Bacteria TMDL for Cedar Creek and Crooked Creek in Grant and Sioux Counties, North Dakota

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1.0 INTRODUCTION AND DESCRIPTION OF THE RIVER AND WATERSHED

The Cedar Creek watershed covers approximately 1,787 square miles (mi^2) in southwest North Dakota and is part of the Missouri River Basin. Cedar Creek is a perennial stream and flows through five counties in southwest North Dakota, providing a recreational and agricultural water supply while it delineates county lines as it flows to the Cannonball River (Figure 1). Originating in the northeast corner of Bowman County and the southeast corner of Slope County, Cedar Creek winds its way in a southeast direction across Adams, Grant and Sioux Counties where it confluences with the Cannonball River 18 miles south of Raleigh, North Dakota. General characteristics and facts on the Cedar Creek watershed and Cedar Creek are provided in Table 1. A 40.3-mile segment of Cedar Creek (ND-10130205-001-S_00) and a 40.68-mile segment of Crooked Creek (ND-10130205-006-S_00) in the Cedar Creek watershed are listed on the state's 2006 Section 303(d) list of impaired waters (Figure 2). Crooked Creek is a tributary of Cedar Creek; TMDL segments are geographically located within the Cedar Creek watershed near the confluence with the Cannonball River.

Table 1. General Characteristics of Cedar Creek and Its Watershed.

Legal Name	Cedar Creek
8-Digit HUC	10130205
Counties Traversed	Slope, Bowman, Adams, Grant, Sioux
Eco-region	Northwestern Great Plains (Level III), Missouri Plateau (Level IV)
Watershed Area	1,787 mi^2
Head Waters	Bowman and Slope county
Outlet	Cannonball River
ND Highways Crossed	Hwy 67, Hwy 22, Hwy 8, Hwy 49, Hwy 31
Stream Class	Class II
Headwater Elevation	2825 Feet (MSL)
Outlet Elevation	1881 Feet (MSL)
River Length	295 miles
Annual Mean Stream Flow for Year 2001	116

1.1 Clean Water Act Section 303(d) Listing Information

Based on the 2006 Section 303(d) List of Impaired Waters Needing TMDLs, the North Dakota Department of Health (NDDoH, 2006) has identified a 40.3 mile segment of the Cedar Creek from its confluence with Hay Creek downstream to its confluence with the Cannonball River (ND-10130205-001-S_00) as fully supporting, but threatened for recreational uses (Table 2). Crooked Creek and its tributaries, a tributary watershed to Cedar Creek consisting of 40.68 stream miles is also listed on the 2006 Section 303(d) list as impaired for recreational uses (Table 3). Recreational uses on Cedar Creek are currently fully supporting but threatened and recreational uses on Crooked Creek are not supporting due to excessive fecal coliform bacteria concentrations. Fecal coliform bacteria levels periodically exceed the State water quality standard and E. coli bacteria originating from human sources have been discovered in Cedar Creek.

Table 2. Cedar Creek Section 303(d) Listing Information (NDDoH, 2006).

Stream Name	Cedar Creek
Assessment Unit ID	ND-10130205-001-S_00
Stream Description	Cedar Creek from its confluence with Hay Creek downstream to its confluence with the Cannonball River
Size	40.3 miles
Designated Use	Recreation
Stream Class	Class II
Use Support	Fully Supporting, but Threatened
Impairment	Fecal Coliform Bacteria
TMDL Priority	Medium

Table 3. Crooked Creek Section 303(d) Listing Information (NDDoH, 2006).

Stream Name	Crooked Creek, including tributaries
Assessment Unit ID	ND-10130205-006-S_00
Stream Description	Crooked Creek, including tributaries
Size	40.68 miles
Designated Use	Recreation
Stream Class	Class III
Use Support	Not Supporting
Impairment	Fecal Coliform Bacteria
TMDL Priority	High, Targeted

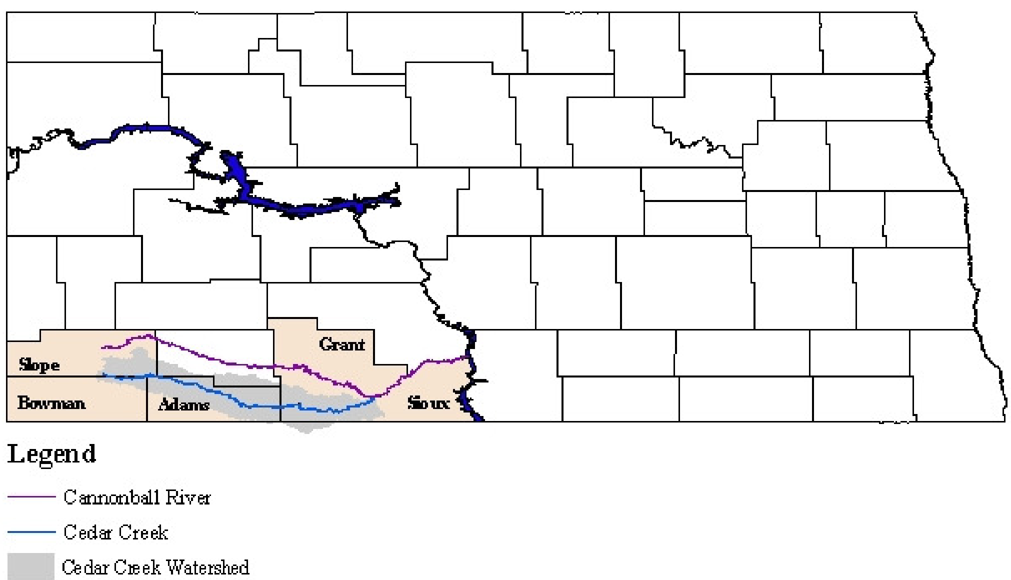

Figure 1. Cedar Creek in North Dakota

1.2 Topography

The Section 303(d) listed segment of Cedar Creek highlighted in this TMDL serves as the border between Grant County and Sioux County, North Dakota. The Crooked Creek watershed lies wholly within Grant County, North Dakota. Topography of the two combined watersheds consists of short grass prairie and rolling plains with prominent sandstone buttes. Elevation of the area ranges between 1,800-feet (MSL) to 2,700-feet (MSL) (Soil Survey of Grant County, USDA Soil Conservation Service, 1988). Glaciation has had little to no effect on the topography of the area leaving original soils in place and a complex stream drainage system.

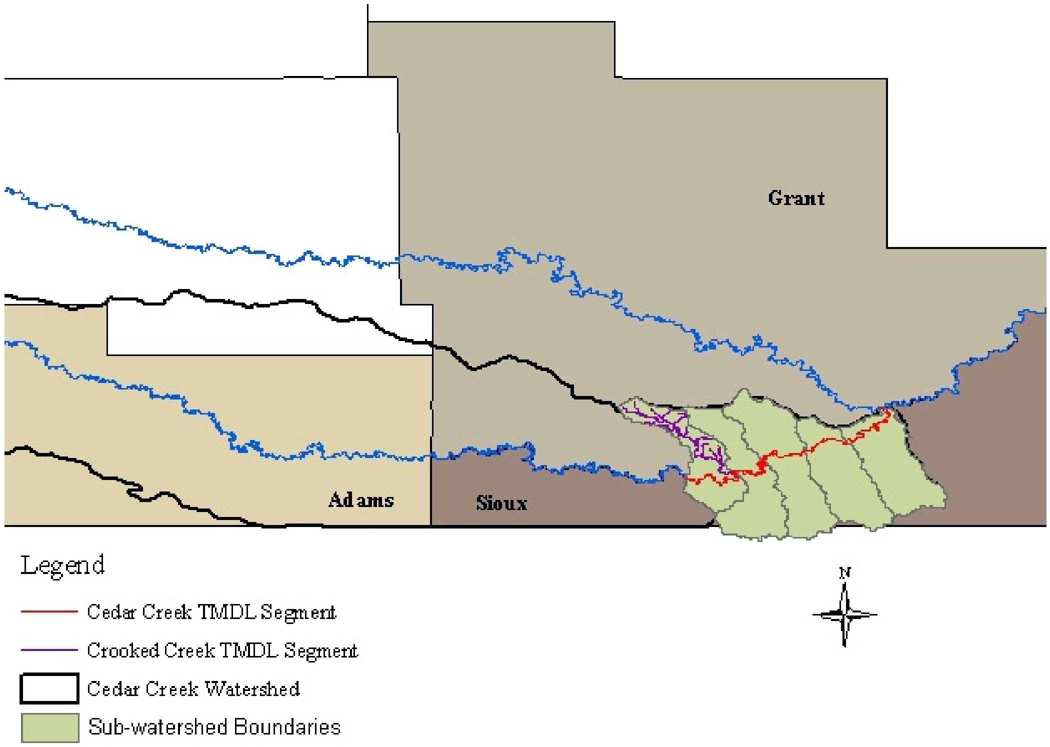

Figure 2. Cedar Creek and Crooked Creek TMDL Listed Segments

1.3 Land Use/Land Cover

Land use in the two combined TMDL listed watersheds is the same and is primarily agriculture (Figure 3). Eighty-nine (89) percent of the sub-watershed is pasture or rangeland (Table 4), with the primary agricultural practice being livestock production, specifically cow-calf operations. Thin top soil of siltstone, sandstone, and shale minimize crop production leaving range and pasture land consisting of short grass prairie, forbs, and a wide variety of forage ideal for beef production. Crop production consists of small grain crops such as spring wheat, oats, and barley accounting for approximately 4 percent of the land use. With the advent of no-till and minimum tillage technologies, the region is seeing an increase in higher water use crops such as corn, grown and cut for feed silage, flax, and sunflower. Approximately four percent of the watershed crosses the state line into South Dakota, where land use is unknown. Taking into consideration the dominance of range and pasture in ND, and the inconsequential area, it is safe to assume that range and pasture dominate the four percent of the watershed in South Dakota. Other land uses include roads, water, and woods.

