# *E. COLI*/FECAL COLIFORM BACTERIA TOTAL MAXIMUM DAILY LOAD FOR REACHES OF THE BIG SIOUX RIVER, MINNEHAHA COUNTY SOUTH DAKOTA

Topical Report RSI-2181

*prepared for*

South Dakota Department of Environment
and Natural Resources
523 East Capitol
Joe Foss Building
Pierre, South Dakota 57501

September 2012

RESPEC
CONSULTING & SERVICES

# *E. COLI*/FECAL COLIFORM BACTERIA TOTAL MAXIMUM DAILY LOAD FOR REACHES OF THE BIG SIOUX RIVER, MINNEHAHA COUNTY SOUTH DAKOTA

Topical Report RSI-2181

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523 East Capitol
Joe Foss Building
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September 2012

| Total Maximum Daily Load Summary | |
|---|---|
| **Waterbody Name/Description** | Big Sioux River (S2, T104N, R49W to I-90) |
| **Assessment Unit I.D.** | SD-BS-R-BIG_SIOUX_08 |
| **Waterbody Type** | River |
| **Size of Impaired Waterbody** | 28.5 miles (45.8 kilometers) |
| **Size of Watershed (Incremental)** | 79.0 square miles (204.7 square kilometers) |
| **Location** | 12-digit Hydrologic Unit Code (HUC): 101702030604, 101702030605, and 101702031201 |
| **Impaired Designated Use(s)** | Immersion Recreation |
| **303(d) Listing Parameter** | *E. coli* Bacteria, Fecal Coliform Bacteria |
| **Cycle Most Recently Listed** | 2010 South Dakota Integrated Report |
| **TMDL Priority Ranking** | 1 |
| **TMDL Criteria Threshold Values** | Indicator Name: *E. coli* Bacteria<br>Threshold Values: Maximum daily concentration of 235 colony-forming units per 100 milliliters (cfu/100 mL) and a geometric mean of at least five samples over a 30-day period 126 cfu/100 mL. These criteria apply from May through September. |
| **Analytical Approach** | Load duration curves and HSPF modeling |
| **High Flow Zone LA** | $11{,}706 \times 10^9$ cfu/day |
| **High Flow Zone PS WLA** | $80 \times 10^9$ cfu/day |
| **High Flow Zone MS4 WLA** | 0 cfu/day |
| **High Flow Zone MOS** | $3{,}386 \times 10^9$ cfu/day |
| **High Flow Zone TMDL** | $15{,}171 \times 10^9$ cfu/day |

| Total Maximum Daily Load Summary | |
|---|---|
| **Waterbody Name/Description** | Big Sioux River (I-90 to diversion return) |
| **Assessment Unit I.D.** | SD-BS-R-BIG_SIOUX_10 |
| **Waterbody Type** | River |
| **Size of Impaired Waterbody** | 15.8 miles (25.4 kilometers) |
| **Size of Watershed (Incremental)** | 40.9 square miles (106.0 square kilometers) |
| **Location** | 12-Digit Hydrologic Unit Code (HUC): 101702031203 |
| **Impaired Designated Use(s)** | Immersion Recreation and Limited Contact Recreation |
| **303(d) Listing Parameter** | *E. coli* Bacteria, Fecal Coliform Bacteria |
| **Cycle Most Recently Listed** | 2010 South Dakota Integrated Report |
| **TMDL Priority Ranking** | 1 |
| **TMDL Criteria Threshold Values** | Indicator Name: *E. coli* Bacteria<br>Threshold Values: Maximum daily concentration of 235 colony-forming units per 100 milliliters (cfu/100 mL) and a geometric mean of at least five samples over a 30-day period 126 cfu/100 mL. These criteria apply from May through September. |
| **Analytical Approach** | Load duration curves and HSPF modeling |
| **High Flow Zone LA** | $2{,}454 \times 10^9$ cfu/day |
| **High Flow Zone PS WLA** | 0 cfu/day |
| **High Flow Zone MS4 WLA** | $2{,}176 \times 10^9$ cfu/day |
| **High Flow Zone MOS** | $782 \times 10^9$ cfu/day |
| **High Flow Zone TMDL** | $5{,}412 \times 10^9$ cfu/day |

| Total Maximum Daily Load Summary | |
|---|---|
| **Waterbody Name/Description** | Big Sioux River (Diversion return to Sioux Falls Wastewater Treatment Plant [WWTP]) |
| **Assessment Unit I.D.** | SD-BS-R-BIG_SIOUX_11 |
| **Waterbody Type** | River |
| **Size of Impaired Waterbody** | 4.7 miles (7.5 kilometers) |
| **Size of Watershed (Incremental)** | 49.0 square miles (127.0 square kilometers) |
| **Location** | 12-digit Hydrologic Unit Code (HUC): 101702031705 |
| **Impaired Designated Use(s)** | Immersion Recreation and Limited Contact Recreation |
| **303(d) Listing Parameter** | *E. coli* Bacteria, Fecal Coliform Bacteria |
| **Cycle Most Recently Listed** | 2010 South Dakota Integrated Report |
| **TMDL Priority Ranking** | 1 |
| **TMDL Criteria Threshold Values** | Indicator Name: *E. coli* Bacteria<br>Threshold Values: Maximum daily concentration of 235 colony-forming units per 100 milliliters (cfu/100 mL) and a geometric mean of at least five samples over a 30-day period 126 cfu/100 mL. These criteria apply from May through September. |
| **Analytical Approach** | Load duration curves and HSPF modeling |
| **High Flow Zone LA** | $12{,}302 \times 10^9$ cfu/day |
| **High Flow Zone PS WLA** | $37 \times 10^9$ cfu/day |
| **High Flow Zone MS4 WLA** | $1{,}521 \times 10^9$ cfu/day |
| **High Flow Zone MOS** | $4{,}358 \times 10^9$ cfu/day |
| **High Flow Zone TMDL** | $18{,}218 \times 10^9$ cfu/day |

| Total Maximum Daily Load Summary | |
|---|---|
| **Waterbody Name/Description** | Big Sioux River (Sioux Falls Wastewater Treatment Plant [WWTP] to above Brandon) |
| **Assessment Unit I.D.** | SD-BS-R-BIG_SIOUX_12 |
| **Waterbody Type** | River |
| **Size of Impaired Waterbody** | 4.2 miles (6.8 kilometers) |
| **Size of Watershed (Incremental)** | 45.3 square miles (117.4 square kilometers) |
| **Location** | 12-digit Hydrologic Unit Code (HUC): 101702031705 |
| **Impaired Designated Use(s)** | Immersion Recreation |
| **303(d) Listing Parameter** | *E. coli* Bacteria, Fecal Coliform Bacteria |
| **Cycle Most Recently Listed** | 2010 South Dakota Integrated Report |
| **TMDL Priority Ranking** | 1 |
| **TMDL Criteria Threshold Values** | Indicator Name: *E. coli* Bacteria<br>Threshold Values: Maximum daily concentration of 235 colony-forming units per 100 milliliters (cfu/100 mL) and a geometric mean of at least five samples over a 30-day period 126 cfu/100 mL. These criteria apply from May through September. |
| **Analytical Approach** | Load duration curves and HSPF modeling |
| **High Flow Zone LA** | $13{,}617 \times 10^9$ cfu/day |
| **High Flow Zone PS WLA** | $257 \times 10^9$ cfu/day |
| **High Flow Zone MS4 WLA** | 0 cfu/day |
| **High Flow Zone MOS** | $4{,}655 \times 10^9$ cfu/day |
| **High Flow Zone TMDL** | $18{,}529 \times 10^9$ cfu/day |

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# 1.0 INTRODUCTION

The intent of this document is to clearly identify the components of a Total Maximum Daily Load (TMDL), support adequate public participation, and facilitate the U.S. Environmental Protection Agency (EPA) review. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by the EPA. This TMDL document addresses *E. coli* and fecal coliform bacteria impairments on the Big Sioux River within the Lower Big Sioux River Watershed local to the city of Sioux Falls. The impaired reaches SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12 were assigned to priority category 1 (high priority) in the 2010 Impaired Waterbodies List [South Dakota Department of Environment and Natural Resources, 2010]. From the 2008 to the 2010 cycles, the South Dakota Department of Environment and Natural Resources (SD DENR) integrated SD-BS-R-BIG_SIOUX_09 into the upstream and downstream reaches because of the differences in beneficial use designations and TMDL development [South Dakota Department of Environment and Natural Resources, 2010]. Reaches listed as impaired in the 2008 Impaired Waterbodies List, which were slightly different from the 2010 reaches, included SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_09, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12 [South Dakota Department of Environment and Natural Resources, 2008].

Although the 303(d) listings include fecal coliform bacteria, this document focuses on TMDLs for *E. coli*, because the intent of the SD DENR is to replace the fecal coliform bacteria standard in 2015 with an *E. coli* standard. The TMDLs for *E. coli* are expected to address the fecal coliform 303(d) listings for multiple reasons. First, in three recent South Dakota TMDLs (Big Sioux River, Cheyenne River, and Whitewood Creek), *E. coli* concentrations were found to be slightly higher than fecal coliform concentrations for paired samples as indicated by the mean ratio of *E. coli* to fecal coliform, even though *E. coli* is a subset of fecal coliform. This may be the result of the inherent variability of bacteria or the different methods used to quantify these bacteria. Fecal coliform concentrations are determined by a direct count using a membrane filtration technique; whereas, *E. coli* concentrations are quantified using a multiple-well chromogenic substrate technique to achieve a statistical value. Both techniques are valid and sensitive [Larson, 2011]. Second, the current *E. coli* water-quality standard is approximately 59 percent of the current fecal coliform water-quality standard. These Sioux Falls *E. coli* TMDLs use a translator function to convert fecal coliform bacteria to *E. coli* where the mean *E. coli* concentration is approximately 144 percent of the mean fecal coliform concentration because of the laboratory method differences. Using the 95$^{th}$ percentile as the critical level in the flow zones, the *E. coli* TMDLs should be sufficient to address the fecal coliform listings. Third, a fecal coliform concentration of 182 colony-forming units per 100 millimeters (cfu/100 mL) (218 cfu/100 mL less than the current fecal coliform water-quality standard) would be required in the translator function to achieve a calculated *E. coli* concentration of 235 cfu/100 mL (the current *E. coli* water-quality standard). This proves that the current *E. coli* water-

quality standard is stricter than the current fecal coliform water-quality standard and would thus indirectly address the fecal coliform water-quality standard exceedances.

## 1.1 WATERSHED CHARACTERISTICS

The Lower Big Sioux River Watershed is located in eastern South Dakota and drains approximately 2,195 square miles in South Dakota and an additional 1,120 square miles in Minnesota and Iowa. The Sioux Falls TMDL Assessment Project area, which includes the city of Sioux Falls (the state's largest city), lies within the Lower Big Sioux River Watershed. The project area drains approximately 214 square miles within the state of South Dakota.

Figure 1-1 provides the impaired (Section 303(d) listed) reaches on the Lower Big Sioux River located within the project area [South Dakota Department of Environment and Natural Resources, 2010]. Segment SD-BS-R-BIG_SIOUX_08 begins near Dell Rapids at the Moody/Minnehaha county line and ends at Interstate-90 (I-90). Before this assessment, Segment SD-BS-R-BIG_SIOUX_08 was defined as extending from near Dell Rapids to below Baltic. During this assessment, Segment SD-BS-R-BIG_SIOUX_08 was expanded to include the portion of Segment SD-BS-R-BIG_SIOUX_09 above the diversion split or at I-29. The remainder of Segment SD-BS-R-BIG_SIOUX_09 below the diversion to Skunk Creek was incorporated into Segment SD-BS-R-BIG_SIOUX_10. Segment SD-BS-R-BIG_SIOUX_10 begins at I-90 and ends at the diversion return. Segment SD-BS-R-BIG_SIOUX_11 begins at the diversion return and ends at the Sioux Falls Wastewater Treatment Plant (WWTP), and Segment SD-CH-R-BIG_SIOUX_12 begins at the Sioux Falls WWTP and ends above Brandon, South Dakota. The Big Sioux River upstream of the project area and Skunk Creek are both project area influences that have recently completed TMDLs. Both project area influences have the limited contact recreation beneficial use as opposed to the more stringent immersion recreation use of the project area. These TMDLs represent the contiguous Reaches SD-BS-R-BIG_SIOUX_08 through SD-BS-R-BIG_SIOUX_12.

The Sioux Falls TMDL project area receives 73 percent of its average annual precipitation—24.7 inches—during the growing season of April through September [South Dakota State University, 2008]. The South Dakota normal precipitation levels and the Sioux Falls project area location (red box) are shown in Figure 1-2. Local storms with short durations often produce heavy rainfall events. These storms can elevate to severe thunderstorms and occasionally produce tornadoes. The average seasonal snowfall is 41.1 inches per year [U.S. Department of Commerce National Climatic Data Center, 2004]. Watershed land use is predominantly cropland and pasture. A complete list of watershed land uses and percent areas is shown in Table 1-1.

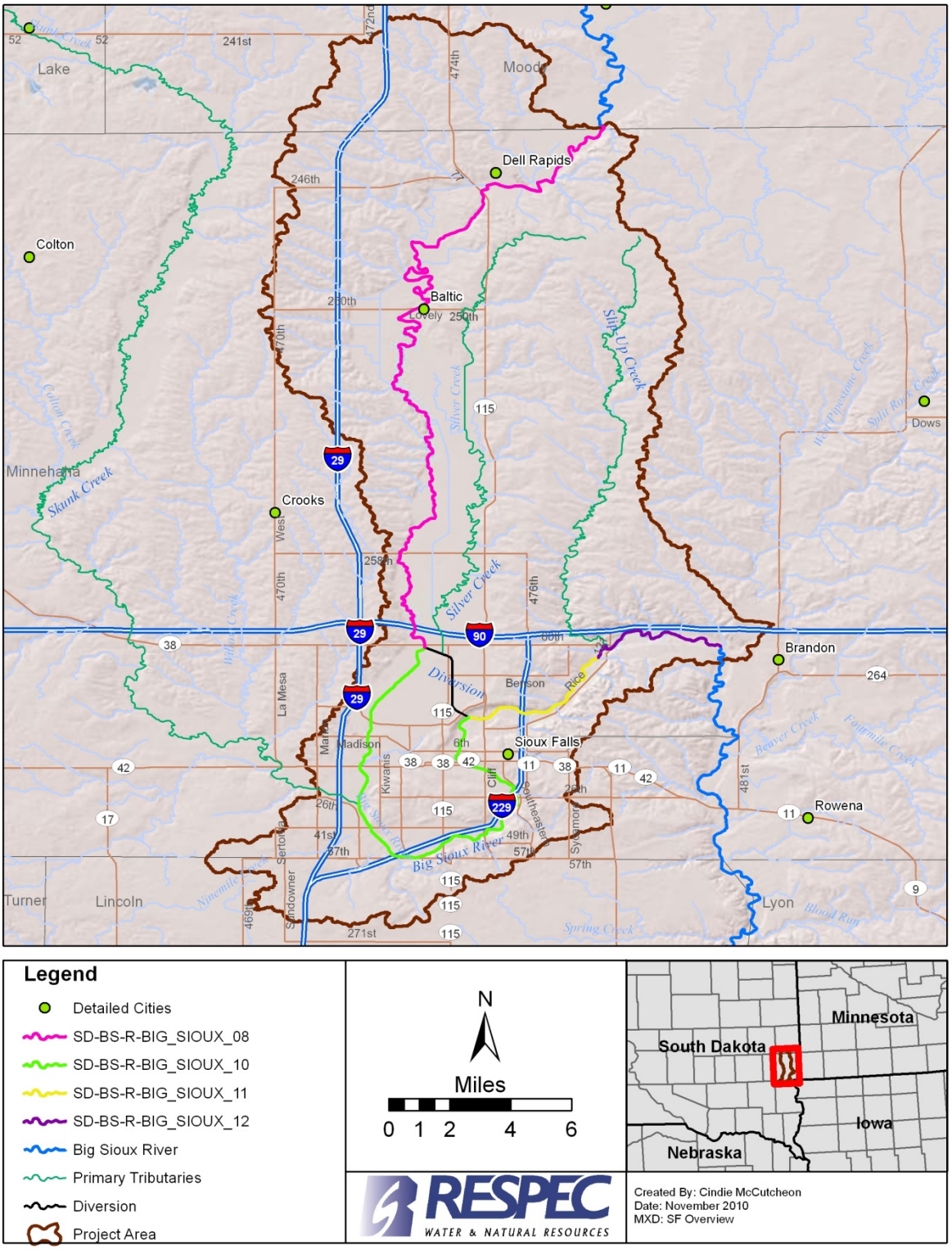



**Figure 1-1.** Project Area and Bacteria-Impaired Reaches.

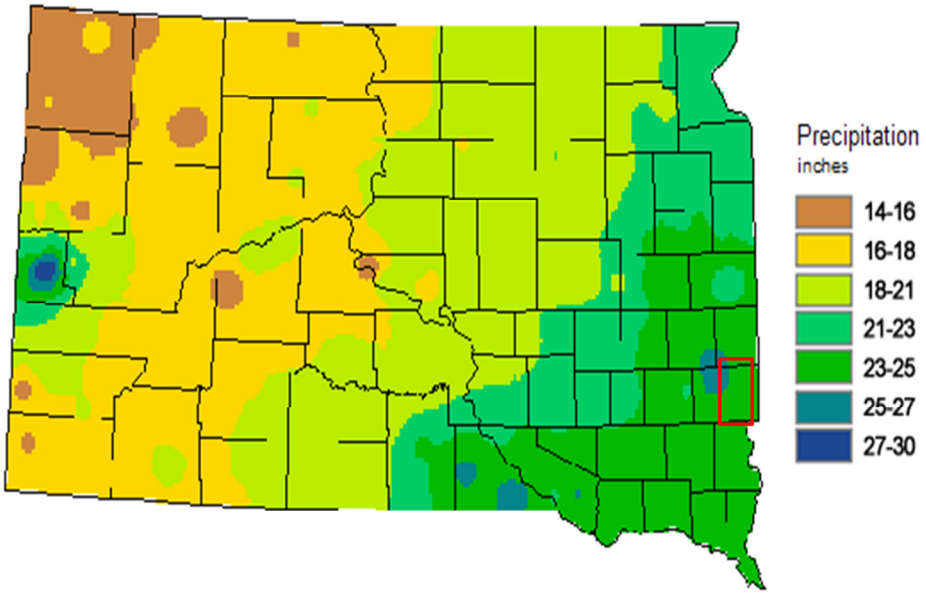



**Figure 1-2.** South Dakota Normal Precipitation Levels for 1971–2002 [South Dakota State University, 2008].

## 1.2 CLEAN WATER ACT SECTION 303(D) LISTING INFORMATION

Four Big Sioux River Reaches (SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12) within the project area were listed as impaired in South Dakota's 2010 303(d) list [South Dakota Department of Environment and Natural Resources, 2010] because of sample concentrations of *E. coli*/fecal coliform bacteria that exceeded the daily maximum criterion for the protection of the immersion recreation use. Two reaches (SD-BS-R-BIG_SIOUX_10 and BS-R-BIG_SIOUX_11) were also listed as impaired for the protection of the limited contact recreation use.

The immersion recreation use criteria are more stringent than the limited contact recreation use criteria. Big Sioux River Reaches SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12 were listed as impaired because of fecal coliform bacteria in nearly every integrated report since 1998. Segment SD-BS-R-BIG_SIOUX_08 was first listed as impaired in South Dakota's 2010 303(d) list [South Dakota Department of Environment and Natural Resources, 2010]. However, the earlier version of this reach was listed with the other reaches in the 2004 303(d) list [South Dakota Department of Environment and Natural Resources, 2004]. In 2008, the EPA approved a fecal coliform TMDL for Segment SD-BS-R-BIG_SIOUX_08 that is defined as extending from near Dell Rapids to below Baltic. Because the boundaries for this segment have been expanded since then, this *E. coli* TMDL is not directly comparable to the 2008 fecal coliform TMDL. Once the EPA approves the new *E. coli* TMDL for Segment SD-BS-R-BIG_SIOUX_08, and if the fecal coliform water-quality standard is changed, the 2008 fecal coliform TMDL for Segment SD-BS-R-BIG_SIOUX_08 is expected to be withdrawn.

## Table 1-1. Land Use by TMDL Reach Endpoint

| Land Use | Reach 8 Land Use Drainage Area ($mi^2$) | Percent at TMDL Reach 8 Endpoint[a] | Reach 10 Land Use Drainage Area ($mi^2$) | Percent at TMDL Reach 10 Endpoint[a] | Reach 11 Land Use Drainage Area ($mi^2$) | Percent at TMDL Reach 11 Endpoint[a] | Reach 12 Land Use Drainage Area ($mi^2$) | Percent at TMDL Reach 12 Endpoint[a] |
|---|---|---|---|---|---|---|---|---|
| Cultivated Crops | 1,668.7 | 61.1 | 2,053.9 | 61.2 | 2,075.7 | 61.0 | 2,099.4 | 61.0 |
| Pasture/Hay | 794.7 | 29.1 | 949.7 | 28.3 | 959.6 | 28.2 | 974.0 | 28.3 |
| Developed, Open Space | – | 0.0 | – | 0.0 | – | 0.0 | – | 0.0 |
| Developed, Low Intensity | 10.9 | 0.4 | 26.8 | 0.8 | 30.6 | 0.9 | 31.0 | 0.9 |
| Developed, Medium Intensity | 2.7 | 0.1 | 3.4 | 0.1 | 3.4 | 0.1 | 3.4 | 0.1 |
| Grassland/Herbaceous | 16.4 | 0.6 | 16.8 | 0.5 | 17.0 | 0.5 | 17.2 | 0.5 |
| Deciduous Forest | 54.6 | 2.0 | 60.4 | 1.8 | 61.3 | 1.8 | 62.0 | 1.8 |
| Developed, High Intensity | 10.9 | 0.4 | 20.1 | 0.6 | 23.8 | 0.7 | 24.1 | 0.7 |
| Emergent Herbaceous Wetlands | 95.6 | 3.5 | 117.5 | 3.5 | 115.7 | 3.4 | 117.0 | 3.4 |
| Open Water | 71.0 | 2.6 | 94.0 | 2.8 | 95.3 | 2.8 | 96.4 | 2.8 |
| Barren Land | – | 0.0 | – | 0.0 | – | 0.0 | – | 0.0 |
| Woody Wetlands | – | 0.0 | 3.4 | 0.1 | 3.4 | 0.1 | 3.4 | 0.1 |
| Shrub/Scrub | 5.5 | 0.2 | 10.1 | 0.3 | 10.2 | 0.3 | 10.3 | 0.3 |
| Evergreen Forest | – | 0.0 | – | 99.9 | – | 0.0 | – | 99.8/ |
| **Total Drainage Area ($mi^2$)** | **2,731.1** | | **3,356.0** | | **3396.0** | | **3438.2** | |

(a) See Figure 1-1, National Land Cover Data 2002 (total project area is 214 $mi^2$).

## 1.3 AVAILABLE WATER-QUALITY AND WATER-QUANTITY DATA

The SD DENR, the United States Geological Service (USGS), and the East Dakota Water Development District (EDWDD) fecal coliform and *E. coli* data were used from multiple sites within the project area from 2000. Earlier data were excluded because of the expansion of the city of Sioux Falls boundaries and the significant amount of data available after 2000. For the purposes of this TMDL summary, data were used from the following stations: (1) along the Big Sioux River at the Minnehaha county line to below Baltic (BSR010), (2) at the I-90 bridge upstream of Sioux Falls (BSR020), (3) at Silver Creek (BSR030), (4) at the I-229 bridge (BSR050), (5) near South Western Avenue bridge at Sioux Falls (BSR060), (6) from Skunk Creek to the diversion return (BSR070), (7) at North Cliff at Sioux Falls (BSR080), (8) at the Bahnson Avenue bridge (BSR090), (9) at the bridge downstream of Slip-Up Creek (BSR100), and (10) near Brandon (BSR110). Figure 1-3 illustrates the monitoring stations within the Sioux Falls study area. Table 1-2 provides available date ranges and the number of *E. coli* samples which are in Table 1-3. Data collected from each project site (2000 to 2009) were used to calculate percent exceedance of the daily maximum and geometric mean *E. coli* criterion and to determine the *E. coli* concentration ranges. All data, including Sioux Falls National Pollutant Discharge Elimination System (NPDES) data, were used in the watershed model development.

Historical data collected from May 1 to September 30 (effective criterion period) from each project site were used to calculate percent exceedance of the daily maximum *E. coli* bacteria criterion of 235 cfu/100 mL and to determine *E. coli* concentration ranges (Table 1-3). A combination of *E. coli* data (when available) and translated fecal coliform data (when *E. coli* data were unavailable) was used in the calculation.

Additional monitoring was completed in 2009 on three key tributaries (Skunk Creek, Slip-Up Creek, and Silver Creek), on the diversion canal which delivers flow around the Sioux Falls area and at multiple sites along the Big Sioux River. A list of these sites is included in Table 1-4. This additional monitoring increased the understanding of the flows and associated bacteria concentrations throughout the watershed and the flow that is diverted around the city of Sioux Falls. The locations of these sites are shown in Figure 1-4.

Because the NPDES-regulated stormwater discharges must be addressed by the municipal separate stormwater sewer system (MS4) portion of the wasteload allocation (WLA) component of this TMDL, additional urban stormwater monitoring was completed in 2009 within the storm drainage network for the Sioux Falls study area. A list of these sites is included in Table 1-4, and their locations are shown in Figure 1-5. Sample types occurring at each site, including integrated bacteria samples, grab bacteria samples, and stage-height measurements for flow, are provided in Tables 1-4 and 1-5.

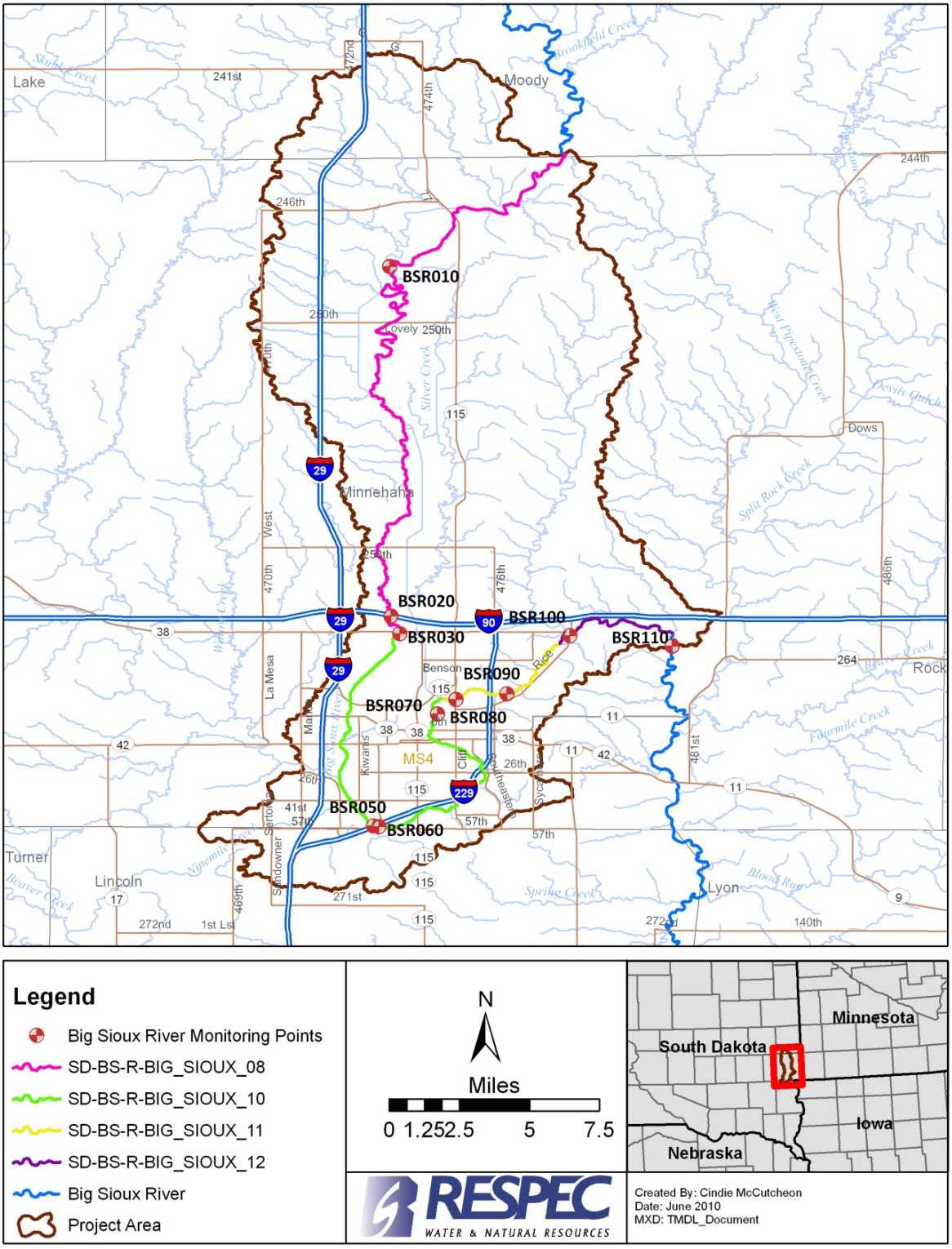



**Figure 1-3.** Monitoring Stations Within the Sioux Falls Study Area Along the Big Sioux River.

**Table 1-2. Water-Quality Station *E. coli* Data and Transformed Fecal Coliform Data (Where *E. coli* Data Were Unavailable) in the Sioux Falls Study Area of the Lower Big Sioux River Watershed (Recreational Season)**

| Observed Bacteria Monitoring Stations | Project I.D. | Segment | Period of Data Availability | Number of Samples[(a)] | Number of Actual *E. coli* Samples[(a)] | Number of Translated *E. coli* Samples |
|---|---|---|---|---|---|---|
| Big Sioux River Minnehaha County line to below Baltic | BSR010 | SD-BS-R-BIG_SIOUX_08 | 05/24/2000–09/15/2009 | 57 | 9 | 48 |
| Big Sioux River I-90 Bridge upstream of Sioux Falls | BSR020 | SD-BS-R-BIG_SIOUX_08 | 05/03/2000–09/21/2009 | 249 | 28 | 221 |
| Big Sioux River at Silver Creek | BSR030 | SD-BS-R-BIG_SIOUX_08 | 07/11/2000–09/12/2001 | 10 | 0 | 10 |
| Big Sioux River at I-229 Bridge | BSR050 | SD-BS-R-BIG_SIOUX_10 | 06/12/2000–09/23/2009 | 31 | 5 | 26 |
| Big Sioux River near South Western Avenue Bridge at Sioux Falls | BSR060 | SD-BS-R-BIG_SIOUX_10 | 05/05/2009–09/21/2009 | 23 | 23 | 0 |
| Big Sioux River from Skunk Creek to diversion return | BSR070 | SD-BS-R-BIG_SIOUX_10 | 05/31/2000–09/21/2009 | 66 | 22 | 44 |
| Big Sioux River at North Cliff at Sioux Falls | BSR080 | SD-BS-R-BIG_SIOUX_11 | 07/11/2000–09/21/2009 | 33 | 23 | 10 |
| Big Sioux River at Bahnson Avenue Bridge | BSR090 | SD-BS-R-BIG_SIOUX_11 | 05/03/2000–09/14/2009 | 214 | 9 | 205 |
| Big Sioux River at bridge downstream of Slip-Up Creek | BSR100 | SD-BS-R-BIG_SIOUX_12 | 05/03/2000–09/15/2009 | 229 | 9 | 220 |
| Big Sioux River near Brandon | BSR110 | SD-BS-R-BIG_SIOUX_12 | 05/31/2000–09/21/2009 | 79 | 28 | 51 |

(a) The "Number of Samples" columns indicate the number of samples within the recreation season.

