Escherichia coli (*E. coli*) Bacteria Total Maximum Daily Load (TMDL) for Deadwood Creek, Lawrence County, South Dakota

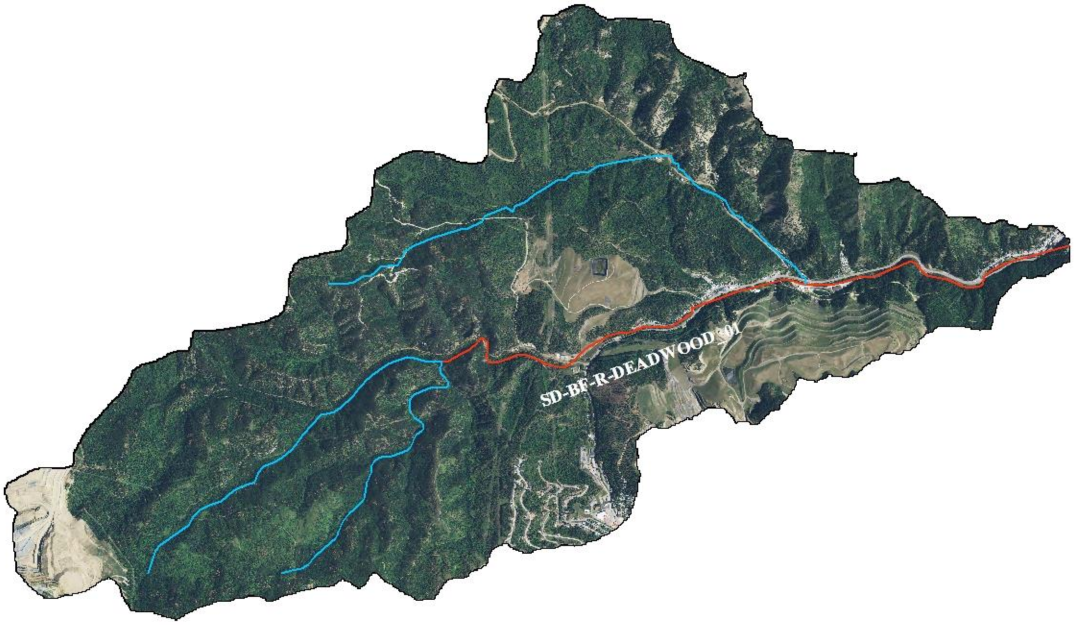

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Table of Contents

Table of Contents (continued)

List of Tables

List of Tables (continued)

List of Figures

List of Figures (continued)

List of Acronyms

ADB	Assessment Database
ARSD	Administrative Rules of South Dakota
AUID	Assessment Unit Identification
BIT	Bacteria Indicator Tool
BMP	Best Management Practice
BTWTF	Blacktail Water Treatment Facility
CAFO	Confined Animal Feeding Operation
CFU	Colony Forming Units
CFS	Cubic Feet per Second
DMR	Discharge Monitoring Report
ICIS	Integrated Compliance Information System
LA	Load Allocation
LDSD	Lead Deadwood Sanitary District
LDC	Load Duration Curve
MGD	Million Gallons per Day
MPN	Most Probable Number
MOS	Margin Of Safety
NPDES	National Pollutant Discharge Elimination System
SDCL	South Dakota Codified Law
SD DENR	South Dakota Department of Environment and Natural Resources
SD DENR SWQP	South Dakota Department of Environment and Natural Resources Surface Water Quality Program
SD DENR FP	South Dakota Department of Environment and Natural Resources Feedlot Program
SD GF&P	South Dakota Game Fish and Parks
SOP	Standard Operating Procedures
SSM	Single Sample Maximum
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	Wasteload Allocation
WQM	Water Quality Monitoring
WWTF	Wastewater Treatment Facility

Total Maximum Daily Load Summary

Deadwood Creek of the Whitewood Creek Basin - Segment SD-BF-R-DEADWOOD_01

Waterbody Type: River/Stream

Reach Number: SD-BF-R-DEADWOOD_01

303(d) Listing Parameter: Pathogens (*Escherichia coli*)

Designated Uses of Concern: Immersion Recreation Waters

Size of Impaired Waterbody: Reach SD-BF-R-DEADWOOD_01 - Approximately 5.96 km
Entire length – Approximately 9.15 km

Size of Watershed: Watershed size for Segment SD-BF-R-DEADWOOD_01- 2,094.2 hectares (ha)
Entire Sub-watershed Size – 2,094.2 ha

Indicator(s): Concentration of *Escherichia coli* (colony forming units per 100mL)

Analytical Approach: Load Duration Curve

Location: Hydrologic Unit Codes (12-digit HUC): 101202020208

TMDL Priority Ranking: High (2020 IR)

Target (Water Quality Standards): *Escherichia coli* (*E. coli*) - Maximum daily concentration of ≤ 235 CFU/100mL and a geometric mean of ≤ 126 CFUs/100mL based on a minimum of five (5) samples obtained during separate 24-hour periods for any 30-day period (calendar month).

***E. coli* (CFU/day)**

	High Flow Zone (0-10%)
Loading Allocation	2.64 x 10^{11}
Waste Load Allocation	0.00 x 10^{00}
Margin of Safety	2.93 x 10^{10}
TMDL	2.93 x 10^{11}

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 of Segment SD-BF-R-DEADWOOD_01 of Deadwood Creek (Rutabaga Gulch to Whitewood Creek) in the Whitewood Creek Basin (Figure 1). This impairment has been assigned a priority category 1 (high-priority) in the 2014, 2016, 2018, and 2020 impaired waterbodies list. Sufficient data was collected to determine that the beneficial use of immersion recreation is not supported. The segment has been listed as non-supporting for immersion recreation use and has subsequently been included on the 2014, 2016, 2018 and 2020 §303(d) lists.

2.0 Watershed Characteristics

2.1 General

Location of the Deadwood Creek Watershed in South Dakota

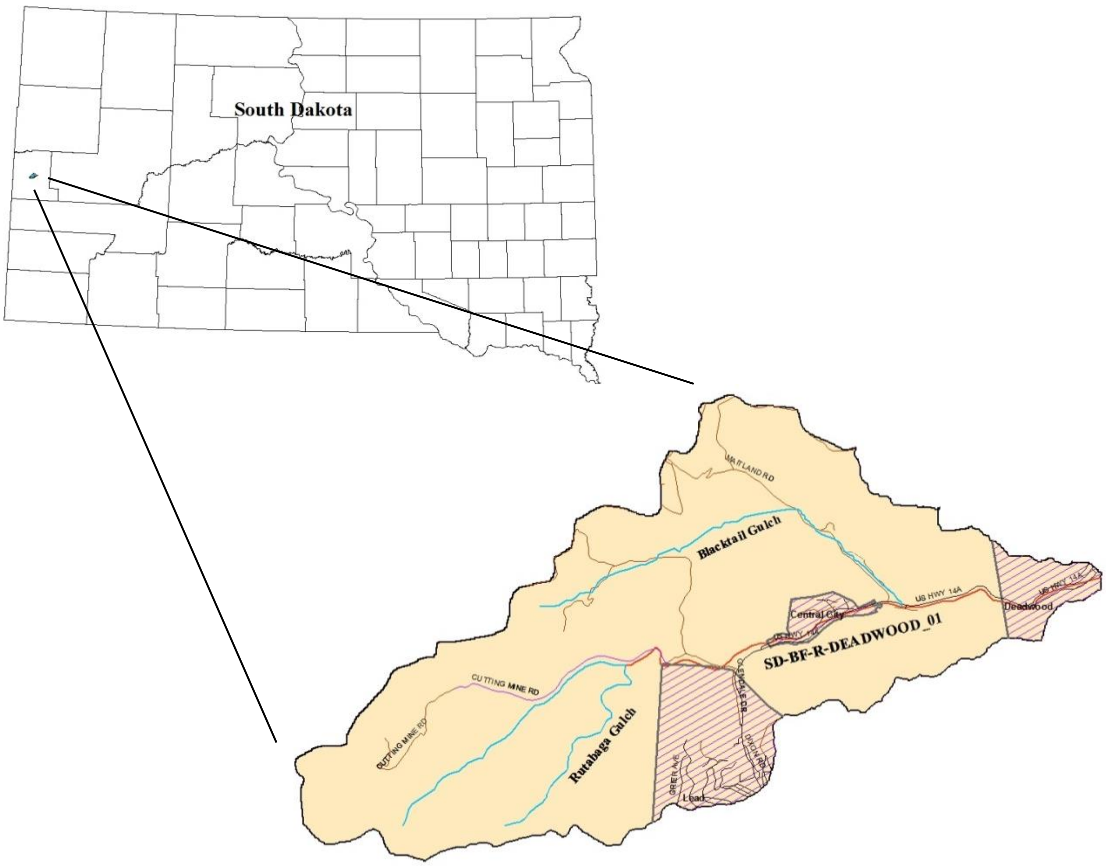

Figure 1 Location of the Deadwood Creek watershed within South Dakota.

2.1.1 Topography

Deadwood Creek is a perennial mountain stream located in Lawrence County, South Dakota. Deadwood Creek is a tributary of Whitewood Creek, which empties into the Belle Fourche River.

Drainage area of Deadwood Creek watershed is approximately 20.97 square kilometers at the confluence with Whitewood Creek in Deadwood, South Dakota. The Deadwood Creek watershed has a maximum elevation of 2,015 meters and a minimum elevation of 1,384 meters near the confluence of Whitewood Creek. The impaired (303(d) listed) segment of Deadwood Creek has a combined length of 5.96 stream kilometers beginning at the confluence of Rutabaga Gulch and ends where Deadwood Creek enters Whitewood Creek in Deadwood, South Dakota (Figure 1, Figure 2 and Table 1).

Table 1 Clean Water Act Section 303(d) Listing Information for Deadwood Creek based on the 2020 Integrated Report*

Waterbody AUID	From	To	Parameter
SD-BF-R-DEADWOOD_01	Rutabaga Gulch	Whitewood Creek	*E. coli* Bacteria

*** See Figure 1 map for segment location**

2.1.2 Watershed Description

Deadwood Creek Watershed including AUID identifiers, Assessment and WQM Monitoring Sites, Segment Length, and Permitted Surface Water Discharge Outlet (SWD – Outlet 013) in 2020

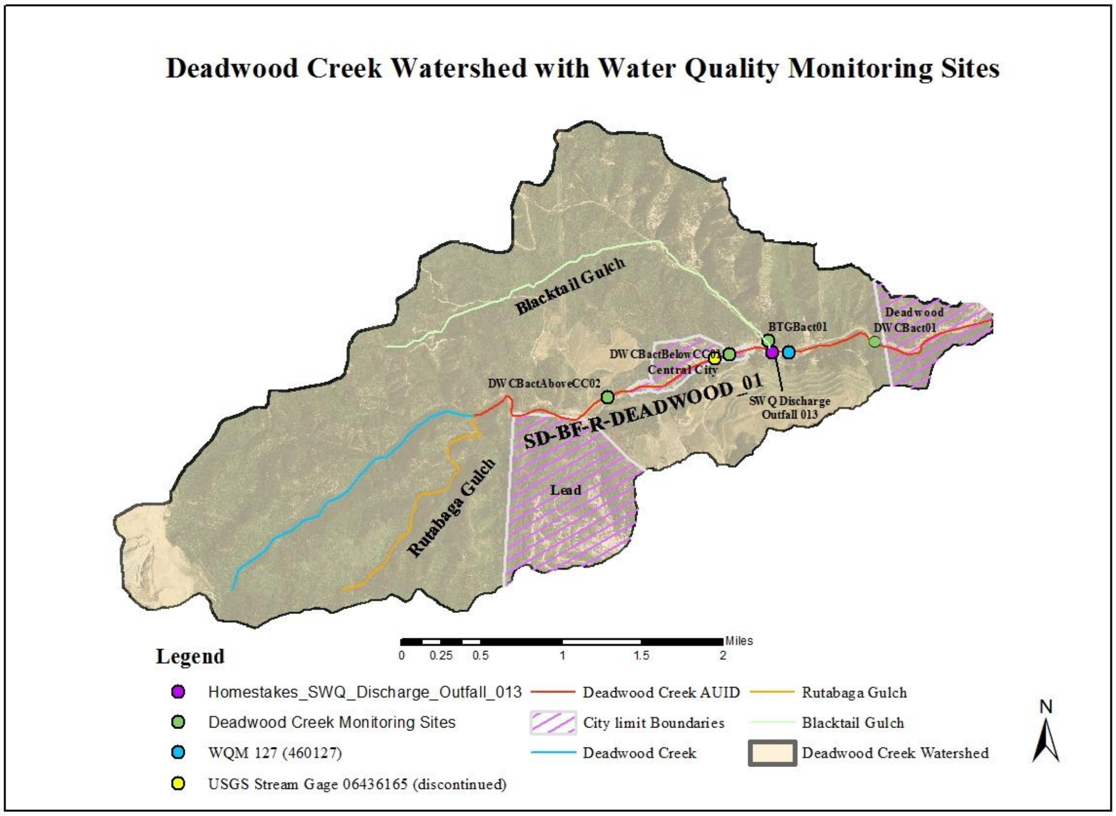

Figure 2 Deadwood Creek watershed with monitoring sites, AUID identifier, current ADB segment, city limit boundaries and SWQ Discharge Outfall.

2.1.3 Geology

The underlying geology in the Deadwood Creek watershed is shown in Figure 3. The main geology of the impaired segment of Deadwood Creek, Rutabaga Gulch Creek to Whitewood Creek (SD-CH-

R-DEADWOOD_01) flows through (X_q) Metaquartzite made up of Light-tan quartzite, siliceous schist, and minor chert. Metamorphosed siltstone (X_{si}) Medium-gray to dark greenish-gray phyllite, slate, and biotite schist containing minor chert and amphibolite. Locally intruded by thin metagabbro sills. Laterally equivalent to X_{ms}. Metamorphosed carbonaceous shale (X_{sc1}) made up of Dark-gray to gray, siliceous biotite phyllite, and schist. Light-tan quartzite, siliceous schist, and minor chert. The other major geologic group in the impaired segment is Trachytic intrusive rocks (T_t) composed of Tan to reddish-brown, iron-stained stocks, laccoliths, sills, and dikes of trachyte, quartz trachyte, and rhyolite. Contains phenocrysts of sanidine, orthoclase, anorthoclase, aegirines-augite, and biotite in a fine grained orthoclase-quartz-biotite groundmass (Martin et al., 2004).

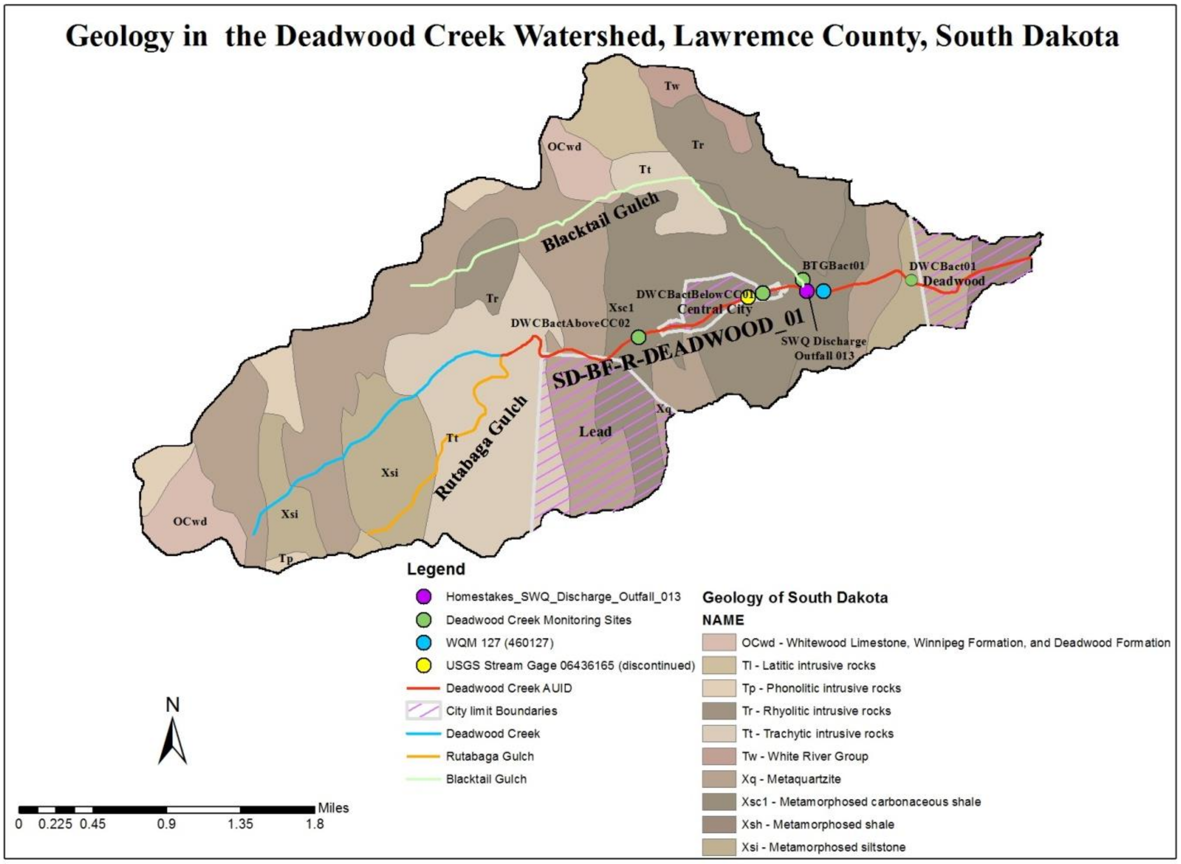

Figure 3 Underlying geology of the Deadwood Creek watershed, Lawrence County, South Dakota.

2.1.4 Soils

The major soil name in the Deadwood Creek watershed based on coverage are composed of Pactola-Buska channery silt loams, 20 to 60 percent slope, at 17.3 percent of the watershed and Grizzly-Mineshaft complex, 40 to 80 percent slope, at 15.5 percent of the soils in the Deadwood Creek watershed (Figure 4 and Table 2).

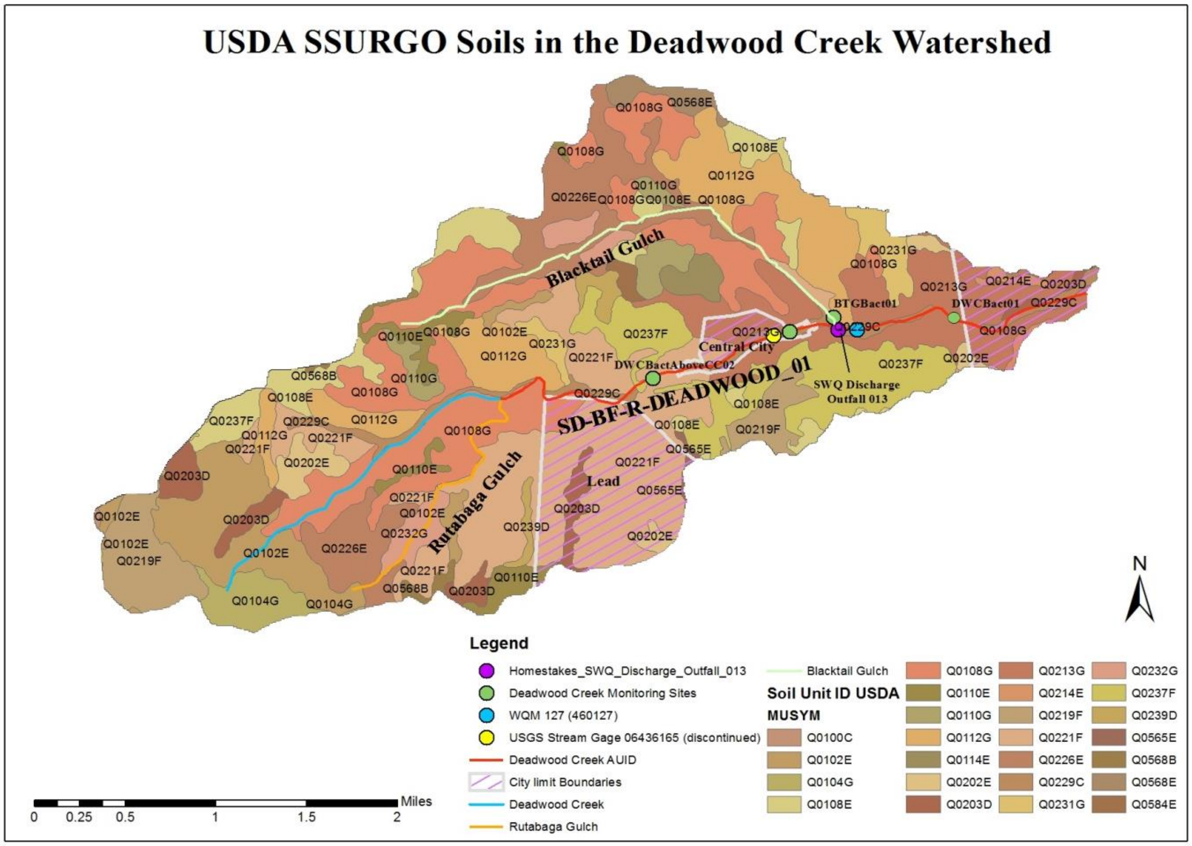

Figure 4 USDA SSURGO soils within the Deadwood Creek Watershed

Table 2 Deadwood Creek USDA soil map units, kilometers^2, acres, and percent soil in the watershed

Map Unit Symbol	Soil Unit Name	Kilometers^2	Acres	Percent of Deadwood Creek
Q0100C	Goldmine loam, 3 to 12 percent slopes	0.008	2.1	0.0%
Q0102E	Goldmine-Goldmine, moderately deep complex, 10 to 40 percent slopes	1.297	320.5	6.2%
Q0104G	Goldmine-Rubbleland complex, 40 to 75 percent slopes	0.380	93.8	1.8%
Q0108E	Grizzly-Mineshaft complex, 10 to 40 percent slopes	1.056	260.9	5.0%
Q0108G	Grizzly-Mineshaft complex, 40 to 80 percent slopes	3.244	801.7	15.5%
Q0110E	Grizzly-Rock outcrop complex, 10 to 40 percent slopes	0.435	107.5	2.1%
Q0110G	Grizzly-Rock outcrop complex, 40 to 80 percent slopes	0.335	82.7	1.6%
Q0112G	Grizzly-Rubbleland-Rock outcrop complex, 40 to 80 percent slopes	1.848	456.7	8.8%
Q0114E	Grizzly-Virkula complex, 10 to 40 percent slopes	0.161	39.8	0.8%
Q0202E	Buska-Rock outcrop complex, 10 to 40 percent slopes	0.336	83.0	1.6%
Q0203D	Buska-Virkula, high mica loams, 2 to 15 percent slopes	0.498	123.1	2.4%
Q0213G	Hisega-Buska complex, 40 to 80 percent slopes	1.919	474.3	9.2%
Q0214E	Hisega-Rock outcrop complex, 10 to 40 percent slopes	0.054	13.3	0.3%
Q0219F	Typic Udarents-Rock outcrop complex, 6 to 60 percent slopes	0.910	224.9	4.3%
Q0221F	Pactola-Buska channery silt loams, 20 to 60 percent slopes	3.627	896.2	17.3%
Q0226E	Pactola-Virkula-Rock outcrop complex, 10 to 40 percent slopes	1.635	404.0	7.8%
Q0229C	Rapidcreek very gravelly loam, noncalcareous, 1 to 9 percent slopes, rarely flooded	0.478	118.0	2.3%
Q0231G	Buska-Rock outcrop complex, 40 to 80 percent slopes	0.330	81.6	1.6%
Q0232G	Pactola-Pactola, shallow-Rock outcrop complex, 40 to 80 percent slopes	0.386	95.3	1.8%
Q0237F	Typic Udarents, reclaimed, 3 to 60 percent slopes	1.489	368.0	7.1%
Q0239D	Virkula-Pactola complex, 2 to 15 percent slopes	0.172	42.6	0.8%
Q0565E	Rockoa, moist-Hickok-Rock outcrop complex, 10 to 40 percent slopes	0.030	7.5	0.1%
Q0568B	Roubaix silt loam, 0 to 6 percent slopes	0.067	16.6	0.3%
Q0568E	Roubaix silt loam, 6 to 40 percent slopes	0.177	43.7	0.8%
Q0584E	Vanocker-Citadel complex, 10 to 40 percent slopes	0.067	16.6	0.3%
Total acres Deadwood Creek		**20.94**	**5,174.4**	**100.0%**

Highest percentage soils (km^2) (acres)	Anthropogenic (Udarents) rock outcrop complex	Anthropogenic (Udarents) reclaimed soils

Gold mining in and around the Deadwood Creek watershed has had and is having an impact on soils and landuse in localized portions of the watershed. Figure 5 shows location of past and present anthropogenic (mining) disturbances in the Deadwood Creek watershed. Mine tailings from Homestake/Barrick Gold underground and open pit mines were placed southeast of Deadwood Creek to Lead City limits and northwest of Deadwood Creek and Central City. Homestake mine was closed in 2002 and tailings have been capped with Typic Udarents-reclaimed, 3 to 60 percent slope soils and revegetated with native grass (Figure 5). On the western edge of the watershed, Wharf mine an open pit heap leach mining operation owned by Coeur Mining, Inc. is currently in operation and has exposed approximately 0.607 km^2 of Typic Udarents-Rock outcrop complex, 6 to 60 percent slopes.

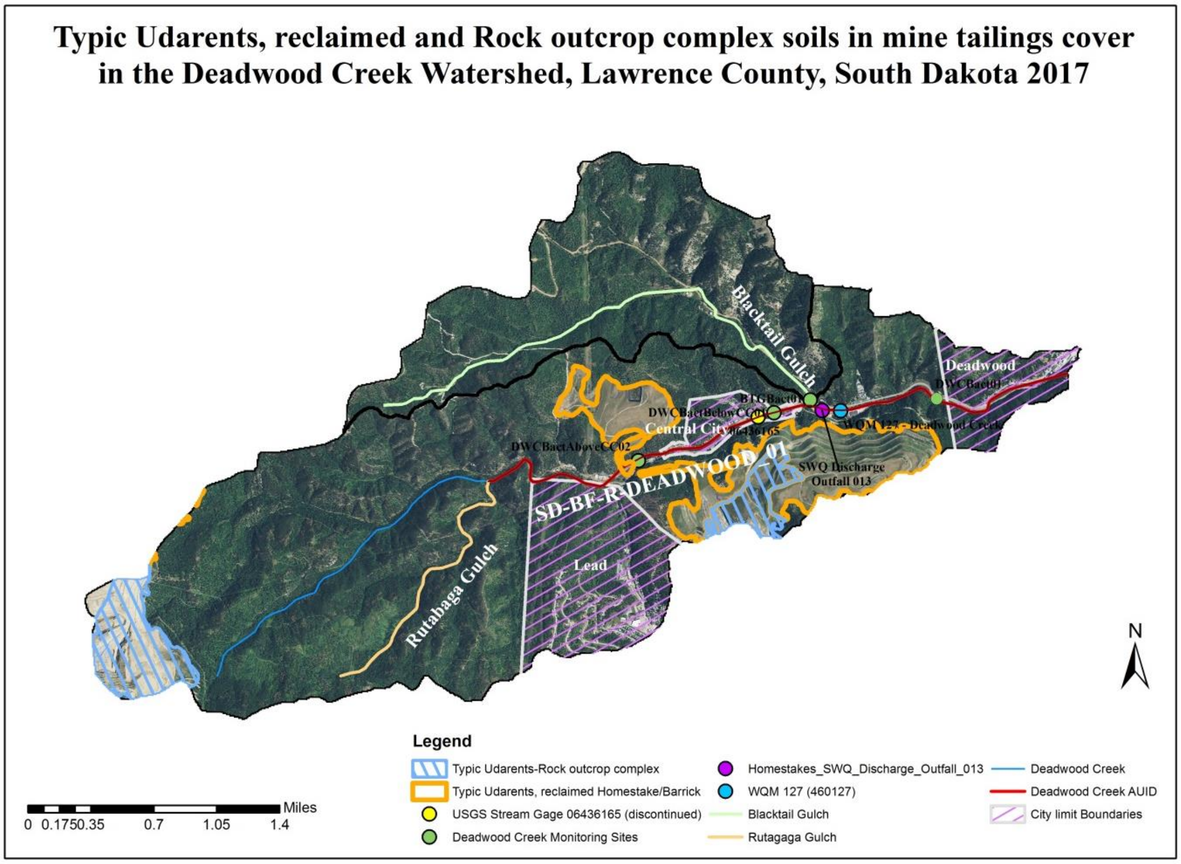
Typic Udarents, reclaimed and Rock outcrop complex soils in mine tailings cover in the Deadwood Creek Watershed, Lawrence County, South Dakota 2017

Figure 5 Anthropogenic reclaimed and rock outcrop complex soil (Udarents soils) locations covering Homestake/Barrick and Wharf gold mine tailings in the Deadwood Creek watershed.

