— DRAFT —

CENTRAL BIG SIOUX RIVER WATERSHED

WATER QUALITY MASTER PLAN

Topical Report RSI-2323

prepared for

City of Sioux Falls
1203 N. Western Avenue
Sioux Falls, South Dakota 57104-1201

May 2013

RESPEC CONSULTING & SERVICES

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Topical Report RSI-2323

by

Jared K. Oswald
Tyler P. French
Peter P. Rausch
Adam J. Rutz

RESPEC
P.O. Box 725
Rapid City, South Dakota 57709

prepared for

City of Sioux Falls
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1.0 OVERVIEW

The Central Big Sioux River Watershed (CBSRW) project area encompasses approximately 1,282,560 acres and includes 65 12-digit Hydrologic Unit Codes (HUCs) in portions of two 8-digit HUCs (10170202 and 10170203), as illustrated in Figure 1-1. The Big Sioux River and its tributaries in the project area drain parts of Brookings, Deuel, Hamlin, Lake, Lincoln, Minnehaha, Moody, and Turner Counties in South Dakota as well as portions in Lincoln and Pipestone Counties of southwestern Minnesota. The Big Sioux River is a natural, permanent, stable river with several intermittent tributaries that only flow during snowmelt and rainfall events. Discharge in the river can be significantly impacted by wet or dry periods as well as stormwater runoff.

Stakeholders in the watershed have come together to address the water-quality concerns within the CBSRW to develop this water-quality master plan to guide implementation efforts. This plan builds on past accomplishments in the CBSRW and complements water-quality efforts by the city of Sioux Falls, the Brookings County Conservation District, the Minnehaha Conservation District (MCD), the Lake County Conservation District, the Moody County Conservation District (MCCD), the U.S. Geological Survey (USGS), the East Dakota Water Development District (EDWDD), the South Dakota Association of Conservation Districts (SDACD), and the South Dakota Department of Environment and Natural Resources (SD DENR).

This master plan addresses the U.S. Environmental Protection Agency's (EPA's) Nine Key Elements as outlined in South Dakota Department of Environment and Natural Resources [2012]. Table 1-1 displays these nine key elements and their corresponding location within this master plan.

1.1 PROJECT GOALS

The CBSRW project requires the support of multiple entities to achieve needed water-quality improvements. The CBSRW decision makers are faced with the challenge of selecting the best combination of practices to implement, among the many options available, that will result in the most cost-effective, achievable, and practical management strategy possible.

Given the complexity of implementation options, a key contribution to the formation of the CBSRW Water-Quality Master Plan is the development of a watershed-scale, decision-support model used to facilitate prioritization and placement of Best Management Practices (BMPs) within the watershed. Government and local watershed planning agencies can use the decision-support framework as they coordinate watershed-scale investments within the CBSRW project area. The CBSRW Decision Support Model (CBSRW DSM) can assist in identifying priority areas and priority management practices optimized for cost, water-quality impact, and implementation feasibility.

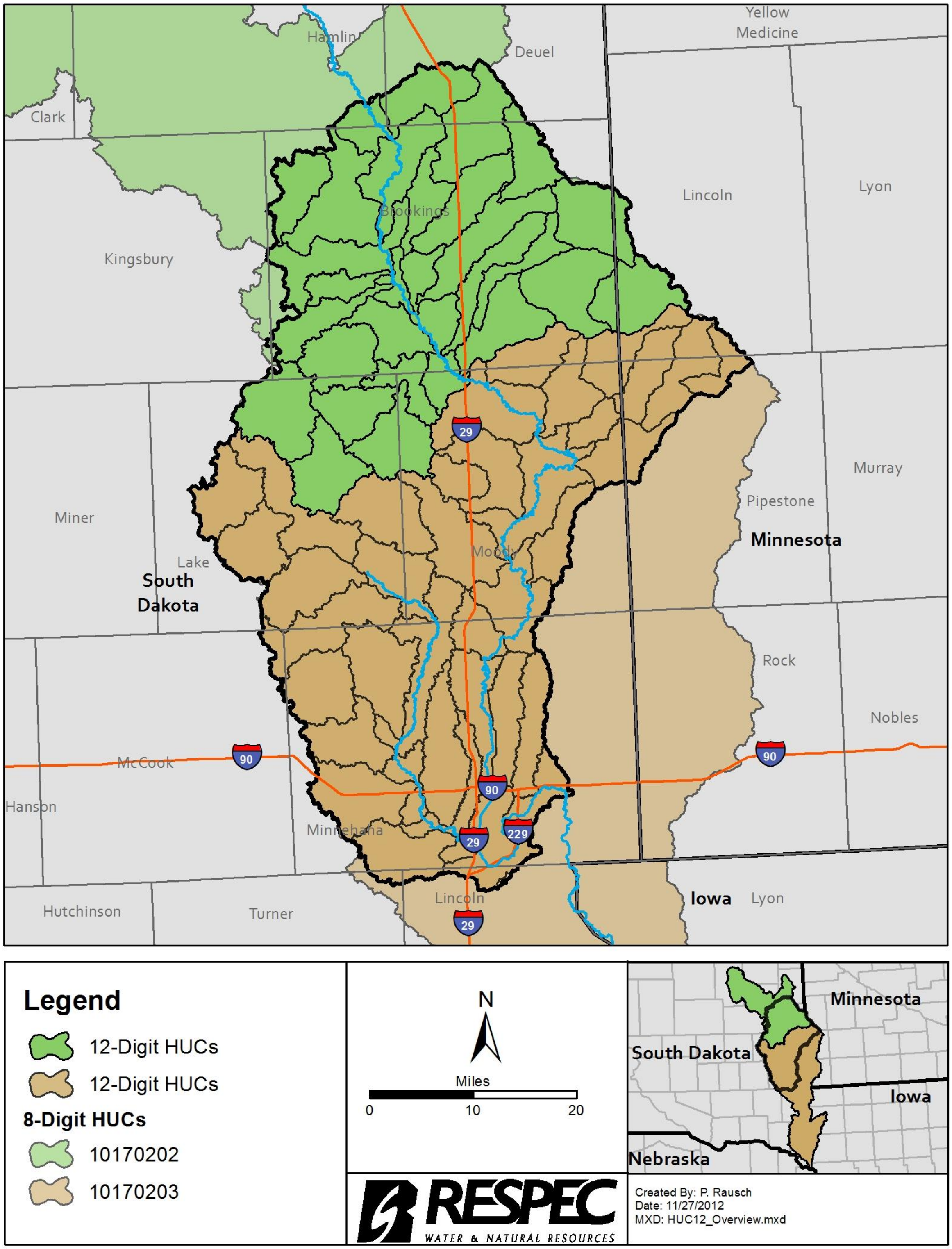

Figure 1-1. Delineation of 12-Digit Hydrologic Unit Codes Within the Central Big Sioux River Watershed Project Area.

Table 1-1. Sections of the Central Big Sioux River Watershed Master Plan That Fulfill the U.S. Environmental Protection Agency's Nine Key Elements for Watershed Planning (Page 1 of 2)

EPA Nine Key Elements for Watershed Planning	Applicable TMDL Sections and/or TMDL Implementation Plan[a]
1. Identification of **causes of impairment and pollutant sources** or groups of similar sources that need to be controlled to achieve needed **load reductions** and **any other goals** identified in the watershed plan.	6.2 Priority Sources
2. Estimate of the **load reductions expected from management measures**.	7.4 Expected Exceedance and Load Reductions
3. Description of the **BMPs** that will need to be implemented to **achieve load reductions** in item (2) and a description of the **critical areas** in which those measures will be needed to implement this plan.	6.0 Implementation Strategy 6.2.1 Agricultural BMPs 6.2.2 Urban BMPs
4. Estimate of the amounts of **needed technical and financial assistance**, associated **costs**, and/or the **sources and authorities** that will be relied upon to implement these plans.	7.3 Sources of Technical and Financial Assistance
5. An **information, education, and public participation component** used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint-source management measures that will be implemented.	8.0 Information, Education, and Outreach
6. **Schedule** for implementing the nonpoint-source management measures identified in this plan that is reasonably expeditious.	7.1 BMP Implementation Schedule
7. A description of **interim measurable milestones** for determining whether nonpoint-source management measures or other control actions are being implemented.	7.1 BMP Implementation Schedule
8. A set of criteria that can be used to determine whether loading reductions are achieved over time and substantial progress is made toward attaining water-quality standards, and, if not, the criteria for determining whether the Watershed Master Plan needs to be revised.	7.0 Tracking Progress Toward Meeting TMDL Goals

Table 1-1. Sections of the Central Big Sioux River Watershed Master Plan That Fulfill the U.S. Environmental Protection Agency's Nine Key Elements for Watershed Planning (Page 1 of 2)

EPA Nine Key Elements for Watershed Planning	Applicable TMDL Sections and/or TMDL Implementation Plan[a]
9. A **monitoring component to evaluate the effectiveness of implementation efforts** over time, measured against the criteria established under item (8) above.	10.1 Monitoring

(a) TMDL = Total Maximum Daily Load

1.2 ACKNOWLEDGEMENTS

RESPEC would like to acknowledge and thank the members of the CBSRW Master Plan Technical Review Committee for their continued support, participation, and diligence in developing the CBSRW Water-Quality Master Plan. Without the cooperation of these individuals, the CBSRW Water-Quality Master Plan would not have been possible. Table 1-2 lists the individual members of the Technical Review Committee.

Table 1-2. The Central Big Sioux River Watershed Master Plan Technical Review Committee Members

Member	Organization
Mr. Bryan Read	City of Brandon
Mr. Craig Spencer	Augustana College
Mr. Darrell DeBoer	Brookings County Conservation District
Ms. Deb Springman	East Dakota Water Development District
Mr. Jack Majeres	Moody County Conservation District
Ms. Jacqueline Lanning	City of Brookings
Mr. Jeppe Kjaersgaard	South Dakota State University
Mr. Jeremy Schelhaas	South Dakota Department of Environment and Natural Resources
Mr. Mike Boerger	City of Watertown
Mr. Mike Kuck	South Dakota Association of Conservation Districts
Mr. Robert Kappel	City of Sioux Falls (Chair)

2.0 WATERSHED CHARACTERISTICS

The various watershed characteristics that influence watershed hydrology and water quality are summarized below. Many of these characteristics are imported as variables into the CBSRW DSM to assess the fate and transport of contaminants within the watershed. A general summary of each characteristic is described with a brief summary of how it impacts sediment and/or bacteria transport.

2.1 SOILS

A variety of parent materials have derived the soils within the Central Big Sioux Watershed. The fine-grained upland soils have built up over glacial till or eolian (Loess) deposits. Coarse-grained soils, which were derived from glacial outwash and alluvial sediments, can be found near present and past water courses. Near Dell Rapids, a shift to highly erodible soils is noticeable. Moody, Nora, and Trent soil series are common within the project area.

Understanding soil characteristics is important to both bacteria and sediment model development. The ratios of sand, silt, and clay for a given soil type dictates the amount of infiltration/deep percolation and runoff. The runoff portion of any precipitation event becomes the transport mechanism for land-deposited bacteria and for soil particles. Soil information was gathered from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) Database.

2.2 CLIMATE

The CBSRW receives an average annual precipitation of 24.7 inches, and 73 percent falls during the growing season of April through September. On average, 45 rainfall events occur in the watershed annually, with an average depth of 0.54 inch. The average, seasonal snowfall is 41.1 inches per year, which contributes to significant snowmelt runoff in the spring months [U.S. Department of Commerce National Climatic Data Center, 2004].

Several meteorological time-series are required to effectively understand how water, bacteria, and sediment travel through the watershed and to execute the CBSRW DSM. Precipitation and evapotranspiration (ET), which is the amount of water consumed by plants and lost to the atmosphere, are both needed to calculate the water balance. Air temperature, wind speed, solar radiation, dewpoint temperature, and cloud cover are used to calculate snowmelt and snow accumulation processes. Most of the meteorological data required by the CBSRW DSM are available through the EPA and the **Better Assessment Science Integrating Point and Nonpoint Sources (BASINS)** system. This system provides data developed by the National Climatic Data Center (NCDC).

Figure 2-1 displays the meteorological zones set up within the model. These zones were delineated based on the location of precipitation gages and are used to distribute rainfall within the model.

2.3 LAND COVER AND LAND USE

Land cover and land use information are gathered from the Multi-Resolution Land Characteristics Consortium National Land Cover Database (NLCD). Land use in the watershed is predominantly agricultural; approximately 61 percent of the area is cultivated cropland and 26 percent of the area is grasslands, pasture, and hay land. Eight percent of the watershed is urban and the remaining 5 percent consists of water and other land use categories.

Information from the NLCD is input into the CBSRW DSM. Land cover and land use are important factors affecting the amount of any precipitation event that reaches the ground surface and the potential for that water to travel to local waterbodies.

2.4 BACTERIA SOURCES

Considering the distributions and activities of human, pet, livestock, and wildlife populations within the watershed are vital to understanding bacteria water-quality impairments. The **Bacteria Source Load Calculator Version 4.0** (**BSLC**), which was developed by the Biological Systems Engineering Department at Virginia Polytechnic Institute and State University, was used to accumulate bacteria loadings to the proper land uses throughout the watershed. The **BSLC** allows the user to distribute human, pet, livestock, and wildlife characteristics in the watershed to areas they are known to inhabit based on local knowledge and professional judgment. It also applies the loadings onto the land or directly to the stream based on an understanding of stream access. These land and stream loadings from the **BSLC** were then input into the CBSRW DSM and used to understand the fate and transport of bacteria within adjacent waterbodies.

2.4.1 Livestock

Livestock count and distribution for each county in the project area was based on population data from the 2007 Census of Agriculture completed by the U.S. Department of Agriculture. Feedlot locations, species, and estimated populations were gathered by CBSRW implementation specialists for a majority of the project area during a drive-by survey conducted in 2006. The remainder of the feedlot locations were identified with aerial imagery.

Species of interest included hogs, chickens, turkeys, cattle, sheep, horses, and goats. The county populations of hogs, chickens, and turkeys were distributed based on the available pasture and cropland acres.

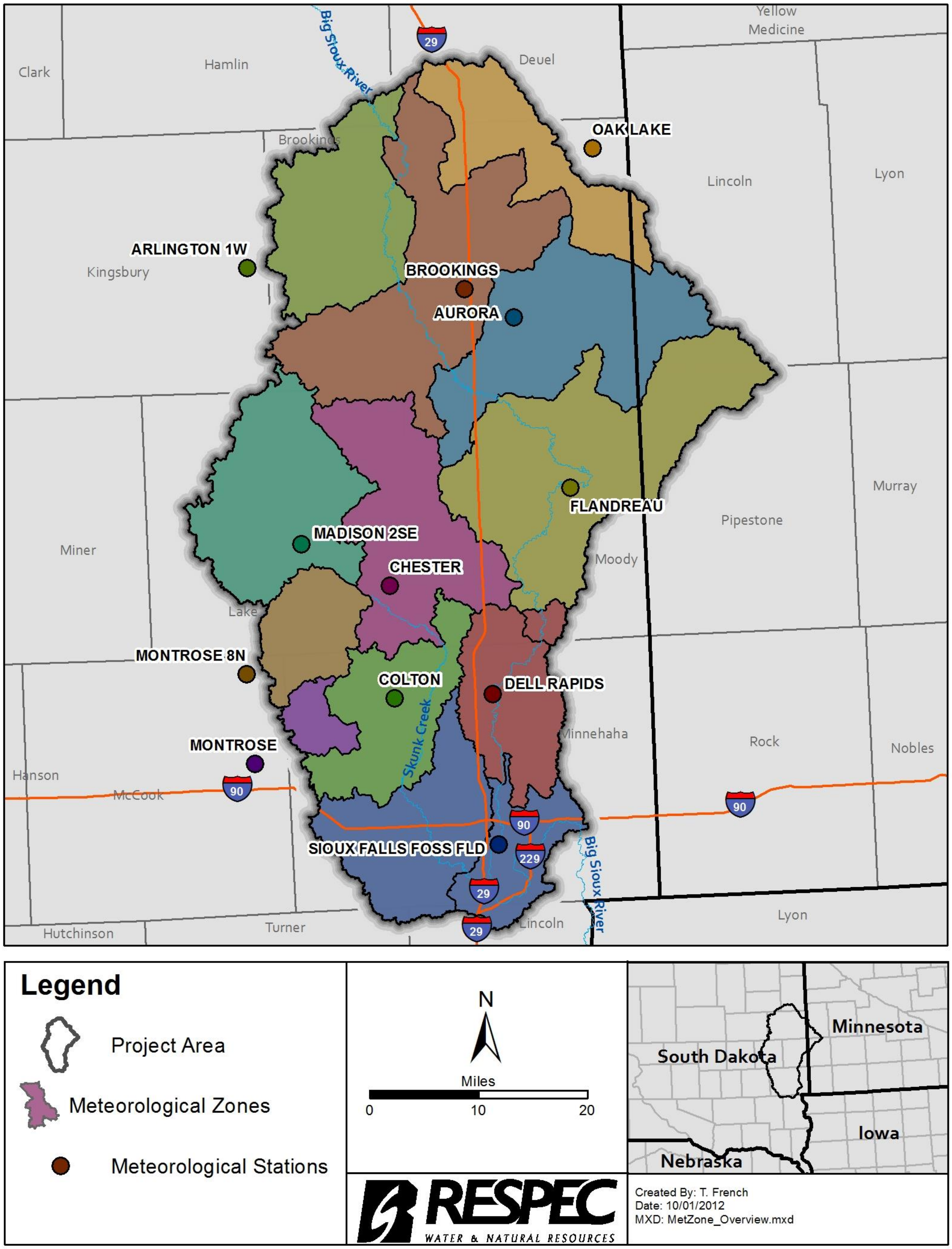

Figure 2-1. Precipitation Gages and Associated Meteorological Zones Within the Central Big Sioux River Watershed.

The CBSRW DSM assumed these species were confined throughout the year and manure was spread on cropland during the spring and fall. The county populations of cattle, sheep, goats, and horses were distributed to pasture and feedlot areas found within each meteorological zone.

2.4.2 Wildlife

Wildlife counts were based on population data from the 2002 South Dakota Game Report (No. 2003-11). Reported wildlife species within the watershed include whitetail deer, raccoons, muskrats, beavers, nesting Canada geese, wild turkeys, skunks, and cottontail rabbits. All of these species were represented in the **BSLC**. Duck populations were not supplied by the South Dakota Game Report but were represented in the **BSLC** by assuming that there is the same population of ducks as nesting Canada geese.

Similar to the livestock estimation, county wildlife populations were distributed based on the percentage of habitat area for each species. The **BSLC** was referenced to find the habitat (land use) preference for each of the species and the bacteria loads were applied equally to these land uses. The land use preferences are provided in Table 2-1.

Table 2-1. Wildlife Land Use Preferences

Species	Habitat Type
Deer	cropland, pasture, residential, wetlands, and all riparian zones
Beaver	open water, wetlands, and all riparian zones
Muskrat	open water, wetlands, and all riparian zones
Raccoons	cropland and all riparian zones
Skunks	cropland, pasture, wetlands, and all riparian zones
Nesting Canada Geese	cropland, open water, wetlands, and all riparian zones
Rabbits	cropland, pasture, wetlands, and all riparian zones
Wild Turkey	cropland, pasture, riparian cropland, and riparian pasture

2.4.3 Humans and Pets

Population data for the project area was gathered from the 2010 U.S. Census. Table 2-2 provides the total county population from the census, the estimated urban and rural population within the project area, and the estimated number of urban and rural households within the project area.

For urban populations, the **BSLC** assumes that all households within city limits are on a municipal sewer system, which results in no land or direct stream load from humans in urban areas. To estimate bacteria loading from pets in urban areas, the BSLC suggests a default of one pet (one dog or two cats) per household.

Table 2-2. Population Statistics in the Central Big Sioux River Watershed

County	State	Rural Households	Rural Population	Urban Households	Urban Population
Brookings	South Dakota	2,294	5,460	9,297	22,126
Deuel	South Dakota	100	240	84	202
Hamlin	South Dakota	22	58	258	675
Kingsbury	South Dakota	1	2	424	992
Lake	South Dakota	2,288	5,514	2,811	6,775
McCook	South Dakota	9	23	–	–
Minnehaha	South Dakota	12,130	29,839	48,373	118,998
Moody	South Dakota	1,143	2,949	1,360	3,508
Lincoln	Minnesota	199	468	–	–
Pipestone	Minnesota	145	345	–	–

The BSLC uses a rural population to estimate land and stream loadings from failed septic systems as well as impacts from pets. The number of rural septic systems was determined by manually marking each rural dwelling found on a 2010 Bing aerial base map supplied by ArcGIS. Septic systems were categorized as old-aged, middle-aged, or new-aged based on a technique recommended in the BSLC that uses USGS 7.5-minute quadrangle maps. Old-aged systems were given a failure rate of 40 percent, middle-aged systems were given 20 percent, and new-aged systems were given 3 percent. The SD DENR supplied a list of updated septic systems that was used to change failure rates of those old- and middle-aged systems that had been repaired or replaced.

The BSLC considers a fraction of the houses, on septic found within the riparian zone buffer of a stream, to be straight pipe systems. Buffer widths and house age were used to estimate if a dwelling was potentially discharging via a straight pipe directly to the stream. Buffer widths are based on stream order and are provided in Table 2-3. The BSLC suggests that 10 percent of the old-aged and 2 percent of the middle-aged houses within the buffer are straight pipes.

2.5 KEY FEATURES

Various features within the watershed that attribute to hydrologic alteration within the Big Sioux River and supporting tributaries are present. The hydrologic alteration that these features cause can also have a significant impact on water-quality processes and, therefore, were accounted for during the CBSRW DSM development. These features are outlined in the sections below and are displayed in Figure 2-2.

Table 2-3. Stream Order-Based Buffer Distances

Stream Order	Buffer (ft)
1	98
2	98
3	164
4	100
5	656

2.5.1 Cities

Larger cities within the watershed include Sioux Falls, Brookings, Madison, Dell Rapids, Hartford, and Flandreau. Areas of dense human population and development have the potential to produce high levels of pollutants and high volumes of stormwater, which can raise in-stream pollutant levels after rainstorms because the amount of impervious area is significant.

2.5.2 Lakes

Much of the CBSRW lies on the Prairie Coteau, an area of closely spaced wetlands and lakes with no definite drainage pattern. The headwaters of many tributaries to the Big Sioux River include these lakes, which results in significant flow attenuation and pollutant settling in those areas.

2.5.3 City of Sioux Falls Diversion Structure

The city of Sioux Falls lies on a large oxbow of the Big Sioux River. To minimize flooding potential, a canal system was constructed to divert the majority of the Big Sioux River's flow out of the oxbow and around the city. Skunk Creek flows into the oxbow downstream from the diversion point, and often accounts for the majority of the Big Sioux River flow through Sioux Falls.