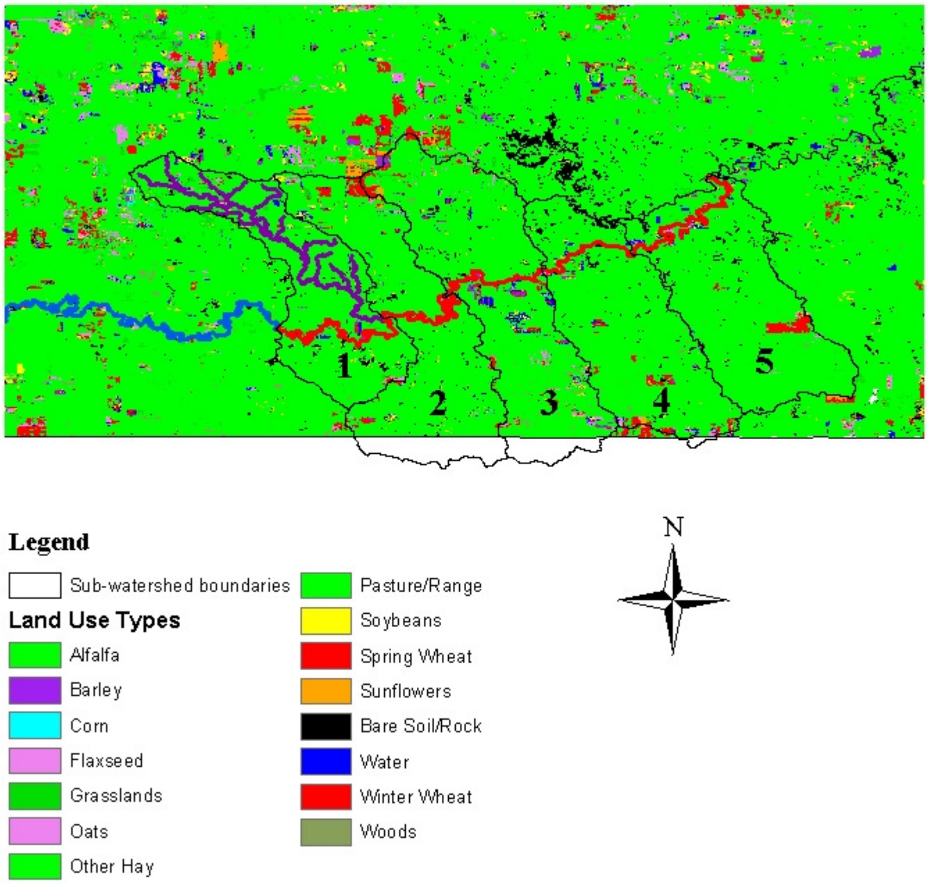

Figure 3. Land Use in the TMDL Listed Watersheds (NDSU, 2003)

Table 4. Land Use Acreage by Sub-watershed.

Land Use Type	Sub-watershed 1 (Acres)	2 (Acres)	3 (Acres)	4 (Acres)	5 (Acres)	Total Acres	%
Pasture/Range	21,726	22,274	26,085	24,596	25,255	119,936	89
Grasslands	570	258	159	52	90	1,129	0.8
Other Hay/Alfalfa	419	782	1,926	327	756	4,210	3
Small Grain (wheat, oats, barley)	399	896	1,820	786	904	4,805	4
Row Crops (corn, sunflower)	8	44	88	51	1	192	0.1
Other Crops (soybean, flax)	238	229	302	99	103	971	0.7
Bare Soil/Rock	460	287	345	680	468	2,240	2
Water	219	128	568	215	213	1,343	1
Woods	20	16	253	77	34	400	0.2

1.4 Climate and Precipitation

Southwest North Dakota has a climate characterized by severe fluctuations in temperature, precipitation, near continuous air movement, and low relative humidity. Temperatures of the region range from a monthly average of 27° F in January to 85° F in August with an annual average temperature of 56° F over the last twenty years (Figure 4) (NDAWN, 2003).

Precipitation events are sporadic occurring primarily as rainfall in late spring and early summer (Figure 5). Based on precipitation records obtained from the North Dakota Agriculture Weather Network (NDAWN) station at Mott, ND, average annual precipitation is 15.76 inches (NDAWN, 2003).

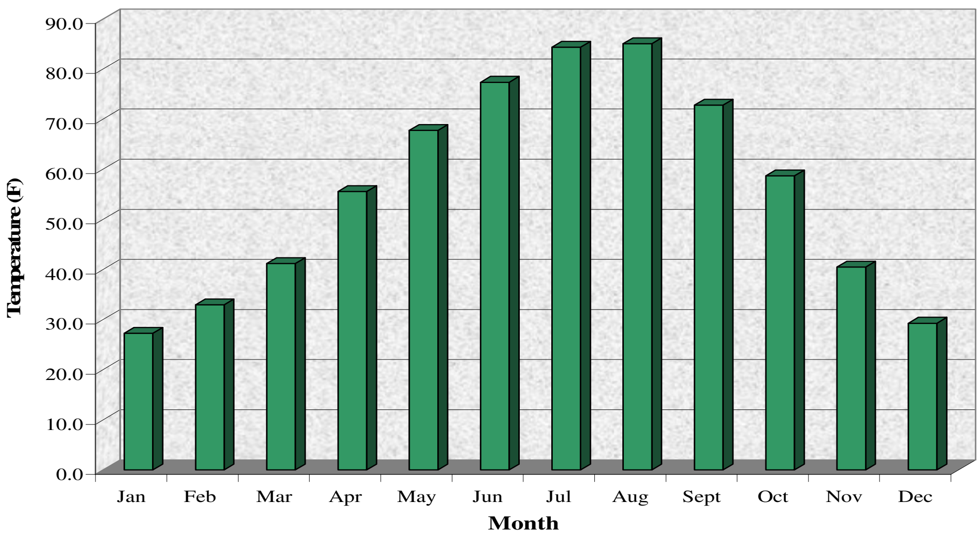

Figure 4. Average Monthly Temperatures from 1983-2002 Recorded at the NDAWN, Mott, ND Weather Station.

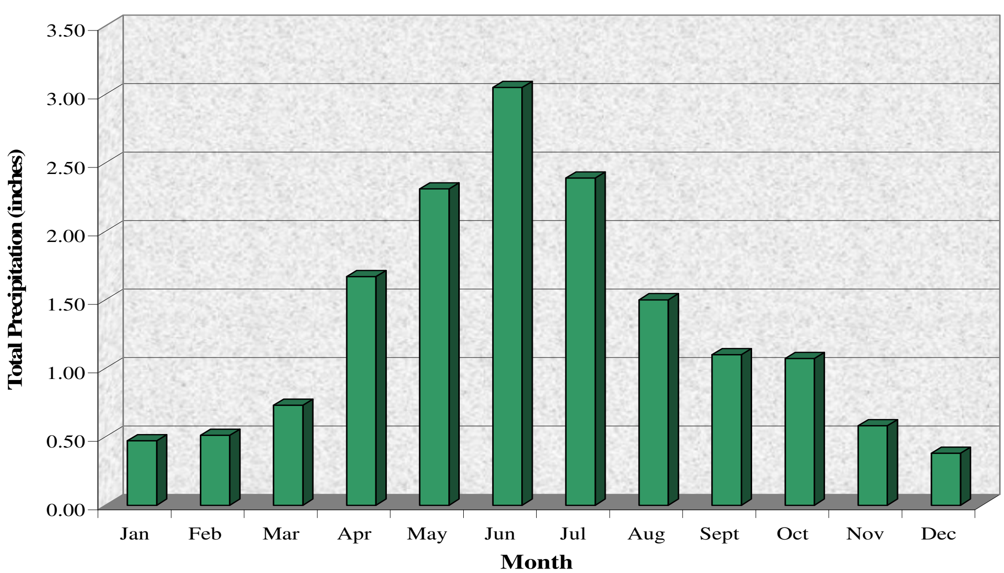

Figure 5. Average Monthly Precipitation from 1983-2002 Recorded at the NDAWN, Mott, ND Weather Station.

1.5 Available Steam Water Quality Data

Fecal coliform bacteria samples have been collected at two locations within the TMDL listed watershed (Figure 6). One site, station ID 380077, is located on the Cedar Creek near the downstream end of the reach before it confluences with the Cannonball River. In addition to fecal coliform bacteria, E. coli bacteria has been collected at station 380077. The second station, station ID 385022, is located on Crooked Creek, a tributary of the Cedar Creek. This site was monitored for fecal coliform bacteria in 1999 and 2001.

Monitoring station 380077 is located eighteen miles south of Raleigh, North Dakota at the Highway 31 Bridge. It is an NDDoH ambient monitoring station that has been regularly monitored since 1994. It is also located at a United States Geological Survey (USGS) gauging station (06353000). The sample frequency for this site was every six weeks during the recreation seasons of 1994 through 2000 and 2003 and 2004. In support of TMDL development, sample frequency was increased to twice per week sampling during the 2001 and 2002 recreation seasons. The second monitoring site, station ID 385022, was monitored semimonthly during the months of May, June and July of 1999 and semimonthly during July and August of 2001. The recreation season in North Dakota is May 1 to September 30.

Table 5. General Statistics for Water Quality Data and Monitoring Station Descriptions.

STORET	Location Description	# Collected / Years Collected	Max. (CFU/100 mL)	Min. (CFU/100 mL)	Geometric Mean (CFU/100 mL)	% Greater than 400 CFU/100 mL	% Samples Exceeding the 200 CFU/100 mL Standard
380077	Cedar Creek, Eighteen miles S. of Raleigh @ Hwy 31 bridge	62 / 1994-2002	1600*	10	185	31	40
385022	Crooked Creek, near its confluence with Cedar Creek	9 / 1999/2001	1600*	60	301	44	44

* Some of the samples returned results of "too numerous to count," a value of 1600 was used in these situations.

Location descriptions and statistics for water quality data for each monitoring station are shown in Table 5**.** Station 380077 is the furthest downstream site and had 40 percent of the samples exceed the 200 colony forming units (CFU) per 100 milliliters (mL) water quality standard. Station 385022 is located on Crooked Creek near its confluence with Cedar Creek, 44 percent of the samples collected at this site exceed the water quality standard. The maximum fecal coliform bacteria concentration at both stations was 1600 CFU/100 mL. It should be noted that a value of 1600 CFU/100 mL was used when a sample returned a result of "too numerous to count" and represents the maximum colonies the microbiology lab will count for a sample. While a value of 1600 CFU/100 mL may be a significant underestimation in the cases of "too numerous to count," there is no other defensible value that can be used for these cases. Less than 10 percent of the samples returned results of "too numerous to count," so there is a minimal influence on the results. The minimum fecal coliform bacteria concentrations at stations 380077 and 385022 were 10 and 60 CFU/100 mL, respectively.

The segment of the Cedar Creek from its confluence with Hay Creek downstream to its confluence with the Cannonball River (ND-10130205-001-S_00) is listed as fully supporting, but threatened for recreational uses. Crooked Creek and its tributaries (ND-10130205-006-S_00) are listed as not supporting recreational uses. A recreation use determination was made using fecal coliform data collected between 1994 and 2003 at station 380077, and data from 1999 and 2001 at station 385022. Based on fecal coliform data, the following beneficial use support criteria were used:

Criterion 1: The geometric mean of the samples should not exceed 200 CFU/100 mL.
Criterion 2: Not more than 10 percent of the samples should have a density exceeding 400 CFU/100 mL.

The two criteria were then applied using the following use support decision criteria:

Fully Supporting: Both criteria 1 and 2 are met.
Fully Supporting but Threatened: Criterion 1 is met, but 2 is not.
Not Supporting: Criterion 1 is not met, or Criteria 1 and 2 are not met.