2.1.5 Land Use/Land Cover

The entire watershed (Segment SD-BF-R-DEADWOOD_01) is located within the Black Hills National Forest and landuse is predominantly evergreen forest (76 percent, 15.96 km^2) covered with ponderosa pine followed by Shrub/Scrub (7.3 percent, 1.54 km^2) and Herbaceous plants 4.9 percent, 1.04 km^2. High, medium, low intensity developed, and open developed landuse in the watershed totaled 6.1 percent, 1.29 km^2. The majority of developed lands were in Central City, 0.32 km^2, northwest portions of Lead, 1.78 km^2, and the western portion of the City of Deadwood, 0.75 km^2, in South Dakota (Figure 6).

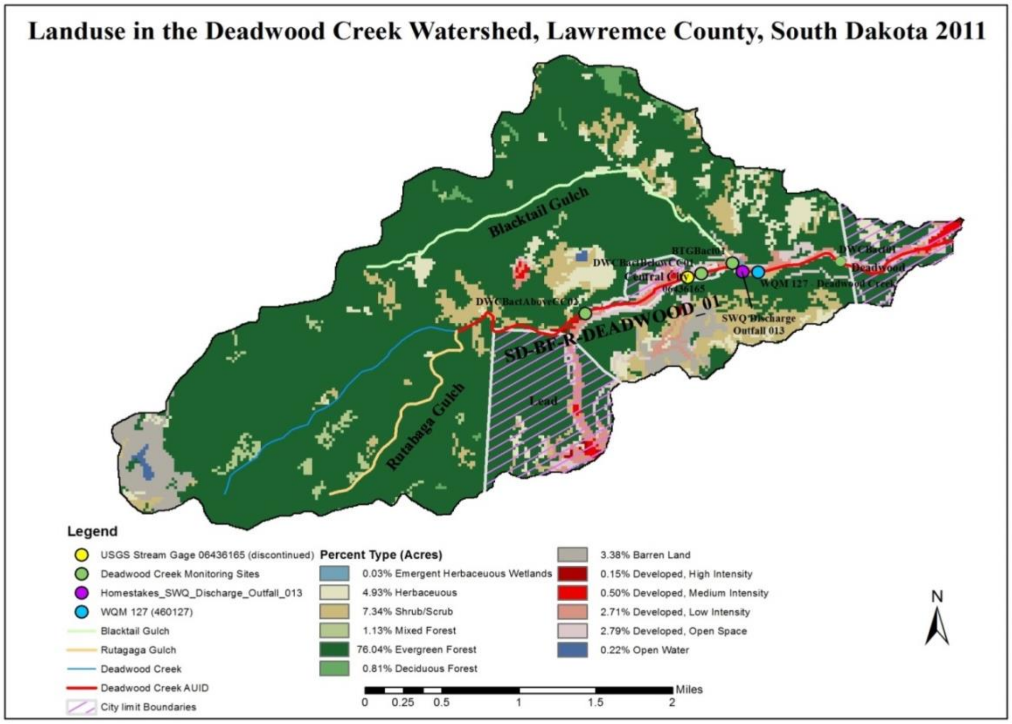

Figure 6 2011 Landuse categories in Deadwood Creek, Lawrence County, South Dakota

2.1.6 Climate and Precipitation

Daily precipitation, snowfall, minimum and maximum temperature data for Lead, South Dakota (Station ID:GHCND:USC00394834) from 1998 through 2017 was downloaded using the online National Climate Data Center (https://www.ncdc.noaa.gov/cdo-web/).

Table 3 Average annual precipitation, snowfall in inches, maximum and minimum temperatures, and yearly maximum and minimum temperatures in degrees Fahrenheit for the Deadwood Creek Watershed from 1998 through 2017.

Year	Annual Precipitation (inches)	Annual Snowfall (inches)	Yearly Maximun Temperature °F	Average Yearly Maximum Temperature °F	Yearly Minimum Temperature °F	Average Yearly Minimum Temperature °F
1998	42.73	259.4	96	54.79	-18	35.11
1999	30.42	146.1	93	57.26	-7	35.80
2000	31.85	228.8	94	55.87	-13	34.03
2001	24.94	132.6	95	56.29	-10	35.65
2002	22.10	106.3	96	55.01	-11	33.57
2003	27.34	137.2	94	55.78	-16	34.52
2004	22.98	90.2	91	55.96	-16	34.71
2005	32.14	134.1	96	56.27	-12	35.34
2006	33.31	208.5	98	56.38	-22	35.54
2007	32.20	147.9	94	56.52	-13	35.25
2008	42.74	326.3	89	53.10	-22	32.01
2009	35.08	291.2	88	52.92	-12	32.07
2010	33.05	165.2	93	54.93	-13	33.93
2011	30.84	175.2	94	54.46	-24	33.10
2012	21.86	112.4	96	59.29	-8	35.81
2013	49.52	238.1	92	54.19	-17	33.81
2014	33.98	144.8	100	58.42	-15	36.76
2015	35.51	99.2	93	60.72	-6	36.85
2016	21.60	98.1	96	59.84	-18	37.23
2017	20.83	75.3	94	59.08	-16	35.86
Period Average	**31.25**	**165.8**	**94**	**56.35**	**-14**	**34.85**

Data indicate the Deadwood Creek watershed in the Black Hills of South Dakota receives approximately 31 inches of average annual precipitation (0.79 m) and averages approximately 166 inches (4.2 m) of snowfall based on the last 20 years of data from the National Climate Data Center website. The highest yearly maximum temperature was 100 °F (37.8 °C) in 2014 and the lowest yearly minimum temperature was -24 °F (-31.1 °C) in 2011 (Table 3). Over 70 percent of the annual precipitation in this watershed occurs during the months of April through September.

3.0 Water Quality Standards

3.1 Numeric Standards

Water quality standards are comprised of three main parts as defined in the Federal Clean Water Act (33 U.S.C. §1251 et seq.) and Administrative Rules of South Dakota (ARSD) Chapter 74:51:01

- Beneficial Uses – Functions or activities that reflect waterbody management goals
- Criteria – Numeric concentrations or narrative statements that represent the level of water quality required to support beneficial uses
- Antidegradation – Additional policies that protect high quality waters

Each waterbody within South Dakota is assigned beneficial uses. All waters (both lakes and streams) 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.

Beneficial use classifications of surface waters of the state are established in ARSD §74:51:01:42 and waters of this section do not limit the actual use of such waters. The classifications designate the minimum quality at which the surface waters of the state are to be maintained and protected. The following are the beneficial use classifications in South Dakota:

(1) Domestic water supply waters;
(2) Coldwater permanent fish life propagation waters;
(3) Coldwater marginal fish life propagation waters;
(4) Warmwater permanent fish life propagation waters;
(5) Warmwater semipermanent fish life propagation waters;
(6) Warmwater marginal fish life propagation waters;
(7) Immersion recreation waters;
(8) Limited contact recreation waters;
(9) Fish and wildlife propagation, recreation, and stock watering waters;
(10) Irrigation waters; and
(11) Commerce and industry waters.

Highlighted = Beneficial use classifications assigned to Deadwood Creek
Red = Impaired use

E. coli bacteria standards in South Dakota are expressed as a count/100mL. Laboratory results for *E. coli* and fecal coliform were expressed as Most Probable Number (MPN) and Colony Forming Units (CFU), respectively. Both units are considered equivalent and representative of the number or count of bacteria/100mL. To standardize, all bacteria data are expressed as CFU/100 mL and bacteria loading is expressed as CFU/day (SD DENR, 2018a).

Table 4 Numeric surface water quality standards for Deadwood Creek, Lawrence County, South Dakota 2018

Parameter	Segment		
	SD-BF-R-DEADWOOD_01		
	Criterion and units of measure	**Special Conditions**	**Beneficial Use**
Total Suspended Solids	≤ 90 mg/L	30-day average	Coldwater marginal fish life propagation waters
	≤ 158 mg/L	daily maximum	
Total Ammonia Nitrogen as N	Equal to or less than the result from Equation 3 in Appendix A, mg/L (SDCL§74:51:01)	30-day average May 1 – October 31	Coldwater marginal fish life propagation waters
	Equal to or less than the result from Equation 1 in Appendix A, mg/L (SDCL§74:51:01)	Daily maximum	Coldwater marginal fish life propagation waters
Dissolved Oxygen **(Anywhere in the water column of a Non-stratified water body)**	≥ 5 mg/L	Daily minimum	Coldwater marginal fish life propagation waters
Un-disassociated Hydrogen Sulfide	≤ 0.002 mg/L	Daily maximum	Coldwater marginal fish life propagation waters
pH	≥ 6.5 - ≤ 9.0	See SDCL §74:51:01:07	Coldwater marginal fish life propagation waters
Undisassociated hydrogen sulfide	≤ 0.002 mg/L	Daily maximum	Coldwater marginal fish life propagation waters
Water Temperature	≤ 75.2 °F	See SDCL §74:51:01:46.01	Coldwater marginal fish life propagation waters (Black Hills Trout Management Area)
Escherichia coli **(May 1 – September 30)**	≤ 126 CFU/100 mL	Geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period (calendar month, 2018 IR listing methodology)	Immersion recreation
	≤ 235 CFU/100 mL	In any one sample	
Escherichia coli **(May 1 – September 30)**	≤ 630 CFU/100 mL	Geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period (calendar month, 2018 IR listing methodology)	Limited contact recreation
	≤ 1,178 CFU/100 mL	In any one sample	
Total alkalinity as calcium carbonate	≤ 750 mg/L	30-day average	Fish and wildlife propagation, recreation, and stock watering
	≤ 1313 mg/L	Daily maximum	
Total Dissolved Solids	≤ 2,500 mg/L	30-day average	Fish and wildlife propagation, recreation and stock watering
	≤ 4,375 mg/L	Daily maximum	
Nitrates as N	≤ 50 mg/L	30-day average	Fish and wildlife propagation, recreation, and stock watering
	≤ 88 mg/L	Daily maximum	
pH	≥ 6.0 - ≤ 9.5	See SDCL §74:51:01:07	Fish and wildlife propagation, recreation, and stock watering
Total petroleum hydrocarbon	≤ 10 mg/L	See SDCL §74:51:01:10	Fish and wildlife propagation, recreation, and stock watering
Oil and grease	≤ 10 mg/L	See SDCL §74:51:01:10	Fish and wildlife propagation, recreation, and stock watering
Conductivity @ 25°C	≤ 2,500 µmhos/cm	30-day average	Irrigation waters
	≤ 4,375 µmhos/cm	Daily maximum	
Sodium adsorption ratio	≤ 10	Sodium adsorption ratio: a calculated value that evaluates the sodium hazard of irrigation water based on the Gapon equation and expressed by the mathematical expression: $\frac{Na^{+}}{\sqrt{\frac{Ca^{+2} + Mg^{+2}}{2}}}$ where Na^{+}, Ca^{+2}, and Mg^{+2} are expressed as milliequivalents per liter	Irrigation waters

pH Equation 1: For waters where salmonid fish are present. $(0.275/(1+10^{7.204-pH})) + (39.0/(1+10^{pH-7.204}))$

pH = the pH of the water quality sample in standard units.

pH Equation 3: For waters where early life stages are present. $(((0.0577/(1 + 10^{7.688-pH})) + (2.487/(1+10^{pH-7.688}))) * MIN(2.85, 1.45 * 10^{0.028 * (25-T)})$

MIN = use either 2.85 or the value of 1.45 $^{0.028 * (25-T)}$, whichever is the smaller value. T = the water temperature of the sample in degrees Centigrade.

pH = the pH of the water quality sample in standard units.

Highlighted = Only impaired water quality parameter in Deadwood Creek (Segment SD-BF-R_DEADWOOD_01) in 2014, 2016, and 2018 IR reports.

These standards consist of suites of criteria that provide physical and chemical benchmarks from which management decisions can be developed. Individual parameters determine the support of these beneficial uses. Each beneficial use classification has a set of unique, numeric criteria. Water quality values that exceed those criteria impair the beneficial use and violate water quality standards.

Deadwood Creek has been assigned the following beneficial uses: (3) Coldwater marginal fish life propagation (Rutabaga Gulch to Whitewood Creek), (7) Immersion recreation, (8) Limited contact recreation, (9) Fish and wildlife propagation, recreation and stock watering waters, and (10) Irrigation waters. Table 4 lists the most stringent criteria that must be met to support the specified beneficial uses. When multiple criteria exist for a particular parameter, the most stringent criterion was used.

TMDLs must also consider downstream water quality standards. In this case, Deadwood Creek SD-BF-R-DEADWOOD_01 flows into Whitewood Creek segment SD-BF-R-WHITEWOOD_03 which is assigned similar beneficial uses classifications except for the fishery designation. Deadwood Creeks assigned fisheries beneficial use is coldwater marginal and Whitewood Creek fisheries beneficial use is coldwater permanent fish life propagation water. Coldwater permanent fish life propagation water standards have more stringent requirements for dissolved oxygen and Total Suspended Solids (TSS) and unlike coldwater marginal fisheries have chloride standards. As the date of this report Segment SD-BF-R- WHITEWOOD_03 has never been listed for parameters associated with coldwater permanent fish life propagation waters beneficial use. Whitewood Creek Segment SD-BF-R-WHITEWOOD_03 is on the 303(d) list (impaired waterbodies list) for exceeding the *E. coli* bacteria standard for immersion recreation. This segment has EPA approved TMDLs for Fecal Coliform and *E. coli*. (approved, July 2011). All other assigned beneficial use classifications immersion recreation, limited contact recreation, fish, and wildlife propagation, recreation, stock watering, and irrigation waters and are subject to the same criteria listed in Table 4. Because of this agreement, TMDLs established to meet Deadwood Creek's water quality standards will also be protective of downstream water quality standards.

3.2 Narrative Standards

In addition to physical and chemical standards, South Dakota has developed narrative criteria for the protection of aquatic life uses (ASRD § 74:51:01:12). *All waters of the state must be free from substances, whether attributable to human-induced point source discharge or non-point source activities, in concentration or combinations which will adversely impact the structure and function of indigenous or intentionally introduced aquatic communities*.

South Dakota has narrative standards that may also be applied to the undesired eutrophication of lakes and streams. ARSD § 74:51:01:05; 06; 08; 09 contains language that prohibits the presence of materials causing pollutants to form, visible pollutants, taste and odor producing materials, and nuisance aquatic life. Specific ARSD narrative languages for the above conditions are provided below.

§ **74:51:01:05. Materials causing pollutants to form in waters.** *Wastes discharged into surface waters of the state may not contain a parameter which violates the criterion for the waters' existing or designated beneficial use or impairs the aquatic community as it naturally occurs. Where the interaction of materials in the wastes and the waters causes the existence of such a parameter, the material is considered a pollutant and the discharge of such pollutants may not cause the criterion for this parameter to be violated or cause impairment to the aquatic community.*

§ **74:51:01:06. Visible pollutants prohibited.** *Raw or treated sewage, garbage, rubble, un-permitted fill materials, municipal wastes, industrial wastes, or agricultural wastes which produce floating solids, scum, oil slicks, material discoloration, visible gassing, sludge deposits, sediments, slimes,* *algal blooms, fungus growths, or other offensive effects may not be discharged or caused to be discharged into surface waters of the state.*

§ **74:51:01:08. Taste-and odor-producing materials.** *Materials which will impart undesirable tastes or undesirable odors to the receiving water may not be discharged or caused to be discharged into surface waters of the state in concentrations that impair a beneficial use.*

§ **74:51:01:09. Nuisance aquatic life.** *Materials which produce nuisance aquatic life may not be discharged or caused to be discharged into surface waters of the state in concentrations that impair an existing or designated beneficial use or create a human health problem.*

3.3 *E. coli* Water Quality Standards

South Dakota has adopted numeric *E. coli* criteria for the protection of the immersion (7) and limited contact recreation uses (8). Immersion recreation waters are to be maintained suitable for activities such as swimming, bathing, water skiing and other similar activities with a high degree of water contact that make bodily exposure and ingestion more likely. Limited contact recreation waters are to be maintained suitable for boating, fishing, and other water-related recreation other than immersion recreation.

Through the 1970's and 1980's EPA epidemiological studies identified *E. coli* as a good predictor of gastrointestinal illnesses in fresh waters (US EPA, 1986). *E. coli* is a class of bacteria naturally found in the intestinal tract of humans and warm-blooded animals. The presence and concentration of *E. coli* in surface waters, typically measured in Colony Forming Units (CFU) or counts (#)/100mL, is used to identify fecal contamination and as an indicator for the likely presence of other pathogenic microorganisms. In 1986 EPA recommended states adopt *E. coli* criteria for immersion recreation based on a rate of 8 illnesses per 1,000 swimmers (US EPA, 1986). While it is generally understood that limited contact recreation is associated with a reduced illnesses risk and different routes of exposure, it is difficult to directly relate an illness rate to these activities from epidemiological studies based on immersion recreation. Therefore, to protect downstream uses and establish effluent limitations for limited contact recreation waters, EPA has suggested numeric criteria five times the immersion recreation values (US EPA, 2002). Because of the reduced risk, the multiplier was considered protective of the limited contact recreation use through the EPA and SD DENR water quality standards review and approval process.

The South Dakota *E. coli* criteria for the immersion recreation beneficial use requires that 1) no single sample SSM exceed 235 CFU/100 mL and 2) during a 30-day period, the geometric mean of a minimum of 5 samples collected during separate 24-hr periods must not exceed 126 CFU/100 mL (ARSD 74:51:01:50). The *E. coli* criteria for the limited contact recreation beneficial use requires that 1) no single sample exceed 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 (ARSD 74:51:01:51). As noted, these limited contact criteria are five times the corresponding immersion criteria. *E. coli* criteria apply from May 1st through September 30th, which is considered the recreation season. The numeric *E. coli* criteria applicable to Deadwood Creek (SD-BF-R-DEADWOOD_01) are the immersion recreation values listed in Table 4 ($\leq$ 235 CFU/100 mL SSM, $\leq$ 126 CFU/100mL 30-day geometric mean).

3.4 Numeric TMDL Targets

TMDLs are required to identify a numeric target to measure whether or not the applicable water quality standard is attained. A maximum allowable load, or TMDL, is ultimately calculated by multiplying this target with a flow value and a unit conversion factor. Generally, the pollutant causing the impairment and the parameter expressed as a numeric water quality criterion are the same. In these cases, selecting a TMDL target is as simple as applying the numeric criteria. Occasionally impairment is caused by narrative water quality criteria violations or by parameters that cannot be easily expressed as a load. When this occurs, the narrative criteria must be translated into a numeric TMDL target (e.g., nuisance aquatic life translated into a total phosphorus target) or a surrogate target established (e.g., a pH cause addressed through a total nitrogen target) and a demonstration should show how the chosen target is protective of water quality standards.

As seen from Table 4, there are two numeric *E. coli* criteria for TMDL target consideration. When multiple numeric criteria exist for a single parameter, the most stringent criterion is selected as the TMDL target. To judge whether one is more protective of the beneficial use, it is necessary to further elaborate how the criteria were derived.

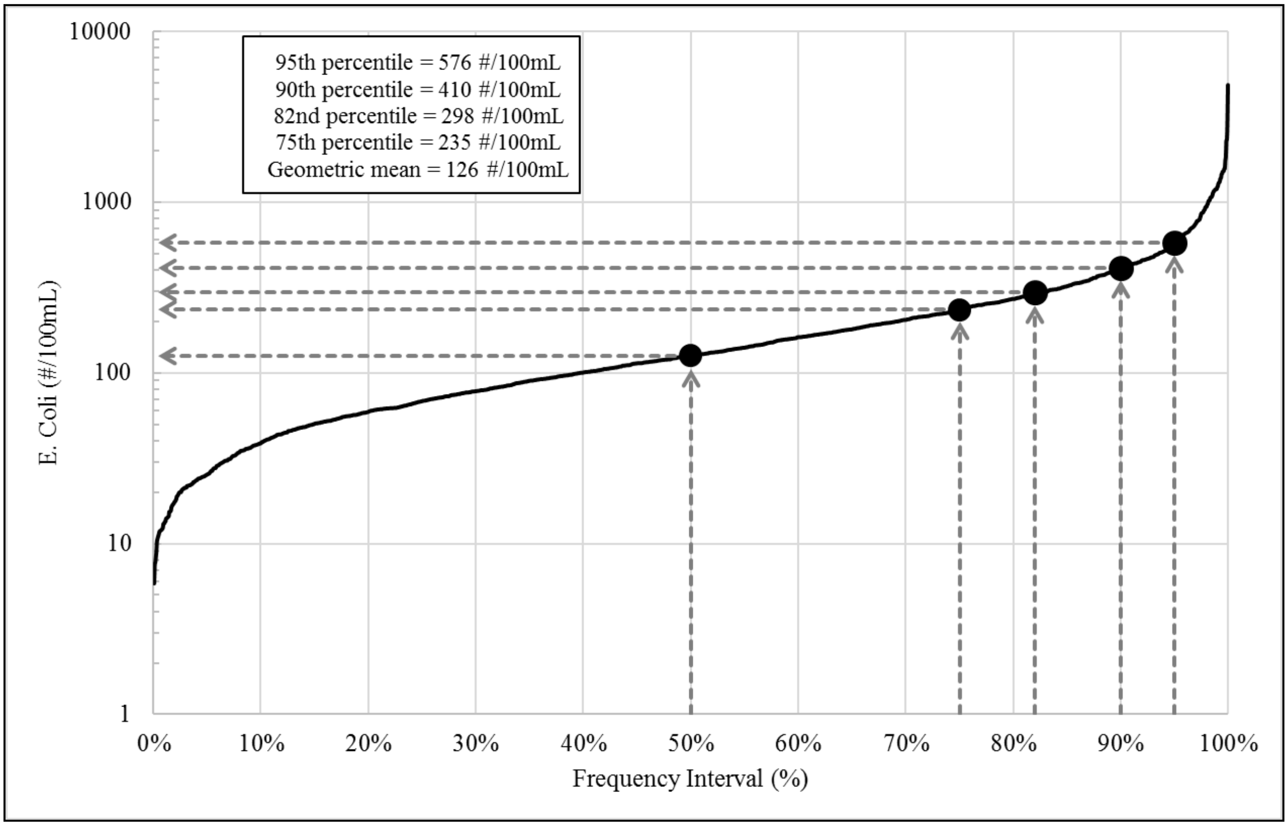

Figure 7 Log-Normal Frequency Distribution Used to Establish South Dakota's Immersion Recreation *E. coli* Criteria of 126 (GM) and 235 (SSM) #/100mL (EPA, 1986).

South Dakota's *E. coli* criteria are based on EPA recommendations originally published in 1986 (US EPA, 1986). EPA issued slightly modified recommendations in 2012 that did not substantially change the underlying analysis or criteria values in South Dakota (US EPA, 2012). As recommended, SD DENR adopted *E. coli* criteria that contain two components: a geometric mean (GM) and a single sample maximum (SSM). The GM was established from epidemiological studies by comparing average summer exposure to an illness rate of 8:1,000. The SSM component was computed using the GM value and the corresponding variance observed in the epidemiological study dataset (i.e., log-standard deviation of 0.4). EPA provided four different SSM values corresponding to the 75th, 82nd, 90th, and 95th percentiles of the expected water quality sampling distribution around the GM to account for different recreational use intensities (Figure 7). South Dakota adopted the most stringent recommendation, the 75th percentile, into state water quality standard regulations as the SSM protective of designated beaches.

Dual criteria were established to balance the inherent variability of bacteria data and provide flexibility for handling different sampling routines. Together, the GM and SSM describe a water quality distribution expected to be protective of immersion contact recreation. The GM and SSM are equally protective of the beneficial use because they are based on the same illness rate and that differ simply representing different statistical values and sampling timeframes. While this investigation has revealed the GM and SSM *E. coli* criteria to be equally protective of the immersion recreation use, a likewise conclusion can be made for the GM and SSM criteria associated with the limited contact recreation use since those values were simply derived as five times the immersion values.

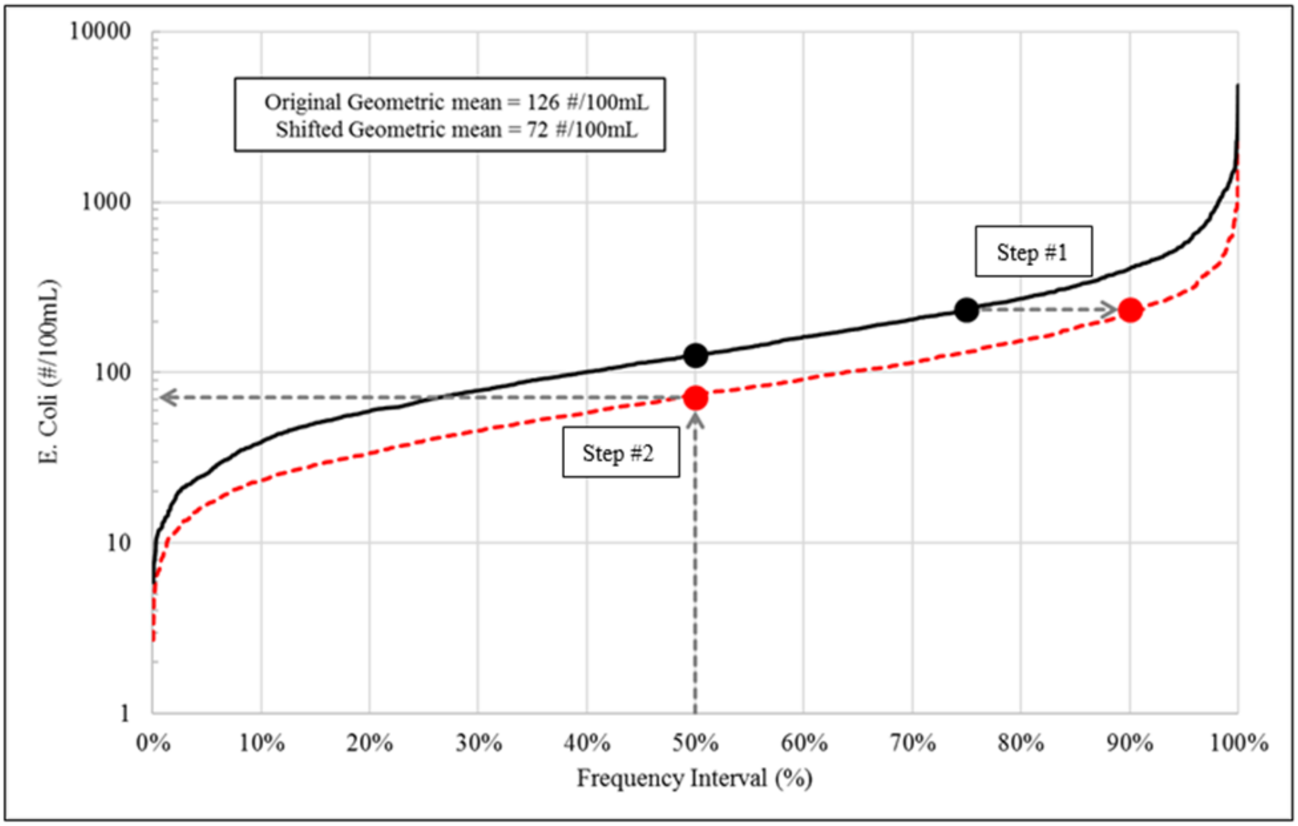

Figure 8 The Effective Impact of South Dakota's *E. coli* Assessment Method on the Criteria's Original Log-Normal Frequency Distribution (Black line = original; red dotted line = shifted)

As described in EPA's *Protocol for Developing Pathogen TMDLs*, the availability of data may dictate which criterion should be used as the TMDL target (EPA, 2001). When a geometric mean of the sampling dataset can be calculated as defined by South Dakota Administrative Rules (i.e., at least five samples separated by a minimum of 24-hours over a 30-day period, (calendar month) and compared to the GM criterion, SD DENR uses the GM criterion as the TMDL target. This establishes a smaller overall loading capacity and is considered a conservative approach to setting the TMDL.