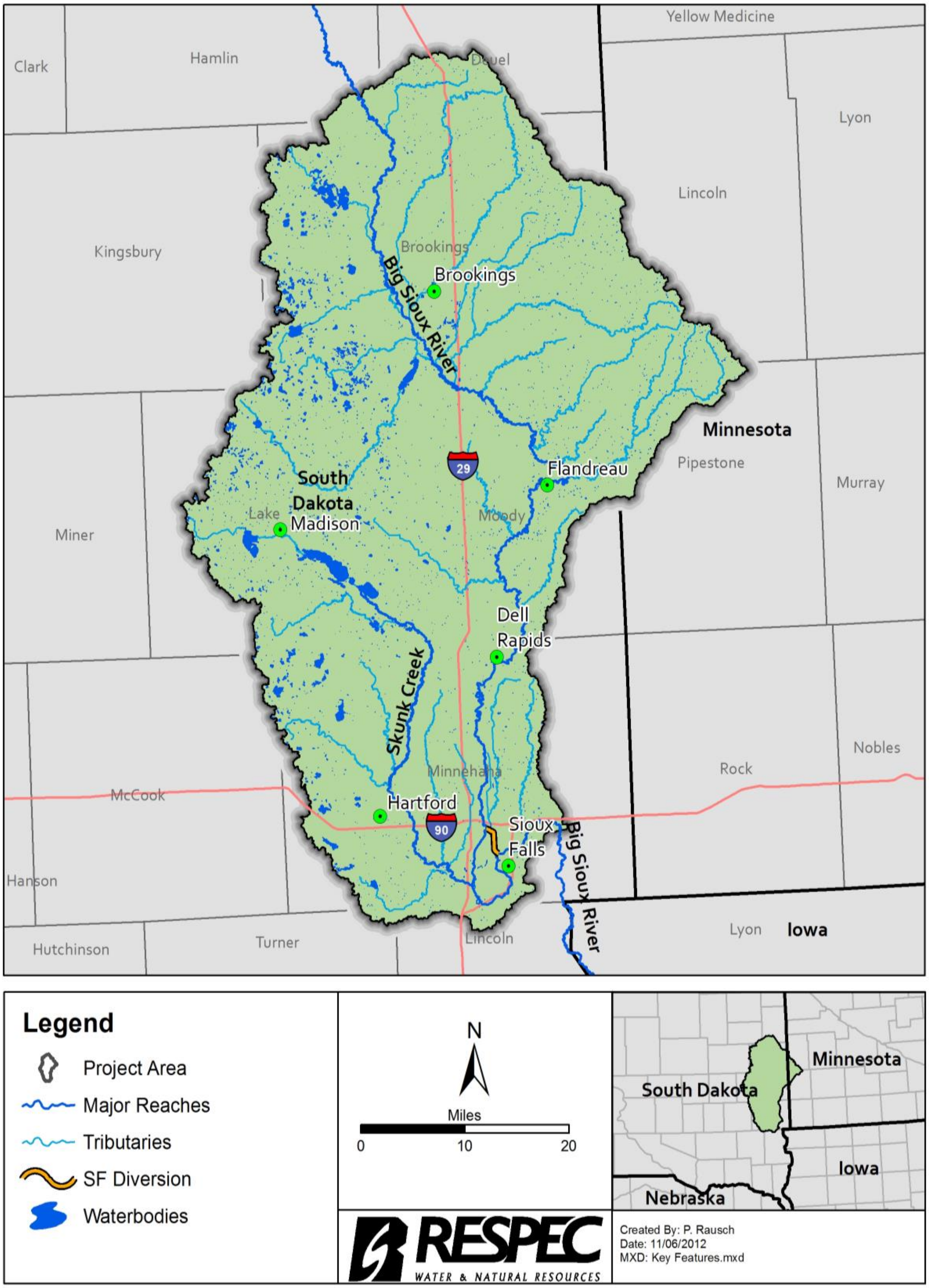

Figure 2-2. Key Features Located Within the Central Big Sioux River Watershed.

3.0 WATER QUANTITY AND QUALITY

A summary of compiled information that is applicable to stream listing is summarized in the sections below.

3.1 303(D) IMPAIRED WATERBODIES

Eight impaired stream reaches listed as nonsupportive of their assigned beneficial uses in South Dakota's 2012 303(d) list of impaired waterbodies [South Dakota Department of Environment and Natural Resources, 2012] are within the project area. Four of the listed impairments are located on the Big Sioux River and the remaining four listings are located on tributaries to the Big Sioux River.

These reaches were impaired because of sample concentrations of *E. coli* and Fecal Coliform bacteria and Total Suspended Solids (TSS) that exceeded their assigned beneficial use criterions. The four impaired reaches on the Big Sioux River were all listed for impairment of the Immersion Recreation beneficial use as well as impairment of the Warm-water Semipermanent Fish Life Propagation beneficial use. In addition, two reaches (SD-BS-R-BIG_SIOUX_10 and BS-R-BIG_SIOUX_11) were listed as impaired for the Limited Contact Recreation beneficial use.

The four impaired tributary reaches were listed for impairment of the Limited Contact Recreation beneficial use. One reach, Skunk Creek (SD-BS-R-SKUNK_01) was also listed as impaired for its warm-water marginal fish life propagation beneficial use because of TSS criterion exceedances. Table 3-1 provides all 303(d) listed waterbodies within the project area, their number of years on the 303(d) list, their impairments, and their respective water-quality threshold values. The reaches are also illustrated in Figure 3-1.

3.2 FLOW

Flow in the Central Big Sioux River can be significantly impacted by wet or dry periods and stormwater runoff. Eleven U.S. Geological Survey (USGS) gaging stations are located within the project area, as illustrated in Figure 3-2. Each of these stations was used for the hydrologic calibration of the CBSRW DSM. Site 06479770, near the northern boundary of the CBSRW Project Area, was used as a boundary condition where historically observed flow is input to the upstream end of the CBSRW DSM and represents conditions above the modeling domain, and, therefore, was not used for calibration. The other sites were used to calibrate and validate the CBSRW DSM hydrology predictions. Site 06481480 on Skunk Creek does not have continuous flow data, so only individual flow measurements at the site were used for calibration at that site.

Table 3-1. 303(d) Listed Impaired Waterbodies in the Central Big Sioux River Watershed Project Area (Page 1 of 2)

Waterbody Name/Description	Assessment Unit I.D.	Years Listed	Impaired Waterbody Length	Impaired Designated Use(s)	303(d) Listing Parameter	Water-Quality Criteria Threshold Values (Bacteria criteria apply from May 1 through September 30)
Big Sioux River (S2, T104N, R49W to I-90)	SD-BS-R-BIG_SIOUX_08	2004 2006 2008 2010 2012	28.5 miles	Immersion Recreation	*E. coli* Bacteria Fecal Coliform Bacteria	*E. coli*: Daily maximum 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. Fecal Coliform: Daily maximum of ≤ 400 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 200 cfu/100 mL.
		2010 2012		Warm-Water Semipermanent Fish Life	TSS	Maximum daily concentration of ≤ 158 milligrams per liter (mg/L) and a 30-day average of at least three consecutive grab or composite samples taken on separate weeks in a 30-day period of ≤ 90 mg/L.
Big Sioux River (I-90 to diversion return)	SD-BS-R-BIG_SIOUX_10	2004 2006 2008 2010 2012	15.8 miles	Immersion Recreation and Limited Contact Recreation	*E. coli* Bacteria Fecal Coliform Bacteria	**Immersion Recreation:** *E. coli*: Daily maximum of ≤ 235 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 126 cfu/100 mL. Fecal Coliform: Daily maximum of ≤ 400 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 200 cfu/100 mL. **Limited Contact Recreation:** *E coli:* Maximum daily concentration of ≤ 1,178 cfu/100 mL and a geometric mean of at least five samples over a 30-day period of ≤ 630 cfu/100 mL. Fecal Coliform: Maximum daily concentration of ≤ 2,000 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 1,000 cfu/100 mL.
		2010 2012		Warm-Water Semipermanent Fish Life	TSS	Maximum daily concentration of ≤ 158 mg/L and a 30-day average of at least three consecutive grab or composite samples taken on separate weeks in a 30-day period of ≤ 90 mg/L.
Big Sioux River (Diversion return to Sioux Falls Waste Water Treatment Plant (WWTP)	SD-BS-R-BIG_SIOUX_11	2004 2006 2008 2010 2012	4.7 miles	Immersion Recreation and Limited Contact Recreation	*E. coli* Bacteria Fecal Coliform Bacteria	**Immersion Recreation:** *E. coli*: Daily maximum of ≤ 235 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 126 cfu/100 mL. Fecal Coliform: Daily maximum of ≤ 400 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 200 cfu/100 mL. **Limited Contact Recreation:** *E coli:* Maximum daily concentration of ≤ 1,178 cfu/100 mL and a geometric mean of at least five samples over a 30-day period of ≤ 630 cfu/100 mL. Fecal Coliform: Maximum daily concentration of ≤ 2,000 cfu/100 mL and a geometric mean of at least five samples over a 30 -day period ≤ 1,000 cfu/100 mL.
		2004 2010 2012		Warm-Water Semipermanent Fish Life	TSS	Maximum daily concentration of ≤ 158 mg/L and a 30-day average of at least three consecutive grab or composite samples taken on separate weeks in a 30-day period of ≤ 90 mg/L.
		2004 2006 2008 2010 2012		Immersion Recreation	E. coli Bacteria Fecal Coliform Bacteria	E. coli: Daily maximum of ≤ 235 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 126 cfu/100 mL. Fecal Coliform: Daily maximum of ≤ 400 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 200 cfu/100 mL.
		2004 2010 2012		Warm-Water Semipermanent Fish Life	TSS	Maximum daily concentration of ≤ 158 mg/L and a 30-day average of at least three consecutive grab or composite samples taken on separate weeks in a 30-day period of ≤ 90 mg/L.

Table 3-1. 303(d) Listed Impaired Waterbodies in the Central Big Sioux River Watershed Project Area (Page 2 of 2)

Waterbody Name/Description	Assessment Unit I.D.	Years Listed	Impaired Waterbody Length	Impaired Designated Use(s)	303(d) Listing Parameter	Water Quality Criteria Threshold Values (Bacteria criteria apply from May 1 through September 30)
Big Sioux River (Sioux Falls WWTP to above Brandon)	SD-BS-R-BIG_SIOUX_12	2004 2006 2008 2010 2012	4.2 miles	Immersion Recreation	*E. coli* Bacteria Fecal Coliform Bacteria	*E. coli*: Daily maximum of ≤ 235 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 126 cfu/100 mL. Fecal Coliform: Daily maximum of ≤ 400 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 200 cfu/100 mL.
		2004 2010 2012		Warm-Water Semipermanent Fish Life	TSS	Maximum daily concentration of ≤ 158 mg/L and a 30-day average of at least three consecutive grab or composite samples taken on separate weeks in a 30-day period ≤ 90 mg/L.
Peg Munky Run Creek (Big Sioux River to S17, T113N, R50W)	SD-BS-R-PEG_MUNKY_RUN_01	2008 2010 2012	6.4 miles	Limited Contact Recreation	Fecal Coliform	Maximum daily concentration of ≤ 2,000 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 1,000 cfu/100 mL.
Sixmile Creek (Big Sioux River to S30, T112N, R48W)	SD-BS-R-SIXMILE_01	2010 2012	29.4 miles	Limited Contact Recreation	Fecal Coliform	Maximum daily concentration of ≤ 2,000 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 1,000 cfu/100 mL.
Skunk Creek (Brandt Lake to Big Sioux River)	SD-BS-R-SKUNK_01	2008 2012	59.7 miles	Limited Contact Recreation	Fecal Coliform	Maximum daily concentration of ≤ 2,000 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 1,000 cfu/100 mL.
		2012		Warm-Water Marginal Fish Life	TSS	Maximum daily concentration of ≤ 263 mg/L and a 30-day average of at least three consecutive grab or composite samples taken on separate weeks in a 30-day period ≤ 150 mg/L.
Spring Creek (Big Sioux River to S22, T109, R47W)	SD-BS-R-SPRING_01	2008 2010 2012	20.8 miles	Limited Contact Recreation	Fecal Coliform	Maximum daily concentration of ≤ 2,000 cfu/100 mL and a geometric mean of at least five samples over a 30-day period ≤ 1,000 cfu/100 mL.

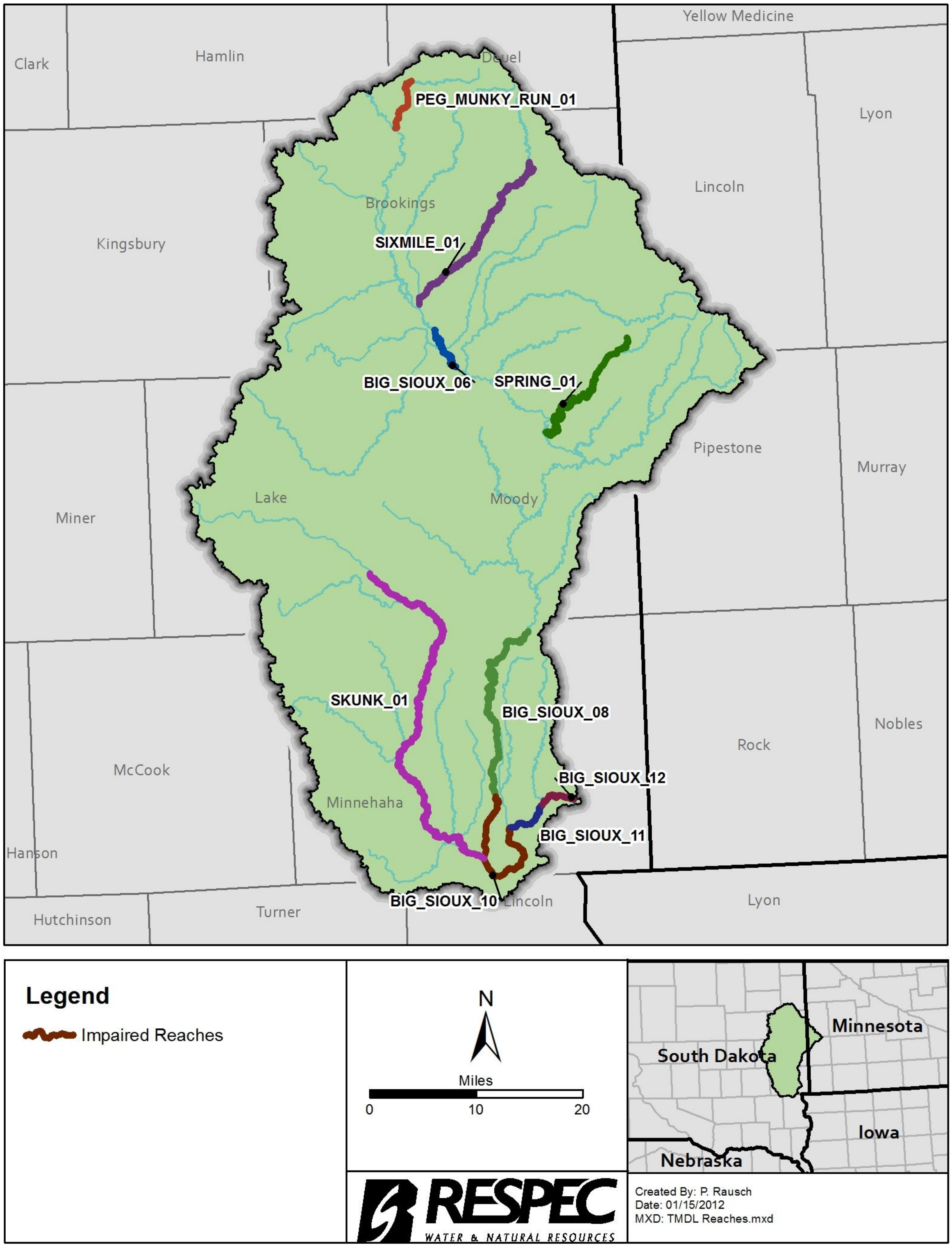

Figure 3-1. Impaired River and Stream Reaches Within the Central Big Sioux River Watershed.

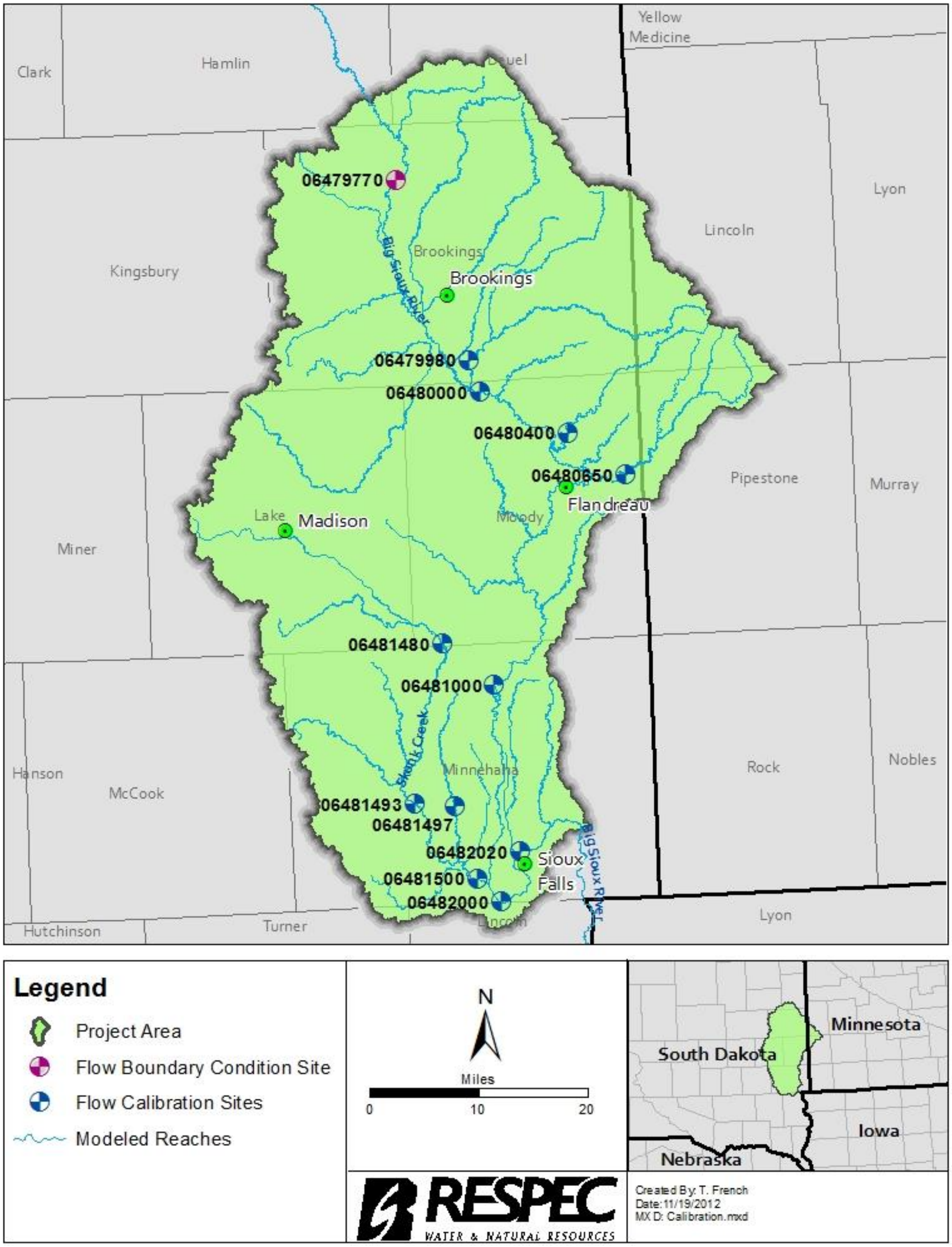

Figure 3-2. Location of U.S. Geological Survey Gaging Stations Used for Hydrologic Calibration and Validation of the Central Big Sioux River Watershed Decision Support Model.

Table 3-2 represents historical flow measurement stations, their corresponding period of record, their average discharge over this period, and the range of flows observed.

Table 3-2. Historical Flow Measuring Stations Within the Central Big Sioux River Watershed

Station I.D.	Period of Record	Average Flow Over Period of Record (cfs)	Flow Range (cfs)
06481000	01/01/2005–12/31/2009	490	1.6–5,200
06482000	01/27/2005–12/18/2009	432	12–3,900
06482020	01/01/2005–12/31/2009	632	32–8,290
06480000	01/01/2005–12/31/2009	337	16–6,000
06480650	04/21/2005–04/29/2008	279	25–620
06479980	06/16/2005–03/19/2009	870	103–2,450
06481480	01/27/2005–12/15/2009	72	1.2–520
06481493	04/12/2005–03/12/2007	938	154–2,360
06481500	01/01/2005–12/31/2009	132	3–4,930
06480400	10/17/2007–07/08/2009	35	8.4–62
06481497	04/12/2005–04/14/2008	167	16–722

3.3 STORMWATER MONITORING

Stormwater monitoring within the storm drainage network for the city of Sioux Falls was performed in 2009. The monitoring plan was implemented throughout the project area with the support of the Sioux Falls Water Reclamation and city health laboratories. Monitoring focused on stormwater outfalls, three key tributaries (Skunk Creek, Slip-up Creek, and Silver Creek), the diversion canal that sends flow around the Sioux Falls area, and multiple sites along the Big Sioux River. This stormwater monitoring increased the understanding of the impact that the city of Sioux Falls stormwater has on the Big Sioux River, as attributed from the city's municipal separate stormwater sewer system (MS4) discharge. Figure 3-3 displays the 2009 stormwater monitoring sites.