**Table 1-3. *E. coli* and Transformed Fecal Coliform (Where *E. coli* Were Unavailable) Percent Exceedance of *E. coli* Concentration Criteria and *E. coli* Concentration Ranges for Project Sites Within the Sioux Falls Study Area of the Lower Big Sioux River Watershed (Recreational Season)**

| Monitoring Stations | Project I.D. | Total Number of Samples | Daily Maximum Exceedances | Daily Maximum Percent Exceedance | Daily Maximum Concentration Range (cfu/100 mL)[a] | Geometric Mean[b] Values | Geometric Mean[b] Exceedances | Geometric Mean Percent Exceedance | Geometric Mean[b] Concentration Range (cfu/100 mL)[a] |
|---|---|---|---|---|---|---|---|---|---|
| Big Sioux River Minnehaha County line to below Baltic | BSR010 | 57 | 23 | 40 | 18–28,499 | 0 | N/A | N/A | N/A |
| Big Sioux River I-90 Bridge upstream of Sioux Falls | BSR020 | 249 | 120 | 48 | 10–3,822 | 282 | 218 | 77 | 27–940 |
| Big Sioux River at Silver Creek | BSR030 | 10 | 7 | 70 | 74–30,370 | 0 | N/A | N/A | N/A |
| Big Sioux River at I-229 Bridge | BSR050 | 31 | 14 | 45 | 18–7,635 | 0 | N/A | N/A | N/A |
| Big Sioux River Near South Western Avenue Bridge at Sioux Falls | BSR060 | 23 | 15 | 65 | 75–12,033 | 21 | 20 | 95 | 105–2,698 |
| Big Sioux River from Skunk Creek to diversion return | BSR070 | 66 | 42 | 64 | 17–14,136 | 24 | 24 | 100 | 224–2,970 |
| Big Sioux River at North Cliff at Sioux Falls | BSR080 | 33 | 26 | 79 | 55–18,286 | 23 | 21 | 91 | 112–1,947 |
| Big Sioux River at Bahnson Avenue Bridge | BSR090 | 214 | 129 | 60 | 17–12,931 | 171 | 167 | 98 | 74–1,748 |
| Big Sioux River at bridge downstream of Slip-Up Creek | BSR100 | 229 | 143 | 62 | 18–21,283 | 227 | 215 | 95 | 77–2,660 |
| Big Sioux River near Brandon | BSR110 | 79 | 44 | 56 | 10–15,724 | 38 | 31 | 82 | 39–1,045 |

(a) cfu/100 mL = colony-forming units per 100 milliliters.

(b) The running 30-day geometric mean concentration is calculated for each 30-day window in the recreational season. South Dakota criteria require at least five samples in a 30-day period to calculate a 30-day geometric mean.

**Table 1-4. 2009 Mainstem and Large Tributary Monitoring Site List With Descriptions**

| Project I.D. | Name | Big Sioux River TMDL Reach | Type of Sampling |
|---|---|---|---|
| BSR020 | Big Sioux River I-90 Bridge upstream of Sioux Falls | SD-BS-R-BIG_SIOUX_08 | ISCO, Grab, Stage height |
| SKC030 | Skunk Creek at Marion Road Bridge at Sioux Falls | N/A | ISCO, Grab, Stage height |
| BSR060 | Big Sioux River near South Western Avenue Bridge at Sioux Falls | SD-BS-R-BIG_SIOUX_10 | ISCO, Grab, Stage height |
| BSR070 | Big Sioux River From Skunk Creek To diversion return | SD-BS-R-BIG_SIOUX_10 | Grab |
| SVC010 | Silver Creek 259 Street Bridge | N/A | ISCO, Grab |
| BSR080 | Big Sioux River at North Cliff at Sioux Falls | SD-BS-R-BIG_SIOUX_11 | ISCO, Grab, Stage height |
| SUC020 | Slip-Up Creek upstream of confluence with Big Sioux | N/A | ISCO, Grab, Stage height |
| BSR110 | Big Sioux River near Brandon | SD-BS-R-BIG_SIOUX_12 | ISCO, Grab, Stage height |

A total of 653 paired fecal coliform and *E. coli* samples existed along the Big Sioux River throughout the study area. The *E. coli* samples combined from all monitoring stations were in exceedance of the daily maximum criteria (75 percent at that time). Bacteria sample data for the Big Sioux River impaired reaches showed a statistically significant correlation (*Spearman* $r_s$ = 0.94) between fecal coliform bacteria and *E. coli* concentrations. Because the two indicators are closely related, the transformed fecal coliform bacteria data are expected to address *E. coli* impairments to the immersion recreation and limited contact recreation use of the Big Sioux River. The paired fecal coliform and *E. coli* data were used to develop a translator function to convert fecal coliform concentrations to *E. coli* concentrations. The first step for translation requires the regression analysis equation developed using observed Sioux Falls bacteria data (Equation 1-1) to convert fecal coliform concentration to *E. coli* concentrations. Once concentrations were available, they were combined with flow data to compute loading estimates. The mean ratio of *E. coli* to fecal coliform was calculated to be 1.439 cfu *E. coli*/cfu fecal coliform. Although *E. coli* is a subset of fecal coliform, *E. coli* concentrations were found to be slightly higher than fecal coliform concentrations for paired samples as indicated by the mean ratio of *E. coli* to fecal coliform in three recent South Dakota TMDLs (Big Sioux River, Cheyenne River, and Whitewood Creek). This may be the result of the inherent variability of bacteria or the different methods used to quantify these bacteria. Fecal coliform concentrations are determined by a direct count using a membrane filtration technique; whereas, *E. coli* concentrations are quantified using a multiple-well chromogenic substrate technique to achieve a statistical value. Both techniques are valid and sensitive [Larson, 2011].

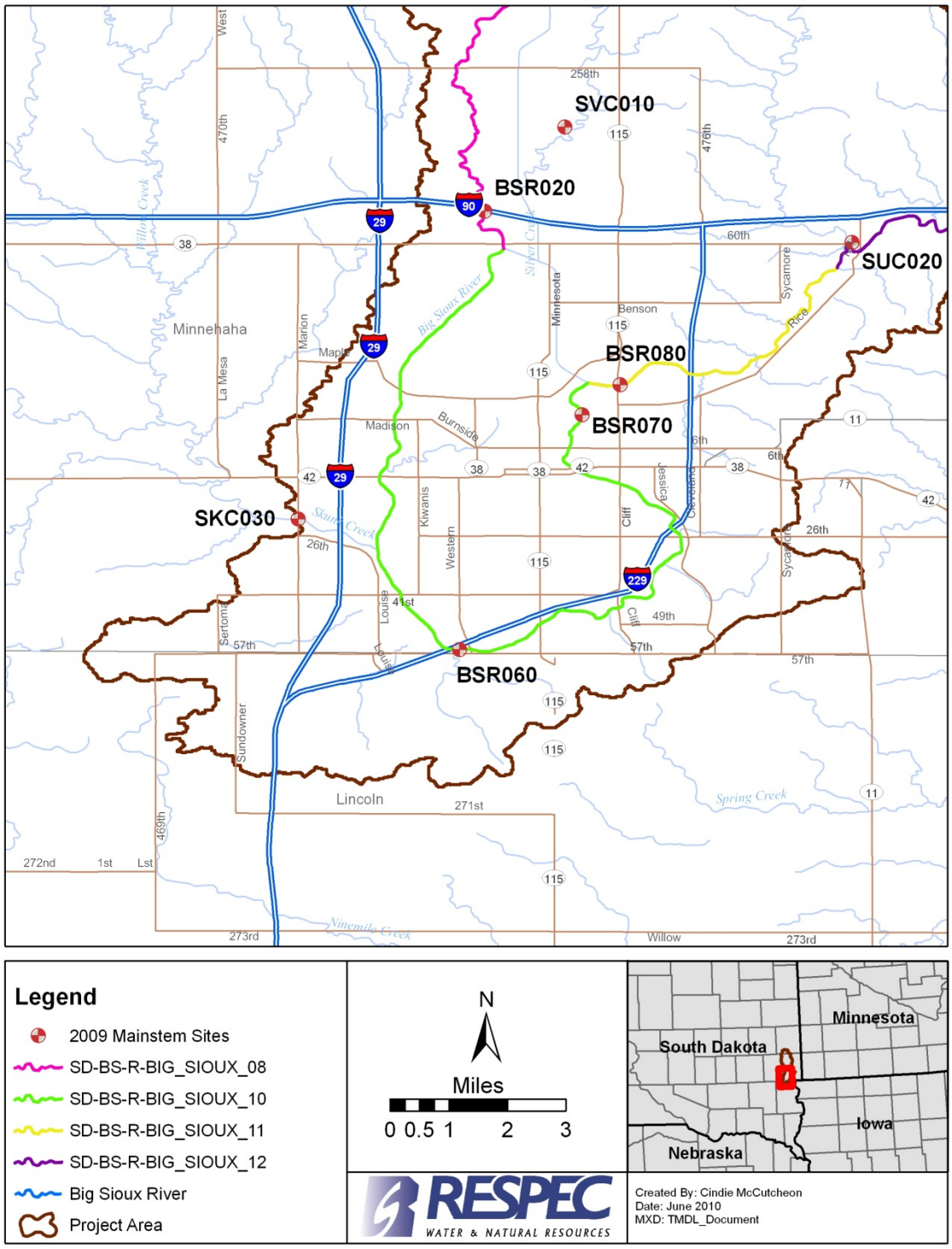



**Figure 1-4.** 2009 Mainstem and Large Tributary Monitoring Sites Within the Sioux Falls Study Area.

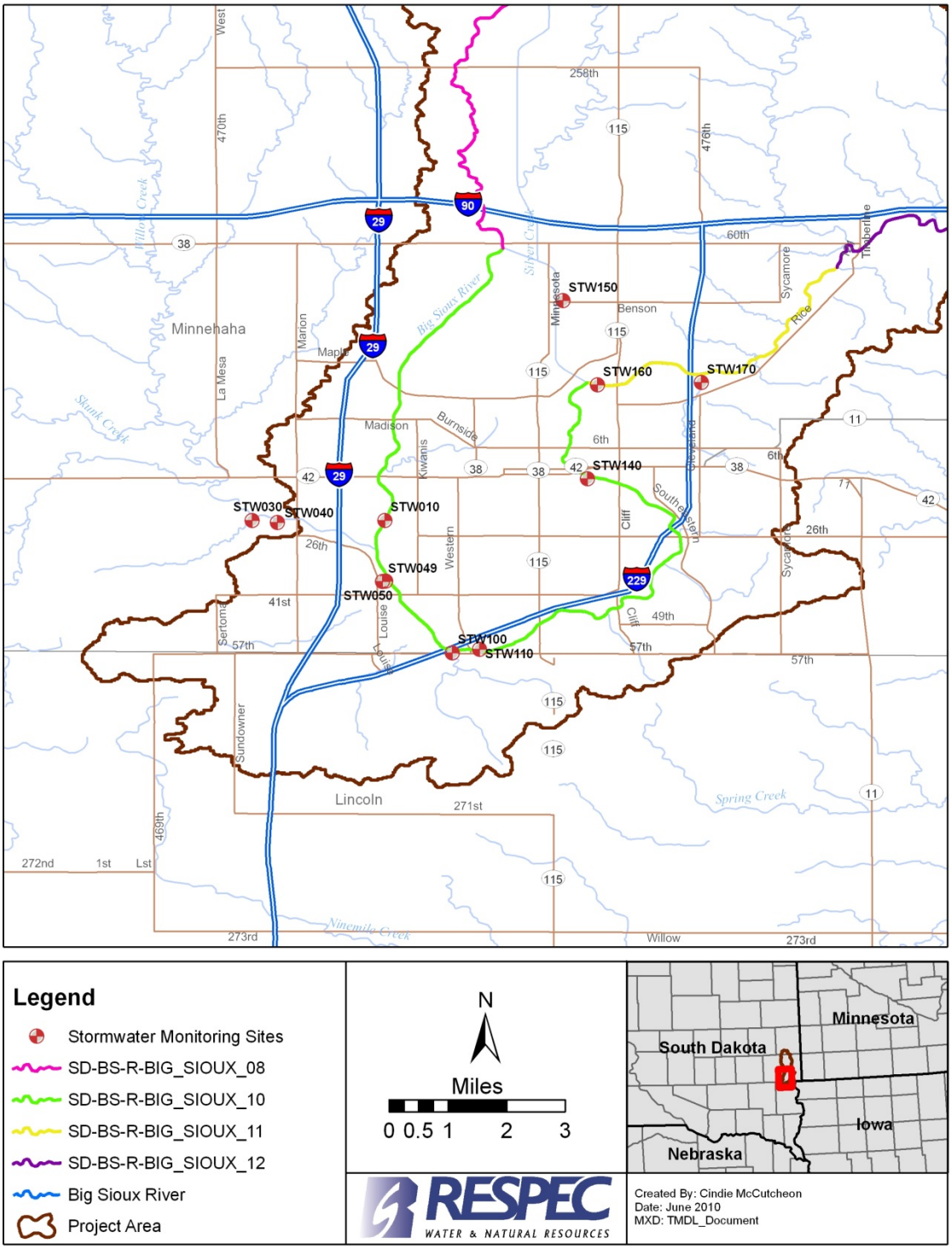



**Figure 1-5.** 2009 Stormwater Monitoring Sites Within the Sioux Falls Study Area.

$$(E) = 2.5643(F)^{0.8579} \quad (1\text{-}1)$$

where:

$F$ = fecal coliform concentration

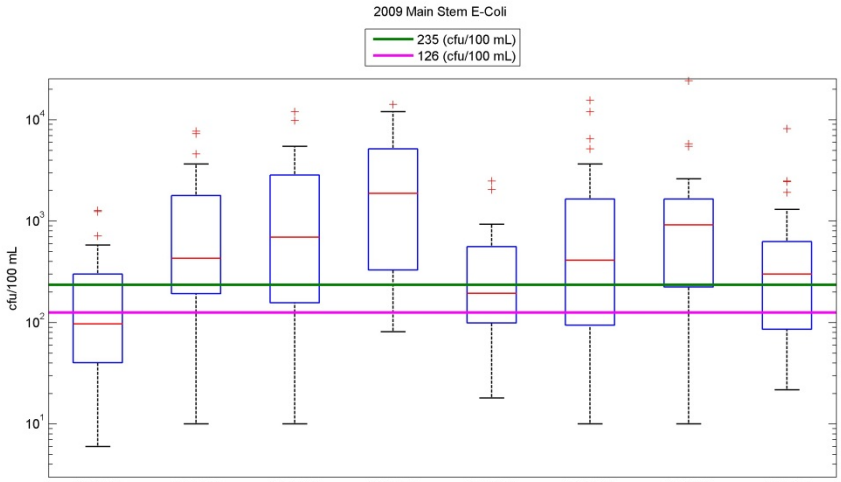
$E$ = *E. coli* concentration.

**Table 1-5. 2009 Stormwater Monitoring Site List With Descriptions**

| Project I.D. | Name | Type of Sampling |
|---|---|---|
| STW010 | Storm Drain near the Zoo | Grab |
| STW030 | Urban Stream Channel near S. Dunham Circle | ISCO, Grab, Stage height |
| STW040 | Stormwater Channel near W. Silver Valley Drive | ISCO, Grab, Stage height |
| STW049 | Storm Drain near PetSmart upstream of Detention Structure | Grab, Stage height |
| STW050 | Storm Drain near PetSmart | ISCO, Grab, Stage height |
| STW100 | Urban Stream Channel near 57th Street | ISCO, Grab, Stage height |
| STW110 | Storm Drain in Yankton Trail Park | ISCO, Grab, Stage height |
| STW140 | Storm Drain along Beadle Greenway | ISCO, Grab, Stage height |
| STW150 | Stormwater Channel near E. Benson Road | ISCO, Grab, Stage height |
| STW160 | Storm Drain near John Morrell | Grab |
| STW170 | Urban Stream Channel near E. Rice Street | ISCO, Grab, Stage height |

RESPEC grab sample data obtained during the 2009 monitoring effort (not including replicates) were used to create boxplots illustrating the range of *E. coli* concentrations (cfu/100 mL) at each site during multiple flow conditions. Three boxplots are included from mainstem and large tributary sites. Figure 1-6 is a boxplot showing the combined baseflow and stormflow, Figure 1-7 shows baseflow, and Figure 1-8 shows the stormflow. Three boxplots are also included from the stormwater sites. Figure 1-9 provides the combined baseflow and stormflow, Figure 1-10 provides the baseflow, and Figure 1-11 provides the stormflow. Note that stormwater sites do not have a set bacteria criteria. Percent exceedances discussed in this section are of the Big Sioux River daily maximum *E. coli* criteria (235 cfu/100 mL).

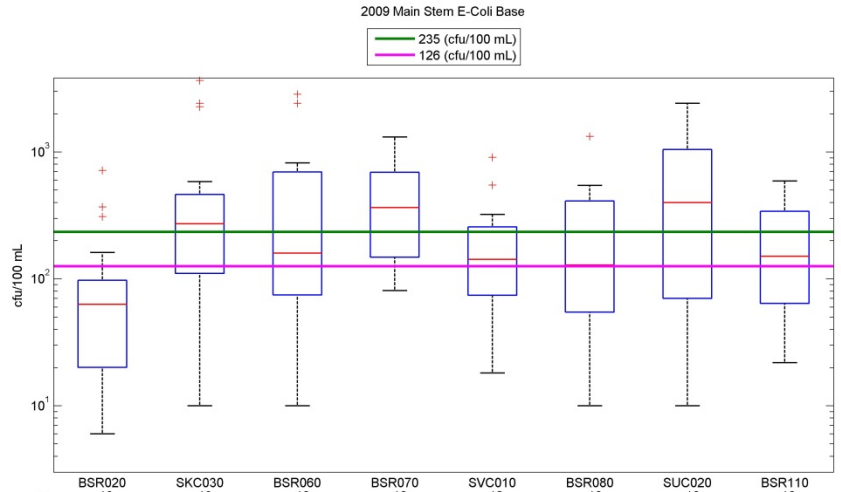
RSI-1827-10-007




| | BSR020 | SKC030 | BSR060 | BSR070 | SVC010 | BSR080 | SUC020 | BSR110 |
|---|---|---|---|---|---|---|---|---|
| n | 35 | 36 | 35 | 22 | 26 | 35 | 35 | 35 |
| Min | 6 | 10 | 10 | 81 | 18.1 | 10 | 10 | 21.8 |
| Max | 1274 | 7701 | 12033 | 14136 | 2481 | 15531 | 24196 | 8164 |
| q1 | 40.25 | 193.2 | 156.5 | 331 | 99 | 94.05 | 225 | 85.93 |
| Median | 97 | 430.5 | 695 | 1885 | 194.4 | 411 | 921 | 300 |
| q3 | 300 | 1785 | 2851 | 5170 | 560 | 1654 | 1652.5 | 627.8 |
| Mean | 226 | 1323 | 2152.3 | 3550 | 457.4 | 1800.5 | 1927.6 | 738.9 |
| 90th% | 583 | 3580 | 5480 | 11449 | 927.9 | 5172 | 5475 | 1918 |
| 95th% | 1114 | 6472 | 11476 | 12874 | 2136 | 10647 | 5712.5 | 2479 |
| % Exceeded | 34 | 69 | 57 | 82 | 46 | 66 | 74 | 54 |
| % Exceed30 | 61 | 95 | 91 | 100 | 100 | 89 | 95 | 68 |
| n 30 | 57 | 56 | 56 | 32 | 40 | 57 | 56 | 56 |

**Figure 1-6.** *E. coli* Boxplots for Combined Baseflow and Stormflow From the 2009 Mainstem and Tributary Sampling Sites in the Sioux Falls Study Area of the Lower Big Sioux River Watershed.

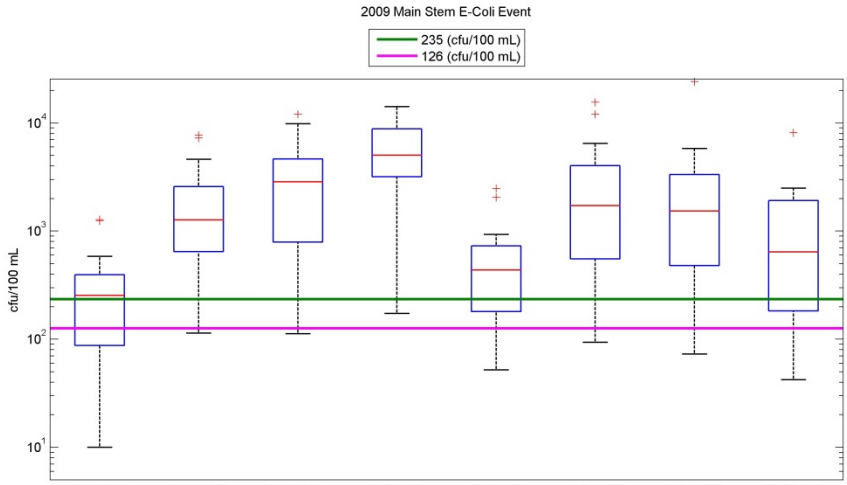
RSI-1827-10-008




| | BSR020 | SKC030 | BSR060 | BSR070 | SVC010 | BSR080 | SUC020 | BSR110 |
|---|---|---|---|---|---|---|---|---|
| n | 19 | 19 | 18 | 10 | 12 | 18 | 18 | 18 |
| Min | 6 | 10 | 10 | 81 | 18.1 | 10 | 10 | 21.8 |
| Max | 717 | 3654 | 2851 | 1310 | 909 | 1330 | 2420 | 591 |
| q1 | 20 | 110.3 | 74.9 | 148 | 74.4 | 54.8 | 70.3 | 64 |
| Median | 63 | 272 | 159.5 | 365 | 142 | 128.5 | 400 | 151 |
| q3 | 97.8 | 462 | 695 | 691 | 257 | 410 | 1046 | 340 |
| Mean | 119 | 629.1 | 519 | 471.9 | 228 | 260.2 | 680.5 | 206 |
| 90th% | 345 | 2364 | 1940 | 1149 | 656 | 523.2 | 1667 | 437 |
| 95th% | 560 | 3099 | 2678 | 1310 | 873 | 1016 | 2120 | 539 |
| % Exceeded | 16 | 53 | 39 | 70 | 25 | 44 | 61 | 39 |
| % Exceed30 | 20 | 67 | 56 | 100 | 33 | 44 | 67 | 33 |
| n 30 | 15 | 15 | 9 | 2 | 6 | 9 | 9 | 9 |

**Figure 1-7.** *E. coli* Boxplots for Baseflow From the 2009 Mainstem and Tributary Sampling Sites in the Sioux Falls Study Area of the Lower Big Sioux River Watershed.

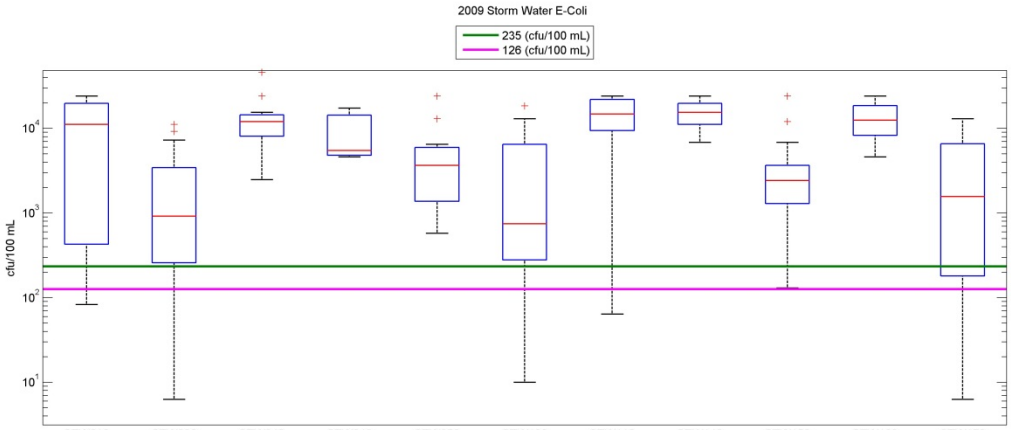
RSI-1827-10-009




| | BSR020 | SKC030 | BSR060 | BSR070 | SVC010 | BSR080 | SUC020 | BSR110 |
|---|---|---|---|---|---|---|---|---|
| n | 16 | 17 | 17 | 12 | 14 | 17 | 17 | 17 |
| Min | 10 | 113.7 | 111.9 | 173 | 52 | 93.4 | 72.7 | 42.2 |
| Max | 1274 | 7701 | 12033 | 14136 | 2481 | 15531 | 24196 | 8164 |
| q1 | 87.5 | 644.8 | 792.05 | 3179.5 | 180 | 552.75 | 479 | 182.3 |
| Median | 255 | 1270 | 2851 | 5027 | 436 | 1722 | 1530 | 640 |
| q3 | 394.5 | 2588 | 4634 | 8843.5 | 728 | 4030.5 | 3326.3 | 1918 |
| Mean | 353.5 | 2098 | 3881.8 | 6115.2 | 653.9 | 3431.3 | 3248.1 | 1303 |
| 90th% | 1180 | 6738 | 11587 | 12664 | 2093 | 10924 | 5728 | 2481 |
| 95th% | 1266 | 7550 | 12033 | 13926 | 2395 | 14307 | 17754 | 6178 |
| % Exceeded | 56 | 88 | 76 | 92 | 64 | 88 | 88 | 71 |
| % Exceed30 | 87 | 100 | 100 | 100 | 100 | 100 | 100 | 93 |
| n 30 | 15 | 14 | 14 | 11 | 13 | 15 | 14 | 14 |

**Figure 1-8.** *E. coli* Boxplots for Stormflows From the 2009 Mainstem and Tributary Sampling Sites in the Sioux Falls Study Area of the Lower Big Sioux River Watershed.

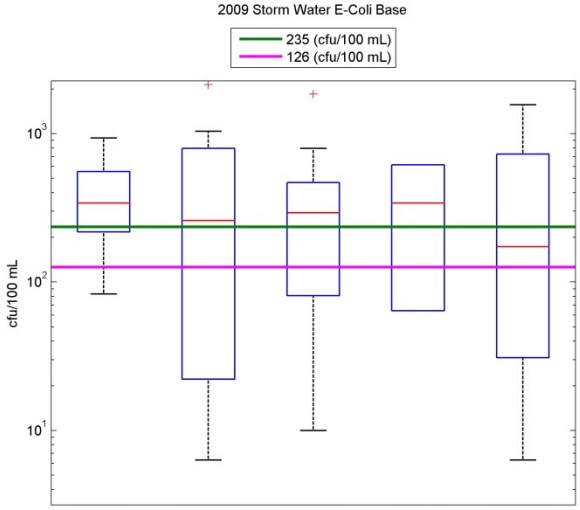
RSI-1827-10-010




| | STW010 | STW030 | STW040 | STW049 | STW050 | STW100 | STW110 | STW140 | STW150 | STW160 | STW170 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| n | 14 | 30 | 13 | 3 | 15 | 34 | 16 | 9 | 15 | 4 | 29 |
| Min | 83 | 6.3 | 2490 | 4611 | 579 | 10 | 64 | 6870 | 130 | 4611 | 6.3 |
| Max | 24196 | 11199 | 46110 | 17330 | 24196 | 18500 | 24200 | 24196 | 24196 | 24190 | 12997 |
| q1 | 430 | 259 | 8128.5 | 4828.3 | 1382.8 | 279 | 9448.5 | 11189 | 1293.5 | 8322 | 180.25 |
| Median | 11200 | 923.2 | 12030 | 5480 | 3654 | 750.05 | 14833 | 15530 | 2420 | 12515 | 1565 |
| q3 | 19863 | 3440 | 14485 | 14368 | 5967.5 | 6488 | 22028 | 19861 | 3654 | 18594 | 6584.3 |
| Mean | 10422 | 2406.6 | 13894 | 9140.3 | 5106.5 | 3654.6 | 14373 | 15386 | 4477.9 | 13458 | 3390.2 |
| 90th% | 20296 | 7070 | 28579 | 17330 | 13000 | 10714 | 24196 | 22463 | 12030 | 24190 | 8605.2 |
| 95th% | 23329 | 9210 | 42823 | 17330 | 21397 | 12999 | 24199 | 24196 | 21154 | 24190 | 9399.3 |
| % Exceeded | 93 | 80 | 100 | 100 | 100 | 79 | 94 | 100 | 87 | 100 | 72 |
| % Exceed30 | 100 | 96 | 100 | NaN | 100 | 98 | 100 | 100 | 100 | NaN | 100 |
| n 30 | 14 | 47 | 8 | 0 | 8 | 54 | 11 | 1 | 8 | 0 | 46 |

**Figure 1-9.** *E. coli* Combined Boxplots for Baseflow and Stormflow From the 2009 Urban Stormwater Sites in the Sioux Falls Study Area of the Lower Big Sioux River Watershed.

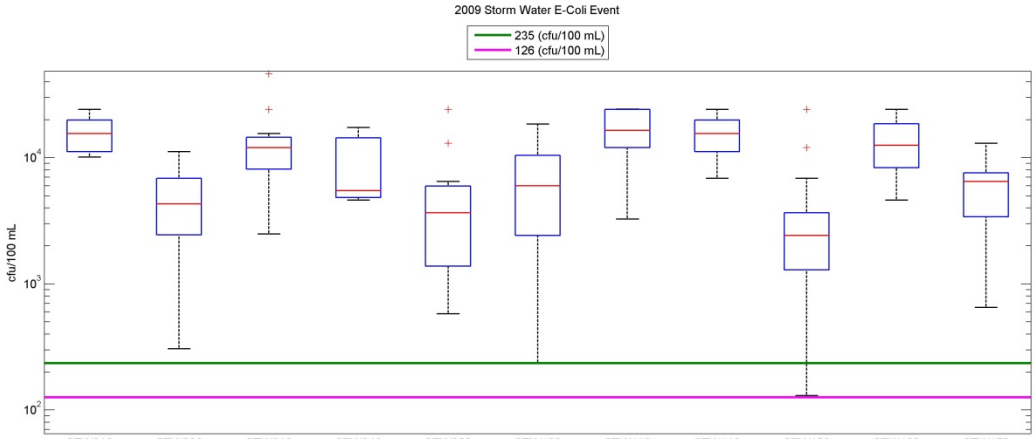
RSI-1827-10-011




| | STW010 | STW030 | STW100 | STW110 | STW170 |
|---|---|---|---|---|---|
| n | 5 | 16 | 16 | 2 | 14 |
| Min | 83 | 6.3 | 10 | 64 | 6.3 |
| Max | 933 | 2140 | 1850 | 616 | 1565 |
| q1 | 217 | 22.1 | 80.9 | 64 | 30.9 |
| Median | 341 | 260.5 | 293.5 | 340 | 173.5 |
| q3 | 556 | 796.7 | 468.5 | 616 | 730 |
| Mean | 410 | 457.7 | 380.4 | 340 | 423.1 |
| 90th% | 933 | 1034 | 777.6 | 616 | 1357 |
| 95th% | 933 | 1810 | 1533 | 616 | 1519 |
| % Exceeded | 80 | 63 | 63 | 50 | 43 |
| % Exceed30 | 100 | 86 | 63 | NaN | 67 |
| n 30 | 1 | 7 | 8 | 0 | 6 |

**Figure 1-10.** *E. coli* Boxplots for Baseflows From the 2009 Urban Stormwater Sites in the Sioux Falls Study Area of the Lower Big Sioux River Watershed.

RSI-1827-10-012




| | STW010 | STW030 | STW040 | STW049 | STW050 | STW100 | STW110 | STW140 | STW150 | STW160 | STW170 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| n | 9 | 14 | 13 | 3 | 15 | 18 | 14 | 9 | 15 | 4 | 15 |
| Min | 10112 | 305 | 2490 | 4611 | 579 | 235 | 3255 | 6870 | 130 | 4611 | 651 |
| Max | 24196 | 11199 | 46110 | 17330 | 24196 | 18500 | 24200 | 24196 | 24196 | 24190 | 12997 |
| q1 | 11200 | 2450 | 8128.5 | 4828.3 | 1382.8 | 2420 | 12033 | 11189 | 1293.5 | 8322 | 3395 |
| Median | 15530 | 4306 | 12030 | 5480 | 3654 | 5981.5 | 16430 | 15530 | 2420 | 12515 | 6490 |
| q3 | 19863 | 6870 | 14485 | 14368 | 5967.5 | 10460 | 24196 | 19861 | 3654 | 18594 | 7593.3 |
| Mean | 15984 | 4633.9 | 13894 | 9140.3 | 5106.5 | 6565 | 16378 | 15386 | 4477.9 | 13458 | 6159.5 |
| 90th% | 22463 | 9408.9 | 28579 | 17330 | 13000 | 12999 | 24196 | 22463 | 12030 | 24190 | 9210 |
| 95th% | 24196 | 10801 | 42823 | 17330 | 21397 | 16300 | 24199 | 24196 | 21154 | 24190 | 12050 |
| % Exceeded | 100 | 100 | 100 | 100 | 100 | 94 | 100 | 100 | 87 | 100 | 100 |
| % Exceed30 | 100 | 100 | 100 | NaN | 100 | 100 | 100 | 100 | 100 | NaN | 100 |
| n 30 | 5 | 13 | 8 | 0 | 8 | 14 | 9 | 1 | 8 | 0 | 13 |

**Figure 1-11.** *E. coli* Boxplots for Stormflows From the 2009 Urban Stormwater Sites in the Sioux Falls Study Area of the Lower Big Sioux River Watershed.

