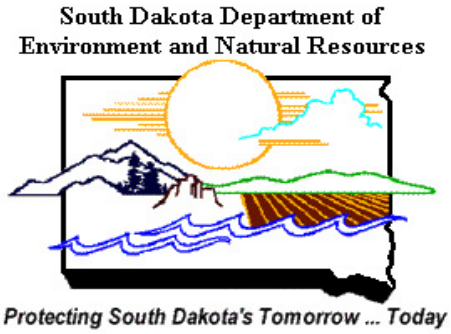
Pathogen Total Maximum Daily Load (TMDL) for Long Creek in Lincoln, Minnehaha, and Turner Counties South Dakota



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Total Maximum Daily Load Summary
Long Creek of the Vermillion River Basin - Segments R3 (SD-VM-R-LONG_01)

Waterbody Type:	River/Stream
Reach Number:	Segment R3: SD-VM-R-LONG_01
303(d) Listing Parameter:	Pathogens (*Escherichia coli* and fecal coliform)
Designated Uses of Concern:	Limited Contact Recreation Waters
Size of Impaired Waterbody:	Segment R3 - Approximately 34.7 km in length Entire length – Approximately 81.1 km in length
Size of Watershed:	Segment R3 - 50,266.7 hectares (ha) Entire Subwatershed Size - 50,266.7 ha
Indicator(s):	Concentration of fecal coliform and *Escherichia coli* (colony forming units per 100ml)
Analytical Approach:	Bacteria Source Load Calculator (Ver 3.0) with Load Duration Curve Framework
Location:	Hydrologic Unit Codes (12-digit HUC): 101701021001
TMDL Priority Ranking:	Priority 1 (2010 IR)
Target (Water Quality Standards):	*Escherichia coli* - Maximum daily concentration of ≤ 1,178 CFUs/100mL and a geometric mean of < 630 based on a minimum of five (5) samples obtained during separate 24-hour periods for any 30-day period. Fecal coliform - Maximum daily concentration of ≤ 2,000 CFU/100mL and a geometric mean of < 1,000 based on a minimum of five (5) samples obtained during separate 24-hour periods for any 30-day period and they may not exceed this value in more than 20 percent of the samples examined in this same 30-day period. These criteria apply from May through September.

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	E. Coli (cfu/day)	Fecal Coliform (cfu/day)
High Flow Zone LA	3.61×10^{12}	5.66×10^{12}
High Flow Zone WLA	7.04×10^{10}	1.20×10^{11}
High Flow Zone MOS	4.09×10^{11}	6.42×10^{11}
High Flow Zone TMDL	4.09×10^{12}	6.42×10^{12}

1.0 Objective

The intent of this document is to clearly identify the components of the TMDL, support adequate public participation, and facilitate the US Environmental Protection Agency (US EPA) review. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by US EPA. This TMDL document addresses the pathogen impairment for the only segment of Long Creek in the Vermillion River Basin: Segment R3 (Vermillion River to State Highway 44) has been assigned a priority category 1 (high-priority) in the 2012 impaired waterbodies list.

2.0 Watershed Characteristics

2.1 General

The project area for Segment R3 of Long Creek is shown in Figure 1. Long Creek, which is located in the Vermillion River Basin, drains approximately 124,211.7 total acres (194.1 miles^2) in southeastern South Dakota (SD). It encompasses three classified segments. The first segment (Segment R3) runs from the Vermillion River four miles north of Centerville, SD and 1.5 miles to Highway 44 in Lennox, SD. The second segment runs from SD Highway 44 to 276th St in Turner County (see accompanying table). The final segment runs from 276th St. in Turner County north into southwestern Minnehaha County and has been assigned only the Beneficial Uses 9 and 10, which are described below. Segment R3 is the only segment of Long Creek that is subject to this TMDL.

Segment R3 of Long Creek within the Vermillion River Basin is currently classified with the following beneficial uses:

Chapter 74:51:03:01 of the South Dakota Administrative Rules assigns all streams in South Dakota the beneficial uses of:

> *Beneficial Use Classification 9: Fish and wildlife propagation, recreation, and stock watering waters*
> *Beneficial Use Classification 10: Irrigation waters*

Chapter 74:51:03:25 of the South Dakota Administrative Rules assigns the following additional beneficial use classifications to the East Fork of the Vermillion River from the Vermillion River to the McCook-Lake County Line:

> *Beneficial Use Classification 5: Warmwater semipermanent fish life propagation waters*
> *Beneficial Use Classification 6: Warmwater marginal fish life propagation waters*
> *Beneficial Use Classification 8: Limited contact recreation waters*

This reach (Segment R3) is only 21.7 miles in length running from the Vermillion River to the Highway 44 just south of Lennox, SD. Only small intermittent tributaries merge with Long Creek prior to its confluence with the Vermillion River near Centerville, SD (Figure 1).

The Vermillion River watershed is located along the boundary between the James River Lowland and the Prairie Coteau Level IV ecoregions which are both part of the greater Northern Glaciated Plains. A flat to gently rolling landscape composed of glacial drift characterizes the Northern Glaciated Plains ecoregion. This ecoregion is also characterized by dense concentrations of temporary and seasonal wetlands. Native grasses include Eastern wheatgrass, green needlegrass, big bluestem, and blue grama but most areas are extensively tilled to corn and soybeans interspersed with pastureland (Bryce et al., 1996 and Chapman et al., 2001). Wildlife species present in the area include whitetail deer, red fox, beavers, raccoons, ring-necked pheasants, mourning doves, and numerous other species of songbirds, waterfowl, reptiles, and amphibians (SD Game, Fish, and Parks, 2002).

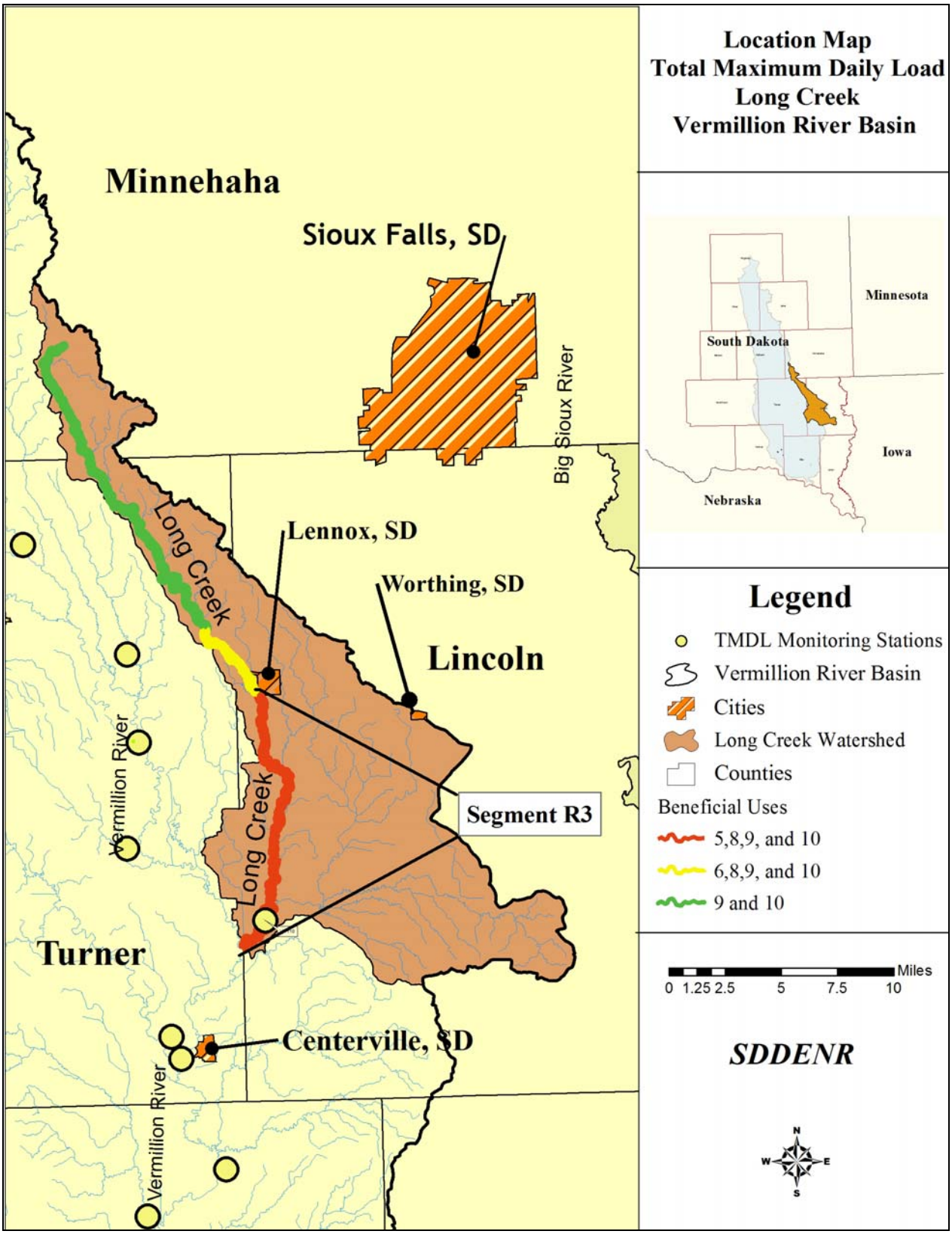

Figure 1. Location of Segment R3, Long Creek of the Vermillion River (South Dakota).

Table 1. Long Creek of the Vermillion River Assessment, Reach and Segment Designations.

Segment	MAPID (2012 IR)	Length miles	Description	South Dakota Monitoring Stations for Mainstem River	
				Mainstem Sites	Tributary Sites
SD-VM-R-LONG_01	R3	21.7	Vermillion River to SD Highway 44 near Lennox, SD		VRT10

Livestock uses are also a significant landuse type within this watershed. During the animal feeding operation (AFO) inventory conducted during the Vermillion River Basin Watershed Assessment, 34 AFOs were found within 500 meters of Long Creek. Each one of the operations was ranked by the Agricultural Nonpoint Source Computer Model (AGNPS). Twenty two or 65% of the AFOs exhibited an AGNPS rating of 50 or greater.

The impaired reach of Long Creek lies within west central Lincoln County (Figure 1). Silty soil associations formed in glacial drift and till on the uplands include Wentworth-Chancellor, Egan-Chancellor, Chancellor-Wakonda-Tetonka associations. Silty and loamy soils formed in alluvium on bottom lands include Lamo-Bon-Clamo and Delmont-Graceville-Talmo associations (NRCS, 1974).

There are two communities (Lennox and Worthing, SD) within the Long Creek watershed each requiring a waste load allocation (WLA). There is also an ethanol plant within the Long Creek watershed located near Chancellor, SD. A WLA is not required for this plant as it does not emit any pathogens and surface water discharge permit (NPDES) parameters do not outline the monitoring of pathogens as part of the permit conditions.