3.4 *E. COLI* WATER-QUALITY DATA

Bacteria sampling data collected from multiple monitoring sites during the recreation season (May 1 through September 30) in the CBSRW Project Area from 2005–2009 were used in calibrating and validating the CBSRW DSM. These data provided a sufficient time

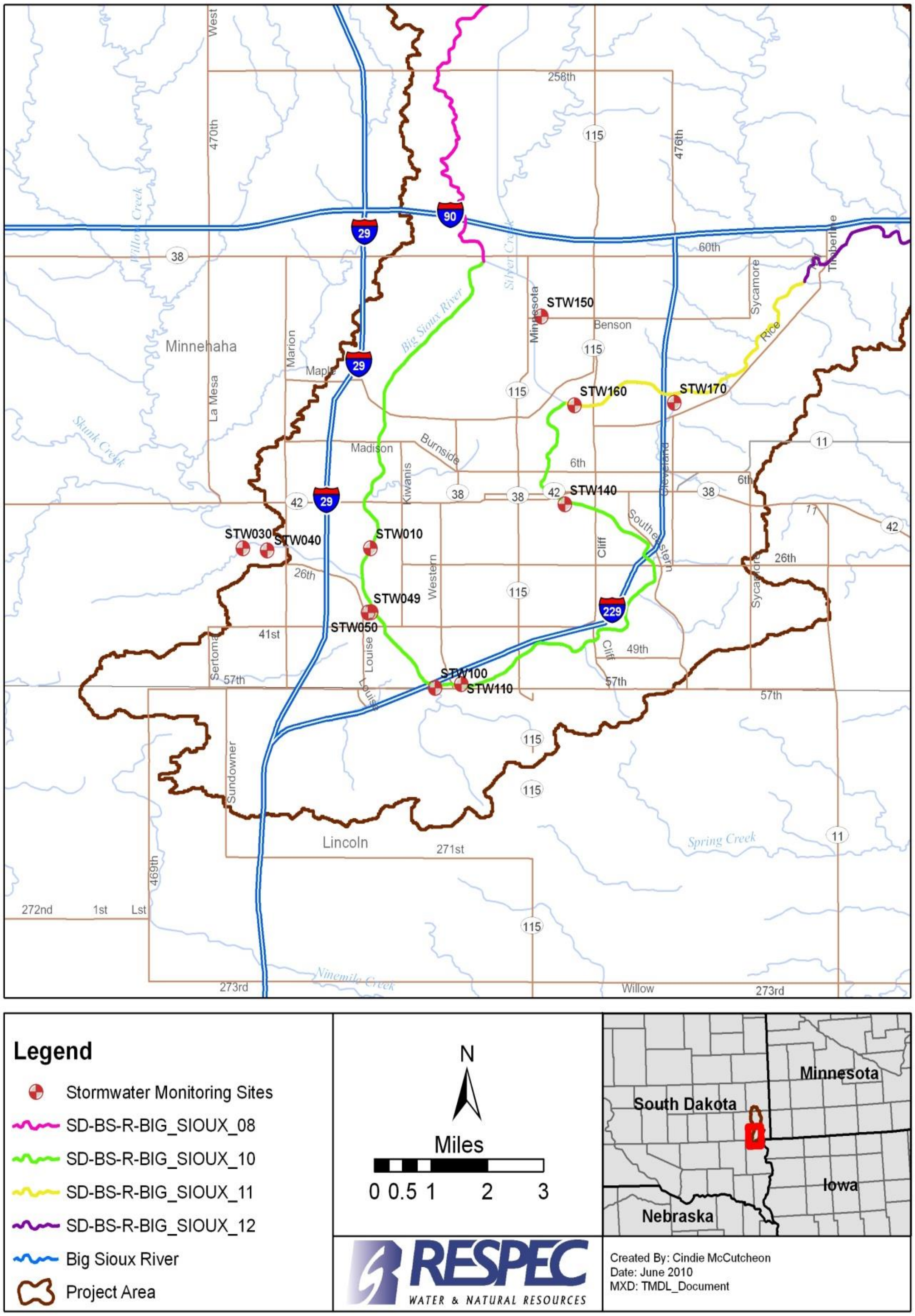

Figure 3-3. 2009 Stormwater Monitoring Sites Within the Sioux Falls Total Maximum Daily Load Project Area.

period, including wet and dry years. Compiled data consisted of *E. coli* and fecal coliform concentration values. Fecal coliform concentration values were translated to *E. coli* concentration values using a regression relationship that resulted in an R^2 value of 0.88. Table 3-3 displays data, collected from each monitoring site from 2000 to 2009, that was used to calculate percent exceedance of the daily maximum *E. coli* bacteria criterion of 235 cfu/100 mL) and to find *E. coli* concentration ranges. Note that not all monitoring sites are located on waters with a criterion of 235 cfu/100 mL, which is applicable to those waters with an assigned beneficial use of immersion recreation. These locations are designated accordingly in Table 3-3. Water-quality monitoring sites within the CBSRW with *E. coli* and translated *E. coli* data used for CBSRW DSM calibration and validation are displayed in Figure 3-4.

3.5 TOTAL SUSPENDED SOLIDS WATER-QUALITY DATA

TSS sampling data collected from multiple monitoring sites in the CBSRW Project Area were compiled for CBSRW DSM calibration and validation. Table 3-4 displays data, collected from each project site from 2005 to 2009 that was used to calculate the percent exceedance of the daily maximum TSS criterion of 158 mg/L and to find TSS concentration ranges. Note that not all monitoring sites are located on waters with a criterion of 158 mg/L, which is applicable to those waterbodies designated as warm-water semipermanent fish life propagation waters. These locations are designated accordingly in Table 3-4. Water-quality monitoring sites within the CBSRW with TSS data used for CBSRW DSM development and calibration are also displayed in Figure 3-4.

3.6 REQUIRED *E. COLI* LOAD REDUCTIONS

The *E. coli* TMDL required flow-weighted percent reductions were gathered from the individual TMDL documents for the eight impaired reaches within the CBSRW project area and are displayed in Table 3-5. The overall reductions required for the individual TMDL reaches provide a general understanding of the magnitude of the bacteria reductions necessary to meet the assigned TMDL. Values range from 45 percent for SD-BS-R-SPRING_01 to 97 percent for SD-BS-R-BIG_SIOUX_10 and SD-BS-R-BIG_SIOUX_11. The *E. coli* impaired reach on Sixmile Creek, SD-BS-R-SIXMILE_01, was listed in 2010 and 2012, and a TMDL has not been completed to date.

Table 3-3. ***E. coli*** **Recreation Season Sampling Data Percent Exceedances of the Daily Maximum** ***E. coli*** **Bacteria Criterion and** ***E. coli*** **Concentration Ranges for Project Sites within the Sioux Falls Total Maximum Daily Load Project Area (Page 1 of 2)**

Site I.D.	Time Period	Number of Samples Exceeding Criterion	Total Number of Samples	Percent Exceedance of 235 cfu/100 mL Criterion	Concentration Range (cfu/100 mL)	Site Applicability to 235 cfu/100 mL Criterion
BAC020	05/03/2006–09/18/2007	11	13	85	148–6,000	
BSR010	05/10/2006–09/15/2009	6	28	21	10–5,200	X
BSR020	05/02/2006–09/21/2009	68	158	43	7–4,500	X
BSR050	05/01/2006–09/23/2009	10	25	40	10–11,200	X
BSR060	05/04/2009–09/21/2009	71	90	79	30–23,000	X
BSR070	05/09/2006–09/21/2009	38	63	60	10–14,136	X
BSR080	05/04/2009–09/21/2009	72	84	86	10–19,863	X
BSR090	05/02/2006–09/14/2009	32	73	44	10–5,100	X
BSR100	05/02/2006–09/15/2009	43	80	54	10–4,840	X
BSR180	05/01/2006–09/23/2009	7	25	28	10–3,300	
BSR190	05/01/2006–09/23/2009	5	25	20	10–3,800	
BSR200	05/10/2006–09/15/2009	2	24	8	10–290	
BSR220	05/01/2006–09/23/2009	5	26	19	10–620	
BSR230	05/10/2006–09/15/2009	7	24	29	10–520	
BSR260	05/10/2006–09/15/2009	5	25	20	9.7–530	
BUF050	05/03/2006–07/07/2008	8	15	53	10–4,400	
CNC010	05/03/2006–09/08/2008	18	21	86	20–7,800	
FLA070	05/02/2006–09/09/2008	14	20	70	20–8,400	
JAC030	05/02/2006–09/09/2008	10	17	59	10–3,700	

Table 3-4. *E. coli* Recreation Season Sampling Data Percent Exceedances of the Daily Maximum *E. coli* Bacteria Criterion and *E. coli* Concentration Ranges for Project Sites within the Sioux Falls Total Maximum Daily Load Project Area (Page 2 of 2)

Site I.D.	Time Period	Number of Samples Exceeding Criterion	Total Number of Samples	Percent Exceedance of 235 cfu/100 mL Criterion	Concentration Range (cfu/100 mL)	Site Applicability to 235 cfu/100 mL Criterion
NDC020	05/02/2006–08/13/2008	4	14	29	10–900	
NDC100	05/02/2006–08/11/2008	11	20	55	10–3,300	
SIX010	05/02/2006–08/13/2008	11	15	73	10–25,000	
SIX050	05/02/2006–09/10/2008	15	21	71	13.9–4,800	
SIX110	05/02/2006–09/10/2008	4	18	22	2–3,600	
SKC020	05/03/2006–09/08/2008	8	20	40	10–6,100	
SKC030	05/03/2006–09/21/2009	89	118	75	10–30,000	
SPR020	05/02/2006–09/09/2008	17	20	85	10–15,000	
SUC020	05/04/2009–09/21/2009	77	86	90	45.7–284,000	
SVC010	05/04/2009–09/21/2009	34	63	54	20–2,481	
WLC020	05/03/2006–09/08/2008	12	20	60	10–8,200	
WSC010	05/03/2006–09/08/2008	12	21	57	20–33,000	

3.7 REQUIRED TOTAL SUSPENDED SOLIDS LOAD REDUCTIONS

The TSS TMDL required flow-weighted percent reductions for the five impaired reaches within the CBSRW Project Area are displayed in Table 3-6. The overall reductions required for the individual TMDL reaches provide a general understanding of the magnitude of the sediment reductions necessary to meet the assigned TMDL. Values range from 35 percent for SD-BS-R-BIG_SIOUX_10 to 61 percent for SD-BS-R-BIG_SIOUX_12. The TSS-impaired reach on Skunk Creek, SD-BS-R-SKUNK_01, was listed in 2012, and a TMDL has not been completed to date.

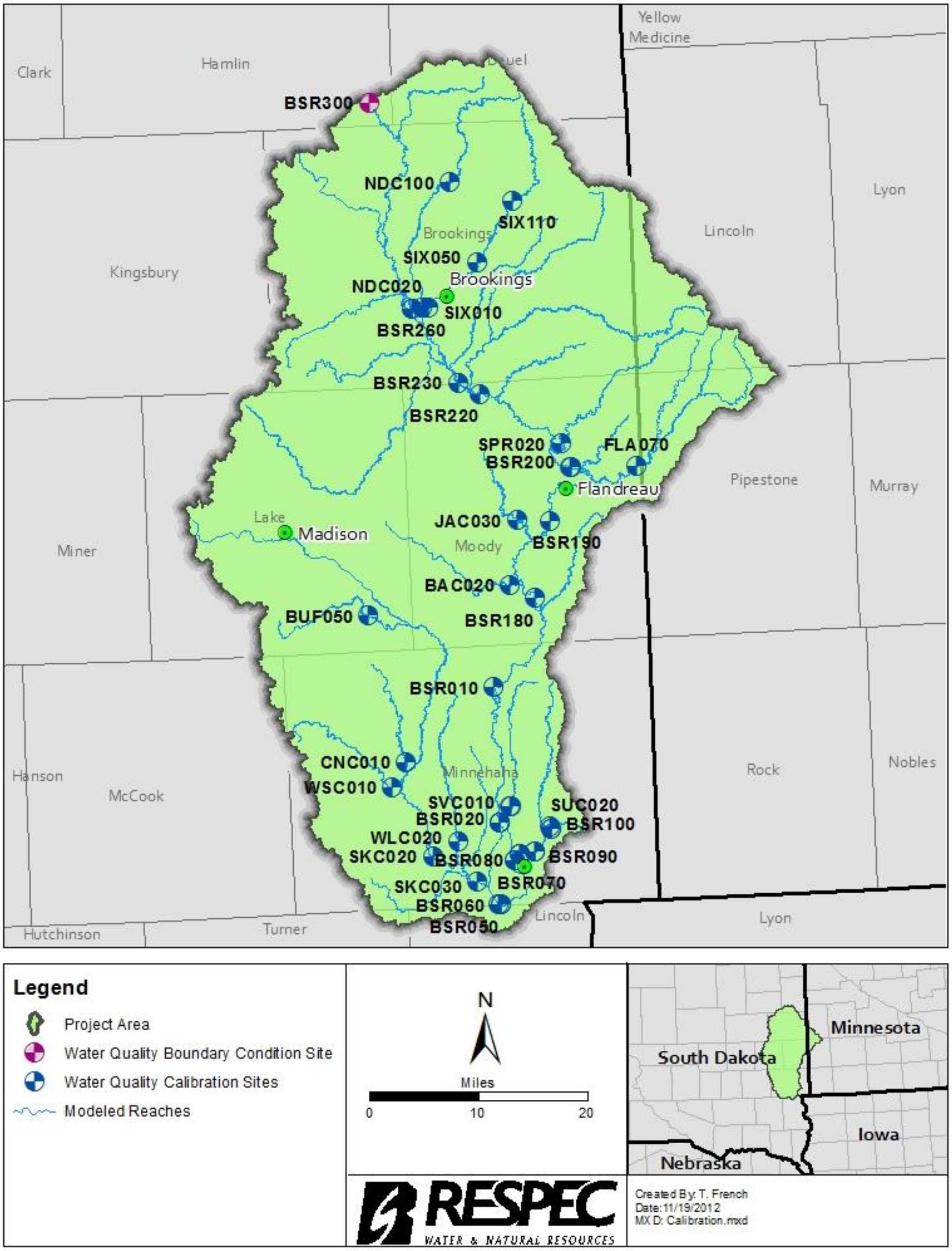

Figure 3-4. Location of Water-Quality Monitoring Sites Used for Model Development and Calibration Within the Central Big Sioux River Watershed Project Area.

Table 3-4. Total Suspended Solids Sampling Data Percent Exceedances of the Daily Maximum Total Suspended Solids Criteria and Total Suspended Solids Concentration Ranges for Project Sites Within the Sioux Falls Total Maximum Daily Load Study Area (Page 1 of 2)

Site I.D.	Time Period	Number of Samples Exceeding Criterion	Total Number of Samples	Percent Exceedance of the 158 mg/L Criterion	Concentration Range (mg/L)	Site Applicability to 158 mg/L Criterion
BAC020	10/24/2005–10/10/2007	1	14	7	8–224	
BSR010	10/13/2005–09/15/2009	0	46	0	3–132	X
BSR020	10/05/2005–09/21/2009	9	201	4	3–450	X
BSR050	10/24/2005–09/23/2009	1	28	4	14–228	X
BSR060	03/03/2009–09/21/2009	7	56	13	5–595	X
BSR070	10/12/2005–09/21/2009	5	73	7	3–595	X
BSR080	03/03/2009–09/21/2009	8	52	15	4–1,080	X
BSR090	10/05/2005–09/14/2009	7	181	4	1.9–772	X
BSR100	10/05/2005–09/15/2009	9	193	5	2.8–252	X
BSR180	10/24/2005–09/23/2009	1	28	4	35–168	X
BSR190	10/24/2005–09/23/2009	1	28	4	35–204	X
BSR200	11/30/2005–09/15/2009	0	45	0	1–144	X
BSR220	10/24/2005–09/23/2009	2	30	7	22–198	X
BSR230	11/30/2005–09/15/2009	5	45	11	3–224	X
BSR260	11/30/2005–09/15/2009	3	46	7	2–252	X
BUF050	05/03/2006–07/07/2008	0	14	0	3–48.0	
CNC010	10/25/2005–10/06/2008	5	23	22	20–304	

Table 3-4. Total Suspended Solids Sampling Data Percent Exceedances of the Daily Maximum Total Suspended Solids Criteria and Total Suspended Solids Concentration Ranges for Project Sites Within the Sioux Falls Total Maximum Daily Load Study Area (Page 2 of 2)

Site I.D.	Time Period	Number of Samples Exceeding Criterion	Total Number of Samples	Percent Exceedance of the 158 mg/L Criterion	Concentration Range (mg/L)	Site Applicability to 158 mg/L Criterion
FLA070	10/24/2005–10/09/2008	1	23	4	3–264	
JAC030	10/24/2005–10/09/2008	0	19	0	4–45.0	
NDC020	10/24/2005–08/13/2008	0	18	0	6–40.0	
NDC100	04/06/2006–08/11/2008	0	20	0	3–80.0	
SIX010	10/24/2005–10/07/2008	0	20	0	3–28.0	
SIX050	10/24/2005–10/07/2008	1	22	5	7–200	
SIX110	04/06/2006–10/07/2008	0	20	0	8–76.0	
SKC020	10/25/2005–10/06/2008	2	23	9	26–212	
SKC030	10/24/2005–09/21/2009	18	105	17	3–832	
SPR020	10/24/2005–10/09/2008	1	23	4	12–1,020	
SUC020	03/03/2009–09/21/2009	5	54	9	3.4–913	
SVC010	04/15/2009–09/21/2009	1	37	3	1.9–600	
WLC020	10/25/2005–10/06/2008	1	23	4	16–212	
WSC010	10/25/2005–10/06/2008	1	23	4	10–200	

Table 3-5. *E. coli* Flow-Weighted Overall Percent Reductions for Impaired Total Maximum Daily Load Reaches in the Central Big Sioux River Watershed

Impaired TMDL Reach	Overall Reduction Required (%)
SD-BS-R-BIG_SIOUX_08	69
SD-BS-R-BIG_SIOUX_10	97
SD-BS-R-BIG_SIOUX_11	97
SD-BS-R-BIG_SIOUX_12	79
SD-BS-R-PEG_MUNKY_RUN_01	72
SD-BS-R-SKUNK_01	93
SD-BS-R-SPRING_01	45

Table 3-6. Total Suspended Solids Flow-Weighted Percent Reductions for Impaired Total Maximum Daily Load Reaches in the Central Big Sioux River

TSS Impaired TMDL Reach	Overall Reduction Required (%)
SD-BS-R-BIG_SIOUX_08	46
SD-BS-R-BIG_SIOUX_10	35
SD-BS-R-BIG_SIOUX_11	56
SD-BS-R-BIG_SIOUX_12	61

4.0 PAST CONSERVATION PROJECTS IN THE CENTRAL BIG SIOUX RIVER

Numerous conservation measures and BMPs have been completed and are currently being implemented within the CBSRW. These projects were made possible through the South Dakota Nonpoint Source Program, EPA Section 319 Grant funding, the EDWDD, the Brookings County Conservation District, the Lake County Conservation District, the Minnehaha County Conservation District, the Moody County Conservation District, the SD DENR, the city of Sioux Falls, and NRCS Conservation Programs such as the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP).

BMPs have been planned and implemented in various locations throughout the watershed to improve water quality within the Big Sioux River. These BMPs, which include positive effects such as controlling the sources of *E. coli* and sediment loading, have positive effects such as improved riparian, rangeland, and cropland conditions; better livestock and wildlife distribution; reduced direct animal access to streams; control of urban stormwater; and the implementation of multiple management plans throughout the watershed. These BMPs are the result of local watershed planning and implementation efforts of proactive, locally led, organizations that have developed mutually beneficial partnerships with farmers; residents; and local, state, and federal government agencies.

Table 4-1 provides a summary of agricultural conservation practices implemented from 2006 to July 2012 in the two 8-digit HUCS that include the project area. This summary provides an estimate of agricultural BMP accomplishments and conservation program implementation in the project area and is not all-inclusive of the BMPs implemented on private and public lands.

Analyses conducted while the developing the TMDLs in the Sioux Falls area indicated that the city of Sioux Falls stormwater system work to control sediment-laden runoff into adjacent streams is excellent, but the management of discharged bacteria needs improvement.

Table 4-1. Summary of Applied Conservation Practices for Both 8-Digit Hydrologic Unit Codes From 2006 to July 2012 [Natural Resources Conservation Service, 2012] (Page 1 of 2)

Applied Conservation Practice and NRCS Code	Associated Unit	8-Digit HUC 10170202 Total	8-Digit HUC 10170203 Total	Total
Access Control, 472	Acre	30.4	0	30.4
Animal Mortality Facility, 316	Number	1	7	8
Closure of Waste Impoundment, 360	Number	0	1	1
Conservation Completion Incentive First Year, CCIA	Number	0	1	1
Conservation Completion Incentive Second Year, CCIB	Number	1	1	2
Cover Crop, 340	Acre	620.6	58.3	678.9
Critical Area Planting, 342	Acre	12.1	162.8	174.9
Cropland Annual Payment	Dollars	11,075.43	14,361.86	25,437.29
Diversion, 362	Feet	1,173	467.5	1,640.5
Fence, 382	Feet	61,581.9	84,548.1	146,130
Field Border, 386	Acre	0	9.7	9.7
Forage and Biomass Planting, 512	Acre	149.5	0	149.5
Forest Site Preparation, 490	Acre	1.9	8.5	10.4
Grade Stabilization Structure, 410	Number	1	0	1
Grassed Waterway, 412	Acre	0	18.1	18.1
Heavy Use Area Protection, 561	Acre	42.4	97.4	139.8
Integrated Pest Management, 595	Acre	30.4	0	30.4
Irrigation Pipeline, 430	Feet	2,999	0	2,999
Irrigation System–Sprinkler–Low Pressure Conve, 442	Acre	0	145	145
Irrigation System–Sprinkler, 442	Acre	655.9	279.5	935.4
Irrigation Water Management, 449	Acre	508.3	424.5	932.8
Mulching, 484	Acre	5.7	21.5	27.2
Nutrient Management, 590	Acre	1,260.9	1,830.3	3,091.2
Obstruction Removal, 500	Acre	0	1	1
Pasture and Hayland Planting, 512	Acre	0	129	129
Pasture Annual Payment	Dollars	4,059.16	7,277.59	11,336.75
Pasture Cropland Annual Payment	Dollars	312.9	0	312.9
Pest Management, 595	Acre	705.7	877.5	1,583.2
Pipeline, 516	Feet	41,467.5	37,554	79,021.5

Table 4-1. Summary of Applied Conservation Practices for Both 8-Digit Hydrologic Unit Codes From 2006 to July 2012 [Natural Resources Conservation Service, 2012] (Page 2 of 2)

Applied Conservation Practice and NRCS Code	Associated Unit	8-Digit HUC 10170202 Total	8-Digit HUC 10170203 Total	Total
Pond, 378	Number	0	2	2
Prescribed Grazing, 528	Acre	695.5	1,004.3	1,699.8
Pumping Plant, 533	Number	0	1	1
Range Planting, 550	Acre	59	48	107
Residue and Tillage Management–No Till/Strip Till/Direct Seed, 329	Acre	0	1,720.7	1,720.7
Residue Management–No-Till/Strip Till, 329A	Acre	250	0	250
Seasonal High Tunnel System for Crops, 798	Square Feet	4,356	6,516	10,872
Sediment Basin, 350	Number	1	9	10
Stream Crossing, 578	Number	14	0	14
Subsurface Drain, 606	Feet	7,300	32,828	40,128
Supplemental Payment	Dollars	606.6	0	606.6
Terrace, 600	Feet	1,700	2,869	4,569
Underground Outlet, 620	Feet	175	1,818	1,993
Upland Wildlife Habitat Management, 645	Acre	0	20	20
Vegetated Treatment Area, 635	Acre	0	2	2
Waste Storage Facility, 313	Number	3	11	14
Wastewater and Feedlot Runoff Control, 784	A.U.	617	43.5	660.5
Water and Sediment Control Basin, 638	Number	15	25	40
Watering Facility, 614	Number	29	3,333	3,362
Water Well, 642	Number	0	1	1
Well Decommissioning, 351	Number	0	1	1
Windbreak/Shelterbelt Establishment, 380	Feet	12,024	15,625	27,649
Windbreak/Shelterbelt Renovation, 650	Feet	10,895	3,900	14,795

5.0 WATERSHED MODELING

An **Hydrologic Simulation Program-Fortran** (**HSPF**) watershed model application was originally developed as part of the Sioux Falls TMDL project for the reaches of the Big Sioux River designated 8 through 12 by the SD DENR. The simulation time period was October 1, 2005–September 30, 2009. This period spans an adequate balance of wet and dry climatic periods, which is preferred when calibrating a hydrologic model in a region with variable meteorological and soil moisture conditions. This time period also reflects a representative land use in and around the city of Sioux Falls, which has changed significantly in the last 10 years. That **HSPF** model application was expanded to include the Skunk Creek watershed and the Big Sioux River watershed upstream to a point near Estelline, South Dakota. The original model domain developed for the Sioux Falls TMDL project is illustrated with the expanded model area, in Figure 5-1.