When a proper GM cannot be calculated, SD DENR uses the SSM as the TMDL target. This is permissible because the SSM is equally protective of the beneficial use as discussed above. Although this target selection leads to the establishment of a larger allowable load, in some respects it is more appropriate because timeframes align better (i.e., the SSM is associated with a single day and TMDLs establish daily loads, versus the 30-day GM). Additionally, certain aspects of SD DENR's *E. coli* assessment method, when combined with a SSM TMDL target, result in an expected dataset GM more protective than the GM criterion. SD DENR uses assessment methods to define how to interpret and apply water quality standards to 303(d) impairment decisions. These methods are further discussed in Section 4.2, however for this discussion, it is important to note that SD DENR allows a 10% exceedance frequency of both the SSM and GM. In other words, as long as the *E. coli* dataset meets other age and size requirements, a waterbody is considered impaired (i.e., not meeting water quality standards) when greater than 10% of samples exceed either the SSM or GM. Water quality standards are met if the exceedance frequency is 10% or less.

Returning to the original distribution used to establish South Dakota's Immersion Recreation *E. coli* criteria in Figure 7, remember that SD DENR chose to adopt a SSM concentration based on the most stringent recommendation (75th percentile). According to assessment methods in South Dakota, however, the SSM concentration is treated as a 90th percentile (i.e., 10% exceedance frequency). Step #1 in Figure 8 shows how doing so effectively moves the SSM point to the right. If the original log-normal frequency distribution with a log-standard deviation of 0.4 is subsequently re-fitted to this new 90th percentile point at 235 CFU/100mL (red dotted line), the corresponding 50th percentile (GM) is 72 CFU/100mL as shown in Step #2 of Figure 8.

The GM associated with this shifted distribution is more stringent than the GM of the original distribution (126 CFU/100mL), thus this demonstrates that attaining a maximum daily SSM target in a TMDL will also achieve the 30-day GM criterion when following South Dakota's assessment method. A similar conclusion was determined by EPA in *An Approach for Using Load Duration Curves in the Development of TMDLs* (US EPA, 2007) using Michigan criteria as an example. Once again, this outcome holds true for South Dakota's limited contact recreation *E. coli* criteria since they were simply derived as five times the immersion values.

Finally, while the SSM is associated with a single day of sampling and the GM is associated with 30 days of sampling, it is not technically appropriate to refer to them as "acute" and "chronic" criteria. Those terms distinguish timeframes over which harm-to-use impacts develop, not the sampling or averaging timeframe as with the SSM and GM. Acute refers to an effect that comes about rapidly over short periods of time. Chronic refers to an effect that can build up over longer periods, sometimes as long as the lifetime of a subject. In the case of *E. coli*, gastrointestinal illness develops within a matter of hours to days. Both the SSM and GM are derived from this same timeframe and based on the same underlying illness rate, thus treating the SSM as an acute criterion and assuming it to be less stringent is incorrect. EPA recommends states use the GM and SSM together, rather than just the GM or just the SSM, to judge whether water quality is protective of recreational uses. SD DENR follows these guidelines and only relies on one criterion when forced by data availability.

During the Deadwood Creek watershed assessment project, an attempt was made to collect enough bacteria samples to evaluate the SSM and the GM water quality criteria based on the immersion recreation waters beneficial use. As mentioned earlier, the GM and SSM are equally protective of the beneficial use because they are based on the same illness rate and that differ simply representing different statistical values and sampling timeframes. Assessment data indicate that enough *E. coli* bacteria samples were collected to calculate ten 30-day geometric mean values throughout the Deadwood Creek watershed (Table 8). None of these calculated GM values exceeded the GM criterion based on the immersion recreation beneficial use criterion (GM $\leq$ 126 CFU/100mL). However, analysis of daily *E. coli* bacteria data collected in the Deadwood Creek watershed to assess the daily Single Sample Maximum SSM criterion, (SSM $\leq$ 235 CFU/100mL) exceeded water quality standards for immersion recreation waters (Table 7). Based on these data, the immersion recreation SSM for *E.*

coli criterion (235 CFU/100mL) was selected as the numeric TMDL target for Deadwood Creek because daily SSM *E. coli* bacteria collected during the assessment project exceeded the SSM and all calculated GM *E. coli* bacteria values met immersion recreation criteria. Refer to Section 4.0 for a thorough review of Deadwood Creek sampling and results.

3.5 Assessment Methods

Assessment methods document the decision making process used to define whether water quality standards are met. SD DENR evaluates monitoring data following these established procedures to determine if: 1) one or more beneficial use is not supported, 2) the waterbody is impaired, and 3) it should be placed on the next 303(d) list. Waterbodies impaired by pollutants require TMDLs and these assessment methods are commonly used again in the process sometime after TMDLs have been established and restoration efforts have been implemented. In select cases, attainment is judged instead by comparing current conditions to TMDL loading limits. For example, when certain characteristics of the pollutant (e.g., bioaccumulative) or waterbody (e.g., a reservoir filling with sediment) prioritize loading concerns. Table 5 presents South Dakota's assessment method for *E. coli* Bacteria and describes what constitutes a minimum sample size and how an impairment decision is made.

Table 5 Assessment Methods for Determining Support Status for Section 303(d) (SD DENR 2020).

Description	Minimum Sample Size	Impairment Determination Approach
FOR CONVENTIONAL PARAMETERS (Such as dissolved oxygen, TSS, *E. coli* bacteria, pH, water temperature, etc.)	STREAMS: a minimum of 10 samples for any one parameter are required within a waterbody reach. A minimum of two chronic (calculated) results are required for chronic criteria (30-day averages and geomeans). LAKES: at least two independent years of sample data and at least two sampling events per year.	STREAMS: >10% exceedance for daily maximum criteria (or 3 or more exceedances between 10 and 19 samples) or >10% exceedance for chronic criteria (or 2 or more exceedances between 2 and 19 samples) LAKES: >10% exceedance when 20 or more samples were available. If < 20 samples were available, 3 exceedances were considered impaired. See lakes listing methodology section for specifics on parameters associated with a vertical profile (i.e., dissolved oxygen, water temperature, pH, and specific conductance).

The assessment method mentions chronic and acute criteria. Although these terms do not directly relate to *E. coli* criteria for reasons previously discussed, the assessment method is organized together with other conventional parameters in the Integrated Report to show that a consistent approach is applied to many pollutants. In this limited definition, chronic refers to the GM and acute refers to the SSM *E. coli* criteria. Different assessment methods have been established for toxic parameters and mercury in fish tissue. In the next section, data collection activities are summarized, and monitoring results are evaluated using this assessment method.

4.0 Data Collection and Results

4.1 Water Quality Data and Discharge Information

4.1.1 Water Quality Data

The Deadwood Creek Water Quality Monitoring (WQM) site was established in late 1998 by the South Dakota Department of Environment and Natural Resources (SD DENR) and began collecting monthly water quality samples including fecal coliform bacteria during the recreation season (May 1st through September 30th). The assigned WQM number for Deadwood Creek is WQM 127 with a STORET number of DENR 460127 (STORET/WQX is a US EPA Database) and is located near Central City, SD (AUID: SD-BF-R-DEADWOOD_01) and was part of the Statewide Ambient Surface Water Quality Monitoring Program (Figure 2 and Appendix A, Table A4). *E. coli* bacteria sampling was not initiated at WQM 127 (DENR 460127) until the spring of 2009 because fecal coliform bacteria were the indicator organisms for immersion and limited contact recreation waters in South Dakota (Table 4). Beginning in May 2009, *Escherichia coli* (*E. coli*) bacteria was added as an additional indicator organism for immersion and limited contact recreation waters in South Dakota because *E. coli* bacteria are a more appropriate indicator of bacterial contamination. There are six species of fecal coliform bacteria found in animal and human waste. *E. coli* is one type of the six species of fecal coliform bacteria. A rare strain of *E. coli*, *E. coli* 0157:H7 can cause potentially dangerous outbreaks and illness. Between 2009 and 2016, both indicator species were used during this time to transition NPDES permits based on fecal coliform bacteria to an *E. coli* bacteria based criteria. By January 2016 fecal coliform bacteria was removed from the Surface Water Quality Standards for (ARSD 74:51:01:50, immersion recreation waters and ARSD 74:51:01:51, limited contact recreation waters) as an indicator of bacterial contamination during the recreation season.

Table 6 305(b) and 303(d) Integrated Report fecal coliform and *E. coli* bacteria data and listing status for Deadwood Creek (segment SD-BF-R-DEADWOOD_01) from 1996 through 2018

Deadwood Creek Watershed

305 (b) Report or Integrated Report	Water Years	Fecal Coliform Bacteria**				E. coli Bacteria*			
Year	Oct 1st - Sept. 30th	Exceedances	WQM 127 Samples	Exceedance %	Listed	Exceedances	WQM 127 Samples	Exceedance %	Listed
1998 (305 (b))	1996-1997	No Data	Site first sampled late 1998	-	-				
2000 (305 (b))	1995-1999	0	7	0.0%	N				
2002 (305 (b))	1996-2001	0	17	0.0%	N				
2004 (IR)	1998-2003	0	27	0.0%	N				
2006 (IR)	2000-2005	0	27	0.0%	N				
2008 (IR)	2002-2007	0	27	0.0%	N				
2010 (IR)	2004-2009*	0	27	0.0%	N	0	5	0.0%	N
2012 (IR)	2006-2011	2	30	6.7%	N	2	15	13.3%	N
2014 (IR)	2008-2013	2	30	6.7%	N	4	25	16.0%	Y
2016 (IR) and Assessment	2010-2015	5	62	8.1%	N	10	67	14.9%	Y
2018 (IR) and Assessment	2012-2017	2	52	3.8%	N	9	79	11.4%	Y

Red = Exceeds based on SSM immersion recreaion standard criteria for *E. coli* Bacteria
*** = *E. coli* bacteria first sampled in May 2009**
**** = Fecal Coliform Bacteria not collected after September 2014 (*E. coli* better indicator of impairment)**

Each Integrated Report cycle uses all available stream data from the last five years to assess compliance with water quality standards based on SSM and where available, GM criteria (Table 6).

Deadwood Creek (segment SD-BF-R-DEADWOOD_01) was first listed on the 303(d) list of impaired waters in 2014 for *E. coli* bacteria based on beneficial use based water quality standards for immersion recreation waters, based on the Single Sample Maximum, SSM standard ($\leq$ 235 CFU/100 mL). Deadwood Creek has continued to be as listed as impaired on the 2016 and 2018 Integrated Reports (Table 6).

Once listed in 2014, the Deadwood Creek assessment project was developed by SD DENR WP personnel and initiated by installing monitoring sites, collecting stage data, measuring discharge, and collecting *E. coli* bacteria and fecal coliform bacteria samples in the watershed during the recreation season (May 1st through September 30th) in 2014, 2015, 2017 and 2018.

Sample collection on Deadwood Creek at monitoring site DWCBact01 began by collecting 18 *E. coli* bacteria, and 18 fecal coliform bacteria samples from June through October 2014 and 21 *E. coli* bacteria, and 21 fecal coliform bacteria samples were collected from May through September 2015 (Appendix A, Table A1 and Figure 2). Also, in 2015, an additional monitoring site was installed on Blacktail Gulch (BTGBact01) near the confluence of Deadwood Creek to monitor bacterial concentrations, discharge, and loadings originating from the Blacktail Gulch watershed. Beneficial uses assigned to Blacktail Gulch are (9) Fish and wildlife propagation, recreation, and stock watering waters and (10) Irrigation waters. These assigned uses do not require bacterial monitoring during the recreation season and are not included in any Integrated Report. However, Blacktail Gulch bacterial concentrations and loadings ultimately affect concentrations and loadings in Deadwood Creek. A total of 23 *E. coli* bacteria and 23 fecal coliform bacteria samples were collected in 2015 and one additional *E. coli* bacteria sample was collected in 2018. Five additional monthly *E. coli* bacteria samples were collected from the Blacktail Gulch discharge pipe to Deadwood Creek from May through September 2018 to further assess Blacktail Gulch loadings to Deadwood Creek (Appendix A, Table A2).

A total of 14 additional *E. coli* bacteria samples were collected from Deadwood Creek (six samples above Central City (DWCBactAboveCC02) and six samples below Central City limits (DWCBactBelowCC01)) in September 2017 and one sample set (one above and one below Central City) in 2018 to assess *E. coli* bacteria loading potential of Central City, South Dakota temporally (Table 7, Appendix A, Table A1 and Figure 2 for site locations).

Table 7 All assessment (2014, 2015, 2017, and 2018) and WQM 127 (1998 through 2018) bacteria samples, exceedance based on SSM criteria, and percentages for Blacktail Gulch and Deadwood Creek, South Dakota

					Samples		Exceedence		Percentage	
	Data Type	Creek Sampled and general location	Monitoring Site	Date range*	*E. coli* Bacteria	Fecal Coliform	*E. coli* Bacteria	Fecal Coliform	*E. coli* Bacteria	Fecal Coliform
Upstream	**Assessment**	Deadwood Creek above and below Centtral City	DWCBactAboveCC / DWCBactBelowCC	2017, 2018	14	-	0	-	**0.0%**	-
	Assessment	Blacktail Gulch tributary near confluence	BTGBact01	2015, 2018	30	23	3	1	**10.0%**	4.3%
	WQM 127	Deadwood Creek below Blacktail Gulch confluence	WQM 127	2009-2018[1] / 1998-2014[2]	49	76	9	2	**18.4%**	2.6%
	Assessment	Deadwood Creek near broken boot gold mine	DWCBact01	2014, 2015, 2017, 2018	44	39	3	3	**6.8%**	7.7%
↓ Downstream	**Total Assessment**	Deadwood Creek all sites including Blacktail Gulch	All	2014, 2015, 2017, 2018	137	138	15	6	**10.9%**	4.3%
	All Data	All Deadwood Creek Only (Assessment and WQM)		2009-2018	107	115	12	5	**11.2%**	4.3%

*** = All data collected during recreation season only (May 1st through September 30th)**

Red = Exceeds based on SSM for immersion recreaion criteria for *E. coli* Bacteria

Purple = Blacktail Gulch tributaryloading contributes to overall Deadwood Creek loading at WQM 127

[1] = *E. coli* Bacteria years sampled

[2] = Fecal Coliform Bacteria years sampled

Five samples were collected in Deadwood Creek above and/or below the Blacktail Water Treatment Facility (BTWTF) outfall 013A discharge in 2018. Four of these five samples were collected to monitor *E. coli* bacteria counts above and below the BTWTF discharge to Deadwood Creek. Sample pairs (above/below outfall) collected on 5/10/18 and 5/30/18 were used to evaluate *E. coli* Bacteria counts above and below outfall 013A (Appendix A, Table A1). Data show *E. coli* Bacteria counts collected above the outfall were numerically higher (14 CFU/100 mL (5/10/18) and 57 CFU/100 mL (5/30/18)) than bacteria counts below the discharge (9 CFU/100 mL (5/10/18) and 33 CFU/100 mL (5/30/18)) and suggest that BTWTF discharge reduces/dilutes *E. coli* Bacteria counts (CFU/100 mL) in Deadwood Creek below the BTWTF outfall (Appendix A, Table A1).

Two *E. coli* bacteria effluent samples were collected from Homestake (Barrick) Mine Blacktail Water Treatment Facility (BTWTF) outfall discharge in 2018. Samples were collected to spot check and verify that BTWTF is not a source of *E. coli* Bacteria to Deadwood Creek. One sample was collected by Homestake mine closure personnel on 03/21/2018 from process water after going through polish filters and the other sample collected on 05/10/2018 by SD DENR Watershed Protection Program (SD DENR WPP) personnel from the surface water discharge pipe as it leaves the water treatment facility (Appendix A, Table A3). Sample results were below the detection limit for *E coli* bacteria (< 1 MPN/100 mL) indicating that the BTWTF does not discharge bacteria to Deadwood Creek.

76 fecal coliform and 49 *E. coli* bacteria samples have been collected monthly during the recreation season at the ambient surface water quality monitoring site 460127, (WQM 127) on Deadwood Creek

(Appendix A, Table A4 and Table 7). Fecal coliform bacteria samples have been collected at this site from August 1998 through September 2014 and *E. coli* bacteria samples have been collected from May 2009 through September 2018 by SD DENR Surface Water Quality Program (SWQP) staff (Appendix A, Table A4).

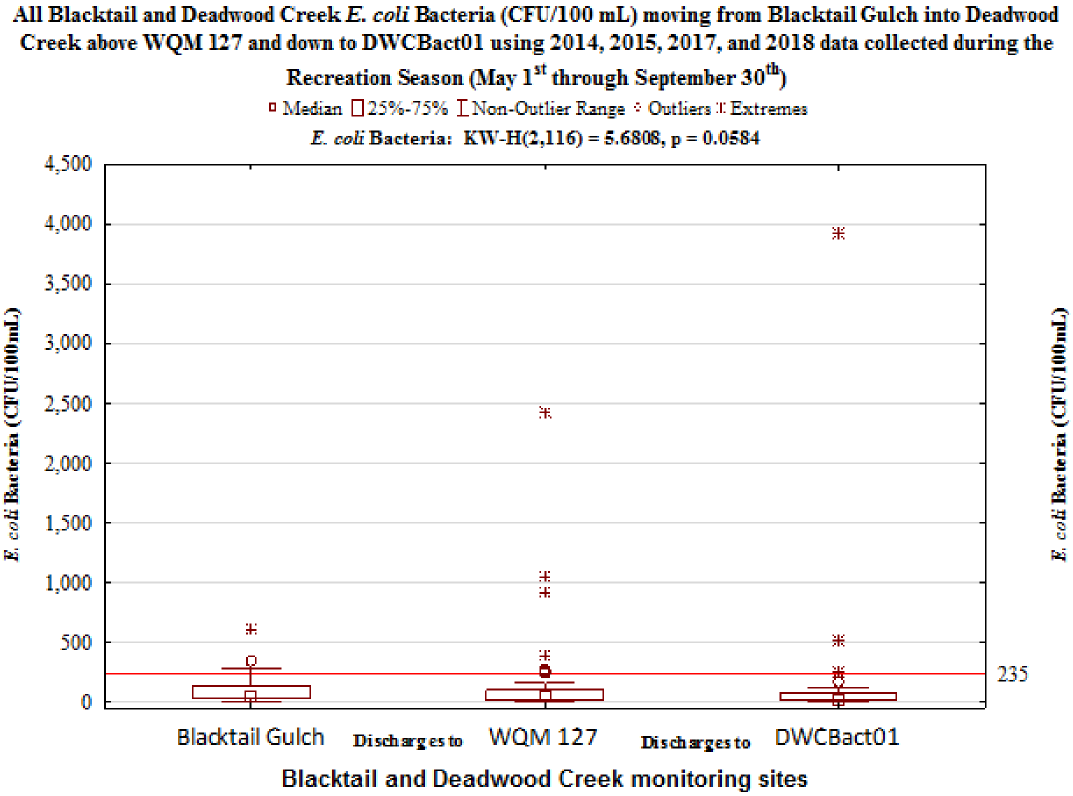

Figure 9 Distribution of E. coli between Blacktail Gulch tributary to Deadwood Creek and WQM 127 and DWCBact01 monitoring sites on Deadwood Creek

Data indicate that fecal coliform bacteria had low exceedances percentages based on all available data (2 out of 76, 2.6 %); while *E. coli* bacteria exceeded water quality standards based on the SSM criteria for immersion recreation waters using WQM 127 (9 out of 49, 18.4 %) data and overall Deadwood Creek sample data (11.2 %).

Blacktail Gulch tributary (BTGBact01) *E. coli* bacteria exceedance percentage (10.0 %) was similar to the overall percentage in Deadwood Creek when using all available *E. coli* bacteria data (Table 7). Increased exceedance percentages in *E. coli* bacteria compared to fecal coliform bacteria may be attributed to *E. coli* bacteria having a more stringent (lower) exceedance threshold (235 CFU/100 mL) than fecal coliform bacteria (400 CFU/100 mL) based on South Dakota numeric water quality standards. Overall distribution of *E. coli* bacteria data (median, 25%-75% range, non-outlier range, outliers, and extremes) by monitoring site during the assessment is shown in Figure 9 with all monitoring sites statically similar ($KW\text{-}H_{(2,116)} = 5.6808$, $p = 0.0584$).

Table 8 *E. coli* and fecal coliform bacteria geometric mean values collected during the recreation season from Blacktail and Deadwood Creeks in 2014, 2015 and 2017 expressed in CFU/100 mL

AUID Reach/(Geometric Mean Standard)		Position in Segment	Month/Year	Mean Discharge (cfs)	Sample Count to Calculate (#)	Geometric Mean Fecal Coliform (CFU/100 mL)	Sample Count to Calculate (#)	Geometric Mean E. coli CFU/100 mL)
SD-BF-R-DEADWOOD_01 **IR**-(Fecal Coliform < 200 CFU/100 mL, *E. coli* < 126 CFU/100 mL)	Blacktail Gulch 01[1]	L	July-15	1.04	5	62	5	92
	Blacktail Gulch 01	L	August-15	1.10	5	91	5	74
	Blacktail Gulch 01	L	September-15	0.47	6	37	6	41
	Deadwood Creek 01	M	July-14	6.92	5	25	5	43
	Deadwood Creek 01	M	September-14	6.70	6	10	6	22
	Deadwood Creek 01	M	July-15	4.79	5	39	5	44
	Deadwood Creek 01	M	August-15	4.12	5	36	5	46
	Deadwood Creek 01	M	September-15	2.37	5	12	5	9
	Deadwood Creek above Central City 02	U	September-17	0.61	-	-	6	5
	Deadwood Creek below Central City 01	M	September-17	0.68	-	-	6	58

1= Blacktail Gulch is a tributary to Deadwood Creek

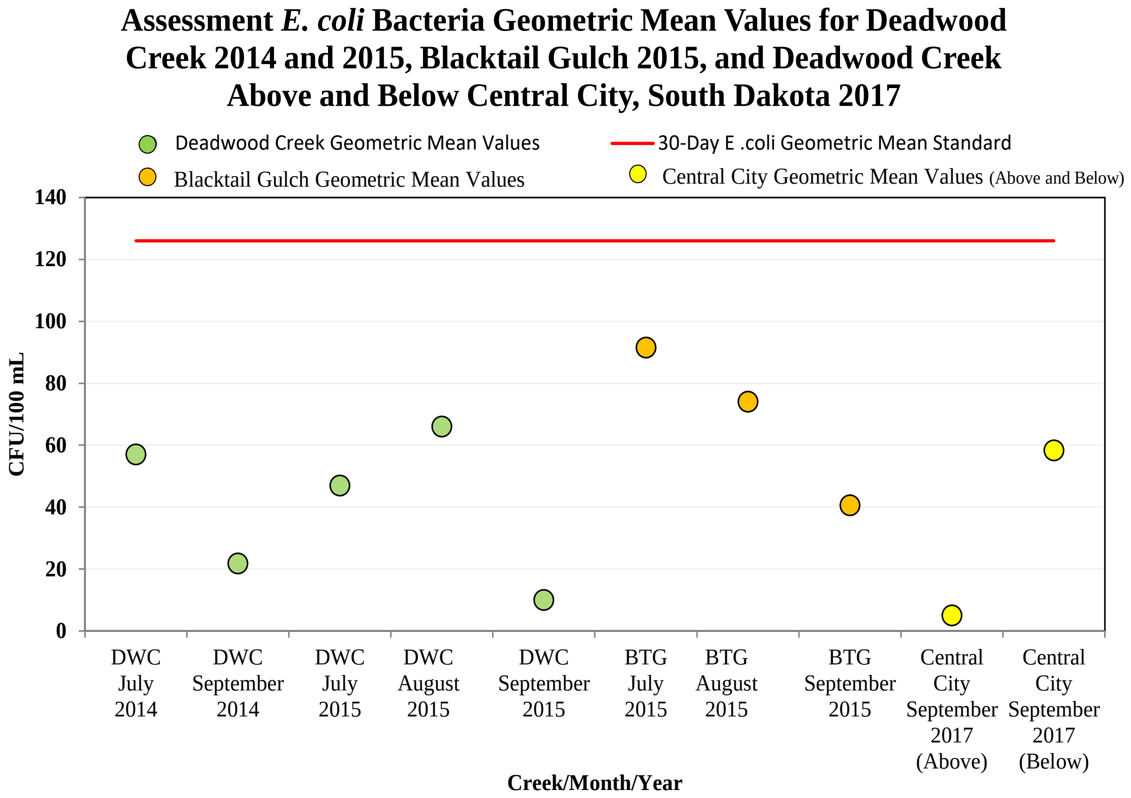

Figure 10 Assessment *E. coli* Bacteria Geometric Mean Values for Deadwood Creek, Blacktail Gulch, and Deadwood Creek above and below Central City, South Dakota, 2014, 2015, and 2017

During the project enough bacteria samples (minimum of 5 samples) were collected within 30-day periods at Blacktail Gulch (BTGBact01) in 2015 and Deadwood Creek (DWCBact01) 2014 and 2015, and in September 2017 in Deadwood Creek above and below Central City during the recreation season (various months between May 1st through September 30th). Data was used to assess compliance with the 30-day geometric mean standard (Table 8 and Figure 10). Data show that geometric mean data collected within the Deadwood Creek watershed did not exceed the 30-day geometric mean GM standard based on the immersion recreation beneficial use standards for *E. coli* (< 126 CFU/100 mL) and for comparison, fecal coliform bacteria (< 200 CFU/100 mL).

Twelve *E. coli* bacteria samples were collected in September 2017 from Deadwood Creek, six samples above and six samples below Central City, South Dakota (Figure 2) and two samples were collected May 2018, one above and one below Central City (Appendix A, Table A1, Figure 11, and Table 8)). Data was used to examine to what extent development has on *E. coli* bacteria counts (CFU/100 mL) and 30-day geometric mean GM values.

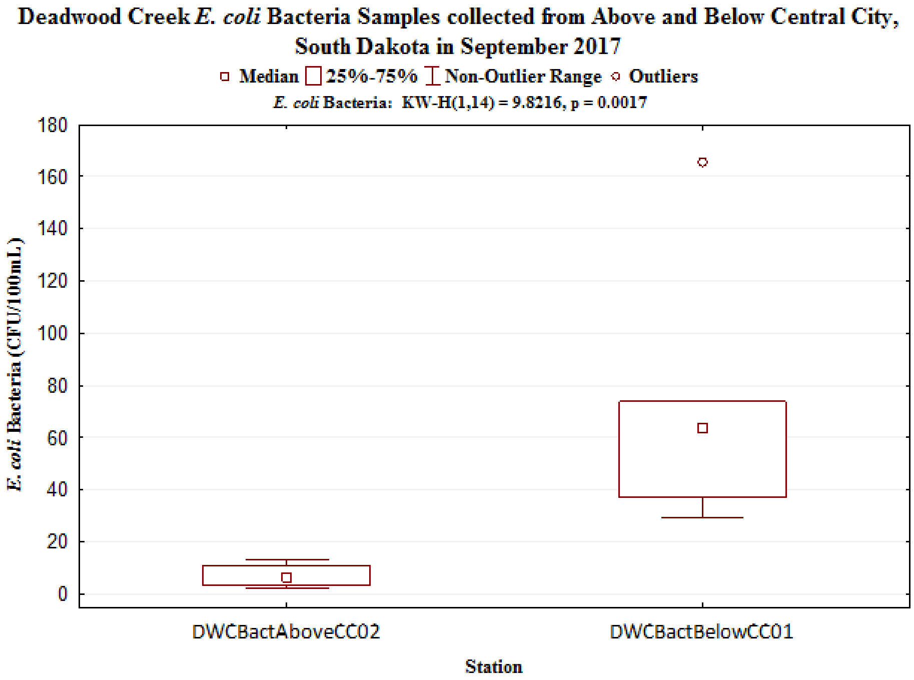

Figure 11 Box Plot of Deadwood Creek *E. coli* Bacteria samples collected from above and below Central City, South Dakota in 2017

A statistically significant increase (KW-H $_{(1,14)}$ = 9.8216, p = 0.0017) in bacterial counts was observed below Central City in comparison to samples collected above Central City; although no samples exceeded the immersion recreation standard (< 235 CFU/100mL) for *E. coli* bacteria (Figure 11).