BSR020 is the primary monitoring site located in Reach SD-BS-R-BIG_SIOUX_08, and it is the first mainstem site into the city. The boxplot of combined baseflow and stormflow for this site shows the lowest percent exceedance (34 percent) and the lowest median concentration (97 cfu/100 mL) of all sites. Although BSR020 has a less significant bacteria problem than all other reaches within the project area, the bacteria problem is still very prominent. A flow-weighted average reduction of 69 percent is required on the 95$^{th}$ percentile concentration in SD-BS-R-BIG_SIOUX_08. A concern and potential issue is that Reach SD-BS-R-BIG_SIOUX_07 has less-stringent criteria, and unless more-stringent criteria are adopted and Best Management Practices (BMPs) are implemented, achieving the beneficial use of Reach SD-BS-R-BIG_SIOUX_08 may be difficult.

Skunk Creek (SKC030) enters TMDL Reach SD-BS-R-BIG_SIOUX_10 upstream of BSR060 and has over double the exceedance of BSR020 during combined baseflow and stormflow (69 percent). The median concentration at SKC030 (430 cfu/100 mL) is over four times that of BSR020. The two Big Sioux River Reach SD-BS-R-BIG_SIOUX_10 sites following Skunk Creek's contribution (BSR060 and BSR070) have high impairment with exceedances of 57 percent and 82 percent and median concentrations of 695 cfu/100 mL and 1,885 cfu/100 mL, respectively. The high impairment levels are likely because Skunk Creek contributes a significant flow volume to the Big Sioux River and Skunk Creek's less-stringent daily maximum standard (1,178 cfu/100 mL) allows greater bacteria concentrations. The significant flow contribution from Skunk Creek is related to the diversion of much of the Big Sioux River recreational season flows (May–September) around the city of Sioux Falls (Reach SD-BS-R-BIG_SIOUX_10) through a diversion canal (see Figure 1-1 for canal location). Because of the diversion, runoff from Sioux Falls (and flow from Skunk Creek) accounts for the majority of the Big Sioux River recreational season flow. Based on continuous data from 2005 through 2009, Skunk Creek accounts for approximately 45 percent of flow volume in July and September to 67 percent of flow volume in May, which averages to 58 percent over the entire recreation season. Figure 1-12 shows the monthly flow volume contribution percentage to the Big Sioux River directly downstream of Skunk Creek. Note that the concentrations continue to increase from BSR060 to BSR070 (a large stretch of the Big Sioux River within Sioux Falls having minimal tributary inflow). A flow-weighted average reduction of 97 percent is required on the 95$^{th}$ percentile concentration in SD-BS-R-BIG_SIOUX_10.

The MS4 permit is a municipal stormwater discharge permit that authorizes the discharge of stormwater from the municipal separate storm sewer system. For the Sioux Falls TMDLs, the permit refers to stormwater runoff from the city of Sioux Falls into the Big Sioux River and its tributaries. The level of stormwater-quality control is defined in federal regulations in terms of maximum extent practicable (MEP). MEP considers the practicality and/or economics in treating low-frequency, very large events, and it recognizes that the majority of stormwater loadings are generated by the frequent, smaller events.

All stormwater monitoring sites, except STW150, STW160, and STW170, flow into Reach SD-BS-R-BIG_SIOUX_10. The MS4 contributes significantly to impairment in SD-BS-R-

BIG_SIOUX_10, because four out of the eight stormwater outfalls flowing into this reach have 100 percent exceedance of the daily maximum criteria of the receiving Big Sioux River and the other four stormwater outfalls have a minimum exceedance of 79 percent. The average median *E. coli* concentration at the eight outfalls is over 8,000 cfu/100 mL, which is over 50 times the current *E. coli* criteria for the Big Sioux River in the project area.

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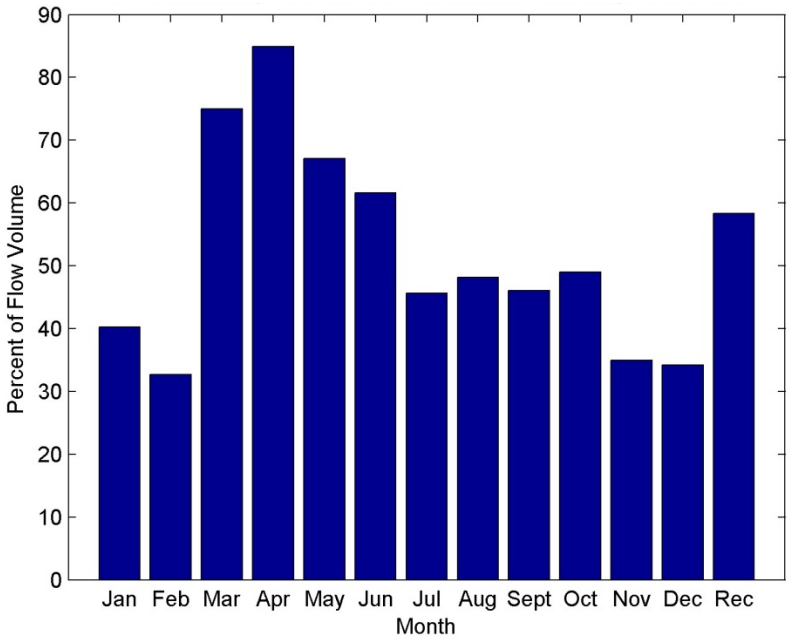


**Figure 1-12.** Skunk Creek Monthly Flow Volume Contribution Percentage to the Big Sioux River Directly Downstream of Skunk Creek.

The diversion dilutes the high concentrations caused by Skunk Creek and the MS4 when it reenters the Big Sioux River at the beginning of Reach SD-BS-R-BIG_SIOUX_11. Silver Creek, which flows into the diversion, has the lowest exceedance (46 percent) and median concentration (194 cfu/100 mL) of all sites except BSR020 because of limited overland runoff. However, Skunk Creek and the MS4 continue to be a source of impairment to BSR080 in Reach SD-BS-R-BIG_SIOUX_11 (66 percent exceedance and a median concentration of 411 cfu/ 100 mL). Skunk Creek contributes to 19 percent of the flow of Reach SD-BS-R-BIG_SIOUX_11. Because of the diversion, the median concentration drops approximately from 974 cfu/100 mL to 411 cfu/100 mL at BSR080. The MS4 continues to impact loading in this reach as STW150 flows into the diversion, and the remaining two stormwater monitoring sites (STW160 and STW170) flow directly to Reach SD-BS-R-BIG_SIOUX_11. STW150 has an 87 percent exceedance and a median concentration of 2,420 mg/L. STW160 has a 100 percent exceedance and a median concentration of 12,515 mg/L, and STW170 has a 72 percent exceedance and median concentration of 1,565 mg/L. A flow-weighted average reduction of 97 percent is required on the 95$^{th}$ percentile concentration in SD-BS-R-BIG_SIOUX_11.

Skunk Creek continues to be a source of impairment even in Reach SD-BS-R-BIG_SIOUX_12 (BSR110 has an exceedance of 54 percent and a median concentration of 300 cfu/100 mL), because it makes up approximately 18 percent of the flow. Slip-Up Creek (median concentration of 921 cfu/100 mL) enters TMDL Reach SD-BS-R-BIG_SIOUX_12 between BSR080 and BSR110 and has higher median concentrations and percent exceedances than either site, and higher overland storm flow potential probably causes this. Thus the drop in median concentration from Reach SD-BS-R-BIG_SIOUX_11 to Reach SD-BS-R-BIG_SIOUX_12 is likely caused by bacterial decay. A flow-weighted average reduction of 79 percent is required on the 95$^{th}$ percentile concentration in SD-BS-R-BIG_SIOUX_12.

During events, the MS4 is a significant source of impairment to Reaches SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12. Only five of the eleven stormwater sites had baseflow; the other six sites only responded to storm events. All mainstem and tributary sites had baseflow data. All sites with baseflow data had higher median concentrations and percent exceedance values during stormflow than during baseflow. Median concentrations at mainstem and tributary sites ranged from 63 cfu/100 mL to 400 cfu/100 mL during baseflow and from 255 cfu/100 mL to 5,027 cfu/100 mL during stormflow. Median concentrations at stormwater sites ranged from 173 cfu/100 mL to 341 cfu/100 mL during baseflow and from 2,040 cfu/100 mL to 16,430 cfu/100 mL during stormflow. Nine out of the eleven stormwater sites had 100 percent exceedance of the daily maximum criteria during stormflows, while the other two stormwater sites had a minimum exceedance of 87 percent. Based on results presented in Figure 1-11, stormflow within Sioux Falls is clearly a primary source of bacteria loads in the Big Sioux River.

Current BMPs within the study area, such as detention ponds and constructed wetland channels/basins, were focused on sediment and thus do not appear to significantly decrease bacteria concentrations. At least three of the eleven stormwater sites (STW030, STW100, and STW170) are located downstream of current BMPs. These sites have exceedances of the Big Sioux River criteria of 43 to 63 percent during baseflows and more than 90 percent during stormflows. Of the 11 sites, the median concentrations during stormflows at STW030, STW100, and STW170 rank 9$^{th}$ highest, 7$^{th}$ highest, and 6$^{th}$ highest, respectively. Because of these high stormflow bacteria concentrations, future BMPs should also focus on reducing bacteria concentrations.

The USGS monitors long-term streamflow on the Big Sioux River at USGS 06481000 Big Sioux River near Dell Rapids, USGS 06482000 Big Sioux River at Sioux Falls, USGS 06482020 Big Sioux River at Cliff Avenue at Sioux Falls, and on Skunk Creek at USGS 06481500 Skunk Creek at Sioux Falls. These streamflow gages are illustrated in Figure 1-13. Each of these stations provided an adequate streamflow dataset during the simulation period. Two additional streamflow gages also existed but did not have continuous flow data (BSR020 at the I-90 Bridge upstream of Sioux Falls and BSR110 near Brandon). These sites are shown in Figure 1-4. Additional flow data were collected as a part of the 2009 monitoring effort.

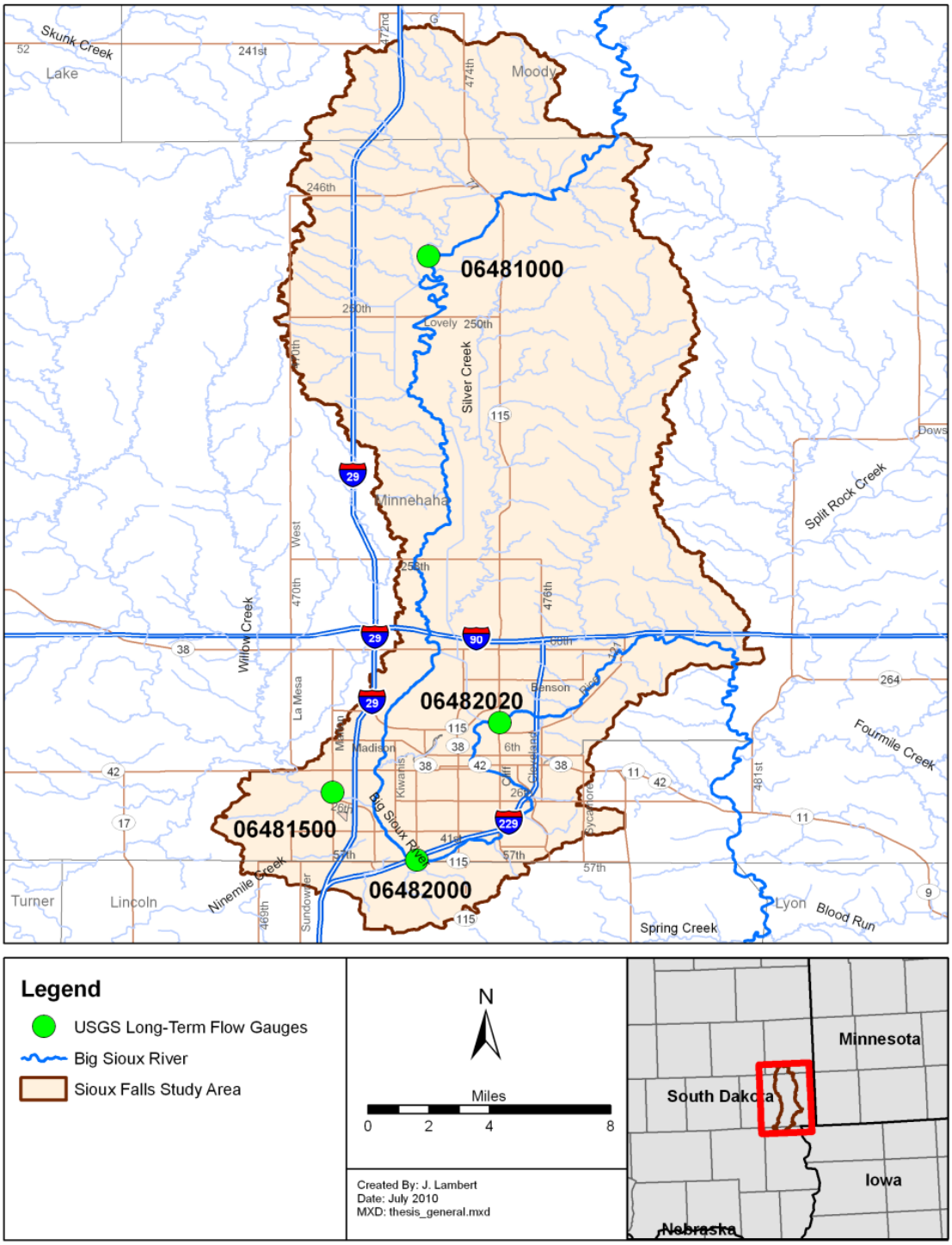


**Figure 1-13.** Long-Term U.S. Geological Survey Streamflow Gages on the Big Sioux River and Skunk Creek.

# 2.0 WATER-QUALITY STANDARDS AND TOTAL MAXIMUM DAILY LOAD TARGETS

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 may be assigned by the state based on a beneficial use analysis of each waterbody. Water-quality standards are defined in South Dakota state statutes in support of these uses (Administrative Rules of South Dakota [ARSD] 74:51:01–74:51:03). These standards consist of suites of criteria that provide physical and chemical benchmarks for management decisions [Administrative Rules of South Dakota, 2010].

Additional narrative standards that may apply can be found in ARSD Articles 74:51:01:05; 06; 08; 09; and 12 [Administrative Rules of South Dakota, 2010]. These standards generally prohibit the presence of materials that cause pollutants to form, visible pollutants, nuisance aquatic life, and pollutants impacting biological integrity.

Big Sioux River Reaches SD-BS-R-BIG_SIOUX_08 and SD-BS-R-BIG_SIOUX_10 were assigned the following beneficial uses: domestic water supply, fish and wildlife propagation, immersion recreation, irrigation waters, limited contact recreation, and warm-water semipermanent fish life. Big Sioux River Reaches SD-BS-R-BIG_SIOUX_11 and SD-BS-R-BIG_SIOUX_12 were assigned the same beneficial uses with the exception of domestic water supply, which is not a beneficial use in these downstream reaches. Table 2-1 lists water-quality criteria that must be met to support the beneficial uses currently assigned to the Big Sioux River within the city of Sioux Falls. All listed reaches must meet the more stringent standards of immersion recreation because it is listed as impaired for both immersion recreation and limited contact recreation.

South Dakota recently adopted *E. coli* criteria for the protection of the limited contact and immersion recreation uses. Big Sioux River Reaches SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12 require an *E. coli* TMDL because the parameter is listed as a cause of impairment to this stream in the 2010 South Dakota Integrated Report [South Dakota Department of Environment and Natural Resources, 2010]. More than 10 percent of the samples must exceed water-quality criteria for that parameter to be included as a cause of impairment on the 303(d) Impaired Waters List. Also, for a parameter to be considered representative of actual conditions, at least 20 samples of the parameter are required. The sample threshold is reduced to ten samples if three or more samples exceed daily maximum water-quality standards.

**Table 2-1. State Surface Water-Quality Standards for the Big Sioux River in the City of Sioux Falls (Page 1 of 2)**

| Parameter | Criteria | Unit of Measure | Special Conditions |
|---|---|---|---|
| Total alkalinity as calcium carbonate[a] | ≤ 750 | mg/L | 30-day average |
| | ≤ 1,313 | mg/L | Daily maximum |
| Total dissolved solids[a] | ≤ 2,500 | mg/L | 30-day average |
| | ≤ 4,375 | mg/L | Daily maximum |
| Total dissolved solids[b] | ≤ 1,000 | mg/L | 30-day average |
| | ≤ 1,750 | mg/L | Daily maximum |
| Total petroleum hydrocarbon[a] | ≤ 10 | mg/L | Daily maximum |
| Total petroleum hydrocarbon[b] | ≤ 1.0 | mg/L | Daily maximum |
| Oil and grease[a] | ≤ 10 | mg/L | Daily maximum |
| Nitrates as N[b] | ≤ 10 | mg/L | Daily maximum |
| Nitrates as N[a] | ≤ 50 | mg/L | 30-day average |
| | ≤ 88 | mg/L | Daily maximum |
| Dissolved oxygen[c,d,e] | ≥ 5.0 | mg/L | Daily minimum |
| Total suspended solids[c] | ≤ 90 | mg/L | 30-day average |
| | ≤ 158 | mg/L | Daily maximum |
| Temperature[c] | ≤ 90 | °F | Daily maximum |
| pH[a] | 6.0 and ≤ 9.0 | Standard units | |
| pH[c,d] | 6.5 and ≤ 9.0 | Standard units | |
| Undisassociated hydrogen sulfide[c] | ≤ 0.002 | mg/L | Daily maximum |
| Total ammonia nitrogen as N[c] | Equation-based limit | mg/L | 30-day average |
| | Equation-based limit | mg/L | Daily maximum |

**Table 2-1. State Surface Water-Quality Standards for the Big Sioux River in the City of Sioux Falls (Page 2 of 2)**

| Parameter | Criteria | Unit of Measure | Special Conditions |
|---|---|---|---|
| Fecal coliform[d] | < 200 | cfu /100 mL | Geometric mean[f] (May 1–Sep 30) |
| | < 400 | cfu /100 mL | Daily maximum (May 1–Sep 30) |
| Sodium adsorption ratio[g] | ≤ 10 | | Daily maximum |
| Conductivity at 25°C[g] | ≤ 2,500 | micromhos/cm | 30-day average |
| | ≤ 4,375 | micromhos/cm | Daily maximum |
| *E. coli*[d] | ≤ 126 | cfu /100 mL | Geometric mean[f] (May 1–Sep 30) |
| | ≤ 235 | cfu /100 mL | Daily maximum[f] (May 1–Sep 30) |

(a) Criteria for fish and wildlife propagation, recreation, and stock watering use.
(b) Criteria for domestic water supply, which apply to TMDL Reaches SD-BS-R-BIG_SIOUX_8 and SD-BS-R-BIG_SIOUX_10.
(c) Criteria for warm-water semipermanent fish life propagation use.
(d) Criteria for immersion recreation use.
(e) Criteria for limited contact recreation use.
(f) Geometric mean must be based on a minimum of five samples obtained during separate 24-hour periods for any 30-day period.
(g) Criteria for irrigation use.

Current *E. coli* criteria for the immersion recreation and limited contact recreation use require: (1) no sample exceeds 235 cfu/100 mL and 1,178 cfu/100 mL, respectively, and (2) the geometric mean of a minimum of five samples collected during separate 24-hour periods for any 30-day period must not exceed 126 cfu/100 mL and 630 cfu/100 mL, respectively. The geometric mean, as defined in ARSD Article 74:51:01:01, is the *nth* root of a product of *n* factors. The *E. coli* criteria are applicable from May 1 through September 30.

Impaired reaches must meet the more stringent standards of immersion recreation because they are listed as impaired for both immersion recreation and limited contact recreation. The numeric TMDL target established for the Big Sioux River's immersion recreation use impairment was determined for each of the five flow conditions or zones and was based on either the daily maximum (235 cfu/100 mL) or 30-day average (126 cfu/100 mL) *E. coli* bacteria criterion (depending on which criterion required the greatest load reduction).

According to ARSD Article 74:51:01:04, pollutants may not cause the more stringent criterion to be exceeded if they are discharged into a segment and the criteria for that segment's designated beneficial use are not exceeded, but the waters flow into another segment whose designated beneficial use requires a more stringent parameter criterion. Skunk Creek and the Big Sioux River Reach SD-BS-R-BIG_SIOUX_07 are currently assigned a limited contact recreation beneficial use, which has less-stringent *E. coli* criteria (geometric mean criteria of 630 cfu/100 mL and daily maximum criteria of 1,178 cfu/ 100 mL) than the Big Sioux River Project area's immersion recreation beneficial use (geometric mean criteria of 126 cfu/100 mL and daily maximum criteria of 235 cfu/100 mL). Because Skunk Creek and Reach SD-BS-R-BIG_SIOUX_07 are relatively large contributors of flow to the Big Sioux River, the discrepancy in water-quality standards is a concern. *E. coli* concentrations in these waterbodies at their current water-quality standards have the potential to cause water-quality standard exceedances in the Big Sioux River within the project area without any urban load contribution from the city of Sioux Falls. This potential for exceedance could make it very difficult for the Big Sioux River within the project area to support its assigned beneficial use. The Skunk Creek Watershed and Reach SD-BS-R-BIG_SIOUX_07 are not part of the current TMDL assessment for the Big Sioux River through the city of Sioux Falls. This means that, currently, a framework in place to evaluate potential load reductions that can be achieved through BMP implementation is not in place.

# 3.0 SIGNIFICANT SOURCES

## 3.1 POINT SOURCES

Multiple permitted point-source discharges are located in the Lower Big Sioux River Watershed project area and are listed in Table 3-1. These permitted point sources include the Dell Rapids WWTP in Reach SD-BS-R-BIG_SIOUX_08, the Baltic WWTP in Reach SD-BS-R-BIG_SIOUX_08, the Sioux Falls MS4 permit in Reaches SD-BS-R-BIG_SIOUX_10 and SD-BS-R-BIG_SIOUX_11, John Morrell & Company in Reach SD-BS-R-BIG_SIOUX_11, and the Sioux Falls WWTP in Reach SD-BS-R-BIG_SIOUX_12. Figure 3-1 identifies these point sources. The fecal coliform daily maximum and geometric mean effluent limits for the listed facilities are 400 cfu/100 mL and 200 cfu/100 mL, respectively. The facilities do not currently have *E. coli* effluent limits; however, the current *E. coli* criteria were used to calculate the WLAs for these facilities, and the SD DENR will be including *E. coli* limits to each of these permits when reissued. The permit area covered by the MS4 includes "all areas within the corporate boundary of the city of Sioux Falls served by, or otherwise contributing to, discharges to state waters from municipal separate storm sewers owned or operated by the city of Sioux Falls and interstate highways operated by South Dakota Department of Transportation" [South Dakota Department of Environment and Natural Resources, 1999].

**Table 3-1. Point Sources Within the Sioux Falls Project Area**

| Point Sources | Permit Number | Flow (mgd)[a] | Reach | Fecal Coliform Criteria | |
|---|---|---|---|---|---|
| | | | | Daily Maximum (cfu/100 mL) | Geometric Mean (cfu/100 mL) |
| Dell Rapids WWTP | SD-0022101 | 4.38 | 8 | 400 | 200 |
| Baltic WWTP | SD-0022284 | 4.56 | 8 | 400 | 200 |
| Sioux Falls NPDES MS4 | SDS-000001 | N/A | 10, 11 | N/A | N/A |
| John Morrell & Company | SD-0000078 | 4.2 | 11 | 400 | 200 |
| Sioux Falls WWTP | SD-0022128 | 28.9 | 12 | 400 | 200 |

(a) mgd = million gallons per day.

The Baltic WWTP and the Dell Rapids WWTP are lagoons. According to Buscher [2010], the Baltic WWTP has not discharged in the last 5 years, and the Dell Rapids WWTP typically discharges in May and November each year. The November discharge is outside of the recreation season.

These point sources are negligible in their load contribution and do not require reductions to current loadings. Based on the data provided, they are in compliance with their individual permits. As previously stated, two of these permitted facilities are lagoons that did not discharge during the assessment period. The other two facilities use disinfectants to

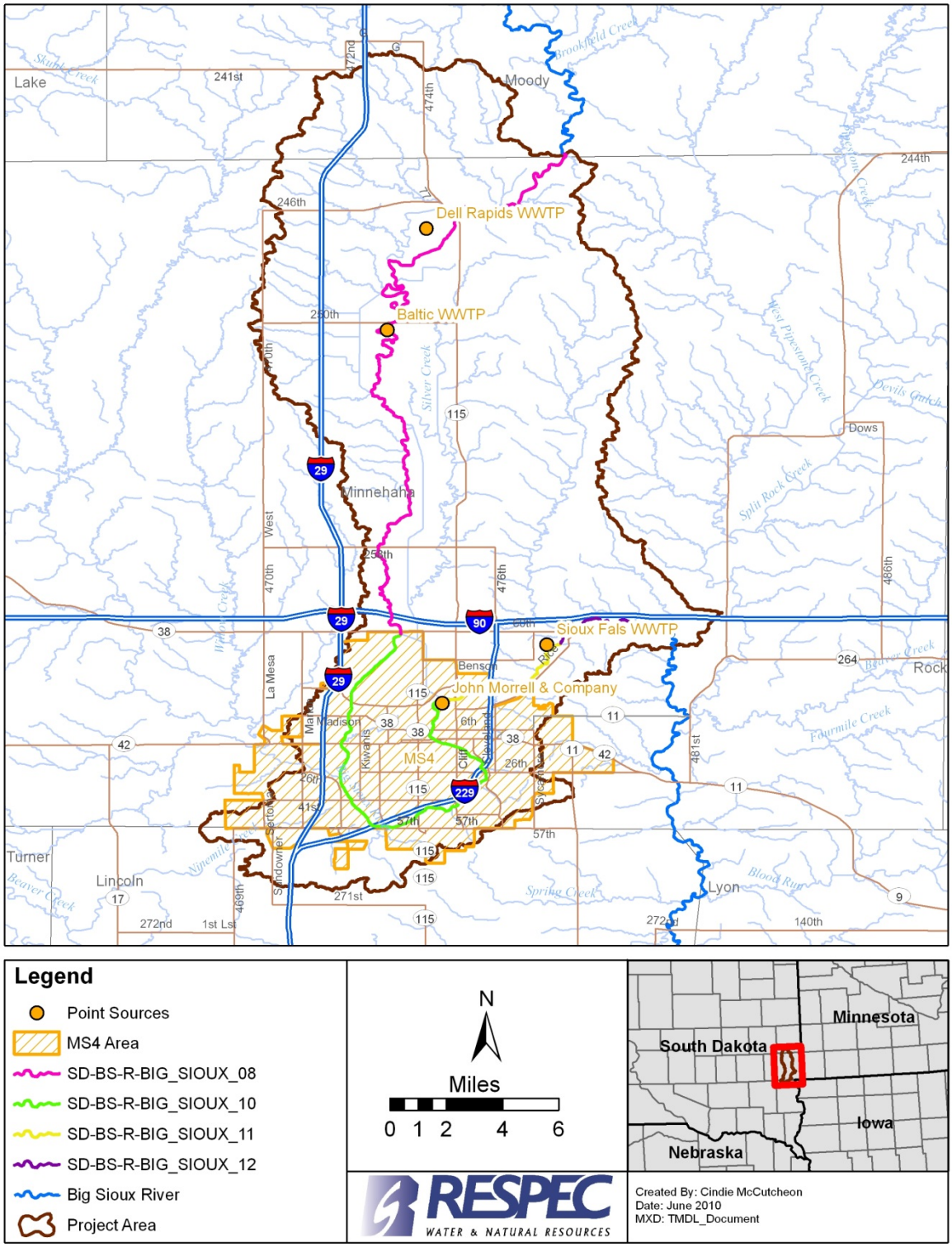


**Figure 3-1.** Point Sources, Including the MS4, Within the Sioux Falls Study Area.

control bacteria loadings and they account for less than 0.1 percent of the loadings within the given reach.

## 3.2 NONPOINT SOURCES

Based on a review of available information and communication with state and local authorities, the primary nonpoint sources of bacteria within the Lower Big Sioux River Watershed include runoff from livestock operations and/or agricultural runoff. Wildlife and human sources are also nonpoint sources in the watershed. Bacteria source loads within the study area are provided in Table 3-2. Livestock numbers were estimated based on 2007 U.S. Department of Agriculture Census information [U.S. Department of Agriculture, 2009]. Wildlife numbers were estimated from the 2002 South Dakota Game Report [Huxoll, 2003]. Septic system numbers were based on information provided in the 2010 Census.

**Table 3-2. Estimated Count of Bacteria Sources Within the Big Sioux River Total Maximum Daily Load Project Area**

| Bacteria Source | Number |
|---|---|
| *Livestock* | |
| Cattle | 4,951 |
| Horses | 359 |
| Sheep | 913 |
| Hogs | 6,628 |
| Poultry | 226 |
| *Wildlife* | |
| Deer | 756 |
| Beaver | 169 |
| Muskrats | 986 |
| Raccoons | 753 |
| Skunks | 763 |
| Nesting Canadian Geese | 313 |
| Rabbits | 6,315 |
| Wild Turkeys | 125 |
| *Humans* | |
| Septic | 1,585 |

Bacterial loadings for the model were estimated using the simulated hydrologic response of each modeled land use and the corresponding event mean concentrations (EMCs) for each land use, which were derived from 2009 sample data based on representative land use draining to particular sampling sites. For example, one sampling site was predominantly residential, so the concentrations observed from that site were used as the EMC for all residential land. There were multiple sampling sites, and each had a targeted representative land use. In some instances, the EMCs were adjusted within the range of concentrations observed for the land use through the calibration process to account for spatial variability in the watershed and to align with downstream sampling measurements.

### 3.2.1 Human

Human bacteria were identified in four out of eight bacterial source tracking tests, which are discussed further in Section 3.3. Although these source tracking tests suggest the presence of human sources, further quantification is required to verify these human sources. In general, human bacterial sources in urban settings can include cross connections between sanitary sewers and storm drain systems, overflows from sanitary sewer systems, and wet weather discharges from centralized wastewater collection and treatment facilities. The city of Sioux Falls has investigated and removed any existing cross connections. Outside city limits, septic systems are a potential human source of bacteria loads because much of the land beyond city limits is rural.

### 3.2.2 Domestic Animals

Pet waste is a contributor to the bacteria in the Big Sioux River. A recreational trail exists along the Big Sioux River throughout Sioux Falls which can accumulate pet waste. Also, pet waste may not be properly disposed of on private property along the river and within the stormwater drainage network. Pet waste can be washed off during precipitation events.

### 3.2.3 Agriculture

Manure from livestock is a potential source of bacteria to the stream. Livestock in the basin are predominantly beef cattle. Other livestock in the basin include dairy cattle, chickens, swine, sheep, and horses. Livestock contribute bacteria loads to the Big Sioux River directly by defecating while wading in the stream and indirectly by defecating on pastures or cropland that can be washed off during precipitation events. Both the indirect and direct sources of bacteria loads from livestock were represented in the modeling applications.

### 3.2.4 Natural Background/Wildlife

Wildlife within the watershed is a natural background source of bacteria. Similar to livestock, wildlife (including waterfowl and large game species) contribute bacteria loads to the

Big Sioux River directly by defecating while wading in the stream and indirectly by defecating on lands that are washed off during precipitation events.

## 3.3 BACTERIAL SOURCE TRACKING

In June 2009, RESPEC collected a fecal coliform source tracking event sample from eight stormwater sites draining into the Big Sioux River in Sioux Falls to aid in locating sources of impairment and prioritizing BMP implementation. Figure 3-2 shows the locations of the bacterial source tracking sites. One sample was taken during a storm event at each site. STW040 had a second, duplicate sample collected for quality assurance and quality control purposes. These samples were analyzed for the presence of the human *Enterococcus faecium* gene biomarker. The biomarker was detected at four of the sites, provided in Table 3-3, and indicates that human fecal contamination was present. No quantification analysis was performed on these samples. Results of *E. coli* concentration samples taken concurrently with bacterial source tracking samples are also provided in Table 3-3.