The Vermillion River basin has a subhumid, continental climate characterized by pronounced seasonal differences in temperature, precipitation, and other climatic variables. Temperature varies slightly from the northern to the southern end of the basin. Annual temperatures are slightly cooler at the northern parts of the basin. January is typically the coldest month (13^{o}F in the north and 19^{o}F in the south). July is typically the warmest month (73^{o}F in the north and 75^{o}F in the south). Figure 1 shows that Long Creek watershed is located in the east central part of the Vermillion River Basin.

The frost free days at the northern end of the basin are typically from May 17th to September 21st, while the southern frost free days are from May 4th to October 5th. The average annual precipitation in the watershed is somewhat variable, both spatially and temporally, ranging from 22 to 26 inches Generally, average annual precipitation decreases as you move north within the study watershed. Average seasonal snowfall for this region is approximately 30 inches.

The average rainfall for Lincoln County, where most of the watershed resides, is approximately 24 inches per year with 76% falling during the April through September. The average annual snowfall is approximately 34 inches but varies widely from year to

year (NRCS, 1974). As shown on Figure 1 and Table 1, there was only one TMDL monitoring station located within the Long Creek watershed.

Although Long Creek is approximately 56.8 miles in length, the water quality standards (Beneficial Uses 5,8,9,10) only apply from the Vermillion River (just north of Centerville, SD) to Highway 44 (just south of Lennox, SD) which is approximately 21.7 miles long (Figure 1, Table 1). The data used to determine impairment included one TMDL station installed as part of the overall Vermillion River Basin Watershed Assessment. The water quality data for the period 2004-2011 indicated Segment R3 (2012 IR) was impaired via pathogens and could not support the limited contact recreational use.

Although South Dakota has recently adopted *Escherichia coli* criteria for the protection of the limited contact and immersion recreation uses, the data collected from Long Creek Segment R3 indicated fecal coliform was the only parameter of concern.

Segment SD-VM-R-LONG_01 (Segment R3, 2012IR) was first listed in 2008 as impaired for the limited contact recreation (pathogens). The two latest IR reports (2010 and 2012), show non-support of the limited contact use due to fecal coliform bacteria. This TMDL will address this fecal coliform and *E. coli* bacteria impairment for this segment only.

Land use/land cover, livestock, wildlife, septic tanks and sewerage systems are a determinant in identifying and quantifying sources of pathogens within a watershed. Table 2 shows the significant percentages of 11-land use categories taken from the 2001 National Land Cover Data set (NLCD, 2001) for the Long Creek Watershed in the Vermillion River Basin.

Table 2. Landuse for the East and West Forks of the Vermillion River.

NLCD (2001 National Land Cover Data Set)	**Long Creek**
11-Open Water	**0.3%**
21-Developed, Open Space	**5.1%**
22-Developed, Low Intensity	**0.4%**
23-Developed, Medium Intensity	**0.2%**
24-Developed High Intensity	**0.0%**
31-Barren Land, Rock, Sand, Clay	**0.1%**
41-Deciduous Forest	**0.4%**
71-Grassland, Herbaceous	**1.7%**
81-Pasture, Hay	**10.1%**
82-Cultivated Crops	**80.8%**
90-Woody Wetlands	**0.1%**
95-Emergent Herbaceous Wetlands	**0.9%**
Total	**100.0%**

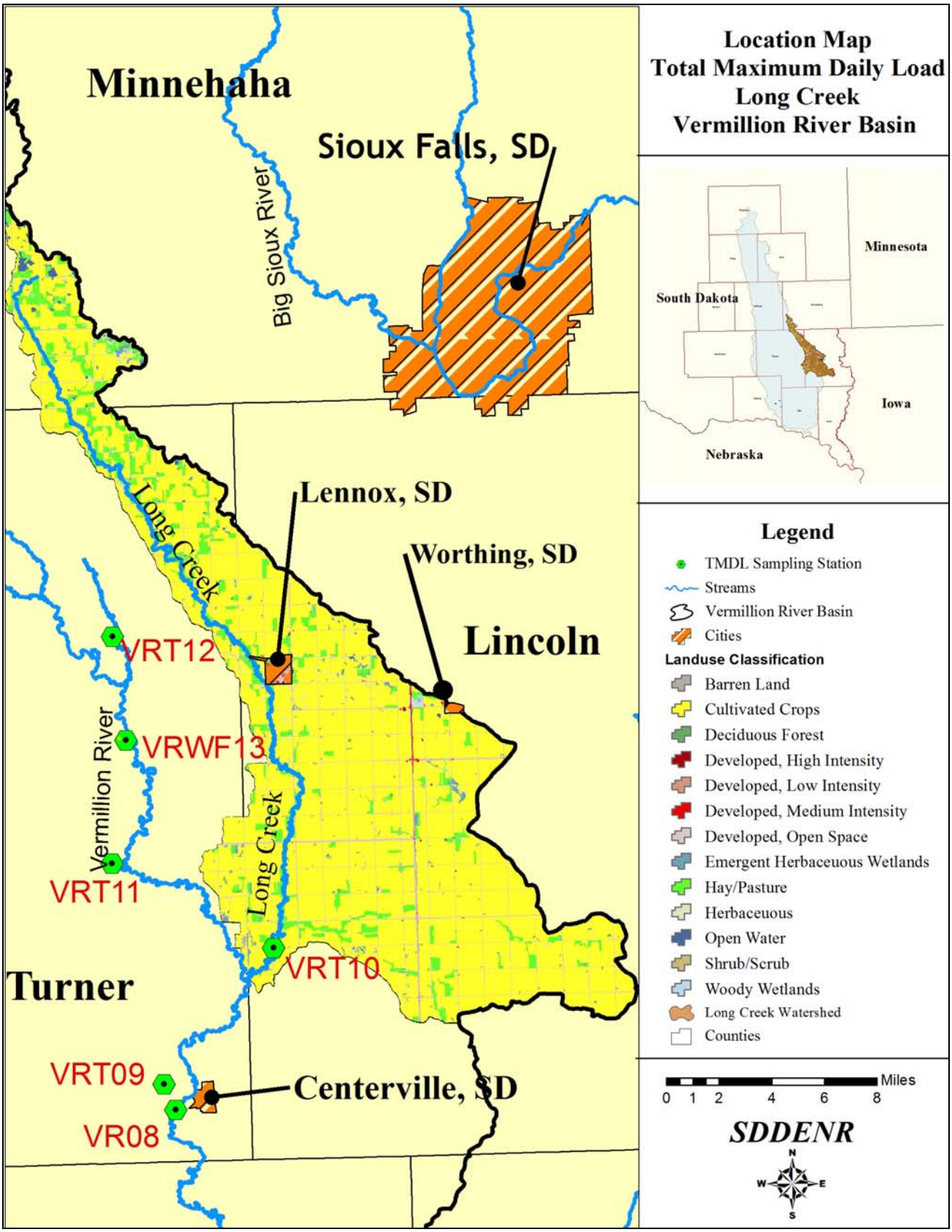

Figure 2. Landuse for Long Creek in the Vermillion River Basin (2001 NLCD).

3.0 Problem Identification

Pathogen sources are overland runoff from nearby croplands and feedlots, inflow from tributaries, and septic tanks. Two wastewater treatment facilities (WWTF) are located in the watershed and one ethanol plant which is currently not regulated for pathogens as part of its NPDES permit.

Long Creek was first listed as impaired due to exceedence of fecal coliform and *E. coli* criteria in the 2008 Integrated Report. Water quality data collected from the Vermillion River Basin Watershed Assessment (Section 319) was used to determine support status. Initial listings on the Vermillion River mainstem spawned the development of the basin wide watershed assessment project which began in 2004. This project collected data at more than thirty sites for approximately two years ending in 2006. Data from the watershed assessment (Site VRT10) were used to determine support status of the beneficial uses. Methodology used to determine support status is described in South Dakota's Integrated Report, which is submitted to EPA biennially (SDDENR 2012). In brief:

"For Streams: >10% violation rate (3 or more exceedances between 10 and 19 samples) for daily maximum criteria. >10% violation rate (2 or more exceedances between 2 and 19 samples) for 30-day average criteria."

"To ensure a sufficient number of samples were available for each stream segment (usually a minimum of 20) the period of record considered for this report was from October 1, 2006, to September 30, 2011, (5 years) for streams."

Since 1983, the USGS has operated a gaging station on the mainstem of the Vermillion (USGS Gage# 06479010). This gage is located approximately three miles north of the city of Vermillion, SD. This site was used to predict long-term flows for mainstem sites on the Vermillion River, including Site VR08, which is located near Centerville, SD (Figure 1). Once the long-term flow record was calculated for VR08, a two-year daily discharge record for Site VRT10 (Long Creek monitoring stations) was calculated using the AQUARIUS software. Flow records were compared and Site VR08, since it was the closest downstream mainstem site, was used to estimate a long-term flow record for Site VRT10. The resulting equation shown below was used to predict a long term flow record for Long Creek.

$$VRT10Q = (0.2743*VR08Q) + 3.3672 \ (R^2 = 0.62, p<0.05)$$

Intensive water quality monitoring was conducted at Site VRT10 beginning in 2005 and was collected through 2006. Water quality monitoring over this period showed that approximately 12.5% of the fecal coliform samples and 17% of the *E. coli* samples exceeded the daily maximum standard for Segment R3. Samples were collected to infrequently to determine compliance with the geometric mean standard which requires the collection of five samples during separate 24-hour periods for any 30-day period (Table 4). The maximum concentration observed from Site VRT10 was 53,000 colony-forming units per 100 mL (CFU/100mL). Table 3 summarizes the sampling results for Segment R3. All samples and their corresponding flows can be found in Appendix A.

Figure 3 and Figure 4 show *E. coli* and fecal coliform concentrations categorized by flow. Four flowzones are shown: Extreme, High, Mid-Range, and Low/Dry. Violations of the pathogen criterion occurred across the three higher flow conditions. The most significant violations were

sampled during storm events (>50% stormflow). Additional violations were found within higher flow zones (Figure 3). Mid-Range flowzone violations are indicative of streambank erosion in both the mainstem and tributaries along with sheet and rill erosion from farm field and feedlot runoff during moist conditions (Cleland, 2003). Lower flow violations can be attributed to bacteria delivered from tributaries from smaller storm events, cattle standing in the stream, and septic tank inputs.

Four flowzones were used for Long Creek because of the natural breaks with the flow distribution and the limited number of samples collected in the dry zone (90-100%). For the lowest flow zones reductions for fecal coliform and *E. coli* are not needed. Creating an additional lower zone will not change the source allocation nor will it change the remediation efforts, i.e. they would remain the same.