Based on all geometric mean data collected during the Deadwood Creek assessment project (Table 8 and Figure 10), setting *E. coli* TMDL target loads based on the single sample maximum (SSM) criteria (< 235 CFU/100 mL) will ensure that the geometric mean GM criteria (GM< 126 CFU/100 mL) will also be achieved.

Deadwood Creek flows along the southern edge of Central City (Figure 2) and because of its location and steep topography of the town in the watershed increases runoff from streets, buildings, yards, and roads may end up in Deadwood Creek. Development in and along the creek has also increased access to humans and pets that may directly impact *E. coli* bacteria loadings in the Deadwood Creek watershed. More information on data comparisons with the source characteristics of Central City can be found in Section 5.2.2. of this report.

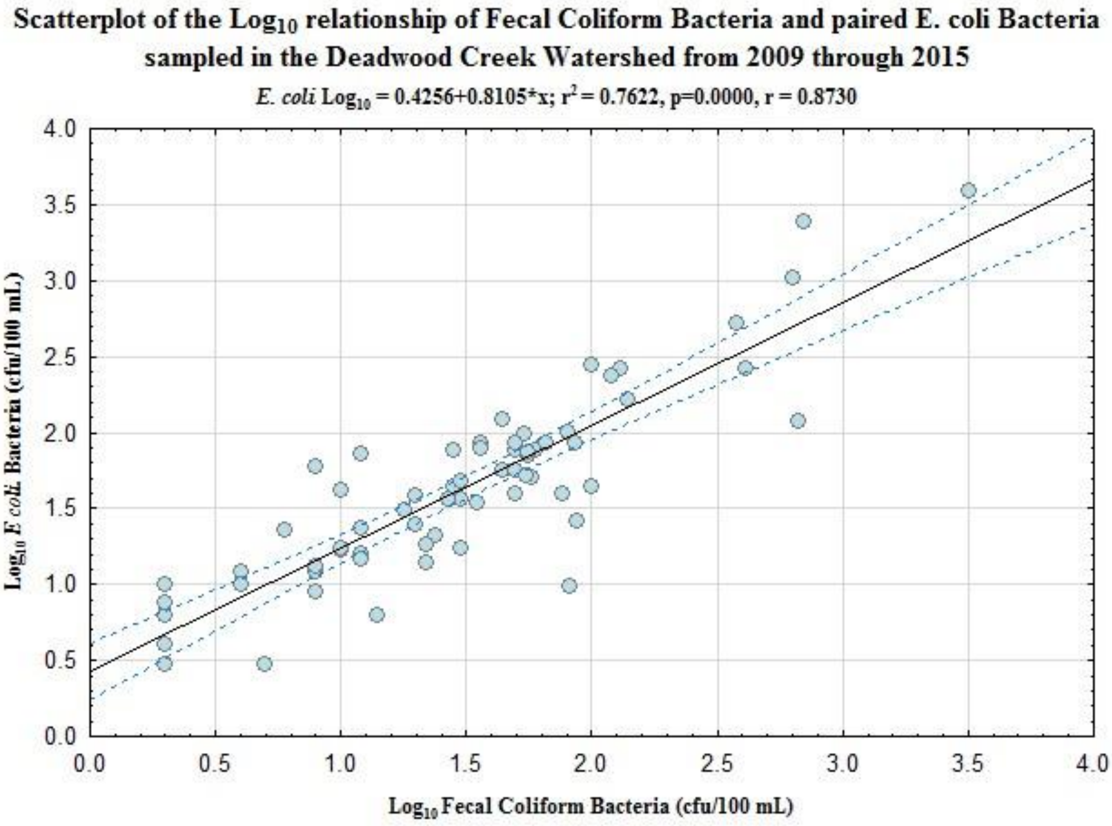

Figure 12 Fecal coliform and *E. coli* bacteria (Log $_{10}$) relationship for Deadwood and Blacktail Creeks using all available paired data from 2009 through 2015 for segment SD-BF-R-DEADWOOD_01.

Fecal coliform bacteria can provide a useful surrogate for *E. coli* in TMDL development. *E. coli* is a fecal coliform bacterium and both indicators originate from common sources in relatively consistent proportions. A relational analysis was performed on paired fecal coliform and *E. coli* concentrations collected from Deadwood Creek at monitoring sites DWCBact01 and WQM127 ecoregion (IV) 17c (Black Hills Core Highlands), which includes the entire Deadwood Creek watershed. Fecal coliform and *E. coli* bacteria counts (CFU/100mL) from 63 paired stream samples were logarithmically transformed (Log_{10}) and plotted in Figure 12.

E. coli (Y-axis) was plotted as a function of fecal coliform (X-axis) and the result was a best fit linear relationship yielding an r^2 value of 0.7622 and a slope equation of r = 0.8730 relationship suggesting a significant relationship exists between fecal coliform bacteria and *E. coli* bacteria in Deadwood Creek (Figure 12). Thus, fecal coliform bacteria counts collected in Deadwood Creek before 2009 could be translated into *E. coli* bacteria counts expanding the overall *E. coli* bacteria dataset both numerically and spatially. This relationship also justifies the use of fecal coliform based literature values for determining bacteria source allocations in Section 5.2.

Translation analysis consisted of converting fecal coliform bacteria counts to $\log_{(10)}$ and inserting each value into the variable in the equation shown in Figure 12 (*E. coli* $Log_{(10)} = 0.4256 + 0.8105 * x$) and then apply the antilog to the result ($10^{\wedge(}\log^{(10)}$) to translate the fecal coliform to *E. coli* bacteria (CFU/100 mL).

All available fecal coliform bacteria data collected from 2004 through 2008 at 460127, WQM 127 and corresponding daily discharge data from USGS monitoring site 06436165 within the applicable timeframe (May 1 to September 30) for recreation waters were transformed/translated and used to supplement the lack of *E. coli* sample data within this time frame within the load duration curve. This approach allowed for a broader distribution of bacteria loading across the entire flow frequency curve for the impaired segment of Deadwood Creek (Figure 12).

All sample data collected during this project followed SD DENR Watershed Protection Program Standard Operating Procedures (SD WPP SOP), Quality Assurance Project Plan (QAPP) and Surface Water Quality Standard Operating Procedures (SWQP SOP) for proper field, data collection, and Quality Assurance/Quality Control (QA/QC) techniques (SD DENR, 2011, SD DENR 2016a, DENR, 2017, SD DENR, 2018b). QA/QC results for water quality sampling during this project are in Appendix A, Tables A5 and A6 and indicate that all samples were within precision criteria based on log range and blank sample analysis techniques.

4.1.2 Discharge Data and Information

Flow and flow frequency analysis was analyzed using Microsoft Excel® software line of best fit. This program was used to calculate and generate stage-discharge relationships for DWCBact01 and BTGBact01 monitoring sites using OTT Thalimedes (DWCBact01) and OTT Orpheus Mini (BTGBact01) stage data loggers recording stage every 15-minutes and instantaneous discharge measurements were collected using a SonTec Flow Tracker® handheld ADV® (Acoustic Doppler Velocimeter) flowmeter.

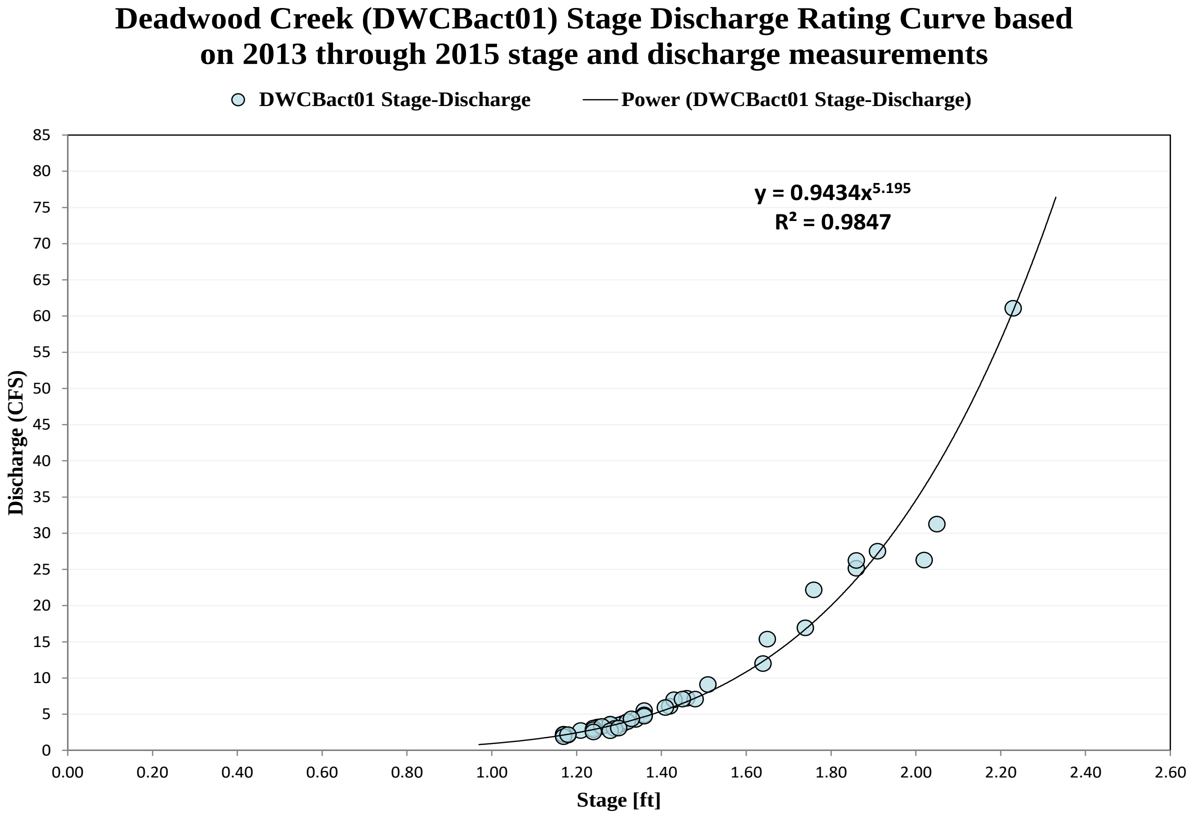

Figure 13 Rating curve for monitoring site DWCBact01 on Deadwood Creek near the Broken Boot Mine with data from 2013 through 2015

Discharge and associated stage values were used to develop stage discharge rating curves to estimate discharge at DWCBact01 (2013 through 2015) on Deadwood Creek and discharge at BTGBact01 (2015) on Blacktail Gulch monitoring site over the period of record (Figure 13 and Figure 14). Rating curve development involved using functions available in Excel® to create the best fit line between paired stage and discharge points. The ensuing rating curve equations were used to estimate discharge values for each monitoring site and corresponding stage measurement. Both curves (DWCBact01 and BTGBact01) had similar stage discharge relationships, $R^2 = 0.9847$ and 0.9895, respectively (Figure 13 and Figure 14).

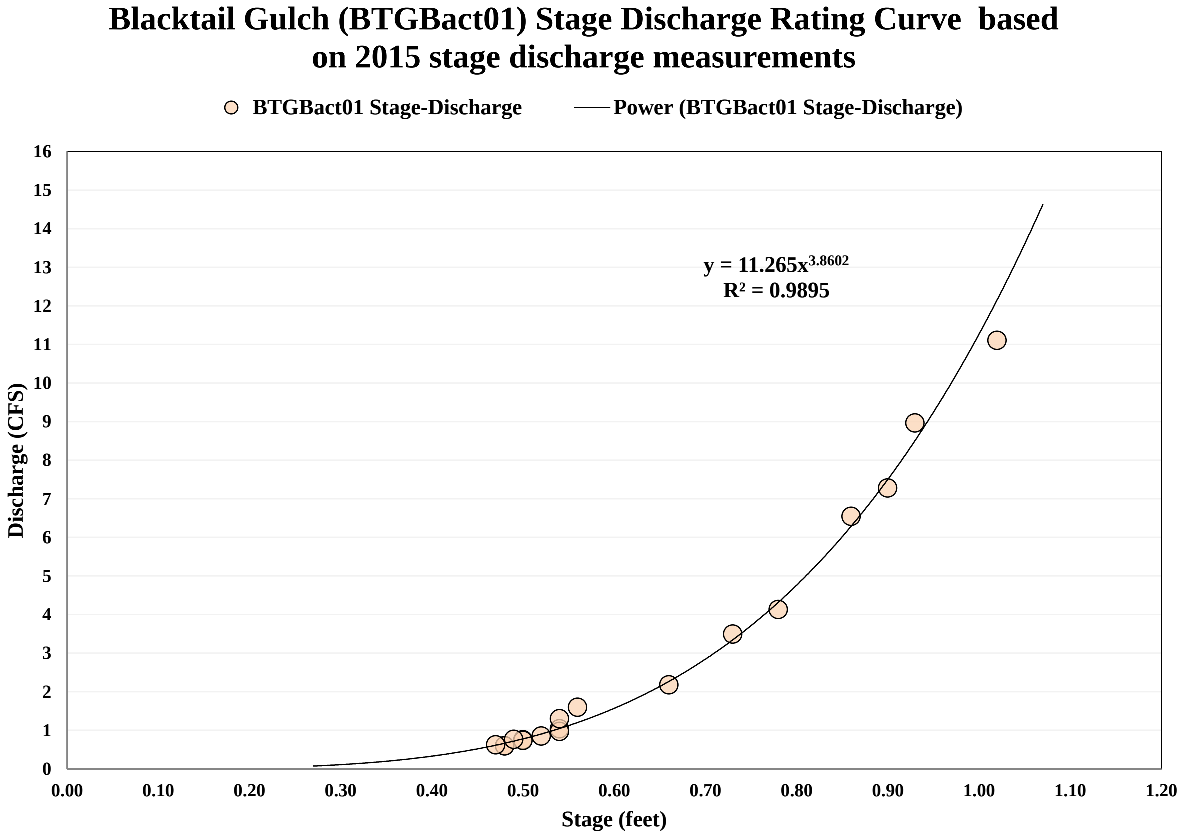

Figure 14 Rating curve for monitoring site BTGBact01 on Blacktail Gulch upstream of Highway 14A near Central City, South Dakota in 2015

Average daily discharges were calculated using USGS and SD DENR 15-minute discharge measurements and were graphed for the USGS monitoring site (06436165) and SD DENR WPP monitoring site DWCBact01 near the Broken Boot gold mine from 8/19/2013 through 9/30/2015 for comparison (Figure 15). The USGS monitoring site at Central City 06436165 is approximately 1.8 stream kilometers (1.1 stream miles) upstream of SD DENR monitoring site DWCBact01 as measured using ArcMap™ software (Figure 2 for locations).

Average daily discharge at downstream monitoring site DWCBact01 is generally greater than USGS monitoring site 06436165 because of increased drainage area, additional discharge from BlackTail Water Treatment Facility (BTWTF), Blacktail Gulch, and runoff from roads and other impervious surfaces discharge to Deadwood Creek between USGS monitoring site 06436165 and DWCBact01.

This can be seen especially during rain events where average daily discharge peaks were higher at the DWCBact01 monitoring site than the USGS monitoring site upstream. Additionally, the delay or lag in DWCBact01 average daily discharge values returning to similar discharge to that of USGS discharge (black arrows) can be seen after major rain events indicating that the increased drainage area and associated discharges were higher thus causing a measured reduction in discharge at DWCBact01 (Figure 15).

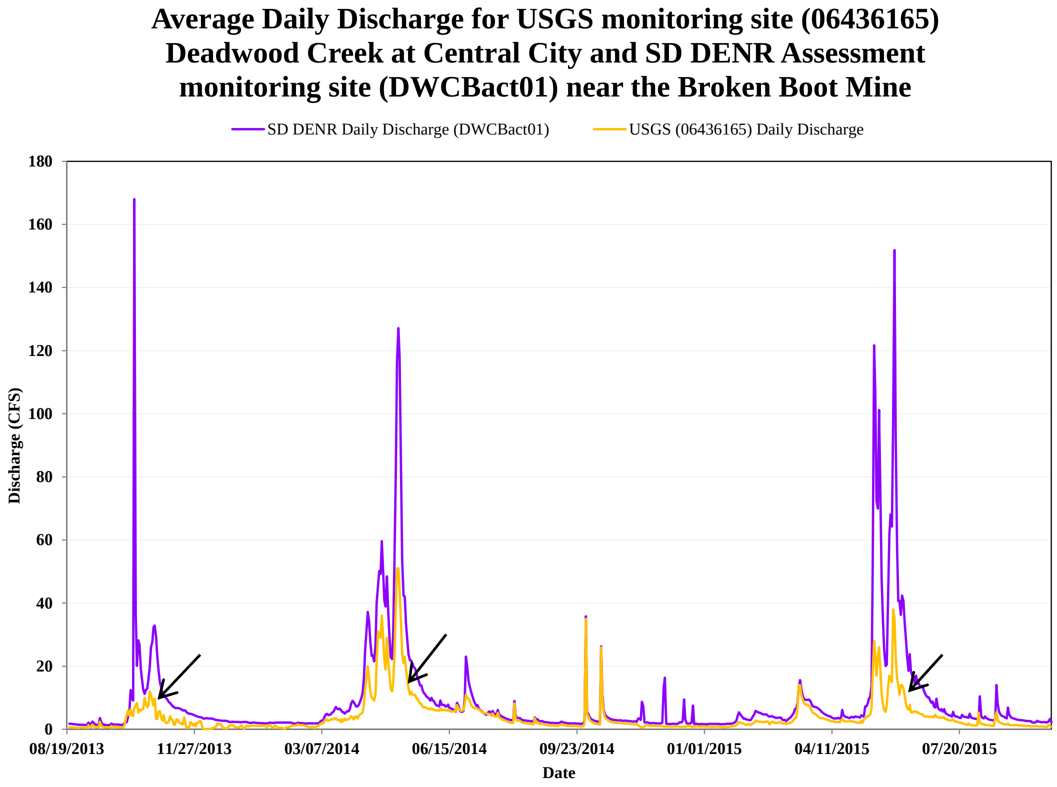

Figure 15 Average daily discharge (CFS) for USGS monitoring site 06436165 and SD DENR monitoring site DWCBact01 from 8/19/2013 through 9/30/2015

United States Geological Survey (USGS) had one stream gaging station in the Deadwood Creek watershed (Table 9 and Figure 2 for site location). This monitoring site was installed by USGS in 2004 and was cosponsored by SD DENR and was contracted by Homestake Mine (Barrick Gold Corporation) to monitor discharge in Deadwood Creek for design and development of the BlackTail Water Treatment Facility BTWTF. This facility is designed to treat waste rock tailing water collected from various locations throughout the Deadwood Creek watershed.

Table 9 USGS monitoring site on Deadwood Creek used for long-term flow and flow frequency analysis

USGS Station Number	USGS Site Name	Available Data Dates*	AUID Segment
06436165	Deadwood Creek at Central City, South Dakota	2004 - 2015	SD-BF-R-DEADWOOD_01

*** = Monitoring site discontinued September 30, 2015.**

Long-term USGS discharge (15 minute) data for the dates listed in Table 9 were used to develop flow frequency curve analysis for segment SD-BF-R-DEADWOOD_01 (06436165, Deadwood Creek at Central City) on Deadwood Creek (Figure 16). Flow frequency curve represents all measured discharge (CFS) sorted from low flows to high flows to calculate total daily discharge (CFS) per day. Each discharge value was assigned a percent ranking from low discharge (100 percent of the discharges were higher than the lowest measured discharge) to high discharge (0 percent of the discharges were higher than the highest measured discharge) to represent the overall percentage of all measured discharges in Deadwood Creek. The USGS data set offered the longest discharge record in Deadwood Creek.

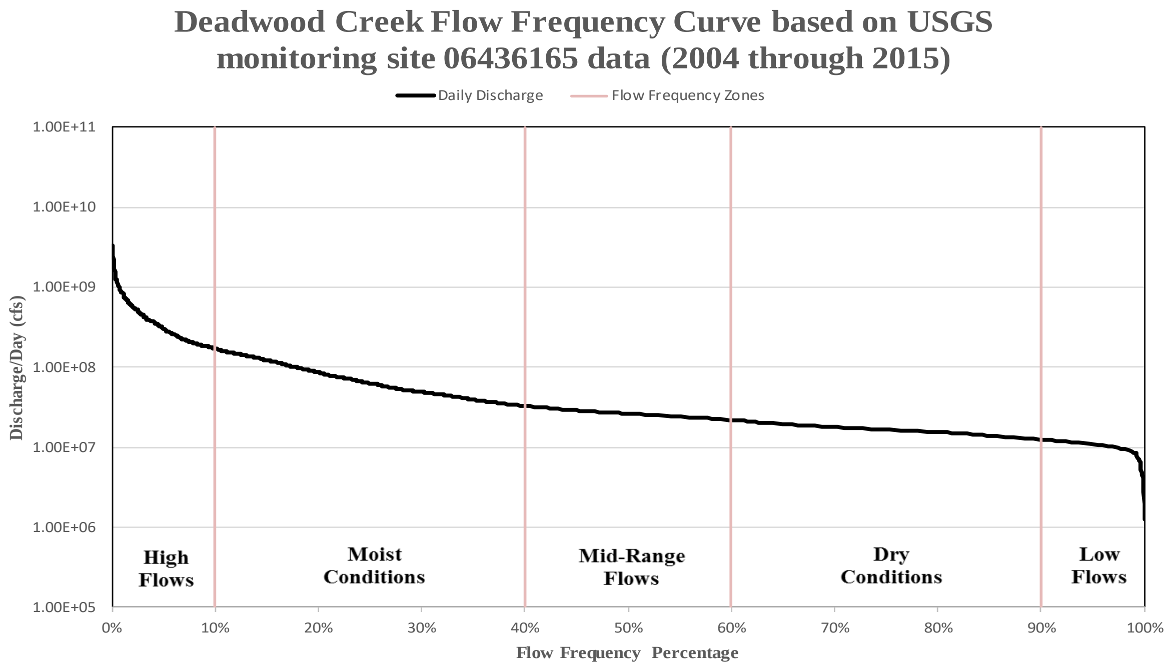

Figure 16 Flow frequency curve for Deadwood Creek representing USGS daily discharge collected at USGS monitoring site 06436165 from 2004 through 2015 and DWCBact01 2014 through 2015

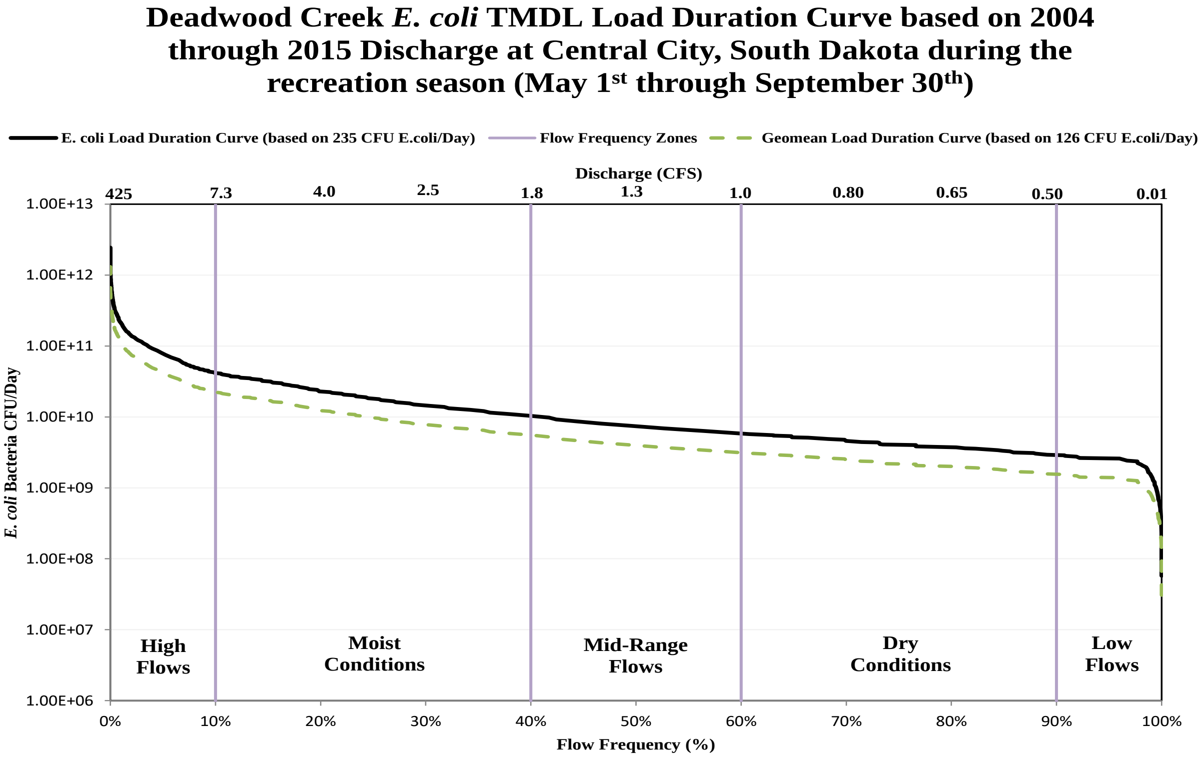

Figure 17 Load duration curve for Deadwood Creek representing *E. coli* bacteria TMDL load based on flow frequency percentage from 2004 through 2015 data.

Flow frequency curve discharge values were then converted to loads by multiplying daily discharges by the *E. coli* bacteria standards assigned to immersion recreation waters (≤ 235 CFU *E. coli*/100 mL single sample maximum, (SSM), and represents the Load Duration Curve (LDC) which is represented by the solid black line. The 30-day geometric mean standard ≤ 126 CFU *E. coli*/100 mL, is represented by the green dashed line. Figure 17 represents the *E. coli* bacteria load duration curve representing the *E. coli* TMDL expressed as *E. coli* Bacteria (CFU/Day) based on flow frequency percentage for Deadwood Creek.

4.2 Existing Conditions and Assessment Results

E. coli Bacteria in Deadwood Creek was first identified as impairing immersion recreation uses in the 2014 303(d) List using data collected at WQM 127 from 2009 through 2013. Sampling at WQM 127 continues as part of routine monitoring from 2014 through 2020. Routine monitoring through 2018 revealed continued *E. coli* bacteria impairment and listing on the 2016, 2018, and 2020 303(d) lists based on Conventional Parameter assessment methods listing criteria (Table 5). Additional monitoring sites were setup as part of the Deadwood Creek Watershed Assessment project which was part of a wider Whitewood Creek Watershed Assessment project in 2014 through 2015, with additional data (samples) collected in 2017 and 2018 during the recreation season (Table 6 and Table 7). Based on all available data collected in Deadwood Creek, *E. coli* bacteria has and continues to exceed water quality standards since 2014.

Table 10 Summary statistics for all available water quality monitoring site data collected from the Deadwood Creek Watershed (2004 through 2018), Lawrence County, South Dakota.