## 3.4 SOURCE ASSESSMENT MODELING RESULTS

The watershed modeling package selected for this assessment was the EPA **HSPF** model. **HSPF** is a comprehensive watershed model of hydrology and water quality that includes modeling of both land surface and subsurface hydrologic and water-quality processes and is linked and closely integrated with corresponding stream and reservoir processes. **HSPF** is considered a premier, high-level model among those currently available for comprehensive watershed assessments.

The **HSPF** model was used to determine the contribution of *E. coli* bacteria from identified sources in the project area and to evaluate the implementation of BMPs to control these sources. The Big Sioux River drainage basin was represented in the model using twenty-four subwatersheds and two boundary conditions that represent Skunk Creek and the Big Sioux River at Dell Rapids. As mentioned earlier, nonpoint source bacterial loadings for **HSPF** were estimated using the EMCs for each land use, which were derived from sample data based on representative land uses draining to particular sampling sites. For example, one sampling site was predominantly residential so the concentrations from that site were used as the EMCs for all residential, land. EMCs were applied throughout the watershed. The buildup and washoff of *E. coli* were simulated based on the EMC values and precipitation.

Source assessment modeling results were summarized using the following categories: nonpoint sources, MS4 (local: contributions from MS4 system located within the current reach boundaries), and (upstream: contributions from MS4 system located upstream of current reach boundaries), Big Sioux River boundary conditions, Skunk Creek, and Slip-Up Creek. A diagram of sources is included in Figure 3-3. The nonpoint source category includes all areas north of the

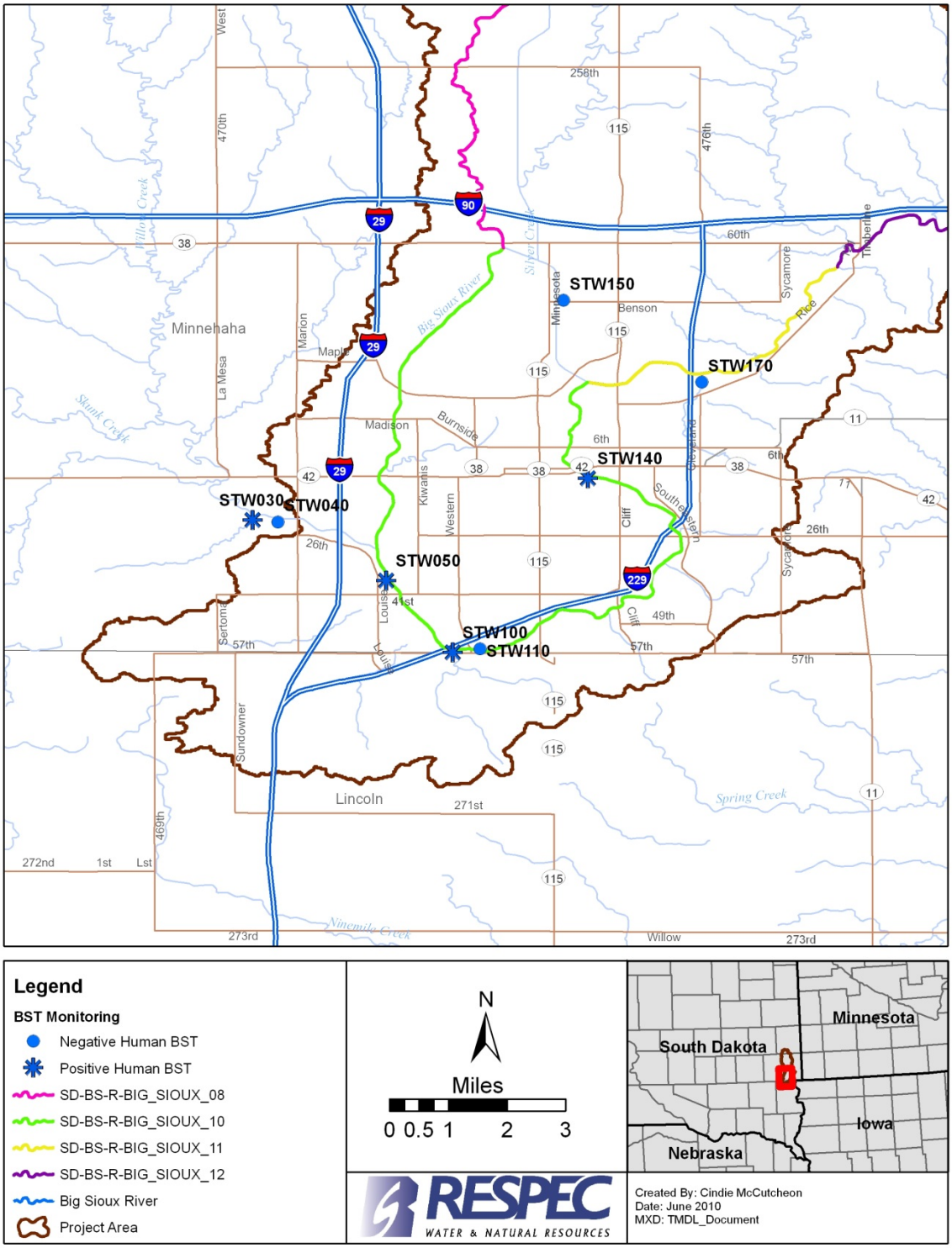


**Figure 3-2.** Bacterial Source Tracking Stations Used Within the Sioux Falls Study Area of the Lower Big Sioux River Watershed.

Sioux Falls MS4 except the Slip-Up Watershed (local Big Sioux River in Reach SD-BS-R-BIG_SIOUX_08) and Silver Creek. A time-series plot of average daily loads by source occurring on each date from 2005 through 2009 was created. Pie charts, shown in Figure 3-4, were then produced for each of the four TMDL endpoints for each source throughout the recreational season. Note that the WLA percent contribution for the non-MS4 point sources was not included in Figure 3-4 because it was insignificant (less than 1 percent of the overall load). Source contributions to SD-BS-R-BIG_SIOUX_08, included in the pie charts, were from the Big Sioux River upstream of the boundary conditions and nonpoint sources. SD-BS-R-BIG_SIOUX_10 loads were primarily from the MS4 and Skunk Creek because most of the Big Sioux River water is diverted around the city. Small percentages of the Reach SD-BS-R-BIG_SIOUX_10 loads were from Big Sioux River boundary conditions and nonpoint sources. Reach SD-BS-R-BIG_SIOUX_11 loads were a combination of the upstream MS4, Skunk Creek, nonpoint sources, Big Sioux River boundary conditions, and the local MS4. Finally, Reach SD-BS-R-BIG_SIOUX_12 loads were attributed to the upstream MS4, Skunk Creek, nonpoint sources, Slip-Up Creek, and Big Sioux River boundary conditions.

**Table 3-3. Results of 2009 Presence/Absence Analysis of *Human Enterococcus Faecium* Gene Biomarker at Eight Urban Stormwater Outfalls in Sioux Falls**

| Project I.D. | Location | Human Enterococcus Biomarker Detection | Result (MPN/ 100 mL)[(a)] |
|---|---|---|---|
| STW030 | Urban Stream Channel near S. Dunham Circle | **Positive** | 9,210 |
| STW040 | Stormwater Channel near W. Silver Valley Drive | Negative | 14,680 |
| STW050 | Storm Drain near PetSmart | **Positive** | 6,490 |
| STW100 | Urban Stream Channel near 57th Street | **Positive** | 9,800 |
| STW110 | Storm Drain in Yankton Trail Park | Negative | 12,030 |
| STW140 | Storm Drain along Beadle Greenway | **Positive** | 14,130 |
| STW150 | Stormwater Channel near E. Benson Road | Negative | 12,030 |
| STW170 | Urban Stream Channel Near E. Rice Street | Negative | 2,990 |

(a) MPN/100 mL = most probable number per 100 milliliters.

Table 3-4 shows both the amount and percentage of reduction required from *E. coli* load contributions for each reach using the average flow simulated and the acute criterion. Source-specific loading targets were established, and the corresponding load departure (simulated load minus target load) was calculated. The table also shows the average daily simulated *E. coli* load

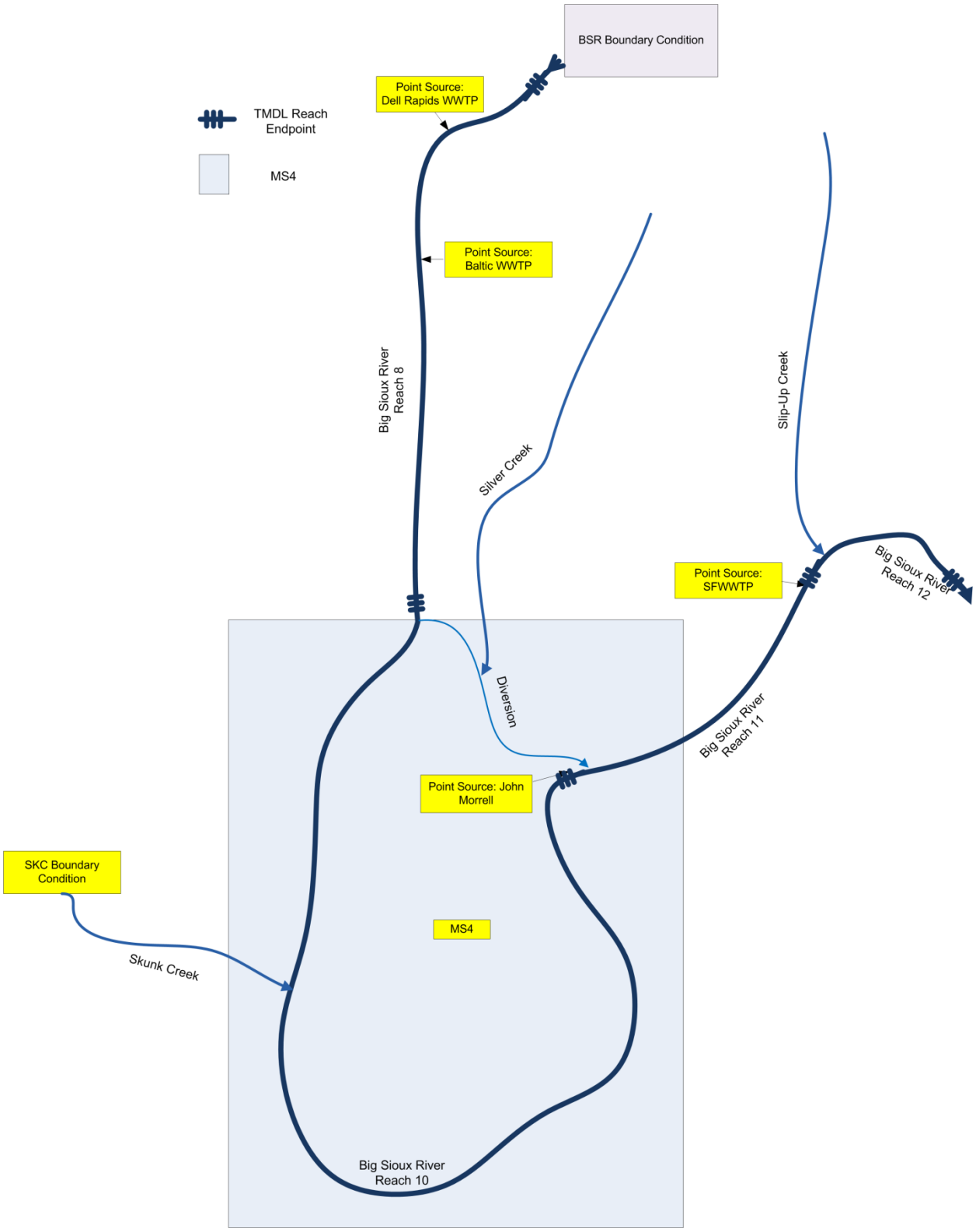


**Figure 3-3.** Diagram of Sources Used in the Source Assessment Pie Charts.

during the recreational season and the average flow simulated during the recreational season that each contribution accounts for. The percent of contribution on a flow volume basis from each source based on model application predictions (percent of reach flow) and the percent contribution on an *E. coli* load basis from each source based on model application predictions (percent of reach load) are also included. Even though nonpoint sources make up over 40 percent of the load contribution in Reach SD-BS-R-BIG_SIOUX_08, they only account for a very small percentage of the flow (4 percent). Thus the bacteria concentration of the nonpoint sources is far higher than the Big Sioux River boundary condition concentration. Similarly, in Reach SD-BS-R-BIG_SIOUX_10, the MS4 and Skunk Creek make up approximately equal portions of the load contribution, but the percentage of flow from the MS4 is far smaller showing that the MS4 has a much greater concentration than Skunk Creek. Required reductions that are based on model predictions tend to be slightly lower for each reach than those calculated based on observed data. This is primarily because of the continuous nature of model predictions as opposed to specific data that often target storm events.

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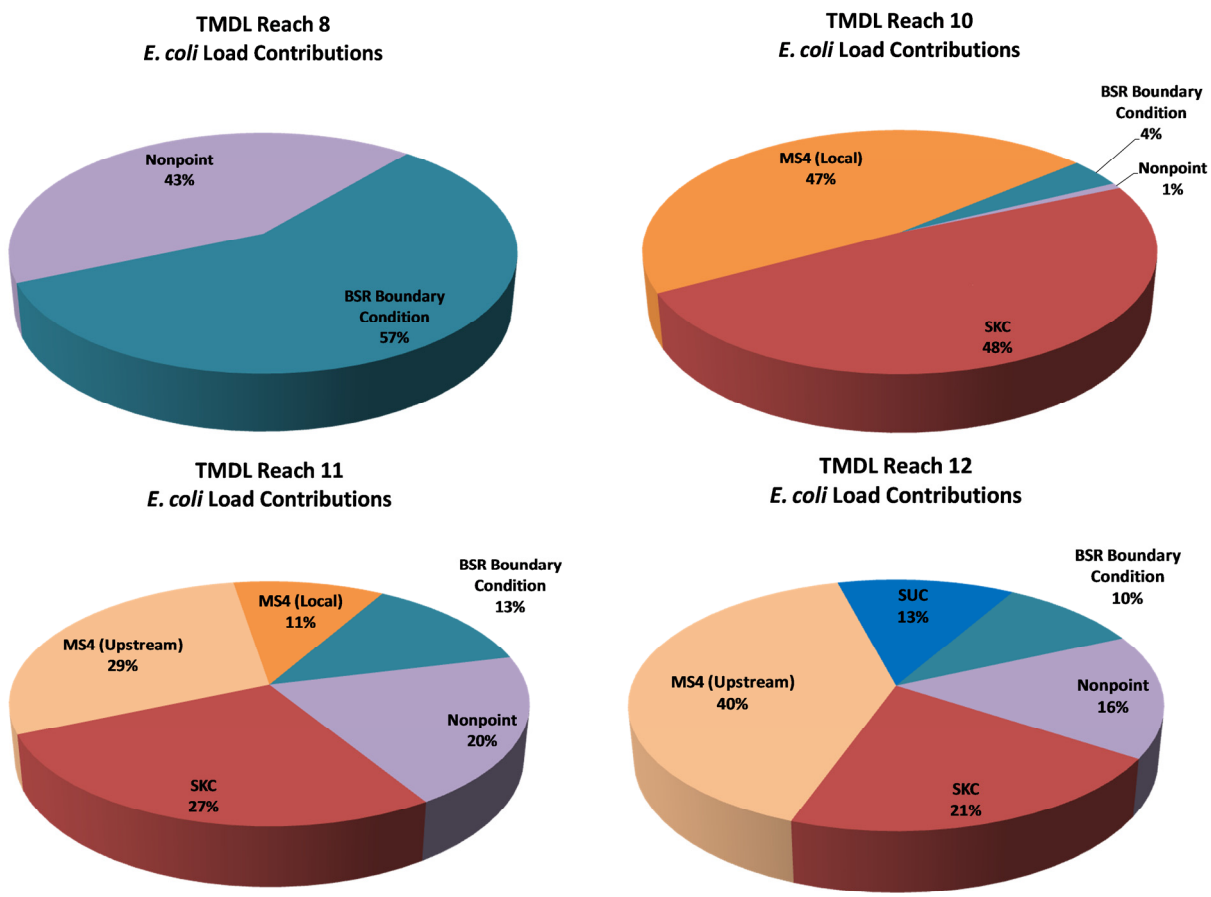


**Figure 3-4.** Source Assessment Modeling Results Within the Sioux Falls Study Area of the Lower Big Sioux River Watershed.

**Table 3-4. Load Reduction in Colony-Forming Units and Percent for Corresponding Sections of Load Contribution Pie Charts (Shown in Figure 3-3)**

| TMDL Reach | Sources | Average Flow (cfs) | % of Reach Flow | Average Load ($10^6$ cfu/day) | % of Reach Load | Load Reduction Required ($10^6$ cfu/day) | Modeled % Reduction Required |
|---|---|---|---|---|---|---|---|
| 8 | Nonpoint – Local Big Sioux River Reach 8 | 18 | 4 | $1.69 \times 10^6$ | **43** | | |
| | BSR BC | 477 | 96 | $2.29 \times 10^6$ | **57** | | |
| | **Total TMDL Reach 8** | | | | | $1.11 \times 10^6$ | 28 |
| 10 | MS4 | 15 | 7 | $3.36 \times 10^6$ | **47** | | |
| | SKC | 125 | 58 | $3.50 \times 10^6$ | **48** | | |
| | Nonpoint– Local Big Sioux River Reach 8 | 8 | 4 | $5.44 \times 10^4$ | **1** | | |
| | BSR BC | 67 | 31 | $2.79 \times 10^5$ | **4** | | |
| | **Total TMDL Reach 10** | | | | | $5.97 \times 10^6$ | 83 |
| 11 | MS4 | 23 | 3 | $4.63 \times 10^6$ | **40** | | |
| | SKC | 125 | 19 | $3.19 \times 10^6$ | **27** | | |
| | Nonpoint– Local Big Sioux River Reach 8 and Silver Creek | 25 | 4 | $2.32 \times 10^6$ | **20** | | |
| | BSR BC | 477 | 73 | $1.50 \times 10^6$ | **13** | | |
| | **Total TMDL Reach 11** | | | | | $7.92 \times 10^6$ | 68 |
| 12 | SUC | 7 | 1 | $1.74 \times 10^6$ | **13** | | |
| | MS4 | 23 | 3 | $5.66 \times 10^6$ | **40** | | |
| | SKC | 125 | 18 | $2.98 \times 10^6$ | **21** | | |
| | Nonpoint– Local Big Sioux River Reach 8 and Silver Creek | 25 | 4 | $2.24 \times 10^6$ | **16** | | |
| | BSR BC | 477 | 70 | $1.39 \times 10^6$ | **10** | | |
| | **Total TMDL Reach 12** | | | | | $1.01 \times 10^7$ | 72 |

Annual loadographs of the MS4 loads for Reaches SD-BS-R-BIG_SIOUX_10 and SD-BS-R-BIG_SIOUX_11 developed from water year 2005 to 2009 predictions are illustrated in Figure 35 and Figure 3-6, respectively. The modeled MS4 loads (maroon lines on the loadographs) were developed as the product of the modeled MS4 flows and the EMCs, and the ideal loads (blue

lines on the loadographs) were developed as the product of the modeled MS4 flows and the Big Sioux River acute *E. coli* criteria of 235 cfu/100 mL. Note that the *E. coli* water-quality standard of 235 cfu/100 mL is not written for the MS4 flows from the city of Sioux Falls. However, if the same standard would be applied to the MS4 flows, the required reduction in bacteria loads from the city, calculated using the graphed loadograph values, would be approximately 97 percent in Reaches SD-BS-R-BIG_SIOUX_10 and SD-BS-R-BIG_SIOUX_11. This is consistent with the concentration data collected at the 11 stormwater outfalls. The average median of these sites during events was 9,370 cfu/100 mL, and this indicates an approximate 97.5 percent reduction is required on a concentration basis during events.

Model results showed that if a 75 percent removal efficiency was implemented on 100 percent of the MS4 area, the percent exceedance of the daily maximum concentration criteria would decrease by only 8 percent within Reaches SD-BS-R-BIG_SIOUX_10 and SD-BS-R-BIG_SIOUX_11. The same removal efficiency on the entire MS4 area would, however, decrease the load by 30 percent and 24 percent in these reaches, respectively. This indicates that *E. coli* removal in runoff from the city would have a fairly large impact on load reduction but a fairly small impact on overall Big Sioux River *E. coli* concentrations. The reason for the differences in the impacts is because the largest loadings occur during significant rainfall events (greater than 0.1 inch) that only occur approximately 42 times per year. During the remaining 323 days of the year, bacteria loading and associated concentrations are driven by sources outside the MS4 boundary. Thus water-quality trading options and a more detailed cost/water-quality benefit ratio of BMP implementation, using the data found in this study, are needed for the Sioux Falls project area to ensure that loading and concentration goals are realized.

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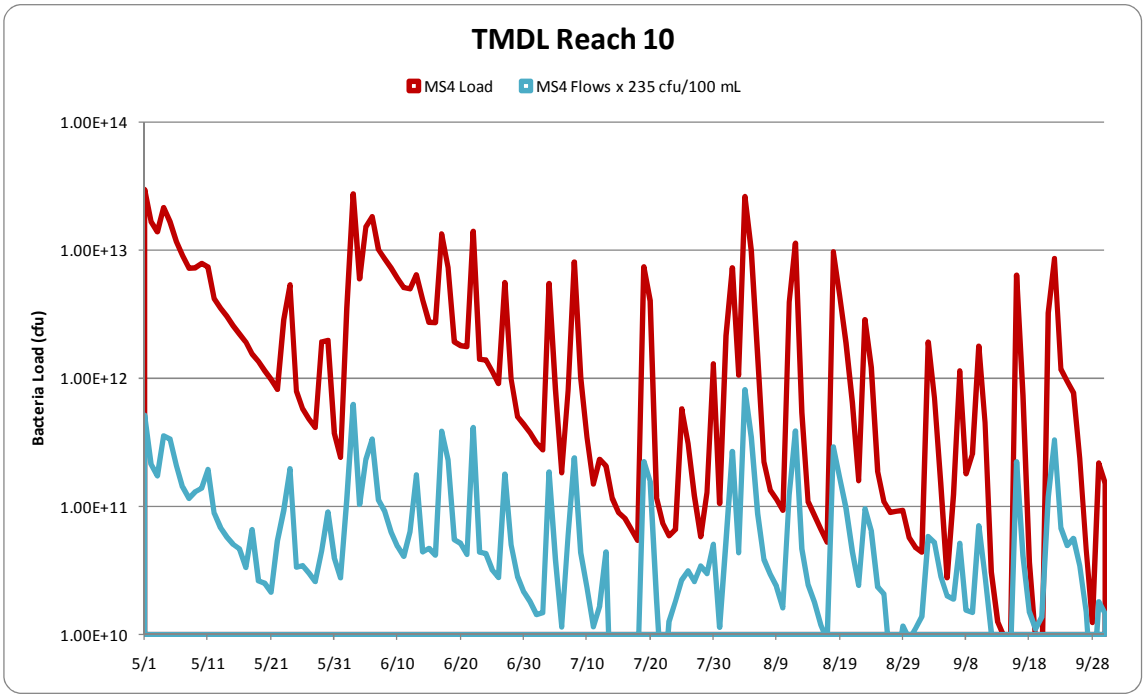


**Figure 3-5.** Time-Series of Average Daily MS4 Load and the Product of MS4 Flows and the Acute Criteria in Reach SD-BS-R-BIG_SIOUX_10.

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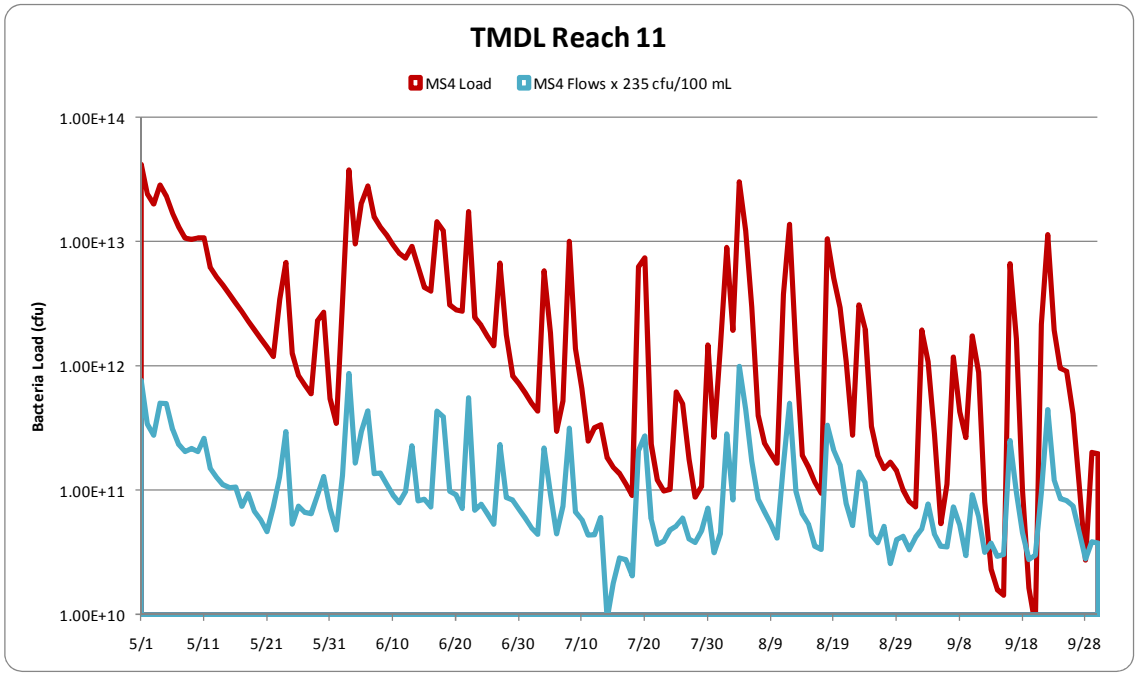


**Figure 3-6.** Time-Series of Average Daily MS4 Load and the Product of MS4 Flows and the Acute Criteria in Reach SD-BS-R-BIG_SIOUX_11.

# 4.0 TECHNICAL ANALYSES

The TMDL was developed using the load duration curve (LDC) approach and resulted in a flow variable target that considers the entire flow regime within the recreational season (May 1–September 30). The LDC is a dynamic expression of the allowable daily load for any given flow within the recreational season. To interpret and implement the TMDL, the LDC flow intervals were grouped into five flow zones: high flows (0–10 percent), moist conditions (10–40 percent), midrange flows (40–60 percent), dry conditions (60–90 percent), and low flows (90–100 percent) according to the U.S. Environmental Protection Agency [2007].

According to conclusions drawn from 2009 mainstem, tributary, and stormwater sites discussed in Section 1.3 and based on the boxplots in Figures 1-6 through 1-11, bacteria loads in the Big Sioux River Basin in Sioux Falls seem to be more of an acute, stormwater-related problem than a chronic problem. Comparing required acute load reductions with required geometric mean load reductions confirms this statement, because required acute load reductions are higher. LDCs corroborate that bacteria loads in this watershed are generally higher during higher flow conditions, which generally reflect potential indirect source contributions from stormwater runoff [U.S. Environmental Protection Agency, 2007]. Loads exceeding the criteria more often in the low flow zone would indicate potential direct source load contributions or sources in close proximity to the stream, such as failing septic systems or livestock in the stream channel, while those farther left on the plot indicate nonpoint source load contributions [U.S. Environmental Protection Agency, 2007]. For the purpose of this report, critical criteria were defined as the criteria (daily maximum or geometric mean) requiring the highest amount of reduction. Thus the decision to set the critical criteria for these bacteria TMDL to the daily maximum criteria was made, and they are presented in the LDCs and the TMDL tables in this report. However, a chronic problem exists in the project as well. Thus geometric mean-based LDCs can be found in Appendix A. Addressing the acute impairment will resolve the chronic issues.

Using the acute criteria bacteria LDCs were constructed for each bacteria-impaired reach of the Big Sioux River within the project area (SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12). The LDC for each reach includes two curves where the MS4 is applicable and one curve where the MS4 is not. The upper curve represents loading capacity within each reach and was constructed using the product of simulated flow at respective TMDL endpoints, the daily maximum bacteria criteria, and a unit conversion factor. The lower curve represents the WLA and includes both permitted point-source loads and the MS4 load. MS4 loads directly drain to only the two middle reaches, SD-BS-R-BIG_SIOUX_10 and SD-BS-R-BIG_SIOUX_11. Thus, the WLA line, including the MS4, is not included on the SD-BS-R-BIG_SIOUX_08 or SD-BS-R-BIG_SIOUX_12 LDCs. The dotted line across the lower portion of the LDC represents the point-source load for the reach. The MS4 is the only point-source load within Reach SD-BS-R-BIG_SIOUX_10. The space

between the WLA curve and the dotted line (point-source load) represents the NPDES MS4 load, which was calculated using the HSPF model application and the following assumptions:

1. The MS4 load component of the WLA will be flow variable.
2. The existing load allocation (LA) and WLA both require reductions to be achieved in Reaches SD-BS-R-BIG_SIOUX_10 and SD-BS-R-BIG_SIOUX_11.
3. Under the future TMDL, the MS4 will continue to have approximately the same contribution to the total load on a percentage basis but at a reduced amount.

Thus the MS4 load was calculated as a percentage of the difference between the TMDL, the margin of safety (MOS), and the point-source load in each flow zone with that percentage estimated as the existing load shown in Figure 3-4. Points plotted within the LDC for each reach include observed loads that were calculated using observed bacteria (*E. coli* and transformed fecal coliform concentration where *E. coli* was not available [Equation 1-1]) and flow data (observed and simulated where observed was unavailable) from monitoring stations. The locations of the water-quality monitoring sites where observed data were collected on the Big Sioux River are provided in Figure 1-3. Observed bacteria data collected between 2000 and 2009 were applied to the LDC of the reach in which they were collected. Water-quality monitoring sites and flow monitoring sites used to develop the LDCs are provided in Table 4-1. Because Reaches SD-BS-R-BIG_SIOUX_08 and SD-BS-R-BIG_SIOUX_12 do not include local MS4 areas, MS4 allocations or reductions are not required in these reaches.

**Table 4-1. Water-Quality Monitoring Sites and Flow Monitoring Sites Providing Data For Developing Load Duration Curves**

| Reach | *E. coli* Sites Used | Flow Sites Used |
|---|---|---|
| SD-BS-R-BIG_SIOUX_08 | BSR020 | Simulated Flow Only |
| SD-BS-R-BIG_SIOUX_10 | BSR050 | USGS 06482000 and Simulated Flow |
| | BSR060 | |
| | BSR070 | |
| SD-BS-R-BIG_SIOUX_11 | BSR080 | USGS 06482020 |
| | BSR090 | |
| SD-BS-R-BIG_SIOUX_12 | BSR100 | Simulated Flow Only |

When the instantaneous loads are plotted on the LDC, characteristics of the water-quality impairment are illustrated. Instantaneous loads that plot above the solid curve are exceeding the daily maximum water-quality criterion, while those below the curve are in compliance.

As the daily maximum criterion-based LDCs in Figures 4-1 through 4-4 show, exceedance of the daily maximum criterion occurred during all flow conditions in all four TMDL reaches SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12).