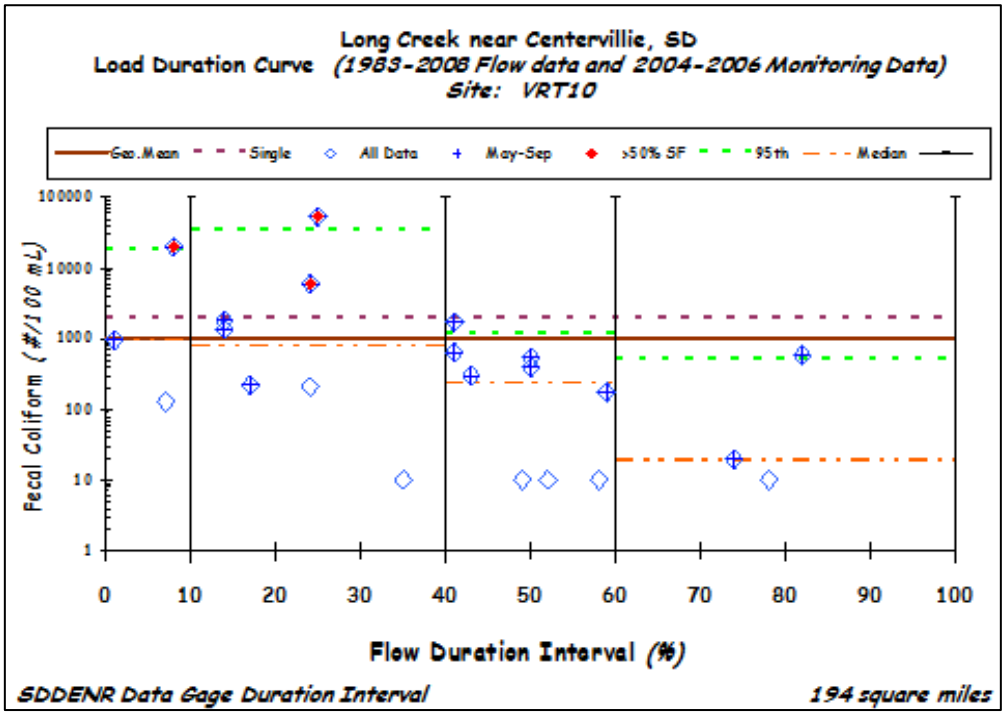

Figure 3. Site VRT10 fecal coliform concentrations for each of the four flowzones.

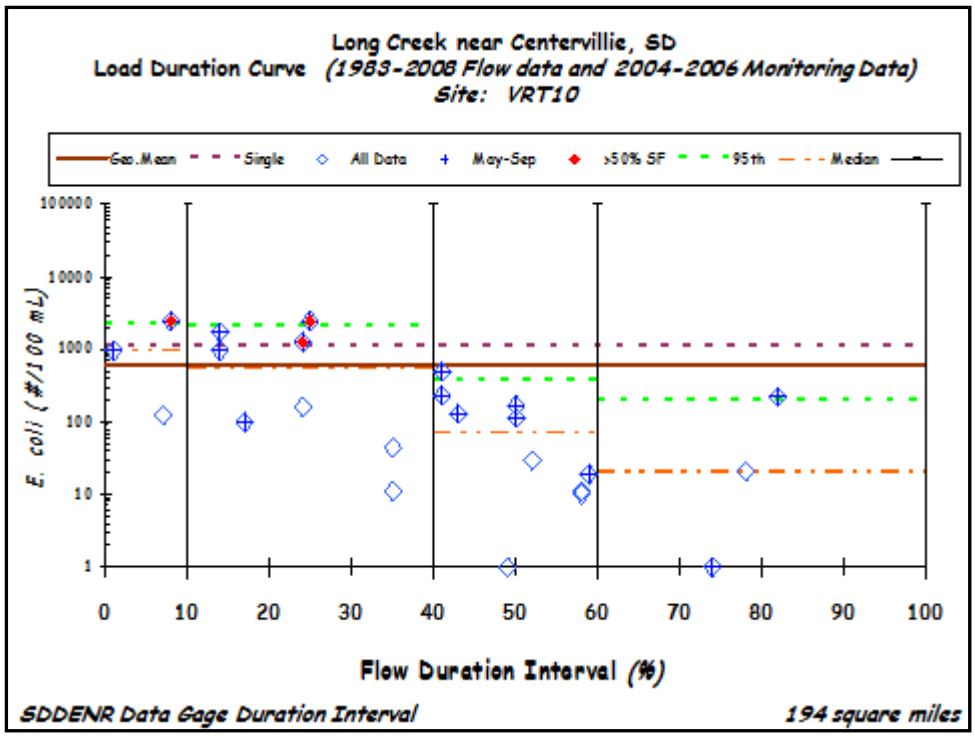

Figure 4. Site VRT10 *E. coli* concentrations for each of the four flowzones.

Table 3. Summary Table of Sampling Results for Segment R3 (Site VRT10).

Statistic	Site VRT10
Count of Fecal Coliform (CFU/100mL)	24
Average of Fecal Coliform (CFU/100mL)	3,670
Max of Fecal Coliform (CFU/100mL)	53,000
Min of Fecal Coliform (CFU/100mL)	10
Count of *E. coli* (CFU/100mL)	25
Average of *E. coli* (CFU/100mL)2	486
Max of *E. coli* (CFU/100mL)2	2420
Min of *E. coli* (CFU/100mL)2	1
Max of Flow Rank* (Higher Flows)	81.5%
Min of Flow Rank* (Lower Flows)	1.4%
# of Fecal Coliform Samples > 1,000 CFU/100mL (Chronic)	6
# of Fecal Coliform Samples > 2,000 CFU/100mL (Daily Max)	3
# of *E. coli* Samples >630 CFU/100ml (Chronic)	6
# of *E. coli* Samples >1,178 CFU/100ml (Daily)	4
Date of First Sample	3/21/2005
Date of Last Sample	9/26/2006
Baseflow Sampling	Yes
Event Base Sampling	Yes
Monthly Sampling	Yes

4.0 Description of Applicable Water Quality Standards & Numeric Water Quality Targets

4.1 South Dakota Water Quality Standards

Each waterbody within SD are assigned designated or beneficial uses. All waters (both lakes and streams) within SD are designated with the use of fish and wildlife propagation, recreation, and stock watering. All streams are assigned the use of irrigation. Additional uses are assigned by the state based on a beneficial use analysis of each waterbody. Water quality standards have been defined in SD state statutes in support of these uses. These standards consist of suites of criteria that provide physical and chemical benchmarks from which management decisions can be developed.

Chronic standards, including geometric means and 30-day averages, are applied to a calendar month. While not explicitly described within the water quality standards, this is the method used in the South Dakota Integrated Water Quality Report (IR) as well as in permit development.

Additional "narrative" standards that may apply can be found in the "Administrative rules of South Dakota: Articles 74:51:01:05; 06; 08; and 09". These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, and nuisance aquatic life.

Long Creek from Highway 44 just south of Lennox, SD to the confluence with the Vermillion River has been assigned the beneficial uses of: warm water semipermanent fish life propagation, irrigation waters, limited contact recreation, and fish and wildlife propagation, recreation, and stock watering. Table 4 lists the criteria that must be met to support the specified beneficial uses. When multiple criteria exist for a particular parameter, the most stringent criterion is used.

4.2 Water Quality Targets

Of all the assessed parameters for which surface water quality criteria are established (Table 4), fecal coliform and *E. coli* exceeded criteria for the limited contact recreation beneficial use. These two TMDLs will address the limited contact recreation pathogen impairments.

The fecal coliform criteria for the limited contact recreation beneficial use requires that 1) no sample exceeds 2,000 cfu/100 ml and 2) during a 30-day period, the geometric mean of a minimum of 5 samples collected during separate 24-hour periods must not exceed 1,000 cfu/100 ml. These criteria are applicable from May 1 through September 30. The numeric TMDL targets established for the Long Creek are 1,000 cfu/100 ml for the fecal coliform impairment. This target is based on the chronic threshold.

The *E. coli* criteria for the limited contact recreation beneficial use requires that 1) no sample exceeds 1,178 cfu/100 ml and 2) during a 30-day period, the geometric mean of a minimum of 5 samples collected during separate 24-hour periods must not exceed 630 cfu/100 ml. These criteria are applicable from May 1 through September 30 as well. There was a 17% violation rate for the *E. coli* criteria for the same time period as fecal coliform resulting in an impairment classification for this parameter as well.

Table 4. South Dakota surface water quality standards for Long Creek in Lincoln, Minnehaha, and Turner Counties, South Dakota.

Parameter	Criteria	Unit of Measure	Special Conditions
Total alkalinity as calcium carbonate	≤ 750	mg/L	30-day average
	≤ 1313	mg/L	daily maximum
Chlorides (warmwater semipermanent)	≤ 100	mg/L	30-day average
	≤ 175	mg/L	daily maximum
Dissolved oxygen (warmwater semipermanent)	≥ 5.0	mg/L	Daily minimum May 1-Sept. 30
	≥ 4.0	mg/L	Daily minimum Oct 1-April 30
Total ammonia nitrogen as N (warmwater semipermanent)	Equal to or less than the result from Equation 3 in Appendix A	mg/L	30-day average May 1 - October 31
	Equal to or less than the result from Equation 4 in Appendix A	mg/L	30-day average November 1 – April 30
	Equal to or less than the result from Equation 2 in Appendix A	mg/L	daily maximum
Fecal coliform and *E. coli* (May 1 – September 30) (limited contact recreation)	≤ 1,000 (*E. coli* ≤ 630)	cfu/100 mL	geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period
	≤ 2,000 (*E. coli* ≤ 1,178)	cfu/100 mL	in any one sample
Conductivity at 25°C	≤ 2,500	micromhos/cm	30-day average
	≤ 4,375	micromhos/cm	daily maximum
pH (warmwater semipermanent)	≥ 6.5 and ≤ 9.0	standard units	see § 74:51:01:07
Nitrates as N	≤ 88	mg/L	daily maximum
	≤ 50	mg/L	30-day average
Total dissolved solids	≤ 2,500	mg/L	30-day average
	≤ 4,375	mg/L	daily maximum
Total Suspended Solids (warmwater semipermanent)	≤ 90	mg/L	30-day average
	≤ 158	mg/L	daily maximum
Temperature (warmwater semipermanent)	≤ 90	°F	see § 74:51:01:31
Undisassociated hydrogen sulfide	≤ 0.002	mg/L	
Total petroleum hydrocarbon	≤ 10	mg/L	see § 74:51:01:10
Oil and grease	≤ 10	mg/L	see § 74:51:01:10
Sodium adsorption ratio	≤ 10		see definition

During this study, each site shown in Table 5 exhibited several samples exceeding the fecal coliform daily maximum criterion (2,000 cfu/100 ml). Fecal coliform impairment is a persistent problem shown along multiple reaches in the Vermillion River Basin. Table 5 shows different violation rates between flowzones. In most instances in small rural streams there is typically a significant relationship between high flows (storm events) and high bacteria concentrations and this is exhibited by the Long Creek data. For Segment R3, all violations occurred within the three higher flow zones.