	Monitoring Site					
	Deadwood Creek				Blacktail Gulch	Deadwood Creek only
Statistic	**WQM 127**	**Transformed[1] WQM 127 FC**	**DWCBact01**	**Other Deadwood**	**BTCBact01**	**Total**
Count of *E. coli* (CFU/100mL)	49	25	39	19	30	107[2] / 132[3]
Average of *E. coli* (CFU/100mL)	165	26	155	35	97	138
Max of *E. coli* (CFU/100mL)	>2,420	145	3,920	166	613	3,920
Min of *E. coli* (CFU/100mL)	1	2	3	2	1	1
# of *E. coli* Samples > 126 CFU/100mL	12	1	4	1	8	18
# of *E. coli* Samples >235 CFU/100mL	9	0	3	0	3	12
Date of First Sample	05/11/2009	05/11/2004	06/17/2014	09/19/2017	05/05/2015	05/11/2009
Date of Last Sample	09/18/2018	09/23/2008	09/30/2015	05/30/2018	09/18/2018	09/18/2018
Exceedence Percentage	**18.4%**	0.0%	7.7%	0.0%	**10.0%**	**11.2% / 9.1%**

Red = Exceeds immersion recreation standards criteria for *E. coli* Bacteria

Purple = Blacktail Gulch tributary loading contributes to Deadwood Creek loading at WQM 127

[1] = 2004 - 2008 fecal coliform samples transformed to *E. coli* bacteria samples based on equation in Figure 12, data was used to assess potiential bacterial loading in Deadwood Creek before *E. coli* Bacteria samples were routinely sampled beginning in 2009, Figure 22.

[2] = Count excluding Transformed Fecal Coliform bacteria (used to calculate overall *E. coli* only bacteria exceedance percentage).

[3] = Total count including transformed Fecal Coliform bacteria

During the assessment project enough *E. coli* bacteria samples were collected during the recreation season to evaluate 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). Ten geometric mean values were calculated in the Deadwood Creek Watershed, two in 2014, six in 2015, and two in 2017 (Table 8). Data show that no geometric mean value exceeded the GM > 126 CFU/100 mL threshold for any 30-day period and does not appear to be a concern in the Deadwood Creek watershed.

All *E. coli* Bacteria sample counts collected in Deadwood Creek were plotted by flow frequency intervals based on USGS (site 06436165) discharge data from 2010 through 2015 water year (October 1st through September 30th). Beginning September 30, 2015, the USGS discontinued this site and no longer monitors or supports this monitoring site on Deadwood Creek. USGS discharge data from this site has been used to assign discharge for *E. coli* Bacteria samples collected at SD DENR monitoring site WQM 127 to calculate daily loading and assign the flow frequency interval percentage. WQM 127 monthly sampling continues but without current monitored discharge at this site no loading or flow frequency percentages can be assigned. Monthly WQM 127 *E. coli* Bacteria data collected during the recreation season (May 2016 through September 2018) depicted in Appendix A, Table A 4 (15 samples with 2 samples exceeding immersion recreation standards) and are not included in Figure 18 or included in exceedance percentages by flow zone (Table 11). After September 2015 other *E. coli* Bacteria samples were collected in Deadwood Creek during the recreation season (2017 and early 2018, May) that had discharge measurements at time of sample collection and are included in Figure 18 as Deadwood Creek Other Samples (Appendix A, Table A 1).

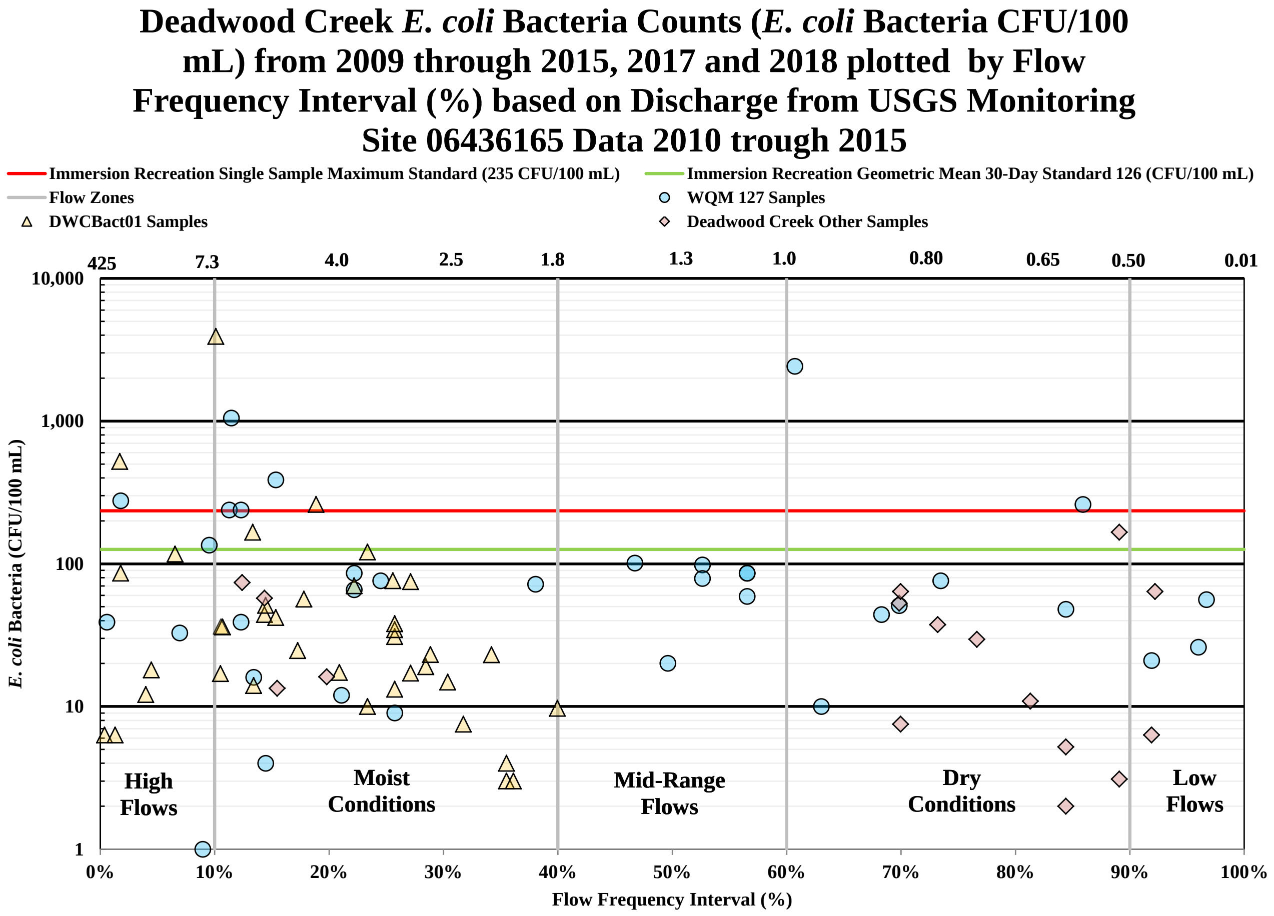

Figure 18 ***E. coli*** **bacteria CFU/100 mL) from 2009 through 2015, 2017, and 2018 plotted by flow frequency intervals based on USGS discharge data 2010 through 2015**

Table 11 *E. coli* Bacteria counts by flow frequency interval and exceedance percentage shows three flow zones have enough *E. coli* bacteria counts that exceed the 10 percent threshold based on the immersion recreation beneficial use criterion, ≤ 235 CFU/100 mL. In most instances in small streams there is typically a significant relationship between high flows (storm events) and high bacteria concentrations and this was exhibited by the Deadwood Creek data. The majority of the of the data was collected during the Deadwood Creek watershed assessment project in (2014 and 2015) which saw most discharges in the high and moist flow frequency zones (tan triangles in Figure 18).

Table 11 Summary *E. coli* Bacteria counts (CFU/100 mL) by flow zone and exceedance percentages based on flow frequency intervals for Deadwood Creek, Lawrence County, South Dakota

			Flow Zone					All Data
Segment	Monitoring Sites	Statistic	High	Moist	Mid Range	Dry	Low	Count/Percent
SD-BF-R-DEADWOOD_01 with Transformed Fecal Coliform data	WQM 127, WQM 127 FC, DWCBact01, Other Deadwood Creek sites	Samples per Flow Zone (sample count)	15	58	11	23	8	115
		Exceedance per Zone (exceedance count)	2	6	0	2	0	10
		Violation Percentage (based on count)	**13%**	**10%**	**0%**	**9%**	**0%**	**9%**

5.0 Significant Sources

5.1 Point Sources

5.1.1 SD-BF-R-DEADWOOD_01, Rutabaga Gulch to Whitewood Creek

Homestake (Barrick) Mine closure office is located in the middle portion of segment SD-BF-R-DEADWOOD_01 which flows through the southern edge of Central City, South Dakota population 134 (Figure 2). Homestake constructed a water collection and treatment system (BlackTail Water Treatment Facility, (BTWTF) at this location in 2005 and 2006 to meet water quality based limits for selenium and total dissolved solids (TDS). This discharge is currently permitted by SD DENR Surface Water Quality Program NPDES permit # SD0025933 Effective date March 2016. The BTWTF plant has been designed to treat an average flow of 140 gallons per minute (0.20 MGD with a peak flow of 686 gallons per minute (0.99 MGD) and discharges to Deadwood Creek at Outfall 013 (SD DENR, 2015). The current Homestake Open Cut Permit was issued in 2011 and was last amended with an effective date of April 2015 by SD DENR. This permit is currently in effect as of the writing of this report. The facility discharges directly into Deadwood Creek approximately 2.6 km (1.6 miles) upstream of the confluence of Deadwood Creek and Whitewood Creek. The discharge point on Deadwood Creek (Outfall Serial Number 013A, Latitude 44.369444°, Longitude -103.758611°) is approximately 70 meters upstream of the Aqueduct Avenue Bridge over Deadwood Creek. A second outfall 014A, Latitude 44.369444°, Longitude -103.757500°) discharges water from the feed pond Underdrain to the combined Blacktail Feed Pond Underdrain/Blacktail stormwater outfall but as of this report has never been used. Both these discharge points (outfalls) receive waters from previous mining operations and waste rock disposal facilities and are considered non-source waters for bacteria. Outfall monitoring parameters outlined in the current NPDES permit for Outfalls 013A and 014A do not require bacterial (*E. coli* Bacteria) monitoring of discharge. Therefore, the WLA for this facility was set at zero in the TMDL. During this project a total of two *E. coli* bacteria samples from the Blacktail WTF effluent were collected in 2018. One sample was collected by Homestake mine closure personnel on 03/21/2018 from the polish filter water; and the other sample collected on 05/10/2018 by SD DENR personnel from the surface water discharge pipe leaving the wastewater treatment facility, Outfall 013A, (Appendix A, Table A3). These samples were collected to verify/validate that no bacteria were present in BTWTF water discharged to Deadwood Creek. Sample results from Midcontinent Testing Laboratories for these samples were < 1.00 MPN/100 mL using Standard Methods SM 9223 B Quanti-Tray® method (APHA, 2017) validating *E. coli* bacteria in treated mine source water effluent discharged to Deadwood Creek is not a source of loading or concern in this watershed (Appendix A, Table A3).

5.1.2 Concentrated Animal Feeding Operations (CAFO)

There are no permitted confined animal feeding operations (CAFO) in the Deadwood Creek watershed, segment SD-BF-R-DEADWOOD_01 based on information from SD DENR Feedlot Program, SD DENR FP. The topography and landuse are not conducive to large animal feeding operations. Based on these data the Waste Load Allocation (WLA) portion of the TMDL was set at zero.

5.2 Non-point Sources

Based on a review of all available information and communications with personnel from SD DENR SWQP: NPDES Surface Water Discharge staff; South Dakota Game Fish and Parks (SD GF&P); Central City; the City of Deadwood; the City of Lead; and with the Lead Deadwood Sanitary District (LDSD) personnel; the primary non-point sources of bacteria (*E. coli* bacteria) within segment SD-BF-R-DEADWOOD_01 are wildlife and human sources (Table 12).

The Bacterial Indicator Tool (BIT) is a spreadsheet that estimates the bacteria contribution from multiple sources. Currently, the tool is enabled for fecal coliform. However, the tool could be adapted for other bacterial indicators, such as *E. coli*, if the necessary bacteria production information is available. The tool estimates the monthly accumulation rate of fecal coliform bacteria on four land uses (cropland, forest, built-up, and pastureland), as well as the asymptotic limit for that accumulation should no wash off occur. The tool also estimates the direct input of fecal coliform bacteria to streams from grazing agricultural animals and failing septic systems.

Table 12 Total bacterial source production percentages by species for Segment SD-BF-R-DEADWOOD_01 of Deadwood Creek, Lawrence County, South Dakota

Source Type		#/Acre	Bacteria/Animal/Day	Bacteria/Acre	Percentage
Build up		6.13 x 10^{-02}	3.45 x 10^{07}	2.11 x 10^{06}	0.4%
Pets[4]		7.72 x 10^{-03}	4.09 x 10^{09}	3.16 x 10^{07}	5.3%
Failing Septic		2.00 x 10^{00}	1.59 x 10^{08}	1.59 x 10^{08}	26.8%
Humans in Watershed		7.72 x 10^{-02}	1.95 x 10^{09}	1.50 x 10^{08}	25.4%
All Wildlife		6.89 x 10^{-02}	1.74 x 10^{11}	2.50 x 10^{08}	42.2%
Total				5.93 x 10^{08}	100.0%
Wildlife Species	**Lawrence Co.[5] #/Sq. Mile**	**#/Acre**	**Bacteria/Animal/Day**	**Bacteria/Acre**	
whitetail deer	12.55	1.96 x 10^{-02}	5.00 x 10^{08}	9.80 x 10^{06}	
mule deer	3.76	5.88 x 10^{-03}	5.00 x 10^{08}	2.94 x 10^{06}	
elk[1]	1.25	1.95 x 10^{-03}	1.04 x 10^{11}	2.03 x 10^{08}	
turkey (wild)	11.29	1.76 x 10^{-02}	9.30 x 10^{07}	1.64 x 10^{06}	
mink[3]	0.56	8.75 x 10^{-04}	1.25 x 10^{08}	1.09 x 10^{05}	
beaver	0.75	1.17 x 10^{-03}	2.50 x 10^{08}	2.93 x 10^{05}	
muskrat[2]	0.25	3.91 x 10^{-04}	1.25 x 10^{08}	4.88 x 10^{04}	
skunk[2]	0.25	3.91 x 10^{-04}	1.25 x 10^{08}	4.88 x 10^{04}	
coyote[4]	0.19	2.97 x 10^{-04}	4.09 x 10^{09}	1.21 x 10^{06}	
fox[4]	0.50	7.81 x 10^{-04}	4.09 x 10^{09}	3.20 x 10^{06}	
raccoon	1.51	2.36 x 10^{-03}	1.25 x 10^{08}	2.95 x 10^{05}	
bobcat[4]	0.56	8.75 x 10^{-04}	4.09 x 10^{09}	3.58 x 10^{06}	
pine martin[2]	0.63	9.84 x 10^{-04}	1.25 x 10^{08}	1.23 x 10^{05}	
cottontail rabbit[2]	7.53	1.18 x 10^{-02}	1.25 x 10^{08}	1.47 x 10^{06}	
squirrel[2]	0.88	1.38 x 10^{-03}	1.25 x 10^{08}	1.72 x 10^{05}	
partridge[3]	0.13	2.03 x 10^{-04}	1.36 x 10^{08}	2.76 x 10^{04}	
sharptail grouse[3]	1.25	1.95 x 10^{-03}	1.36 x 10^{08}	2.66 x 10^{05}	
canada goose	0.25	3.91 x 10^{-04}	5.56 x 10^{10}	2.17 x 10^{07}	

[1] based on BIT beef cattle

[2] based on BIT raccoon

[3] based on BIT chicken

[4] based on BIT dog

[5] County Wildlife counts based on Huxoll, 2003

The build-up source type category incorporates Commercial and Services, Mixed Urban or Built-up, Residential, and Transportation, Communications, and Utilities and are described by type and estimated acreage using ArcMap™ in Table 13.

Table 13 Bacterial Indicator Tool (BIT) Build-up source types, descriptions and acres in the Deadwood Creek Watershed

Build-up Source Type	BIT Description type	Deadwood Acres
Commercial and Services	Commercial	64
Mixed Urban or Built-up	Road, Commercial, Single family low density, Single family high density, and Multifamily residential	80
Residential	Single family low density, Single family high density, and Multifamily residential	159
Transportation, Communications, Utilities	Road	16

5.2.1 Agriculture

The majority of the Deadwood Creek watershed is comprised of mountainous terrane that is over 75 percent forested and 6 percent urban (commercial and services) with soils that are not conducive to agricultural pursuits. Figure 19 shows United States Forest Service (USFS) private grazing allotments acres (light blue areas) totaling 102 acres or 1.97 percent of the watershed area; and the grazing allotment exemption area, (yellow hashed area) making up the remaining portion of the watershed or 98.03 percent.

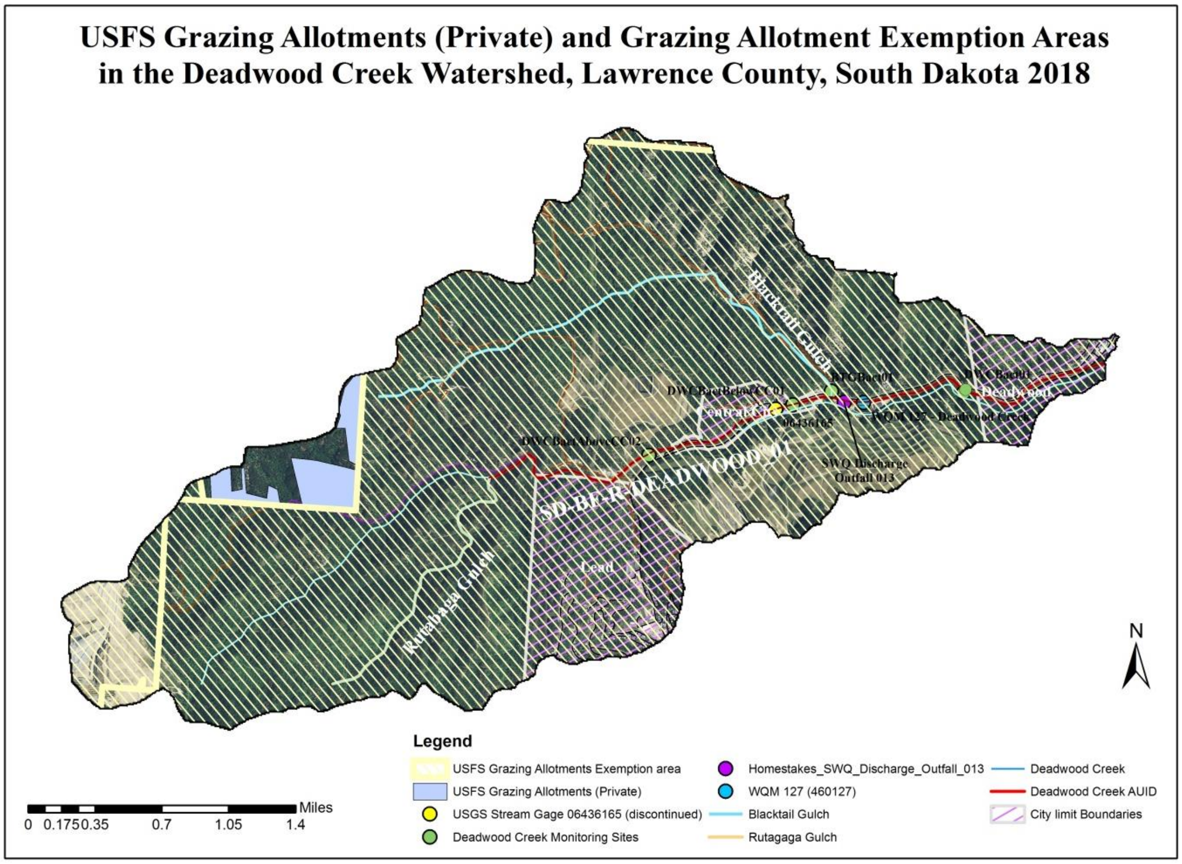

Figure 19 USFS Grazing Allotments and Exemption boundaries in the Deadwood Creek Watershed 2018

5.2.2 Human Sources

Human sources of bacteria in Deadwood Creek were estimated using Environmental Systems Research Institute, Inc. ESRI®, ArcMap™ program and GIS layers to estimate area. Urban areas accounted for approximately 57 acres and residential areas accounted for 159 acres and the human population within the watershed boundary is approximately 400 people. To estimate the number of pets in the watershed, ten percent of the human population was estimated to have pets (40 pets). ArcMap™ was used to count the number of rural residences not connected to the LDSD wastewater collection system and estimate the number of septic systems in the watershed. The counts estimated 21 septic systems within the watershed boundary and assuming a 10% failure rate with two people per system, a total of two failing systems were estimated to be in the Deadwood Creek watershed.

These areas, counts, numbers, and estimates along with Deadwood Creek Assessment results, data analysis, and TMDL were reviewed and presented to the cities of Lead, Deadwood, Central City, Lead Deadwood Sanitary District, and Homestake (Barrick Gold) Mine closure personnel in late 2018 to verify all sources were accounted for (Table 12).

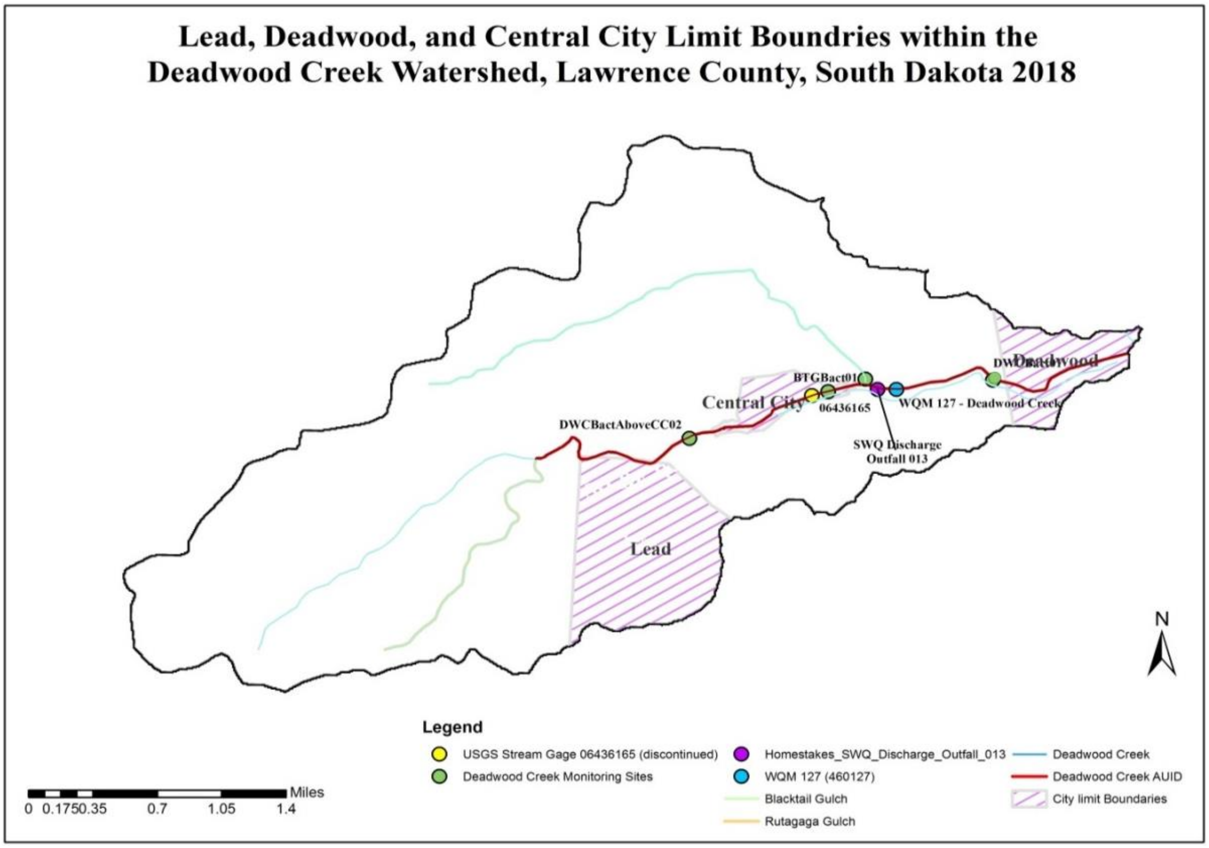

Figure 20 City limit boundaries within the Deadwood Creek Watershed

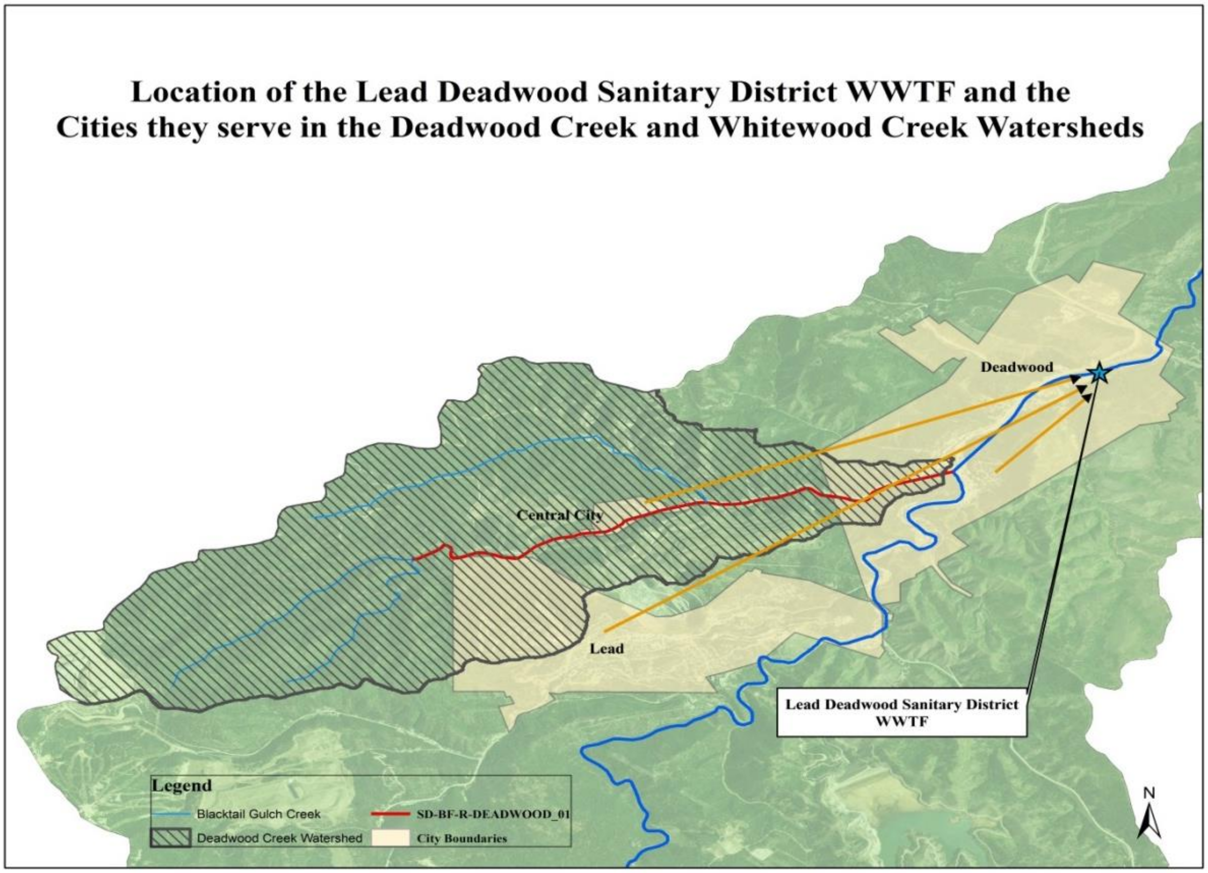

Figure 21 Location of the Lead Deadwood Sanitary District WWTF and the Cities served

Based on the BIT estimates, the largest human source of bacteria in the watershed was failing septic systems (26.8 percent) located outside the city limit boundaries and the LDSD collection system (Table 12). The majority of the Deadwood Creek watershed is relatively rural (forested) except for the northwest portions of Lead, the western portions of the city of Deadwood and all of Central City (Figure 20). Waste from all communities on the LDSD centralized collection system are treated at the LDSD water treatment facility located in the eastern portion of the City of Deadwood and then discharged into Whitewood Creek (Figure 21).