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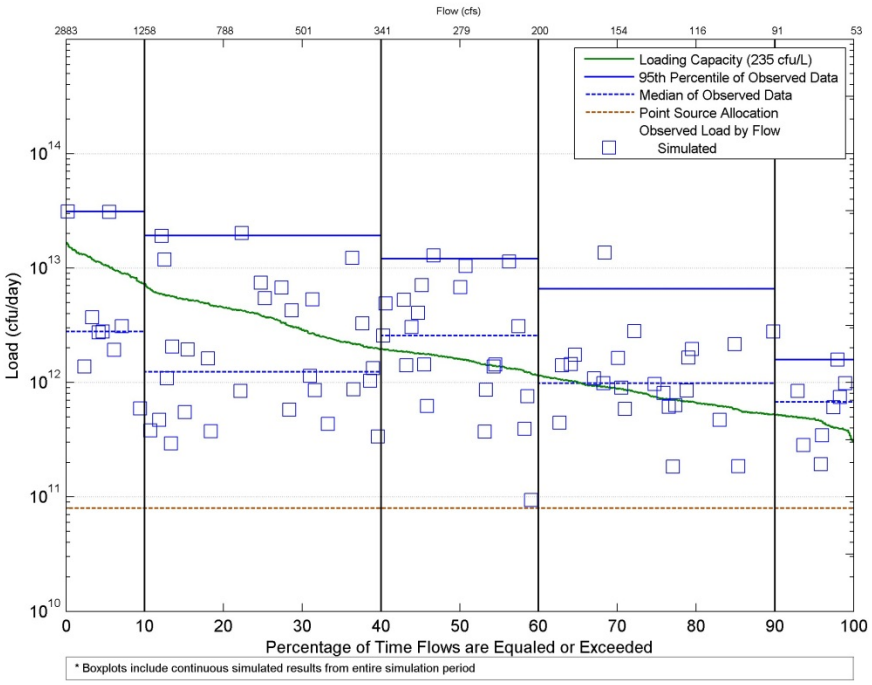


**Figure 4-1.** Reach SD-BS-R-BIG_SIOUX_08 Load Duration Curve Representing Allowable Daily *E. coli* Loads Based on Daily Maximum *E. coli* Criteria.

The LDCs shown in Figures 4-1 through 4-4 represent dynamic expressions of the *E. coli* bacteria TMDLs for Big Sioux River reaches that are based on the daily maximum *E. coli* criterion. These LDCs result in unique loads that correspond to measured and simulated average daily flows. The "simulated," "daily average," and "instantaneous" labels in the LDC legends apply to flow. The "simulated" label implies that paired flow data were not available for the sample, so simulated flow was used to determine the flow regime. The "instantaneous" label was used when a flow measurement occurred at the instant that the water-quality sample was taken. The "daily average" label was used when the daily average USGS flow was the only method available for estimating flow. Instantaneous and daily average flows were applied to the LDC of the reach in which they were collected.

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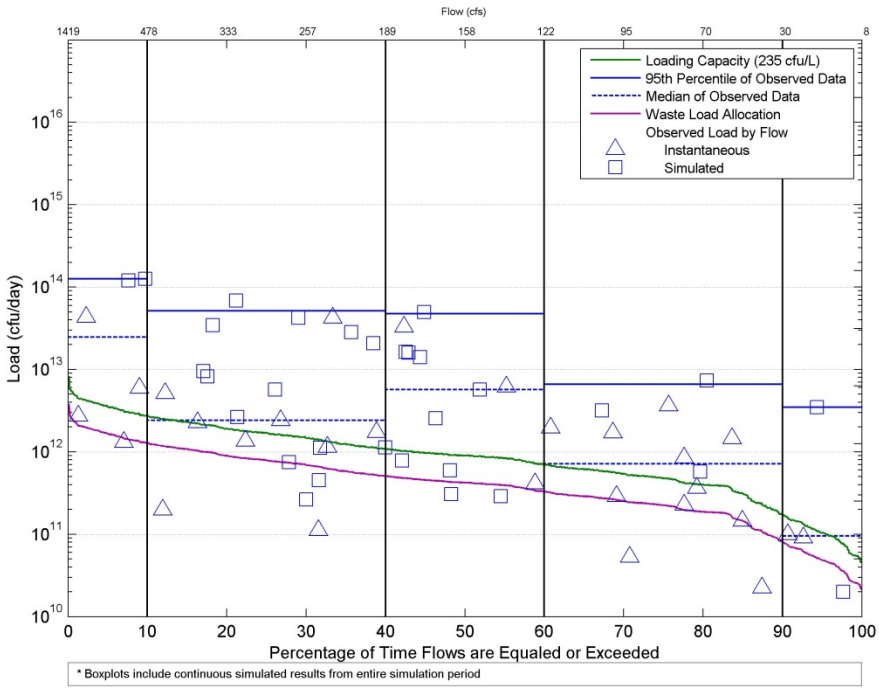


**Figure 4-2.** Reach SD-BS-R-BIG_SIOUX_10 Load Duration Curve Representing Allowable Daily *E. coli* Loads Based on Daily Maximum *E. coli* Criteria.

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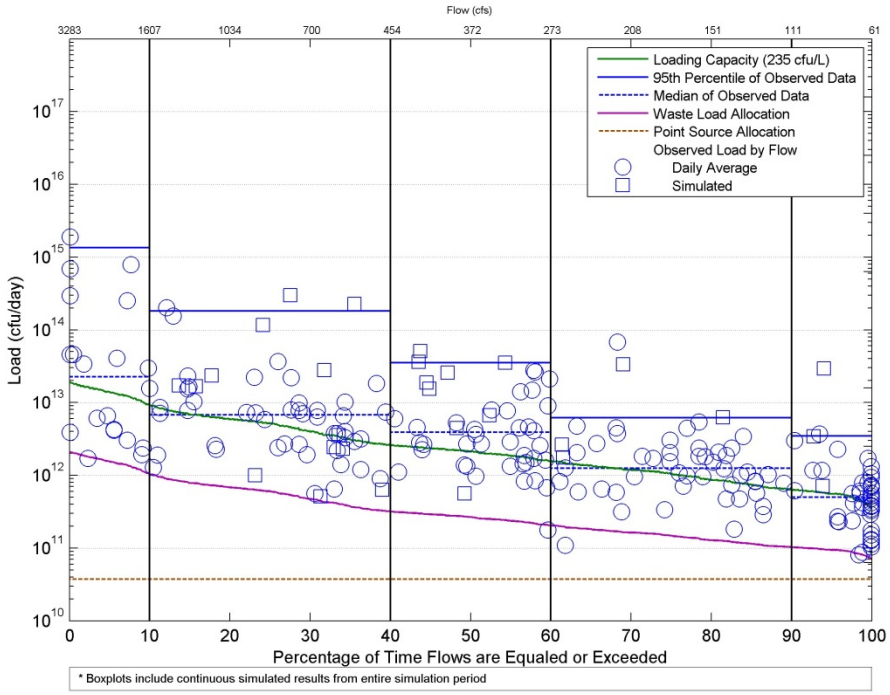


**Figure 4-3.** Reach SD-BS-R-BIG_SIOUX_11 Load Duration Curve Representing Allowable Daily *E. coli* Loads Based on Daily Maximum *E. coli* Criteria.

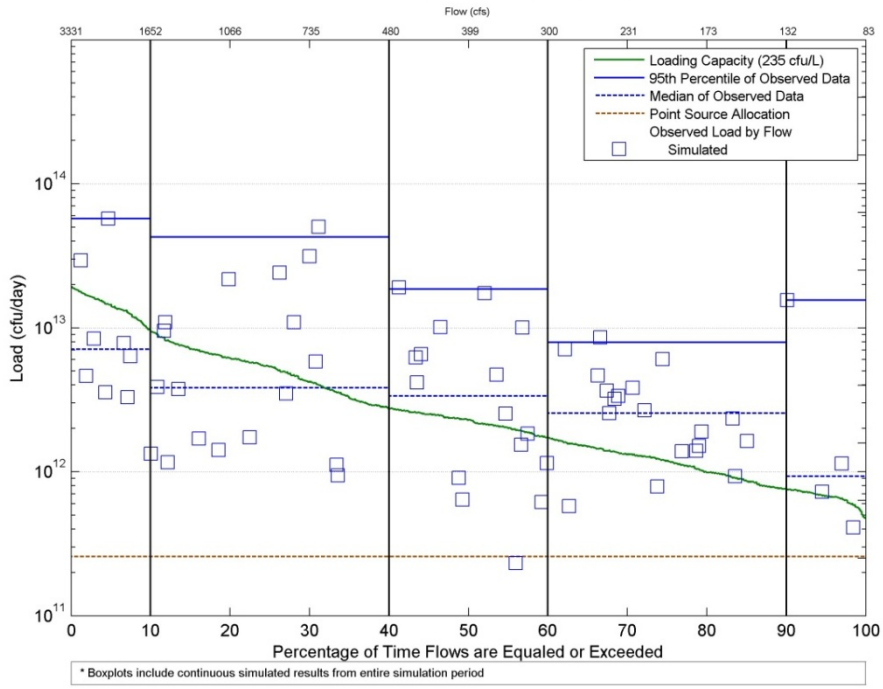


**Figure 4-4.** Reach SD-BS-R-BIG_SIOUX_12 Load Duration Curve Representing Allowable Daily *E. coli* Loads Based on Daily Maximum *E. coli* Criteria.

# 5.0 TOTAL MAXIMUM DAILY LOAD AND ALLOCATIONS

To ensure that all applicable *E. coli* criteria are met and to aid in the implementation of the TMDL, load allocations were calculated for each of the five flow zones using both the daily maximum and geometric mean criteria. As mentioned earlier, the critical criteria for this TMDL are daily maximum criteria because bacteria in the Big Sioux River Basin in the Sioux Falls area were shown to be a highly acute, stormwater-related problem. Thus the TMDL tables are focused on the acute reduction required to meet daily maximum *E. coli* criteria.

TMDL tables were constructed using observed flows (and simulated flows when observed flows were unavailable) and observed bacteria concentrations from water-quality monitoring stations within each reach. Methods used to calculate the TMDL allocations are discussed in detail in this chapter. The TMDL is in effect from May 1 through September 30, because the *E. coli* criteria are applicable only during this period. In addition, only data from this time period were used to develop the TMDL allocations and load reduction goals.

The 95$^{th}$ percentile of the range of loading capacities within a zone was set as the flow zone goal for each of the five flow zones. Bacteria loads experienced during the largest stream flows (e.g., top 5 percent) cannot be feasibly controlled by practical management practices. Thus setting the flow zone goal at the 95$^{th}$ percentile of the range of loading capacities will protect the immersion recreation beneficial use and allow for the natural variability of the system.

## 5.1 LOAD ALLOCATION

The TMDL (loading capacity) is the sum of the LA, WLA, and MOS. To develop the *E. coli* bacteria LA for each of the four TMDL reaches, the loading capacity was first determined using the data sources specified. The daily maximum criterion (235 cfu/ 100 mL) was used to calculate the daily maximum loading capacities, and the geometric mean criterion (126 cfu/100 mL) was used to calculate the geometric mean loading capacities. The loading capacities for the Big Sioux River were calculated by multiplying the specified *E. coli* bacteria criterion by the flow. Portions of the loading capacity were allocated to nonpoint sources as an LA and an MOS to account for uncertainty in the calculations of these load allocations.

## 5.2 WASTE LOAD ALLOCATION

Multiple point sources of *E. coli* bacteria discharge directly to the impaired reaches of the Big Sioux River within the Sioux Falls project area. Point-source discharges also exist upstream of the impaired reaches. These discharges are indirectly accounted for through the use of boundary condition loads. Bacteria loads from these facilities probably do not have a large impact on the impaired reaches of the Big Sioux River because of the travel time and decay

rates of the bacteria in addition to the relatively small loads of facilities; e.g., lagoons. These facilities should not cause exceedance of those standards because bacterial limits are set at the water-quality standard. There are currently 13 concentrated animal feeding operations (CAFOs) in Minnehaha County. CAFOs may exist within the watershed boundaries of Reaches 8, 11, and 12 because agricultural land is present. Note, however, that all of these permitted facilities have a zero discharge except in the rare case of a precipitation event that produces a volume of water greater than the design capacity of the facility. In this case, the permittee is required to notify the SD DENR and develop a plan of action to remediate the problem.

The WLA for the Sioux Falls TMDL is the sum of the point source allocations (PSAs) within each reach and MS4 loads. Details regarding the MS4 loads were provided in Chapter 4.0. The PSAs based on the acute and chronic criteria as well as the model-generated MS4 percentage are shown in Table 5-1. TMDL tables use this percentage to estimate the MS4 loads by flow zone.

**Table 5-1. Big Sioux River *E. coli* Wasteload Allocations and MS4 Percentage**

| Reach | PSA | PSA TMDL Table I.D. | *E. coli* Acute PSA (cfu/day) | *E. coli* Chronic PSA (cfu/day) | MS4 % of (TMDL–PSA) |
|---|---|---|---|---|---|
| SD-BS-R-BIG_SIOUX_08 | Dell Rapids WWTP | PSA 1 | $3.89 \times 10^{10}$ | $2.09 \times 10^{10}$ | 0 |
| SD-BS-R-BIG_SIOUX_08 | Baltic WWTP | PSA 2 | $4.06 \times 10^{10}$ | $2.18 \times 10^{10}$ | 0 |
| SD-BS-R-BIG_SIOUX_10 | N/A | N/A | 0 | 0 | 47% |
| SD-BS-R-BIG_SIOUX_11 | John Morrell & Company | PSA 3 | $3.74 \times 10^{10}$ | $2.00 \times 10^{10}$ | 11% |
| SD-BS-R-BIG_SIOUX_12 | Sioux Falls WWTP | PSA 4 | $2.57 \times 10^{11}$ | $1.38 \times 10^{11}$ | 0 |

## 5.3 MARGIN OF SAFETY

An explicit MOS identified using a duration curve framework is unallocated assimilative capacity intended to account for uncertainty (e.g., loads from tributary streams and effectiveness of controls). An explicit MOS was calculated as the difference between the loading capacity at the midpoint of each of the five flow zones and the loading capacity at the minimum flow in each zone. A substantial MOS is provided using this method, because the loading capacity is typically much less at the minimum flow of a zone than the midpoint. Because the allocations are a direct function of flow, accounting for potential flow variability is an appropriate way to address the MOS.

## 5.4 BASELINE CONDITIONS

Measured sample concentrations and flow data were used to estimate current daily loads (cfu × $10^9$/day) by calculating the product of *E. coli* sample concentrations and transformed fecal coliform sample concentrations (cfu/100 mL) from monitoring sites, the measured flow (cubic feet per second [cfs]) from monitoring sites, and a unit conversion factor (0.0245). The $95^{th}$ percentile of the range of these estimates within each flow zone was defined as the baseline daily load.

Although geometric mean data are not presented in this report, geometric means were calculated and have a lower, overall reduction required to meet load requirements. To estimate current monthly geometric mean loads (cfu × $10^9$/day), the product of the simulated average geometric mean concentrations (cfu/100 mL) and simulated 30-day geometric mean stream flows (cfs) for reach endpoints was multiplied by a conversion factor (0.0245). The $95^{th}$ percentile of the range of these estimates within each flow zone was defined as the baseline 30-day geometric mean load. Geometric mean-based TMDL tables are provided in Appendix B.

Tables 5-2 through 5-5 present load allocations for Reaches SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12 based on the daily maximum criterion for each flow zone. The PSAs from each table are described in Table 5-1. The load allocation tables indicate that load reductions are required for all flow zones in all reaches. Higher load reductions are required in the upper flow zones for Reaches 10 and 11 through the city where loads are the highest, which corroborates that stormwater sources are a key concern in this system.

The flow-weighted percent reductions for all combined flow zones required to meet the TMDL based on the acute water-quality criteria were 69 percent in Reach SD-BS-R-BIG_SIOUX_08, 97 percent in Reach SD-BS-R-BIG_SIOUX_10, 97 percent in Reach SD-BS-R-BIG_SIOUX_11, and 79 percent in Reach SD-BS-R-BIG_SIOUX_12 (observed acute data). The combined flow-weighted percent reductions required (for all flow zones combined) to meet the TMDL based on the chronic water-quality criteria were 63 percent in Reach SD-BS-R-BIG_SIOUX_08, 92 percent in Reach SD-BS-R-BIG_SIOUX_10, 79 percent in Reach SD-BS-R-BIG_SIOUX_11, and 83 percent in Reach SD-BS-R-BIG_SIOUX_12 (simulated chronic data). The acute reductions are higher for all flow zones except Reach SD-BS-R-BIG_SIOUX_12, which verifies the use of acute TMDL reductions for this TMDL.

According to the U.S. Environmental Protection Agency [2007], the high- and low-flow hydrologic conditions should not be selected as critical conditions because these extreme flows do not represent typical conditions.

**Table 5-2. Big Sioux River *E. coli* Bacteria Total Maximum Daily Load Based on the Daily Maximum Criterion for Reach SD-BS-R-BIG_SIOUX_08**

| TMDL Component (cfu × $10^9$/day) | | Flow Zone | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High | | Moist | | Midrange | | Dry | | Low | |
| | | > 1,259 cfs | | 1,259–341 cfs | | 341–201 cfs | | 201–91 cfs | | < 91 cfs | |
| LA | | 11,705 | | 4,180 | | 1,383 | | 806 | | 267 | |
| PSA 1 | WLA | 41 | 80 | 41 | 80 | 41 | 80 | 41 | 80 | 41 | 80 |
| PSA 2 | | 39 | | 39 | | 39 | | 39 | | 39 | |
| MS4 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| MOS | | 3,386 | | 1,833 | | 451 | | 216 | | 174 | |
| TMDL | | 15,171 | | 6,093 | | 1,914 | | 1,102 | | 521 | |
| Current Load[(a)] | | 31,232 | | 19,174 | | 12,020 | | 6,608 | | 1,586 | |
| Load Reduction | | 16,061 | | 13,082 | | 10,106 | | 5,506 | | 1,065 | |
| Load Reduction | | 51% | | 68% | | 84% | | 83% | | 67% | |

(a) Current load is the 95th percentile of the observed daily maximum *E. coli* bacteria load for each flow zone.

**Table 5-3. Big Sioux River *E. coli* Bacteria Total Maximum Daily Load Based on the Daily Maximum Criterion for Reach SD-BS-R-BIG_SIOUX_10**

| TMDL Component (cfu × $10^9$/day) | | Flow Zone | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High | | Moist | | Midrange | | Dry | | Low | |
| | | > 479 cfs | | 479–189 cfs | | 189–122 cfs | | 122–30 cfs | | < 30 cfs | |
| LA | | 2,454 | | 1,037 | | 453 | | 188 | | 55 | |
| No PSA | WLA | 0 | 2,176 | 0 | 920 | 0 | 402 | 0 | 167 | 0 | 49 |
| MS4 | | 2,176 | | 920 | | 402 | | 167 | | 49 | |
| MOS | | 782 | | 607 | | 205 | | 308 | | 58 | |
| TMDL | | 5,412 | | 2,564 | | 1,060 | | 663 | | 162 | |
| Current Load[(a)] | | 119,566 | | 97,202 | | 44,018 | | 6,605 | | 3,482 | |
| Load Reduction | | 114,154 | | 94,638 | | 42,958 | | 5,941 | | 3,320 | |
| Load Reduction | | 95% | | 97% | | 98% | | 90% | | 95% | |

(a) Current load is the 95th percentile of the observed daily maximum *E. coli* bacteria load for each flow zone.

**Table 5-4. Big Sioux River *E. coli* Bacteria Total Maximum Daily Load Based on the Daily Maximum Criterion for Reach SD-BS-R-BIG_SIOUX_11**

| TMDL Component (cfu × $10^9$/day) | | Flow Zone | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High | | Moist | | Midrange | | Dry | | Low | |
| | | > 1,656 cfs | | 1,656–455 cfs | | 455–275 cfs | | 275–112 cfs | | < 112 cfs | |
| LA | | 12,302 | | 5,069 | | 1,738 | | 942 | | 342 | |
| PSA 3 | WLA | 37 | 1,558 | 37 | 664 | 37 | 252 | 37 | 154 | 37 | 80 |
| MS4 | | 1,521 | | 627 | | 215 | | 116 | | 42 | |
| MOS | | 4,358 | | 2,608 | | 559 | | 413 | | 210 | |
| TMDL | | 18,218 | | 8,341 | | 2,549 | | 1,509 | | 632 | |
| Current Load[(a)] | | 1,250,608 | | 148,000 | | 33,968 | | 4,970 | | 1,457 | |
| Load Reduction | | 1,232,390 | | 139,659 | | 31,419 | | 3,461 | | 825 | |
| Load Reduction | | 99% | | 94% | | 92% | | 70% | | 57% | |

(a) Current load is the 95th percentile of the observed daily maximum *E. coli* bacteria load for each flow zone.

**Table 5-5. Big Sioux River *E. coli* Bacteria Total Maximum Daily Load Based on the Daily Maximum Criterion for Reach SD-BS-R-BIG_SIOUX_12**

| TMDL Component (cfu × $10^9$/day) | | Flow Zone | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High | | Moist | | Midrange | | Dry | | Low | |
| | | > 1,703 cfs | | 1703–480 cfs | | 480–301 cfs | | 301–133 cfs | | <133 cfs | |
| LA | | 13,617 | | 5,708 | | 1,882 | | 957 | | 291 | |
| PSA 4 | WLA | 257 | 257 | 257 | 257 | 257 | 257 | 257 | 257 | 257 | 257 |
| MS4 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| MOS | | 4,655 | | 2,627 | | 564 | | 432 | | 203 | |
| TMDL | | 18,529 | | 8,592 | | 2,703 | | 1,646 | | 751 | |
| Current Load[(a)] | | 57,423 | | 42,665 | | 18,602 | | 7,906 | | 15,584 | |
| Load Reduction | | 38,894 | | 34,073 | | 15,899 | | 6,260 | | 14,833 | |
| Load Reduction | | 68% | | 80% | | 85% | | 79% | | 95% | |

(a) Current load is the 95th percentile of the observed daily maximum *E. coli* bacteria load for each flow zone.

# 6.0 SEASONALITY

Stream flows and *E. coli* concentrations in the Big Sioux River showed seasonal variation. Available *E. coli* data were used to calculate monthly median bacteria concentrations for five Big Sioux River project sites. Figure 6-1 depicts higher *E. coli* concentrations during the spring, summer, and early fall. Maximum and minimum average monthly flows for the recreational season were calculated for four project sites and are listed in Table 6-1. Flows were typically highest during spring and early summer and lowest during late summer and fall.

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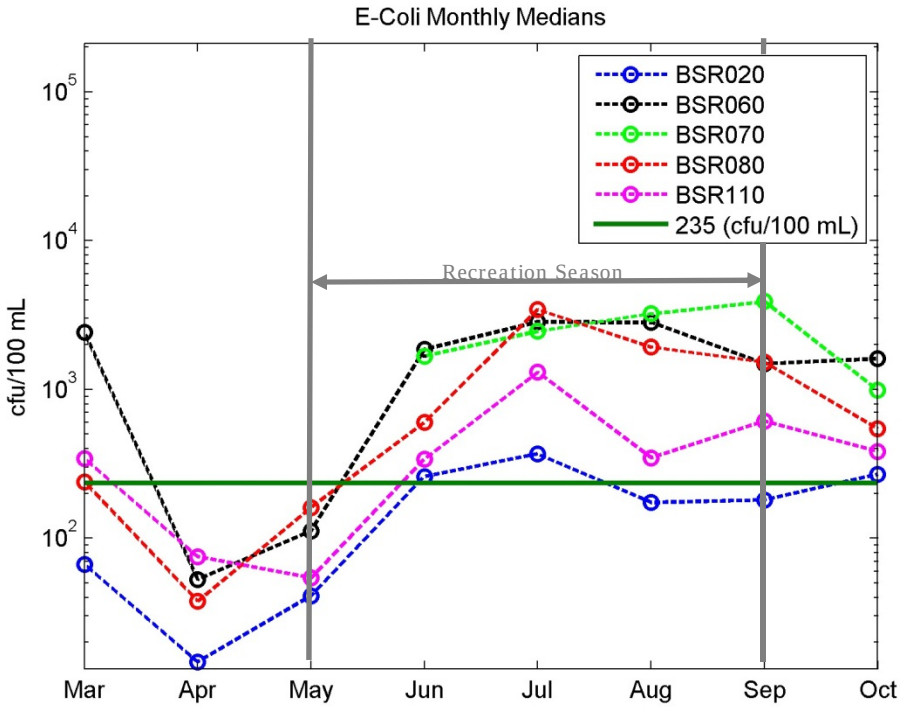


**Figure 6-1.** Monthly Median *E. coli* Concentrations From Additional 2009 RESPEC Data.

The highest bacteria concentrations generally occur during the recreational season. Short-duration, high-intensity rainstorms are common during the summer months. These localized summer storms can cause significant runoff and increased bacteria concentrations for a relatively short period of time while only slightly increasing stream flows. However, by developing the TMDL allocations with the LDC approach, seasonal variability in flow and *E. coli* loads are taken into account, because stream flow and bacteria delivery to the stream are related to seasonal changes in precipitation.

**Table 6-1. Big Sioux River Maximum and Minimum Monthly Average Recreational Season Flows**

| Project I.D. | Maximum Monthly Average Flow | Minimum Monthly Average Flow |
|---|---|---|
| BSR010 | 895 cfs (May) | 145 cfs (August) |
| BSR040 | 102 cfs (June) | 16 cfs (August) |
| BSR060 | 378 cfs (June) | 76 cfs (August) |
| BSR080 | 1,370 cfs (May) | 96 cfs (September) |

This *E. coli* bacteria TMDL is seasonal because it is effective only during the period of May 1 through September 30; therefore, the TMDL is also applicable only during this time period. Summer is also a critical time period because of seasonal differences in precipitation patterns and land uses. Typically, livestock are allowed to graze along the streams during the summer months. The combination of a peak in bacteria sources and the high-intensity rainstorm events common during the summer produces a significant amount of *E. coli* load because of bacterial washoff from the watershed.

# 7.0 PUBLIC PARTICIPATION

During the Big Sioux River *E. coli* bacteria TMDL development, efforts focused on public education, review, and comment. The findings of the assessment were provided to local groups in the watershed, and a 30-day public notice period was provided for public review and comment. The results of these public meetings and comments were considered when developing the TMDLs. The public notice was published in the *Sioux Falls Argus Leader* and the *Dell Rapids Tribune*. The document was also made available through the SD DENR's website.

Several meetings and presentations were held for the Steering Committee (March and April 2009 regarding Sioux Falls land use, November 2009 regarding monitoring, and October 2010 regarding modeling). Steering Committee members include Mr. Robert Kappel and Mr. Andy Berg (City of Sioux Falls), Mr. John Meyer (John Morrell & Company), Ms. Deb Springman (EDWDD), and Mr. Rich Hanson and Ms. Kelli Buscher (SD DENR). Regular updates were provided to the Public Works Department, the City of Sioux Falls, EDWDD, John Morrell & Company, and the SD DENR. Two public meetings were held at the Kuehn Community Center in Sioux Falls as part of this project (May and November 2009), and one public meeting was held at the Sioux Falls Main Public Library (November 2010). Additionally, presentations were given at the annual Western South Dakota Hydrology Conference (WSDHC) and the Eastern South Dakota Water Conference (ESDWC). Scientists and engineers from the Midwest with a background in water quality and stream health regularly attend these conferences in addition to many local stakeholders. The project team provided project updates to the professional and stakeholder communities and received comments during on the technical aspects of the project during the conference. A TMDL website has been available since March 2009, and an EPA MS4 workshop was held in July 2009. A public education video is available online (*www.siouxfalls.org/CityLink16/Programs/Feature_Programs/tmdl_project*). A timeline of all events relating to this TMDL is shown in Figure 7-1.

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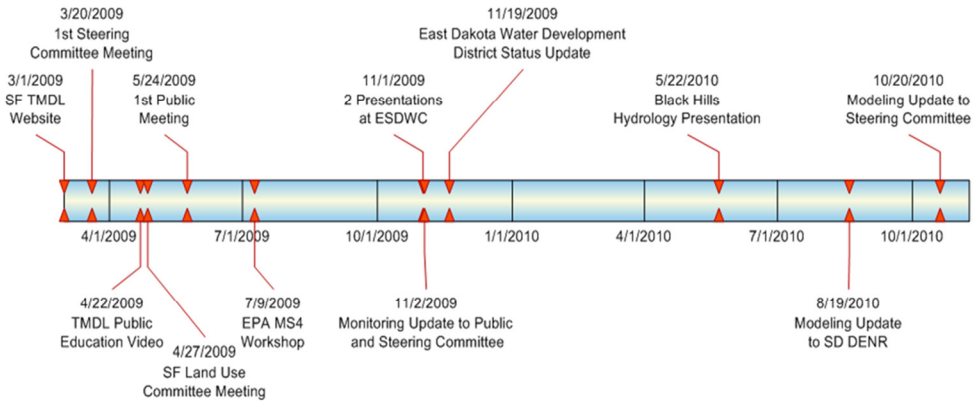


**Figure 7-1.** Timeline of Public Events.

# 8.0 MONITORING STRATEGY

During and after implementing management practices, monitoring will be necessary to ensure that the TMDL goals are attained. SD DENR's ambient water-quality monitoring stations on the Big Sioux River will be used to monitor stream water quality. These stations are sampled on a monthly basis during the recreational season.

Additional monitoring and evaluation efforts should be used to implement effective BMPs. Monitoring locations should be based on the location and the type of BMPs installed.

SD DENR may adjust the load and/or wasteload allocations during the implementation phase of the TMDL as additional information or circumstances develop. Additional information may include monitoring data and BMP effectiveness information and land use information. SD DENR will propose adjustments only in the event that any adjusted LA or WLA will not result in a change to the loading capacity. The adjusted TMDL, including the WLAs and LAs, will be set at a level necessary to implement the applicable water-quality standards, and any adjusted WLA will be supported by a demonstration that load allocations are practicable. SD DENR will notify the EPA of any adjustments to this TMDL within 30 days of their adoption. Adjustment of the load and WLA will be made only after the public has an opportunity to participate.

# 9.0 RESTORATION STRATEGY

## 9.1 SIMULATED MANAGEMENT SCENARIOS

A variety of BMPs could be considered when developing a water-quality management implementation plan in the project area. While several types of control measures are available for reducing *E. coli* bacteria loads, the practicable control measures listed and discussed below are recommended to address the identified sources in the Sioux Falls area. Based on water-quality monitoring, bacterial source tracking, and HSPF model results, it is reasonable that the recommended control measures to be implemented in Sioux Falls are expected to reduce exceedances of the acute *E. coli* criteria from 74 percent (current exceedance) to 3 percent in Reach SD-BS-R-BIG_SIOUX_08, from 90 percent to 4 percent in Reach SD-BS-R-BIG_SIOUX_10, from 80 percent to 4 percent in Reach SD-BS-R-BIG_SIOUX_11, and from 76 percent to 6 percent in Reach SD-BS-R-BIG_SIOUX_12. These load reductions will assist in attaining of the TMDL goals.

The seven management scenarios that were simulated for each bacteria-impaired reach using the HSPF model include the incorporation of the following: (1) future land use, (2) the city's planned BMPs, (3) Big Sioux River upstream of Dell Rapids and Skunk Creek compliance with the current limited recreation acute water-quality standard, (4) Big Sioux River upstream of Dell Rapids and Skunk Creek compliance with the immersion recreation acute water-quality standard, (5) change of flow routing down the Big Sioux River and the diversion (minimum flow through the city maintained at 400 cfs), (6) 90 percent load reduction on agricultural land within the project area boundary north of Sioux Falls local to the Big Sioux River and Silver Creek, and (7) an *E. coli* reduction of 75 percent on 100 percent of the MS4. Modeled percent exceedance of the daily maximum criteria, individual load reduction results, and cumulative load reduction results are presented in the first, second, and third rows, respectively, of each reach's TMDL endpoint in Table 9-1.

Model results are discussed individually by scenario and indicate that implementing future Sioux Falls land use (Scenario 1) would result in load reductions of 0 percent for Reach SD-BS-R-BIG_SIOUX_08, 9 percent for Reaches SD-BS-R-BIG_SIOUX_10 and SD-BS-R-BIG_SIOUX_11, and 11 percent for Reach SD-BS-R-BIG_SIOUX_12. Percent reductions were calculated for the average recreation season (May 1 through September 30) load in the Big Sioux River. Changes are minimal based on the expected growth rates and are sometimes favorable when residential areas are replacing agricultural lands with relatively higher existing loads.