The numeric TMDL target established herein for Segment R3 limited contact recreation use is based on the chronic threshold taken from South Dakota's 30-day geometric mean for fecal coliform and *E. coli* criterion. The chronic threshold represents the numeric target of the chronic standard whereas the chronic standard represents the geometric mean of a minimum of five samples collected within a 30-day period. The numeric targets of 1,000 cfu/100mL for fecal coliform and 630 cfu/100mL for *E. coli* established for Long Creek took into consideration all current water quality standards and will ensure that both the chronic and acute standards are met..

Table 5. Exceedance Rates of the fecal coliform Daily Maximum Criterion for Long Creek (Segment SD-VM-R-LONG_01) of the Vermillion River Basin (2,000 cfu/100ml).

			High	Moist	Mid	Low
Segment R3	VRT10	Samples per Zone	3	8	10	3
		Exceedances per Zone	0	0	0	0
		%Violation	1%	2%	0%	0%

5.0 Data Collection Method

5.1 Water Quality Data and Discharge Information

Stream discharge information collected from 34 sites was used to develop stage/discharge curves for each monitoring site. Both targeted TMDL sites and ambient (monthly) monitoring data were used to assess impairments and develop trend information. Table 6 shows sites used and numbers of samples collected during the project period. The only site used for Long Creek was Site VRT10.

The design of the assessment project was used to identify beneficial use impairments and estimate the sediment, nutrient, and bacteria loadings within the Vermillion River and major individual tributaries in the watershed through hydrologic, chemical and biological monitoring. The information was not only used to develop a TMDL for the Vermillion River but also locate critical areas in the watershed to be targeted for implementation.

A continuous stage record for the project period, with the exception of winter months after freeze up was maintained for each site. Discrete discharge measurements were taken on a regular schedule and during storm surges. Discharge measurements were taken with a hand-held current velocity meter under wadeable conditions or from a bridge crane during high flows using methods outlined by the U.S. Geological Survey (USGS). Discharge measurements and water level data were used to calculate a stage/discharge table for all stream systems. Four USGS Gages (Gage No. 06478600, Gage No. 06478690, Gage No. 06478650, and Gage No. 06479010) have been recording daily

discharge information since, at least, 1995. These gages were used to help develop a long-term flow records for all of the other for monitoring sites located upstream. Ambient monitoring locations, as part of the Section 106 water quality monitoring network, had approximately two years worth of discharge data (2009-2011) that could were also related back to the long-term USGS gage.

Samples were collected during spring runoff, storm events, and monthly base flows. Locations of sites monitoring tributaries and the Vermillion River mainstem can be found in Figure 1 and Table 6. Intensive sampling was conducted on a temporal basis over the course of two years (Jan'05 – Dec'06). Five ambient stations were also used to conduct long-term (1968 to Present) trend analysis (TSS or fecal coliform vs. time). Samples were collected during the spring snowmelt runoff, and baseflow conditions for spring (March 1 to May 31), summer (June 1 to September 15), and fall (September 16 to November 15). Baseflow was defined as no significant increase in flow.

Storm event samples for each season were collected at or as near as possible to the peak discharge. During the project personnel from the Vermillion Basin Water Development collected all samples and periodically aided by SDDENR. Autosamplers were used to collect at some of the more remote locations. The autosamplers were programmed to collect composite samples over the course of a storm event.

All sampling and discharge data collection conducted during this project were done with methods in accordance with the South Dakota *Standard Operating Procedures for Field Samplers* developed by the Water Resource Assistance Program and approved by USEPA Region VIII. All samples collected in SD, including the mainstem, were sent to the State Health Laboratory in Pierre, SD for analysis.

Table 6. Site and sample description, and sample numbers collected as part of the overall Vermillion River Basin Watershed TMDL Assessment (2004-2006). Long Creek (Site VRT10) was monitored as part of the river basin assessment.

Site ID	Description	USGS Gage	Year	Samples	Blanks	Dups	Storm
Blank			2005-06		56		
VR01	Vermillion River at Vermillion, SD		2005-06	5		3	16
VR03	Vermillion River North of Vermillion, SD	6479010	2005-06	7		1	15
VR05	Vermillion River near Hub City, SD		2005-06	10			13
VR06	Vermillion River (Colfax Corner)		2005-06	9		1	14
VR08	Vermillion River at Centerville, SD		2005-06	9		1	13
VR13	Vermillion River near Hurley, SD		2005-06	9		2	16
VREF14	East Fork Vermillion River East of Parker, SD	6478600	2005-06	7		3	18
VREF17	East Lake Vermillion Outlet		2005-06	9			11
VREF19	East Fork Vermillion River near Montrose, SD		2005-06	8		3	17
VREF23	East Fork Vermillion River South of Winfred, SD		2005-06	7		1	12
VREF25	East Fork Vermillion River Outlet from Lake Thompson		2005-06	7		1	10
VREFT18	East Fork Vermillion River Unnamed Tributary		2005-06	3		3	15
VREFT21	Little Vermillion River Outlet near Montrose, SD		2005-06	9		3	16
VREFT29	Little Vermillion River near Salem, SD	6478540	2005-06	1			2
VRELV27	East Lake Vermillion South End		2005-06	43			
VRELV28	East Lake Vermillion North End		2005-06	27		5	
VRSL26	Silver Lake		2005-06	27		4	
VRT02	Yankton Clay Ditch		2005-06	2		1	7
VRT04	Clay Creek Ditch		2005-06	6		3	16
VRT07	Frog Creek		2005-06	9		1	11
VRT09	Turkey Ridge Creek		2005-06	9		2	14
VRT10	Long Creek		2005-06	8		4	13
VRT11	Hurley Creek		2005-06	4		1	12
VRT12	Camp Creek		2005-06	7			10
VRWF15	WestFork Vermillion River near Marion, SD	6478690	2005-06	9		1	14
VRWF20	West Fork Vermillion River near Salem, SD		2005-06	8		2	13
VRWF22	West Fork Vermillion River near Canova, SD		2005-06	8			10
VRWF24	West Fork Vermillion River near Howard, SD		2005-06	6		2	11
WQM150	East Fork Vermillion River North of Montrose, SD		2005-06	43			
WQM154	East Fork Vermillion River South of Montrose, SD		2005-06	43			
WQM4	Vermillion River near Wakonda, SD		2005-06	53			
WQM5	Vermillion River near Vermillion, SD		2005-06	54			
WQM61	Vermillion River near Parker, SD		2005-06	53			
VRT30	Spirit Mound Creek		2006			3	7
VRT31	Baptist Creek		2006	4		2	5
VRT32	Ash Creek		2006	6		1	5
VRT33	Clay Creek		2006	6		2	5
VRT34	Turkey Creek		2006	8			3
VSS-1	City of Vermillion, 48" Storm Sewer		2006				6
VSS-2	City of Vermillion, 36" Storm Sewer East		2006			1	6
VSS-3	City of Vermillion, 36" Storm Sewer West		2006				5
VSS-4	City of Vermillion, 60" Concrete Storm Sewer East		2006				1

6.0 Source Assessment and Allocation

6.1 Point Sources

There are three documented point sources within this 124,211.7 acre subwatershed (SDDENR, Surface Water Quality Program) (Table 7).

The city of Lennox, SD wastewater treatment facility (WWTF) (NPDES Permit# SD0021768) is located approximately in the northern part of Segment R3 just ½ mile southwest of the city. Lennox serves a population of 2,111 (2010 census). The city invested in the construction of a new sequencing batch reactor mechanical aeration system treatment facility, including ultraviolet disinfection of effluent prior to discharge and 2.4 acres of infiltration basins in 2009. This new mechanical plant is authorized to continuously discharge to Long Creek. To calculate a waste load allocation (WLA) the 80th percentile flow from the discharge monitoring reports (DMR) was multiplied by the daily maximum criteria for fecal coliform (2,000 cfus/100 ml) and *E. coli* (1,178 cfus/100 ml).

The city of Worthing, SD WWTF (NPDES Permit# SD0021474) is located on small tributary of Snake Creek near the central part of Lincoln County. Snake Creek drains to Long Creek. This gravity-flow collection system consists of three-ponds. The system began operating in 1997 and serves a population of 877 people (2010 census). It is authorized to discharge from one outfall as part of its permit. The V-notch weir has an average design discharge of 80,000 gallons per day. The discharge empties into a small tributary draining to Long Creek. The tributary is only subject to beneficial uses 9) fish and wildlife propagation; and 10) irrigation waters. There are no fecal coliform limits established for this permit or receiving waterbody. To calculate a WLA the 80th percentile flow from the DMR was multiplied by the daily maximum criteria for fecal coliform (2,000 cfus/100 ml) and *E. coli* (1,178 cfus/100 ml).

These two facilities have been allotted a WLA for both fecal coliform bacteria and *E. coli.* The third NPDES regulated facility in the watershed is an ethanol plant. This facility is not regulated for bacteria and is not permitted to discharge fecal coliform or *E. coli* to its receiving water. It has no WLA for this TMDL.

Table 7. Permitted Facilities within the Long Creek Drainage.

Permit Number	Facility Name	System Description	Flow used for WLA (cfs)
SD0021768	LENNOX – CITY OF	mechanical	0.18
SD0021474	WORTHING – CITY OF	Pond system	1.4

Table 8 includes the information used by SDDENR to calculate a maximum allowable discharge for each facility. The WLA calculation was based on the effluent limits included in the surface water discharge permit, multiplied by the 80th percentile maximum flow rate. The normal operation of these systems would typically result in only a small portion of the calculated daily amounts actually being discharged. It is important to note all discharges are required to meet the chronic water quality thresholds (standard) for Long Creek.

Including the WLA in the load duration curve required several factors be taken into account. The maximum (total or sum) fecal coliform waste load for the two systems is 1.20 x 10^{11} cfu/day coupled with a total or sum flow of 1.25 cfs. A flow of 1.58 cfs is met or exceeded in Long Creek approximately 100% of the time, i.e. >1% of the time the discharge falls below this flow level. Arbitrarily adding this load to the entire flow regime would be a misrepresentation of how these two intermittent wastewater systems function and exaggerate their contribution to the load capacity. Although the city of Worthing does discharge it only does so occurs 1-3 times per year. All facilities generally discharge outside of the recreation season (May 1 through September 30) when the limited contact beneficial use does not apply.

E.coli was recently added to the water quality standards and is not included in the current surface water discharge permits. The WLA for *E. coli* was calculated by multiplying the threshold of the daily max standard (1,178 cfu/100ml) by the 80th percentile flow from the DMR data from each of the facilities in Table 7 specified in the current WLAs for fecal coliform. When the current permit expires, the fecal coliform WLA will be replaced with a WLA for *E. coli*. The new permits will likely provide an *E. coli* WLA of 7.04 x 10^{10} cfu/100ml assuming the same flow rate. This load is based on the daily max standard and was used as a reasonable WLA for the *E.coli* TMDL. The *E.coli* wasteload contributed by these two treatment facilities are insignificant and not contributing to the impairment of the classified segment of the Long Creek.

Table 8. Discharge Monitoring Report Data for TWO WWTF in the West Fork Watershed.