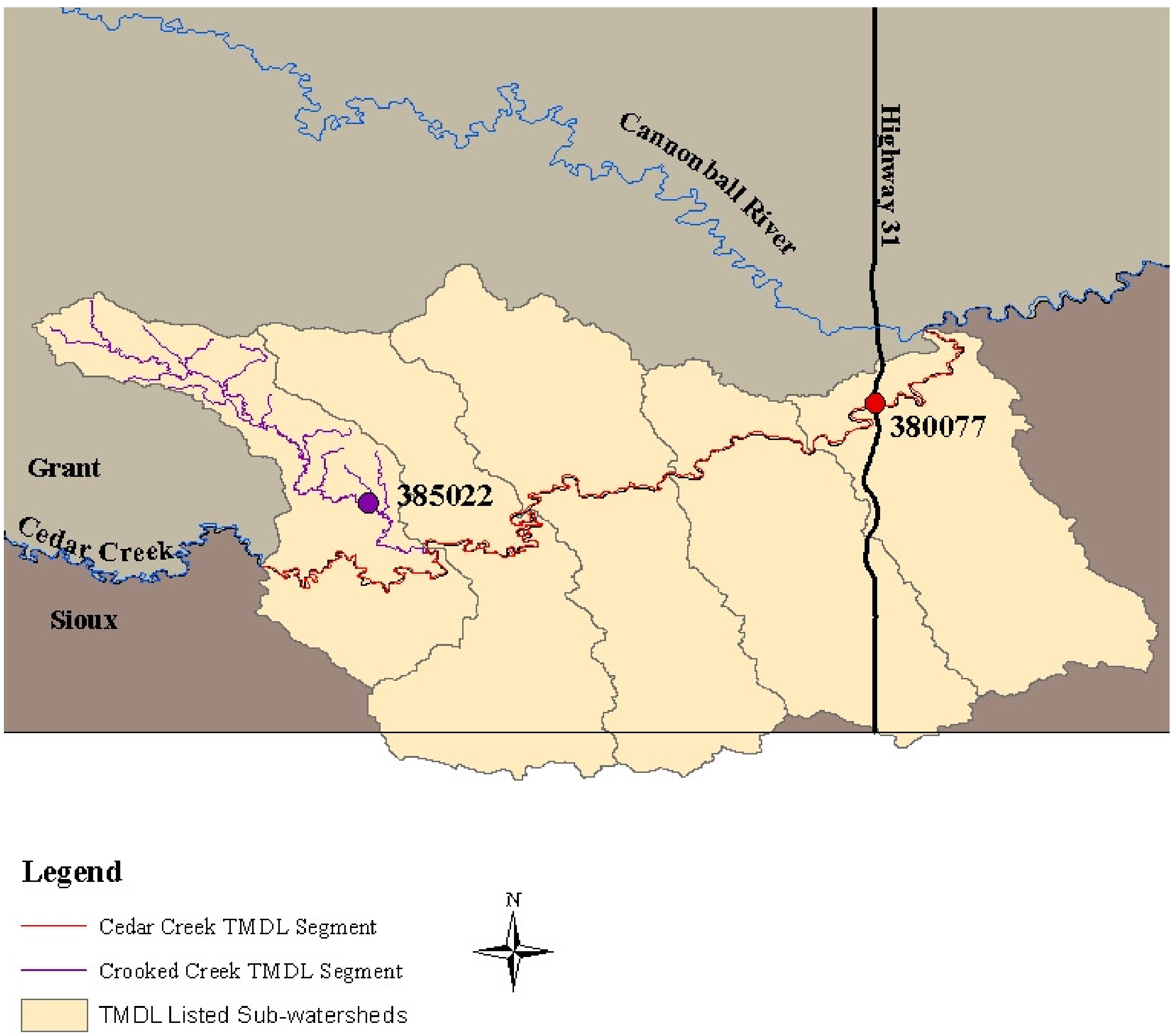

Figure 6. Water Quality Monitoring Station Locations on the TMDL Listed Streams.

A geometric mean of 185 CFU/100 mL at station 380077 indicates that criterion one was met and 31 percent of samples exceed 400 CFU/100 mL (Table 5) indicates criterion two was not met, therefore establishing a fully supporting, but threatened beneficial use support decision.

For the Crooked Creek listed segment, fecal coliform bacteria samples from station 385022 resulted in a geometric mean of 301 CFU/100 mL, while 44 percent of samples exceed 400 CFU/100 mL, indicating both criteria one and two were not met. Therefore, establishing a not supporting beneficial use support decision for Crooked Creek and its tributaries was made for this waterbody.

2.0 WATER QUALITY STANDARDS

Cedar Creek and Crooked Creek are not meeting designated uses for recreation due to total fecal coliform bacteria levels that exceed the State water quality standard. The fecal coliform standard applicable to the Cedar Creek and Crooked Creek is 200 CFU/100 mL. This standard only applies during the recreation season of May 1 to September 30 of each calendar year. State narrative standards are also applicable and are discussed in Section 2.1 of the TMDL.

2.1 Narrative Water Quality Standards

The North Dakota Department of Health has set narrative water quality standards that apply to all surface waters in the State. The narrative general water quality standards are listed below (NDDoH, 2006).

- All waters of the State shall be free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations that are toxic or harmful to humans, animals, plants, or resident aquatic biota.

- No discharge of pollutants, which alone or in combination with other substances shall:

  a. Cause a public health hazard or injury to environmental resources;
  b. Impair existing or reasonable beneficial uses of the receiving water; or
  c. Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters.

In addition to the narrative standards, the NDDoH has set a biological goal for all surface waters in the state. The goal states “the biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites” (NDDoH, 2001).

2.2 Numeric Stream Water Quality Standards

The Cedar Creek is a Class II stream. The NDDoH definition of a Class II stream is shown below (NDDoH, 2006).

> **Class II** – The quality of the waters in this class shall be suitable for the propagation and/or protection of resident fish species and other aquatic biota and for swimming, boating, and other water recreation. The quality of the waters shall be for irrigation, stock watering, and wildlife without injurious effects. After treatment consisting of coagulation, settling, filtration, and chlorination, or equivalent treatment processes, the water quality shall meet the bacteriological, physical, and chemical requirements of the department for municipal or domestic use. Additional treatment for municipal use may be required to meet the drinking water requirements of the Department. Streams in this classification may be intermittent in nature, which would make these waters of limited value for beneficial uses such as municipal water, fish life, or irrigation.

Crooked Creek is a Class III stream. The NDDoH definition of a Class III stream is shown below (NDDoH, 2006).

> **Class III –** The quality of the waters in this class shall be suitable for agricultural and industrial uses such as stock watering, irrigation, washing, and cooling. These streams have low average flows and, generally, prolonged periods of no flow. They are of limited seasonal value for immersion recreation, fish life, and aquatic biota. The quality of these waters must be maintained to protect recreation, fish, and aquatic biota.

Numeric criteria have been developed for Class II and III streams for fecal coliform bacteria. Fecal coliform bacteria standards have been established and are shown in Table 6. The fecal coliform standard applies only during the recreation season from May 1 to September 30.

Table 6. North Dakota Fecal Coliform Bacteria Standards for Class II and III Streams.

	Standard	
Parameter	**Geometric Mean[1]**	**Maximum[2]**
Fecal Coliform Bacteria	200 CFU/100 mL	400 CFU/100 mL

[1] Expressed as a geometric mean of representative samples collected during any consecutive 30-day period.
[2] No more than 10 percent of samples collected during any consecutive 30-day period shall individually exceed the standard.

3.0 TMDL TARGETS

A TMDL target is the value that is measured to judge the success of the TMDL effort. TMDL targets must be based on State water quality standards, but can also include site specific values when no numeric criteria are specified in the standard. The following TMDL target for the Cedar Creek is based on the NDDoH water quality standard for fecal coliform bacteria.

3.1 Cedar Creek and Crooked Creek Targets

Both Cedar Creek and Crooked Creek, including its tributaries, are impaired because of fecal coliform bacteria. Cedar Creek is fully supporting, but threatened, and Crooked Creek is not supporting beneficial uses because of fecal coliform bacteria counts exceeding the North Dakota water quality standard. The North Dakota water quality standard for fecal coliform bacteria is a geometric mean concentration of 200 CFU/100 mL during the recreation season from May 1 to September 30. Thus, the TMDL target for this report is 200 CFU/100 mL. In addition, no more than 10 percent of samples collected for fecal coliform should exceed 400 CFU/100 mL.

4.0 SIGNIFICANT SOURCES

There are no known point sources in this TMDL listed segment of the Cedar Creek watershed, including Crooked Creek. Fecal coliform bacteria and E. coli bacteria polluting the river are from non-point sources. According to the 2002 National Agricultural Statistics Service (NASS) land use/land cover data, the dominant land use/land cover within an estimated 250 meter riparian buffer around Cedar Creek is pasture, idle crop, and CRP at 96 percent. The watershed is entirely rural with 89 percent of the land classified as range or pasture, while agricultural crop production accounts for 5 percent. The remainder of the watershed is roads, water, woods, hay land, and farmsteads (Figure 3, Table 4). With agriculture being the predominant land use, farms and ranches are located throughout the watershed.
To better determine the sources of fecal coliform bacteria, samples were analyzed by Source Molecular to isolate the genetic make up of E. coli. This process is termed “DNA Fingerprinting.” The goal of “DNA Fingerprinting” is to determine whether E. coli found in Cedar Creek water samples originates from animal or human sources.

Two samples from monitoring station 380077 were analyzed using DNA fingerprinting (i.e. bacteria source tracking) of E. coli to determine if the sources were human or non-human. Both human and animal sources were found in the samples (Table 7), however, of the nine isolates, most were found to be animal sources (only 3 of the 9 were determined to be human sources). Animal feeding areas and livestock grazing are likely contributors. Human sources are likely to be from failing septic systems and/or from the direct discharge of sewage from farmsteads in the watershed.

Table 7. Results from DNA Analysis of E. coli Isolates at Station ID 380077.

STORET Station #	Fecal Coliform mpn*/100 mL	E. coli Isolate # (4-5 colonies of cultured E. coli were analyzed)	Probable Source
380077	=240	1	Animal
		2	Animal
		3	Animal
		4	Animal
380077	=210	1	Human
		2	Human
		3	Animal
		4	Animal
		5	Human

* mpn = most probable number of fecal coliforms in 100mL of sample after 20 hrs of cultivation at 44.5°C

It is not surprising that animal E. coli were dominant in the samples analyzed as livestock production is a dominant agricultural practice in Grant County. Grant County ranked 4th out of 53 counties in North Dakota with an estimated 80,000 cattle (NDASS, 2003). No NDDoH permitted Concentrated Animal Feeding Operations (CAFOs) of 1000 animals or greater are located in the five TMDL sub-watersheds. Seven Animal Feeding Operations (AFOs) of 100 to 1000 animals and four AFOs with fewer than 100 animals are located in the riparian area or in a location where pollution from livestock waste is certain (Espe, 2005). Another two AFOs of fewer than 100 animals are located near Cedar Creek in locations where the threat of pollution from livestock is moderate (Espe, 2005). There may be other AFOs in the TMDL sub-watersheds, however their location and size are unknown.

Wildlife may also contribute to the animal E. coli found in water quality samples, but most likely in a lower concentration. Wildlife are nomadic with fewer numbers concentrating in a specific area, thus decreasing the probability of their contribution of fecal matter in significant quantities.