## Table 9-1. Summary of Load and Exceedance Reductions for *E. coli* Best Management Practices

| | Baseline | Scenario 1 (Future Land Use) | Scenario 2 (Sioux Falls Planned BMPs) | Scenario 3 (Big Sioux River and Skunk Creek Boundaries Below Limited Contact Criteria 1,178 cfu/100 mL) | Scenario 4 (Big Sioux River and Skunk Creek Boundaries Below Immersion Rec Criteria 235 cfu/100 mL) | Scenario 5 (Change of Diversion Flow Routing–Minimum Flow Maintained at 400 cfs) | Scenario 6 (90% Load Reduction on Agriculture Land)[a] | Scenario 7 (*E. coli* Reductions of 75% on 100% of the MS4) |
|---|---|---|---|---|---|---|---|---|
| **Big Sioux River (TMDL Endpoint of Reach 8)** | | | | | | | | |
| Modeled % Exceedance (single sample)[b] | 74% | 74% | 74% | 56% | 13% | 13% | 4% | 3% |
| Individual BMP Percent Load Reduction[c] | – | 0% | 0% | 24% | 27% | 0% | 36% | 0% |
| Cumulative BMP Percent Load Reduction | – | 0% | 0% | 24% | 51% | 51% | 87% | 87% |
| **Big Sioux River (TMDL Endpoint of Reach 10)** | | | | | | | | |
| Modeled % Exceedance (single sample)[b] | 90% | 90% | 90% | 58% | 23% | 19% | 12% | 4% |
| Individual BMP Percent Load Reduction[c] | – | 9% | 0% | 35% | 14% | –8% | 12% | 28% |
| Cumulative BMP Percent Load Reduction | – | 9% | 9% | 44% | 58% | 50% | 62% | 90% |
| **Big Sioux River (TMDL Endpoint of Reach 11)** | | | | | | | | |
| Modeled % Exceedance (single sample)[b] | 80% | 78% | 78% | 42% | 23% | 21% | 14% | 4% |
| Individual BMP Percent Load Reduction[c] | – | 9% | 0% | 25% | 12% | 2% | 21% | 22% |
| Cumulative BMP Percent Load Reduction | – | 9% | 9% | 34% | 46% | 48% | 69% | 91% |
| **Big Sioux River (TMDL Endpoint of Reach 12)** | | | | | | | | |
| Modeled % Exceedance (single sample)[b] | 76% | 72% | 72% | 40% | 27% | 25% | 14% | 6% |
| Individual BMP Percent Load Reduction[c] | – | 11% | 0% | 19% | 10% | 1% | 30% | 19% |
| Cumulative BMP Percent Load Reduction | – | 11% | 11% | 30% | 40% | 41% | 71% | 90% |

(a) Agriculture BMPs for Scenario 6 were on lands within the project area boundary north of Sioux Falls local to the Big Sioux River and Silver Creek.
(b) Modeled Percent Exceedance represents the percent of samples that exceeded the single sample concentration of 235 cfu/100 mL based on the results of the HSPF model application.
(c) Individual Load Reduction is the reduction in average annual load from water years 2005–2009 that correspond to a single BMP (not cumulative BMP effects).

The model results show that implementing planned Sioux Falls BMPs (Scenario 2) would not result in load reductions in any of the four reaches because these BMPs focus on sediment reduction instead of bacteria reduction. Similarly, no decrease in the percent exceedance of the acute concentration standard would occur with implementing Scenario 2. These 0 percent reductions were expected, as the planned BMPs were modeled with a 0 percent bacterial removal efficiency, which was used because planned BMPs are similar to current sediment-focused urban BMPs. Urban BMPs need to continue to be monitored to understand efficiency and/or inefficiency in removing bacteria loads, and future Sioux Falls BMPs should focus on bacteria reduction in addition to sediment reduction and hydrology.

For Scenario 3, *E. coli* concentrations were reduced at the Big Sioux River and Skunk Creek boundary conditions by multiplying each by a reduction factor (0.59 for the Big Sioux River and 0.31 for Skunk Creek) to ensure all concentrations were below the limited contact recreation criteria (1,178 cfu/100 mL) (Scenario 3), as specified for the respective reach's water-quality standards and TMDLs. The model also shows that Scenario 3 would result in a load reduction of 24 percent for Reach SD-BS-R-BIG_SIOUX_08, 35 percent for Reach SD-BS-R-BIG_SIOUX_10, 25 percent for Reach SD-BS-R-BIG_SIOUX_11, and 19 percent for Reach SD-BS-R-BIG_SIOUX_12.

Existing TMDLs for upstream waterbodies (i.e., the Big Sioux River upstream of Reach SD-BS-R-BIG_SIOUX_08 and Skunk Creek) are not conducive in meeting the Big Sioux River TMDL goals for this project because the *E. coli* criteria are less stringent. These TMDLs should be redeveloped to implement immersion recreation *E. coli* criteria, and they should also include analysis of water-quality trading options and animal-feeding operation studies. For example, Skunk Creek currently has a daily maximum *E. coli* criterion of 1,178 cfu/100 mL, which is far higher than the daily maximum *E. coli* criteria of 235 cfu/100 mL in the impaired Big Sioux River reaches. Skunk Creek also contributes significant volume to Reaches SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12. This appears to significantly influence water quality in the Big Sioux River, and SD DENR intends to revise the Skunk Creek TMDL to meet the immersion recreation standard of the downstream Big Sioux River. For Scenario 4, *E. coli* concentrations were reduced at the Big Sioux River and Skunk Creek boundary conditions by multiplying each concentration by a reduction factor (0.12 for the Big Sioux River and 0.06 for Skunk Creek) to ensure that all concentrations were below the more stringent immersion recreation criteria (235 cfu/100 mL). The model shows that Scenario 4 would result in a reduction of average recreation season bacteria loads of approximately 27 percent in Reach SD-BS-R-BIG_SIOUX_08, 14 percent in Reach SD-BS-R-BIG_SIOUX_10, 12 percent in Reach SD-BS-R-BIG_SIOUX_11, and 10 percent in Reach SD-BS-R-BIG_SIOUX_12.

Changing the diversion flow routing, in which all flows up to 400 cfs are routed through the city and excess flows above 400 cfs are routed through the diversion (Scenario 5), did not impact loads in Reach SD-BS-R-BIG_SIOUX_08 because this reach ends at the diversion. Scenario 5

resulted in a load increase of 8 percent in Reach SD-BS-R-BIG_SIOUX_10. This increase occurred because the overall flow increases in the reach and adds its present load to the current reach load. Although implementing this scenario increased loads in SD-BS-R-BIG_SIOUX_10, exceedances (i.e., concentrations) decreased because water was mixed with other water that had lower bacteria concentrations. The percent of exceedance of the acute concentration standard decreased in Reach SD-BS-R-BIG_SIOUX_10 by approximately 4 percent. Scenario 5 resulted in a load reduction of 2 percent and 1 percent in Reaches SD-BS-R-BIG_SIOUX_11 SD-BS-R-BIG_SIOUX_12, respectively.

Simulating agricultural BMP implementation on lands within the project area boundary north of Sioux Falls local to the Big Sioux River and Silver Creek using a 90 percent load reduction on agricultural land (Scenario 6) resulted in load reductions of 36 percent in the Big Sioux River Reach SD-BS-R-BIG_SIOUX_08, 12 percent in Reach SD-BS-R-BIG_SIOUX_10, 21 percent in Reach SD-BS-R-BIG_SIOUX_11, and 30 percent in Reach SD-BS-R-BIG_SIOUX_12. Cumulatively, a 7 to 11 percent decrease in percent exceedance of the acute concentration criteria occurred from agricultural land (located in the project area) load reductions.

Stormwater outfalls are a large contributor to the bacteria loading. Thus the maximum *E. coli* reduction possible on the maximum percent of the MS4 was applied. Scenario 7 included *E. coli* reductions of 75 percent on 100 percent of the Sioux Falls MS4. With the implementation of this scenario, a 0 percent load reduction occurred in Reach SD-BS-R-BIG_SIOUX_08, and load reductions of 28 percent, 22 percent, and 19 percent occurred in Reaches SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12, respectively. However, the percent of exceedance of the acute concentration criteria in these reaches decreased by only 1, 8, 10 , and 8 percent, respectively. This indicates that *E. coli* removal in runoff from the city would have a fairly large impact on load reduction but a fairly small impact on overall *E. coli* concentrations, which is ultimately necessary to avoid human health risks. The most effective load and concentration reductions are believed to occur through implementing BMPs outlined in the city of Sioux Falls' MS4 permit. If preferred concentrations cannot be met by implementing recommended BMPs, pollutant trading should be considered for this study area. Ozone treatment, ultraviolet treatment, and chlorination/dechlorination are other promising, but costly, options for decreasing bacteria concentrations in the Big Sioux River study area.

The city of Sioux Falls has taken the lead in developing the Central Big Sioux River Watershed Implementation Plan. Within this plan, a watershed-scale, decision-support framework based on cost optimization is being developed to support government and local planning agencies as they consider watershed-scale investments to improve water quality. This decision-support framework, which is the preferred approach to prescriptive water-quality based effluent limits within the MS4 permit, will assist in developing the TMDL implementation plan, identifying management practices to achieve pollutant reductions under

an MS4 stormwater permit, and develop a phased BMP installation plan that is optimized for both cost and water-quality effectiveness.

Cumulatively, implementation all seven scenarios would decrease acute concentration criterion from the baseline conditions of 74 to 90 percent exceedance to only 3 to 6 percent exceedance. Thus the cumulative implementation of Scenarios 1 through 7 could be an effective way to achieve maximum *E. coli* reduction in the Big Sioux River throughout the project area.

Overall, these findings indicate that bacteria exceedances in the Big Sioux River study area could be reduced from a range of 74 to 90 percent to a range of 3 to 6 percent with proper planning among state and local regulatory agencies, organizations, stakeholders; through BMP implementation strategies outlined within the City of Sioux Falls's MS4 permit and identified within the Central Big Sioux River Implementation Plan; and access to adequate financial resources. Funds to implement watershed water-quality improvements can be obtained through SD DENR and the United States Department of Agriculture. Specifically, the 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. These programs include Consolidated Water Facilities Construction Program, Clean Water State Revolving Fund Program, and the Section 319 Nonpoint Source Program.

## 9.2 REASONABLE ASSURANCE

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, the EPA states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. Big Sioux River Reaches SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12 are impaired by nonpoint sources and permitted point sources (including MS4s); therefore, the requirement to provide reasonable assurances applies to the *E. coli* TMDLs for these reaches.

The WLAs for the non-MS4 point sources are calculated based on the *E. coli* water-quality criterion and current discharge volumes for each point source. The concentration used in these calculations is equal to the TMDL target. Modeling demonstrates that at these WLAs, the non-MS4 point sources contribute less than 1 percent of the *E. coli* load in these reaches. Therefore, further reductions in the WLAs for the non-MS4 point sources is not likely to be effective in meeting the *E. coli* water-quality criteria in these reaches.

The WLA for the MS4 is calculated based on the loading capacity that remains after accounting for the non-MS4 point sources and the MOS and assumes the MS4 portion of the remaining loading capacity equals its current percent contribution of the total current load. **HSPF** modeling demonstrates that the MS4 contributes a significant portion of the total loading

(11 percent–47 percent), yet reductions of as much as 75 percent on 100 percent of the MS4, while significantly reducing the loading, would result in only a small decrease in the frequency of exceedances of the water-quality criterion. Therefore, further reductions in the WLAs for the MS4 point sources are also not likely to be effective in meeting the *E. coli* water-quality criteria in these reaches.

The following elements provide assurances that nonpoint source control measures can be designed to reduce the *E coli* loading in these reaches, that they are likely to be effective, and have a reasonably high probability of being implemented successfully in the Big Sioux River project area:

- Cooperation among stakeholders will facilitate implementing BMPs. The water-quality assessment work and the development of TMDLs for these reaches were performed as a cooperative project among the city of Sioux Falls, USGS, the EDWDD, RESPEC, and SD DENR. The cooperation among local stakeholders and state and local regulatory agencies, and organizations is expected to continue through the implementation phase, which will increase probability of success.
- Simulation of management scenarios indicates they are likely to be effective. Seven potential BMP scenarios for the four reaches have been conceptually developed and the HSPF model was used to predict the effectiveness of each scenario as well as the cumulative effectiveness. The HSPF model predicts that implementation of six out of the seven scenarios will achieve the required load reductions in Reaches SD-BS-R-BIG_SIOUX_08 and SD-BS-R-BIG_SIOUX_12 and will result in a less than 10 percent exceedance of the water-quality criterion for *E. coli* in all four impaired reaches. Because the model assessed water-quality concentrations within the reaches on an hourly basis over the entire 5-year modeling period, this reduction is a conservative estimate. SD DENR considers a stream segment as fully supporting its designated beneficial use and in compliance with the water-quality standard when less than 10 percent of the total number of samples exceed a water-quality criterion. Therefore, the model predicts that implementation of the BMP scenarios will result in the reaches compliance with the *E. coli* water-quality standard, and they will no longer impaired for immersion recreation use.
- These conservative assumptions were used in the calculations of required load reductions.
  - The percent of reductions in nonpoint source loading required to meet the TMDL is the difference between the baseline loading and the TMDL. The baseline loading value chosen for the four reaches is the 95$^{th}$ percentile of the observed daily maximum *E. coli* load for each flow zone. This means there is only a 5 percent probability that the true load is higher, thus providing a conservative calculation of the necessary loading reductions.

– A relatively large explicit MOS is incorporated into the calculation of the LA for the nonpoint sources. The MOS ranges from 14 percent to 46 percent with an average of 27 percent across all reaches and flow zones. This means that the *E. coli* water-quality criterion could conceivably be met when the actual load reductions are, on average, 27 percent lower than the calculated, required load reductions. Model predictions indicate that expected load reductions within all reaches are within 27 percent of the required load reductions.

- Work on a TMDL implementation plan has begun. Resources have been committed and work has commenced on the development of a watershed-scale decision-support framework has begun. The cost-effective framework supports government and local planning agencies in coordinating investments to achieve required load reductions. This decision-support framework is the first step in developing a TMDL implementation plan that outlines strategies with the best probability of success and milestones for implementation. BMP implementation strategies have already been developed within the city of Sioux Falls MS4 permit and the Central Big Sioux River Implementation Plan.

- SD DENR is committed to revising the Skunk Creek TMDL. The **HSPF** model predicts that Management Scenario 4 will result in significant load and concentration reductions. Under Scenario 4, both Reach 7 of the Big Sioux River and Skunk Creek will be managed to the acute immersion recreation *E. coli* standard of 235 cfu/100 mL instead of their currently designated limited contact recreation standard of 1,178 cfu/100 mL. The SD DENR intends to revise the TMDLs for these stream reaches to reflect this *E coli* standard change. Revising these TMDLs provides additional assurance that the necessary load reductions will be achieved. The WLA for the MS4 that drains into Skunk Creek will need to be incorporated into the revised TMDL for Skunk Creek. It is expected that revisions to the TMDL will be completed within 5 years.

## 9.3 REACHES ADAPTIVE IMPLEMENTATION APPROACH

An adaptive implementation approach will be followed for this TMDL. The EPA defines adaptive implementation as "an iterative implementation process that makes progress toward achieving water-quality goals while using any new data and information to reduce uncertainty and adjust implementation activities" [U.S. Environmental Protection Agency, 2006]. Using an adaptive implementation approach for this TMDL is based on several areas of uncertainty that exist in the TMDL. These areas are presented below, and recommended studies to reduce the level of uncertainty are also presented where appropriate.

- ***E. coli* translator values:** Estimated load reductions included in this TMDL are based on transformed fecal coliform bacteria data. A translator equation was necessary because of the relatively recent adoption of *E. coli* criteria and the lack of corresponding data. While its application provides a reasonable solution to the lack of *E. coli* data, it introduces uncertainty. The continued collection of *E. coli* data is needed to develop a

thorough dataset and to reduce the reliance on the translator equation for setting base loadings in this TMDL. Therefore, TMDL target reductions should be revised in the future based on the collection of additional *E. coli* data.

- **Loading sources:** The source assessment presented in Chapter 3.0 of this TMDL is based on relatively general sources of load contributions. To effectively achieve *E. coli* reduction in the Big Sioux River, further understanding of specific sources of *E. coli* to the impaired reaches is needed. The International Stormwater BMP Database project team states, "those working to address pathogen impairments on streams should focus first and foremost on sources controls. This requires a clear identification of the primary sources of bacteria" [Clary et al., 2010]. To obtain a better understanding of the sources, a relatively intensive monitoring network consisting of spatially distributed sampling locations would need to be established within the project area. The benefit of the recommended monitoring would be that portions of the watershed with elevated bacteria levels could, at least potentially, be isolated and investigated further for potential source areas and remedial actions. Bacterial source tracking analyses for the identification sources of bacteria of human origin could also be included as part of this monitoring effort.

- **BMP effectiveness:** Uncertainty also exists in the effectiveness of stormwater BMPs with regard to bacteria. A recent analysis of data available in the International Stormwater BMP Database indicates that "the majority of conventional stormwater BMPs in the BMP database do not appear to be effective at reducing fecal indicator bacteria concentrations to primary contact (i.e., Immersion Recreation) stream standards, which is the ultimate target of TMDLs" [Clary et al., 2010]. However, this study also found that select BMP categories (specifically, retention [wet] ponds, bioretention, and various types of media filters) provide reduction in bacteria concentrations [Clary et al., 2010]. Additional BMP efficacy data are needed to guide implementing stormwater bacteria controls in systems such as the Big Sioux River watershed. As a result, this TMDL implementation should include identification of BMPs that are effective in reducing bacteria loads to the impaired reaches. Further evaluation of applicable BMP studies, such as those included in the aforementioned BMP database and monitoring of BMPs implemented within the project area, will accomplish this objective.

These areas of uncertainty support using an adaptive implementation approach for this TMDL based on phased implementation rather than water quality-based effluent limitations within the MS4 permit. As noted in Chapter 8.0, SD DENR will notify the EPA of any adjustments to this TMDL within 30 days of their adoption.

# 10.0 REFERENCES


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# APPENDIX A

# GEOMETRIC MEAN-BASED LOAD DURATION CURVES

RSI-1827-10-026

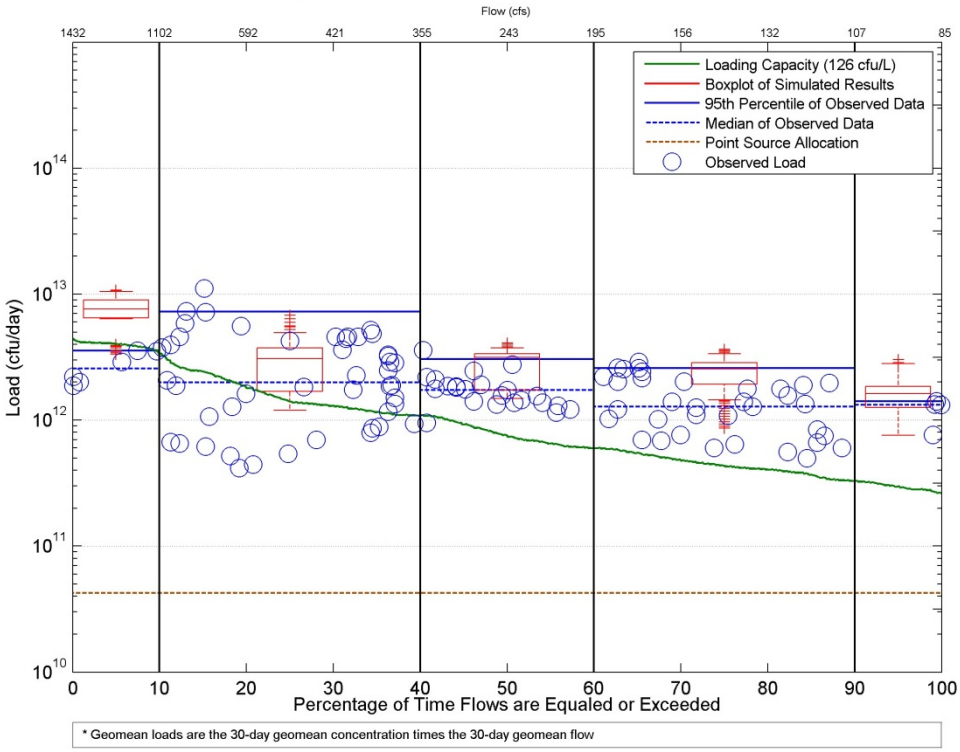


**Figure A-1.** 30-Day Geometric Mean-Based LDC for Reach SD-BS-R-BIG_SIOUX_08.

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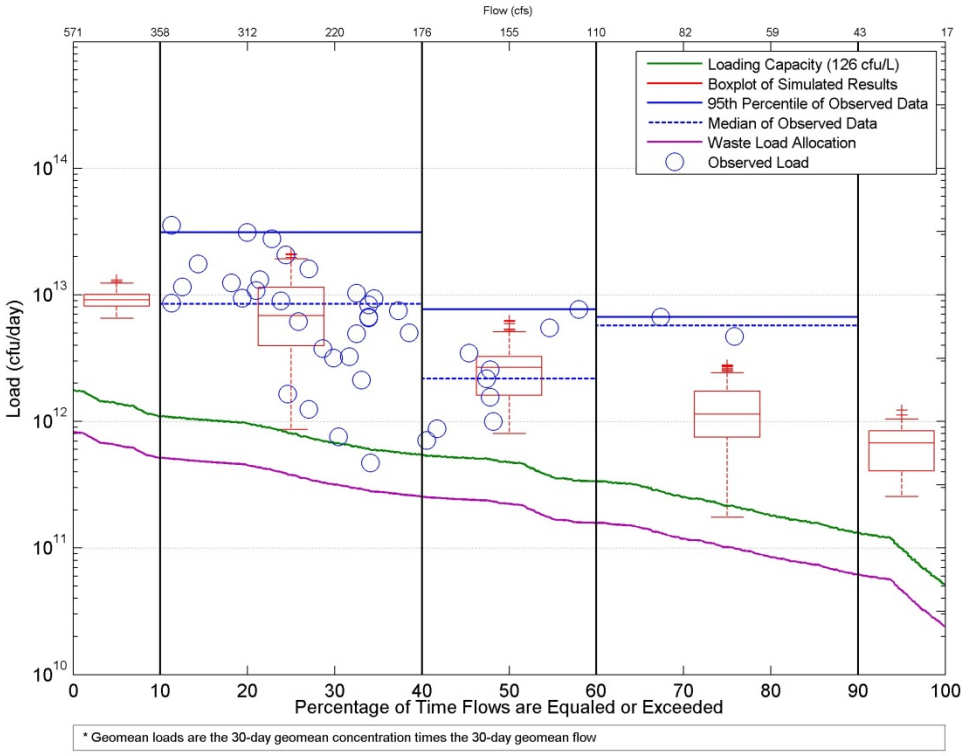


**Figure A-2.** 30-Day Geometric Mean-Based LDC for Reach SD-BS-R-BIG_SIOUX_10.

RSI-1827-10-028

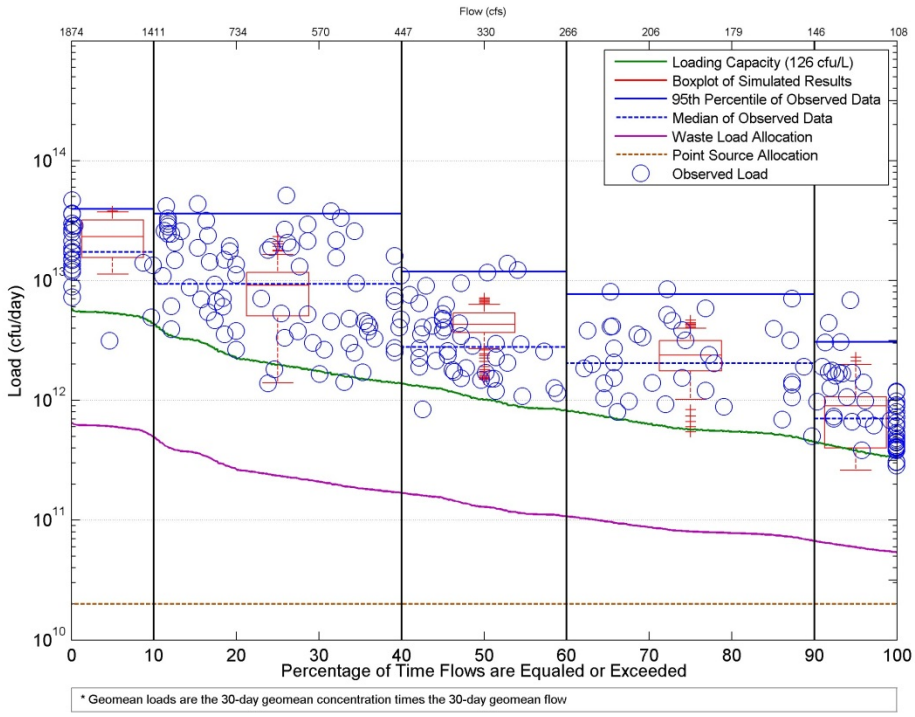


**Figure A-3.** 30-Day Geometric Mean-Based LDC for Reach SD-BS-R-BIG_SIOUX_11.

RSI-1827-10-029

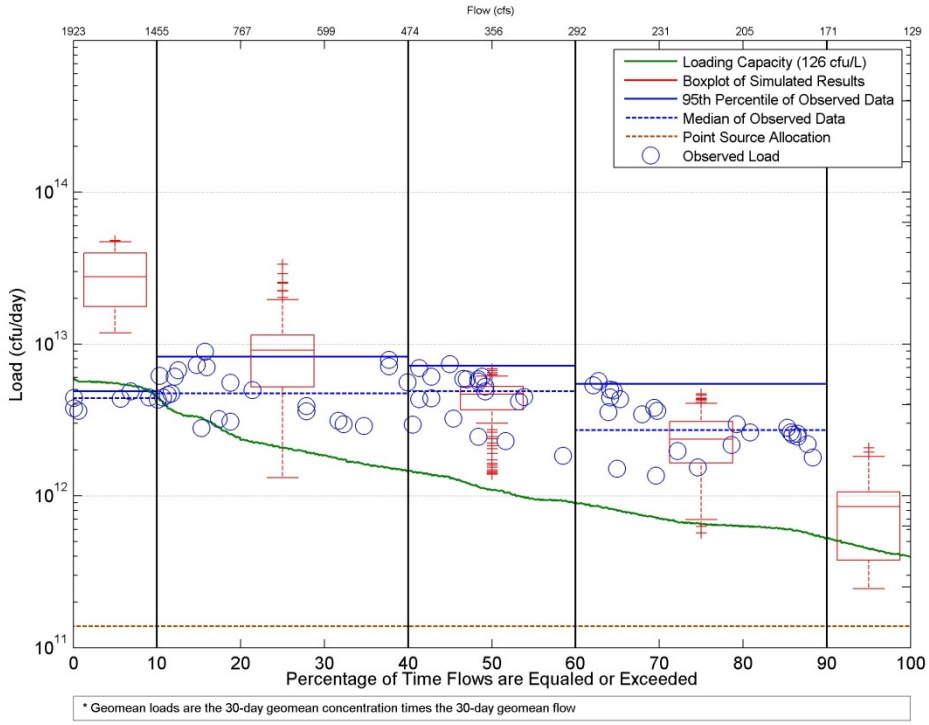


**Figure A-4.** 30-Day Geometric Mean-Based LDC for Reach SD-BS-R-BIG_SIOUX_12.

# APPENDIX B

# GEOMETRIC MEAN-BASED TOTAL MAXIMUM DAILY LOAD TABLES

**Table B-1. 30-Day Geometric Mean-Based Total Maximum Daily Load Table Based on Simulated Data for Reach SD-BS-R-BIG_SIOUX_08**

| TMDL Component (cfu × $10^9$/day) | | Flow Zone | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High | | Moist | | Midrange | | Dry | | Low | |
| | | > 1,103 cfs | | 1,103–355 cfs | | 355–195 cfs | | 195–107 cfs | | < 107 cfs | |
| LA | | 3,531 | | 2,413 | | 856 | | 409 | | 212 | |
| PSA 1 | WLA | 41 | 80 | 41 | 80 | 41 | 80 | 41 | 80 | 41 | 80 |
| PSA 2 | | 39 | | 39 | | 39 | | 39 | | 39 | |
| MS4 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| MOS | | 636 | | 311 | | 147 | | 103 | | 35 | |
| TMDL | | 4,245 | | 2,804 | | 1,083 | | 592 | | 327 | |
| Current Load[(a)] | | 10,466 | | 4,926 | | 3,756 | | 3,357 | | 2,811 | |
| Load Reduction | | 6,221 | | 2,122 | | 2,673 | | 2,765 | | 2,484 | |
| Load Reduction | | 59% | | 43% | | 71% | | 82% | | 88% | |

(a) Current load is the 95th percentile of the geometric mean simulated fecal coliform bacteria load for each flow zone.

**Table B-2. 30-Day Geometric Mean-Based Total Maximum Daily Load Table Based on Simulated Data for Reach SD-BS-R-BIG_SIOUX_10**

| TMDL Component (cfu × $10^9$/day) | | Flow Zone | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High | | Moist | | Midrange | | Dry | | Low | |
| | | > 358 cfs | | 358–177 cfs | | 177–110 cfs | | 110–43 cfs | | < 43 cfs | |
| LA | | 775 | | 434 | | 210 | | 131 | | 44 | |
| No PSA | WLA | 0 | 687 | 0 | 385 | 0 | 187 | 0 | 116 | 0 | 38 |
| MS4 | | 687 | | 385 | | 187 | | 116 | | 38 | |
| MOS | | 284 | | 261 | | 139 | | 84 | | 48 | |
| TMDL | | 1,746 | | 1,080 | | 536 | | 331 | | 130 | |
| Current Load[(a)] | | 12,352 | | 19,309 | | 5,180 | | 2,424 | | 1,046 | |
| Load Reduction | | 10,606 | | 18,229 | | 4,644 | | 2,093 | | 917 | |
| Load Reduction | | 86% | | 94% | | 90% | | 86% | | 88% | |

(a) Current load is the 95th percentile of the geometric mean simulated fecal coliform bacteria load for each flow zone.

**Table B-3. 30-Day Geometric Mean-Based Total Maximum Daily Load Table Based on Simulated Data for Reach SD-BS-R-BIG_SIOUX_11**

| TMDL Component (cfu × $10^9$/day) | | Flow Zone | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High | | Moist | | Midrange | | Dry | | Low | |
| | | > 1,415 cfs | | 1,415–450 cfs | | 450–266 cfs | | 266–147 cfs | | < 147 cfs | |
| LA | | 4,047 | | 2,657 | | 1,005 | | 576 | | 330 | |
| PSA 3 | WLA | 20 | 520 | 20 | 349 | 20 | 144 | 20 | 91 | 20 | 61 |
| MS4 | | 500 | | 329 | | 124 | | 71 | | 41 | |
| MOS | | 993 | | 601 | | 197 | | 122 | | 50 | |
| TMDL | | 5,560 | | 3,607 | | 1,346 | | 789 | | 441 | |
| Current Load[(a)] | | 37,332 | | 16,435 | | 6,405 | | 4,002 | | 1,985 | |
| Load Reduction | | 31,772 | | 12,827 | | 5,059 | | 3,214 | | 1,544 | |
| Load Reduction | | 85% | | 78% | | 79% | | 80% | | 78% | |

(a) Current load is the 95th percentile of the geometric mean simulated fecal coliform bacteria load for each flow zone.

**Table B-4. 30-Day Geometric Mean-Based Total Maximum Daily Load Table Based on Simulated Data for Reach SD-BS-R-BIG_SIOUX_12**

| TMDL Component (cfu × $10^9$/day) | | Flow Zone | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High | | Moist | | Midrange | | Dry | | Low | |
| | | > 1,459 cfs | | 1,459–475 cfs | | 475–292 cfs | | 292–171 cfs | | < 171 cfs | |
| LA | | 4,553 | | 2,975 | | 1,097 | | 611 | | 329 | |
| PSA 4 | WLA | 138 | 138 | 138 | 138 | 138 | 138 | 138 | 138 | 138 | 138 |
| MS4 | | 0 | | 0 | | 0 | | 0 | | 0 | |
| MOS | | 1,018 | | 611 | | 196 | | 127 | | 53 | |
| TMDL | | 5,709 | | 3,724 | | 1,431 | | 876 | | 520 | |
| Current Load[(a)] | | 47,160 | | 19,651 | | 6,194 | | 4,074 | | 1,811 | |
| Load Reduction | | 41,451 | | 15,927 | | 4,764 | | 3,198 | | 1,291 | |
| Load Reduction | | 88% | | 81% | | 77% | | 78% | | 71% | |

(a) Current load is the 95th percentile of the geometric mean simulated fecal coliform bacteria load for each flow zone.