The **HSPF** watershed modeling system is a comprehensive package for simulating watershed hydrology and water quality for both conventional and toxic organic pollutants. **HSPF** is capable of simulating the hydrologic and associated water-quality processes on pervious and impervious land surfaces and in streams and well-mixed impoundments [Bicknell et al., 2001]. **HSPF** serves as the watershed modeling component of the CBSRW DSM.

5.1 HYDROLOGY

Historical data collected at USGS Water-Quality Monitoring (WQM) sites were used in validating hydrologic model performance. Simulated predictions were compared to observed data, and adjustments to the model application parameters were made accordingly to improve the correlations. The final hydrologic model application had flow calibrated at ten sites with coefficients of determination (R^2) above 0.81 for daily flow simulation and above 0.92 for monthly flow simulation. According to the accepted model performance criteria displayed in Figure 5-2, these statistics indicate "very good" model performance.

Annual and monthly water balance statistics are useful for evaluating the long-term and seasonal accuracy of the model. Assessing the yearly variability provides an understanding of how well the model represents wet and dry periods. Understanding monthly variability is important because snow accumulation and melt processes as well as seasonality have a hydrologic influence. Evaluating simulated hydrologic responses to individual runoff events allows the model to be calibrated for different rainfall intensities and frequencies as well as the timing and volume of spring snowmelt. Graphical comparisons of simulated and observed data were made for annual, monthly, and storm event hydrology and provide qualitative measurements of model performance. Figures 5-3 through 5-5 display examples of these comparisons for USGS Site 06480000 on the Big Sioux River south of Brookings, South Dakota.

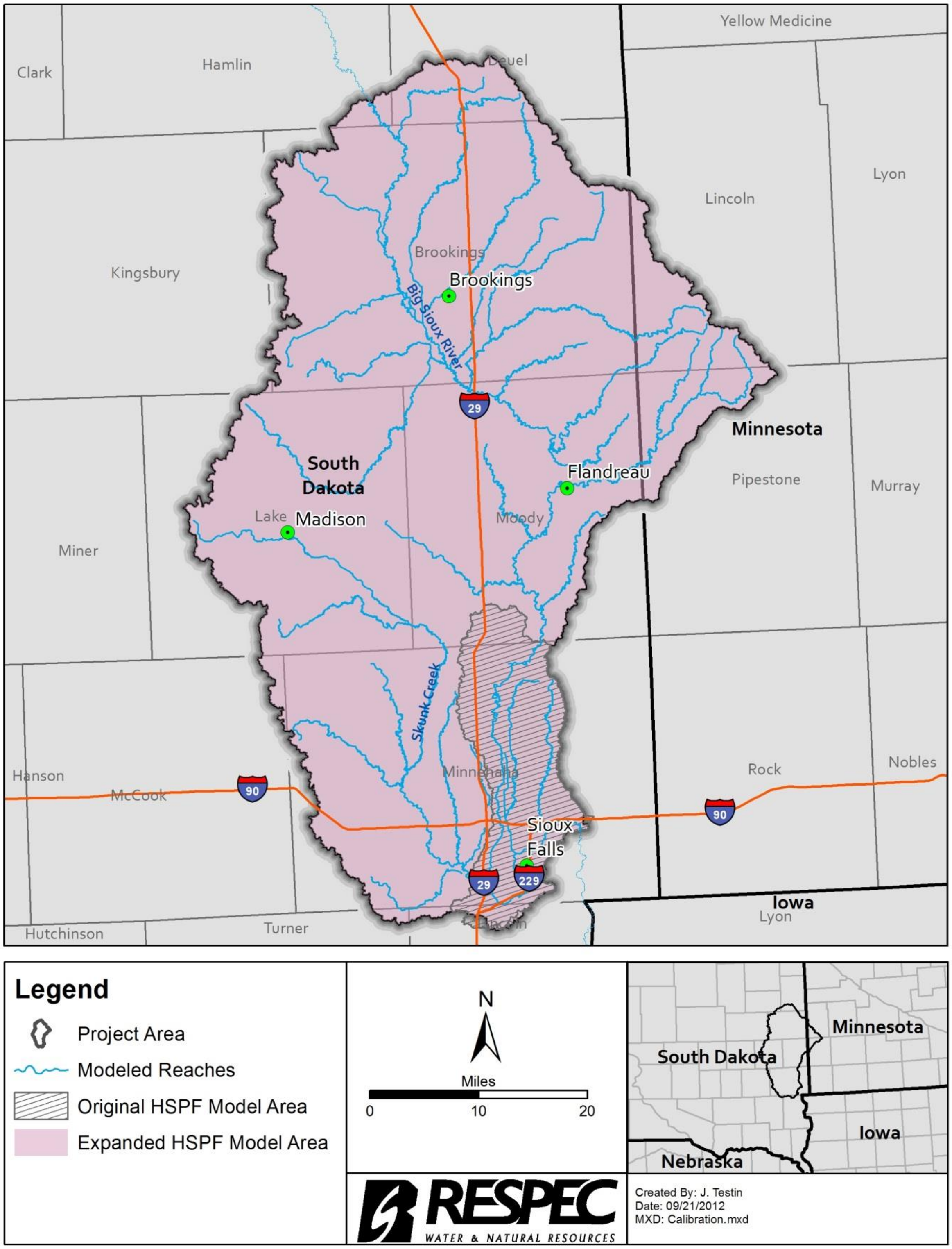

Figure 5-1. Original and Expanded Watershed Model Area.

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Figure 5-2. *R* and R^2 Performance Criteria for Model Calibration and Validation [Donigian, Jr., 2002].

RSI-2012-13-010

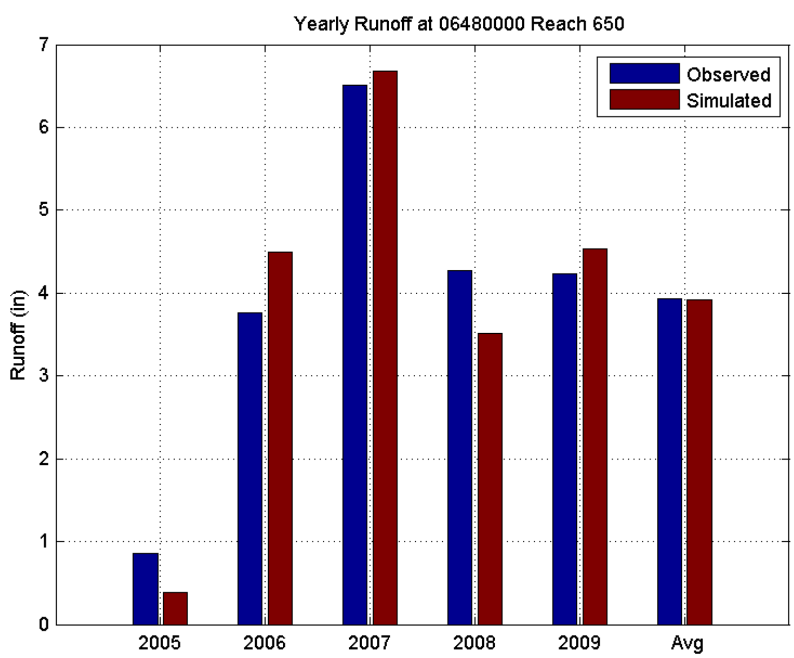

Figure 5-3. Annual Runoff Observed and Simulated at U.S. Geological Survey Site 06480000 on the Big Sioux River South of Brookings, South Dakota.

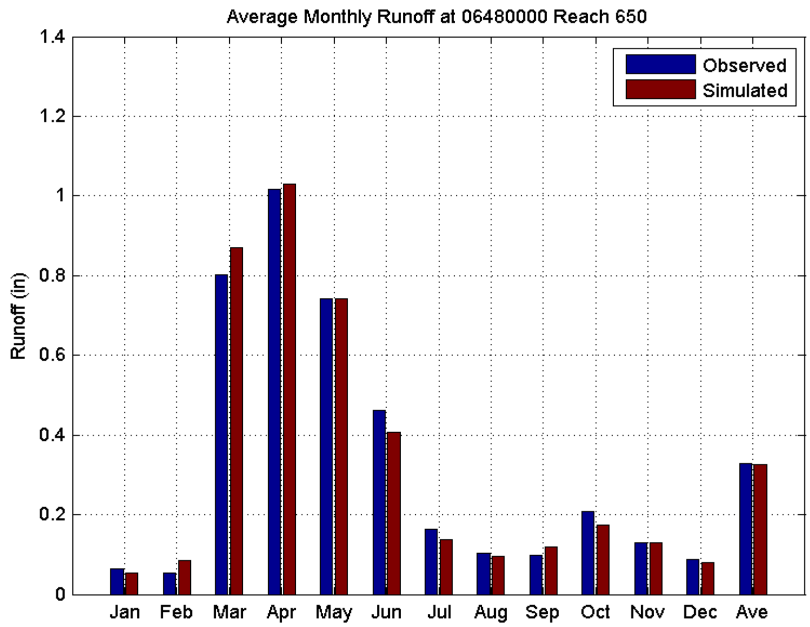

Figure 5-4. Average Monthly Runoff Observed and Simulated at U.S. Geological Survey Site 06480000 on the Big Sioux River South of Brookings, South Dakota.

RSI-2012-13-012

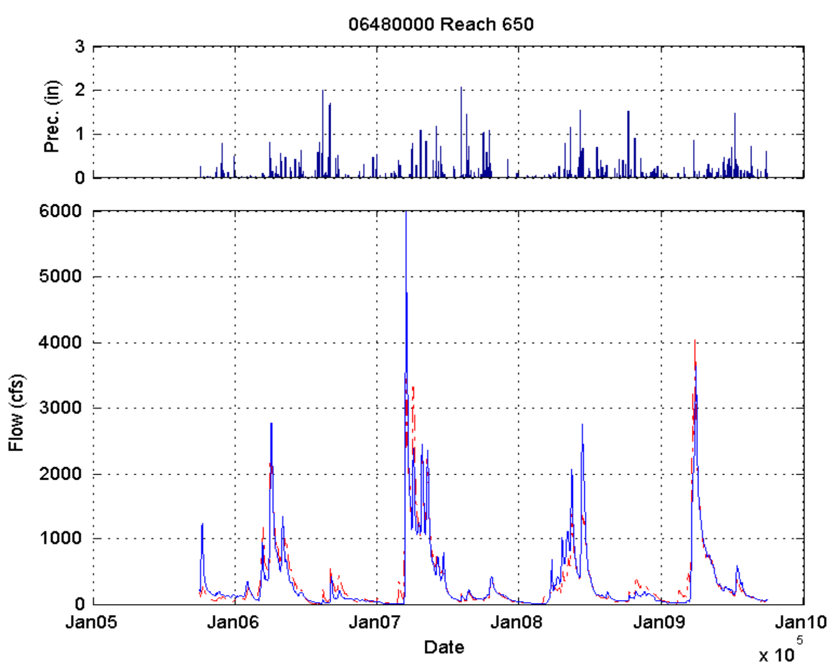

Figure 5-5. Simulated and Observed Hydrograph in Response to Recorded Precipitation Events at U.S. Geological Survey Site 06480000 on the Big Sioux River South of Brookings, South Dakota.

5.2 BACTERIA AND SEDIMENT CALIBRATION

The **BSLC** was used to estimate the land and stream deposition of bacteria from livestock, wildlife, and septic systems throughout the watershed. The only exception to this was within the cities of Sioux Falls and Brookings, where monitoring data collected in 2009 were used to estimate average bacteria and sediment concentrations from stormwater originating from general urban source categories (i.e., commercial and residential). Within the stream, the model estimates scour and the deposition of sediment as well as bacterial die-off and decay. These in-stream processes, as well as the load-application processes, were calibrated to match simulated and observed pollutant concentrations. Similar to hydrology calibration, graphical plots of pollutant concentrations were used to qualitatively evaluate model performance with parameter adjustments made accordingly.

Example bacteria and sediment calibration plots for BSR220 on the Big Sioux River are illustrated in Figures 5-6 and 5-7, respectively. These figures display *E. coli* and sediment continuous time-series predictions throughout the modeling period. In the lower graphs, the blue dots symbolize samples measured in the river, and the red line tracks the simulated concentrations on an hourly time step throughout the modeling period. In the upper graphs, the dashed red line represents simulated flow and the blue line represents measured flow. Plotting both concentration and flow over the same time-series shows the relationship between flow and concentration. The calibration of concentrations at low or high flows can be evaluated to better understand whether concentrations are coming from storm events or direct loadings to the stream. As demonstrated by figures, the model performance of matching the general trends through the different flow regimes is excellent. All aspects of the CBSRW DSM are discussed in detail in Oswald [2012].

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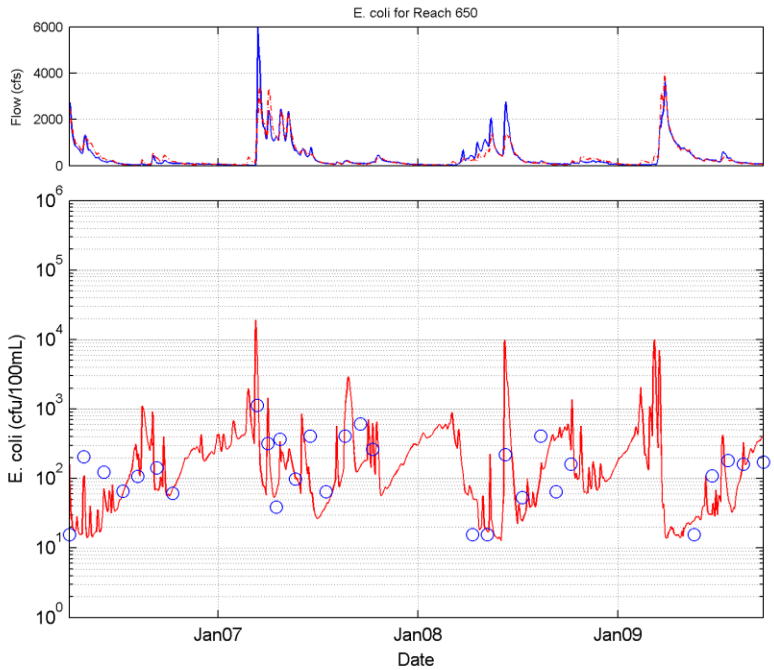

Figure 5-6. *E. coli* Time Series at BSR220 on the Big Sioux River South of Brookings, South Dakota.

RSI-2012-13-014

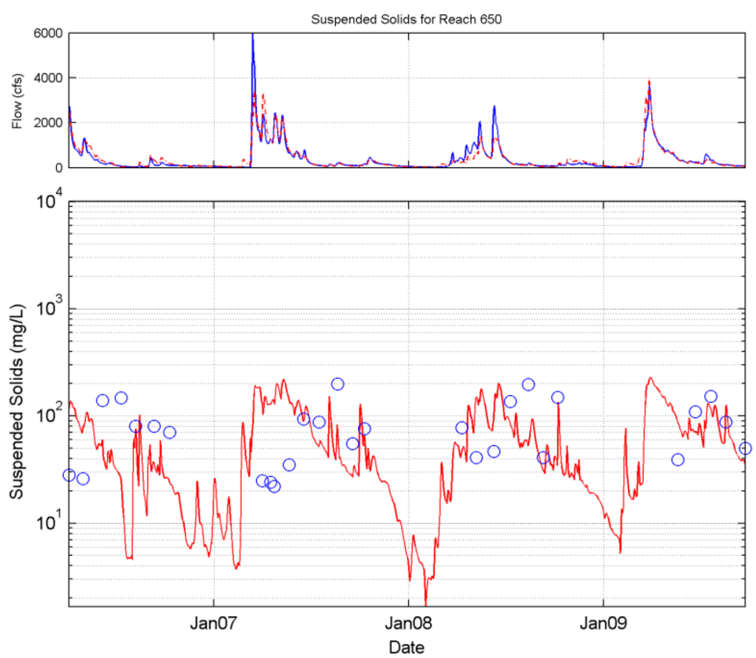

Figure 5-7. Sediment Time Series at BSR220 on the Big Sioux River South of Brookings, South Dakota.

6.0 IMPLEMENTATION STRATEGY

The following implementation strategy is designed to guide watershed implementation specialists in determining the most-cost effective means of bringing impaired reaches within the CBSRW into compliance with designated water-quality standards. For this plan, the Big Sioux River TMDL Reach 12 (hereafter referred to as “Reach 12”) was chosen as the endpoint for implementation effect comparison, because it is the endpoint of the study area. Pollutant priority was given to *E. coli* bacteria over sediment because it required larger reductions and the greater potential human health risks.

Three different elements were prioritized to focus implementation efforts: (1) geographic areas of the watershed, (2) land uses, and (3) implementation practices. Implementation specialists using this strategy will be able to compare the impacts of implementing in one area versus another, identify which land uses within an area should be implemented, and which practices are most applicable to treat the pollutants of concern. This information can be used to develop ranking factors for a cost-share docket designed to prioritize BMPs to achieve water-quality goals with the limited available funds. .

6.1 AREA PRIORITIZATION

The CBSRW DSM was used to identify priority areas for BMP implementation. For this implementation strategy, priority areas are those that significantly contribute to exceedances of bacteria water-quality standards within Reach 12. Four supplementary factors were determined to further prioritize areas: (1) the total number of bacteria TMDL reaches significantly impacted by the area, (2) the total number of sediment TMDL reaches significantly impacted by the area, (3) contribution level to exceedances of sediment water-quality standards within Reach 12, and (4) a Bacteria Reduction Efficiency Index. Each of the four supplementary factors may be considered independently or together, as illustrated in Figure 6-1. Each of the factors is discussed in detail in the following sections.

6.1.1 Bacteria Exceedance Contributions

The CBSRW DSM was used to determine the relative contribution of each area to exceedances of the *E. coli* bacteria standard during the recreation season in each of the bacteria-impaired reaches. This exceedance contribution method, developed specifically for this project, assesses the areas that contribute to concentration exceedances within an impaired reach. A rank was assigned to each area (none, low, medium, and high) based on the relative contribution to exceedances in water-quality standards. A “none” rank indicates that pollutants originating from an area have no impact on the impaired reach in question, and while pollutants from areas designated with a “medium” or “high” rank contribute significantly to exceedances.

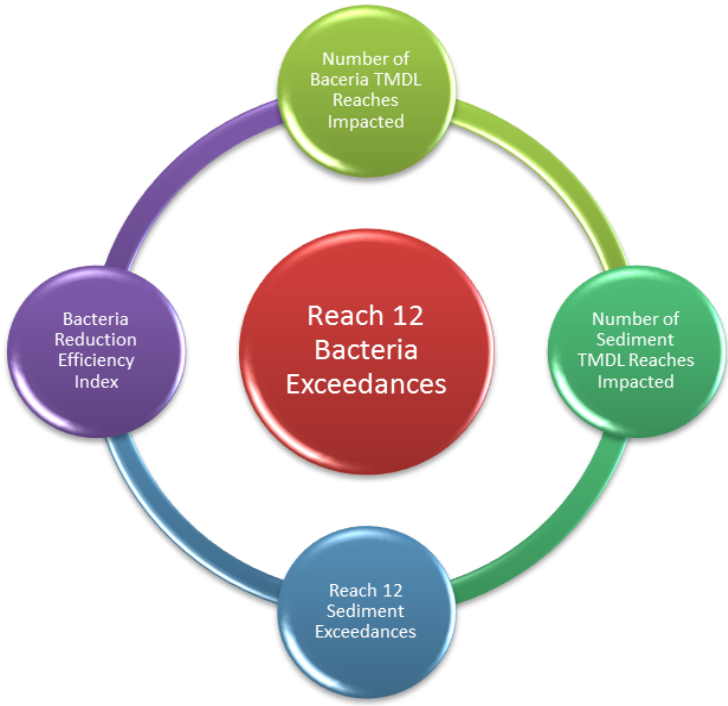

Figure 6-1. Supplemental Ranking Factors to Further Prioritize Areas for Implementing Best Management Practices.

As stated previously, the areas that contribute significantly (a rank of high or medium) to Reach 12 were identified as the priority areas for this implementation strategy. Figure 6-2 displays the ranks for exceedance contributions to Reach 12. The ranks for exceedance contributions to all other TMDL reaches are displayed in Appendix A, Table A-1 and Figures A-1 through A-7.

This exceedance contribution method was chosen instead of a load-based analysis method to identify priority implementation areas. A load-based analysis, often completed within a TMDL study, identifies areas that contribute the greatest amount of overall load (in pounds of sediment or number of coliform units) to a given reach. Implementing BMPs in the areas identified using a load-based method has the potential to reduce the overall pollutant load, but may do little to reduce the percentage of time the waterbody exceeds water-quality standards. In contrast, the exceedance contribution method identifies areas where implementing BMPs would have the greatest impact on the percent of time a waterbody exceeds water-quality standards, which is the goal of every implementation project.