The identification of human E. coli (Table 7) is a concern and indicates that failing septic systems or direct discharge sewage systems are most likely located within the watershed. Single-family dwellings and farmsteads are located throughout the watershed. These types of dwellings have been identified on Cedar Creek near ambient monitoring station 380077. While it has not been documented, land application of septic sludge may be another source of contamination. As stated previously, the possibility of point source pollution from wastewater treatment facilities is unlikely in the 220-mi^2 watershed.

5.0 TECHNICAL ANALYSIS

In TMDL development, the goal is to define the linkage between the water quality target and the identified source or sources of the pollutant (i.e. fecal coliform bacteria) to determine the load reduction needed to meet the TMDL target. To determine the cause-and-effect relationship between the water quality target and the identified source, the "load duration curve" methodology was used.

The loading capacity or total maximum daily load (TMDL) is the amount of a pollutant (e.g. fecal coliform bacteria) a waterbody can receive and still meet and maintain water quality standards and beneficial uses. The following technical analysis addresses the fecal coliform reductions necessary to achieve the water quality standards target of 200 CFU/100 mL with a margin of safety.

In Section 4.0, significant sources of fecal coliform loading were defined as non-point sources originating from failing septic systems and livestock. An important factor in determining non-point source pollution loads is variability in stream flows and loads associated with high and low flow. To better characterize the hydrograph of the TMDL listed stream segment, a load duration curve was derived for monitoring site 380077 located south of Raleigh, North Dakota (Figure 6). The load duration curve for this site was derived using the 200 CFU/100 mL water quality standard. Flows for site 380077 were obtained from the discharge record at the United States Geological Survey (USGS) gauge site (06353000) co-located with site 380077.

A hydrograph or flow duration curve for Cedar Creek was developed by generating a flow frequency table using daily stream flow data over a 20 year period (1983-2002) and plotting the points as a flow duration curve (Figure 7). For purposes of this TMDL, low flow is defined as flows which are exceeded 80 percent of the time or flows less than 3 cubic feet per second (cfs). High flows are flows that are exceeded less than 20 percent of the time or flows greater than 62 cfs. Moderate flows are flows between 3 cfs and 62 cfs.

Observed in-stream fecal coliform bacteria concentrations collected at monitoring site 380077 were converted to pollutant loads by multiplying concentrations by the flow and a conversion factor. These loads are plotted against the percent exceeded of the flow on the day of sample collection (Figure 8). Points plotted above the 200 CFU/100 mL target curve exceed the water quality target. Points plotted on or below the target curve meet the water quality target of 200 CFU/100 mL (Figure 8).

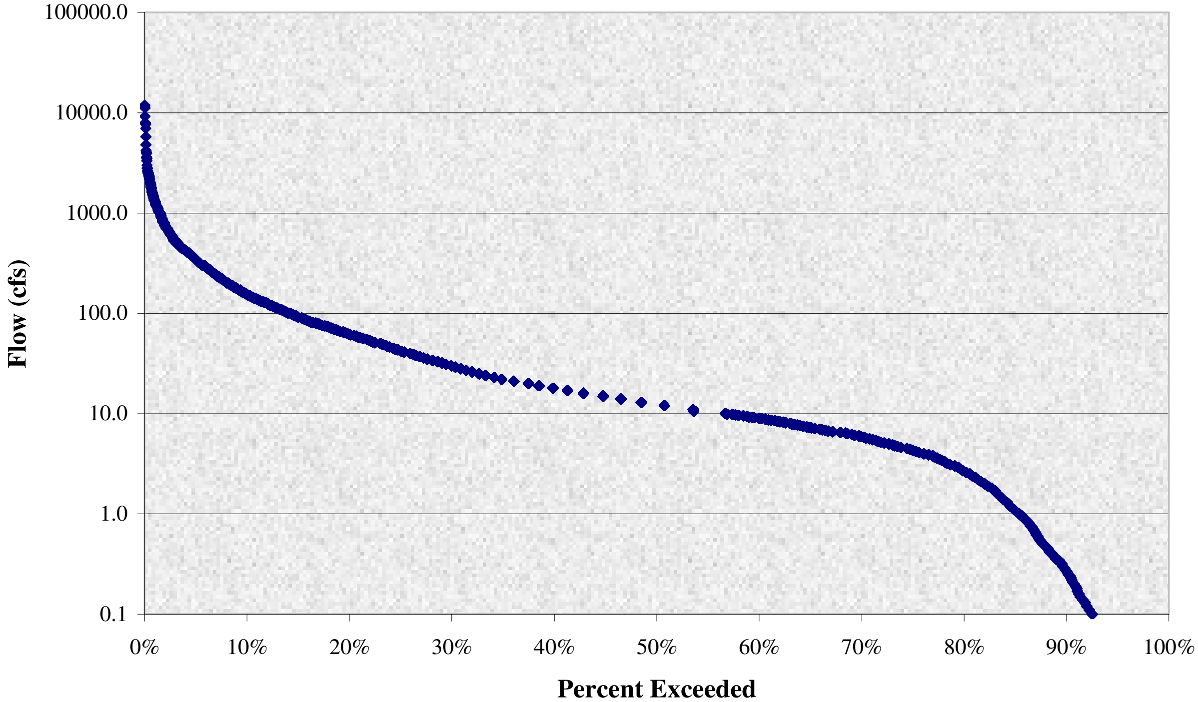

Figure 7. Cedar Creek Flow Duration Curve at Station ID 380077 Co-located with USGS Station 06353000) at Raleigh, North Dakota, (The curve reflects flows collected from 1983-2002.

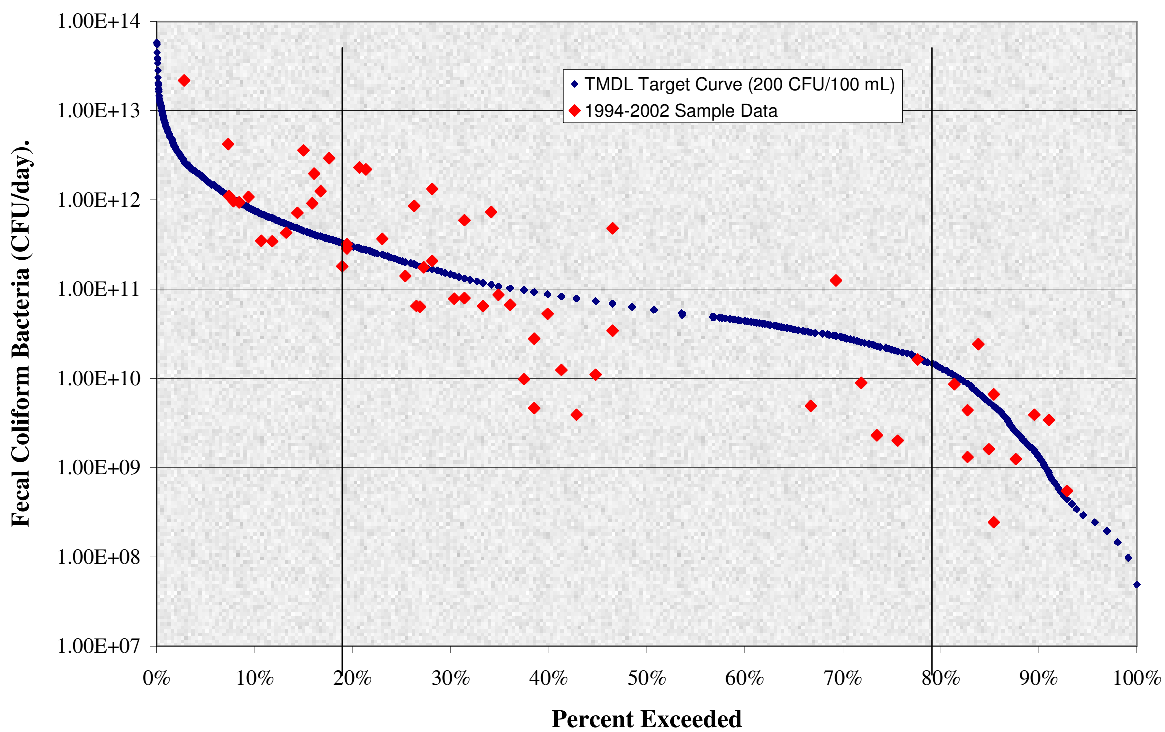

Figure 8. Cedar Creek Load Duration Curve at at Station ID 380077 Co-located with USGS Station 06353000) at Raleigh, North Dakota, (The curve reflects flows collected from 1983-2002 and fecal coliform data collected from 1994-2002).

Observed loads plotted on the load duration curve exceeded the target curve within all three flow regimes (high - <3 cfs; moderate - 3 to 80 cfs; high - >80 cfs). Those loads above the target curve in the low flow regime (less than 3 cfs) indicate direct sources of pollution, such as point sources or livestock located in close proximity to the stream. Since there are no known point sources in the watershed, loading sources exceeding the target curve in the low flow regime are considered to originate from direct deposit of fecal matter by livestock utilizing the river as a water source during low flows. Discharges from failing septic systems are also likely occurring at low flow. Fecal coliform bacteria loads above the target line in the moderate flow regime, between 3 cfs and 62 cfs, and those loads greater than 62 cfs in the high flow regime indicate non-point source pollution. Specific non-point sources of pollution and their potential to contribute fecal coliform bacteria loads under high, moderate, and low flow regimes in the Cedar Creek watershed are described in Table 8.

A linear regression was developed for each flow regime (high, moderate, and low) using only the sample loads that occur above the TMDL target (200 CFU/100 mL) curve (Figures 9, 10, and 11). The linear regression line for each flow regime was then used with the percent exceeded of the average daily discharge for the period of record 1983-2002, to calculate existing fecal coliform bacteria loads and the fecal coliform load for each flow regime necessary to reach the TMDL target concentration of 200 CFU/100 mL

Table 8. Non-point Sources of Pollution and Their Potential to Pollute at a Given Flow Regime.

Non-point Sources	Flow Regime		
	High Flow	Moderate Flow	Low Flow
Riparian Area Grazing (Livestock)	H[1]	H	H
Animal Feeding Operations	H	M[1]	L[1]
Manure Application to Crop and Range Land	H	M	L
Intensive Upland Grazing (Livestock)	H	M	L

[1]Potential importance of non-point source area to contribute fecal coliform bacteria loads under a given flow regime rated as H: High; M: Medium; and L: Low.