**EPA REGION 8 TMDL REVIEW**

TMDL Document Info:

| | |
|---|---|
| **Document Name:** | **E. Coli/Fecal Coliform Bacteria Total Maximum Daily Load for Segments of the Big Sioux River, Minnehaha County South Dakota** |
| **Submitted by:** | **South Dakota Department of Environment and Natural Resources** |
| **Date Received:** | **June 1, 2012** |
| **Review Date:** | **August 15, 2012** |
| **Reviewer:** | **Bonnie Lavelle, EPA Region 8** |
| **Rough Draft / Public Notice / Final Draft?** | **Public Notice Draft** |
| **Notes:** | |

Reviewers Final Recommendation(s) to EPA Administrator (used for final draft review only):

- ☐ Approve
- ☐ Partial Approval
- ☐ Disapprove
- ☐ Insufficient Information

## Approval Notes to Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the minimum submission requirements and TMDL elements identified in the following 8 sections:

1. Problem Description
   1.1.. TMDL Document Submittal Letter
   1.2. Identification of the Waterbody, Impairments, and Study Boundaries
   1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
   4.1. Data Set Description
   4.2. Waste Load Allocations (WLA)
   4.3. Load Allocations (LA)
   4.4. Margin of Safety (MOS)
   4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered "impaired." When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant**.** A well written TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's minimum submission requirements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in the minimum submission requirements denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review template is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

# 1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

## 1.1 TMDL Document Submittal Letter

When a TMDL document is submitted to EPA requesting formal comments or a final review and approval, the submittal package should include a letter identifying the document being submitted and the purpose of the submission.

Minimum Submission Requirements.

☒ A TMDL submittal letter should be included with each TMDL document submitted to EPA requesting a formal review.

☒ The submittal letter should specify whether the TMDL document is being submitted for initial review and comments, public review and comments, or final review and approval.

☐ Each TMDL document submitted to EPA for final review and approval should 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**.** The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information ☐ N/A

***Summary:*** *The document was transmitted to EPA by email on June 1, 2012. South Dakota requested formal review by EPA and stated that the document had been made available to the public for a 30-day period for review. The deadline for submitting public comments was July 1, 2012.*

***Comments:*** *None.*

## 1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Minimum Submission Requirements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☒ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***

***Pollutant and waterbody segment(s) for which the TMDL is being established:***
*The impaired segments of the Big Sioux River addressed by this TMDL document are located in south-eastern South Dakota, and are part of the larger Missouri River basin. The Big Sioux River segments included in this TMDL document have a total drainage area of approximately 137,088 acres in South Dakota.*

*This TMDL document covers four (4) listed segments of the Big Sioux River (HUC 10170203) including: 1) Big Sioux River from S2, T104N, R49W to Hwy I-90 (28.5 miles, SD-BS-R-BIG_SIOUX_08); 2) Big Sioux River from Hwy I-90 to the diversion return (15.8 miles, SD-BS-R-BIG_SIOUX_10); 3) Big Sioux River from diversion return to Sioux Falls wastewater treatment plant (WWTP) (4.7 miles, SD-BS-R-BIG_SIOUX_11); and 4) Big Sioux River from Sioux Falls wastewater treatment plant to above Brandon, SD (4.2 miles, SD-BS-R-BIG_SIOUX_12). All four segments are listed as high priority for TMDL development.*

*Previously, segment SD-BS-R-BIG_SIOUX_08 was defined as being from near Dell Rapids to below Baltic. Segment SD-BS-R-BIG_SIOUX_08 has been expanded to include the portion of Segment SD-BS-R-BIG_SIOUX_09 above the diversion split at I-90. The remainder of Segment SD-BS-R-BIG_SIOUX_09 (below the diversion to Skunk Creek) has been incorporated into Segment SD-BS-R-BIG_SIOUX_10.*

*The designated uses for these four Big Sioux River segments are:*

- *warmwater semi-permanent fish life propagation waters,*
- *immersion recreation waters,*
- *limited contact recreation waters,*
- *irrigation, fish and wildlife propagation, recreation, and stock watering waters.*

*In addition, Big Sioux River segments 08 and 10 have been assigned domestic water supply beneficial use. In 2010, South Dakota listed these four segments on the 303(d) list as impaired for immersion recreational use due to elevated E. Coli and fecal coliform concentrations ( segments 10 and 11 are also impaired for limited contact recreation use), and impaired for warmwater semi-permanent fish life due to elevated total suspended solids (TSS) concentrations. The TSS impairments in these segments are being addressed by SDDENR in a separate TMDL document. A fecal coliform TMDL for Big Sioux River segment 08 was approved by EPA in May 2008. When the E. coli TMDL for segment 08 is approved by EPA, the existing fecal coliform TMDL for segment 08 can be withdrawn.*

*Section 1.0,"Introduction", and Section 2.0, "Water-Quality Targets and Total Maximum Daily Load Targets", identify the impairments to these segments as they appear on the State's 303(d) list in the 2010 South Dakota Integrated Report for Surface Water Quality Assessment. EPA approved the 303(d) list on July 9, 2010.*

*Figure 1-1 is a map of the project area and the impaired segments that shows the general location of the Big Sioux River and major tributaries within the project area. Figure 3-1 is a map that shows the location of point sources including the MS4 within the project area. Figure 3-3 is a schematic of the impaired segments and locations of the major tributaries, the point sources and MS4 area within the overall project area.*

*The Lower Big Sioux River Watershed is located in eastern South Dakota and drains approximately 2,195 square miles in South Dakota and an additional 1,120 square miles in Minnesota and Iowa. The designated Sioux Falls TMDL Assessment Project Area is a sub-area of the Lower Big Sioux River Watershed and drains a much smaller area (approximately 214 square miles or 6.5% of the watershed) all of which is within South Dakota.*

***Impairment status**:*
*The following impairment status information is an excerpt from the document "2010 South Dakota Integrated Report for Surface Water Quality Assessment" dated March 29, 2010 (2010 Integrated Report).*

| ***Reach*** | ***Data Source*** | ***Impaired Use*** | ***Cause*** | ***Source*** | ***Priority*** |
|---|---|---|---|---|---|
| *SD-BS-R-BIG_SIOUX_08* | *DENR USGS* | *Immersion Recreation* | *E. coli fecal coliform* | *Livestock (grazing or feeding operations)* | *1* |
| *SD-BS-R-BIG_SIOUX_10* | *DENR USGS* | *Immersion Recreation*<br><br>*Limited Contact Recreation* | *E. coli fecal coliform*<br><br>*E. coli fecal coliform* | *Residential Districts* | *1* |
| *SD-BS-R-BIG_SIOUX_11* | *DENR USGS* | *Immersion Recreation*<br><br>*Limited Contact Recreation* | *E. coli fecal coliform*<br><br>*E. coli* | *Municipal (urbanized high density area)*<br>*Livestock (grazing or feeding operations)* | *1* |
| *SD-BS-R-BIG_SIOUX_12* | *DENR* | *Immersion Recreation* | *E. coli fecal coliform* | *Livestock (grazing or feeding operations)* | *1* |

*The 303(d) list identifies impairments due to both E. coli and fecal coliform; however, this document develops TMDLs for E.coli only. South Dakota Department of Environment and Natural Resources (SD DENR) intends to drop the fecal coliform bacteria standard in 2015. Also, the TMDLs for E. coli are expected to address the fecal coliform water quality standard exceedances. This is because data from paired water samples collected in the project area indicate that the mean of the E.Coli concentrations is slightly higher than the mean of the fecal coliform concentrations. This result is consistent with data from three recent South Dakota TMDLs: Big Sioux River, Cheyenne River, and Whitewood Creek. Given that the water quality criteria that applies to any one sample for E. coli is 59% of the water quality criteria for fecal coliform, reductions in the bacteria loading to meet the WQC for E. coli are expected to also achieve the WQC for fecal coliform.*

***Comments:***

***Section 1.2, Clean Water Act Section 303(d) Listing Information (page 4):*** *Please include additional information about the fecal coliform TMDL for Segment SD-BS-R-BIG_SIOUX_08 that was approved in May 2008. We understand that since boundaries for segment 8 have changed since 2008, the new E. Coli TMDL and the 2008 fecal coliform TMDL are not directly comparable. Once the new TMDL is approved by EPA, the existing fecal coliform TMDL can be withdrawn. We recommend that you include a few sentences explaining this in the TMDL document. Section 1.2 seems to be the appropriate place.*

*Suggested language:*

*In 2008, EPA approved a fecal coliform TMDL for Segment SD-BS-R-BIG_SIOUX_08, defined as being from near Dell Rapids to below Baltic. Since the boundaries for this segment have since been expanded, this E. Coli TMDL is not directly comparable to the 2008 fecal coliform TMDL. It's expected that once EPA approves the new E. coli TMDL for Segment SD-BS-R-BIG_SIOUX_08, the 2008 fecal coliform TMDL for Segment SD-BS-R-BIG_SIOUX_08 will be withdrawn.*

**SDDENR Response:**

Additional information about the approval of the fecal coliform TMDL for Segment SD-BS-R-BIG_SIOUX_08 was included in Section 1.2. The suggested language was included in Section 1.2 with the exception of the last sentence; which was modified to read…"It's expected that once EPA approves the new E. coli TMDL for Segment SD-BS-R-BIG_SIOUX_08 and if the fecal coliform water quality standard is changed or removed, the 2008 fecal coliform TMDL for Segment SD-BS-R-BIG_SIOUX_08 will be withdrawn."

## 1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g. insufficient data were available to determine if this water quality criterion is being attained).

Minimum Submission Requirements:

☒ The TMDL 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 anti-degradation policy. (40 C.F.R. §130.7(c)(1)).

☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the significant sources. Therefore, <u>all TMDL documents must be written to meet the existing water quality standards</u> for that waterbody (CWA §303(d)(1)(C)). *Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.*

☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.

| |
|---|
| ☒ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements. |

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***
*Summary tables included at the beginning of the document (pages i-iv) provide a description of the applicable water quality standards for each of the four segments of the Big Sioux River addressed in this TMDL. The description includes the designated uses assigned to each segment, and the applicable numeric water quality criteria.*

*The E. Coli and fecal coliform water quality criteria (WQC) for the impaired designated uses for these reaches are as follows:*

***South Dakota DENR Surface Water Quality Criteria for E. Coli***

| ***Designated Use*** | ***WQC (mean)[1]*** | ***WQC (single sample)*** | ***Applicable Period*** |
|---|---|---|---|
| *Immersion Recreation* | *≤ 126 cfu/mL* | *≤ 235 cfu/mL* | *May 1- September 30* |
| *Limited Contact Recreation* | *≤ 630 cfu/mL* | *≤ 1,178 cfu/mL* | *May 1- September 30* |

*[1]Geometric mean of minimum 5 samples obtained during separate 24-hr periods for any 30-day period*

***South Dakota DENR Surface Water Quality Criteria for Fecal Coliform***

| ***Designated Use*** | ***WQC (mean)[1]*** | ***WQC (single sample)*** | ***Applicable Period*** |
|---|---|---|---|
| *Immersion Recreation* | *≤ 200 cfu/mL* | *≤ 400 cfu/mL* | *May 1- September 30* |
| *Limited Contact Recreation* | *≤ 1,000 cfu/mL* | *≤ 2000 cfu/mL* | *May 1- September 30* |

*[1]Geometric mean of minimum 5 samples obtained during separate 24-hr periods for any 30-day period*

*Additionally, Section 2.0, Water Quality Standards and Total Maximum Daily Load Targets, provides a description of all designated uses (not just the impaired uses) that have been assigned to all four segments of the Big Sioux River included in the TMDL.*

*The designated uses are:*

| *Big Sioux River Segment* | *Designated Uses* |
|---|---|
| *SD-BS-R-BIG_SIOUX_08* | *Domestic water supply, fish and wildlife propagation, immersion recreation, irrigation waters, limited contact recreation, and warmwater semi-permanent fish life* |
| *SD-BS-R-BIG_SIOUX_10* | *Domestic water supply, fish and wildlife propagation, immersion recreation, irrigation waters, limited contact recreation, and warmwater semi-permanent fish life* |

| | |
|---|---|
| *SD-BS-R-BIG_SIOUX_11* | *Fish and wildlife propagation, immersion recreation, irrigation waters, limited contact recreation, and warmwater semi-permanent fish life* |
| *SD-BS-R-BIG_SIOUX_12* | *Fish and wildlife propagation, immersion recreation, irrigation waters, limited contact recreation, and warmwater semi-permanent fish life* |

*Section 4.0, Technical Analysis, describes the TMDL development using the load duration curve (LDC) approach. Specific standards-related details of the LDCs are as follows:*

- *The LDCs were developed for the entire flow regime within the recreational season (May 1-September 30). The LDCs were constructed using the product of simulated flows at reach endpoints, the daily maximum E. Coli WQC, and a unit conversion factor.*
- *Separate LDCs were developed for each of the four impaired segments.*
- *The single sample or daily maximum WQC for E. Coli for immersion recreation use (235 cfu/100 mL) was chosen as the water quality target and this value was used to construct the LDCs.*
- *LDCs based on the geometric mean WQC for E. Coli for immersion recreation use (126 cfu/100mL) were also constructed and are included in Appendix A of the document for comparison and to support the conclusion that reductions in loadings necessary to achieve the daily maximum WQC for E. Coli will result in achieving the geometric mean WQC for E. Coli.*

*Tables 5-2 through 5-5 present the TMDL, the margin of safety (MOS), load allocations (LA), and waste load allocations (WLA) for all flow zones and all four impaired segments. The TMDL for each flow zone for each segment is the 95$^{th}$ percentile of the range of loading capacities within that flow zone. The margin of safety is the difference between the loading capacity at the midpoint of the flow zone and the loading capacity at the minimum flow within each flow zone. The MS4 load is estimated based on the % of the total load as determined by the HSPF model and the point source allocation is the product of the discharge of the point source and the target E. Coli criteria. The remaining capacity is allocated to the non point sources as the LA.*

***Comments:***

*None.*

## 2. Water Quality Targets

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

Minimum Submission Requirements:

☒ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained. *Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.*

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***

***Numeric water quality target for each waterbody/pollutant combination:***
*Section 1.0, "Introduction", states that although the 303(d) listings include fecal coliform bacteria, this TMDL report focuses on TMDLs for E. Coli. Reductions in the bacteria loading to meet the WQC for E. coli are expected to also achieve the WQC for fecal coliform.*

*Section 2.0, "Water Quality Standards and Total Maximum Daily Load Targets", states that impaired segments must meet the more stringent standards of immersion recreation since they are listed as impaired for both immersion recreation and limited contact recreation.*

*The numeric TMDL targets established for the four impaired segments of the Big Sioux River are based on the daily maximum and 30-day geometric mean water quality standards for E. coli established to protect the immersion recreation beneficial uses. The water quality targets for these TMDLs are based on the numeric water quality standards for E. coli bacteria established to protect the immersion recreation beneficial uses for the impaired segments of the Big Sioux River. The E. coli targets for the Big Sioux River segments are: 235 cfu/100 mL daily maximum; or 126 cfu/100 mL 30-day geometric mean, depending on which criterion required the greatest load reduction.*

*LDCs based on the geometric mean WQC for E. Coli for immersion recreation use (126 cfu/100mL) are included in Appendix A. A comparison of the LDCs based on the daily maximum WQC for E. Coli and the geometric mean WQC for E.Coli support the conclusion that reductions in loadings necessary to achieve the daily maximum WQC for E. Coli will result in achieving the geometric mean WQC for E. Coli.*

*Therefore, the daily maximum WQC for E. Coli for immersion recreation use (235 cfu/100 mL) was chosen as the water quality target.*

***Comments:*** *None.*

# 3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each significant source (or source category) should be identified and quantified to the maximum practical extent. This may be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach may be appropriate. The approach should be clearly defined in the document.

Minimum Submission Requirements:

☒ The TMDL should include an identification of all potentially significant point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.

☒ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified, characterized, and properly quantified.

☐ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary***:

*The TMDL document includes a breakdown of the land uses in the Big Sioux River watershed in Table 1-1. The TMDL document identifies the main E. coli sources as a combination of point sources and nonpoint sources within and upstream of the impaired segments. A total of 5 permitted point sources are located within the drainage area of the four segments. These are the Dell Rapids Wastewater Treatment Plant (WWTP)*

*in segment 8, the Baltic WWTP also in segment 8, John Morrell & Company in segment 11 and the Sioux Falls WWTP in segment 12 and the Sioux Falls NPDES MS4 in segments 10 and 11. Nonpoint source loading from overland runoff from nearby croplands and feedlots, and inflow from tributaries also contribute to the total E. coli load. The document provides an estimate of the number of livestock, wildlife and septic systems within the project area.*

*The HSPF model was used to determine the contribution of E. coli bacteria from identified sources in the project area and to evaluate the implementation of BMPs to control these sources. Source assessment modeling results were summarized using the following categories: nonpoint sources, MS4 (local (contributions from MS4 system located within the current reach boundaries)), MS4 (upstream (contributions from MS4 system located upstream of current reach boundaries), Big Sioux River boundary conditions, Skunk Creek, and Slip-Up Creek.*

***Comments:***

1. ***Section 5.2, Waste Load Allocation (page 42):*** *This section states that because of a biohazard concern, the locations of the CAFOs are not available. EPA requests that, at a minimum, the document identifies the segments where the CAFOs are located.*

2. ***Section 3.1, Point Sources (page 25)****: Please include the NPDES permit numbers for the point sources shown in Table 3-1.*

**SDDENR Response:**

1. Approximately thirteen CAFOs exist in Minnehaha County and given the predominance of agriculture (pasture land and cropland) it is likely that a CAFO exists in all of the segments of the Big Sioux River assessed for this TMDL document.

2. NPDES permit numbers were added to the point sources shown in Table 3-1.

# 4. TMDL Technical Analysis

TMDL determinations should be supported by a robust data set and an appropriate level of technical analysis**.** This applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways, such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum LAs + \sum WLAs + MOS$$

Where:

| | | |
|---|---|---|
| TMDL = | Total Pollutant Loading Capacity of the waterbody | |
| LAs | = | Pollutant Load Allocations |
| WLAs | = | Pollutant Wasteload Allocations |
| MOS | = | The portion of the Load Capacity allocated to the Margin of safety. |

Minimum Submission Requirements:

- ☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. 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 total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.
- ☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify 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.
- ☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

(1) the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
(2) the distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
(4) present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
(5) 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.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1) ). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***
*The technical analysis includes a description of the analytical processes used, results from water quality modeling, assumptions and other pertinent information. The TMDL technical analysis for the four impaired segments of the Big Sioux River describes how the E. coli loads were derived in order to meet the applicable water quality standards.*

*A combination of HSPF modeling along with load duration curves were used in a weight of evidence technical analysis for the Big Sioux River E. coli TMDLs. The HSPF model was used to determine the contribution of E. coli bacteria from identified sources in the project area and to evaluate the implementation of BMPs to control these sources. The evaluation of the BMPs was performed by comparing the predicted load reductions and the frequency percent exceedance of the WQC for each BMP alternative. The Big Sioux River drainage basin was represented in the model using 24 sub watersheds and two boundary conditions which represent Skunk Creek and the Big Sioux River at Dell Rapids. Nonpoint source bacterial loadings for HSPF were estimated using the event mean concentrations (EMCs) for each land use, which were derived from sample data based on representative land uses draining to particular sampling sites. EMCs were applied throughout the watershed. The buildup and wash off of E. coli was simulated based on the EMC values and precipitation.*

*The TMDL loads and loading capacities were derived using the load duration curve (LDC) approach that results in a flow-variable target that considers the entire flow regime. The LDC is a dynamic expression of the allowable load for any given day. The LDCs were constructed using the product of simulated flow (from the HSPF model) at the endpoint for each reach and the E. Coli WQC and a unit conversion factor.*

*The MS4 load was calculated using the HSPF model application. Instantaneous loads within each reach were plotted on the LDCs. These instantaneous loads were calculated using concentrations of E. Coli measured directly from sampling locations within each reach and estimated E.Coli concentrations transformed from observed fecal coliform concentrations using the equation derived from paired samples. Flow values were from direct measurements and simulated where direct measurements were not available.*

*To aid in the interpretation of the TMDL, the LDC flow intervals were grouped into five flow zones. Once the loading capacity was derived for each flow zone then the load allocations were calculated by subtracting the WLA and MOS. The calculated loads for each flow regime for all four segments are included in Tables 5-2, 5-3, 5-4 and 5-5 of the TMDL document.*

***Comments:***

1. ***Section 9.1, Simulated Management Scenarios (page 53):*** *The last paragraph on this page states that "the project team is working closely with SD DENR to determine if the Skunk Creek TMDL should be revisited to meet the immersion recreation standard". EPA understands that SD DENR intends to revise the Skunk Creek TMDL. Language in Section 9.2 states this. Please change the language on page 53 to be consistent with the language on page 56 and with what we understand is the intention. We suggest: "the project team is working closely with SD DENR to revise the Skunk Creek TMDL to meet the immersion recreation standard of the downstream Big Sioux River."*

2. *Please provide the land use distribution contributing to each stormwater monitoring location along with the event mean concentrations used in the HSPF model. EPA was not able to find it in the "Model Application, Development, Calibration, and Validation" (MADCV) document that was provided to us. The MADCV document provides a good explanation of the methodology and identifies seven land use categories but doesn't indicate which apply to the various stormwater monitoring sites or the actual EMC concentrations.*

3. ***Section 9.2, Reasonable Assurance (page 55):*** *Thank you for including a separate reasonable assurance section. We believe the section can be expanded with more information that will give more weight to the assurances. The following is suggested replacement language for the text in Section 9.2.*

***Note: This language is intended to completely replace the existing Section 9.2.***

*When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions.*

*Big Sioux River segments SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-R-BIG_SIOUX_12 are impaired by nonpoint sources and permitted point sources (including MS4). Therefore, the requirement to provide reasonable assurances applies to the E. coli TMDLs for these segments.*

*The WLAs for the non-MS4 point sources are calculated based on the E. coli water quality criterion and current discharge volumes for each point source. The concentration used in these calculations is equal to the TMDL target. Modeling demonstrates that at these WLAs, the non-MS4 point sources contribute less than 1 percent of the E. coli load in these segments. Therefore, further reductions in the WLAs for the non-MS4 point sources is not likely to have much effect on meeting the E. Coli water quality criteria in these segments.*

*The WLA for the MS4 is calculated based on the loading capacity that remains after accounting for the non-MS4 point sources and the margin of safety and assumes the MS4 portion of the remaining loading capacity equals its current percent contribution of the total current load. HSPF modeling demonstrates that the MS4 contributes a*

*significant portion of the total loading (11% - 47%), yet reductions of as much as 75% on 100 % of the MS4, while significantly reducing the loading, would result in only a small decrease in the frequency of exceedances of the water quality criterion. Therefore, further reductions in the WLAs for the MS4 point sources are also not likely to be effective in meeting the E. coli water quality criteria in these segments.*

*The following elements provide assurances that nonpoint source control measures can feasibly be designed to reduce the E coli loading in these segments, that they are likely to be effective, and that they have a reasonably high probability of being implemented successfully in the Big Sioux River project area:*

- *Cooperation among stakeholders will facilitate implementation. The water quality assessment work and the development of TMDLs for these segments were performed as a cooperative project among the City of Sioux Falls, USGS, the East Dakota Water Development District, RESPEC and SD DENR. The cooperation among local stakeholders, state and local regulatory agencies and organizations is expected to continue through the implementation phase, increasing the probability of success.*
- *Simulation of management scenarios indicates they are likely to be effective. Seven potential BMP scenarios for the four segments have been conceptually developed and the HSPF model was used to predict the effectiveness of each as well as the cumulative effectiveness. The HSPF model predicts that implementation of six of the seven scenarios will achieve the required load reductions in segments SD-BS-R-BIG_SIOUX_08 and SD-BS-R-BIG_SIOUX_12 and will result in a less than 10% exceedance of the water quality criterion for E. Coli in all four impaired segments. Because the model assessed water-quality concentrations within the reaches on an hourly basis over the entire 5-year modeling period, this is a conservative estimate of the reductions that will be achieved. SD DENR considers a stream segment with less than 10% of the total number of samples exceeding a water quality criterion as fully supporting its designated beneficial use and in compliance with the water quality standard. Therefore, the model predicts that implementation of the BMP scenarios will result in the segments being incompliance with the E. Coli water quality standard and no longer impaired for immersion recreation use.*
- *Conservative assumptions were used in the calculations of required load reductions.*
    - *The percent reductions in nonpoint source loading required to meet the TMDL are the difference between the baseline loading and the TMDL. The baseline loading value chosen for the four segments is the 95$^{th}$ percentile of the observed daily maximum E. coli load for each flow zone. This means this is only a 5% probability that the true load is higher, thus providing conservatism in the calculation of the necessary loading reductions.*
    - *A relatively large explicit margin of safety is incorporated into the calculation of the LA for the nonpoint sources. The margin of safety ranges from 14% to 46% with an average of 27% across all segments and flow zones. This means that the E. coli water quality criterion could conceivably be met when the actual load reductions are, on average, 27% lower than the calculated required load reductions. Model predictions indicate that expected load reductions within all segments are within 27% of the required load reductions.*
- *Work is underway on a TMDL implementation plan. Resources have been committed and work is underway on the development of a watershed-scale decision support framework that is based on cost optimization to support government and local planning agencies to coordinate investments to achieve required load reductions. This decision support framework is the first step in the development of a TMDL implementation plan that outlines strategies with the best probability of being successful and milestones for implementation. BMP implementation strategies have already been developed within the City of Sioux Falls MS4 permit and the Central Big Sioux River Implementation Plan.*
- *SDDENR commitment to revise the Skunk Creek TMDL. The HSPF model predicts that Management Scenario 4 will result in significant load and concentration reductions. Under Scenario 4, both Reach 7 of the Big Sioux River and Skunk Creek will be managed to the acute immersion recreation E. coli standard of 235 cfu/100 mL instead of their currently designated limited contact recreation standard of 1,178 cfu/100 mL. The SD DENR intends to revise the TMDLs for these stream segments to reflect this.*

*The commitment to revise these TMDLs provides additional assurance that the necessary load reductions will be achieved. The WLA for the MS4 that drains into Skunk Creek will need to be incorporated into the revised TMDL for Skunk Creek. It is expected that the necessary TMDL revisions will be completed within 5 years.*

**SDDENR Response:**

1. The language on page 53 was changed to reflect SDDENR's intent to revise the Skunk Creek TMDL and be consistent with the language on page 56.

2. Land use distribution contributing to each stormwater monitoring location was included and the event mean concentrations used in the HSPF Model were added to the Model Application, Development, Calibration, and Validation (MADCV) document.

3. The suggested language to replace the existing Section 9.2 was added to the document and replaced the existing language.

## 4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Minimum Submission Requirements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☐ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary***:

***Description and summary of all available water quality data relevant to the water quality assessment and TMDL analysis:*** *The data description and summary for the four impaired segments of the Big Sioux River are included mainly in Section 1.3., Available Water-Quality Data, and are plotted on the load duration curves. Sampling was conducted on a temporal basis over the period from January 2000 to October 2009 and included 1,673 total samples of which 1471 were analyzed for fecal coliform and 202 were analyzed for E. coli.*

*Although data are available from monitoring that occurred prior to the year 2000, only data collected during the period 2000-2009 were used the TMDL analysis. The earlier data were excluded because of the expansion of the City of Sioux Falls boundaries and the significant amount of data available after the year 2000.*

***Comments:***

1. *Summary tables and box plots of the data used in this TMDL are included but the complete data set is not. Please provide the complete data set in electronic format (Excel spreadsheet is preferred).*

**SDDENR Response:**

The complete data set will be sent to EPA in an electronic format.

## 4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Minimum Submission Requirements:

☒ EPA regulations require that a TMDL include WLAs for all significant and/or NPDES permitted point sources of the pollutant. TMDLs must identify the portion of the loading capacity allocated to individual existing and/or future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☐ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary***:
*Table 3-1 identifies five permitted point sources located within the drainage area of the four segments. These are the Dell Rapids Wastewater Treatment Plant (WWTP) in segment 8, the Baltic WWTP also in segment 8, John Morrell & Company in segment 11 and the Sioux Falls WWTP in segment 12 and the Sioux Falls NPDES MS4 in segments 10 and 11. A WLA for the Sioux Falls MS4 was derived for segments 10 and 11. WLAs for the other four point sources were derived and are included in Tables 5-2, 5-4 and 5-5.*

***Comments***:
*As mentioned in the comments to the Source Analysis section above, the TMDL needs to include permit numbers for each of the wastewater sources listed in Table 3-1. Also, EPA requests that the document provides the discharge flow rates used in the calculations of the WLAs. These discharge flow rates can be included in Table 3-1.*

**SDDENR Response:**

Permit numbers and flow rates used in the calculations of the WLAs was added to the document in Table 3-1.

## 4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Minimum Submission Requirements:

☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.

☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary***:

*The Load Allocation section explains how the loading capacity and load allocation was derived. Tables 5-2, 5-3, 5-4 and 5-5 show the load allocations for each of the five flow regimes for each segment.*

***Comments***:

*None.*

## 4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

Minimum Submission Requirements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d) (1) (C), 40 C.F.R. §130.7(c)(1) ). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

☐ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.

☒ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.

☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***

*The Big Sioux River TMDLs include explicit MOSs for each segment that were derived by calculating the difference between the loading capacity at the mid-point of each of the five flow zones and the loading capacity at the minimum flow in each zone. The explicit MOS values are included in Tables 5-2, 5-3, 5-4 and 5-5 of the TMDL document. This approach provides a MOS ranging from 14% to 46%, with an average of 27% across all segments and flow zones.*

***Comments**: None.*

### 4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Minimum Submission Requirements:

☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1) ).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary**:*
*By using the load duration curve approach to develop the TMDL allocations seasonal variability in E. coli loads are taken into account. Highest steam flows typically occur during late spring, and the lowest stream flows occur during the winter months.*

***Comments**: None.*

## 5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Minimum Submission Requirements:

☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii) ).

☐ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary***:

*The Public Participation section of the TMDL document describes the public participation process that has occurred during the development of the TMDLs for the Big Sioux River. In particular, the State has encouraged participation through public meetings in the watershed, and a website was developed and maintained throughout the project. The TMDL was available for a 30-day public notice period prior to finalization.*

***Comments***:

*None.*

# 6. Monitoring Strategy

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

Minimum Submission Requirements:

☒ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☐ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL. http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***

*The Big Sioux River will continue to be monitored as part of DENR's ambient water quality monitoring at existing stations along the Big Sioux River. These stations are sampled monthly during the recreation season (May – September). Additional monitoring is expected to be designed to evaluate the effectiveness of implemented BMPs. Accordingly, monitoring locations are expected to be based on the location and type of BMPs installed.*

*The TMDL document recognizes that continued collection of E. Coli data is needed to develop a more robust dataset to reduce the reliance on the translator equation for this TMDL to set base loadings. TMDL target reductions will be revised in the future based on the collection of additional E. Coli data.*

***Comments:*** *None.*

# 7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Minimum Submission Requirements:

☐ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***
*A variety of BMPs are proposed for consideration during development of the implementation plan as described in Section 9.1of the TMDL document. Several types of control measures are available for reducing E. coli bacteria loads; however the BMPs determined to be practicable by the stakeholders are listed and recommended to address the identified sources in the Sioux Falls area.*

*Based on water quality monitoring, bacterial source tracking, and HSPF model results, the recommended control measures to be implemented in Sioux Falls are expected to reduce exceedances of the acute E. coli criteria from the current 74 percent to 9 percent in Reach SD-BS-R-BIG_SIOUX_08, from 90 percent to 12 percent in Reach SD-BS-RBIG_ SIOUX_10, from 80 percent to 14 percent in Reach SD-BS-R-BIG_SIOUX_11, and from 76 percent to 20 percent in Reach SD-BS-R-BIG_SIOUX_12. These load reductions will assist in the attainment of the TMDL goal.*

*The seven management scenarios that were simulated for each bacteria-impaired reach using the HSPF model include the incorporation of: (1) future land use, (2) the city's planned BMPs, (3) Big Sioux River upstream of Dell Rapids and Skunk Creek compliance with the current limited recreation acute water-quality standard, (4) Big Sioux River upstream of Dell Rapids and Skunk Creek compliance with the immersion recreation acute water-quality standard, (5) change of flow routing down the Big Sioux River and the diversion (minimum flow through the city maintained at 400 cfs), (6) a 90 percent load reduction on agricultural land within the project area boundary north of Sioux Falls local to the Big Sioux River and Silver Creek, and (7) an E. coli reduction of 75 percent on 100 percent of the MS4. Table 9-1 shows the modeled percent exceedance of the daily maximum criteria, individual load reduction results, and cumulative load reduction results for each scenario considered in each of the four stream segments of the Big Sioux River.*

***Comments:***

***Section 9.3, Adaptive Implementation Approach, 2nd Bullet (page 56)****: The existing language seems to imply that new or revised South Dakota water quality criteria will result in an increased TMDL target. Since EPA's recommendations for ambient water quality criteria for protecting human health in ambient waters designated for primary contact recreation are still draft, EPA believes it's better to simply describe EPA's proposed revisions and state that if South Dakota adopts the final EPA recommendations, the water quality target will change. There is no need to imply that the water quality target will increase since that is unknown at this time.*

*The following is suggested replacement language for the text in Section 9.3, second bullet:*

***(Note: This language is intended to completely replace the existing paragraph.)***

***New or revised bacteria criteria:*** *The TMDL water quality target is the South Dakota surface water quality standard for E. coli of ≤235 cfu/100mL in any one sample.*

*On December 21, 2011, EPA announced the availability of the draft document, "Recreational Water Quality Criteria" that contains EPA's draft ambient water quality criteria recommendations for protecting human health in ambient waters that are designated for primary contact recreation. Once final, these recommendations are intended to be EPA guidance to States and authorized Tribes in developing water quality standards.*

*The EPA draft "Recreational Water Quality Criteria" differ from the existing South Dakota water quality criteria for E. Coli in several ways. EPA introduces a new term, Statistical Threshold Value (STV) as a clarification and replacement for the term "single sample maximum". There are no longer recommendations for different criteria for beaches used with more or less frequency. The proposed recommendations allow States flexibility in the duration or averaging period used in the calculation of a geometric mean concentration. Also, EPA provides tools to support States and Tribes in managing recreational waters and for considering alternate water quality criteria. The tools include sanitary surveys, predictive models, epidemiological studies, quantitative microbial risk assessment, and approaches for developing criteria using alternative fecal indicators and/or methods.*

*South Dakota may change the State E. coli water quality criteria after EPA finalizes and publishes revised recreational bacteria criteria (expected in October 2012). South Dakota could develop site-specific criteria for the Big Sioux River in accordance with EPA's final recommendations (including possibly a sanitary survey and site-specific quantitative microbial risk assessment). If adopted, the new site-specific criteria would change the TMDL target. Therefore, TMDL revisions may be necessary in the future.*

**SDDENR Response:**

The second bullet in Section 9.3 was removed. This was done because discussion of future *E. coli* and fecal coliform criteria would be conjectural and inappropriate at this time.