Facility	Total # of Discharges over last 5 year (2007-2011)	# of Discharges within recreation Season	% of Dischargers within recreation season	Avg. Concentration of available fecal Daily Max Samples (cfu/100ml)
Worthing	15	5	33%	n/a
Lennox	continuous	n/a	n/a	1,051

Flow data used to develop the flow frequency curve includes daily flow data. The flow record provided over 30 years of daily flow data which included all wastewater treatment facility discharges during that time period. The flow variability, as a result of the intermittent operation of these facilities, is fully accounted for in the flow frequency curve.

6.2 Nonpoint Sources

Nonpoint sources of fecal coliform bacteria for the Long Creek Watershed come primarily from agricultural sources. County wide livestock data, from the 2007 and 2009 National Agricultural Statistic Survey (NASS), and wildlife data, from the 2002 South Dakota Game Fish and Parks county wildlife assessment, were used to derive density estimates for livestock and wildlife densities, respectively. The 2007 livestock data reflects the "on the ground" conditions exhibited in the water quality data collected during the watershed assessment. The 2002 SDGFP Wildlife data was the most current available for each county within the State of South Dakota.

Statistically derived livestock estimates (beef cattle, hogs, etc.) from the NASS 2007 Agricultural Census was used for each county involved in the Segment R3 watershed (Appendix B). Livestock

animals per acre for each county were then multiplied by the acres from each county within the watershed. Table 9 shows the acres of Long Creek watershed that are located within each county. The animals listed in Table 9 (wildlife and livestock) are the largest animals and most densely populated within the involved counties (Lincoln, Minnehaha, and Turner). The density estimates were then multiplied by the acres of watershed found within each county, which is also found in Table 9.

The animal density information was used to estimate relative source contributions of bacteria loads. For example, based on the 2007 density estimates there were 425 dairy cows in the watershed resulting in an estimated input of 3.17E+13 cfus per day (425 cows X 7.45E+10 cfus). Daily outputs from each animal type were taken from the reference worksheet found on the Bacterial Indicator Tool (BIT). The EPA BIT tool is a spreadsheet that estimates the bacteria contribution from multiple sources.

Human inputs were determined through several GIS county wide feature datasets provided by the SD Dept. of Transportation (SDDOT). The dataset was used primarily for assessing county roads and structures along roads, such as rural residences (both occupied and unoccupied), were documented. The number of occupied residences for the acres of watershed within each county were used to estimate how many septic tanks were located in the watershed in each county. It was assumed on average that each residence contained two people. It was assumed that 25% of these septic tanks were failing. The daily human output of 1.88E+11 fecal coliform per human was taken from the BIT Tool Reference worksheet which lists the USGS as the source of the human output estimate (EPA BIT tool). The total estimate of 1.20E+14 fecal coliform from humans was used in Table 7 and Table 8.

Table 9. Human Input Estimates

County	Occupied
Lincoln	472
Minnehaha	61
Turner	102
Total Occupied Residences	635
# per household	2
Total Population	1,270
25% Failure Rate for Septic Tank	0.25
USGS Human Daily Estimate	1.88E+11
Total Human Contribution	**1.20E+14**

6.2.1 Agriculture

Manure from livestock is a potential source of fecal coliform to the stream. Livestock in the basin are predominantly hogs and beef cattle. Livestock can contribute fecal coliform bacteria directly to the stream by defecating while wading in the stream. They also can contribute by defecating while grazing on rangelands that get washed off during precipitation events. Table 8 allocates the sources for bacteria production in the watershed into four primary categories. The summary is based on several assumptions. Feedlot numbers were calculated as the sum of all dairy, hog, and the NASS estimate of beef in feeding areas. All remaining livestock were assumed to be on grass.

Table 10. Fecal Coliform Allocations for Long Creek, Vermillion River Basin.

Source	Percentage
Feedlots	73.6%
Livestock on Grass	9.3%
Wildlife	1.4%
Septic Tanks	15.7%

6.2.2 Human

There are two separate point sources within the Long Creek watershed which were previously described. Failing onsite septic systems are assumed to be the primary human source not served by the POTW within the watershed. Human fecal production was estimated at 1.88E+11 (Bacterial Indicator Tool Reference Worksheet - USGS estimate). When included as a total load in the table, the remaining population accounted for about 15.7% of all fecal coliforms/*E. coli* produced in the watershed assuming a 25% failure rate for the onsite wastewater systems.

6.2.3 Natural background/wildlife

Wildlife within the watershed is a natural background source of fecal coliform bacteria. Wildlife population density estimates were obtained from the South Dakota Department of Game, Fish, and Parks (Table 11). The contribution of bacteria from wildlife in the Long Creek watershed was insignificant (1.4%) in comparison to livestock sources.

Table 11. Long Creek Potential Nonpoint Sources and Percent Contribution (animal density is individuals per acre).

			Animal Density Estimnate per County (NASS, 2007)			
Animal Type	Fecal Coliform (#/animal/day)	Animal Type Used for Estimate	LINCOLN (animals/acre)	MINNEHAHA (animals/acre)	TURNER (animals/acre)	Total Fecal Coliform
CATTLE ON GRASS	4.57E+09	Cow	0.0518	0.0923	0.0676	3.32E+13
CATTLE, COWS, MILK - INVENTORY	7.45E+10	Dairy Cow	0.0012	0.0099	0.0163	4.20E+13
CATTLE, ON FEED - INVENTORY	7.27E+10	Beef Cow	0.0456	0.0405	0.0403	3.99E+14
CHICKENS, BROILERS - INVENTORY	1.81E+08	Broilers	0.0006	0.0012	0.0001	1.26E+10
EQUINE, HORSES & PONIES - INVENTORY	2.59E+10	Horse	0.0025	0.0044	0.0019	8.31E+12
HOGS - INVENTORY	1.02E+10	Hog	0.0764	0.1178	0.1554	1.19E+14
SHEEP, INCL LAMBS - INVENTORY	1.66E+10	Sheep	0.0106	0.0107	0.0333	2.97E+13
TURKEYS - INVENTORY	1.04E+08	Turkey (Wild)	0.0000	0.0000	0.0001	7.12E+08
Whitetail Deer	5.00E+08	Deer	0.0031	0.0056	0.0043	2.22E+11
Turkey	1.04E+08	Turkey (Wild)	0.0011	0.0012	0.0006	1.38E+10
Opossum	1.25E+08	Raccooon	0.0027	0.0048	0.0030	4.63E+10
Mink	2.50E+07	Muskrat	0.0046	0.0031	0.0019	1.25E+10
Beaver	2.50E+08	Beaver	0.0053	0.0035	0.0028	1.47E+11
Muskrat	2.50E+07	Muskrat	0.0027	0.0207	0.0020	1.35E+10
Skunk	1.25E+08	Raccoon	0.0054	0.0058	0.0035	8.01E+10
Badger	1.25E+08	Raccoon	0.0022	0.0010	0.0014	3.00E+10
Coyote	4.09E+09	Dog	0.0030	0.0008	0.0013	1.27E+12
Fox	1.25E+08	Raccoon	0.0033	0.0031	0.0018	4.66E+10
Raccoon	1.25E+08	Raccoon	0.0087	0.0067	0.0058	1.25E+11
Jackrabbit	1.25E+08	Raccoon	0.0016	0.0021	0.0009	2.44E+10
Cottontail Rabbit	1.25E+08	Raccoon	0.0191	0.0345	0.0127	3.03E+11
Squirrel	1.25E+08	Raccoon	0.0191	0.0307	0.0203	3.17E+11
Partridge	1.37E+08	Layers	0.0068	0.0021	0.0006	9.07E+10
Nest Canada Geese	4.90E+10	Goose	0.0005	0.0071	0.0013	7.84E+12
Septic Tanks in each county	1.88E+11	Human	236	31	51	1.20E+14
County Acres in Long Creek Watershed ======>			91,378	12,063	20,770	

Source	Total Contribution	Percent Contribution
Cattle on Grass	3.32E+13	4.4%
Beef Cattle on Feed	3.99E+14	52.4%
Dairy Cow	4.20E+13	5.5%
Chickens, Turkeys, Goats	1.33E+10	0.0%
Hogs	1.19E+14	15.7%
Sheep	2.97E+13	3.9%
Horses	8.31E+12	1.1%
All Wildlife	1.04E+13	1.4%
Septic Tanks	1.20E+14	15.7%
Total	7.61E+14	100%

6.2.4 Tributary Contributions

Long Creek has several smaller unnamed tributaries which drain very intermittently. These tributaries drain mainly portions of central Lincoln County (Figure 1). The significance of these smaller intermittent streams on Long Creek was not determined. The monitoring site (Site VRT10) was located at the mouth of Long Creek so the tributary contributions were included in the load duration curve.

7.0 Linkage Analyses

7.1 Load Duration Curve Analysis

This fecal coliform TMDL was developed using a Load Duration Curve (LDC) approach resulting in a flow-variable target that considers the entire flow regime. For Long Creek, Figures 3 and 4 show violations occurring within the two highest flowzones. The LDC approach was deemed an appropriate method for identifying possible sources of bacteria based on the flow zone.

The LDC is a dynamic expression of the allowable load for any given day. To aid in interpretation and implementation of the TMDL, the LDC flow intervals were grouped into four flow zones representing high flows (0–10 percent), moist conditions (10-40 percent), mid-range flows (40–60 percent), and low-dry conditions (60–100 percent). According to EPA's *An Approach for Using Load Duration Curves in the Development of TMDLs* (USEPA, 2006) five zones are usually recommended but for this particular dataset four flow zones were chosen. These zones were based on 28 years of flow data (1983-2011), and 2.5 years of sampling data collected from Vermillion River as part of the watershed assessment.

For Long Creek instantaneous loads were calculated by multiplying the fecal coliform and *E. coli* concentrations collected from SD DENR TMDL Site VRT10 relating the daily average flow from VR08 to the daily average flow from USGS Gage No. 06479010 for the same period. Flow was then predicted using the long-term record from the USGS gage, and a unit's conversion factor.

When the instantaneous loads are plotted on the LDC, characteristics of the water quality impairment are shown. Instantaneous loads that plot above the curve are exceeding the TMDL, while those below the curve are in compliance. As the plot shows, pathogen samples collected from Long Creek exceed the daily maximum and geometric mean criterion within the two upper flow zones (Figure 5 and 6). Loads exceeding the criteria in the high flow zones imply storm runoff from animal feeding operations or storm sewer runoff. Loads shown in the low flow zone typically indicate a point source load or livestock defecating in the stream.