An excellent example of the different priority areas that are identified using the exceedance contribution or load based methods is a comparison Figure 6-2 and Figure 6-3. Figure 6-2, which displays ranks for exceedance contributions to Reach 12, illustrates that many of the "high" rank areas are outside of the city of Sioux Falls boundary. In contrast, the areas

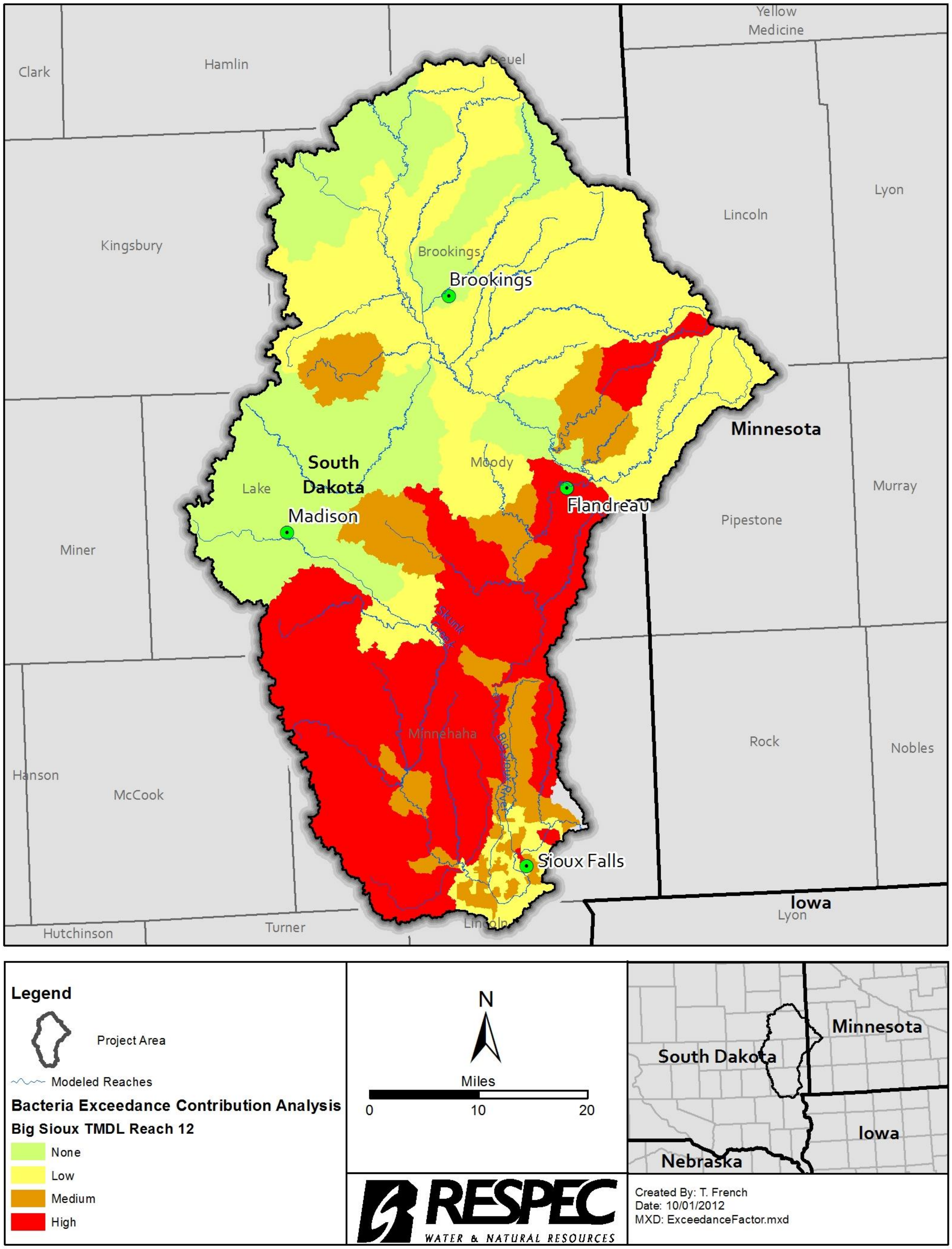

Figure 6-2. Areas Ranked Using an Exceedance Contribution Analysis Method for Bacteria in Reach 12.

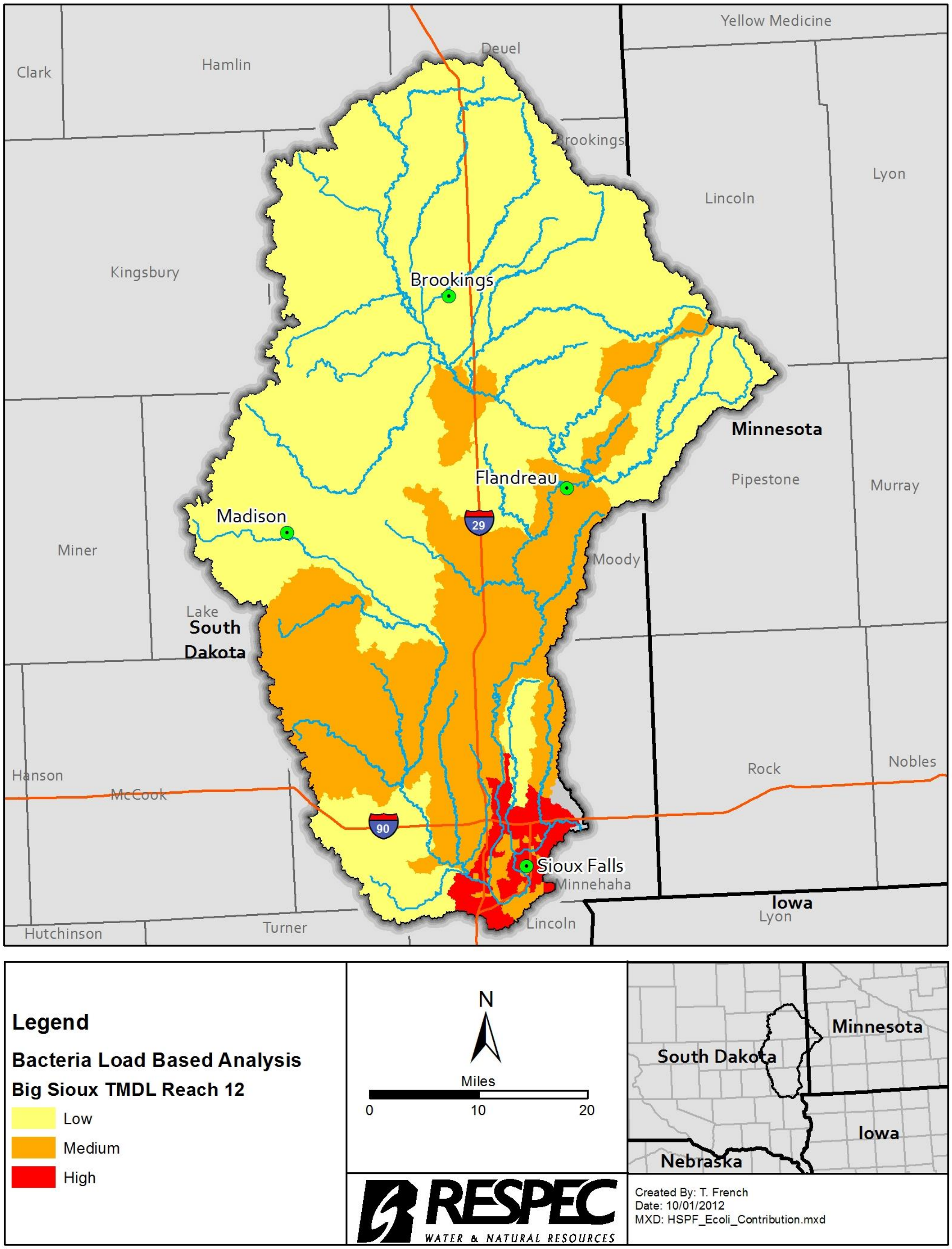

Figure 6-3. Areas Ranked Using a Load-Based Analysis Method for Bacteria in Reach 12.

ranked “high” by the load-based method, displayed in Figure 6-3, are predominantly within the city of Sioux Falls boundary. This result is from the fact that the majority of the city of Sioux Falls stormwater system contributes a large load during rainfall-runoff events, but, since it typically only flows during these relatively infrequent events, it has a smaller effect on daily concentrations within Reach 12.

6.1.2 Number of Bacteria Total Maximum Daily Load Reaches Impacted

The analysis described in Section 6.1.1 indicates that many areas within the CBSRW significantly impact multiple bacteria TMDL reaches. Because this implementation strategy focuses on the Reach 12, it further prioritizes areas that impact additional TMDL reaches, which results in the improvement of multiple TMDL reaches. Figure 6-4 maps all of the areas of the CBSRW by the number of bacteria TMDL reaches impacted.

For example, the CBSRW DSM indicates that the area around Flandreau, South Dakota, has high or medium impacts to Big Sioux TMDL Reach 08, Big Sioux TMDL Reach 10, Big Sioux TMDL Reach 11, and Big Sioux TMDL Reach 12 for a total of four bacteria TMDL reaches (illustrated in Figure 6-4). Implementing bacteria BMPs within this area should improve the water quality throughout all four TMDL reaches. Some areas do not impact any TMDL reaches with a rank of high or medium and are indicated with a rank of zero in Figure 6-4.

6.1.3 Sediment Exceedance Contributions

All areas within the CBSRW were also assessed for impacts to sediment TMDL reaches using the exceedance contribution method described in Section 6.1.1. The results of the sediment exceedance contribution analysis for Reach 12 are displayed in Figure 6-5. This analysis determined that the majority of areas identified as a high or medium rank for sediment are within areas identified as a high or medium rank for bacteria.

A correlation of *E. coli* concentrations to sediment concentrations from samples taken throughout the CBSRW resulted in an R^2 of 0.38. This positive correlation implies that efforts to reduce bacteria concentrations will inherently result in a reduction of sediment concentrations. Based on this correlation, and the fact that the majority of high priority areas for sediment are within high priority areas for bacteria, implementing bacteria BMPs in these areas is assumed to result in positive impacts to sediment exceedances.

6.1.4 Number of Sediment Total Maximum Daily Load Reaches Impacted

Similar to the bacteria assessment, the CBSRW DSM indicated that many areas significantly impact multiple sediment TMDL reaches. Focusing implementation efforts in areas that impact multiple TMDL reaches will result in greater improvement of the CBSRW as a whole. Figure 6-6 maps the areas by the number of sediment TMDL reaches impacted.

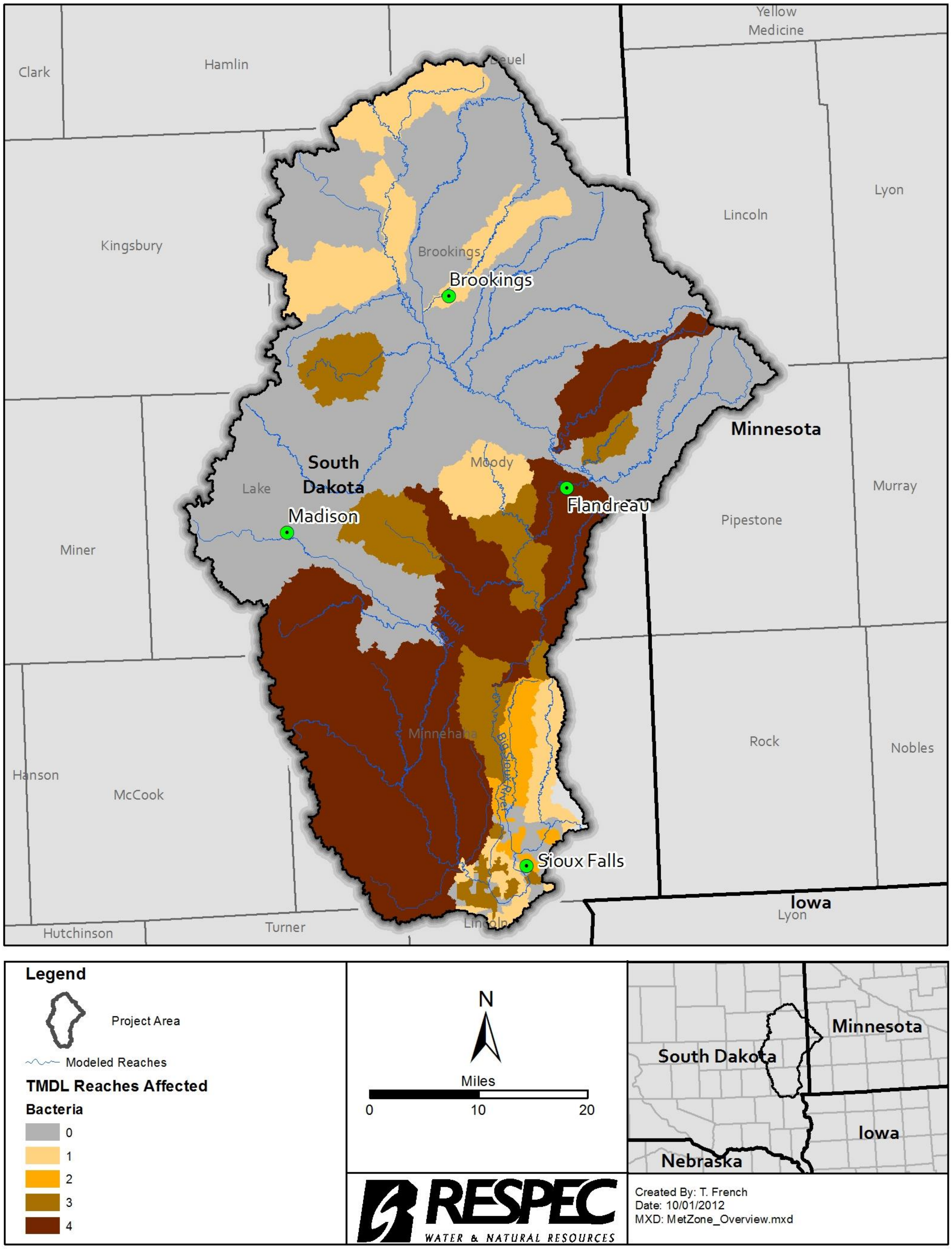

Figure 6-4. Areas Identified by Number of *E. coli* Impaired Total Maximum Daily Load Reaches Impacted.

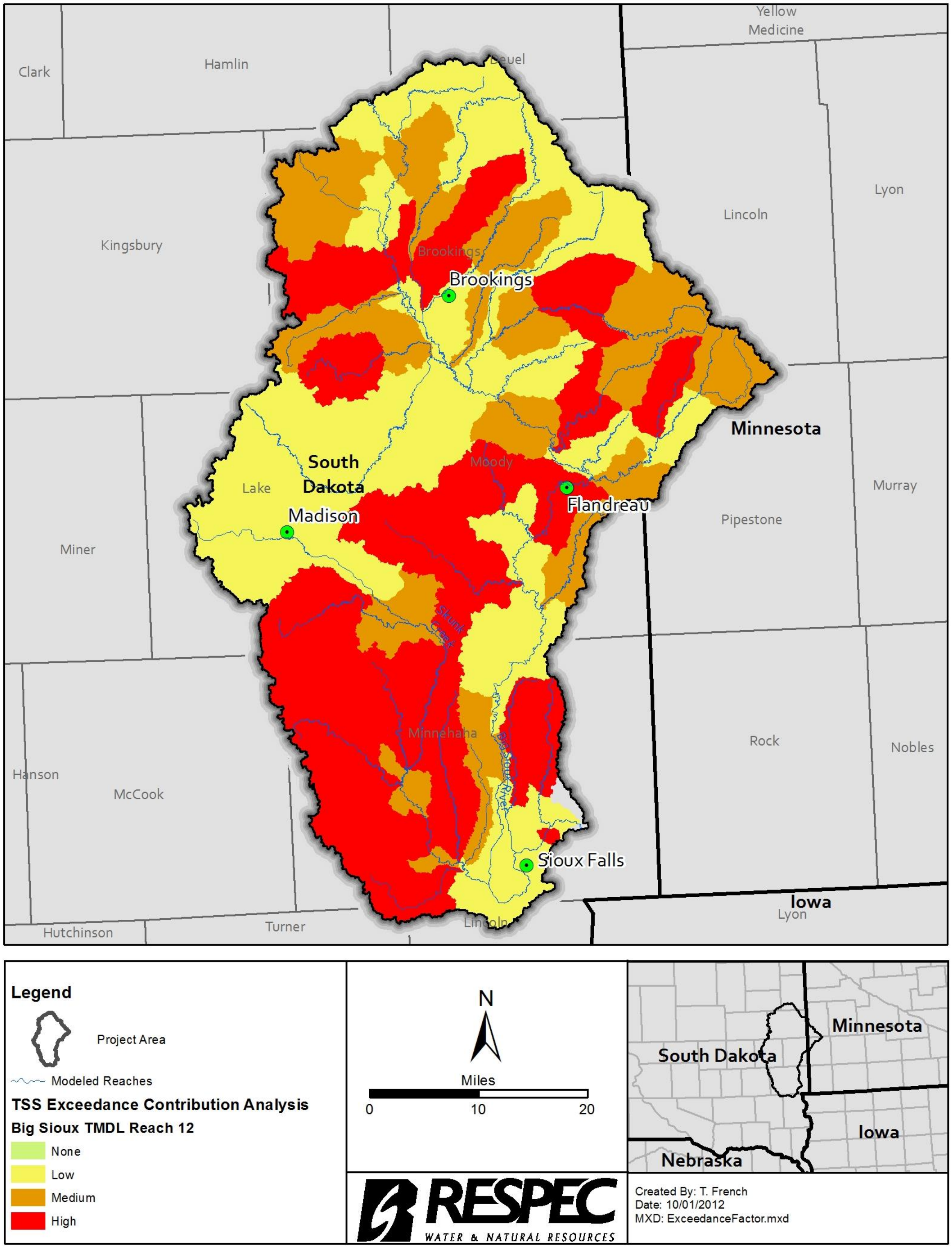

Figure 6-5. Areas Ranked Using an Exceedance Contribution Analysis for Sediment in Reach 12.

6.1.5 Bacteria Reduction Efficiency Index

The Reach 12 priority areas identified in Figure 6-2 were further prioritized by calculating a Bacteria Reduction Efficiency Index (BREI). This index was designed to identify the areas where implemented BMPs would result in the greatest bacteria concentration reductions for the lowest cost. Assumed bacteria removal efficiencies, associated with implementing realistic levels of conservation management alternatives, were input into the CBSRW DSM for both agricultural and urban areas. The CBSRW DSM was then used to assess the fate and transport of the bacteria from the individual areas and predict reductions in median concentration at Reach 12.

For agricultural areas, conservation management alternatives were selected to target land loading from cropland, pasture, and animal feeding operations (AFO) areas, as well as direct stream loading by livestock in pastures and AFO areas. These alternatives included vegetated stream buffers along cropland and pasture, fencing and watering facilities in pastures along streams, and waste treatment lagoons for AFOs. All of these BMPs were considered "implemented" immediately within the CBSRW DSM. The costs associated with implementing these practices were taken from the 2012 NRCS EQIP cost-share docket.

Within urban areas, regionally-sized retention ponds were used as realistic BMPs with potentially high levels of bacteria reduction. A tool created by the Urban Drainage and Flood Control District (UDFCD) of Colorado called **BMP-REALCOST** was used to determine the number, sizes, and costs of retention ponds to be constructed in urban areas.

For both agricultural and urban alternatives, the net present values (NPV) of construction, land acquisition, and 10 years of maintenance and practice recurrence were estimated to provide longer-term cost comparisons within the scope of this implementation plan. For each area, the estimated investment cost was divided by the predicted reduction in median concentration to determine cost/reduction. The BREI for each area was then determined by normalizing each cost/reduction by the lowest cost/reduction, which resulted in a BREI of "1" for the area where BMP implementation is estimated to be most economical and higher BREI values for areas where BMP implementation is predicted to be less economical. Categorized BREIs are displayed in Figure 6-7 by 12-digit HUCs outside the city of Sioux Falls and by assigned model reach areas within the city of Sioux Falls (i.e., Sioux Falls 362). A majority of the areas identified as having a BREI of less than 100 are within areas where agriculture is the predominant land use, with the exception of Sioux Falls 362 and Sioux Falls 132.

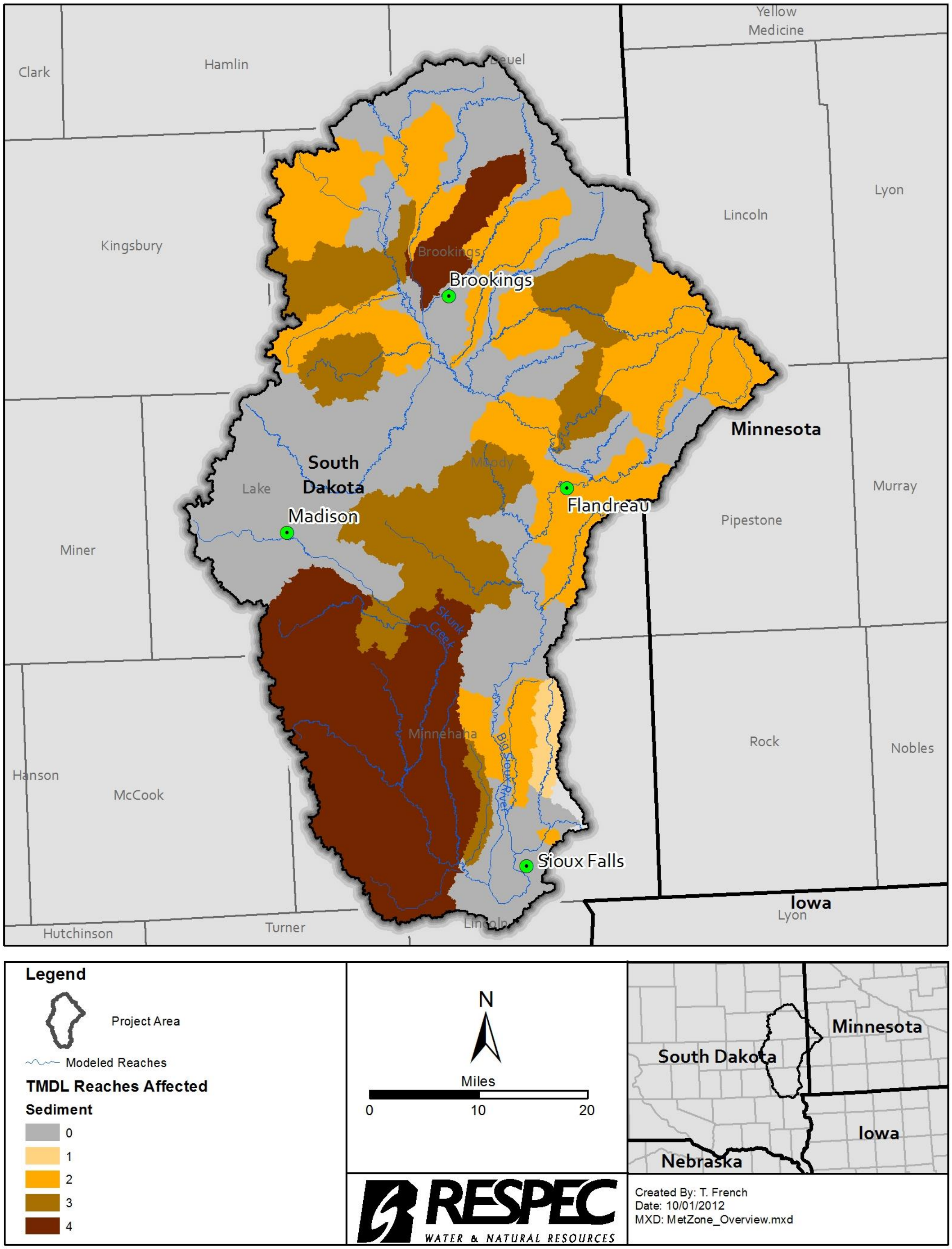

Figure 6-6. Areas Identified by Number of Sediment Impaired Total Maximum Daily Load Reaches Impacted.