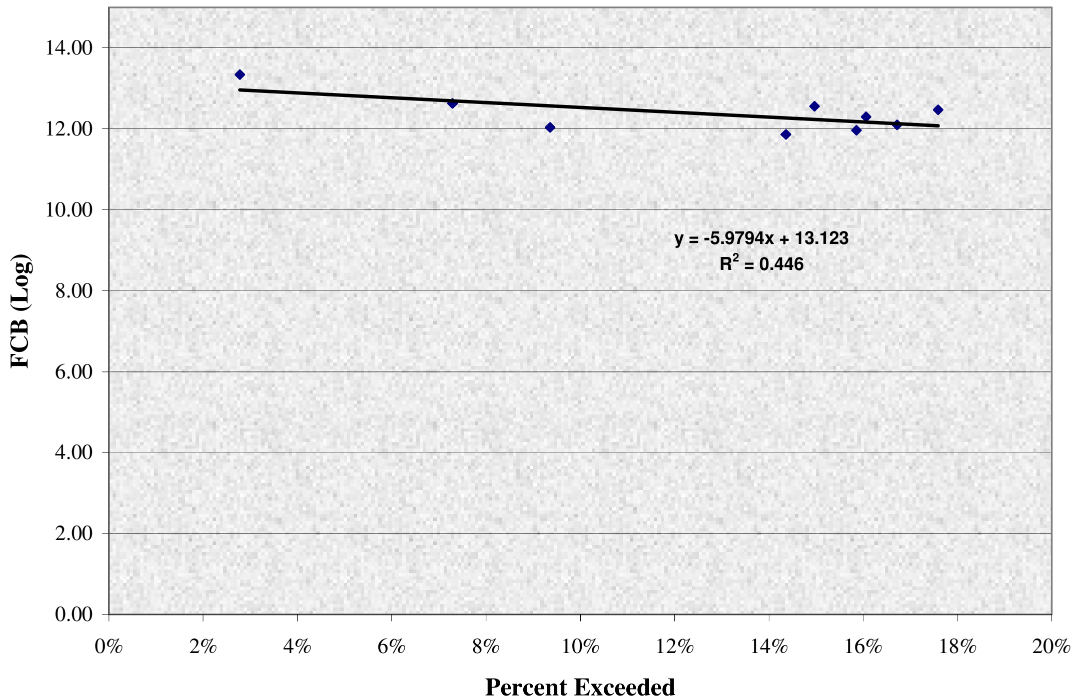

Figure 9. Linear Regression of Points Exceeding the TMDL Target Curve at High Flow.

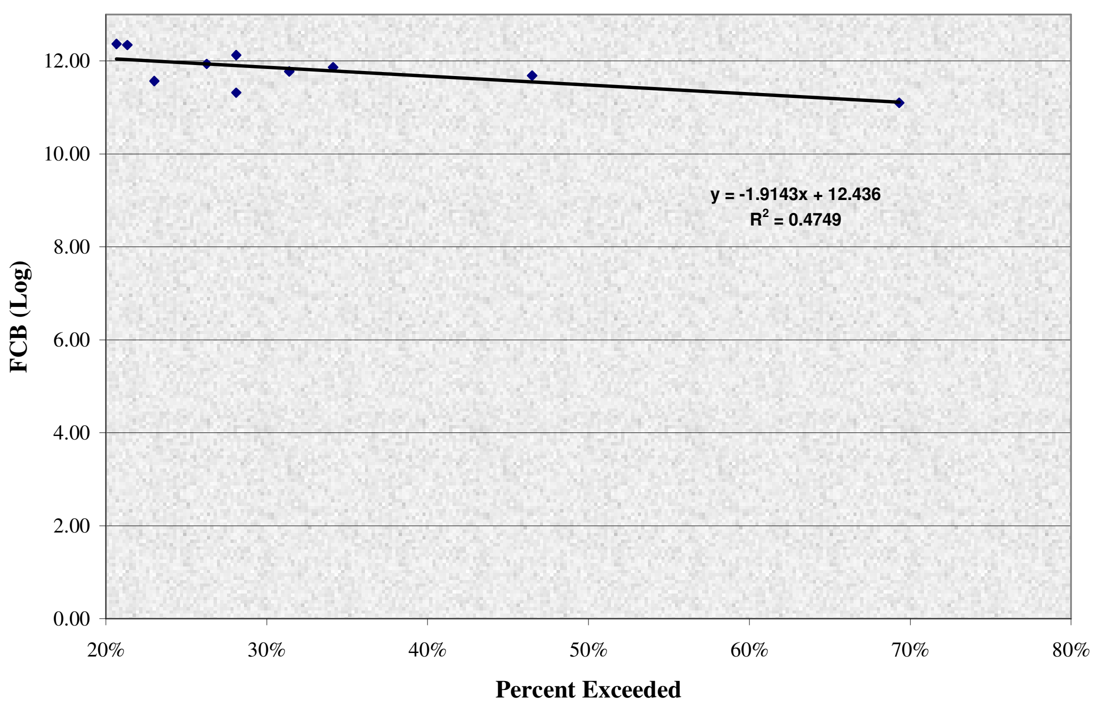

Figure 10. Linear Regression of Points Exceeding the TMDL Target Curve at Moderate Flow.

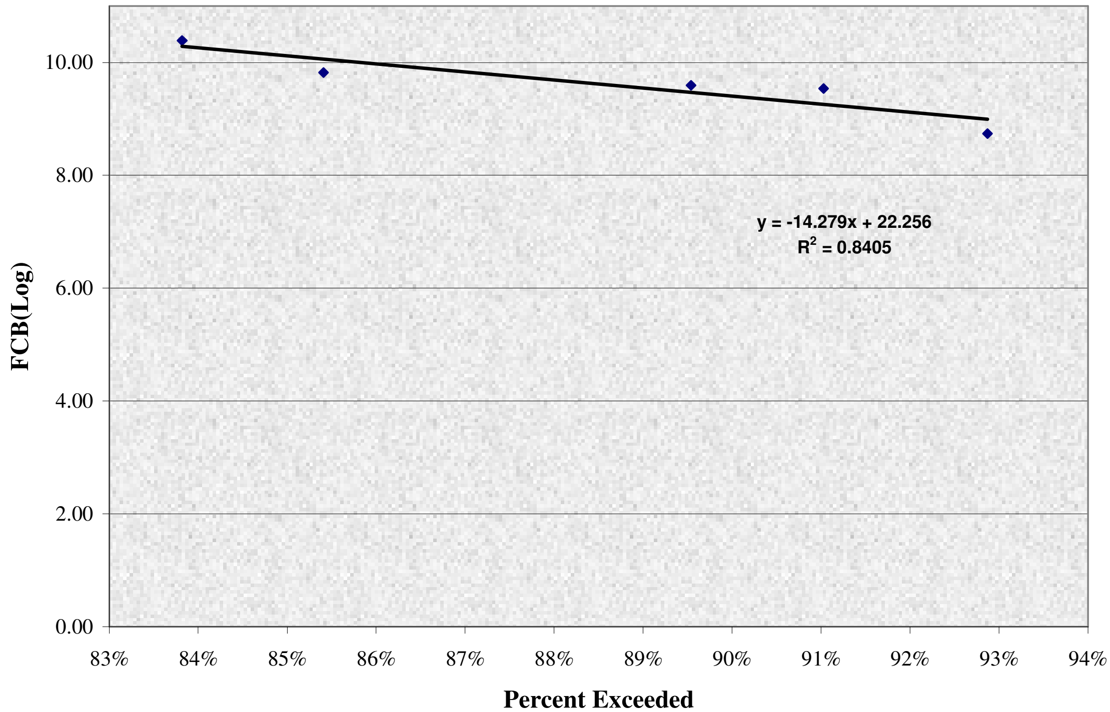

Figure 11. Linear Regression of Points Exceeding the TMDL Target Curve at Low Flow.

The load reductions derived from the Cedar Creek TMDL will also be used for the listed segment of Crooked Creek because of the limited samples collected on Crooked Creek. There are several factors that make this approach appropriate. Crooked Creek is a tributary to Cedar Creek and contributes to the bacteria load in the listed segment of Cedar Creek. The watersheds of Cedar Creek and Crooked Creek have nearly identical land use patterns. Approximately 90 percent of the land use in the Crooked Creek watershed (Sub-watershed 1) is pasture/range (Figure 3, Table 4). In the overall Cedar Creek watershed, pasture/range constitutes 89 percent of the land use (Table 4). The fecal coliform bacteria concentrations at the sites on Crooked Creek and Cedar Creek are fairly similar as far as the percent of samples exceeding 200 CFU/100ml and 400 CFU/100ml (Table 5). The sources of bacteria and the BMPs that will be used to reduce bacteria loading in the two watersheds are identical.

One of the more important concerns regarding non-point sources is variability in stream flows. Variable stream flows often cause different source areas and loading mechanisms to dominate (Cleland, 2003). As previously described, three flow regimes were selected to represent the hydrology of the watershed (Figure 8). In southwest North Dakota, rain events are also variable. Rain events can be sporadic and heavy or light, occurring over a short duration. Precipitation events of large magnitude, occurring at a faster rate than absorption, contribute to high runoff events. These events are represented by runoff in the high flow regime. The moderate flow regime is represented by runoff that contributes to the stream over a longer duration and for a longer period of time. The low flow regime is characteristic of drought or precipitation events of small magnitude that do not contribute to runoff. By relating runoff characteristics to each flow regime one can infer which sources are most likely to contribute to fecal coliform loading. Animals grazing in the riparian area contribute fecal coliform bacteria by depositing manure where it has an immediate impact on water quality. Due to the close proximity of manure to the stream or by direct deposition in the stream, riparian grazing impacts water quality at high, moderate, and low flow (Table 8). In contrast, intensive grazing of livestock in the upland and not in the riparian area has a high potential to impact water quality at high flows, moderate impact at moderate flows, and minimal impact at low flows (Table 8). Exclusion of livestock from the riparian area eliminates the potential of direct manure deposit and therefore is considered to be of greater importance at low flows. However, intensive grazing in the upland creates the potential for manure accumulation and availability for runoff at high flows and a high potential for fecal coliform bacteria contamination. Best professional judgment indicates that the three flow regimes are adequate in identifying source areas and loading mechanisms.

6.0 MARGIN OF SAFETY AND SEASONALITY

6.1 Margin of Safety

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency (EPA) regulations require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety (MOS) can be either incorporated into conservative assumptions used to develop the TMDL (implicit) or added to a separate component of the TMDL (explicit).

To account for the uncertainty associated with known sources and the load reductions necessary to reach the water quality target of 200 CFU/100 mL, a 10 percent explicit margin of safety was used for this TMDL. The margin of safety was calculated as 10 percent of the TMDL. In other words 10 percent of the TMDL is set aside from both the load allocation and the wasteload allocation as a margin of safety. The 10 percent margin of safety was derived by taking 10 percent of the TMDL for each flow regime.

6.2 Seasonality

Section 303(d)(1)(C) of the Clean Water Act and associated regulations require that a TMDL be established with seasonal variations. The Cedar Creek TMDL addresses seasonality because the flow duration curve was developed using 20 years of USGS gauge data encompassing all 12 months of the year. Additionally, the water quality standard is seasonally based on the recreation season from May 1 to September 30 and controls will be designed to reduce coliform loads during the seasons covered by the standard.

7.0 TMDL

Table 9 provides the reader an outline of the critical elements of the Cedar Creek and Crooked Creek TMDL. Table 10 provides a summary of average daily loads necessary to meet the water quality target (i.e. TMDL). This load or TMDL includes a load allocation from known non-point sources, a waste load allocation from known point sources and a margin of safety.

Table 9. TMDL Summary for Cedar Creek and Crooked Creek.