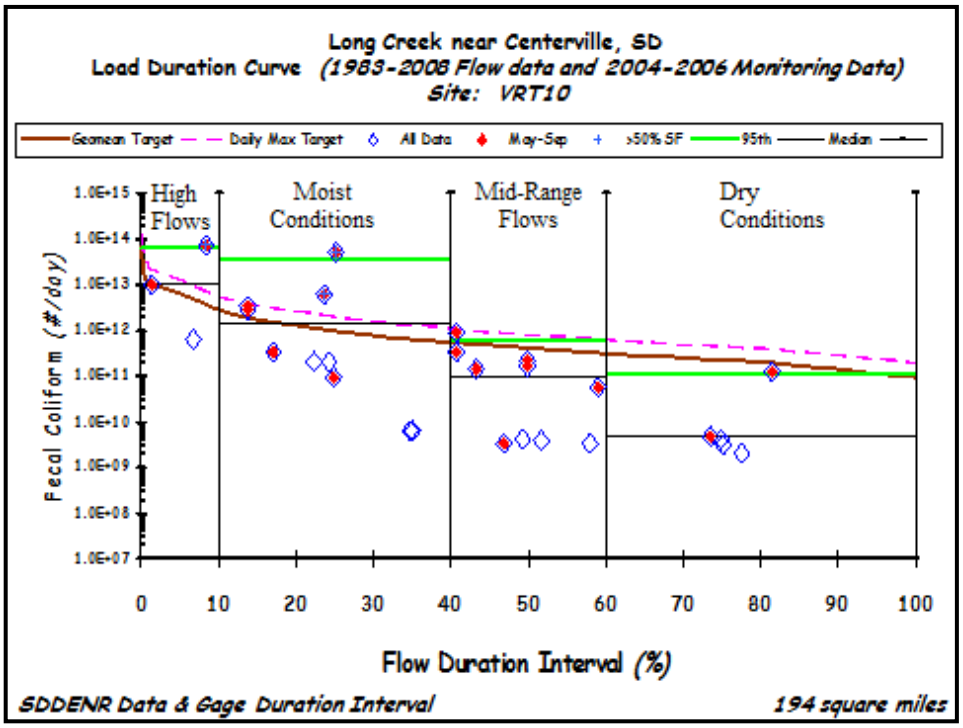

Figure 5. Long Creek (Segment R3, 2012 IR) - Load duration curve representing allowable daily fecal coliform loads based on the geometric mean and daily maximum cirteria (≤1,000 cfu/100ml and ≤2,000 cfu/100ml, respectively). Plot showing median and 95th percentiles, and daily loads for each flowzone. The geometric mean (1,000 cfu/100 ml) was used to determine the loading capacity for Long Creekand the TMDL. Observed concentrations are also displayed.

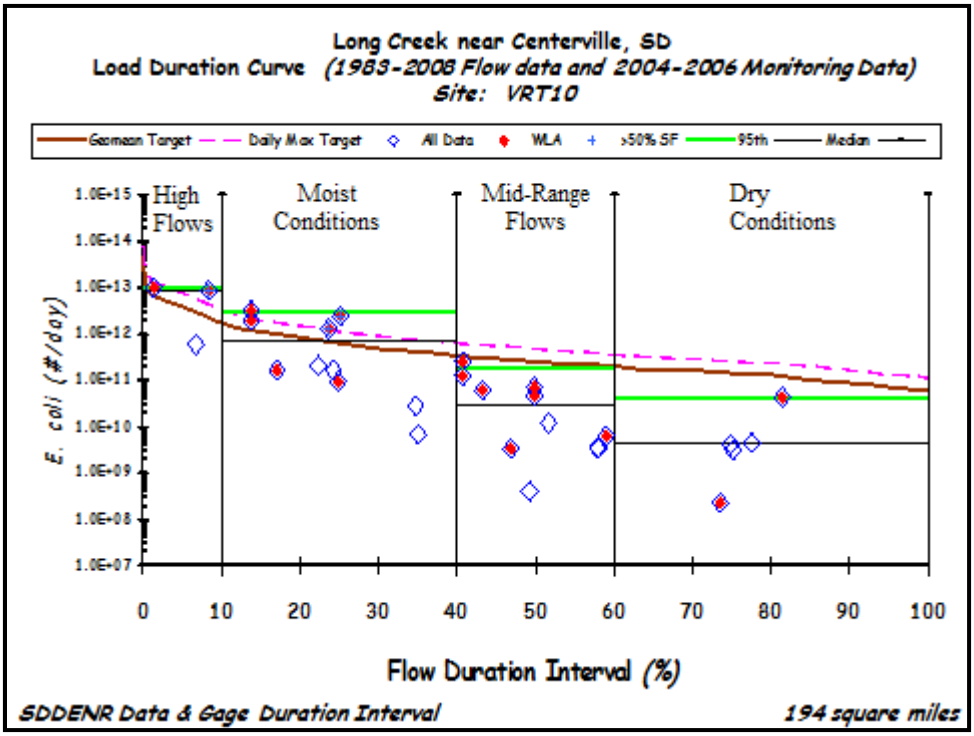

Figure 6. Long Creek (Segment R3, 2012 IR) - Load duration curve representing allowable daily E. coli loads based on the gemotric mean and daily maximum criteria (<630 cfu/100ml and <1,178 cfu/100ml, respectively). Plot showing median and 95th percentiles, and daily loads for each flow zone. The geometric mean (630 cfu/100ml) was used to determine the loading capacity for Long Creek and the TMDL. Observed concentrations are also displayed.

8.0 TMDL Allocations – Fecal Coliform

8.1 TMDL Fecal Coliform Load Duration Curve

The LDC (Figure 5 and Table 12) represents the dynamic expression of the Fecal Coliform TMDL for Long Creek, resulting in a unique maximum daily load that corresponds to a measured average daily flow. To aid in the implementation of the TMDL and estimation of needed fecal coliform load reductions, Table 12 presents a combination of allocations for each of four flow zones. Methods used to calculate the TMDL components are discussed below. This TMDL is in effect from year round and is based on daily flow and the chronic threshold from the water quality standard (geometric mean).

8.1.1 Extreme or High Flows (0-10%)

The extreme flow zone is composed of the highest flows exceeding 110 cfs. The flows in this range are greater than 110 cfs only 10% of the time. Although a total of 24 samples were used in the development of the LDC, only three samples were collected in this zone and one exceeded the fecal coliform chronic standard (1,000 cfu/100ml). Using the 95th percentile flow with the chronic standard (1,000 cfu/100 ml) from this zone to calculate the TMDL goal is appropriate and provides assurance that the water quality criteria will not be exceeded.

8.1.2 High Range Flows (10-40%)

The estimated discharge record for Long Creek indicated that the 10-40% flows ranged between 110 cfs and 22 cfs. Out of the eight samples collected in this zone four exceeded the chronic standard. The 95th percentile load from this zone was 6.48E+13cfu/day which was used to set the TMDL goal for this zone (Table 12).

The violation rate from this zone (50%) requires a 97% reduction to achieve full support of the limited contact beneficial use (Table 12).

8.1.3 Mid-Range Flows (40-60%)

Mid-Range flows ranged from 22 cfs to 13 cfs. Ten samples were collected in this flow zone and one sample exceeded the chronic water quality standard. Although this lone violation was not classified as storm event sample it was still collected from the higher end of the flowzone. The flows from this zone are expected to persist longer throughout the year and are low enough within Long Creek where livestock are able to enter the side channels to drink or cool down during hot summer periods (Table 12).

The violation rate from this zone (10%) requires a 90% reduction in order to achieve the full support of the limited contact beneficial use (Table 12)

8.1.4 Low and dry Flows (60-100%)

Low flows ranged below 13 cfs. The flows typically occur during late summer and can persist through late fall. None of three samples collected from this zone exhibited concentrations higher than 600 cfus/100ml. No reductions were required for this zone (Table 12).

Table 12. Long Creek – Fecal Coliform Total Maximum Daily Load (TMDL) allocations by flow zone (Site VRT10).

Station ID:	**Site VRT10 - Long Creek**			
Station name:	**DENR Gaging Station upstream of USGS Gage 06479010**			
Parameter of Concern	**Flow Zone (expressed as tons/day)**			
Fecal Coliform	**Extreme Flows (0-10)**	**High-Range (10-40)**	**Mid Range Flows (40-60)**	**Low Flows (60-100)**
Flow Range	**<2786**	**<110**	**<22**	**<13**
Median Flow Per Zone	262	40	16	8
Load Allocation	5.66E+12	7.56E+11	2.37E+11	6.04E+10
WLA - Lennox, SD (SD0021768)	1.36E+10	1.36E+10	1.36E+10	1.36E+10
WLA - Worthing, SD (SD0021474)	1.06E+11	1.06E+11	1.06E+11	1.06E+11
MOS (10% Explicit)	6.42E+11	9.73E+10	3.96E+10	2.00E+10
TMDL	**6.42E+12**	**9.73E+11**	**3.96E+11**	**2.00E+11**
	Existing Condition per Zone (expressed as cfus/day)			
95th Percentile Load per Zone	6.48E+13	3.57E+13	6.43E+11	1.05E+11
Load Reduction	**90.1%**	**97.3%**	**38.4%**	**-90.3%**
95th Percentile Concentration per Zone	18,097	36,515	1,228	542
Number of Values	3	8	10	3
Current Load or existing Condition is the 95th Percentile of the observed fecal coliform Load for each flow zone.				

8.2 Fecal Coliform Allocations – Long Creek, Segment R3 (2012 IR)

8.2.1 Load Allocation (LA)

To develop the bacterial load allocation (LA), the loading capacity (LC) was first determined. The LC for Long Creek (Highway 44 to the Vermillion River) was calculated by multiplying the geometric mean (1,000 cfu/100 ml) fecal coliform threshold by the daily average flow estimated for Site VRT10, which was the only monitoring site within this segment and watershed (Figure 5).

The geometric mean criterion (1,000 cfu/100 ml) was used for the calculation of the LC, rather than the daily maximum criterion (2,000 cfu/100 ml) because the chronic threshold is considered more protective. The geometric mean, as defined in ARSD § 74:51:01:01, is the arithmetic mean of a minimum of five separate grab or composite samples taken on separate 24-hour periods in a 30-day period. The 30-day average fecal coliform criteria (ARSD § 74:51:01:48) applies at all times but compliance can only be determined when a minimum of five samples are obtained during separate 24-hour periods for any 30-day period. In many instances, only one or two samples were collected during any 30-day period, so the chronic threshold was applied to each flowzone in Figure 5. Although the daily maximum criteria are exceeded, to be conservative it was decided to use the chronic threshold to develop the loading capacity of the stream to ensure that the most stringent water quality standards are met. Additional data would be needed to accurately assess compliance with the geometric mean criterion. The loading capacities and reductions derived from the available data are estimates (i.e., the calculated loading capacities and reductions may be higher or lower if/when a more extensive data set is collected to fully assess compliance with the chronic standard). For each of the four flow zones, the 95th percentile of the range of LCs within a zone was set as the flow zone goal. Setting the flow zone goal at the 95th percentile within each flowzone protects the

limited contact recreation beneficial use and will also incorporate the natural variability of the system (Figure 5).

Portions of the LC were allocated to point sources as a waste-load allocation (WLA) and nonpoint sources as a load allocation (LA). A fraction of the LC was also reserved as a margin of safety (MOS) to account for uncertainty in the calculations of these load allocations. The method used to calculate the MOS is discussed below. The LA was determined by subtracting the WLA and MOS from the LC. Thus, the TMDL (and LC) is the sum of WLA, LA, and MOS.