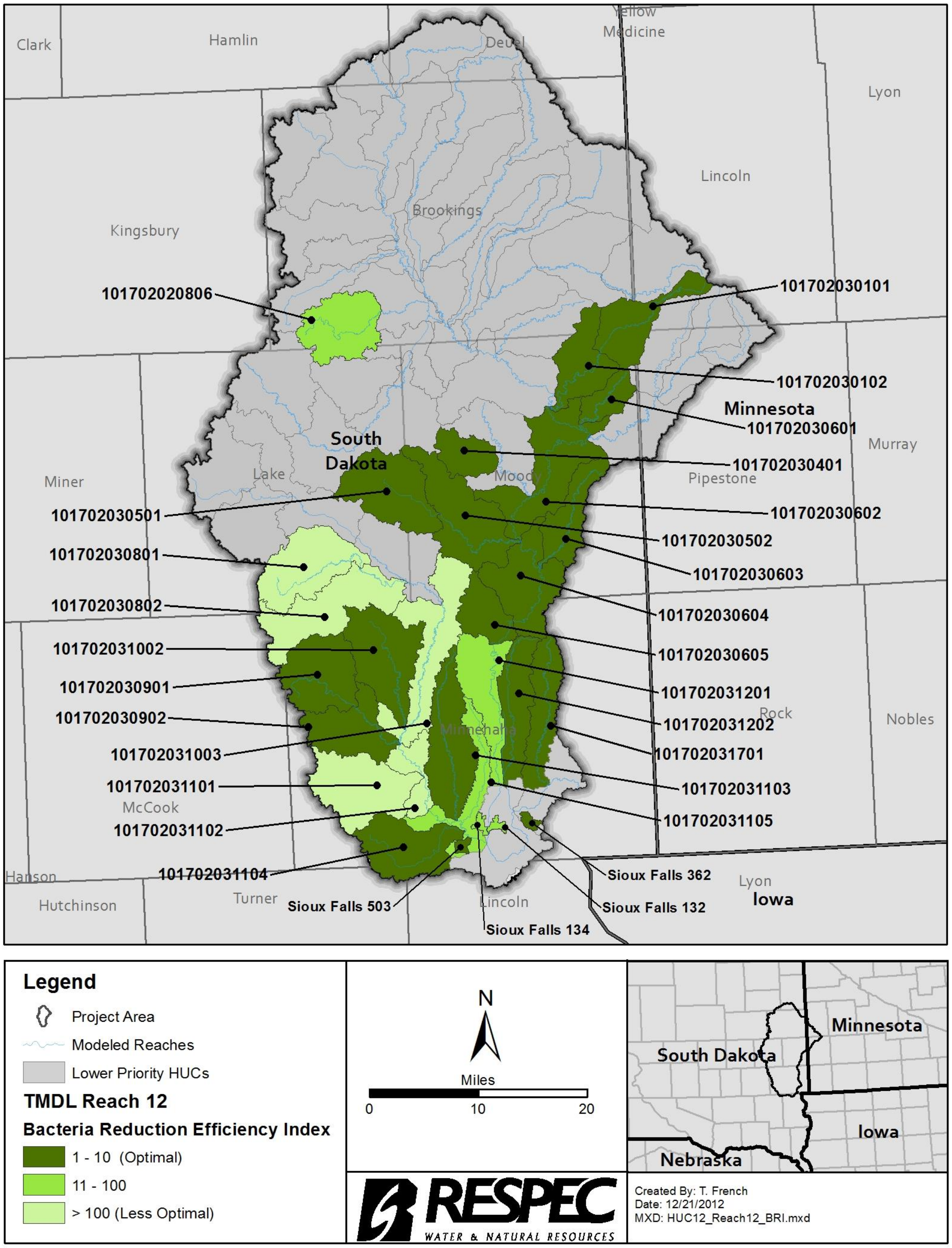

Figure 6-7. Results of Bacteria Reduction Efficiency Index Analysis Conducted on Medium and High Priority Implementation Areas Affecting Reach 12 (Those areas identified as "Lower Priority" do not contribute significantly to Reach 12).

6.2 PRIORITY SOURCES

Section 6.1 outlined factors for prioritizing areas. To prioritize which types of BMPs to implement within these areas, the dominant general pollutant source of each area was identified based on exceedance contribution level during each of the five flow regimes: high, moist, midrange, dry, and low. A contribution to exceedances during dry or low flow conditions indicates direct stream sources (i.e., direct stream defecation by livestock/wildlife or failing septic systems) and during high or moist flow conditions it indicates land sources washed-off during rainfall events (i.e., pet waste in urban runoff or livestock/wildlife waste from agricultural land uses). A contribution to exceedances during all flow conditions indicates both sources. Areas within Sioux Falls are identified with the Sioux Falls MS4 (urban area) as the main source. Identifying pollutant sources results in the prioritizing the BMP type for effective implementation in each area.

Table 6-1 is a prioritization matrix that includes all of the area and source prioritization factors for the Reach 12 priority areas. This matrix, ordered by BREI, indicates the impact of each area to bacteria and sediment exceedances in Reach 12, the number of impaired TMDL reaches impacted by pollutants originating in the designated area, and the dominant sources of bacteria.

Furthermore, the CBSRW DSM was used to determine which land use types are dominant contributors of land source bacteria to exceedances of the bacteria standards. This was performed for all Reach 12 Priority Areas to determine overall average load contributions by land use type. The land use categories were evaluated by load, rather than exceedance contribution, because exceedances of the bacteria standard caused by land sources generally occur when large loads are washed off during rainstorm events, and because load is more easily quantified. The relative load contributions by land use type are shown in Figure 6-8. To identify the land use types for which implementation may be most effective, the average seasonal loads contributed by each land use were normalized by respective total land use area. These values are provided in Table 6-2. This information provides implementation specialists with the priority land uses that should be targeted to achieve concentration reductions.

Figure 6-8 shows that cropland is the greatest overall bacteria load contributor, but Table 6-2 shows that cropland has a relatively low contribution per acre. Pastures contribute the second highest load with the highest contribution per acre. This indicates that it may be most cost-effective to target pastures for bacteria reduction.

Categories within Table 6-1 represent factors that can be used to develop a cost-share ranking system for BMP implementation projects applied for within the CBSRW study area. Implementation efforts should focus on areas with the lowest BREIs and the identified sources therein. Applicable BMPs will differ based on primary land use type: agricultural or urban. A table similar to Table 6-1 that includes all areas of the CBSRW and their impacts to every TMDL reach within the watershed is included in Table A-1 of Appendix A.

Table 6-1. Prioritization Matrix for Reach 12 (the Areas With Bacteria Reduction Efficiency Index Values Less Than 50 Are Included)

HUC12 or Model Reach	BREI Reach 12	Bacteria Impact to Reach 12	Sediment Impact to Reach 12	Impaired TMDL Reaches Affected		Bacteria Source		
				Bacteria	Sediment	Direct Stream	Land	Sioux Falls MS4
101702030502	1	High	High	4	3	High	Medium	
101702030603	2	High	Medium	4	2	High	High	
101702030602	2	High	High	4	2	High		
101702030604	2	High		4	0	High	High	
101702030101	2	High	Medium	4	2	High	Medium	
Sioux Falls 362	2	Medium		2	0			High
101702030901	2	High	High	4	4	High	High	
101702031701	3	High	High	1	1	Medium	Medium	
101702030501	3	Medium	High	3	3	High		
101702031002	3	High	High	4	4	High	High	
101702030102	4	Medium	High	4	3	High	Medium	
101702030401	5	Medium		3	0	High		
101702030605	5	High		4	0	High	High	
101702030402	5	Medium	High	4	3	High		
101702030601	5	Medium		3	0	High	Medium	
101702031104	6	High	High	4	4	High	Medium	Medium
101702030902	7	High	High	4	4	High	High	
101702031202	7	Medium	High	2	2	High	Medium	
101702031103	8	High	High	4	4	High	High	
Sioux Falls 503	10	Medium		3	0			High
101702031105	11	High	Medium	4	4	High	Medium	High
101702031201	12	High	Medium	3	2	High	High	
Sioux Falls 134	23	Medium	High	3	0	High	Medium	High

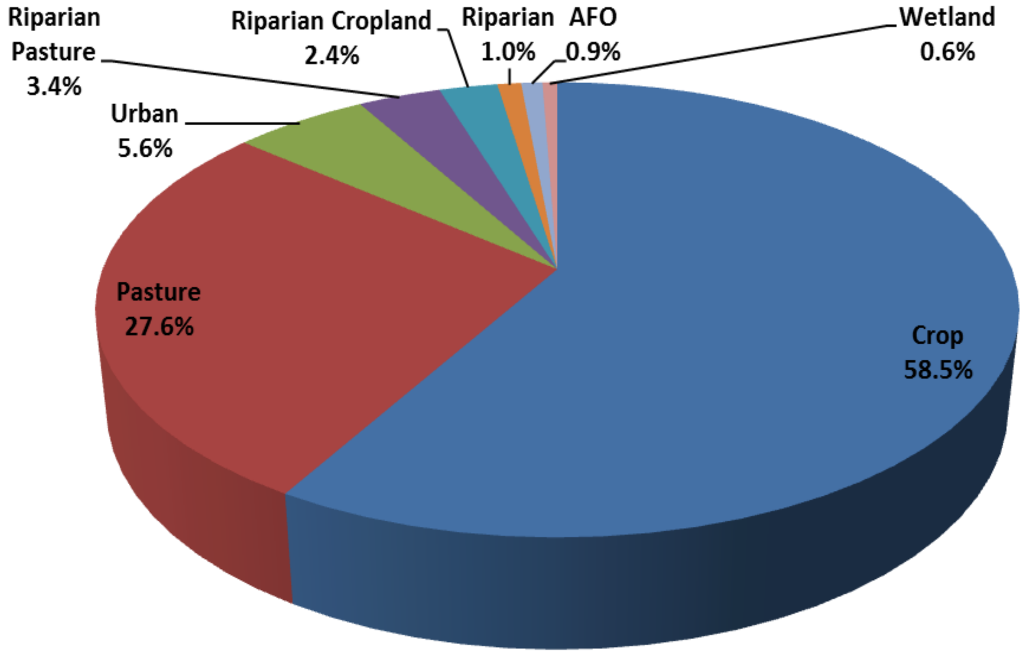

Figure 6-8. Bacteria Load Contribution by Land Use Type for the Reach 12 Priority Areas.

Table 6-2. Average Seasonal Bacteria Load Contribution per Acre of Land Use Type for the Reach 12 Priority Areas

Land Use	10^6 CFU/Recreation Season/Acre
Pasture	12,400
AFO	10,000
Urban	8,900
Riparian Pasture	8,000
Riparian Cropland	6,000
Crop	5,200
Riparian	4,000
Wetland	1,800

Table 6-1 may be used in the event that an agricultural producer located in HUC 101702030602 submits an application for funding to develop access control and off-stream watering for livestock. The CBSRW DSM indicates that this HUC has a high impact to both bacteria and sediment exceedances in Reach 12. The HUC impacts a total of four bacteria TMDL reaches and two sediment TMDL reaches, and it has a near optimal BREI. This explains why this HUC should rank high for implementation. Furthermore, the CBSRW DSM indicates that direct stream bacteria sources are the major causes for impairment in this HUC. This agricultural producer's application should rank very high because controlling livestock stream access can greatly reduce direct stream loading.

If another agricultural producer located in HUC 101702030402 submits an application for funding to develop field borders, a practice generally used to reduce land loading to streams, this producer's application would not rank as high as the first. This HUC has a medium impact to bacteria exceedances in Reach 12, has a less optimal BREI than the first, and was indicated by the CBSRW DSM to contribute mainly direct stream bacteria loads. However, this does not mean that this second producer should not get funding. It is imperative that implementation specialists in the CBSRW consider the unique characteristics of each application and ensure that funding is spent on the appropriate projects.

6.3 PRIORITY PRACTICES

Once priority areas and their priority pollutant sources are identified, implementing practices that will be most effective for a provided scenario is important. For agricultural areas, common NRCS practices were researched to determine pollutant removal rankings and land use applicability. Common stormwater management practices were also researched to determine applicability within urban settings. Properly implementing the practices identified in the following sections will result in positive impacts to water quality in the CBSRW.

6.3.1 Agricultural Best Management Practices

Direct stream loading of bacteria and sediment is very common in agricultural areas. Bacteria are often produced by wildlife and livestock populations immediately in and around stream, wetland, and riparian areas. Direct stream loading of sediment is often caused by failing banks induced by overgrazing riparian areas or not providing an adequate vegetated stream buffer. Table 6-3 lists BMPs provided by the NRCS that reduce direct stream bacteria loadings through implementation in Stream/River, Riparian, and Wetland areas.

Land loading is caused by overland runoff during storm events. BMPs that aid in reducing land loading of bacteria and sediment are often tied to specific land uses and agricultural practices. Table 6-4 lists BMPs provided by the NRCS that reduce land loadings of bacteria and sediment through implementation on Rangeland, Cropland, and lands within the CBSRW that house AFOs.

Table 6-3. Natural Resources Conservation Service Supplemented Best Management Practices for Reducing Direct Stream Bacteria Loadings (Higher Ranks Indicate More Effective Removal)

BMP Type	NRCS Code	Bacteria Removal Rank	Sediment Removal Rank
Heavy Use Area Protection	561	5	2
Wetland Enhancement	659	4	2
Pond	378	N/R	N/R
Tree/Shrub Establishment	612	3	4
Access Control	472	2	N/R
Fence	382	N/R	N/R
Critical Area Planting	342	1	4
Grassed Waterway	412	1	2
Prescribed Grazing	528	1	3
Spring Development	574	1	1
Streambank and Shoreline Protection	580	1	3
Watering Facility	614	1	2
Wetland Creation	658	1	2
Wetland Restoration	657	1	2
Wetland Wildlife Habitat Management	644	1	3

In both Table 6-3 and Table 6-4, the NRCS documented sediment removal ranks are also provided for each practice. Practices with no sediment removal rank given by the NRCS are tagged with "N/R" (No Rank), but many of those practices still apply to sediment removal.

6.3.2 Urban Best Management Practices

Within an urban setting, possible direct stream sources of bacteria include septic systems, illegal discharges, and cross-connections between sanitary and storm sewers. Generally, the best ways to identify and eliminate illicit direct stream sources include regular inspections and monitoring.

Wildlife may also contribute to direct stream source bacteria loading in urban areas. Buffers of tall vegetation around small bodies of open water may deter geese from loitering, while buffers of tall vegetation along streams and drainages may deter other wildlife from defecating directly into the stream.

Table 6-4. Natural Resources Conservation Service Supplemented Best Management Practices for Reducing Land Bacteria Loadings (Higher Ranks Indicate More Effective Removal)

BMP Type	NRCS Code	Bacteria Removal Rank	Sediment Removal Rank
Heavy Use Area Protection	561	5	2
Waste Treatment Lagoon	359	4	N/R
Pond	378	N/R	N/R
Irrigation System, Microirrigation	441	3	N/R
Irrigation Water Management	449	3	3
Manure Transfer	634	3	N/R
Riparian Forest Buffer	391	3	4
Riparian Herbaceous Cover	390	3	4
Tree/Shrub Establishment	612	3	4
Access Control	472	2	N/R
Fence	382	N/R	N/R
Grazing Land Mechanical Treatment	548	2	2
Terrace	600	2	3
Water and Sediment Control Basin	638	2	4
Conservation Cover	327	1	3
Conservation Crop Rotation	328	1	2
Cover Crop	340	1	2
Critical Area Planting	342	1	4
Drainage Water Management	554	1	N/R
Field Border	386	1	2
Forage Harvest Management	511	1	2
Nutrient Management	590	1	N/R
Prescribed Grazing	528	1	3
Range Planting	550	1	3
Vegetated Treatment Area	635	1	N/R

One common land source of bacteria in urban areas is pet waste. Bacteria loading from pet waste can be reduced by educating residents and using programs to remove waste from common areas, such as parks.

The removal of bacteria from urban stormwater runoff has been documented to be effectively achieved by regional (large-scale) BMPs including infiltration basins, retention ponds, and extended detention basins (EDBs). The associated bacteria and sediment concentration reduction efficiencies assumed for properly installed and maintained large-scale BMPs are provided in Table 6-5.

Table 6-5. Bacteria and Sediment Removal Efficiency of Select Regional Urban Stormwater Best Management Practices

BMP Type	Bacteria Removal Efficiency (%)	Sediment Removal Efficiency (%)
Extended Detention Basin	40[a]	65[b]
Retention Pond	80[a]	80[b]
Infiltration Basin	96[c]	50[c]

(a) Clary et al. [2010].
(b) Leisenring et al. [2011].
(c) Birch et al. [2006].

Although it is not modeled in any scenarios for this plan, widespread stormwater source control can also have a major impact on adjacent stream water quality. This includes BMPs referred to as Low-Impact Development (LID) that serve to reduce, attenuate, or eliminate stormwater runoff on the scale of individual lots. LID implementation not only reduces runoff, but also removes pollutants. Table 6-6 lists potential LID practices.

Table 6-6. Effective Low-Impact Development Practices for Stormwater Runoff

Low-Impact Development Practices	Benefit
Drought-Tolerant Native Plant Landscaping	Decrease Water Use
Lawn Aeration	Increase Soil Permeability and Stormwater Retention
Permeable Paving	Filter Pollutants from Stormwater
Rain Garden	Reduce Stormwater Runoff and Filter Pollutants
Bio-Swale	Reduce Stormwater Runoff and Filter Pollutants
Green Walls and Green Roofs	Reduce Stormwater Runoff
Vegetated Buffers to Ponds and Drainages	Filter Pollutants from Stormwater and Reduce Direct Defecation from Wildlife

7.0 TRACKING PROGRESS TOWARD MEETING TOTAL MAXIMUM DAILY LOAD GOALS

7.1 BEST MANAGEMENT PRACTICE IMPLEMENTATION SCHEDULE

Because size of the project area is substantial, an approach of outlining priority areas within the watershed, recommending BMPs for implementation, describing milestone measures, and monitoring BMP effectiveness is necessary to achieve the concentration and load reductions required to bring the impaired stream segments into compliance with their assigned beneficial uses. Achieving these reductions depends on a number of factors including voluntary participation efforts, available technical and financial assistance, and BMP effectiveness.

Implementing the TMDLs will take many years to attain water-quality standards. To attain this water quality master plan's goal of reducing *E. coli* bacteria and sediment impairments by implementing point- and nonpoint-source BMPs, a 10-year adaptive implementation schedule is recommended. This plan should be revisited and revised as necessary after the first 5 years. The schedule for TMDL implementation activities, associated milestones, and associated costs is provided in Table 7-1.

Milestones of both BMP amounts and costs are recommended for implementation within this plan. The amounts were based on past conservation practice implementation within the project area as well as conversations with local implementation specialists (both urban and agricultural) and NRCS District Conservationists. Specifically, meetings were held with Mr. Bob Kappel and Mr. Andy Berg (City of Sioux Falls Public Works) as well as Mr. Barry Berg (South Dakota Association of Conservation Districts) to discuss practices and develop milestone amounts. Agricultural costs were based on traditional EQIP payment rates from the FY2013 Practice Payment Schedule, assuming that, on average, these rates represent 60 percent of total costs.

For point sources, such as wastewater treatment plants, future National Pollutant Discharge Elimination System (NPDES) permits are anticipated to continue to include recommended control measures for *E. coli* bacteria and TSS discharges. To achieve the necessary reductions from nonpoint-source *E. coli* and sediment loadings, a significantly increased amount of technical and financial program assistance will be required. The following are vital components of a successful nonpoint-source management plan: BMP implementation through on-the-ground projects; proper watershed planning in cooperation with willing landowners, land management agencies, and stakeholders; thorough monitoring throughout the CBSRW; and continued public outreach.

