10	1	26	2	2
% Silt	0	0	2	0	10
% Sand	32	99	52	21	86

Table 7-10. Mean total habitat scores and weighted embeddedness values for Prairie Dog Creek stations in 2007 and 2008 compared to habitat scores and embeddedness values presented in 10th percentile intervals for 129 plains stream stations in the Northwestern Great Plains (NGP) ecoregion of Wyoming.

Prairie Dog Creek			Range in Habitat Score and Embeddedness Value by 10th Percentile Intervals for NGP Streams			
Station	Mean Habitat Score	Mean Embeddedness Value	Percentile	Range in Habitat Scores by 10th Percentile Interval	Percentile	Range in Embeddedness Values by 10th Percentile Interval
PD1	135	70	0.10 - 9.99%	<91.0	0.10 - 9.99%	20.0 - 21.0
PD5	133	ND*	10.00 - 19.99%	91.0 - 101.9	10.00 - 19.99%	21.1 - 24.6
PD6	128	66	20.00 - 29.99%	102.0 - 117.9	20.00 - 29.99%	24.7 - 30.0
PD8	133	50	30.00 - 39.99%	118.0 -126.4	30.00 - 39.99%	30.1 - 36.4
PD10	160	ND*	40.00 - 49.99%	126.6 - 132.4	40.00 - 49.99%	36.5 - 40.8
			50.00 - 59.99%	132.5 -134.4	50.00 - 59.99%	40.9 - 49.0
			60.00 - 69.99%	134.5 - 137.9	60.00 - 69.99%	49.1 - 58.0
			70.00 - 79.99%	138.0 - 142.9	70.00 - 79.99%	58.1 - 68.0
			80.00 - 89.99%	143.0 -151.4	80.00 - 89.99%	68.1 - 90.0
			90.00 - 100.00%	151.5 - 169.0	90.00 - 99.99%	90.1 - 100.0

Note: *ND = embeddedness values were not determined since substrate was dominated by sand in one or more years.

Figure 7-9. Biological condition at Prairie Dog Creek stations, 2007 and 2008.



8. CONCLUSIONS AND RECOMMENDATIONS

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. These trans-basin diversions from Tunnel Hill are likely more responsible for water quality issues than current anthropogenic activities. 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 information collected in the PDWA can be used to facilitate watershed improvement activities. There is an opportunity for additional correlations among parameters as part of the process for using information in the PDWA to guide remediation efforts. Some of this work has been done through the development of the DRAFT Prairie Dog Creek Watershed Plan. To facilitate improvement efforts on the watershed, SCCD recommends completion of the following:

- SCCD-NRCS will continue to work closely with watershed landowners and residents and WDEQ to finalize the Prairie Dog Creek Plan and ensure it meets the necessary requirements from WDEQ and USEPA and is consistent with landowner needs and expectations;
- SCCD-NRCS will work with watershed residents and landowners to implement the Prairie Dog Creek Watershed Plan, especially information and education activities to encourage landowner participation in improvement activities;
- SCCD-NRCS will incorporate the Prairie Dog Creek watershed in future monitoring schedules on a three-year rotation, with the next year of monitoring scheduled for 2011;
- SCCD-NRCS will incorporate future monitoring results into existing efforts to have a better long-term understanding of the watershed; and
- SCCD-NRCS will continue to work with WDEQ and other partners to identify realistic approaches to better understand load estimates and reductions from non-point sources.

By definition, non-point source pollution concerns are difficult to associate with any single source or point of origin. SCCD-NRCS will continue to support and encourage voluntary, incentive-based programs to facilitate long-term improvements on a watershed scale.

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APPENDICES

APPENDIX A

MAPS

APPENDIX B

HISTORICAL AND CURRENT WATER QUALITY DATA

APPENDIX C

2007-2008 WATER QUALITY DATA COLLECTED BY SCCD

APPENDIX D

BENTHIC MACROINVERTEBRATE DATA

APPENDIX E

QUALITY ASSURANCE/QUALITY CONTROL