8.2.2 Waste Load Allocation (WLA) – Fecal Coliform

There were three facilities or NPDES Permit holders in the Long Creek Watershed. Two are authorized to discharge bacteria. The third NPDES permit was issued to an ethanol plant which is authorized to discharge non-contact cooling and process water which has no pathogen impact on the receiving water.

The WLA is constant across all flow conditions and ensures that water quality standards will be attained. The WLA calculation was based on the effluent limits included in the surface water discharge permit, multiplied by the 80th percentile discharge monitoring report (DMR) flow rate. The normal operation of these systems would typically result in only a small portion of the calculated daily amounts actually being discharged. It is important to note all discharges are required to meet the chronic water quality thresholds (standard) for Long Creek.

The Worthing, SD WWTF consists of a three retention pond system that may periodically require a portion of the final pond to be discharged into an unnamed tributary of Snake Creek which is not assigned a recreational beneficial use. Although it is authorized to discharge it is not required to monitor for bacteria as part of its permit. It has been assigned a WLA of 1.06E+11 cfu/day. Reviewing the DMR data shows that the city of Worthing discharged only 25 times during the period of Jan'2000 through Dec'2010. Twenty of these discharge events occurred outside the recreational season (October 1-April 30). The Worthing WWTF WLA accounts for 27% and 53% of the fecal coliform TMDL within the two lower flow zones, respectively (Table 12). The WLA and LC calculations are based on the chronic threshold (1,000 cfu/100ml) and an explicit 10% safety margin. The two lower flow zones do not require a reduction and when flow in the two lower zones is not effluent driven the WLA can be considered solely included as LA in the overall load capacity. The Worthing facility is also located approximately 20 miles north and east of Long Creek minimizing its impact on the LC of Long Creek.

The Lennox, SD WWTF is a continuous discharger into Long Creek and is required to monitor fecal coliform as part of its NPDES permit. The fecal coliform WLA for this facility is 1.36E+10 cfu/day. The Lennox WWTF accounts for 13% of the LC of Long Creek at the lowest flow zone and 0.02% of the LC at the highest flow zone (Table 12). This facility has a negligible impact within the flowzones that require a 90.1% and 97.3 % reduction (Table 12).

All the NPDES facilities identified in these TMDLS have mechanisms in place that reduce fecal coliform and *E. coli* bacteria. Bacteria in the wastewater lagoons and ponds are viable for short periods due to extended retention time and resultant exposure to the ultraviolet light. This is evident in the bacteria data collected required by the permit. The relative assumption is fecal coliform and

E. coli bacteria contributions from the Worthing and Lennox facilities are minor and not causing impairment. Emphasis should be placed on reducing bacteria inputs from livestock sources (feedlots and grazing) to bring the recreational use of the classified segment of the West Fork of the Vermillion River into compliance.

9.0 TMDL Allocations – *E. coli*

9.1 TMDL Load Duration Curve

The LDC (Figure 6 and Table 13) represents the dynamic expression of the Fecal Coliform TMDL for Long Creek, resulting in a unique maximum daily load that corresponds to a measured average daily flow. To aid in the implementation of the TMDL and estimation of needed fecal coliform load reductions, Table 13 presents a combination of allocations for each of four flow zones. Methods used to calculate the TMDL components are discussed below. This TMDL is in effect from year round and is based on daily flow and the chronic threshold from the water quality standard (geometric mean).

9.1.1 Extreme Flows (0-10%)

The extreme flow zone is composed of the highest flows exceeding 110 cfs. The flows in this range are greater than 110 cfs only 10% of the time. Although a total of 24 samples were used in the development of the LDC, only three samples were collected in this zone and one exceeded the E. coli chronic standard (630 cfu/100ml). Using the 95th percentile flow with the chronic standard (630 cfu/100 ml) from this zone to calculate the TMDL goal is appropriate and provides assurance that the water quality criteria will not be exceeded.

9.1.2 High Range Flows (10-40%)

The estimated discharge record for Long Creek indicated that the 10-40% flows ranged between 110 cfs and 22 cfs. Out of the eight samples collected in this zone four exceeded the chronic standard. The 95th percentile load from this zone was 2.96E+13cfu/day which was used to set the TMDL goal for this zone (Table 13).

The violation rate from this zone (50%) requires a 79% reduction to achieve full support of the limited contact beneficial use (Table 13).

9.1.3 Mid-Range Flows (40-60%)

Mid-Range flows ranged from 22 cfs to 13 cfs. Ten samples were collected in this flow zone with no violations of the chronic water quality standard. The flows from this zone are expected to persist longer throughout the year and are low enough within Long Creek where livestock are able to enter the side channels to drink or cool down during hot summer periods (Table 13).

9.1.4 Low and dry Flows (60-100%)

Low flows ranged below 13 cfs. The flows typically occur during late summer and can persist through late fall. None of three samples collected from this zone exhibited concentrations higher than 218 cfus/100ml. No reductions were required for this zone (Table 13).

Table 13. Long Creek – *E. coli* Total Maximum Daily Load (TMDL) allocations by flow zone (Site VRT10).

Station ID:	**Site VRT10 - Long Creek**			
Station name:	**DENR Gaging Station upstream of USGS Gage 06479010**			
Parameter of Concern	**Flow Zone (expressed as tons/day)**			
E. coli	**Extreme Flows (0-10)**	**High-Range (10-40)**	**Mid Range Flows (40-60)**	**Low Flows (60-100)**
Flow Range	**<2786 >110**	**<110 >22**	**<22 >13**	**<13**
Median Flow Per Zone	262	40	16	8
Load Allocation	3.57E+12	4.81E+11	1.54E+11	4.30E+10
WLA - Lennox, SD (SD0021768)	8.03E+09	8.03E+09	8.03E+09	8.03E+09
WLA - Worthing, SD (SD0021474)	6.24E+10	6.24E+10	6.24E+10	6.24E+10
MOS (10% Explicit)	4.04E+11	6.13E+10	2.50E+10	1.26E+10
TMDL	**4.04E+12**	**6.13E+11**	**2.50E+11**	**1.26E+11**
	Existing Condition per Zone (expressed as cfus/day)			
95th Percentile Load per Zone	9.74E+12	2.96E+12	1.94E+11	3.85E+10
Load Reduction	**58.5%**	**79.3%**	**-28.6%**	**-227.0%**
95th Percentile Concentration per Zone	2,276	2,180	371	199
Number of Values	3	8	10	3
Current Load or existing Condition is the 95th Percentile of the observed *E. coli* Load for each flow zone.				

9.2 *E. coli* Allocations – Long Creek, Segment R3 (2012 IR)

9.2.1 Load Allocation (LA)

To develop the bacterial load allocation (LA), the loading capacity (LC) was first determined. The LC for Long Creek (Highway 44 to the Vermillion River) was calculated by multiplying the geometric mean (630 cfu/100 ml) *E. coli* threshold by the daily average flow estimated for Site VRT10, which was the only monitoring site within this segment and watershed (Figure 6).

The geometric mean criterion (630 cfu/100 ml) was used for the calculation of the LC, rather than the daily maximum criterion (1,138 cfu/100 ml) because the chronic threshold is considered more protective. The geometric mean, as defined in ARSD § 74:51:01:01, is the arithmetic mean of a minimum of five separate grab or composite samples taken on separate 24-hour periods in a 30-day period. The 30-day average fecal coliform criteria (ARSD § 74:51:01:48) applies at all times but compliance can only be determined when a minimum of five samples are obtained during separate 24-hour periods for any 30-day period. In many instances, only one or two samples were collected during any 30-day period, so the chronic threshold was applied to each flowzone in Figure 6. Although the daily maximum criteria are exceeded, to be conservative it was decided to use the chronic threshold to develop the loading capacity of the stream to ensure that the most stringent water quality standards are met. Additional data would be needed to accurately assess compliance with the geometric mean criterion. The loading capacities and reductions derived from the available data are estimates (i.e., the calculated loading capacities and reductions may be higher or lower if/when a more extensive data set is collected to fully assess compliance with the chronic standard). For each of the four flow zones, the 95th percentile of the range of LCs within a zone was set as the flow zone goal. Setting the flow zone goal at the 95th percentile within each flowzone protects the limited contact recreation beneficial use and will also incorporate the natural variability of the system (Figure 6).

Portions of the LC were allocated to point sources as a waste-load allocation (WLA) and nonpoint sources as a load allocation (LA). A fraction of the LC was also reserved as a margin of safety (MOS) to account for uncertainty in the calculations of these load allocations. The method used to calculate the MOS is discussed below. The LA was determined by subtracting the WLA and MOS from the LC. Thus, the TMDL (and LC) is the sum of WLA, LA, and MOS.

9.2.2 Waste Load Allocation (WLA) – *E. coli*

The WLA is constant across all flow conditions and ensures that water quality standards will be attained. The WLA calculation was based on the effluent limits included in the surface water discharge permit, multiplied by the 80th percentile discharge monitoring report (DMR) flow rate. The normal operation of these systems would typically result in only a small portion of the calculated daily amounts actually being discharged. It is important to note all discharges are required to meet the chronic water quality thresholds (standard) for Long Creek.

The Worthing, SD WWTF consists of a three retention pond system that may periodically require a portion of the final pond to be discharged into an unnamed tributary of Snake Creek which is not assigned a recreational beneficial use. Although it is authorized to discharge it is not required to monitor for bacteria as part of its permit. It has been assigned a WLA of 6.24E+10 cfu/day. Reviewing the DMR data shows that the city of Worthing discharged only 25 times during the period of Jan'2000 through Dec'2010. Twenty of these discharge events occurred outside the recreational season (October 1-April 30). The Worthing WWTF WLA accounts for 25% and 49% of the *E. coli* TMDL within the two lower flow zones, respectively (Table 13). The WLA and LC calculations are based on the chronic threshold (630 cfu/100ml) and an explicit 10% safety margin. The two lower flow zones do not require a reduction and when flow in the two lower zones is not effluent driven the WLA can be considered solely included as LA in the overall load capacity. The Worthing facility is also located approximately 20 miles north and east of Long Creek minimizing its impact on the LC of Long Creek.

The Lennox, SD WWTF is a continuous discharger into Long Creek and is required to monitor bacteria as part of its NPDES permit. The *E. coli* WLA for this facility is 8.03E+09 cfu/day. The Lennox WWTF accounts for 6.4% of the LC of Long Creek at the lowest flow zone and 0.2% of the LC at the highest flow zone (Table 13). This facility has a negligible impact within the flowzones that require a 58.5% and 79.3% reduction (Table 13).

All the NPDES facilities identified in these TMDLS have mechanisms in place that reduce fecal coliform and *E. coli* bacteria. Bacteria in the wastewater lagoons and ponds are viable for short periods due to extended retention time and resultant exposure to the ultraviolet light. This is evident in the bacteria data collected required by the permit. The relative assumption is fecal coliform and *E. coli* bacteria contributions from the Worthing and Lennox facilities are minor and not causing impairment. Emphasis should be placed on reducing bacteria inputs from livestock sources (feedlots and grazing) to bring the recreational use of the classified segment of the West Fork of the Vermillion River into compliance.