Table 7-1. Central Big Sioux River Watershed Implementation Schedule, Milestones, and Costs (Page 1 of 3)

Source or Land Use Category	Recommended BMP or Implementation Activity	Bacteria Load Reduced		Description of Measurable Milestone	Measureable Milestones		Milestone Costs	
		Direct Stream	Indirect		0–5 Years	0–10 Years	0–5 Years	0–10 Years
Point Sources								
Stormwater/MS4s	Review *E. coli* BMPs in Stormwater Management Plans	N/A	N/A	Number of plans reviewed	2	4	TBD	TBD
	Review sediment BMPs in Stormwater Management Plans	N/A	N/A	Number of plans reviewed	2	4	TBD	TBD
	Comprehensive study of *E. coli* discharge potential from urbanized areas	N/A	N/A	Number of areas evaluated	2	2	TBD	TBD
	Comprehensive study of sediment discharge potential from urbanized areas	N/A	N/A	Number of areas evaluated	2	2	TBD	TBD
Concentrated Animal Feeding Operations (CAFOs)	Evaluate *E. coli* discharge potential from CAFOs	N/A	N/A	Number of CAFOs evaluated	6	12	TBD	TBD
Nonpoint Sources								
Agricultural	Prescribed Grazing (528)		X	Number of acres	1,338	2,677	$25,100	$50,100
	Grassed Waterway (412)	X		Number of acres	8	16	$22,900	$45,800
	Pond (378)	X	X	Number developed	5	10	$152,500	$305,000
	Watering Facilities (614)	X		Number developed	33	67	$25,900	$51,900
	Water and Sediment Control Basins (638)		X	Number developed	21	43	$39,700	$79,400
	Irrigation Water Management (449)		X	Number of acres	847	1,694	$7,500	$15,000
	Cover Crop (340)		X	Number of acres	677	1,354	$31,900	$63,700
	Nutrient Management (590)		X	Number of acres	1,261	2,522	$21,900	$43,900
	Terrace (600)		X	Number of feet	3,308	6,615	$8,600	$17,100
	Filter Strip (393), Riparian Buffer		X	Number of acres	50	100	$7,500	$15,000

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Table 7-1. Central Big Sioux River Watershed Implementation Schedule, Milestones, and Costs (Page 2 of 3)

Source or Land Use Category	Recommended BMP or Implementation Activity	Bacteria Load Reduced		Measurable Units	Measureable Milestones		Milestone Costs	
		Direct Stream	Land		0–5 Years	0–10 Years	0–5 Years	0–10 Years
Agricultural (cont.)	Field Border (386)		X	Number of acres	24	49	$3,200	$6,400
	Ag Waste System - Waste Storage Facility (313), Waste Facility Cover (367), Vegetated Treatment System			Number	26	52	$5,200,000	$10,400,000
	Clean Water Diversion (362)		X	Number of feet	4,000	8,000	$16,000	$32,000
	Conservation Tillage (329)		X	Number of acres	2,500	5,000	$59,150	$118,300
Urban/Residential	Initiate pet waste management programs in areas along the Big Sioux River and stormwater drainage networks		X	Number of programs	2	5	$30,000	$40,000
	Perform rural septic system assessment and inventory of systems within riparian zone buffer	N/A	N/A	Number of systems assessed	80	160	TBD	TBD
	Replace/repair failing rural septic systems within riparian zone buffer	X	X	Number of systems updated	16	32	$96,000	$192,000
	Perform urban septic system assessment and inventory of systems within city limits	N/A	N/A	Number of towns/cities assessed	2	5	TBD	TBD
	Replace, repair, or connect failing urban septic systems to publicly owned treatment works	X	X	Number of systems updated/connected	106	106	TBD	TBD
	Structural storm water systems, public	X	X	Number of sites	7	14	$7,700,000	$15,400,000
	Structural storm water systems, private[a]	X	X	Number of sites	70	140	$1,750,000	$3,500,000
	Initiate low impact development program which includes practices such as porous landscape design, bio-swales, green walls and green roofs, lawn aeration, and permeable paving.	N/A	N/A	Number of programs	1	1	TBD	TBD

Table 7-1. Central Big Sioux River Watershed Implementation Schedule, Milestones, and Costs (Page 3 of 3)

Source or Land Use Category	Recommended BMP or Implementation Activity	Bacteria Load Reduced		Measurable Units	Measureable Milestones		Milestone Costs	
		Direct Stream	Land		0–5 Years	0–10 Years	0–5 Years	0–10 Years
Outreach	Hold public information and progress report meetings	N/A	N/A	Number of meetings	15	15	TBD	TBD
	Administer watershed tours	N/A	N/A	Number of tours	5	10	TBD	TBD
	Enhance outreach activities within the watershed	N/A	N/A	Number of people contacted	5,000	10,000	TBD	TBD
	Increase public support for BMP implementation within watershed via media messaging	N/A	N/A	Number of media messages completed	40	80	TBD	TBD
Monitoring	Rural water-quality sampling	N/A	N/A	Number of sites	25	25	$63,000	$126,000
	Rural discharge measurement	N/A	N/A	Number of sites	13	13	TBD	TBD
	Urban water-quality sampling and flow measurement, stream ambient and storm events	N/A	N/A	Number of sites	5	10	TBD	TBD
	Urban water-quality sampling and flow measurement, MS4 outfall storm events	N/A	N/A	Number of sites	10	20	TBD	TBD
	Monitor implemented agricultural BMP effectiveness	N/A	N/A	Number of BMPs	TBD	TBD	TBD	TBD
	Monitor implemented urban BMP effectiveness	N/A	N/A	Number of BMPs	2	4	TBD	TBD
	Monitor NPDES permitted facility discharge limits	N/A	N/A	Number of facilities	22	22	TBD	TBD

N/A = Not Applicable

(a) Not responsible to meet private goals.

7.2 BEST MANAGEMENT PRACTICE IMPLEMENTATION FUNDING

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

Locally led conservation efforts can turn to the NRCS for support in adopting or developing conservation practices and programs within the CBSRW. Numerous conservation programs, stemming from the 2008 Farm Bill, are available to eligible landowners, agriculture producers, and watershed stakeholders to provide financial and technical assistance in implementing conservation practices and programs that promote sustainability and aide in managing South Dakota's natural resources.

One such program is the EQIP. EQIP is a voluntary conservation program that promotes incentives for implementing conservation practices and programs that are important for improving or maintaining the health of our natural resources. EQIP provides conservation practice payments to eligible applicants based on a portion of the average cost associated with practice implementation. Local NRCS personnel work with approved applicants in developing a plan of operations that identifies the resource concern and the appropriate conservation practice or measures needed to address the concern and offer financial assistance to implement conservation practices and activities deemed fit by the NRCS and the approved applicant. The practices or programs for implementation are subject to NRCS technical standards adapted for local and site specific conditions. EQIP application and program information are provided through the NRCS online (*http://www.sd.nrcs.usda.gov/programs/EQIP.html*).

To assist in managing implementation efforts within the CBSRW, all associated costs of nonpoint management measures recommended within this implementation plan were obtained from South Dakota's 2012 EQIP Practice Payment Schedule. This schedule outlines all conservation practices available for 2012 financial assistance as well as associated costs, limitations, and caveats for each practice. South Dakota's 2012 EQIP Practice Payment Schedule is provided online (*http://efotg.sc.egov.usda.gov/references/public/SD/FY2012_EQIP_Practice_Payment_Schedule.pdf*) [Natural Resources Conservation Service, 2012]. The associated costs of recommended implementation efforts within the CBSRW are displayed in Table 7-1.

7.3 SOURCES OF TECHNICAL AND FINANCIAL ASSISTANCE

There are multiple technical and financial assistance sources available to implement TMDLs in the CBSRW. Numerous private companies and organizations and local, state, and federal agencies provide technical assistance to address point- and nonpoint-source pollution. A smaller number of these organizations and agencies also provide financial assistance. Agencies and organizations with technical and financial programs that can possibly assist with conservation and water-quality implementation projects are provided in Table 7-2.

Table 7-2. Sources of Technical and Financial Assistance in the Central Big Sioux River Watershed (Page 1 of 2)

Agency or Organization	Website	Assistance	BMP Categories							
			WWTP	Discharge Permits	MS4s and Stormwater	Wetland	Urban/ Residential	Rangeland	Cropland	Outreach
Local										
Cities		Financial, Technical	X		X	X	X	X	X	X
Counties		Financial, Technical							X	X
East Dakota Water Development District	http://www.eastdakota.org/	Financial, Technical				X	X	X	X	X
Moody County Conservation District	http://moodyconservation.org/	Financial, Technical				X	X	X	X	X
Lake County Conservation District	http://www.sdconservation.org/Districts/lake.html	Financial, Technical				X	X	X	X	X
Minnehaha County Conservation District	http://www.minnehahacd.org/	Financial, Technical				X	X	X	X	X
Brookings County Conservation District	http://www.brookingsconservation.org/	Financial, Technical				X	X	X	X	X
State										
South Dakota State University—Extension Resources Service	http://www.sdstate.edu/sdces/store/index.cfm	Technical	X	X	X	X	X	X	X	X
South Dakota Association of Conservation Districts	http://www.sdconservation.org/	Financial, Technical				X	X	X	X	X
South Dakota Department of Environment and Natural Resources	http://denr.sd.gov/	Financial, Technical	X	X	X	X	X	X	X	X
South Dakota Game, Fish and Parks	http://gfp.sd.gov/	Financial, Technical				X		X	X	X
South Dakota Department of Agriculture	http://sdda.sd.gov/	Financial, Technical				X	X	X	X	X
South Dakota State University—Water Resources Institute	http://www.sdstate.edu/abe/wri/	Technical				X	X	X	X	
South Dakota State Engineer's Office	http://www.state.sd.us/boa/ose/	Financial, Technical				X	X	X	X	
South Dakota Water Management Board	http://denr.sd.gov/des/wr/wmb.aspx	Financial, Technical				X	X	X	X	X
South Dakota Office of Public Lands	http://www.sdpubliclands.com/	Financial	X			X	X			

Table 7-2. Sources of Technical and Financial Assistance in the Central Big Sioux River Watershed (Page 2 of 2)

Agency or Organization	Website	Assistance	BMP Categories							
			WWTP	Discharge Permits	MS4s and Stormwater	Wetland	Urban/ Residential	Rangeland	Cropland	Outreach
Federal										
U.S. Army Corps of Engineers	http://www.usace.army.mil	Financial, Technical		X				X	X	
Natural Resources Conservation Service	http://www.nrcs.usda.gov	Financial, Technical				X	X	X	X	X
Farm Service Agency	http://www.fsa.usda.gov	Financial, Technical				X	X	X	X	X
Rural Development	http://www.rurdev.usda.gov	Financial, Technical	X			X	X		X	X
Bureau of Reclamation	http://www.usbr.gov/	Financial, Technical				X	X	X		X
U.S. Environmental Protection Agency	http://www.epa.gov	Financial, Technical	X	X	X	X	X	X	X	X
U.S. Fish and Wildlife Service	http://www.fws.gov	Financial, Technical				X	X	X	X	X
U.S. Geological Survey	http://www.usgs.gov	Technical				X	X	X	X	
Private										
Ducks Unlimited	http://www.ducks.org	Financial, Technical				X		X	X	
South Dakota Cattlemen's Association	http://www.sdcattlemen.org/	Financial, Technical				X		X	X	
South Dakota Corn Growers Association	http://www.sdcorn.org/	Financial, Technical							X	
South Dakota Soybean Association	http://www.sdsoybean.org/	Financial, Technical							X	
South Dakota Association of Rural Water Systems	http://www.sdarws.com	Financial, Technical				X	X	X		
Northern Prairies Land Trust	http://www.northernprairies.org/	Financial, Technical				X	X	X	X	X
National Fish and Wildlife Foundation	http://www.nfwf.org	Financial				X	X	X	X	

7.4 EXPECTED EXCEEDANCE AND LOAD REDUCTIONS

The CBSRW DSM showed that at the end of the 10-year plan, implementing optimum BMPs within the areas identified in Table 6-1 could reduce *E. coli* exceedances by 6 percent and annual *E. coli* loads by 8 percent at Big Sioux River Reach 12, under funding consistent with historical amounts. Potential reductions to be achieved by the 10-year plan, as estimated by the CBSRW DSM, are shown in Table 7-3 for all TMDL reaches of the CBSRW.

Table 7-3. Potential Reductions to Be Achieved by the 10-Year Plan in All Total Maximum Daily Load Reaches as Indicated by the Central Big Sioux River Watershed Decision Support Model, Based on Implementation in the Reach 12 Priority Areas[(a)]

Reach	Change in Exceedance (%)	Load Reduction (%)
Big Sioux TMDL Reach 8	10	17
Big Sioux TMDL Reach 10	3	14
Big Sioux TMDL Reach 11	6	10
Big Sioux TMDL Reach 12	6	8
Skunk Creek	8	15
Spring Creek	25	41
Peg Munky Run	0	0
Sixmile	0	0

(a) Peg Munky Run Creek and Sixmile Creek show zero reductions because those areas are not included in the Reach 12 Priority Areas.

8.0 INFORMATION, EDUCATION, AND OUTREACH

Current communication, education, and outreach efforts established by local conservation districts and organizations should continue to incorporate effectiveness and user feedback surveys that would complement current outreach programs within the CBSRW project area. Conservation districts; non-governmental organizations; and local, state, and federal government agencies have created several effective information, education, and outreach products and programs that have reached thousands of residents, landowners, and stakeholders during the implementation of their water-quality management planning and implementation efforts. Stakeholders should continue their public outreach efforts and communicate to the general public through website updates, newsletters, news articles, flyers, displays, and public meetings.

As part of an adaptive TMDL implementation approach, education and outreach activities should survey targeted audience members to obtain information regarding delivery method effectiveness that helps develop and improve future outreach efforts. Coordinated outreach efforts should continue to increase the awareness of *E. coli* and sediment pollution problems within the watershed. These outreach efforts should be coupled with information regarding available technical and financial assistance for implementing BMPs to target these constituents.

9.0 CRITERIA FOR TOTAL MAXIMUM DAILY LOAD IMPLEMENTATION GOAL ACHIEVEMENT

As part of an adaptive TMDL implementation plan, establishing water-quality benchmarks that can be used to track implementation progress towards attaining TMDL goals is critical. Criteria for tracking implementation progress will be based on observed concentration reductions from implementation monitoring within the CBSRW.

Load reduction criteria have been derived through *E. coli* and TSS TMDL assessments performed within the CBSRW. The reductions required by those TMDL assessments cannot be expected to occur within the scope of this 10-year Water Quality Master Plan under historical funding amounts. However, with proper planning and implementation effort there is reasonable assurance that significant concentration reductions may be achieved with the availability of adequate technical and financial assistance.

In the case that the interim benchmarks of this plan are not met, a revision to the plan must be made. This revision should include but is not limited to the following:

- An assessment of BMP implementation efforts (location, type, land use)
- An assessment of direct monitoring of implemented BMPs
- A reassessment of loading sources
- A reassessment of the model with updated loading sources (if applicable)
- An analysis of the time it takes for BMP implementation results to be seen
- An analysis of BMP maintenance and current operation.

10.0 RECOMMENDATIONS FOR FUTURE WORK

10.1 MONITORING

Consistent watershed-scale monitoring is an integral component of a successful watershed-based implementation plan. Monitoring results can be used to assess the effectiveness of implementation efforts over time and can guide future conservation practices and implementation activities within the watershed. Monitoring and evaluation efforts that target the effectiveness of implemented BMPs should focus on determining whether concentration reductions are achieved over time and progress made toward attaining the TMDL milestones shown previously in Table 7-1.

Past monitoring data in the project area was obtained from 17 Big Sioux River mainstem and 18 tributary monitoring sites. In-stream water-quality monitoring should continue through the SD DENR's ambient water-quality monitoring stations within the project area. Monitoring at locations spanning all TMDL reaches within the CRSRW over implementation of this 10-year plan is suggested. Additional locations for future monitoring are displayed in Figure 10-1 and described in Table 10-1. These were identified as locations to fill in the existing monitoring network and better isolate pollutant sources. For example, Site 1 is suggested because no flow data currently exists for Sixmile Creek, and Site 6 is suggested to isolate the water quality coming from the upper Skunk Creek Watershed through Brandt Lake.

Over the course of the 10-year plan, the locations of monitoring sites should be continually assessed and updated by the CBSRW Technical Advisory Committee to determine implementation effectiveness. The monitoring program should also include bacteria source tracking. This technology, although still being developed, can offer great insight and reduce the uncertainty of loading sources.

Adopting a regular BMP monitoring program for use within the watershed is also recommended. This program will need to be thorough and strategic in placing monitoring locations over the course of implementation activities, so as to maximize the information obtained regarding water-quality conditions resulting from implementation efforts. Where applicable, the additional in-stream monitoring of individual, or systems, of BMPs should be conducted to obtain a direct correlation between water-quality conditions and BMP implementation.

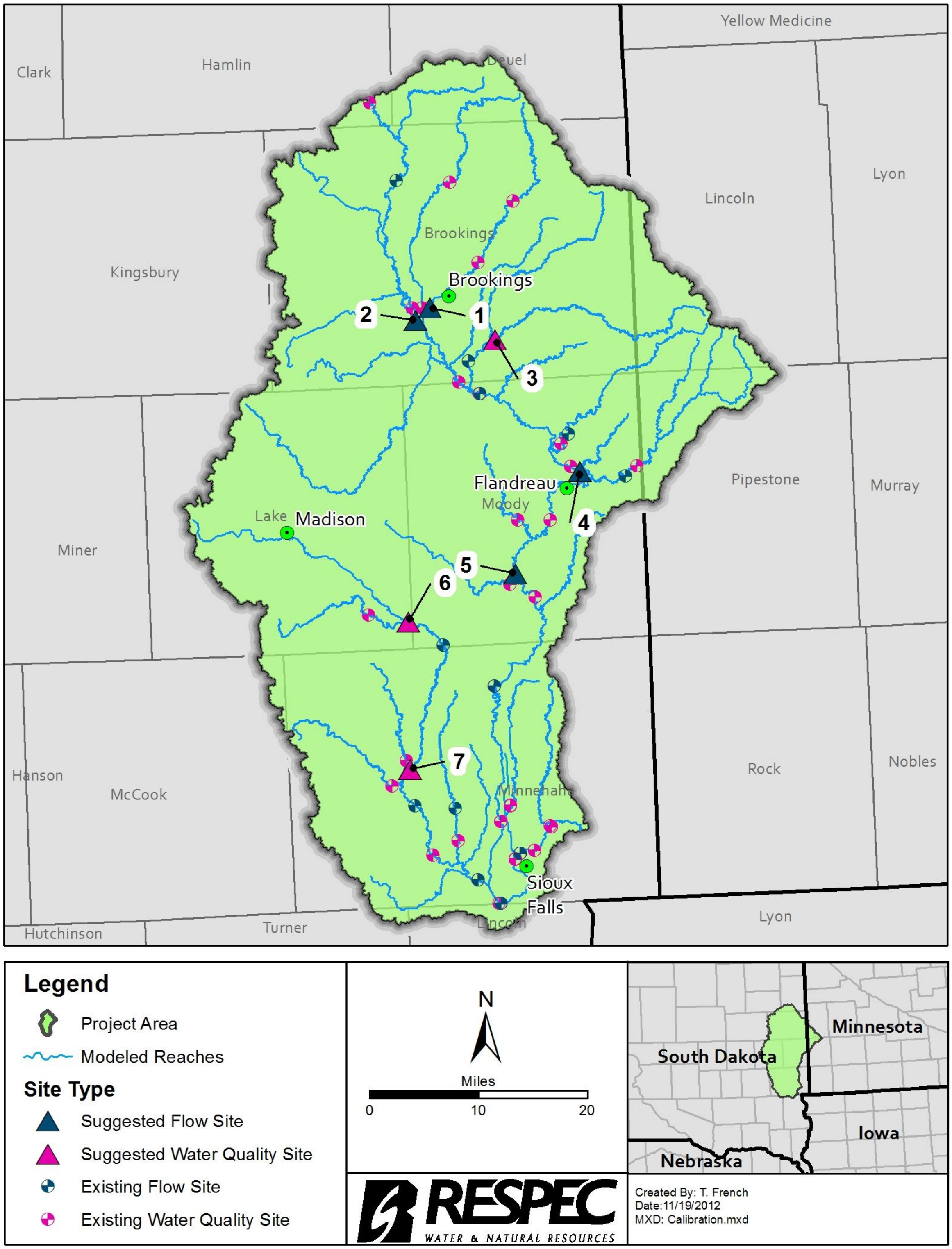

Figure 10-1. Suggested Additional Monitoring Locations Within the Central Big Sioux River Watershed.

Table 10-1. Suggested Additional Monitoring Sites

Number	Description	Type
1	Sixmile Creek Above North Deer Creek	Flow
2	BSR Above Sixmile Creek	Flow
3	Medary Creek Above Deer Creek	Water Quality
4	BSR Above Mud Creek	Flow
5	BSR Above Bachelor Creek	Flow
6	Skunk Creek Above Buffalo Creek	Water Quality
7	Skunk Creek Above Colton Creek	Water Quality

10.2 MODELING

All future monitoring within the watershed, both consistent water-quality sampling and monitoring implementation activities, should be used to enhance and update the CBSRW DSM. As implementation efforts within the watershed increase over the course of the project timeline, the CBSRW DSM should be updated to better reflect conditions resulting from implementation activities. Updates are also necessary to account for changes in watershed characteristics, such as climatic or physical alterations. This will ensure the CBSRW DSM is representing current conditions as accurately as possible and will provide a better tool for assessing the watershed. Updates to the model are recommended to be performed every 5 years to ensure proper refinement and accuracy of the model.

10.3 WATER-QUALITY TRADING

The CBSRW has the potential to become one of the best implementation projects in the region because of its unique structure and land layout. Highly productive agricultural communities, coupled with surrounding permitted stormwater municipalities, provide the potential for a large-scale water-quality trading project. Water-quality trading projects allow for achieving water-quality goals through innovative and efficient techniques.

Trading is based on the fact that, within a watershed, very different costs can be associated with restoring a degraded waterbody through BMP implementation for varying pollutant sources. Programs allow facilities facing higher pollution control costs to meet their permitted obligations by purchasing environmentally equivalent, or superior, pollution reductions from another source at a lower cost to achieve the same, or better, water-quality improvements within the watershed [U.S. Environmental Protection Agency, 2012].

As part of an adaptive implementation approach, future water-quality trading projects are recommended for the CBSRW to optimize conservation dollars and more rapidly improve water-quality in the Big Sioux River and its tributaries. Water-quality trading projects have the potential to more effectively aid in reaching required TMDL load reductions within the CBSRW from an economical and implementable standpoint.