Category	Description	Explanation
Beneficial Use Impaired	Recreation	Contact Recreation (i.e. swimming, fishing)
Pollutant	Fecal Coliform Bacteria	See Section 2.1
TMDL Target	200 CFU/100 mL	Based on North Dakota water quality standards
Significant Sources	Non-point Sources	No Point Sources in Sub-Watershed
Margin of Safety (MOS)	Explicit	10%

The TMDL can be generically described by the following equation:

TMDL = WLA + LA + MOS

Where:

TMDL = Total Maximum Daily Load, or the maximum loading a waterbody can receive without violating water quality standards;
WLA = Wasteload allocation, or the portion of the TMDL allocated to existing or future point sources;
LA = Load allocation, or the portion of the TMDL allocated to existing or future non-point sources; and
MOS = Margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The margin of safety can be provided implicitly through analytical assumptions or explicitly by reserving a portion of the loading capacity.

Based on the "load duration curve" analyses (See Section 5), an average daily load (TMDL) of fecal coliform at high flows is estimated to be 1.457E+12 CFU/day (Table 10). At high flows, the margin of safety is 10 percent of the TMDL or 1.457E+11 CFU/day. Since there are no point sources in the watershed the entire remaining load is allocated to non-point sources. The load allocation is therefore the difference between the TMDL and the 10 percent margin of safety or 1.311E+12 CFU/day. To meet the water quality standard of 200 CFU/100 mL at moderate and low flows, the average daily load (TMDL) allocations are 8.408E+10 and 3.560E+09 CFU/day, respectively. At moderate flows the margin of safety is 10 percent of the TMDL or 8.408E+09 CFU/day and at low flows the margin of safety is 3.560E+08 CFU/day. At moderate and low flows all of the remaining load is also allocated to non-point sources, therefore the load allocation is the difference between the TMDL and the 10 percent margin of safety or 7.567E+10 CFU/day for moderate flows and 3.204E+09 CFU/day for low flows (Table 10).

Table 10. Fecal Coliform Bacteria Loads (expressed as CFU/day) for the Cedar Creek at Site 380077.

	Flow Regime		
	High Flow	**Moderate Flow**	**Low Flow**
Existing Load	4.374E+12	3.947E+11	1.265E+10
TMDL	1.457E+12	8.408E+10	3.560E+09
WLA	0.000E+0	0.000E+0	0.000E+0
LA	1.311E+12	7.567E+10	3.204E+09
MOS	1.457E+11	8.408E+09	3.560E+08

Future monitoring to determine compliance with loads listed in Table 10 is dependent upon financial support and available staff. While limited to 8-9 samples per year, ambient monitoring will be continued at Station 380077 south of Raleigh. Implementation of BMPs necessary to achieve the TMDL will be accomplished through the Environmental Quality Incentive Program (EQIP) and/or the 319 non-point Source Pollution Management Program (319). If 319 is used for implementation, monitoring will be included as a component of the project to document BMP effectiveness. If EQIP is used, NRCS has no requirements to monitor or to document program effectiveness.

8.0 ALLOCATION

All of the non-point source load is allocated as a single load because there is not enough detailed source data to allocate the load to specific non-point sources (e.g., animal feeding, septic systems, riparian grazing, upland grazing). Because there are no known point sources, the entire fecal coliform load for this TMDL was allocated to non-point sources in the watershed. To achieve the TMDL targets identified in the report it will require the wide spread support and voluntary participation of landowners and residents in the immediate watershed as well as those living upstream. The TMDL's described in this report are a plan to improve water quality by implementing best management practices through non-regulatory approaches. "Best management practices (BMPs) are methods, measures, or practices that are determined to be a reasonable and cost effective means for a land owner to meet non-point source pollution control needs," (USEPA, 2001). This TMDL plan is put forth as a recommendation for what needs to be accomplished for Crooked Creek and its tributaries and Cedar Creek from its confluence with Hay Creek downstream to its confluence with the Cannonball River to restore and maintain its recreational uses. It is recommended that as BMPs are implemented to achieve these TMDL targets, water quality monitoring should also be implemented to measure BMP effectiveness and to determine through adaptive management if loading allocation recommendations need to be adjusted.

Non-point source pollution is the sole contributor to elevated fecal coliform bacteria levels to Cedar Creek and Crooked Creek, no point source pollution sources are located within the watershed. Three flow regimes (high flows, moderate flows, and low flows) have been identified for the TMDL. Each flow regime has the capacity to deliver pollutant loads from different sources in the watershed at varying magnitudes. To reduce non-point source pollution for each flow regime, specific BMPs are described that will mitigate the effects of fecal coliform loading to the impaired reach. Table 11 illustrates specific BMPs that when implemented in the watershed and based on specific hydrologic conditions, will result in reducing fecal coliform loading necessary to meet the water quality target.

Table 11. Management Practices and Flow Regimes Affected by Implementation of BMPs.

Management Practice	Flow Regime and Expected Reduction		
	High Flow-70%	Moderate Flow-80%	Low Flow-74%
Livestock Exclusion From Riparian Area	X	X	X
Water Well & Tank Development	X	X	X
Prescribed Grazing	X	X	X
Waste Management System	X	X	
Vegetative Filter Strip		X	
Septic System Repair		X	X

Note: X Denotes potential of management practice to contribute to reduction needed under defined flow regime.

Controlling non-point sources is an immense undertaking requiring extensive financial and technical support. Provided that technical and financial assistance is available to landowners and livestock producers in the Crooked Creek and Cedar Creek watersheds, these BMPs have the potential to significantly reduce fecal coliform loads. The following describe in detail those BMPs listed in Table 11 that will reduce fecal coliform bacteria levels in Cedar Creek and Crooked Creek.

8.1 Livestock Management Recommendations

Livestock management BMPs are designed to promote healthy water quality and riparian areas through management of livestock and associated grazing land. Fecal matter from livestock, erosion from poorly managed grazing, land and riparian areas can be a significant source of fecal coliform bacteria loading to surface water. Precipitation, plant cover, number of animals, and soils are factors that affect the amount of bacteria delivered to a waterbody because of livestock. These specific BMPs are known to reduce non-point source pollution from livestock. These BMPs include:

<u>Livestock exclusion from riparian areas</u> – This practice is established to remove livestock from grazing riparian areas and watering in the stream. Livestock exclusion is accomplished through fencing. A reduction in stream bank erosion can be expected by minimizing or eliminating hoof trampling. A stable stream bank will support vegetation that will hold banks in place and serve a secondary function as a filter from non-point source runoff. Added vegetation will create aquatic habitat and shading for macroinvertebrates and fish. Direct deposit of fecal matter into the stream and stream banks will be eliminated as a result of livestock exclusion by fencing.

<u>Water well and tank development</u> – Fencing animals from stream access requires and alternative water source. Installing water wells and tanks satisfies this need. Installing water tanks provides a quality water source and keeps animals from wading and defecating in streams. This will reduce the probability of pathogenic infections to livestock and the public.

<u>Prescribed grazing</u> – To increase ground cover and ground stability by rotating livestock throughout multiple fields. Grazing with a specified rotation minimizes overgrazing and resulting erosion. The Natural Resources Conservation Service (NRCS) recommends grazing systems to improve and maintain water quality and quantity. Duration, intensity, frequency, and season of grazing can be managed to enhance vegetation cover and litter, resulting in reduced runoff, improved infiltration, increased quantity of soil water for plant growth, and better manure distribution and increased rate of decomposition, (NRCS, 1998). In a study by Tiedemann et al. (1998), as presented by USEPA (1993), the effects of four grazing strategies on bacteria levels in thirteen watersheds in Oregon were studied during the summer of 1984. Results of the study (Table 12) showed that when livestock are managed at a stocking rate of 19 acres per animal unit month, with water developments and fencing, bacteria levels were reduced significantly.

<u>Waste management system</u> – Waste management systems can be effective in controlling up to 90 percent of fecal coliform loading originating from confined animal feeding areas (Table 13). A waste management system is made up of various components designed to control non-point source pollution from concentrated animal feeding operations (CAFOs) and animal feeding operations (AFOs). Diverting clean water from the feeding area and containing dirty water from the feeding area in a pond are typical practices of a waste management system. Manure handling and application of manure is designed to be adaptive to environmental, soil, and plant conditions to minimize the probability of contamination of surface water.

Table 12. Bacterial Water Quality Response to Four Grazing Strategies (Tiedemann et al., 1988).

	Grazing Strategy	Geometric Mean Fecal Coliform Count
Strategy A:	Ungrazed	40/L
Strategy B:	Grazing without management for livestock distribution; 20.3 ac/AUM.	150/L
Strategy C:	Grazing with management for livestock distribution: fencing and water developments; 19.0 ac/AUM.	90/L
Strategy D:	Intensive grazing management, including practices to attain uniform livestock distribution and improve forage production with cultural practices such as seeding, fertilizing, and forest thinning; 6.9 ac/AUM.	950/L

8.2 Other Recommendations

Vegetative filter strip – Vegetated filter strips are used to reduce the amount of sediment, particulate organics, dissolved contaminants, nutrients, and in the case of this TMDL, fecal coliform bacteria to streams. The effectiveness of filter strips and other BMPs in removing fecal coliform bacteria is quite successful. Results from a study by Pennsylvania State University (1992a) as presented by USEPA (1993) (Table 13), suggest that vegetative filter strips are capable of removing up to 55 percent of fecal coliform loading to rivers and streams (Table 13). The ability of the filter strip to remove contaminants is dependent on field slope, filter strip slope, erosion rate, amount and particulate size distribution of sediment delivered to the filter strip, density and height of vegetation, and runoff volume associated with erosion producing events (NRCS, 2001).

Septic System – Septic systems provide an economically feasible way of disposing of household wastes where other means of waste treatment are unavailable (e.g., public or private treatment facilities). The basis for most septic systems involves the treatment and distribution of household wastes through a series of steps involving the following:

1. A sewer line connecting the house to a septic tank
2. A septic tank that allows solids to settle out of the effluent
3. A distribution system that dispenses the effluent to a leach field
4. A leaching system that allows the effluent to enter the soil

Septic system failure occurs when one or more components of the septic system do not work properly and untreated waste or wastewater leaves the system. Wastes may pond in the leach field and ultimately run off directly into nearby streams or percolate into groundwater. Untreated septic system waste is a potential source of nutrients (nitrogen and phosphorus), organic matter, suspended solids, and fecal coliform bacteria. Results from DNA fingerprinting of E. coli indicate that the furthest downstream monitoring station (380077) on the Cedar Creek contained E. coli of human origin (Table 7). Failing septic systems are the most likely source of human E. coli in the Cedar Creek. Land application of septic system sludge, although unlikely, may also be a source of contamination.

Table 13. Relative Gross Effectiveness[a] of Confined Livestock Control Measures (Pennsylvania State University, 1992a).