5.2.3 Wildlife/Natural background

Wildlife within the watershed is a natural background source of *E. coli* bacteria. Wildlife population density estimates were obtained from the South Dakota Department of Game, Fish, and Parks Report No 2003-11 (Huxoll, 2003). The estimated wildlife contribution of bacteria by species in Deadwood Creek watershed was calculated by taking the number of each wildlife species counted in the Lawrence County by the total number of acres in the county to determine the number of animals per acre. The number of bacteria per animal per day was estimated using species specific values listed in the BIT model and species without values were assigned loading values indicated by species surrogates and are listed in the lower portion of Table 12. The total bacteria by species were calculated by multiplying the number of each species per acre by the total bacteria produced per animal per day. All wildlife species loading were summed to determine the overall wildlife contribution potential based on a per acre basis within the Deadwood Creek watershed and accounted for 42.2 percent of the loading potential.

5.2.4 Tributary Contributions

Several small drainages (Rutabaga Gulch and Blacktail Gulch) intermittently drain into Deadwood Creek during the year. The furthest upstream tributary to Deadwood Creek is Rutabaga Gulch which empties into an undeveloped area in the upper portion of the Deadwood Creek watershed. This watershed was not monitored during this project; however, some samples were collected in Deadwood Creek above Central City in September 2017 and May 2018 as part of an effort to evaluate bacteria *E. coli* counts in Deadwood Creek above and below town. This site (DWCBactAboveCC02) is approximately 1.6 stream kilometers (1 mile) downstream of the confluence of Rutabaga Gulch and Deadwood Creek. These seven *E. coli* sample counts collected above Central City were very low (ranging from 2 CFU/100 mL to 13 CFU/100 mL) compared samples collected downstream of Central City (ranging from 30 CFU/100 mL to 166 CFU/100 mL). Data suggests that tributary discharges from Rutabaga Gulch and *E. coli* Bacteria loading into Deadwood Creek above DWCBactAboveCC02 do not significantly contribute *E. coli* Bacteria counts to Deadwood Creek above Central City.

Further downstream Blacktail Gulch tributary flows into Deadwood Creek downstream of Central City, South Dakota. The lower reach of Blacktail Gulch flows through semi populated rural areas along Maitland Road and continues through a more densely populated area near Highway 14 and the confluence with Deadwood Creek. This tributary was monitored during the recreation season (stage, discharge, and water quality monitoring for fecal coliform and *E. coli* bacteria) in 2015. This site was added to assess bacteria concentrations and loading effects from the confluence of Blacktail Gulch and Deadwood Creek to WQM 127 which is approximately 157 meters downstream. Samples collected at WQM 127 constitute the data that listed Deadwood Creek as an impaired waterbody. Assessment data indicate that 10.0 percent of 30 *E coli* Bacteria samples collected in Blacktail Gulch exceeded water quality standards assigned to Deadwood Creek (the receiving water). Blacktail Gulch *E. coli* Bacteria counts, and loadings may have impact on and contribute increased exceedance percentages (18.4 percent) observed in Deadwood Creek at WQM 127 (Table 10).

Based on the assessment, *E. coli* Bacteria counts and loading from Rutabaga Gulch contributions to Deadwood Creek were negligible and determined to be insignificant. Blacktail Gulch *E. coli* Bacteria counts, and loadings were more significant (10 percent of the samples were greater than the Single Sample Maximum SSM 235 CFU/100 mL, the SSM) because of the proximity of its confluence with Deadwood Creek and WQM 127. Any realized *E. coli* Bacteria reductions from Blacktail Gulch should improve *E. coli* Bacteria counts and loading at WQM 127. Assessment data indicate that by the time *E. coli* bacteria counts/loadings at WQM 127 (18.4%) travel downstream to monitoring site DWCBact01 (located in the lower end of Deadwood Creek), overall *E. coli* Bacteria counts were reduced to below listing criteria, (>10 percent) to 7.7 percent (Table 10).

6.0 TMDL Load Analysis

The TMDL for Deadwood Creek was developed using a Load Duration Curve (LDC) approach resulting in a flow-variable target that considers the entire flow regime. The LDC generated for the impaired segment of Deadwood Creek was separated into five flow zones flow frequency zones (Figure 22). Flow zones were defined according to the flow regime structure and distribution of the observed data following guidance recommended by EPA (US EPA, 2001). Five distinct flow zones were established to facilitate interpretation of the hydrologic conditions and patterns associated with the impairment. The zones were segmented by high flows (0-10 percent), moist conditions (10-40 percent), mid-range flows (40-60 percent), dry conditions (60-90 percent) and low flows (90-100 percent) (Figure 22).

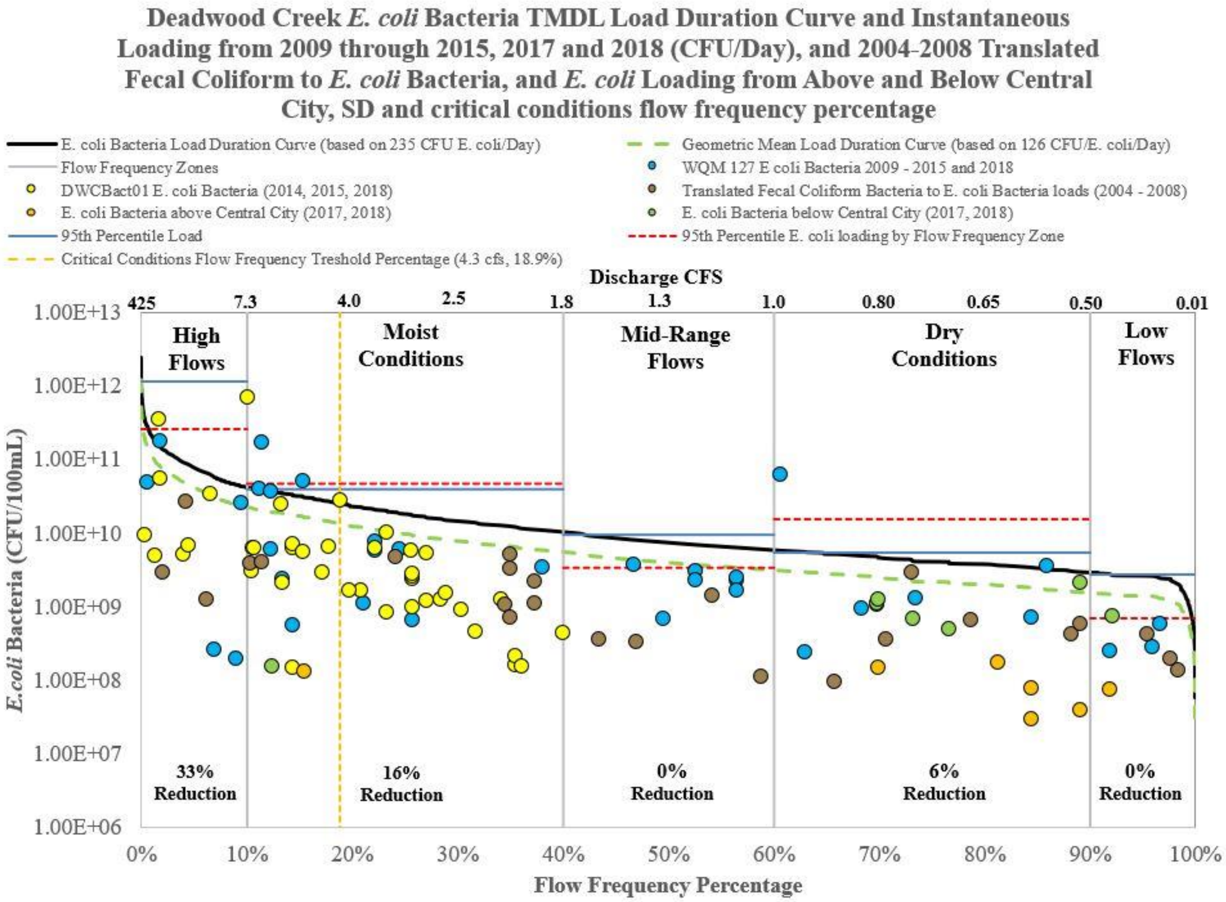

Figure 22 Load Duration Curve for Deadwood Creek segment SD-BF-R-DEADWOOD_01

Deadwood Creek instantaneous loads were calculated by multiplying the *E. coli* Bacteria counts (concentrations) collected from WQM 127 and 15- minute discharge measurements at USGS site 06436165 Deadwood Creek at Central City using data from 2010 through 2015. All other monitoring sites in Deadwood Creek (DWCBact01 2014 and 2015; DWCBactAboveCC02 and DWCBactBelowCC01, 2017 and 2018; and DWCBactup, DWCBactDown and DWCBactDown) had instantaneous discharge measurements collected to calculate *E. coli* Bacteria loading and to determine flow frequency percentages based on instantaneous discharge measurements. These data are plotted on the Load Duration Curve (LDC) for Deadwood Creek for analysis (Figure 22).

When 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 complying. As the plot shows, pathogen samples collected from Deadwood Creek exceed the daily maximum Single Sample Maximum SSM criteria based on immersion recreation beneficial use standards within the high, moist, and dry flow zones (Figure 22). Figure 22 is comparing individual samples against the GM criterion. When GMs are properly calculated from individual samples, there are no GM exceedances in the Deadwood Creek watershed during the project (Table 8 and Figure 10). Loads exceeding the criteria in the high flow zone and the upper portions of the moist flow zone imply storm runoff from the watershed and impervious areas within developed areas in the Deadwood Creek watershed. Loads shown in the dry flow zone typically indicate wildlife and pets defecating in and around the stream, or illicit releases of human waste via failing septic systems or holding tanks (Table 12).

6.1 TMDL Load Duration Curve

Bacteria data represents individual daily loadings calculated based on the flows constructed from the respective USGS gauge (site 06436165). Bacteria loads are plotted against the load frequency curve based on the South Dakota immersion recreation beneficial use numeric standard of $\leq$ 235 CFU/100mL (Table 4). Instantaneous bacterial sample data is well distributed across all flow regimes during the recreation season in Deadwood Creek (Figure 22).

All TMDL components including numeric calculations for each flow zone associated with the impaired segment of Deadwood Creek (Segment SD-BF-R-DEADWOOD_01) are presented in Table 14. The current loads for all flow zones were calculated by multiplying the 95th percentile flow and concentration. Reduction calculations were based on reducing the current load to the daily maximum threshold ($\leq$ 235 CFU/100mL) to assure compliance with South Dakota immersion recreation standards.

E. coli bacteria concentrations and loading in Deadwood Creek ultimately discharge into segment SD-BF-R-WHITEWOOD_03 of Whitewood Creek and is also impaired for *Escherichia coli* bacteria. Meeting this threshold will also assure compliance with South Dakota standards for limited contact recreation waters. No point source discharges contribute to the impaired segment so the WLA was set at zero for all flow zones. As a result, all reductions are required from nonpoint sources (LA). A description for the margin of safety (MOS) used for the TMDL is provided in section 6.2.

6.1.1 High Flows (<10% flow frequency)

The high flow zone represents the high flows in Deadwood Creek. The flow rate for this zone was widely variable ranging from 425 cfs to 7.3 cfs. Flows represented in this zone occur on an infrequent basis and are characteristic of significant run-off events typically during spring and early summer. High flows are commonly the product of spring snowmelt events but may be generated by intense rain events during the summer months. Bacteria sources across the watershed have the potential to be conveyed to the stream channel during high flow conditions. Data availability in this flow zone was relatively good (n=15) representing 13 percent of the total samples collected in the Deadwood Creek watershed (n=115). The 95th percentile bacteria concentration in the high flow zone was calculated at 349 CFU/100mL resulting in a required *E. coli* bacteria load reduction of 33% to achieve compliance with the daily maximum (single sample maximum, SSM) and in turn the GM geometric mean thresholds.

6.1.2 Moist Conditions (10% to 40% flow frequency)

Moist conditions represent the portion of the flow regime that occurs following moderate storm events. Flows in this zone vary from 7.2 cfs to 1.8 cfs. The flows in this zone occur in early to mid-summer near the peak of the recreation season providing for optimal recreational opportunity. Sources of bacteria may be expected to be closer to the channel and somewhat easier to mitigate than those impacting the high flows. Bacteria sources across the watershed have the potential to be conveyed to the stream channel during moist flow conditions. Data availability in this flow zone was good (n=58) representing 50 percent of the total samples collected in the Deadwood Creek watershed assessment project (n=115). This flow zone had the greatest number of samples collected throughout the study with six of those samples exceeding the *E. coli* bacteria beneficial use based standard of 235 CFU/100 mL. The 95th percentile bacteria concentration was calculated at 279 CFU/100mL resulting in a required *E. coli* bacteria load reduction of 16% is required to achieve 100 percent compliance with the daily maximum (single sample maximum SSM) and in turn the GM geometric mean thresholds. This flow zone contains the critical conditions flow frequency threshold percentage (18.9) and is defined as the minimum discharge (4.3 cfs) within the entire flow frequency curve where the majority (largest grouping) of *E. coli* Bacteria samples exceeded WQS. A detailed description and evaluation of critical conditions in Deadwood Creek is provided in Section 8.0 and Table 16 of this report.

6.1.3 Mid-range Flows (40% to 60% flow frequency)

Mid-range flow conditions represent flow rates between 1.7 cfs and 1.1 cfs. This portion of the flow regime likely occurs in mid to late summer. Run-off from storm events is likely minimized by mature vegetative growth present during the peak of the growing season. Flows in this zone may also represent conditions that occur in the fall during recovery periods of dryness. Mid-range flows represent the transition from run-off based flow to base flows. Bacteria sources in this flow zone likely originated near the channel or within the riparian zone. Data availability in this flow zone was fair (n=11) representing 10 percent of the total samples collected in the Deadwood Creek watershed (n=115). The 95th percentile bacteria concentration was calculated at 100 CFU/100mL requiring no reduction (0%) in *E. coli* bacteria loading in this flow zone to achieve 100 percent compliance with the daily maximum (single sample maximum, SSM) and in turn the GM geometric mean thresholds.

6.1.4 Dry Conditions (60% to 90% flow frequency)

Dry conditions represent flow rates between 1.0 cfs and 0.51 cfs. Dry condition flows are best characterized as base flow conditions influenced by ground water sources. Bacteria sources likely originate in the stream channel during dryer flow conditions. Data availability in this flow zone was reasonably good (n=23) representing 20 percent of the total samples collected in the Deadwood Creek watershed (n=115). The 95th percentile bacteria concentration was calculated at 251 CFU/100mL resulting in a required *E. coli* bacteria load reduction of 6% is required to achieve 100 percent compliance with the daily maximum (single sample maximum, SSM) and in turn the GM geometric mean thresholds.

6.1.5 Low Flows (90% to 100% flow frequency)

The Low flow zone represents minimal to no flow conditions of less than $\leq$ 0.50 cfs. Recreation uses and associated standards are applicable to all flow conditions. However, lower flows result in reduced recreational opportunities. Bacteria sources likely originate in the stream channel during low flow conditions. Data availability was relatively low (n=8) representing 7 percent of the total samples collected in the Deadwood Creek watershed (n=115). The low numbers of samples in the lowest flow zone and was a product of the reduced frequency of these flows during the recreational season. The 95th percentile bacteria concentration was calculated at 61 CFU/100mL requiring no reduction (0%) in *E. coli* bacteria loading in this flow zone to achieve 100 percent compliance with the daily maximum (single sample maximum SSM) and in turn the GM geometric mean thresholds.

Table 14 *E. coli* TMDL for segment SD-BF-R-DEADWOOD_01 based on the daily maximum (single sample maximum, SSM) for Deadwood Creek, Lawrence County, South Dakota 2018

***E. coli* Bacteria TMDL for AUID Segment SD-BF-R-DEADWOOD_01**		**Flow Zones**				
		High Flows	**Moist**	**Mid-Range**	**Dry**	**Low Flows**
TMDL Component		**425 cfs - 7.3 cfs**	**7.2 cfs - 1.8 cfs**	**1.7 cfs - 1.1 cfs**	**1.0 cfs - 0.51 cfs**	**0.50 cfs - 0.01 cfs**
WLA*	**CFU/Day**	0	0	0	0	0
LA	**CFU/Day**	2.64E+11	3.36E+10	8.80E+09	5.17E+09	2.59E+09
MOS	**CFU/Day**	2.93E+10	3.74E+09	9.77E+08	5.75E+08	2.87E+08
TMDL @ 235 CFU/Day (95th percentile load per flow zone)		**2.93E+11**	**3.74E+10**	**9.77E+09**	**5.75E+09**	**2.87E+09**
Current Load - 95th percentile load per flow zone	**CFU/Day**	2.31E+11	4.09E+10	3.33E+09	3.44E+09	6.83E+08
95th percentile Concentration per flow zone	**CFU/100 mL**	349	279	100	251	61
Number of Values Assessed	**count**	15	58	11	23	8
Number of *E. coli* counts exceeding 235 CFU/100 mL	**count**	2	6	0	2	0
Percent Load Reduction		**33%**	**16%**	**0%**	**6%**	**0%**

*** = Waste Load Allocation for Blacktail Water Treatment Facility was set to zero because the facility is considered a non-source water for bacteria**

6.2 TMDL Allocations

6.2.1 Waste Load Allocation (WLA)

As outlined in Section 5.1.1, the BTWTF NPDES permit # SD0025933 discharges directly into Deadwood Creek approximately 2.6 km (1.6 miles) upstream of the confluence of Deadwood Creek and Whitewood Creek. The discharge point has two outfalls on Deadwood Creek, outfall 013A that continuously discharges into Deadwood Creek and outfall 014A and as of this report has never been used to discharge water to Deadwood Creek. Both these discharge points (outfalls) receive waters from previous mining operations and waste rock disposal facilities and are considered non-source waters for bacteria. Outfall monitoring parameters outlined in the current NPDES permit for Outfalls 013A and 014A do not require bacterial (*E. coli* Bacteria) monitoring of discharge. During this project two random samples were collected to validate that no *E. coli* Bacteria were present in discharge waters entering Deadwood Creek. Both sample results were < 1 CFU/100 mL (below detection limits) indicating no *E. coli* Bacteria are present in BTWTF discharge to Deadwood Creek and are not a source of *E. coli* Bacteria to Deadwood Creek. Section 5.1.2 indicated that there are no permitted CAFOs in the Deadwood Creek watershed. Thus, the WLA for BTWTF and CAFOs were set at zero (0) in all five flow zones.

6.2.2 Margin of Safety (MOS) – *E. coli* Bacteria

In accordance with TMDL regulations, a margin of safety is to be 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 Deadwood Creek (Segment SD-BF-R-Deadwood_01), the latter approach was used to establish a safety margin.

An explicit MOS was calculated within the duration curve framework to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc.). Ten percent (10%) of the overall load capacity was allocated to each flow zone to assign the MOS as part of the TMDL. The remaining assimilative capacity was allocated to nonpoint sources (LA).

6.2.3 Load Allocation (LA) – *E. coli* Bacteria

To develop the *E. coli* LA for Deadwood Creek, the loading capacity LC was first determined using the data sources specified. One portion of the loading capacity was allocated to the MOS to account for uncertainty in the calculations (see Section 6.2.2) and the other portion WLA is usually assigned to account for point sources (permitted discharge facilities in the watershed). However, in Deadwood Creek, WLA was set to zero because receiving waters are from previous mining operations and waste rock disposal facilities are considered non-source waters for bacteria (see Section 6.2.1). Thus, the LA for Deadwood Creek was calculated as the TMDL minus the 10 percent explicit MOS (LA=TMDL-MOS).

The *E. coli* load capacity for the impaired segment of Deadwood Creek is exclusively attributed to nonpoint sources. Nonpoint source load reductions based on the Deadwood Creek *E. coli* bacteria load duration curve indicates 33 percent reduction is needed in the high flow zone, 16 percent reduction in the moist flow zone, and a 9 percent reduction in the dry flow zone is needed to fully meet 100 percent attainment (Figure 22). Nonpoint source bacterial load reductions for this watershed based on production potential are outlined in Table 12 and indicate/estimate that wildlife produce the most bacteria in the Deadwood Creek watershed based on percentage.

7.0 Seasonal Variation

USGS 15-minute stream discharge in Deadwood Creek (site: 06436165) displayed seasonal variation for the period of record (2010 through 2015) during the recreation season (May 1st through September 30th). In the Deadwood Creek watershed, the highest stream discharge (425 CFS) occurred in August 2010 and the lowest discharge (0.01 CFS) occurred in August 2011. Project data show that during the project period of record discharge was not a good predictor of *E. coli* bacteria counts in Deadwood Creek ($r^2 = 0.0002$) and poorly correlated with discharge ($r = 0.0142$) in segment SD-BF-R-DEADWOOD_01 (Figure 23).

Seasonality is an important factor when considering patterns associated with bacteria contaminations. Bacteria samples used in TMDL analysis were collected monthly from May 1st through September 30th, 2014, 2015, 2017 and 2018 and from WQM 127 from 2004 through 2015, 2017 and 2018 during the recreation season in Deadwood Creek. Table 15 summarizes all available monthly *E. coli* Bacteria data collected during the recreation season.

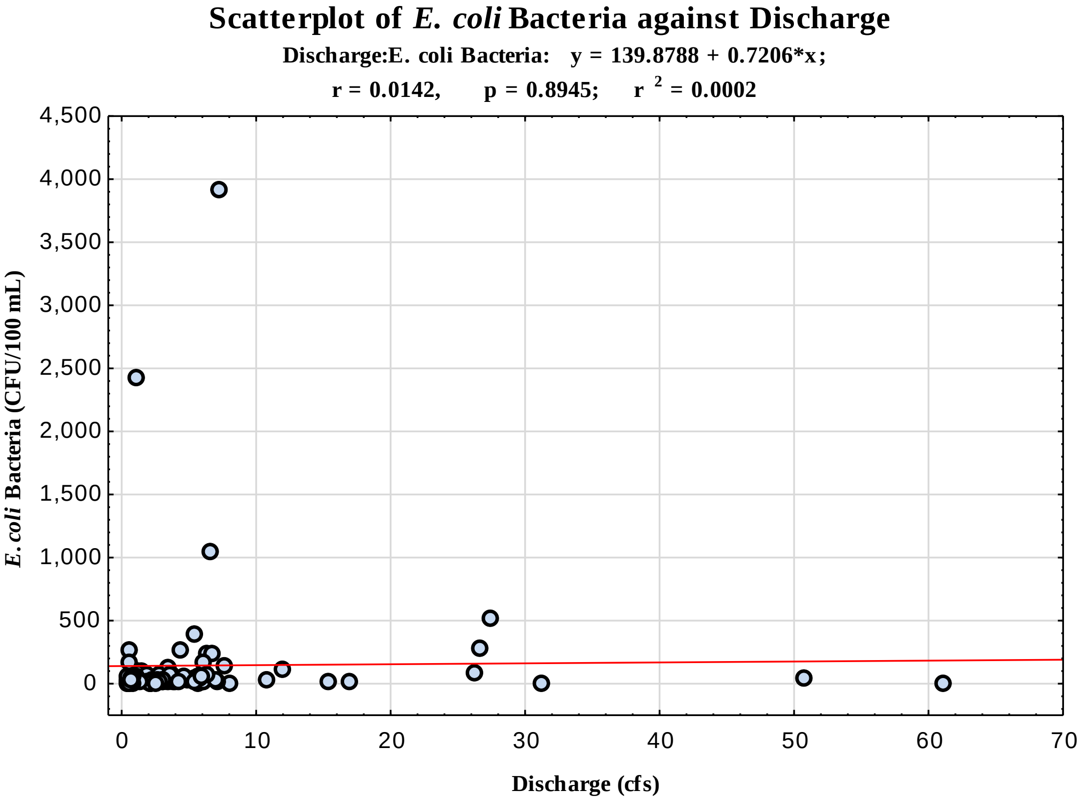

Figure 23 ***E. coli* Bacteria plotted against Discharge in Deadwood Creek, Lawrence County, South Dakota**

Data was analyzed by separating all available monthly *E. coli* Bacteria concentrations/counts collected during the recreation season (May 1st through September 30th) and separating them by month (Table 15). Total *E. coli* Bacteria samples for each month were tabulated along with the number of bacteria counts exceeding the beneficial use based Water Quality Standard (WQS) for immersion recreation waters ($\leq$ 235 CFU/100 mL) based on the SSM criteria. The 95th percentile count for each month was calculated to standardize which months of the recreation season tend to deviate more from the 235 CFU/100 mL standard. Data show that the 95th percentile *E. coli* bacteria count for all data collected from Deadwood Creek in May (140 CFU/100 mL) was the only month that was below the WQS (235

CFU/100 mL), for all other months (June, July, August, and September) the 95th percentile counts exceeded WQS.

Table 15 Monthly *E. coli* Bacteria samples collected during the recreation season for Deadwood Creek from 2004 through 2015, 2017 and 2018

Years	Recreation Season	Discharge Range	Total Samples[1] by Month	*E. coli* Bacteria Counts that Exceeded WQS by Month	95th Percentile Count by Month (CFU/100 mL)	Percent *E. coli* Bacteria reductions required to meet WQS at ≤ 235 CFU/ 100 mL
2004 - 2015, 2017, 2018	May (Spring)	0.45 - 61.05	20	1	140	**0%**
	June (Summer)	0.78 - 31.20	15	2	508	**54%**
	July (Summer)	0.53 - 15.34	22	3	259	**9%**
	August (Summer)	0.37 - 7.24	21	2	387	**39%**
	September (Fall)	0.39 - 27.49	36	2	255	**8%**

[1] = Sample counts includes 2004 - 2008 transformed Fecal Coliform bacteria

Percent reductions required were greatest in June (54 percent, or a 273 CFU/100 mL reduction in bacteria counts) and August (39 percent, or a 152 CFU/100 mL reduction in bacteria counts) are needed to comply with the ten percent Integrated Report (IR) listing criteria.

E. coli Bacteria sample counts were converted to daily loads (CFU/Day) and separated by month during the recreation season to assess monthly loading in Deadwood Creek. Exceedance was determined to be daily loading greater than the 95th percentile load (TMDL) in each flow frequency interval category (Table 15).

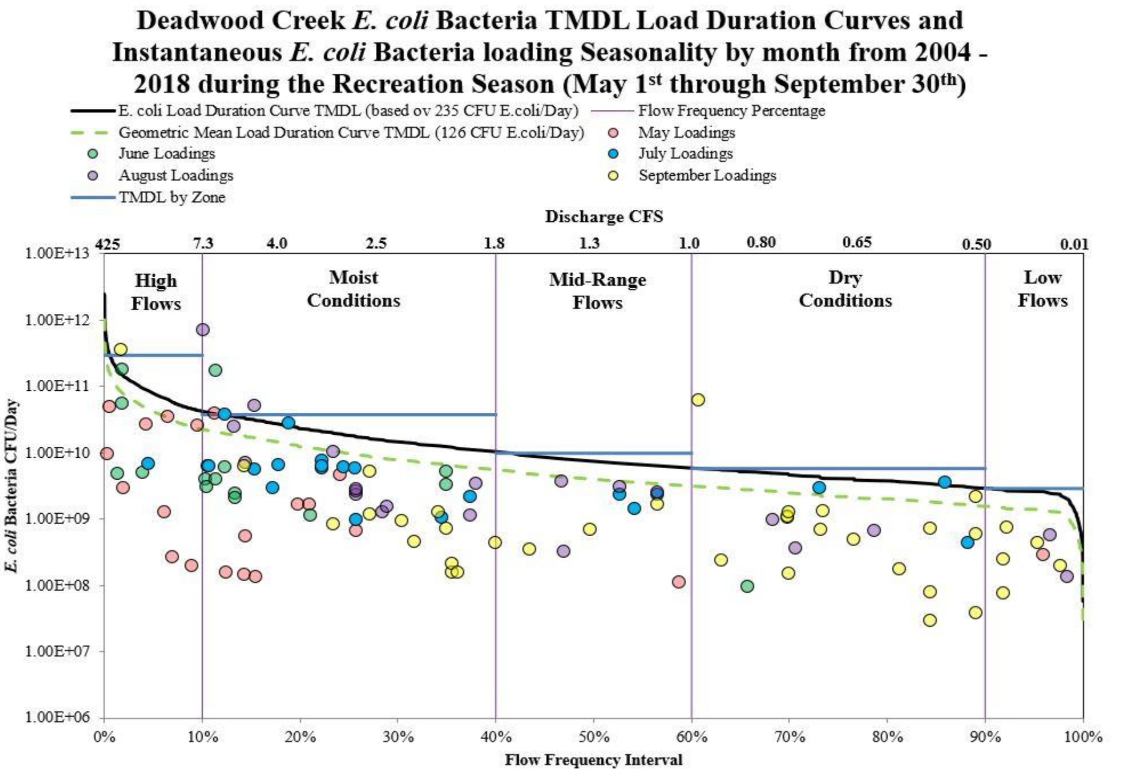

Figure 24 Deadwood Creek *E. coli* Bacteria TMDL load duration curves and instantaneous *E. coli* Bacteria loading seasonality by month and critical condition threshold from 2004 through 2018.