10.0 Margin of Safety (MOS) – Fecal Coliform and *E. coli*

In accordance with the regulations, a margin of safety was established to account for uncertainty in the data analyses. A margin of safety may be provided (1) by using conservative assumptions in the calculation of the loading capacity of the waterbody and (2) by establishing allocations that in total are lower than the defined loading capacity. In the case of Long Creek (Segment R3 2012 IR), the latter approach was used to establish a safety margin.

An 10% explicit MOS was calculated within the duration curve framework to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc.). This 10% explicit MOS was calculated from the TMDL within each flowzone and reserved as unallocated assimilative capacity. The remaining assimilative capacity was attributed nonpoint sources (LA) or point sources (WLA).

As new information becomes available and the TMDL is revisited, this unallocated capacity may be attributed to nonpoint sources and added to the load allocation, or the unallocated capacity may be attributed to point sources and become part of the waste load allocation.

11.0 Seasonal Variation

Discharge in the Vermillion River (USGS gage# 06478600 - near Parker, SD; USGS gage# 06479010 – near Vermillion, SD; and Site VRT10 – near Centerville, SD) all displayed seasonal variation for the period of record (10/1/83 to 9/30/11). Highest stream flows typically occur during spring with highest monthly average stream flow reported in April. The lowest observed stream flows occur during the winter months with the lowest monthly average stream flow reported in January. Fecal coliform and *E. coli* concentrations also displayed seasonal variation relative to flow with most exceedances occurring with the lower three flow zones. During the lower flows livestock have access to the stream allowing them to cool during warmer temperatures of the summer. By using the LDC approach to develop the TMDL allocations, seasonal variability in both types of bacteria loads is taken into account.

Although the TMDL displays seasonality through flow, it is effective throughout the entire year.

12.0 Critical Conditions

Critical conditions occur within the basin during the spring and summer storm events as well as low flow during the summer and fall. Typically, during severe thunderstorms the largest concentrations are highest in the basin during the summer months. However, higher concentrations for Long Creek can occur at lower flows when livestock have access to the streams. At this time, only the higher flow regimes have been targeted for implementation.

13.0 Monitoring Strategy

During and after the implementation of management practices, monitoring will be necessary to assure attainment of the TMDL. Stream water quality monitoring will be accomplished through SD DENR's ambient water quality monitoring stations found within the river basin especially for the

segment addressed in this report. All five WQM stations within the basin, are sampled on a monthly basis.

Additional monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and parameters will be based on a product-specific basis.

The Department may adjust the load and/or wasteload allocations in this TMDL to account for new information or circumstances identified during the implementation of the TMDL. If a review of the new information or circumstances indicates that an adjustment to the LA and WLA is appropriate than the TMDL will be updated following SDDENR programmatic steps including public participation. The Department will propose adjustments only in the event that any adjusted LA or WLA will not result in a change to the loading capacity and will reflect the water quality standards found in the ARSD. The Department will notify EPA of any adjustments to this TMDL within 30 days of their adoption.

14.0 Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. Monthly meetings were held during the assessment phase (2004-2006) through the Vermillion Basin Water Development District (VBWDD) which was the local sponsor for the TMDL project. Meetings minutes are available upon request.
2. A webpage was developed and used during the course of the assessment.
3. Presentations to local groups on the findings of the assessment.
4. 30-day public notice (PN) period for public review and comment.

The findings from these public meetings, the webpage, and 30-day PN comments have been taken into consideration in development of the previous Vermillion River Basin TMDLs as well as this TMDL targeting Long Creek.

15.0 Implementation

Currently, there is an implementation project targeting areas of sediment and bacterial sources within the Vermillion River Basin. During the next Section 319 funding round an increase in funding will be requested for additional BMPs targeting more areas of streambank erosion, animal waste management systems, and grazing management.

Several types of BMPs have been considered in the development of a water quality management implementation plan for the impaired segments of the Vermillion River Basin. The results shown in the Load Duration Curves indicate significant reductions are required in the lower three flow zones. Because of the rural area and the lack of point sources (WWTF) most of the implementation measures should focus on the following:

- Livestock access to streams should be reduced, and livestock should be provided sources of water away from streams.

- Unstable stream banks should be protected by enhancing the riparian vegetation that provides erosion control and filters runoff of pollutants into the stream.
- Filter strips should be installed along the stream bordering cropland and pastureland.
- Animal confinement facilities should implement proper animal waste management systems.
- An assessment of progress will be part of every Section 319 implementation segment, and revisions to the plan will be made as appropriate, in cooperation with basin stakeholders.

Funds to implement watershed water quality improvements can be obtained through SD DENR. SD DENR administers three major funding programs that provide low interest loans and grants for projects that protect and improve water quality in South Dakota. They include: Consolidated Water Facilities Construction program, Clean Water State Revolving Fund (SRF) program, and the Section 319 Nonpoint Source program.

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17.0 APPENDIX A: Water Quality Data

Station	Date	Time	Flow *(cfs)*	Flow Rank	1-day Change in Flow *(mm)*	Stormflow *(%)*	1-day Change in Flow *(cfs)*	Fecal Coliform (cfu/100mL)	*Escherichia Coli* (cfu/100mL)
VRT10	3/21/2005	15:00	11.4	64%	0.001	2%	0.3		
VRT10	4/4/2005	11:20	26.4	35%	-0.017	18%	0.0	10	44.1
VRT10	4/21/2005	11:00	41.5	24%	-0.009	0%	0.0	210	162.0
VRT10	5/12/2005	13:30	39.8	25%	0.098	51%	20.1	53000	2420.0
VRT10	6/1/2005	12:30	145.0	8%	0.447	72%	91.9	20000	2420.0
VRT10	6/6/2005	17:15	411.5	1%	-0.205	50%	0.0	970	980.0
VRT10	6/29/2005	12:30	77.7	14%	0.008	23%	1.6	1800	1733.0
VRT10	6/29/2005	13:00	77.7	14%	0.008	23%	1.6	1400	980.0
VRT10	8/10/2005	16:10	13.1	59%	-0.002	2%	0.0	180	19.4
VRT10	9/22/2005	16:00	9.6	74%	-0.002	4%	0.0	20	1.0
VRT10	11/2/2005	14:00	8.7	78%	-0.001	0%	0.0	10	21.3
VRT10	1/25/2006	14:00	15.8	52%	0.001	1%	0.1	10	29.8
VRT10	2/28/2006	12:00	13.6	58%	0.001	5%	0.3	10	9.8
VRT10	2/28/2006	12:15	13.6	58%	0.001	5%	0.3	10	11.0
VRT10	3/14/2006	16:30	16.6	49%	-0.003	5%	0.0	10	1.0
VRT10	3/29/2006	10:00	26.2	35%	0.015	21%	3.1	10	10.9
VRT10	4/12/2006	15:00	194.8	7%	-0.164	41%	0.0	130	126.0
VRT10	5/4/2006	14:30	63.2	17%	-0.017	13%	0.0	220	**101.4**
VRT10	5/25/2006	15:30	21.4	41%	-0.003	0%	0.0	650	**232.2**
VRT10	5/25/2006	15:45	21.4	41%	-0.003	0%	0.0	1700	**484.1**
VRT10	6/19/2006	14:15	42.5	24%	0.109	67%	22.3	5900	**1253.3**
VRT10	6/27/2006	17:00	16.3	50%	-0.004	13%	0.0	540	115
VRT10	6/27/2006	17:15	16.3	50%	-0.004	13%	0.0	390	173.0
VRT10	8/11/2006	11:30	7.9	82%	0.000	8%	0.0	600	**218.4**
VRT10	9/26/2006	13:30	19.6	43%	0.005	18%	1.0	300	**128.6**

18.0 APPENDIX B: County Livestock Data

NASS Progam	Year	Domain	Domain Category	County	Total County Acres	Livestock Data Item	Total Animal Number	# per acre
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	CATTLE, COWS - INVENTORY	26,813	0.051
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	CATTLE, COWS, BEEF - INVENTORY	21,656	0.042
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	CATTLE, COWS, MILK - INVENTORY	5,157	0.010
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	CATTLE, INCL CALVES - INVENTORY	74,307	0.143
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	CATTLE, ON FEED - INVENTORY	21,096	0.041
				MINNEHAHA	520,746	CATTLE ON GRASS	48,054	0.092
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	CHICKENS, BROILERS - INVENTORY	630	0.001
				MINNEHAHA	520,746	EQUINE, HORSES & PONIES - INVENTORY	2284	0.004
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	HOGS - INVENTORY	61,333	0.118
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	SHEEP, INCL LAMBS - INVENTORY	5,583	0.011
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	TURKEYS - INVENTORY	10	0.000
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	CATTLE, COWS - INVENTORY	26,813	0.051
CENSUS	2007	TOTAL	NOT SPECIFIED	MINNEHAHA	520,746	CATTLE, COWS, BEEF - INVENTORY	21,656	0.042
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	CATTLE, COWS, BEEF - INVENTORY	7,064	0.019
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	CATTLE, COWS, MILK - INVENTORY	427	0.001
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	CATTLE, INCL CALVES - INVENTORY	36,505	0.099
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	CATTLE, ON FEED - INVENTORY	16,884	0.046
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	cattle on grass	19,194	0.052
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	CHICKENS, BROILERS - INVENTORY	210	0.001
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	CHICKENS, LAYERS - INVENTORY	986	0.003
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	EQUINE, HORSES & PONIES - INVENTORY	924	0.002
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	GOATS - INVENTORY	574	0.002
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	HOGS - INVENTORY	28,302	0.076
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	SHEEP, INCL LAMBS - INVENTORY	3920	0.011
CENSUS	2007	TOTAL	NOT SPECIFIED	LINCOLN	370,310	TURKEYS - INVENTORY	14	0.000
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, COWS - INVENTORY	19,503	0.049
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, COWS, BEEF - INVENTORY	13,068	0.033
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, COWS, MILK - INVENTORY	6,435	0.016
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, INCL CALVES - INVENTORY	49,050	0.124
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, ON FEED - INVENTORY	15,904	0.040
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	cattle on grass	26,711	0.068
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	CHICKENS, BROILERS - INVENTORY	35	0.000
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	EQUINE, HORSES & PONIES - INVENTORY	732	0.002

NASS Progam	Year	Domain	Domain Category	County	Total County Acres	Livestock Data Item	Total Animal Number	# per acre
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	HOGS - INVENTORY	61,412	0.155
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	SHEEP, INCL LAMBS - INVENTORY	13,145	0.033
CENSUS	2007	TOTAL	NOT SPECIFIED	TURNER	395,067	TURKEYS - INVENTORY	41	0.000

19.0 APPENDIX C: Public Comments

20.0 Placeholder for EPA Approval letter