Practice[b] Category	Runoff[c] Volume	Total[d] Phosphorus (%)	Total[d] Nitrogen (%)	Sediment (%)	Fecal Coliform (%)
Animal Waste System[e]	-	90	80	60	85
Diversion System[f]	-	70	45	NA	NA
Filter Strips[g]	-	85	NA	60	55
Terrace System	-	85	55	80	NA
Containment Structures[h]	-	60	65	70	90

NA = Not Available
a Actual effectiveness depends on site-specific conditions. Values are not cumulative between practice categories.
b Each category includes several specific types of practices.
c - = reduction; + = increase; 0 = no change in surface runoff.
d Total phosphorus includes total and dissolved phosphorus; total nitrogen includes organic-N, ammonia-N, and nitrate-N
e Includes methods for collecting, storing, and disposing of runoff and process-generated wastewater.
f Specific practices include diversion of uncontaminated water from confinement facilities.
g Includes all practices that reduce contaminant losses using vegetative control measures.
h Includes such practices as waste storage ponds, waste storage structures, waste treatment lagoons.

Septic system failure can occur for several reasons, although the most common reason is improper maintenance (e.g. age, inadequate pumping). Other reasons for failure include improper installation, location, and choice of system. Harmful household chemicals can also cause failure by killing the bacteria that digest the waste.

Results from "DNA Fingerprinting" analysis indicates that loads from onsite wastewater treatment systems are a potential source of bacteria in the Cedar Creek watershed. While the number of systems that are not functioning properly is unknown, it is estimated that 28 percent of the systems in North Dakota are failing (USEPA, 2002). Based on the age of most residences in the Cedar Creek watershed, it is reasonable to assume that this rate is even higher in the Cedar Creek watershed.

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for Cedar Creek and Crooked Creek and a request for comment was mailed to participating agencies, partners, and to those who request a copy. Those included in the mailing of a hard copy included the following:

- Cedar (Sioux County) Soil Conservation District;
- U.S. Environmental Protection Agency, Region VIII;
- Grant County Soil Conservation District;
- Grant County Water Resource Board;
- Natural Resources Conservation Service (State Office and Grant and Sioux County Field Offices);
- Standing Rock Sioux Tribe, Department of Water Resources; and
- U.S. Fish & Wildlife Service.

In addition to mailing copies of this TMDL for Cedar Creek and Crooked Creek to interested parties, the TMDL was been posted on the North Dakota Department of Health, Division of Water Quality web site. A 30 day public notice soliciting comment and participation was also published in the following newspapers:

- Carson Press;
- Grant County News; and
- The Bismarck Tribune.

Other than receipt of EPA Region 8's informal TMDL review form, no comments were received on this TMDL report. A copy of the EPA Region 8 review form is provided in Appendix B.

10.0 MONITORING

To insure that BMPs implemented as part of any watershed restoration plan will reduce fecal coliform loadings to levels prescribed in this TMDL, water quality monitoring will be conducted in accordance with an approved Quality Assurance Project Plan (QAPP). Specifically, monitoring will be conducted for fecal coliform and E. coli. Once a watershed restoration plan (e.g., Section 319 Project Implementation Plan) is implemented, monitoring will be conducted on Cedar Creek and Crooked Creek beginning one year after implementation and extending 1 year after the implementation project is complete.

11.0 TMDL IMPLEMENTATION STRATEGY

Implementation of TMDLs is dependent upon the availability of Section 319 NPS funds and/or other watershed restoration programs (e.g. USDA Environmental Quality Incentive Program), as well as securing a local project sponsor and the required matching funds. Provided these three requirements are in place, a project implementation plan (PIP) is developed in accordance with the TMDL and submitted to the ND Nonpoint Source Pollution Task Force and the US EPA for approval. The implementation of the BMPs contained in the NPS pollution PIP is voluntary. Therefore, success of any TMDL implementation project is ultimately dependent on the producers in the watershed to voluntarily implement BMPs needed to meet the TMDL goal.

Monitoring is an important and required component of any PIP. As a part of the PIP, data are collected to monitor and track the effects of BMP implementation as well as to judge overall project success. Quality Assurance Project Plans (QAPPs) detail the strategy of how, when, and where monitoring will be conducted to gather the data needed to document the TMDL implementation goal(s). As data are gathered and analyzed, watershed restoration tasks are adapted to place BMPs where they will have the greatest benefit to water quality.

12.0 ENDANGERED SPECIES ACT COMPLIANCE

The North Dakota Department of Health has reviewed the list of Threatened and Endangered Species in Grant County as provided by the US Fish and Wildlife Service (Appendix A). Although there are listed species present in Grant, Morton and Sioux Counties, they are not dependent on the waterbodies that are targeted by this TMDL. It is therefore, the Department's best professional judgment that the Cedar Creek and Crooked Creek TMDL poses "No Adverse Effect" to those Threatened and Endangered species listed by the US Fish and Wildlife Service.

As mentioned in Section 9.0, the US Fish and Wildlife Service was sent a copy of this document for their review during the public comment period. No comments were received from the US Fish and Wildlife

Service, therefore we assume they concur with our assessment of "No Adverse Effect" to those Threatened and Endangered species listed for Sioux, Grant and Morton Counties.

13.0 REFERENCES

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Appendix A
Office Transmittal Received from the US Fish and Wildlife Service
and
List of Threatened and Endangered Species and Designated Critical Habitat

U.S. FISH & WILDLIFE SERVICE
3425 MIRIAM AVENUE
BISMARCK ND 58501

Received 12-13-04

OFFICE TRANSMITTAL

TO: Mark A. Glaser
ND Department of Health
Dickinson, ND

☐ ACTION
☑ INFORMATION

FROM: Kevin Johnson DIVISION: Ecological Services DATE: 12-8-04

Information you requested.

Office Transmittal Received from U.S. Fish & Wildlife Service.

FEDERAL THREATENED AND ENDANGERED SPECIES
AND DESIGNATED CRITICAL HABITAT FOUND IN
GRANT, MORTON, AND SIOUX COUNTIES, NORTH DAKOTA

ENDANGERED SPECIES

Birds

Interior least tern (Sterna antillarum): Nests along midstream sandbars of the Missouri and Yellowstone Rivers. (Morton and Sioux counties)

Whooping crane (Grus Americana): Migrates through west and central counties during spring and fall. Prefers to roost on wetlands and stockdams with good visibility. Young adult summered in North Dakota in 1989, 1990, and 1993. Total population 140-150 birds. (Grant, Morton, and Sioux counties)

Fish

Pallid sturgeon (Scaphirhynchus albus): Known only from the Missouri and Yellowstone Rivers. No reproduction has been documented in 15 years. (Morton and Sioux counties)

Mammals

Black-footed ferret (Mustela nigripes): Exclusively associated with prairie dog towns. No records of occurrence in recent years, although there is potential for reintroduction in the future. (Grant, Morton and Sioux counties)

THREATENED SPECIES

Birds

Bald eagle (Haliaeetus leucocephalus): Migrates spring and fall statewide but primarily along the major river courses. It concentrates along the Missouri River during winter and is known to nest in the floodplain forest. (Grant, Morton and Sioux counties)

Piping plover (Charadrius melodus): Nests on midstream sandbars of the Missouri and Yellowstone Rivers and along shorelines of saline wetlands. More nest in North Dakota than any other state. (Morton and Sioux counties)

DESIGNATED CRITICAL HABITAT

Birds

Piping Plover - Missouri River - Critical habitat includes sparsely vegetated channel sandbars, sand and gravel beaches on islands, temporary pools on sandbars and islands, and the interface with the river. (Morton and Sioux counties)

Piping Plover - Lake Sakakawea and Oahe - Critical habitat includes sparsely vegetated shoreline beaches, peninsulas, islands composed of sand, gravel, or shale, and their interface with the water bodies. (Morton and Sioux counties)

Threatened and Endangered Species List and Designated Critical Habitat.

Appendix B
EPA REGION 8 TMDL REVIEW FORM

Document Name:	**Cedar Creek and Crooked Creek Bacteria TMDL**
Submitted by:	**Mike Ell, NDDoH**
Date Received:	**December 4, 2007**
Review Date:	**December 28, 2007**
Reviewer:	**Vern Berry, EPA**
Formal or Informal Review?	**Informal – Public Notice**

This document provides a standard format for EPA Region 8 to provide comments to the North Dakota Department of Health (NDDoH) on TMDL documents provided to the EPA for either official formal or informal review. All TMDL documents are measured against the following 12 review criteria:

1. Water Quality Impairment Status
2. Water Quality Standards
3. Water Quality Targets
4. Significant Sources
5. Technical Analysis
6. Margin of Safety and Seasonality
7. Total Maximum Daily Load
8. Allocation
9. Public Participation
10. Monitoring Strategy
11. Restoration Strategy
12. Endangered Species Act Compliance

Each of the 12 review criteria are described below to provide the rational for the review, followed by EPA's comments. This review is intended to ensure compliance with the Clean Water Act and also to ensure that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Water Quality Impairment Status

Criterion Description – Water Quality Impairment Status
TMDL documents must include a description of the listed water quality impairments. While the 303(d) list identifies probable causes and sources of water quality impairments, the information contained in the 303(d) list is generally not sufficiently detailed to provide the reader with an adequate understanding of the impairments. TMDL documents should include a thorough description/summary of all available water quality data such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and/or appropriate water quality standards.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The Cedar Creek watershed covers approximately 1,787 square miles in southwest North Dakota and is part of the Missouri River basin. The towns of Bowman and Hettinger are the largest population centers in the area. Cedar Creek originates in Slope County and flows southeast through Bowman, Adams, Grant and Sioux Counties before it joins the Cannonball River 18 miles south of Raleigh, North Dakota. Norht Dakota's 2006 303(d) list includes a 40.3 mile segment of Cedar Creek (from confluence with Hay Creek to confluence with Cannonball River; ND-10130205-001-S_00) and a 40.68 mile segment of Crooked Creek (ND-10130205-006-S_00) as impaired for recreational use by fecal coliform bacteria. Crooked Creek is a tributary of Cedar Creek. The listed segment of Cedar Creek is a Class II stream and a medium priority (i.e., 2) for TMDL development, and the listed segment of Crooked Creek is a Class III stream and a high priority (i.e., 1A) for TMDL development. The majority of the land use in this watershed is agricultural. Approximately 89 percent of the sub-watershed is pasture or rangeland – primarilly livestock (cow-calf) production. Another 4 percent of the sub-watershed consists of small grain crops such as wheat, oats and barley. Another 4 percent of the land in the sub-watershed is in South Dakota where the landuse is unknown. The remaining landuses include roads, water, and woods.

2. Water Quality Standards

Criterion Description – Water Quality Standards
The TMDL document must include a description of all applicable water quality standards for all affected jurisdictions. TMDLs result in maintaining and attaining water quality standards. Water quality standards are the basis from which TMDLs are established and the TMDL targets are derived, including the numeric, narrative, use classification, and antidegradation components of the standards.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The listed segments of Cedar Creek and Crooked Creek are impaired for fecal coliform bacteria. The North Dakota Department of Health has set narrative water quality standards that apply to all surface waters of the state. The NDDoH narrative standards include:

"All waters of the state shall be free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to humans, animals, plants, or resident aquatic biota." (See NDAC 33-16-02-08.1.a.(4))

"No discharge of pollutants, which alone or in combination with other substances, shall:
1. Cause a public health hazard or injury to environmental resources;
2. Impair existing or reasonable beneficial uses of the receiving waters; or
3. Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters." (See NDAC 33-16-02-08.1.e.)