Monthly seasonal loading data was also plotted on the load duration curve developed for Deadwood Creek. Data show no real pattern to loading based on month (Figure 24). Monthly *E. coli* Bacteria loading values that exceeded the flow frequency interval TMDLs (blue lines in Figure 24) had no defined patterns with one exceedance in May (red) in the moist flow zone, one exceedance in June (green) in the moist flow zone, two exceedances in August (purple) in the moist flow zone, and two exceedances in September (yellow) one in the high flow zone and one in the dry flow zone (Table 14 and Figure 24).

Seasonal variation is also a component of the load duration curve framework through the establishment of individual flow zones and associated TMDL load allocations (Figure 22). Focusing restoration efforts to account for these seasonal patterns is warranted to achieve TMDL attainment goals.

Since the criteria for *E. coli* Bacteria concentrations are in effect from May 1st through September 30th, the TMDL developed for this parameter (*E. coli* bacteria) and segment are also applicable only during this time period or season.

8.0 Critical Conditions

Critical conditions are for this study defined as the minimum discharge within the entire flow frequency curve/Load Duration Curve (LDC) where the majority of *E. coli* Bacteria exceeds beneficial use based Water Quality Standards (WQS). These discharges are unique to each watershed based on rainfall characteristics, bacteria sources, and watershed morphology and only apply during the recreation season. Critical discharge conditions for the Deadwood Creek watershed and monitoring sites are detailed in Table 16.

Table 16 Critical discharge threshold for the Deadwood Creek watershed

Deadwood Creek *E. coli* Bacteria Exceedances and Critical Conditions Threshold[2]

Flow Frequency Zone	Exceedance counts of *E. coli* Bacteria[1] (CFU/100 mL)	Discharge (cfs)	Flow Frequency Percentage (%)	Monitoring site	
High	520	27.48	1.7	DWCBact01	Critical Conditions Zone 80% of total exceedances
High	276	26.60	1.8	WQM127	
Moist	3,920	7.24	10.1	DWCBact01	
Moist	238	6.70	11.3	WQM127	
Moist	1,050	6.56	11.4	WQM127	
Moist	238	6.31	12.3	WQM127	
Moist	287	5.41	15.3	WQM127	
Moist[4]	260	4.34	18.9	DWCBact01	
Dry[3]	2,420	1.05	60.7	WQM127	
Dry	260	0.55	85.9	WQM127	

[1] = WQS based on immersion recreation criteria ≤ 235 CFU/100 mL

[2]= Exceedances reprsent 80% (8 samples) of the total exceedance observed (10 samples)

[3]= All flow zone exceedances (10 samples) were considered in the critical condition evaluation; however, the majority of the exceedances were in the upper moist and high flow zones (80%) with the two exceedances in the dry flow zone (20%).

[4]= Blue - Minimum discharge within exceedances threshold

All flow zone exceedances (10 samples) were considered in the critical conditions evaluation and were based on bacteria counts that exceeded WQS based on immersion recreation beneficial use standards (≤ 235 CFU/100 mL) and associated discharge (cfs) (Table 16). Data indicate that 80 percent of all exceedances, eight out of ten total exceedances, occurred in the high and the upper portion of the moist flow frequency zones. The two exceedances in the high flow zone were collected with instantaneous discharges ranging from 26.60 to 27.48 cfs and six samples collected in the moist flow zone ranged from 7.24 to 4.34 cfs. The remaining two exceedances occurred in the dry conditions flow zone ranging from 1.05 to 0.55 cfs representing 20 percent of the total *E. coli* Bacteria exceedance counts (Table 16, Figure 22, and Figure 24).

The critical conditions in Deadwood Creek were based on the majority or greatest percentage of *E. coli* bacteria that exceeded WQS over the entire flow frequency curve. These were clustered in high and upper moist flow zones representing 80 percent of all *E. coli* bacteria exceedances in Deadwood Creek (Table 16). The minimum discharge within these data 4.34 (cfs) was chosen as the minimum critical conditions threshold discharge that the majority of *E. coli* bacteria exceedances occur within this watershed (Figure 24). Exceedances in the high and upper moist flow zone were attributed to watershed runoff events.

The remaining two exceedances, 20 percent of all *E. coli* bacteria exceedances, were in the dry flow zone and were not considered as part of the critical condition zone because they comprised a lower overall exceedance percentage and occurred during lower discharge (flow) conditions. Exceedances in this zone occurred during lower flows when wildlife and pets have direct access to streams and contributing tributaries depositing waste directly into the Deadwood Creek watershed.

9.0 Monitoring Strategy

During and after 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 station found within the river basin especially for the segment addressed in this report. As of 2009 monthly *E. coli* bacteria water quality samples have been collected from WQM127 Deadwood Creek at Central City (SD DENR_WQX-460127) during the recreation season. Discharge data assign to WQM127 came from USGS site 06436165 located approximately 1.1 stream kilometers upstream of WQM127. Long term data from this site was used to develop flow frequency and load duration curves for Deadwood Creek. This USGS site was discontinued in September 30, 2015 and as of this report there are no plans recommission this site (USGS, 2019). SD DENR WPP is planning on installing a staff gage and data logger at WQM 127 monitoring site for long term monitoring. Many discharge measurements will be collected over time to develop a rating curve for long term discharge monitoring and TMDL compliance.

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, then 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.

10.0 Public Participation

SD DENR also provided financial support for the Deadwood Creek project and was the primary agency involved in the design, data collection, analysis, and completion of this TMDL document. Bacteria data collected during the Deadwood Creek project was supplemented with bacteria data available from SD DENR's ambient water quality monitoring station WQM 127.

Homestake (Barrick) Mine was originally contacted in early 2014 about the proposed assessment project and granting access to Homestake agricultural property leases along Deadwood and Whitewood Creeks. Homestake closure personnel were extremely helpful and supportive in supplying access, historical, and current information on mine and water treatment operations throughout the assessment. Assessment personnel updated Homestake closure staff throughout the project (2014, 2015, 2017 and 2018).

September 26, 2018, discussions were held with Lead Deadwood Sanitary District (LDSD) Manager; Terry Wolterstroff about the Districts centralized collection system trunk lines and their locations within the Deadwood, Gold Run and Whitewood Creek watersheds; including the overall workings of the water collection and wastewater processing collected from the cities of Lead, Deadwood, and Central City. Deadwood Creek Project results, data analysis, and TMDL results were reviewed and the possible locations within the Deadwood Creek watershed not connected to the centralized collection system. September 27, 2018 similar discussions were conducted with the City of Deadwood Public Works Director, Ron Green, and the Water Departments Superintendent/System Operations Specialist and the City of Lead City Administrator; Mike Stahl, about the project, data analysis, TMDL and if there were areas within their jurisdictions within the Deadwood Creek watershed collection areas that are not connected to LDSD centralized collection system. October 2, 2018, assessment staff met with Board Trustee, Donovan Renner with the City of Central City about the assessment, data analysis, TMDL, and to inquire about potential bacterial sources within Central City limits. Data was used to estimate the number of septic systems in the Deadwood Creek Watershed and to estimate potential load from septic systems based on a 10 percent failure rate within the Deadwood Creek watershed from 2014 through 2018.

This report was public noticed from August 1, 2020 through September 3, 2020 in the Black Hills Pioneer and the Rapid City Journal Newspapers and on the South Dakota Department of Environment and Natural Resources website - Public Notice Page (https://denr.sd.gov/public/default.aspx). During this period no public comments were received.

11.0 Implementation Strategy

Several types of BMPs have been considered in the development of a water quality management implementation plan for the impaired segment of Deadwood Creek within the Whitewood Creek Basin. The results shown in the Load Duration Curve indicate most of the reductions are required in the higher two flow zones (discharge > 5.4 CFS). Because of the rural area and the lack of point sources, all implementation measures should focus on controlling or reducing nonpoint sources of *E. coli* Bacteria the following:

- During the initial design of the implementation project additional *E. coli* Bacteria samples should be taken to further refine and identify specific areas along Blacktail Gulch to the confluence of Deadwood Creek and in Deadwood Creek past WQM 127 to DWCBact01.

- Enhancing the existing riparian vegetation width and density along all tributaries to and along Deadwood Creek watershed and its tributaries will provide erosion control and filters runoff of pollutants including bacteria into the stream.
- Reducing wildlife, domestic animals including pets and human sources access to the streams in the watershed.
- 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 the project sponsor and basin stakeholders.

There are several entities that provide watershed stewardship in the Black Hills area and may have vested interest in a Deadwood Creek Watershed Implementation Project. These include Black Hills Fly Fishers, various municipalities within the watershed including Lead, Deadwood, and Central City, the Lawrence County Conservation District, South Dakota GF&P, and Natural Resource Conservation Service. These entities will most likely be involved in any kind of implementation/restoration project that involves Deadwood Creek.

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 (CW SRF) program, and the Section 319 Nonpoint Source program.

As of this report, there are no implementation or watershed improvement projects underway in the Deadwood Creek Watershed or in Segment SD-BF- R-WHITEWOOD_03 of Whitewood Creek (downstream receiving water) that also has approved TMDLs and is also impaired for *E. coli* Bacteria and Fecal Coliform Bacteria (SD DENR, 2011a and SD DENR, 2011b).

The only scheduled project known to be occurring in 2019 is a South Dakota DOT project that is are replacing small round metal culverts under Highway 14A with two large concrete box culverts which altered Highway 14A. In the fall of 2019, the round metal culvert connecting Blacktail Gulch to Deadwood Creek was removed and replaced with a larger concrete flat-bottomed culvert. Both construction areas were temporarily paved for the fall of 2019 and winter 2020, with final paving and project completion scheduled for the Spring of 2020. As of May 16, 2020, the final paving project has started with temporary paving removed and base aggregate spread prior to application of the permanent road surface.

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APPENDIX A:

Deadwood Creek Fecal Coliform and *E. coli* Bacteria Samples and QA/QC Tables

Table A1 Deadwood Creek routine and event fecal coliform and *E. coli* bacteria monitoring, instantaneous discharge, and water quality data collected during the recreation season (May 1 through September 30) from Deadwood Creek Assessment in 2014, 2015, September 2017 and May of 2018.

Station	Date	*E. coli* Bacteria	Fecal Coliform Bacteria	Discharge	Stage	Dissolved Oxygen	pH	Specific Conductivity	Temperature
		CFU/100mL	CFU/100 mL	cfs	Feet	mg/L	s.u.	µS/cm	°C
DWCBact01	06/17/2014	17	10	7.170	1.46	9.73	8.20	743	11.07
DWCBact01	06/27/2014	14	22	6.070	1.42	9.36	8.52	710	14.25
DWCBact01	07/01/2014	18	22	15.335	1.65	9.66	8.08	480	10.66
DWCBact01	07/10/2014	36	30	6.970	1.43	9.48	8.74	673	15.52
DWCBact01	07/15/2014	42	10	5.470	1.36	9.47	8.70	727	13.84
DWCBact01	07/24/2014	70	56	3.683	1.31	8.91	8.30	802	17.36
DWCBact01	07/31/2014	76	28	3.120	1.25	8.67	8.04	854	15.66
DWCBact01	08/07/2014	121	44	3.480	1.29	9.82	7.82	893	13.73
DWCBact01	08/14/2014	38	20	3.048	1.24	8.84	8.01	764	15.86
DWCBact01	08/21/2014	**3920**	**3200**	7.240	1.48	9.12	7.92	478	16.82
DWCBact01	08/28/2014	19	1	2.700	1.21	8.54	8.24	737	16.69
DWCBact01	09/03/2014	23	6	2.220	1.17	7.85	8.04	901	15.74
DWCBact01	09/18/2014	10	2	3.400	1.28	8.90	8.24	833	14.66
DWCBact01	09/22/2014	3	2	2.090	1.18	8.96	8.40	958	14.11
DWCBact01	09/24/2014	4	2	2.155	1.17	10.50	8.34	964	12.27
DWCBact01	09/29/2014	75	56	2.843	1.25	10.19	8.46	817	11.95
DWCBact01	09/30/2014	**520**	380	27.485	1.91	9.14	8.35	431	11.55
DWCBact01	10/01/2014	44	100	5.879	1.41	9.52	8.30	783	10.41
DWCBact01	05/05/2015	17	10	3.940	1.32	10.50	8.37	744	9.14
DWCBact01	05/12/2015	117	**670**	11.970	1.64	11.00	8.38	480	6.80
DWCBact01	05/19/2015	6	14	61.050	2.23	10.20	8.01	353	7.35
DWCBact01	06/01/2015	6	2	31.200	2.05	9.17	8.10	446	12.50
DWCBact01	06/04/2015	86	50	26.300	2.02	9.78	8.04	483	9.54
DWCBact01	06/10/2015	12	8	16.900	1.74	9.61	8.32	546	12.20
DWCBact01	07/01/2015	36	27	7.060	1.45	9.20	8.74	763	18.00
DWCBact01	07/09/2015	25	20	4.860	1.36	10.50	8.51	778	17.60
DWCBact01	07/15/2015	57	50	4.700	1.36	9.26	8.44	746	15.80
DWCBact01	07/21/2015	**260**	**410**	4.340	1.39	8.42	8.28	971	15.40
DWCBact01	07/27/2015	13	8	3.000	1.29	8.19	8.28	879	17.40
DWCBact01	08/11/2015	23	12	2.690	1.28	8.15	8.26	982	19.10
DWCBact01	08/13/2015	31	18	3.080	1.25	8.91	8.28	810	14.90
DWCBact01	08/20/2015	51	55	5.660	1.40				
DWCBact01	08/25/2015	35	35	3.060	1.30	9.35	8.29	773	13.30
DWCBact01	08/27/2015	166	140	6.110	1.42			617	
DWCBact01	09/09/2015	15	12	2.530	1.23	10.10	8.47	903	12.20
DWCBact01	09/10/2015	17	30	2.820	1.22	9.92	8.69	916	14.40
DWCBact01	09/15/2015	10	82	1.860	1.17	9.02	8.61	804	16.20
DWCBact01	09/21/2015	3	5	2.140	1.18	9.24	8.12	927	14.60
DWCBact01	09/30/2015	8	2	2.480	1.20	10.70	8.35	791	10.90
DWCBactAboveCC02	09/19/2017	6	-	0.486	-	8.83	7.80	328	10.69
DWCBactBelowCC01	09/19/2017	53	-	0.84	-	8.91	8.23	605	11.68
DWCBactAboveCC02	09/20/2017	3	-	0.51	-	8.58	8.16	430	13.12
DWCBactBelowCC01	09/20/2017	166	-	0.52	-	9.07	8.53	611	11.11
DWCBactAboveCC02	09/21/2017	11	-	0.642	-	8.45	8.26	413	15.04
DWCBactBelowCC01	09/21/2017	64	-	0.475	-	8.87	8.50	580	12.98
DWCBactAboveCC02	09/26/2017	8	-	0.805	-	8.77	7.81	420	11.69
DWCBactBelowCC01	09/26/2017	64	-	0.812	-	10.13	8.24	598	9.66
DWCBactAboveCC02	09/27/2017	5	-	0.617	-	8.60	8.07	409	11.06
DWCBactBelowCC01	09/27/2017	37	-	0.745	-	9.42	8.43	592	9.42
DWCBactAboveCC02	09/28/2017	2	-	0.595	-	8.73	8.09	421	11.27
DWCBactBelowCC01	09/28/2017	30	-	0.672	-	9.72	8.53	596	9.64
DWCBactAboveCC02	05/30/2018	13	-	5.387	-	9.31	7.60	199	10.26
DWCBactBelowCC01	05/30/2018	74	-	6.286	-	9.21	8.05	331	10.60
DWCBactOutUP1	05/10/2018	14	-	-	-	-	-	-	-
DWCBactOutDN1	05/10/2018	9	-	-	-	-	-	-	-
DWCBactUp	05/30/2018	57	-	5.958	-	9.04	7.93	369	11.36
DWCBactDown	05/17/2018	16	-	4.182	-	8.31	8.04	502	13.90
DWCBactDown(127)	05/30/2018	33	-	10.763	-	8.53	7.98	396	13.90

Red = Bacteria exceeded water quality standards based on the SSM

Table A 2 Blacktail Gulch (tributary to Deadwood Creek) fecal coliform and *E. coli* bacteria monitoring, instantaneous discharge, and water quality data collected during the recreation season (May 1 through September 30) for 2015 and May through September 2018.

Station	Date	*E. coli* Bacteria	Fecal Coliform Bacteria	Discharge	Stage	Dissolved Oxygen	pH	Specific Conductivity	Temperature
		CFU/100mL	CFU/100 mL	cfs	Feet	mg/L	s.u.	µS/cm	°C
BTGBact01	05/05/2015	1	2	0.796	0.50	10.30	8.80	318	12.60
BTGBact01	05/12/2015	51	130	4.130	0.78	11.50	8.50	2.3	5.48
BTGBact01	05/18/2015	66	28	11.100	1.02	10.60	8.08	194	9.13
BTGBact01	05/20/2015	5	12	7.280	0.90	11.00	8.26	232	6.11
BTGBact01	06/01/2015	11	12	8.960	0.92	9.45	8.38	261	12.70
BTGBact01	06/04/2015	**285**	140	1.540	0.86	9.88	8.31	275	9.68
BTGBact01	06/10/2015	27	23	3.490	0.73	9.99	8.56	301	11.60
BTGBact01	07/01/2015	28	25	1.590	0.56	9.14	8.63	287	19.60
BTGBact01	07/09/2015	57	23	0.962	0.54	8.44	8.60	398	19.90
BTGBact01	07/15/2015	135	110	1.300	0.54	9.54	8.56	421	14.80
BTGBact01	07/21/2015	142	83	0.732	0.50	8.42	8.64	415	15.60
BTGBact01	07/27/2015	210	180	0.593	0.48	9.14	8.66	407	18.50
BTGBact01	08/11/2015	39	33	0.590	0.48	9.19	8.77	424	22.40
BTGBact01	08/13/2015	36	23	0.650	0.47	8.75	8.44	456	14.90
BTGBact01	08/20/2015	130	68	1.280	0.57				
BTGBact01	08/25/2015	36	66	0.758	0.49	10.80	8.69	318	12.70
BTGBact01	08/27/2015	**345**	**1800**	2.210	0.65		8.37	257	
BTGBact01	09/09/2015	79	40	0.615	0.46	10.50	8.25	371	9.16
BTGBact01	09/10/2015	225	148	0.595	0.47	10.40	8.95	348	15.00
BTGBact01	09/15/2015	19	28	0.364	0.45	10.60	8.52	360	18.80
BTGBact01	09/17/2015	86	76	0.334	0.45	9.82	8.33	300	14.30
BTGBact01	09/21/2015	22	10	0.310	0.45	9.32	8.44	370	15.50
BTGBact01	09/30/2015	7	22	0.623	0.46	10.10	8.43	392	10.50
BTGBact01	05/08/2018	1					8.95	301	13.20
BTGBactPipe (outlet)	05/17/2018	6		0.860		8.01	8.40	314	14.66
BTGBact01	05/30/2018	79		4.929		9.16	8.17	207	12.07
BTGBactPipe (outlet)	06/21/2018	**613**				9.40	8.10	202	13.00
BTGBactPipe (outlet)	07/19/2018	109				8.50	8.50	306	20.00
BTGBactPipe (outlet)	08/13/2018	43				9.70	8.60	386	18.00
BTGBactPipe (outlet)	09/18/2018	16				9.30	8.60	399	14.00

Red = Bacteria exceeded water quality standards based on the SSM

Table A 3 Blacktail Water Treatment Facility (BTWTF) *E. coli* bacteria effluent samples collected from two separate BTWTF locations (after polish filters and as effluent leaves the treatment facility and before being discharged into Deadwood Creek) in 2018.

Station	Date	*E. coli* Bacteria	Fecal Coliform Bacteria	Discharge	Stage	Dissolved Oxygen	pH	Specific Conductivity	Temperature
		MPN/100mL	CFU/100 mL	cfs	Feet	mg/L	s.u.	µS/cm	°C
ICB Mixed Efflient APF (Barrick)	03/21/2018	< 1	-	-	-	-	-	-	-
BTWTF013 (SD DENR)	05/10/2018	< 1	-	-	-	-	-	-	-

Table A 4 Deadwood Creek routine monthly fecal coliform and *E. coli* bacteria samples from surface water quality monitoring site WQM 127 (460127) and USGS mean daily discharge collected during the recreation season (May 1 through September 30) from 1998 through 2018.

StationID	SampleDate	SampleTime	USGS Daily Mean Discharge (Site: 06436165) [1]	*Escherichia coli* CFU/100mL	Fecal Coliform CFU/100mL
460127 (WQM 127)	08/18/1998	8:00			38
460127 (WQM 127)	09/22/1998	11:15			60
460127 (WQM 127)	05/26/1999	8:00			6
460127 (WQM 127)	06/22/1999	8:00			22
460127 (WQM 127)	07/20/1999	8:00			54
460127 (WQM 127)	08/03/1999	8:00			10
460127 (WQM 127)	05/15/2000	8:00			14
460127 (WQM 127)	06/06/2000	8:00			16
460127 (WQM 127)	07/11/2000	8:00			300
460127 (WQM 127)	08/14/2000	8:00			26
460127 (WQM 127)	09/19/2000	8:00			60
460127 (WQM 127)	05/15/2001	8:00			2
460127 (WQM 127)	06/11/2001	8:00			8
460127 (WQM 127)	07/18/2001	8:00			90
460127 (WQM 127)	08/16/2001	8:00			16
460127 (WQM 127)	09/17/2001	8:00			2
460127 (WQM 127)	05/13/2002	8:00			4
460127 (WQM 127)	06/17/2002	8:00			46
460127 (WQM 127)	08/22/2002	8:00			280
460127 (WQM 127)	09/23/2002	8:00			18
460127 (WQM 127)	06/03/2003	12:15			4
460127 (WQM 127)	07/08/2003	12:40			18
460127 (WQM 127)	08/20/2003	11:30			56
460127 (WQM 127)	09/15/2003	13:00			20
460127 (WQM 127)	05/11/2004	8:00	0.91		2
460127 (WQM 127)	06/07/2004	12:10	0.78		2
460127 (WQM 127)	07/13/2004	10:25	0.53		22
460127 (WQM 127)	08/19/2004	9:15	0.37		8
460127 (WQM 127)	09/13/2004	12:20	0.39		12
460127 (WQM 127)	05/23/2005	11:15	2.78		56
460127 (WQM 127)	06/20/2005	12:50	1.65		70
460127 (WQM 127)	07/12/2005	10:20	0.69		180
460127 (WQM 127)	08/25/2005	11:05	0.64		30
460127 (WQM 127)	09/20/2005	11:50	0.44		28
460127 (WQM 127)	05/16/2006	12:15	14.70		62
460127 (WQM 127)	06/19/2006	13:30	1.65		120
460127 (WQM 127)	07/25/2006	9:55	1.00		44
460127 (WQM 127)	08/21/2006	13:40	0.71		12
460127 (WQM 127)	09/19/2006	12:30	0.52		34
460127 (WQM 127)	05/10/2007	12:25	10.40		2
460127 (WQM 127)	06/19/2007	11:00	6.33		16
460127 (WQM 127)	07/12/2007	9:25	1.69		16
460127 (WQM 127)	08/14/2007	8:00	1.13		6
460127 (WQM 127)	09/12/2007	12:25	1.64		10
460127 (WQM 127)	05/13/2008	11:40	23.90		2
460127 (WQM 127)	06/17/2008	11:30	6.95		14
460127 (WQM 127)	07/15/2008	9:25	1.49		46
460127 (WQM 127)	08/20/2008	12:15	1.49		20
460127 (WQM 127)	09/23/2008	13:15	1.22		6

Table A 4 (continued) Deadwood Creek routine monthly fecal coliform and *E. coli* bacteria samples from surface water quality monitoring site WQM 127 (460127) and USGS mean daily discharge collected during the recreation season (May 1 through September 30) from 1998 through 2018.

StationID	SampleDate	SampleTime	USGS Daily Mean Discharge (Site: 06436165) ¹	*Escherichia coli* CFU/100mL	Fecal Coliform CFU/100mL
460127 (WQM 127)	05/20/2009	11:20	5.63	4	
460127 (WQM 127)	06/22/2009	12:00	3.80	12	4
460127 (WQM 127)	07/20/2009	12:45	3.62	86	36
460127 (WQM 127)	08/20/2009	12:05	1.26	98	54
460127 (WQM 127)	09/08/2009	12:45	0.84	51	58
460127 (WQM 127)	05/05/2010	12:05	7.59	135	
460127 (WQM 127)	06/14/2010	13:00	6.56	**1050**	**630**
460127 (WQM 127)	07/20/2010	13:05	3.23	76	60
460127 (WQM 127)	08/17/2010	10:15	1.47	101	80
460127 (WQM 127)	09/16/2010	12:30	0.98	10	4
460127 (WQM 127)	05/05/2011	11:55	8.06	1	
460127 (WQM 127)	06/14/2011	12:10	6.31	39	50
460127 (WQM 127)	07/18/2011	13:25	1.20	79	36
460127 (WQM 127)	08/22/2011	13:30	0.88	44	28
460127 (WQM 127)	09/22/2011	13:30	1.05	**2420**	**700**
460127 (WQM 127)	05/22/2012	11:50	0.45	26	88
460127 (WQM 127)	06/11/2012	13:30	0.60	48	30
460127 (WQM 127)	07/11/2012	12:10	0.55	**260**	130
460127 (WQM 127)	08/14/2012	12:00	0.42	56	44
460127 (WQM 127)	09/17/2012	13:30	0.48	21	24
460127 (WQM 127)	05/09/2013	12:20	3.00	9	8
460127 (WQM 127)	06/04/2013	12:50	26.60	**276**	100
460127 (WQM 127)	07/23/2013	12:10	1.10	86	66
460127 (WQM 127)	08/15/2013	12:30	1.18	86	86
460127 (WQM 127)	09/10/2013	14:15	0.71	76	50
460127 (WQM 127)	05/06/2014	12:55	50.80	39	76
460127 (WQM 127)	06/09/2014	14:00	6.04	16	12
460127 (WQM 127)	07/08/2014	9:35	6.31	**238**	120
460127 (WQM 127)	08/14/2014	12:25	1.92	72	12
460127 (WQM 127)	09/15/2014	14:15	1.13	59	8
460127 (WQM 127)	05/12/2015	11:30	6.70	**238**	
460127 (WQM 127)	07/06/2015	11:00	3.64	66	
460127 (WQM 127)	08/18/2015	10:45	5.41	**387**	
460127 (WQM 127)	09/28/2015	9:55	1.39	20	
460127 (WQM 127)	05/05/2016	10:54		15	
460127 (WQM 127)	06/06/2016	11:11		10	
460127 (WQM 127)	07/12/2016	10:56		63	
460127 (WQM 127)	08/08/2016	11:18		51	
460127 (WQM 127)	09/07/2016	11:47		10	
460127 (WQM 127)	05/16/2017	13:58		**921**	
460127 (WQM 127)	06/20/2017	12:41		27	
460127 (WQM 127)	07/20/2017	12:46		142	
460127 (WQM 127)	08/23/2017	12:30		11	
460127 (WQM 127)	09/14/2017	12:46		17	
460127 (WQM 127)	05/17/2018	-		11	
460127 (WQM 127)	06/21/2018	13:33		**261**	
460127 (WQM 127)	07/19/2018	-		84	
460127 (WQM 127)	08/13/2018	12:02		162	
460127 (WQM 127)	09/18/2018			16	

[1] = USGS Site 06436165 installed February 2004 and discontinued October 2015

Red = Bacteria exceeded water quality standards based on the SSM

Table A5. Quality Assurance Quality Control blank sample analysis for samples collected on Deadwood Creek and Blacktail Gulch during the recreation season (May 1st through September 30th from 2014, 2015, and 2017.