# 8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Minimum Submission Requirements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***

*The Big Sioux River E. coli TMDLs include daily loads expressed as colony forming units per day. The daily TMDL loads are included in the TMDL Allocations sections of the TMDL document.*

***Comments:*** *None.*

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

SEP 26 2012

RECEIVED
OCT 1 2012
DEPT. OF ENVIRONMENT AND NATURAL RESOURCES, SECRETARY'S OFFICE

Ref: 8EPR-EP

Steven M. Pirner
Secretary
South Dakota Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Re: TMDL Approval
*Big Sioux River Segments 8, 10, 11, and 12*
*Escherichia coli/Fecal coliform*
*SD-BS-R-BIG_SIOUX_08*
*SD-BS-R-BIG_SIOUX_10*
*SD-BS-R-BIG_SIOUX_11*
*SD-BS-R-BIG_SIOUX_12*

Dear Mr. Pirner:

We have completed our review of the total maximum daily loads as submitted by your office for the waterbodies listed in the enclosure to this letter. In accordance with the Clean Water Act (33 U.S.C. 1251 *et. seq.*), we approve all aspects of the TMDLs referenced above as developed for the water quality limited waterbodies as described in Section 303(d)(1). Based on our review, we feel the separate elements of the TMDL as listed in the enclosed table adequately address the pollutant of concern as given in the table, taking into consideration seasonal variation and a margin of safety.

Thank you for submitting the TMDL for our review and approval. If you have any questions, the most knowledgeable person on my staff is Bonnie Lavelle and she may be reached at 303-312-6579.

Sincerely,

Howard M. Cantor, for
Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

Enclosures

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ENCLOSURE 1: APPROVED TMDLs

# E. coli / Fecal Coliform Bacteria Total Maximum Daily Load for Reaches of the Big Sioux River, Minnehaha County, South Dakota (RESPEC for SD DENR, September 2012)

Submitted: 9/20/2012

| | |
|---|---|
| 4 | Pollutant TMDLs completed. |
| 8 | Causes addressed from the 2010 303(d) list. |
| 0 | Determinations that no pollutant TMDL needed. |

Segment: Big Sioux River from Diversion Return to Sioux Falls Wastewater Treatment Plant

303(d) ID: SD-BS-R-BIG SIOUX 11

Parameter/Pollutant (303(d) list cause): E. COLI - 227

Water Quality Targets: <126 cfu/100mL geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period; <235 cfu/100mL in any one sample

| Allocation* | Value | Units | Permits |
|---|---|---|---|
| WLA | 1.5E+12 | CFU/DAY | SDS-000001 |
| LA | 12.3E+12 | CFU/DAY | |
| TMDL | 18.2E+12 | CFU/DAY | |
| WLA | 3.7E+10 | CFU/DAY | SD-0000078 |
| MOS | 4.4E+12 | CFU/DAY | |

Notes:

**Segment:** Big Sioux River from Hwy I-90 to Diversion Return (Sioux Falls)

**303(d) ID:** SD-BS-R-BIG SIOUX 10

**Parameter/Pollutant (303(d) list cause):** E. COLI - 227

**Water Quality Targets:** <126 cfu/100mL geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period; <235 cfu/100mL in any one sample

| Allocation* | Value | Units | Permits |
|---|---|---|---|
| WLA | 2.2E+12 | CFU/DAY | SDS-000001 |
| LA | 2.5E+12 | CFU/DAY | |
| TMDL | 5.4E+12 | CFU/DAY | |
| MOS | 7.8E+11 | CFU/DAY | |

**Notes:**

Segment: Big Sioux River from S2, T104N, R49W, to Hwy I-90

303(d) ID: SD-BS-R-BIG SIOUX 08

**Parameter/Pollutant (303(d) list cause):** E. COLI - 227

**Water Quality Targets:** <126 cfu/100mL geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period; <235 cfu/100mL in any one sample

| Allocation* | Value | Units | Permits |
|---|---|---|---|
| LA | 11.7 E+12 | CFU/DAY | |
| TMDL | 15.2E+12 | CFU/DAY | |
| MOS | 3.4E+12 | CFU/DAY | |
| WLA | 3.9E+10 | CFU/DAY | SD-0022284 |
| WLA | 4.1E+10 | CFU/DAY | SD-0022101 |

Notes:

**Segment:** Big Sioux River from Sioux Falls Wastewater Treatment Plant to above Brandon

**303(d) ID:** SD-BS-R-BIG SIOUX 12

**Parameter/Pollutant (303(d) list cause):** E. COLI - 227

**Water Quality Targets:** <126 cfu/100mL geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period; <235 cfu/100mL in any one sample

| Allocation* | Value | Units | Permits |
|---|---|---|---|
| LA | 13.6E+12 | CFU/DAY | |
| TMDL | 18.5E+12 | CFU/DAY | |
| WLA | 2.57E+11 | CFU/DAY | SD-0022128 |
| MOS | 4.7E+12 | CFU/DAY | |

**Notes:**

* LA = Load Allocation, WLA = Wasteload Allocation, MOS = Margin of Safety, TMDL = sum(WLAs) + sum(LAs) + MOS

# ENCLOSURE 2: EPA REGION 8 TMDL REVIEW

TMDL Document Info:

| | |
|---|---|
| **Document Name:** | **E. Coli/Fecal Coliform Bacteria Total Maximum Daily Load for Segments of the Big Sioux River, Minnehaha County South Dakota** |
| **Submitted by:** | **South Dakota Department of Environment and Natural Resources** |
| **Date Received:** | **September 20, 2012** |
| **Review Date:** | **September 25, 2012** |
| **Reviewer:** | **Bonnie Lavelle** |
| **Rough Draft / Public Notice / Final Draft?** | **Final** |
| **Notes:** | |

Reviewers Final Recommendation(s) to EPA Administrator (used for final draft review only):

- ☒ Approve
- ☐ Partial Approval
- ☐ Disapprove
- ☐ Insufficient Information

**Approval Notes to Administrator: Based on the review presented below, I recommend approval of the TMDLs submitted in this document.**

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the minimum submission requirements and TMDL elements identified in the following 8 sections:

1. Problem Description
   - 1.1... TMDL Document Submittal Letter
   - 1.2. Identification of the Waterbody, Impairments, and Study Boundaries
   - 1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
   - 4.1. Data Set Description
   - 4.2. Waste Load Allocations (WLA)
   - 4.3. Load Allocations (LA)
   - 4.4. Margin of Safety (MOS)
   - 4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered "impaired." When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant. A well written

TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's minimum submission requirements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in the minimum submission requirements denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review template is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

# 1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

## 1.1 TMDL Document Submittal Letter

When a TMDL document is submitted to EPA requesting formal comments or a final review and approval, the submittal package should include a letter identifying the document being submitted and the purpose of the submission.

Minimum Submission Requirements.

☒ A TMDL submittal letter should be included with each TMDL document submitted to EPA requesting a formal review.

☒ The submittal letter should specify whether the TMDL document is being submitted for initial review and comments, public review and comments, or final review and approval.

☒ Each TMDL document submitted to EPA for final review and approval should 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. The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information ☐ N/A

***Summary:*** *The final version of the E. coli/fecal coliform TMDLs for segments 8,10,11 and 12 of the Big Sioux River was transmitted to EPA by email on September 20, 2012 with a submittal letter requesting final EPA review and approval.*

***Comments:*** *No Comments.*

## 1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Minimum Submission Requirements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☒ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***

***Pollutant and waterbody segment(s) for which the TMDL is being established:***
*The impaired segments of the Big Sioux River addressed by this TMDL document are located in south-eastern South Dakota, and are part of the larger Missouri River basin. The Big Sioux River segments included in this TMDL document have a total drainage area of approximately 137,088 acres in South Dakota.*

*This TMDL document covers four (4) listed segments of the Big Sioux River (HUC 10170203) including: 1) Big Sioux River from S2, T104N, R49W to Hwy I-90 (28.5 miles, SD-BS-R-BIG_SIOUX_08); 2) Big Sioux River from Hwy I-90 to the diversion return (15.8 miles, SD-BS-R-BIG_SIOUX_10); 3) Big Sioux River from diversion return to Sioux Falls wastewater treatment plant (WWTP) (4.7 miles, SD-BS-R-BIG_SIOUX_11); and 4) Big Sioux River from Sioux Falls wastewater treatment plant to above Brandon, SD (4.2 miles, SD-BS-R-BIG_SIOUX_12). All four segments are listed as high priority for TMDL development.*

*Previously, segment SD-BS-R-BIG_SIOUX_08 was defined as being from near Dell Rapids to below Baltic. Segment SD-BS-R-BIG_SIOUX_08 has been expanded to include the portion of Segment SD-BS-R-BIG_SIOUX_09 above the diversion split at I-90. The remainder of Segment SD-BS-R-BIG_SIOUX_09 (below the diversion to Skunk Creek) has been incorporated into Segment SD-BS-R-BIG_SIOUX_10.*

*The designated uses for these four Big Sioux River segments are:*

- *warmwater semi-permanent fish life propagation waters,*
- *immersion recreation waters,*
- *limited contact recreation waters,*
- *irrigation, fish and wildlife propagation, recreation, and stock watering waters.*

*In addition, Big Sioux River segments 08 and 10 have been assigned domestic water supply beneficial use. In 2010, South Dakota listed these four segments on the 303(d) list as impaired for immersion recreational use due to elevated E. Coli and fecal coliform concentrations ( segments 10 and 11 are also impaired for limited contact recreation use), and impaired for warmwater semi-permanent fish life due to elevated total suspended solids (TSS) concentrations. The TSS impairments in these segments are being addressed by SDDENR in a separate TMDL document. A fecal coliform TMDL for Big Sioux River segment 08 was approved by EPA in May 2008. When the E. coli TMDL for segment 08 is approved by EPA, the existing fecal coliform TMDL for segment 08 can be withdrawn.*

*Section 1.0, "Introduction", and Section 2.0, "Water-Quality Targets and Total Maximum Daily Load Targets", identify the impairments to these segments as they appear on the State's 303(d) list in the 2010 South Dakota Integrated Report for Surface Water Quality Assessment. EPA approved the 303(d) list on July 9, 2010.*

*Figure 1-1 is a map of the project area and the impaired segments that shows the general location of the Big Sioux River and major tributaries within the project area. Figure 3-1 is a map that shows the location of point sources including the MS4 within the project area. Figure 3-3 is a schematic of the impaired segments and locations of the major tributaries, the point sources and MS4 area within the overall project area.*

*The Lower Big Sioux River Watershed is located in eastern South Dakota and drains approximately 2,195 square miles in South Dakota and an additional 1,120 square miles in Minnesota and Iowa. The designated Sioux Falls TMDL Assessment Project Area is a sub-area of the Lower Big Sioux River Watershed and drains a much smaller area (approximately 214 square miles or 6.5% of the watershed) all of which is within South Dakota.*

***Impairment status:***
*The following impairment status information is an excerpt from the document "2010 South Dakota Integrated Report for Surface Water Quality Assessment" dated March 29, 2010 (2010 Integrated Report).*

| ***Reach*** | ***Data Source*** | ***Impaired Use*** | ***Cause*** | ***Source*** | ***Priority*** |
|---|---|---|---|---|---|
| *SD-BS-R-BIG_SIOUX_08* | *DENR USGS* | *Immersion Recreation* | *E. coli fecal coliform* | *Livestock (grazing or feeding operations)* | *1* |
| *SD-BS-R-BIG_SIOUX_10* | *DENR USGS* | *Immersion Recreation*<br><br>*Limited Contact Recreation* | *E. coli fecal coliform*<br><br>*E. coli fecal coliform* | *Residential Districts* | *1* |
| *SD-BS-R-BIG_SIOUX_11* | *DENR USGS* | *Immersion Recreation*<br><br>*Limited Contact Recreation* | *E. coli fecal coliform*<br><br>*E. coli* | *Municipal (urbanized high density area)*<br>*Livestock (grazing or feeding operations)* | *1* |
| *SD-BS-R-BIG_SIOUX_12* | *DENR* | *Immersion Recreation* | *E. coli fecal coliform* | *Livestock (grazing or feeding operations)* | *1* |

*The 303(d) list identifies impairments due to both E. coli and fecal coliform; however, this document develops TMDLs for E.coli only. South Dakota Department of Environment and Natural Resources (SD DENR) intends to drop the fecal coliform bacteria standard in 2015. Also, the TMDLs for E. coli are expected to address the fecal coliform water quality standard exceedances. This is because data from paired water samples collected in the project area indicate that the mean of the E.Coli concentrations is slightly higher than the mean of the fecal coliform concentrations. This result is consistent with data from three recent South Dakota TMDLs: Big Sioux River, Cheyenne River, and Whitewood Creek. Given that the water quality criteria that applies to any one sample for E. coli is 59% of the water quality criteria for fecal coliform, reductions in the bacteria loading to meet the WQC for E. coli are expected to also achieve the WQC for fecal coliform.*

***Comments:*** *No comments.*

## 1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g. insufficient data were available to determine if this water quality criterion is being attained).

Minimum Submission Requirements:

☒ The TMDL 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 anti-degradation policy. (40 C.F.R. §130.7(c)(1)).

☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the significant sources. Therefore, all TMDL documents must be written to meet the existing water quality standards for that waterbody (CWA §303(d)(1)(C)). *Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.*

☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.

☒ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***
*Summary tables included at the beginning of the document (pages i-iv) provide a description of the applicable water quality standards for each of the four segments of the Big Sioux River addressed in this TMDL. The description includes the designated uses assigned to each segment, and the applicable numeric water quality criteria.*

*The E. Coli and fecal coliform water quality criteria (WQC) for the impaired designated uses for these reaches are as follows:*

***South Dakota DENR Surface Water Quality Criteria for E. Coli***

| ***Designated Use*** | ***WQC (mean)[1]*** | ***WQC (single sample)*** | ***Applicable Period*** |
|---|---|---|---|
| *Immersion Recreation* | *≤ 126 cfu/mL* | *≤ 235 cfu/mL* | *May 1- September 30* |
| *Limited Contact Recreation* | *≤ 630 cfu/mL* | *≤ 1,178 cfu/mL* | *May 1- September 30* |

*[1]Geometric mean of minimum 5 samples obtained during separate 24-hr periods for any 30-day period*

***South Dakota DENR Surface Water Quality Criteria for Fecal Coliform***

| ***Designated Use*** | ***WQC (mean)[1]*** | ***WQC (single sample)*** | ***Applicable Period*** |
|---|---|---|---|
| *Immersion Recreation* | *≤ 200 cfu/mL* | *≤ 400 cfu/mL* | *May 1- September 30* |
| *Limited Contact Recreation* | *≤ 1,000 cfu/mL* | *≤ 2000 cfu/mL* | *May 1- September 30* |

*[1]Geometric mean of minimum 5 samples obtained during separate 24-hr periods for any 30-day period*

*Additionally, Section 2.0, Water Quality Standards and Total Maximum Daily Load Targets, provides a description of all designated uses (not just the impaired uses) that have been assigned to all four segments of the Big Sioux River included in the TMDL.*

*The designated uses are:*

| *Big Sioux River Segment* | *Designated Uses* |
|---|---|
| *SD-BS-R-BIG_SIOUX_08* | *Domestic water supply, fish and wildlife propagation, immersion recreation, irrigation waters, limited contact recreation, and warmwater semi-permanent fish life* |
| *SD-BS-R-BIG_SIOUX_10* | *Domestic water supply, fish and wildlife propagation, immersion recreation, irrigation waters, limited contact recreation, and warmwater semi-permanent fish life* |
| *SD-BS-R-BIG_SIOUX_11* | *Fish and wildlife propagation, immersion recreation, irrigation waters, limited contact recreation, and warmwater semi-permanent fish life* |
| *SD-BS-R-BIG_SIOUX_12* | *Fish and wildlife propagation, immersion recreation, irrigation waters, limited contact recreation, and warmwater semi-permanent fish life* |

*Section 4.0, Technical Analysis, describes the TMDL development using the load duration curve (LDC) approach. Specific standards-related details of the LDCs are as follows:*

- *The LDCs were developed for the entire flow regime within the recreational season (May 1-September 30). The LDCs were constructed using the product of simulated flows at reach endpoints, the daily maximum E. Coli WQC, and a unit conversion factor.*
- *Separate LDCs were developed for each of the four impaired segments.*
- *The single sample or daily maximum WQC for E. Coli for immersion recreation use (235 cfu/100 mL) was chosen as the water quality target and this value was used to construct the LDCs.*

- *LDCs based on the geometric mean WQC for E. Coli for immersion recreation use (126 cfu/100mL) were also constructed and are included in Appendix A of the document for comparison and to support the conclusion that reductions in loadings necessary to achieve the daily maximum WQC for E. Coli will result in achieving the geometric mean WQC for E. Coli.*

*Tables 5-2 through 5-5 present the TMDL, the margin of safety (MOS), load allocations (LA), and waste load allocations (WLA) for all flow zones and all four impaired segments. The TMDL for each flow zone for each segment is the 95$^{th}$ percentile of the range of loading capacities within that flow zone. The margin of safety is the difference between the loading capacity at the midpoint of the flow zone and the loading capacity at the minimum flow within each flow zone. The MS4 load is estimated based on the % of the total load as determined by the HSPF model and the point source allocation is the product of the discharge of the point source and the target E. Coli criteria. The remaining capacity is allocated to the non point sources as the LA.*

***Comments:*** *No comments.*

# 2. Water Quality Targets

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

Minimum Submission Requirements:

☒ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained. *Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.*

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***

***Numeric water quality target for each waterbody/pollutant combination:***
*Section 1.0, "Introduction", states that although the 303(d) listings include fecal coliform bacteria, this TMDL report focuses on TMDLs for E. Coli. Reductions in the bacteria loading to meet the WQC for E. coli are expected to also achieve the WQC for fecal coliform.*

*Section 2.0, "Water Quality Standards and Total Maximum Daily Load Targets", states that impaired segments must meet the more stringent standards of immersion recreation since they are listed as impaired for both immersion recreation and limited contact recreation.*

*The numeric TMDL targets established for the four impaired segments of the Big Sioux River are based on the daily maximum and 30-day geometric mean water quality standards for E. coli established to protect the immersion recreation beneficial uses. The water quality targets for these TMDLs are based on the numeric water quality standards for E. coli bacteria established to protect the immersion recreation beneficial uses for the impaired segments of the Big Sioux River. The E. coli targets for the Big Sioux River segments are: 235 cfu/100 mL daily maximum; or 126 cfu/100 mL 30-day geometric mean, depending on which criterion required the greatest load reduction.*

*LDCs based on the geometric mean WQC for E. Coli for immersion recreation use (126 cfu/100mL) are included in Appendix A. A comparison of the LDCs based on the daily maximum WQC for E. Coli and the geometric mean WQC for E.Coli support the conclusion that reductions in loadings necessary to achieve the daily maximum WQC for E. Coli will result in achieving the geometric mean WQC for E. Coli.*

*Therefore, the daily maximum WQC for E. Coli for immersion recreation use (235 cfu/100 mL) was chosen as the water quality target.*

***Comments:*** *No comments.*

# 3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each significant source (or source category) should be identified and quantified to the maximum practical extent. This may be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach may be appropriate. The approach should be clearly defined in the document.

Minimum Submission Requirements:

☒ The TMDL should include an identification of all potentially significant point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

| | |
|---|---|
| ☒ | The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads. |
| ☒ | Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified, characterized, and properly quantified. |
| ☐ | The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included. |

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary***:
*The TMDL document includes a breakdown of the land uses in the Big Sioux River watershed in Table 1-1. The TMDL document identifies the main E. coli sources as a combination of point sources and nonpoint sources within and upstream of the impaired segments. A total of 5 permitted point sources are located within the drainage area of the four segments. These are the Dell Rapids Wastewater Treatment Plant (WWTP) in segment 8, the Baltic WWTP also in segment 8, John Morrell & Company in segment 11 and the Sioux Falls WWTP in segment 12 and the Sioux Falls NPDES MS4 in segments 10 and 11. Nonpoint source loading from overland runoff from nearby croplands and feedlots, and inflow from tributaries also contribute to the total E. coli load. The document provides an estimate of the number of livestock, wildlife and septic systems within the project area.*

*There are currently 13 concentrated animal feeding operations (CAFOs) in Minnehaha County. CAFOs may exist within the watershed boundaries of Reaches 8, 11, and 12 because agricultural land is present. Note, however, that all of these permitted facilities have a zero discharge except in the rare case of a precipitation event that produces a volume of water greater than the design capacity of the facility. In this case, the permittee is required to notify the SD DENR and develop a plan of action to remediate the problem.*

*The HSPF model was used to determine the contribution of E. coli bacteria from identified sources in the project area and to evaluate the implementation of BMPs to control these sources. Source assessment modeling results were summarized using the following categories: nonpoint sources, MS4 (local (contributions from MS4 system located within the current reach boundaries)), MS4 (upstream (contributions from MS4 system located upstream of current reach boundaries), Big Sioux River boundary conditions, Skunk Creek, and Slip-Up Creek.*

***Comments***: *No comments.*

# 4. TMDL Technical Analysis

TMDL determinations should be supported by a robust data set and an appropriate level of technical analysis. This applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways, such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum LAs + \sum WLAs + MOS$$

Where:

| | | |
|---|---|---|
| TMDL = | | Total Pollutant Loading Capacity of the waterbody |
| LAs | = | Pollutant Load Allocations |
| WLAs | = | Pollutant Wasteload Allocations |
| MOS | = | The portion of the Load Capacity allocated to the Margin of safety. |

Minimum Submission Requirements:

☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. 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 total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify 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.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

(1) the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
(2) the distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
(4) present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
(5) 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.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1) ). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☒ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***
*The technical analysis includes a description of the analytical processes used, results from water quality modeling, assumptions and other pertinent information. The TMDL technical analysis for the four impaired segments of the Big Sioux River describes how the E. coli loads were derived in order to meet the applicable water quality standards.*

*A combination of HSPF modeling along with load duration curves were used in a weight of evidence technical analysis for the Big Sioux River E. coli TMDLs. The HSPF model was used to determine the contribution of E. coli bacteria from identified sources in the project area and to evaluate the implementation of BMPs to control these sources. The evaluation of the BMPs was performed by comparing the predicted load reductions and the frequency percent exceedance of the WQC for each BMP alternative. The Big Sioux River drainage basin was represented in the model using 24 sub watersheds and two boundary conditions which represent Skunk Creek and the Big Sioux River at Dell Rapids. Nonpoint source bacterial loadings for HSPF were estimated using the event mean concentrations (EMCs) for each land use, which were derived from sample data based on representative land uses draining to particular sampling sites. EMCs were applied throughout the watershed. The buildup and wash off of E. coli was simulated based on the EMC values and precipitation.*

*The TMDL loads and loading capacities were derived using the load duration curve (LDC) approach that results in a flow-variable target that considers the entire flow regime. The LDC is a dynamic expression of the allowable load for any given day. The LDCs were constructed using the product of simulated flow (from the HSPF model) at the endpoint for each reach and the E. Coli WQC and a unit conversion factor.*

*The MS4 load was calculated using the HSPF model application. Instantaneous loads within each reach were plotted on the LDCs. These instantaneous loads were calculated using concentrations of E. Coli measured directly from sampling locations within each reach and estimated E.Coli concentrations transformed from observed fecal coliform concentrations using the equation derived from paired samples. Flow values were from direct measurements and simulated where direct measurements were not available.*

*To aid in the interpretation of the TMDL, the LDC flow intervals were grouped into five flow zones. Once the loading capacity was derived for each flow zone then the load allocations were calculated by subtracting the WLA and MOS. The calculated loads for each flow regime for all four segments are included in Tables 5-2, 5-3, 5-4 and 5-5 of the TMDL document.*

***Comments:*** *No comments.*

## 4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Minimum Submission Requirements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☒ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***
***Description and summary of all available water quality data relevant to the water quality assessment and TMDL analysis:*** *The data description and summary for the four impaired segments of the Big Sioux River are included mainly in Section 1.3., Available Water-Quality Data, and are plotted on the load duration curves. Sampling was conducted on a temporal basis over the period from January 2000 to October 2009 and included 1,673 total samples of which 1471 were analyzed for fecal coliform and 202 were analyzed for E. coli.*

*Although data are available from monitoring that occurred prior to the year 2000, only data collected during the period 2000-2009 were used the TMDL analysis. The earlier data were excluded because of the expansion of the City of Sioux Falls boundaries and the significant amount of data available after the year 2000.*

***Comments:*** *No comments.*

## 4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Minimum Submission Requirements:

☒ EPA regulations require that a TMDL include WLAs for all significant and/or NPDES permitted point sources of the pollutant. TMDLs must identify the portion of the loading capacity allocated to individual existing and/or future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☒ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary***:
*Table 3-1 identifies five permitted point sources located within the drainage area of the four segments. These are the Dell Rapids Wastewater Treatment Plant (WWTP) in segment 8, the Baltic WWTP also in segment 8, John Morrell & Company in segment 11 and the Sioux Falls WWTP in segment 12 and the Sioux Falls NPDES MS4 in segments 10 and 11. A WLA for the Sioux Falls MS4 was derived for segments 10 and 11. WLAs for the other four point sources were derived and are included in Tables 5-2, 5-4 and 5-5.*

*WLAs for high flow zone:*

| ***TMDL Identification*** | ***Point Source*** | ***Permit Number*** | ***WLA (cfu/day)*** |
|---|---|---|---|
| *PSA 1* | *Dell Rapids WWTP* | *SD-0022101* | $4.1 \times 10^{10}$ |
| *PSA 2* | *Baltic WWTP* | *SD-0022284* | $3.9 \times 10^{10}$ |
| *PSA 3* | *John Morrell & Company* | *SD-0000078* | $3.7 \times 10^{10}$ |
| *PSA 4* | *Sioux Falls WWTP* | *SD-0022128* | $2.57 \times 10^{11}$ |
| *N/A* | *Sioux Falls MS4, Reach 10* | *SD-000001* | $2.2 \times 10^{12}$ |
| *N/A* | *Sioux Falls MS4, Reach 11* | *SD-000001* | $1.5 \times 10^{12}$ |

***Comments***: *No comments.*

## 4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Minimum Submission Requirements:

☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.

☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary***:

*The Load Allocation section explains how the loading capacity and load allocation was derived. Tables 5-2, 5-3, 5-4 and 5-5 show the load allocations for each of the five flow regimes for each segment.*

***Comments***: *No comments.*

## 4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

Minimum Submission Requirements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d) (1) (C), 40 C.F.R. §130.7(c)(1) ). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

☐ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.

☒ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.

☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***
*The Big Sioux River TMDLs include explicit MOSs for each segment that were derived by calculating the difference between the loading capacity at the mid-point of each of the five flow zones and the loading capacity at the minimum flow in each zone. The explicit MOS values are included in Tables 5-2, 5-3, 5-4 and 5-5 of the TMDL document. This approach provides a MOS ranging from 14% to 46%, with an average of 27% across all segments and flow zones.*

***Comments:*** *No comments.*

## 4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Minimum Submission Requirements:

☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1) ).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***
*By using the load duration curve approach to develop the TMDL allocations seasonal variability in E. coli loads are taken into account. Highest steam flows typically occur during late spring, and the lowest stream flows occur during the winter months.*

***Comments:*** *No comments.*

## 5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Minimum Submission Requirements:

☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii) ).

☐ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary***:

*The Public Participation section of the TMDL document describes the public participation process that has occurred during the development of the TMDLs for the Big Sioux River. In particular, the State has encouraged participation through public meetings in the watershed, and a website was developed and maintained throughout the project. The TMDL was available for a 30-day public notice period prior to finalization.*

***Comments***: *No comments.*

## 6. Monitoring Strategy

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

Minimum Submission Requirements:

☒ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☐ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques

would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL. http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***
*The Big Sioux River will continue to be monitored as part of DENR's ambient water quality monitoring at existing stations along the Big Sioux River. These stations are sampled monthly during the recreation season (May – September). Additional monitoring is expected to be designed to evaluate the effectiveness of implemented BMPs. Accordingly, monitoring locations are expected to be based on the location and type of BMPs installed.*

*The TMDL document recognizes that continued collection of E. Coli data is needed to develop a more robust dataset to reduce the reliance on the translator equation for this TMDL to set base loadings. TMDL target reductions will be revised in the future based on the collection of additional E. Coli data.*

***Comments:*** *No comments.*

# 7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Minimum Submission Requirements:

☒ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***

*A variety of BMPs are proposed for consideration during development of the implementation plan as described in Section 9.1of the TMDL document. Several types of control measures are available for reducing E. coli bacteria loads; however the BMPs determined to be practicable by the stakeholders are listed and recommended to address the identified sources in the Sioux Falls area.*

*Based on water quality monitoring, bacterial source tracking, and HSPF model results, the recommended control measures to be implemented in Sioux Falls are expected to reduce exceedances of the acute E. coli criteria from the current 74 percent to 9 percent in Reach SD-BS-R-BIG_SIOUX_08, from 90 percent to 12 percent in Reach SD-BS-RBIG_ SIOUX_10, from 80 percent to 14 percent in Reach SD-BS-R-BIG_SIOUX_11, and from 76 percent to 20 percent in Reach SD-BS-R-BIG_SIOUX_12. These load reductions will assist in the attainment of the TMDL goal.*

*The seven management scenarios that were simulated for each bacteria-impaired reach using the HSPF model include the incorporation of: (1) future land use, (2) the city's planned BMPs, (3) Big Sioux River upstream of Dell Rapids and Skunk Creek compliance with the current limited recreation acute water-quality standard, (4) Big Sioux River upstream of Dell Rapids and Skunk Creek compliance with the immersion recreation acute water-quality standard, (5) change of flow routing down the Big Sioux River and the diversion (minimum flow through the city maintained at 400 cfs), (6) a 90 percent load reduction on agricultural land within the project area boundary north of Sioux Falls local to the Big Sioux River and Silver Creek, and (7) an E. coli reduction of 75 percent on 100 percent of the MS4. Table 9-1 shows the modeled percent exceedance of the daily maximum criteria, individual load reduction results, and cumulative load reduction results for each scenario considered in each of the four stream segments of the Big Sioux River.*

***Comments:*** *No comments.*

# 8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Minimum Submission Requirements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

***Summary:***

*The Big Sioux River E. coli TMDLs include daily loads expressed as colony forming units per day. The daily TMDL loads are included in the TMDL Allocations sections of the TMDL document.*

***Comments:*** *No comments.*