In addition to the narrative standards, the NDDH has set a biological goal for all surface waters of the state:
"The biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites." (See NDAC 33-16-02-08.2.a.)

The North Dakota numeric standards for fecal coliform for these stream segments are: 200 cfu/100 mL (geometric mean of representative samples collected during any consecutive 30-day period) and 400 cfu/100 mL (maximum – no more than 10% of samples collected during any consecutive 30-day period shall individually exceed the standard). The fecal coliform standard applies only during recreation season from May 1 to September 30 each year.

Other applicable water quality standards are discussed on pages 8 - 9 of the TMDL.

3. Water Quality Targets

Criterion Description – Water Quality Targets

Quantified targets or endpoints must be provided to address each listed pollutant/water body combination. Target values must represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the TMDL target. For pollutants with narrative standards, the narrative standard must be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include targets representing water column sediment such as TSS, embeddedness, stream morphology, up-slope conditions and a measure of biota).

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☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The main water quality target for this TMDL is based on the numeric fecal coliform standards. Both Cedar Creek and Crooked Creek, including its tributaries, are impaired because of fecal coliform bacteria. Cedar Creek is fully supporting, but threatened, and Crooked Creek is not supporting beneficial uses because fecal coliform counts exceed the North Dakota water quality standard. The North Dakota water quality standard for fecal coliform bateria is a geometric mean concentration of 200 cfu/100 mL during the recreation season from May 1 to September 30. Therefore, the target for this TMDL is 200 cfu/100 mL. In addition, no more than 10 percent of samples collected for fecal coliform should exceed 400 cfu/100 mL.

The water quality target used in this TMDL is: **maintain a geometric mean fecal coliform concentration of 200 cfu/100 mL from May 1 to September 30, and no more than 10 percent of the samples collected should exceed 400 cfu/100 mL.**

4. Significant Sources

Criterion Description – Significant Sources
TMDLs must consider all significant sources of the stressor of concern. All sources or causes of the stressor must be identified or accounted for in some manner. The detail provided in the source assessment step drives the rigor of the allocation step. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source when the relative load contribution from each source has been estimated. Ideally, therefore, the pollutant load from each significant source should be quantified. This can be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach can be employed so long as the approach is clearly defined in the document.

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SUMMARY – The TMDL identifies the major sources of fecal coliform as coming from nonpoint source agricultural landuses within the watershed. There are no known point source contributions in this watershed. Cropland and pastureland are the primary sources identified. Approximately 89 percent of the sub-watershed is pasture or rangeland – primarilly livestock (cow-calf) production. Another 4 percent of the sub-watershed consists of small grain crops such as wheat, oats and barley. Another 4 percent of the land in the sub-watershed is in South Dakota where the landuse is unknown. The remaining landuses include roads, water, and woods. NDDoH identified 7 animal feeding operations of 100 to 1000 animals and 4 animal feeding operations with fewer than 100 animals located in the riparian area or in a location where pollution from livestock waste is certain in the watershed. Another 2 animal feeding operations were identifed with fewer than 100 animals located near the Cedar Creek thought to contribute moderate amount of pollution from livestock. Additional, unidentified animal feeding operations may exist in the watershed.

5. Technical Analysis

Criterion Description – Technical Analysis
*TMDLs must be supported by an appropriate level of technical analysis. It applies to **<u>all</u>** of the components of a TMDL document. It is vitally important that the technical basis for **<u>all</u>** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader. Of particular importance, the cause and effect relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and allocations needs to be supported by an appropriate level of technical analysis.*

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SUMMARY – The technical analysis addresses linkage between the water quality target and the identified sources of fecal coliform bacteria, and describes the models or methods used to derive the TMDL loads that will ensure that the water quality standards are met. To determine the cause and effect relationship between the water quality target and the identified sources, the load duration curve methodology was used.

A hydrograph or flow duration curve for Cedar Creek was devleoped by generating a flow frequency table using daily stream flow data over a 20 year period (1983-2002) and plotting the points as a flow duration curve. To better characterize the hydrograph of the listed stream segment a load duration curve was derived for a monitoring site located south of Raleigh, ND. The load duration curve was derived for this site using the 200 cfu/100 mL fecal coliform water quality standard. Observed in-stream fecal coliform bateria concentration data collected at the monitoring site were converted to pollutant loads by multiplying concentrations by the flow and a conversion factor. These loads were plotted on the load duration curve graph. Points plotted above the 200 cfu/100 mL target curve exceeded the water quality target. The curve was separated into three different flow regimes to facilitate the potential loading sources within each regime.

The load reductions derived from the Cedar Creek TMDL will also be used for the listed segment of Crooked Creek because of the limited samples collected on Crooked Creek. This approach is appropritate for several reasons: 1) Crooked Creek is a tributary to Cedar Creek and contributes to the bacteria load in the listed segment of Cedar Creek; 2) the Cedar Creek and Crooked Creek watersheds have nearly identical land use patterns; 3) the percent of samples exceeding the water quality standard are similar for both creeks; and 4) the sources of bacteria and the BMPs that will be used to reduce bacteria loading in the two watersheds are identical.

COMMENTS – The use of one load duration curve to address 2 listed segments seems acceptable in this instance given the lack of data in Crooked Creek. In the future we hope that watershed assessments will be designed to collect adequate sample datasets to derive separate load duration curves for each listed segment.

EPA Region 8 is working to improve our knowledge of the load duration curve approach developed by Bruce Cleland as supported by the recently released guidance document (http://www.epa.gov/owow/tmdl/duration_curve_guide_aug2007.pdf). We also plan on comparing that guidance/knowledge to the load duration curve approaches used by the Region 8 states. Once the analysis is complete we plan on developing some Regional suggestions on the use of load duration curves to achive better consistency between the states. This may result in suggested changes to parts of North Dakota's load duration curve approach. In particular we plan to look at ND's use of the linear regression lines to derive the existing loads and the load reduction goals used to guide implementation efforts.

6. Margin of Safety and Seasonality

Criterion Description – Margin of Safety and Seasonality

A margin of safety (MOS) is a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (303(d)(1)(c)). The MOS can be implicitly expressed by incorporating a margin of safety into conservative assumptions used to develop the TMDL. In other cases, the MOS can be built in as a separate component of the TMDL (in this case, quantitatively, a TMDL = WLA + LA + MOS). In all cases, specific documentation describing the rational for the MOS is required.

Seasonal considerations, such as critical flow periods (high flow, low flow), also need to be considered when establishing TMDLs , targets, and allocations.

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SUMMARY – To account for the uncertainty associated with known sources and the load reductions necessary to reach the water quality target of 200 cfu/100 mL, a 10% explicit margin of safety is included in the TMDL. The 10% margin of safety was derived by taking 10% of the TMDL load for each flow regime.

Seasonality was adequately addressed in the load duration curve approach which used 20 years of flow data covering all 12 months of the year. Also, the water quality standard is seasonally based on the recreation season from May 1 to September 30 and controls will be designed to reduce fecal coliform loads during the seasons covered by the standard.

7. TMDL

Criterion Description – Total Maximum Daily Load

TMDLs include a quantified pollutant reduction target. According to EPA regulations (see 40 CFR 130.2(i)). TMDLs can be expressed as mass per unit of time, toxicity, % load reduction, or other measure. TMDLs must address, either singly or in combination, each listed pollutant/water body combination.

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SUMMARY – The TMDL established for Cedar Creek is based on the load duration curve described in the Technical Analysis section. This approach uses three flow regimes for the TMDL – high flow, moderate flow and low flow. The fecal coliform TMDL loads are 1.457E+12 cfu/day, 8.408E+10 cfu/day, and 3.560E+09 cfu/day for high, moderate and low flow respectively.

8. Allocation

Criterion Description – Allocation

TMDLs apportion responsibility for taking actions or allocate the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or dividing of responsibility. A performance based allocation approach, where a detailed strategy is articulated for the application of BMPs, may also be appropriate for nonpoint sources. Every effort should be made to be as detailed as possible and also, to base all conclusions on the best available scientific principles.

In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

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SUMMARY – This TMDL addresses the need to achieve reductions in fecal coliform bacteria loads to attain water quality goals in Cedar Creek and Crooked Creek. The allocations in the TMDL include a “load allocation” attributed agricultural to nonpoint sources, and an explicit margin of safety. There are no known point source contributions in this watershed. All of the nonpoint source load is allocated as a single load because there is not enough detailed source data to allocate the load to specific nonpoint sources. Three flow regimes have been identified for the TMDL and each regime has the capacity to deliver pollutant loads from different sources in the watershed at varying magnitudes. To reduce nonpoint source pollution for each flow regime, specific BMPs are described in the TMDL that will mitigate the effects of fecal coliform loading to the impaired stream segments. Section 8.0 of the TMDL describes the specific BMPs in more detail.

9. Public Participation

Criterion Description – Public Participation

The fundamental requirement for public participation is that all stakeholders have an opportunity to be part of the process. Notifications or solicitations for comments regarding the TMDL should clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for review, a copy of the comments received by the state should be also submitted to EPA..

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SUMMARY – The TMDL includes a summary of the public participation process that has occurred. It describes the opportunities the public had to be involved in the TMDL development process. Copies of the draft TMDL were mailed to stakeholders in the watershed during public comment. Also, the draft TMDL was posted on NDoDH's Water Quality Division website, and a public notice for comment was published in three newspapers.

10. Monitoring Strategy

Criterion Description – Monitoring Strategy

TMDLs may have significant uncertainty associated with selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL documents to articulate the means by which the TMDL will be evaluated in the field, and to provide supplemental data in the future to address any uncertainties that may exist when the document is prepared.

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SUMMARY – Future monitoring is recommended in Section 10.0 of the TMDL to address margin of safety and seasonality needs, as well as provide additional data to ensure that the goals of the TMDL are met.

11. Restoration Strategy

Criterion Description – Restoration Strategy
At a minimum, sufficient information should be provided in the TMDL document to demonstrate that if the TMDL were implemented, water quality standards would be attained or maintained. Adding additional detail regarding the proposed approach for the restoration of water quality <u>*is not*</u> *currently a regulatory requirement, but is considered a value added component of a TMDL document.*

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SUMMARY – The North Dakota Department of Health will work with the local soil conservation district, local volunteer groups and landowners to initiate restoration projects in the watershed.

12. Endangered Species Act Compliance

Criterion Description – Endangered Species Act Compliance
EPA's approval of a TMDL may constitute an action subject to the provisions of Section 7 of the Endangered Species Act (ESA). EPA will consult, as appropriate, with the US Fish and Wildlife Service (USFWS) to determine if there is an effect on listed endangered and threatened species pertaining to EPA's approval of the TMDL. The responsibility to consult with the USFWS lies with EPA and is not a requirement under the Clean Water Act for approving TMDLs. States are encouraged, however, to participate with USFWS and EPA in the consultation process and, most importantly, to document in its TMDLs the potential effects (adverse or beneficial) the TMDL may have on listed as well as candidate and proposed species under the ESA.

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SUMMARY – NDDoH will coordinate with the USFWS on potential impacts of this TMDL on endangered and threatened species.