			Total Suspended Solids	**E. coli**	**Fecal Coliform**
Laboratory	**Station ID**	**Date Sampled**	**(PQL: 10 mg/L)**	**(MPN/100 mL) RL = 1**	**(CFU/100 mL) RL = 2**
Energy	DWCBact01B	07/10/2014		0.5	1
Energy	DWCBact01B	09/18/2014		0.5	1
MIDCONTINENT	BTGBact01B	06/01/2015		0.5	1
MIDCONTINENT	BTGBact01B	08/11/2015	5	0.5	1
MIDCONTINENT	BTGBact01B	08/25/2015	5	0.5	1
MIDCONTINENT	DWCBact01B	05/05/2015		0.5	1
MIDCONTINENT	DWCBact01B	06/10/2015		0.5	1
MIDCONTINENT	DWCBact01B	08/27/2015	5	0.5	1
MIDCONTINENT	DWCBact01B	09/30/2015		0.5	1
MIDCONTINENT	DWCBactAboveCC02B	09/19/2017		0.5	
Mean			5	0.5	1
Standard Deviation			0	0	0
QA/QC Criteria Met			TRUE	TRUE	TRUE

Table A6. Quality Assurance Quality Control for precision using log range analysis for fecal coliform, *E. coli*, and Total Suspended Solids samples collected on Deadwood Creek during the recreation season (May 1st through September 30th) from 2014, 2015, and 2017.

			Deadwood Creek QA/QC Precision (Log Range Technique) for 2014, 2015, and 2017								
			Fecal Coliform		**Meets**	***E. coli* Bacteria**		**Meets**	**Total Suspended Solids**		**Meets**
Date	**Site**	**Sample Type**	(CFU/100 mL)	Log$_{10}$	QA/QC	(MPN/100 mL)	Log$_{10}$	QA/QC	(mg/L)	Log$_{10}$	QA/QC
07/10/2014	DWCBact01	Routine	30	1.48		36	1.56				
07/10/2014	DWCBact01R	Replicate	16	1.20		46	1.66				
Range				0.27	TRUE		0.11	TRUE			
09/18/2014	DWCBact01	Routine	2	0.30		10	1.00				
09/18/2014	DWCBact01R	Replicate	6	0.78		4	0.60				
Range				0.48	TRUE		0.40	TRUE			
05/05/2015	DWCBact01	Routine	10	1.00		17	1.23				
05/05/2015	DWCBact01R	Replicate	13	1.11		7	0.85				
Range				0.11	TRUE		0.39	TRUE			
06/01/2015	BTGBact01	Routine	12	1.08		11	1.04				
06/01/2015	BTGBact01R	Replicate	8	0.90		11	1.04				
Range				0.18	TRUE		0.00	TRUE			
06/10/2015	DWCBact01	Routine	8	0.90		12	1.08				
06/10/2015	DWCBact01R	Replicate	12	1.08		15	1.18				
Range				0.18	TRUE		0.10	TRUE			
08/11/2015	BTGBact01	Routine	33	1.52		39	1.59		5	0.70	
08/11/2015	BTGBact01R	Replicate	30	1.48		28	1.45		5	0.70	
Range				0.04	TRUE		0.14	TRUE		0.00	TRUE
08/25/2015	BTGBact01	Routine	66	1.82		36	1.56		5	0.70	
08/25/2015	BTGBact01R	Replicate	50	1.70		53	1.72		5	0.70	
Range				0.12	TRUE		0.17	TRUE		0.00	TRUE
08/27/2015	DWCBact01	Routine	140	2.15		166	2.22				
08/27/2015	DWCBact01R	Replicate	180	2.26		210	2.32				
Range				0.11	TRUE		0.10	TRUE			
09/30/2015	DWCBact01	Routine	2	0.30		7	0.85				
09/30/2015	DWCBact01R	Replicate	5	0.70		10	1.00				
Range				0.40	TRUE		0.15	TRUE			
09/19/2017	DWCBactAboveCC02	Routine				6.3	0.80				
09/19/2017	DWCBactAboveCC02R	Replicate				6.2	0.79				
Range							0.01	TRUE			
Total Range				1.89		**Total Range**	1.56		**Total Range**	0.00	
Mean Range				0.21		**Mean Range**	0.16		**Mean Range**	0.00	
Fecal Coliform Precision Criterion					**0.7**	***E. coli* Precision Criterion**		**0.5**	**TSS Precision Criterion**		**0.0**

APPENDIX B:

EPA Approval Letter and Decision Document

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
Denver, CO 80202-1129
Phone 800-227-8917
www.epa.gov/region08

September 30, 2020

Ref: 8WD-CWS

Mr. Hunter Roberts
Secretary
South Dakota Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol Ave
Pierre, South Dakota 57501-3181

Re: Approval of *Escherichia coli* Bacteria Total Maximum Daily Load Evaluation for Deadwood Creek

Dear Mr. Roberts,

The U.S. Environmental Protection Agency (EPA) has completed review of the total maximum daily load (TMDL) submitted by your office on September 4, 2020. In accordance with the Clean Water Act (33 U.S.C. §1251 *et. seq*.) and the EPA's implementing regulations at 40 C.F.R. Part 130, the EPA hereby approves South Dakota's TMDL for Deadwood Creek. The EPA has determined that the separate elements of the TMDL listed in the enclosure adequately address the pollutant of concern, are designed to attain and maintain applicable water quality standards, consider seasonal variation and includes a margin of safety. The EPA's rationale for this action is contained in the enclosure.

Thank you for submitting this TMDL for our review and approval. If you have any questions, please contact Peter Brumm on my staff at (406) 457-5029.

Sincerely,

JUDY
BLOOM

Digitally signed
by JUDY BLOOM
Date: 2020.09.30
11:36:03 -06'00'

Judy Bloom, Manager
Clean Water Branch

Enclosure
Deadwood Creek *E. coli* TMDL EPA Review Summary

EPA TOTAL MAXIMUM DAILY LOAD (TMDL) REVIEW SUMMARY

TMDL: *E. coli* Bacteria Total Maximum Daily Load Evaluation for Deadwood Creek

ATTAINS TMDL ID: R8-SD-2020-03

LOCATION: Lawrence County, South Dakota

IMPAIRMENTS/POLLUTANTS: The TMDL submittal addresses one river segment with an immersion recreation use that is impaired due to high concentrations of *E. coli* bacteria.

Waterbody/Pollutant Addressed in this TMDL Action

Assessment Unit ID	Waterbody Description	Pollutants Addressed
SD-BF-R-DEADWOOD_01	Deadwood Creek (Rutabaga Gulch to Whitewood Creek)	Escherichia coli (*E. coli*)

BACKGROUND: The South Dakota Department of Environment and Natural Resources (DENR) submitted to EPA the final *E. coli* TMDL for Deadwood Creek with a letter requesting review and approval dated September 4, 2020.

The submittal included:

- Letter requesting EPA's review and approval of the TMDL
- Final TMDL report
- Water quality monitoring data appendix

APPROVAL RECOMMENDATIONS: Based on the review presented below, the reviewer recommends approval of the final Deadwood Creek *E. coli* TMDL. All the required elements of an approvable TMDL have been met.

TMDL Approval Summary	
Number of TMDLs Approved:	1
Number of Causes Addressed by TMDLs:	1

REVIEWERS: Peter Brumm, EPA

The following review summary explains how the TMDL submission meets the statutory and regulatory requirements of TMDLs in accordance with Section 303(d) of the Clean Water Act (CWA), and EPA's implementing regulations in 40 C.F.R. Part 130.

EPA TMDL REVIEW FOR DEADWOOD CREEK E. COLI TMDL

This TMDL review document includes EPA's guidelines that summarize the currently effective statutory and regulatory requirements relating to TMDLs (CWA Section 303(d) and 40 C.F.R. Part 130). These TMDL review guidelines are not themselves regulations. Any differences between these guidelines and EPA's regulations should be resolved in favor of the regulations themselves. The italicized sections of this document describe the information generally necessary for EPA to determine if a TMDL submittal fulfills the legal requirements for approval. The sections in regular type reflect EPA's analysis of the state's compliance with these requirements. Use of the verb "must" below denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation.

1. Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking

The TMDL submittal must clearly identify (40 C.F.R. §130.7(c)(1)):

- *the waterbody as it appears on the State's/Tribe's 303(d) list;*
- *the pollutant for which the TMDL is being established; and*
- *the priority ranking of the waterbody.*

The TMDL submittal must include (40 C.F.R. §130.7(c)(1); 40 C.F.R. §130.2):

- *an identification of the point and nonpoint sources of the pollutant of concern, including location of the source(s) and the quantity of the loading (e.g., lbs. per day);*
- *facility names and NPDES permit numbers for point sources within the watershed; and*
- *a description of the natural background sources, and the magnitude and location of the sources, where it is possible to separate natural background from nonpoint sources.*

This information is necessary for EPA's review of the load and wasteload allocations, which are required by regulation.

The TMDL submittal should also contain a description of any important assumptions made in developing the TMDL, such as:

- *the spatial extent of the watershed in which the impaired waterbody is located;*
- *the assumed distribution of land use in the watershed (e.g., urban, forested, agriculture);*
- *population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources;*
- *present and future growth trends, if taken into consideration in preparing the TMDL (e.g., the TMDL could include the design capacity of a wastewater treatment facility); and*
- *an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment impairments; chlorophyll a and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.*

Deadwood Creek is located in western South Dakota and is part of the larger Belle Fourche River Basin. The impaired waterbody segment subject to this TMDL extends upstream from its confluence at Whitewood Creek to Rutabaga Gulch in Lawrence County and is identified as SD-BF-R-DEADWOOD_01. Figure 1 displays the general location of the Deadwood Creek Watershed and the impaired segment, and Figure 2 shows the location of point source outfalls and monitoring stations where data was collected to support TMDL development.

This segment was first listed as impaired by *E. coli* on South Dakota's 2014 303(d) List and was assigned a high priority (i.e., 1) for TMDL development on the most recent 303(d) list in 2020. This priority ranking information is contained on Page 2. No other known impairments exist for this segment, nor have any previous TMDLs been developed for Deadwood Creek.

Section 2.1.5 (Land Use/Land Cover) and Figure 6 summarize the land use distribution draining into the impaired segment which is predominantly evergreen forest (76%) with portions of developed land use (6.1%) centered in the valley bottoms. Section 5.2 characterizes nonpoint sources into categories of agriculture, human (i.e., septic systems and pets), natural background/wildlife, and tributary contributions. DENR quantified *E. coli* production from these sources using population estimates, Geographic Information System (GIS) analysis, and the Bacterial Indicator Tool (EPA, 2000) with information provided by South Dakota Game Fish and Parks and local municipalities.

Traditional point sources are identified and described in Section 5.1 (Point Sources) by facility name, permit number and discharge characteristics. A single permit (SD0025933), held by the Homestake Mining Company, allows discharges into Deadwood Creek at two locations from the Blacktail Water Treatment Facility. The water collection and treatment system receives water from areas previously mined and waste rock disposal sites. Monitoring data collected by the mine and DENR indicate that no bacteria is present in the discharge. Additionally, there are no permitted Concentrated Animal Feeding Operations (CAFOs) in the Deadwood Creek watershed.

Assessment: EPA concludes that DENR adequately identified the impaired waterbody, the pollutant of concern, the priority ranking, the identification, location and magnitude of the pollutant sources, and the important assumptions and information used to develop the TMDL.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

The TMDL submittal must include:

- *a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the antidegradation policy (40 C.F.R. §130.7(c)(1)); and*
- *a numeric water quality target for each TMDL. If the TMDL is based on a target other than a numeric water quality criterion, then a numeric expression must be developed from a narrative criterion and a description of the process used to derive the target must be included in the submittal (40 C.F.R. §130.2(i)).*

EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

Section 3.0 (Water Quality Standards) describes the water quality standards applicable to the impaired segment with citations to relevant South Dakota regulations. SD-BF-R-DEADWOOD_01 is designated the following beneficial uses:

- coldwater marginal fish life propagation,
- immersion recreation,
- limited contact recreation,
- irrigation,
- fish and wildlife propagation, recreation, and stock watering.

All numeric criteria applicable to these uses are presented in Table 4. DENR determined that *E. coli* is preventing the creek's immersion recreation use from being supported. The numeric *E. coli* criteria for immersion recreation waters are applied directly as water quality targets for the TMDL and are comprised of a 30-day geometric mean criterion (≤ 126 cfu/100mL) and a single sample maximum criterion (≤ 235 cfu/100mL). These criteria are seasonally applicable from May 1 to September 30. DENR expects that meeting the numeric *E. coli* criteria will lead to conditions necessary to support the relevant narrative criteria discussed in Section 3.2 (Narrative Standards).

The TMDL and allocations were calculated using the single sample maximum criterion because the monitoring dataset exhibited exceedances of the single sample maximum criterion but not of the geometric mean criterion. DENR demonstrates in Section 3.4 (Numeric TMDL Targets) that attaining the single sample maximum target will also achieve the geometric mean criterion.

Assessment: EPA concludes that DENR adequately described the applicable water quality standards and numeric water quality target for this TMDL.

3. Loading Capacity - Linking Water Quality and Pollutant Sources

The TMDL submittal must include the loading capacity for each waterbody and pollutant of concern. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

The TMDL submittal must:

- *describe the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model;*
- *contain documentation supporting the TMDL analysis, including the basis for any assumptions; a discussion of strengths and weaknesses in the analytical process; and results from any water quality modeling; and*
- *include a description and summary of the water quality data used for the TMDL analysis.*

EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation (40 C.F.R. §130.2).

The full water quality dataset should be made available as an appendix to the TMDL or as a separate electronic file. Other datasets used (e.g., land use, flow), if not included within the TMDL submittal, should be referenced by source and year. The TMDL analysis should make use of all readily available data for the waterbody unless the TMDL writer determines that the data are not relevant or appropriate.

The pollutant loadings may be expressed as either mass-per-time, toxicity or other appropriate measure (40 C.F.R. §130.2(i)). Most TMDLs should be expressed as daily loads (USEPA. 2006a). If the TMDL is expressed in terms other than a daily load (e.g., annual load), the submittal should explain why it is appropriate to express the TMDL in the unit of measurement chosen.

The TMDL submittal must describe the critical conditions and related physical conditions in the waterbody as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). The critical condition can be thought of as the "worst case" scenario of environmental conditions (e.g., stream flow, temperature, loads) in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. TMDLs should define the applicable critical conditions and describe the approach used to estimate both point and nonpoint source loads under such critical conditions.

DENR relied on the load duration curve approach to define the *E. coli* loading capacity for Deadwood Creek. A load duration curve is a graphic representation of pollutant loads across various flows. The approach helps correlate water quality conditions to stream flow and provides insight into the variability of source contributions. EPA has published guidance on the use of duration curves for TMDL development (USEPA, 2007) and the practice is well established. Using this approach, DENR set the TMDL equivalent to the loading capacity and expressed the TMDL in colony forming units (CFU) per day at five different flow zones (i.e., high, moist, mid-range, dry, and low), as listed in Table 14. The load duration curve, and TMDL based on the curve, is shown visually in Figure 22 with instantaneous loads calculated from the monitoring dataset.

All water quality data used in the analysis is contained in Appendix A (Deadwood Creek Fecal Coliform and *E. coli* Bacteria Samples and QA/QC Tables). Some older fecal coliform data was transformed into *E. coli* to ensure a broad distribution of *E. coli* data across the entire flow frequency curve as described on Pages 21-22.

While the loading capacity is defined for multiple stream flow conditions, DENR determined critical conditions in Deadwood Creek occur at flows above 4.34 cfs. Monitoring data indicated that target exceedances were clustered in the high and upper moist flow zones which DENR attributed to watershed runoff events.

Assessment: EPA concludes that the loading capacity was calculated using an acceptable approach, used a water quality target consistent with water quality criteria, and has been appropriately set at a level necessary to attain and maintain the applicable water quality standards. The pollutant loads have been expressed as daily loads. The critical conditions were described and factored into the calculations and were based on a reasonable approach to establish the relationship between the target and pollutant sources.

4. Load Allocation

The TMDL submittal must include load allocations (LAs). EPA regulations define LAs as the portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution and to natural background sources. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Where possible, separate LAs should be provided for natural background and for nonpoint sources.

In the rare instance that a TMDL concludes that there are no nonpoint sources or natural background for a pollutant, the load allocation must be expressed as zero and the TMDL should include a discussion of the reasoning behind this decision.

As described in Section 6.2 (TMDL Allocations), DENR established a single LA as the allowable load remaining after the WLA and explicit MOS have been accounted for (i.e., LA = TMDL – WLA – MOS). Because the Deadwood Creek WLA equals zero, the calculation can be simplified as LA = TMDL – MOS. Table 14 presents the LA across the TMDL's five flow zones. This composite LA represents all nonpoint source contributions, both human and natural, as one allocation, however, individual nonpoint source categories were characterized in greater depth in Section 5.2 (Nonpoint Sources).

Assessment: EPA concludes that the LA provided in the TMDL is reasonable and will result in attainment of the water quality standards.

5. Wasteload Allocations

The TMDL submittal must include wasteload allocations (WLAs). EPA regulations define WLAs as the portion of a receiving water's loading capacity that is allocated to existing and future point sources (40 C.F.R. §130.2(h)). If no point sources are present or if the TMDL recommends a zero WLA for point sources, the WLA must be expressed as zero. If the TMDL recommends a zero WLA after considering all pollutant sources, there must be a discussion of the reasoning behind this decision, since a zero WLA implies an allocation only to nonpoint sources and natural background will result in attainment of the applicable water quality standards, and all point sources have no measurable contribution.

The individual WLAs may take the form of uniform percentage reductions or individual mass based limitations for dischargers where it can be shown that this solution meets WQSs and does not result in localized impairments. In some cases, WLAs may cover more than one discharger (e.g., if the source is contained within a general permit).

No WLAs are included in this TMDL submittal. There is one permitted point source facility that discharges to Deadwood Creek: the Blacktail Water Treatment Facility (SD0025933). The mine water collection and treatment system is not a contributing source of *E. coli*, as confirmed by samples collected from the effluent, therefore no WLA was established for the facility and a total WLA of zero was established in the *E. coli* TMDL. The rationale for this decision is outlined in Section 6.2.1 (Waste Load Allocation).

Assessment: EPA concludes that the TMDL considered all point sources contributing loads to the impaired segment, upstream segments and tributaries in the watershed and the recommendation of zero WLA was justified and reasonable.

6. Margin of Safety

The TMDL submittal must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load allocations, wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). The MOS may be ***implicit*** *or* ***explicit****.*

If the MOS is ***implicit****, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is* ***explicit****, the loading set aside for the MOS must be identified.*

The Deadwood Creek *E. coli* TMDL includes an explicit MOS derived as 10% of the TMDL. The explicit MOS is included in Table 14 and varies by flow zone.

Assessment: EPA concludes that the TMDL incorporates an adequate explicit margin of safety.

7. Seasonal Variation

The TMDL submittal must be established with consideration of seasonal variations. The method chosen for including seasonal variations in the TMDL must be described (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

The load duration curve method used to establish the TMDL incorporates variations in stream flow, which in turn, is influenced by other climatic and human factors that change throughout the year. To account for these variations, DENR developed the TMDL at five different flow zones (i.e., high, moist, mid-range, dry, low) as listed in Table 14.

The variability of measured stream flows and monitored *E. coli* concentrations are summarized in Section 7.0 (Seasonal Variation). The greatest loading reductions necessary occur in June (54%) and August (39%), however, criterion exceedances were observed every month from May to September. Typically, the highest *E. coli* concentrations and loads are observed during the high and moist flow zones and are associated with spring snowmelt or intense rainfall events. This pattern suggests the spring and early summer periods as important timeframes to focus water quality attainment goals.

Assessment: EPA concludes that seasonal variations were adequately described and considered to ensure the TMDL allocations will be protective of the applicable water quality standards throughout any given year.

8. Reasonable Assurances

When a TMDL is developed for waters impaired by both point and nonpoint sources, EPA guidance (USEPA. 1991) and court decisions say that the TMDL must provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement the applicable water quality standards (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

EPA guidance (USEPA. 1997) also directs Regions to work with States to achieve TMDL load allocations in waters impaired only by nonpoint sources. However, EPA cannot disapprove a TMDL for nonpoint source-only impaired waters, which do not have a demonstration of reasonable assurance that LAs will be achieved, because such a showing is not required by current regulations.

The TMDL contained in this submittal is for a nonpoint source-only impaired water. Still, nonregulatory, voluntary-based reasonable assurances are provided for the LA where the submittal discusses DENR's adaptive management approach to the TMDL process, the monitoring strategy that will be used to gage TMDL effectiveness in the future, and the core aspects of a TMDL implementation strategy. These assurances include the recommendation of specific activities to focus implementation, the identification of watershed partners with shared interests in water quality, and the identification of several potential funding sources, which are discussed throughout Section 11.0 (Implementation Strategy).

Assessment: EPA considered the reasonable assurances contained in the TMDL submittal and concludes that they are adequate to meet the load reductions.

9. Monitoring Plan

The TMDL submittal should include a monitoring plan for all:

- *Phased TMDLs; and*
- *TMDLs with both WLA(s) and LA(s) where reasonable assurances are provided.*

Under certain circumstances, a phased TMDL should be developed when there is significant uncertainty associated with the selection of appropriate numeric targets, estimates of source loadings, assimilative capacity, allocations or when limited existing data are relied upon to develop a TMDL. EPA guidance (USEPA. 2006b) recommends that a phased TMDL submittal, or a separate document (e.g., implementation plan), include a monitoring plan, an explanation of how the supplemental data will be used to address any uncertainties that may exist when the phased TMDL is prepared and a scheduled timeframe for revision of the TMDL.

For TMDLs that need to provide reasonable assurances, the monitoring plan should describe the additional data to be collected to determine if the load reductions included in the TMDL are occurring and leading to attainment of water quality standards.

EPA guidance (USEPA. 1991) recommends post-implementation monitoring for all TMDLs to determine the success of the implementation efforts. Monitoring plans are not a required part of the TMDL and are not approved by EPA but may be necessary to support the decision rationale for approval of the TMDL.

In Section 9.0 (Monitoring Strategy) DENR commits to supporting future ambient water quality monitoring activities to judge progress towards achieving the goals outlined in the TMDL. DENR plans to install a staff gage and data logger at the WQM 127 monitoring site for long term monitoring. Additional *E. coli* monitoring along Blacktail Gulch to the confluence of Deadwood Creek, and in Deadwood Creek past WQM 127 to DWCBact01, are encouraged to further refine source contributions and guide restoration activities.

DENR also maintains the ability to modify the TMDL and allocations as new data becomes available using an adaptive management approach in accordance with the TMDL revision process previously recommended by EPA.

Assessment: Monitoring plans are not a required element of EPA's TMDL review and decision-making process. The TMDL submitted by DENR includes a commitment to monitor progress toward attainment of water quality standards. EPA is taking no action on the monitoring strategy included in the TMDL submittal.

10. Implementation

EPA policy (USEPA. 1997) encourages Regions to work in partnership with States/Tribes to achieve nonpoint source load allocations established for 303(d)-listed waters impaired by nonpoint sources. Regions may assist States/Tribes in developing implementation plans that include reasonable assurances that nonpoint source LAs established in TMDLs for waters impaired solely or primarily by nonpoint sources will in fact be achieved. The policy recognizes that other relevant watershed management processes may be used in the TMDL process. EPA is not required to and does not approve TMDL implementation plans.

EPA encourages States/Tribes to include restoration recommendations (e.g., framework) in all TMDLs for stakeholder and public use to guide future implementation planning. This could include identification of a range of potential management measures and practices that might be feasible for addressing the main loading sources in the watershed (see USEPA. 2008b, Chapter 10). Implementation plans are not a required part of the TMDL and are not approved by EPA but may be necessary to support the decision rationale for approval of the TMDL.

In Section 11.0 (Implementation Strategy) DENR encourages, based on the makeup of contributing pollutant sources within the watershed and the greater loading reductions called for during higher flow zones, that future implementation activities focus on:

- Enhancing the existing riparian vegetation width and density along Deadwood Creek and its tributaries to provide erosion control and filter runoff.
- Reducing wildlife, domestic animals, and pet access to the streams as well as limiting improperly functioning or located septic systems.
- Assessing the impact of CWA Section 319 projects and revising plans in cooperation with basin stakeholders whenever necessary.

The submittal also briefly summarizes a recent South Dakota Department of Transportation project that installed improved culverts in Deadwood Creek.

Assessment: Although not a required element of the TMDL approval, DENR discussed how information derived from the TMDL analysis process can be used to support implementation of the TMDL. EPA is taking no action on the implementation portion of the TMDL submittal.

11. Public Participation

EPA policy is that there must be full and meaningful public participation in the TMDL development process. Each State/Tribe must, therefore, provide for public participation consistent with its own continuing planning process and public participation requirements (40 C.F.R. §25.3 and §130.7(c)(1)(ii)).

The final TMDL submittal must describe the State/Tribe's public participation process, including a summary of significant comments and the State/Tribe's responses to those comments (40 C.F.R. §25.3 and §25.8). Inadequate public participation could be a basis for disapproving a TMDL; however, where EPA determines that a State/Tribe has not provided adequate public participation, EPA may defer its approval action until adequate public participation has been provided for, either by the State/Tribe or by EPA.

Section 10.0 (Public Participation) explains the public engagement process DENR followed during development of the TMDL. The Homestake Mining Company was contacted in early 2014 to share information and granted DENR access to collect water samples. In 2018, the Lead Deadwood Sanitary District, City of Deadwood Public Works Director, City of Deadwood Water Department Superintendent, City of Lead Administrator, and Central City Board Trustee were consulted regarding their knowledge of local *E. coli* sources and asked to provide feedback draft TMDL conclusions.

A draft TMDL report was released for public comment from August 1, 2020 to September 3, 2020. No public comments were submitted. The opportunity for public review and comment was posted on DENR's website and announced in two area newspapers: the Black Hills Pioneer and the Rapid City Journal.

Assessment: EPA has reviewed DENR's public participation process and concludes that DENR involved the public during the development of the TMDL and provided adequate opportunities for the public to comment on the draft report.

12. Submittal Letter

The final TMDL submittal must be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute (40 C.F.R. §130.7(d)(1)). The final submittal letter should contain such identifying information as the waterbody name, location, assessment unit number and the pollutant(s) of concern.

A transmittal letter with the appropriate information was included with the final TMDL report submission from DENR, dated September 4, 2020 and signed by Paul Lorenzen, Environmental Scientist Manager 1, Water Protection Program.

Assessment: EPA concludes that the state's submittal package clearly and unambiguously requested EPA to act on the TMDL in accordance with the Clean Water Act and the submittal contained all necessary supporting information.

References

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USEPA. 1997. *New policies for establishing and implementing Total Maximum Daily Loads (TMDLs)*. Office of Water, U.S. Environmental Protection Agency, Washington, DC.

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USEPA. 2006a. *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit.* Office of Water, Office of Wetlands, Oceans, and Watersheds, U.S. Environmental Protection Agency, Washington, DC.

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USEPA. 2008. *Handbook for Developing Watershed Plans to Restore and Protect our Waters.* EPA-841-B-08-002. Office of Water, Environmental Protection Agency, Washington, DC.

USEPA. 2010. *National Pollutant Discharge Elimination System (NPDES) Permit Writers' Manual, Chapter 6, Water Quality-Based Effluent Limitations.* EPA-833-K-10-001. Office of Water, Office of Wastewater Management, Water Permits Division, Washington, DC.

USEPA. 2014. *Water Quality Standards Handbook: Chapter 1: General Provisions.* EPA-820-B-14-008. EPA Office of Water, Office of Science and Technology, Washington, DC.

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