11.0 REFERENCES

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APPENDIX A

PRIORITIZATION FOR ALL OTHER CENTRAL BIG SIOUX RIVER WATERSHED TOTAL MAXIMUM DAILY LOAD REACHES

Table A-1. 303(d) Listed Impaired Waterbodies in the Central Big Sioux River Watershed Project Area (Page 1 of 3)[(a)]

HUC12 or Subwatershed	Bacteria Reduction Index	Bacteria Reduction Index Reach 8	Contribution to Percent Exceedance for *E. coli*-Impaired TMDL Reach								Bacteria-Impaired TMDL Reaches Affected	Sediment-Impaired TMDL Reaches Affected	Contribution to Sediment in BIG_SIOUX_12	Bacteria BMP Source Focus		
	Reach 12	Reach 8	BIG_SIOUX_08	BIG_SIOUX_10	BIG_SIOUX_11	BIG SIOUX_12	PEG MUNKY RUN	SIXMILE	SKUNK	SPRING				Direct Stream	Land	Sioux Falls MS4
101702030502	1	1	High	Medium	High	High					4	3	High	High	Medium	
101702030603	2	3	High	Medium	High	High					4	2	Medium	High	High	
101702030602	2	3	High	Medium	High	High					4	2	High	High		
101702030604	2	2	High	High	High	High					4	0		High	High	
101702030101	2	4	Medium		High	High				High	4	2	Medium	High	Medium	
Model 362	2				Medium	Medium					2	0				High
101702030901	2			High	High	High			High		4	4	High	High	High	
101702031701	3					High					1	1	High	Medium	Medium	
101702030501	3	5	High		Medium	Medium					3	3	High	High		
101702031002	3			High	High	High			High		4	4	High	High	High	
101702030102	4	7	Medium		Medium	Medium				High	4	3	High	High	Medium	
101702030401	5	9	Medium		Medium	Medium					3	0		High		
101702030605	5	3	High	Medium	High	High					4	0		High	High	
101702030402	5	11	Medium	Medium	Medium	Medium					4	3	High	High		
101702030601	5	11	Medium		Medium	Medium					3	0		High	Medium	
101702031104	6			High	High	High			High		4	4	High	High	Medium	Medium
101702030902	7			High	High	High			High		4	4	High	High	High	
101702031202	7				Medium	Medium					2	2	High	High	Medium	
101702031103	8			High	High	High			High		4	4	High	High	High	
Model 503	10			High	Medium	Medium					3	0				High
101702031105	11			High	High	High			High		4	4	Medium	High	Medium	High
101702031201	12	6	High	High	High	High					3	2	Medium	High	High	
Model 134	23			High	Medium	Medium					3	0				High
Model 132	57			High	Medium	Medium					3	0				High
101702020806	81	123	Medium		Medium	Medium					3	3	High	High	Medium	
101702030801	470			High	High	High			High		4	4	High		High	
101702030802	470			High	High	High			High		4	4	High		High	
101702031102	1149			High	High	High			Medium		4	4	High	Medium	High	
101702031003	1333			High	High	High			High		4	4	High	Medium	High	

Table A-1. 303(d) Listed Impaired Waterbodies in the Central Big Sioux River Watershed Project Area (Page 2 of 3)[(a)]

HUC12 or Subwatershed	Bacteria Reduction Index	Bacteria Reduction Index Reach 8	Contribution to Percent Exceedance for *E. coli*-Impaired TMDL Reach								Bacteria-Impaired TMDL Reaches Affected	Sediment-Impaired TMDL Reaches Affected	Contribution to Sediment in BIG_SIOUX_12	Bacteria BMP Source Focus		
	Reach 12	Reach 8	BIG_SIOUX_08	BIG_SIOUX_10	BIG_SIOUX_11	BIG SIOUX_12	PEG MUNKY RUN	SIXMILE	SKUNK	SPRING				Direct Stream	Land	Sioux Falls MS4
101702031101	2072			High	High	High			Medium		4	4	High	Medium	High	
101702020501											0	2	Medium			
101702020502											1	2	Medium			
101702020601											0	0				
101702020602								High			1	4	High	High	Medium	
101702020701											0	0				
101702020702											0	2	Medium			
101702020703											0	4	High			
101702020704											0	4	High			
101702020801											0	0				
101702020802											0	0				
101702020803											0	0				
101702020804											0	0				
101702020805											0	0				
101702020807											0	2	Medium			
101702020901											0	0				
101702020902											0	0				
101702021001											0	2	Medium			
101702021002											0	3	High			
101702021003											0	2	Medium			
101702021102											1	0				
101702021103							High				1	0		High	Medium	
101702021104											1	2	Medium			
101702021105											1	3	High			
101702021106											1	3	High			
101702021108											0	2	Medium			
101702021109											0	2	Medium			
101702021110											1	3	High			
101702030201											0	0				
101702030202											0	2	Medium			

Table A-1. 303(d) Listed Impaired Waterbodies in the Central Big Sioux River Watershed Project Area (Page 3 of 3)[(a)]

HUC12 or Subwatershed	Bacteria Reduction Index	Bacteria Reduction Index Reach 8	Contribution to Percent Exceedance for *E. coli*-Impaired TMDL Reach								Bacteria-Impaired TMDL Reaches Affected	Sediment-Impaired TMDL Reaches Affected	Contribution to Sediment in BIG_SIOUX_12	Bacteria BMP Source Focus		
	Reach 12	Reach 8	BIG_SIOUX_08	BIG_SIOUX_10	BIG_SIOUX_11	BIG SIOUX_12	PEG MUNKY RUN	SIXMILE	SKUNK	SPRING				Direct Stream	Land	Sioux Falls MS4
101702030301											0	2	Medium			
101702030302											0	2	Medium			
101702030303											0	2	High			
101702030304											0	2	Medium			
101702030701											0	0				
101702030702											0	0				
101702030703											0	0				
101702031001											0	4	Medium			

(a) Blanks indicate that an area does not contribute to that category.

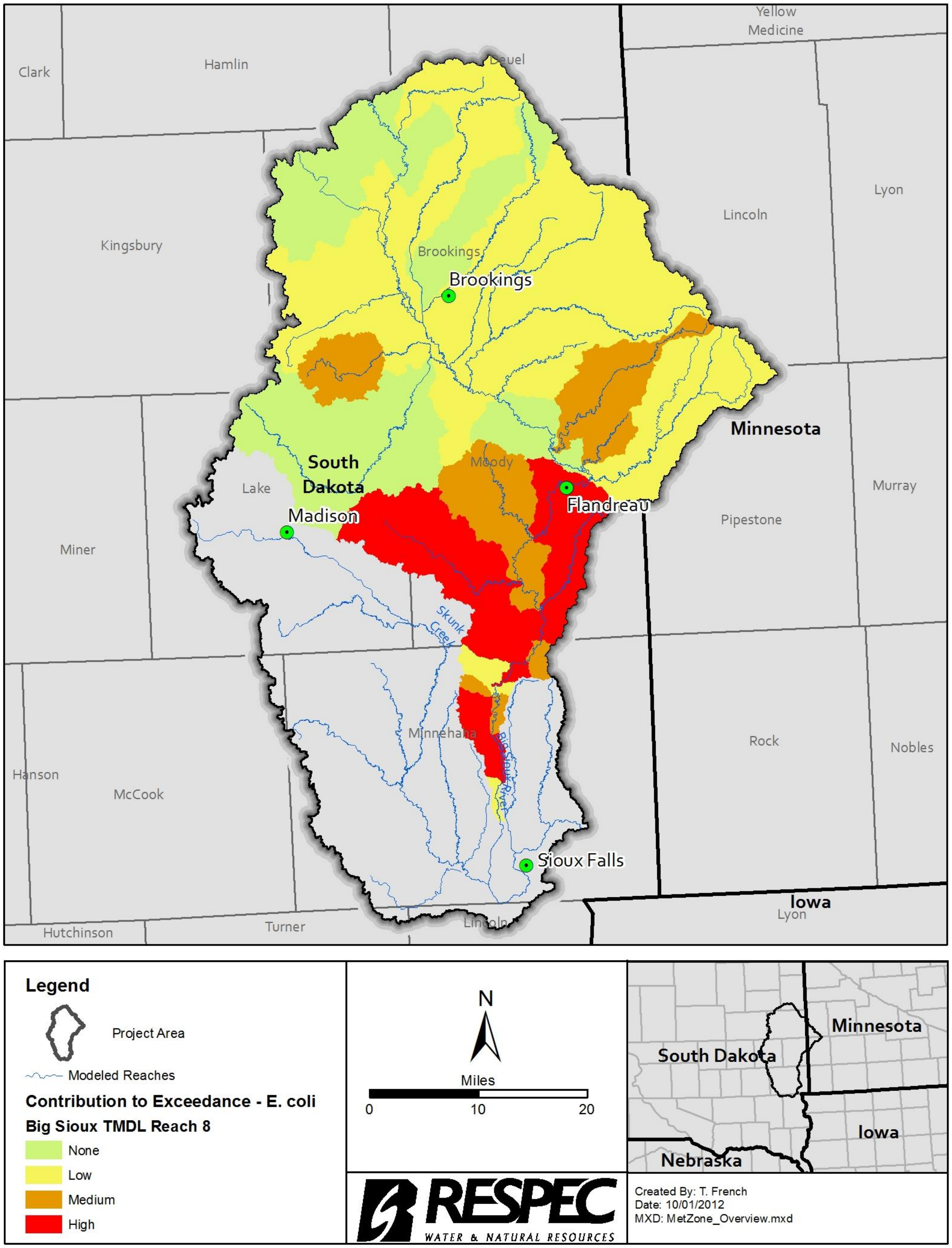

Figure A-1. Priority Areas Representing Contributions to the Number of *E. coli* Exceedances in the Big Sioux River Reach 08.

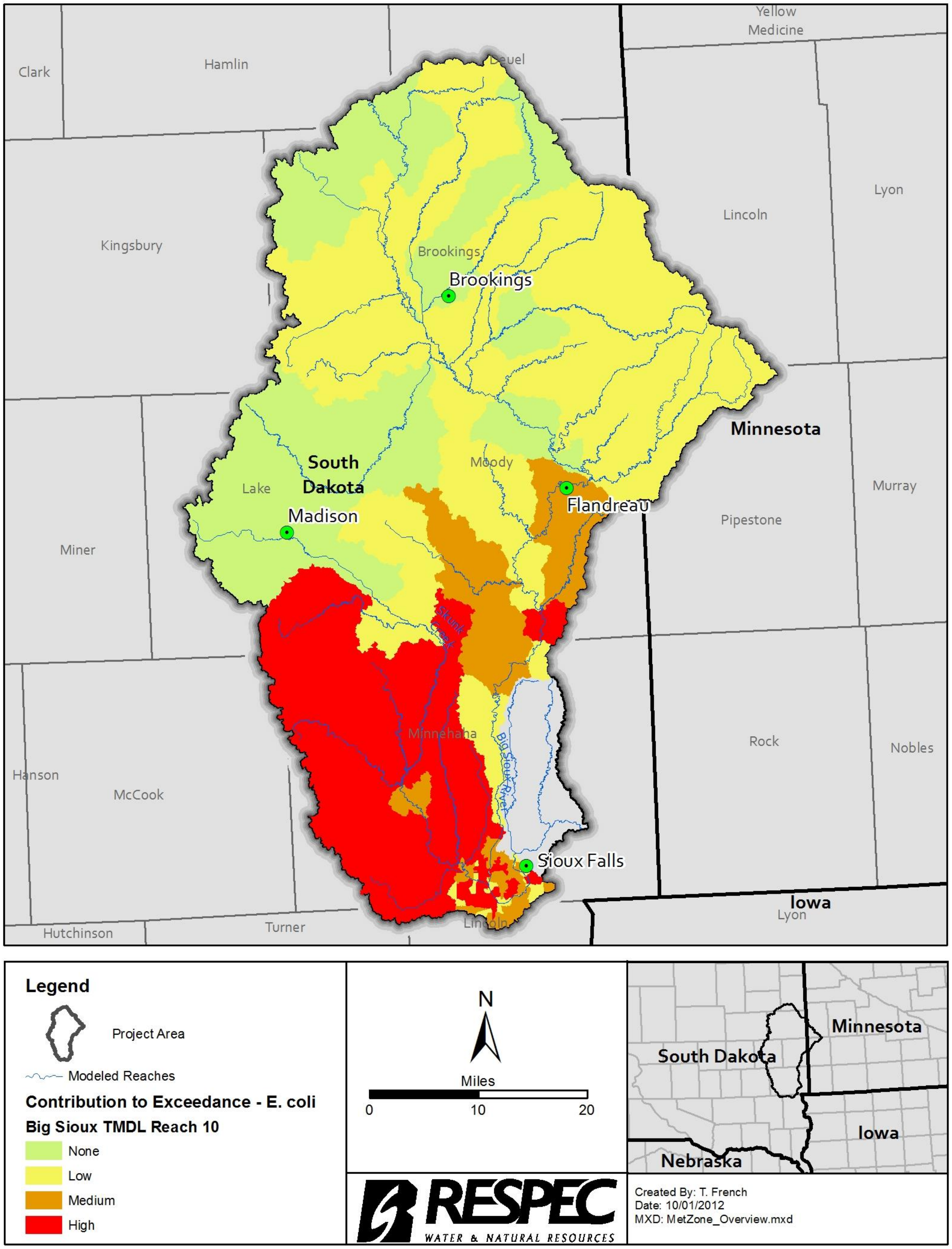

Figure A-2. Priority Areas Representing Contributions to the Number of *E. coli* Exceedances in the Big Sioux River Reach 10.

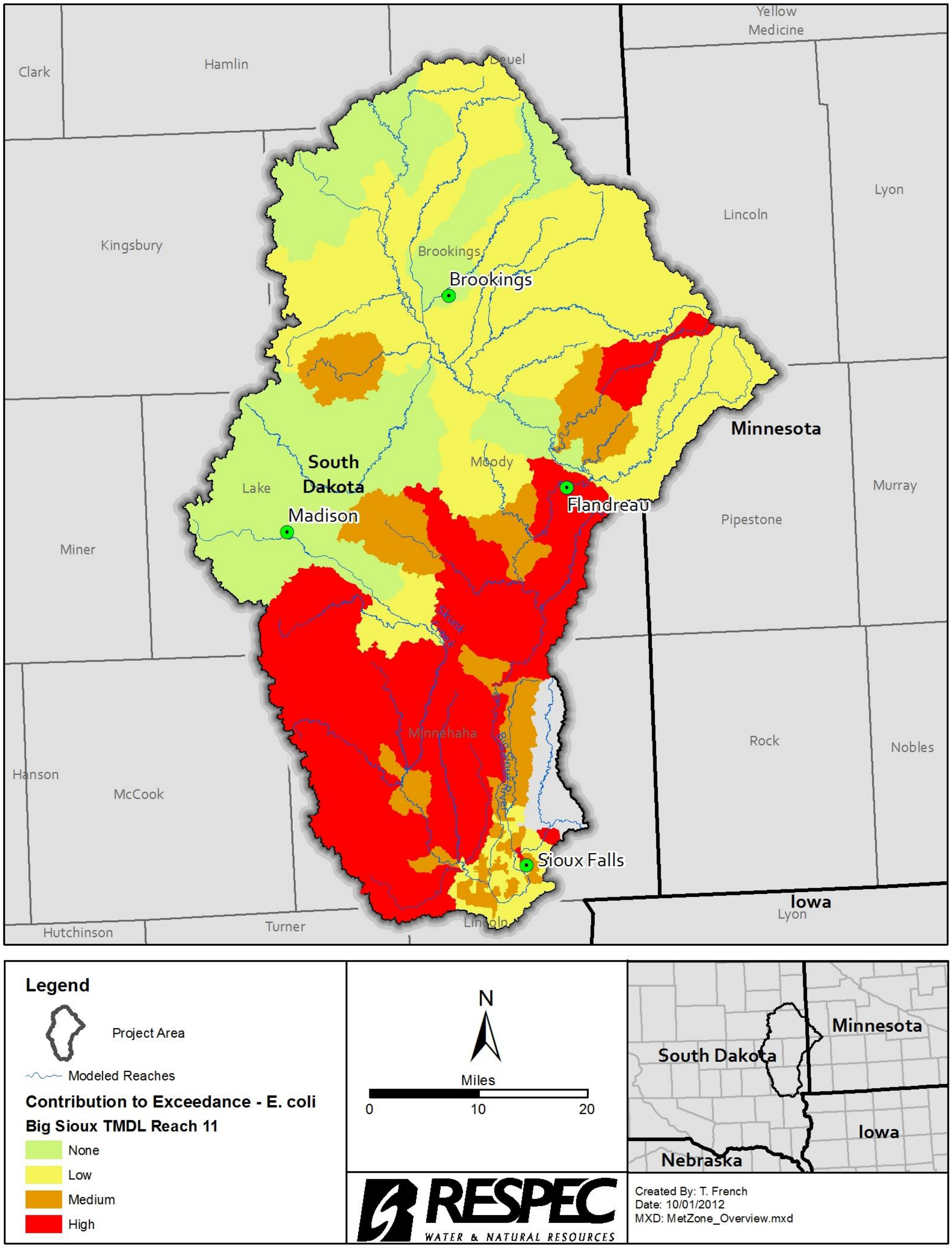

Figure A-3. Priority Areas Representing Contributions to the Number of *E. coli* Exceedances in the Big Sioux River Reach 11.

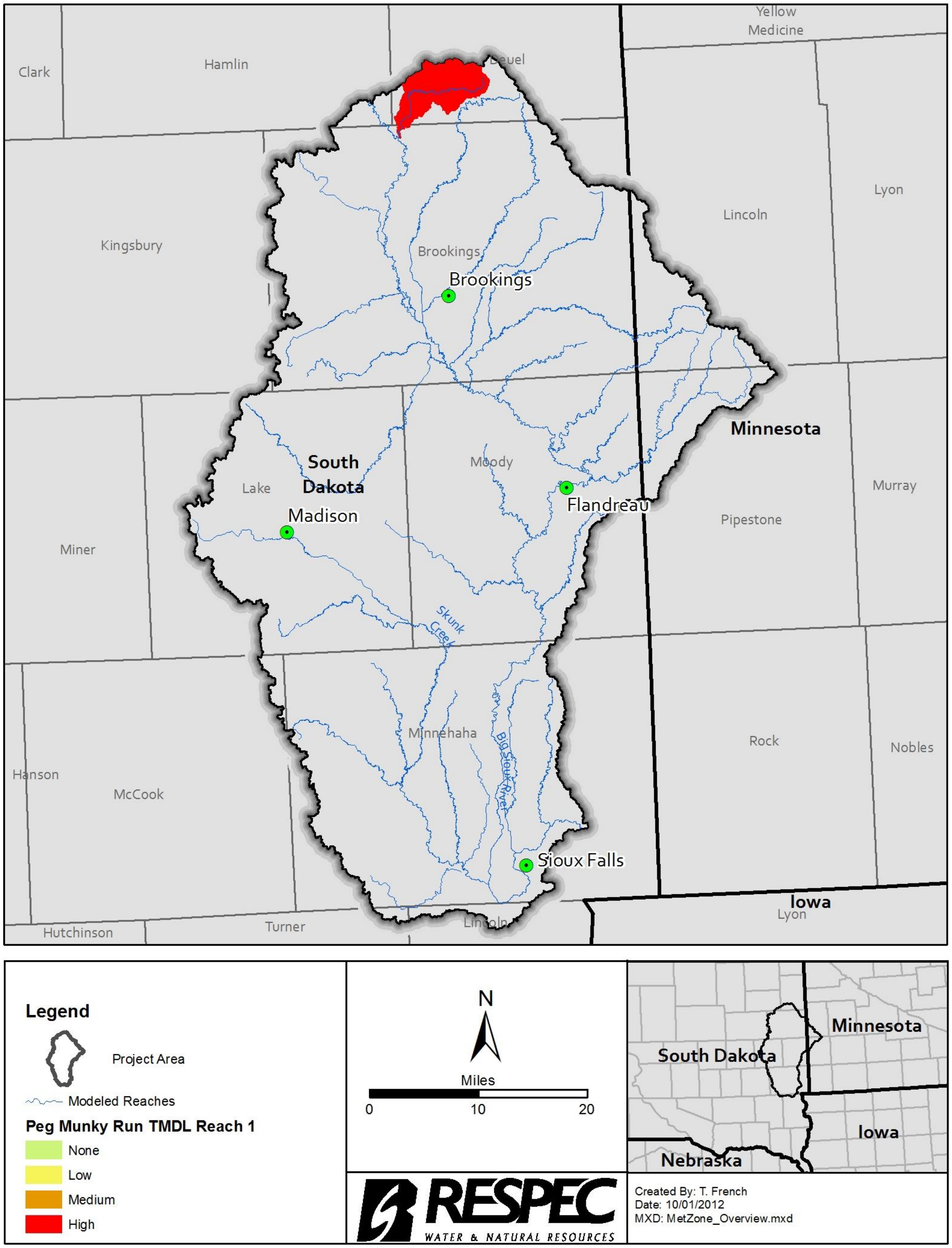

Figure A-4. Priority Areas Representing Contributions to the Number of *E. coli* Exceedances in Peg Munky Run Creek.

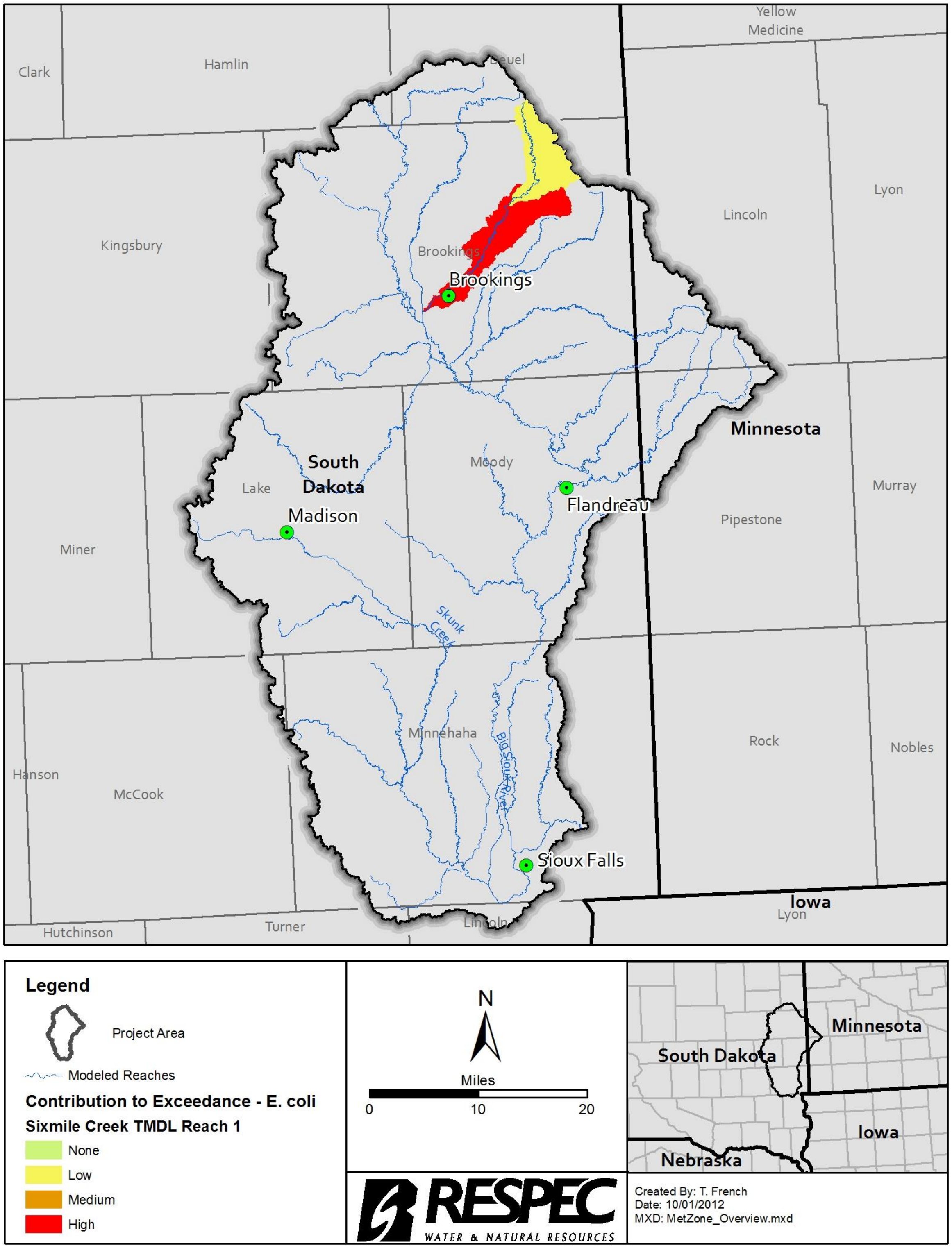

Figure A-5. Priority Areas Representing Contributions to the Number of *E. coli* Exceedances in Sixmile Creek.

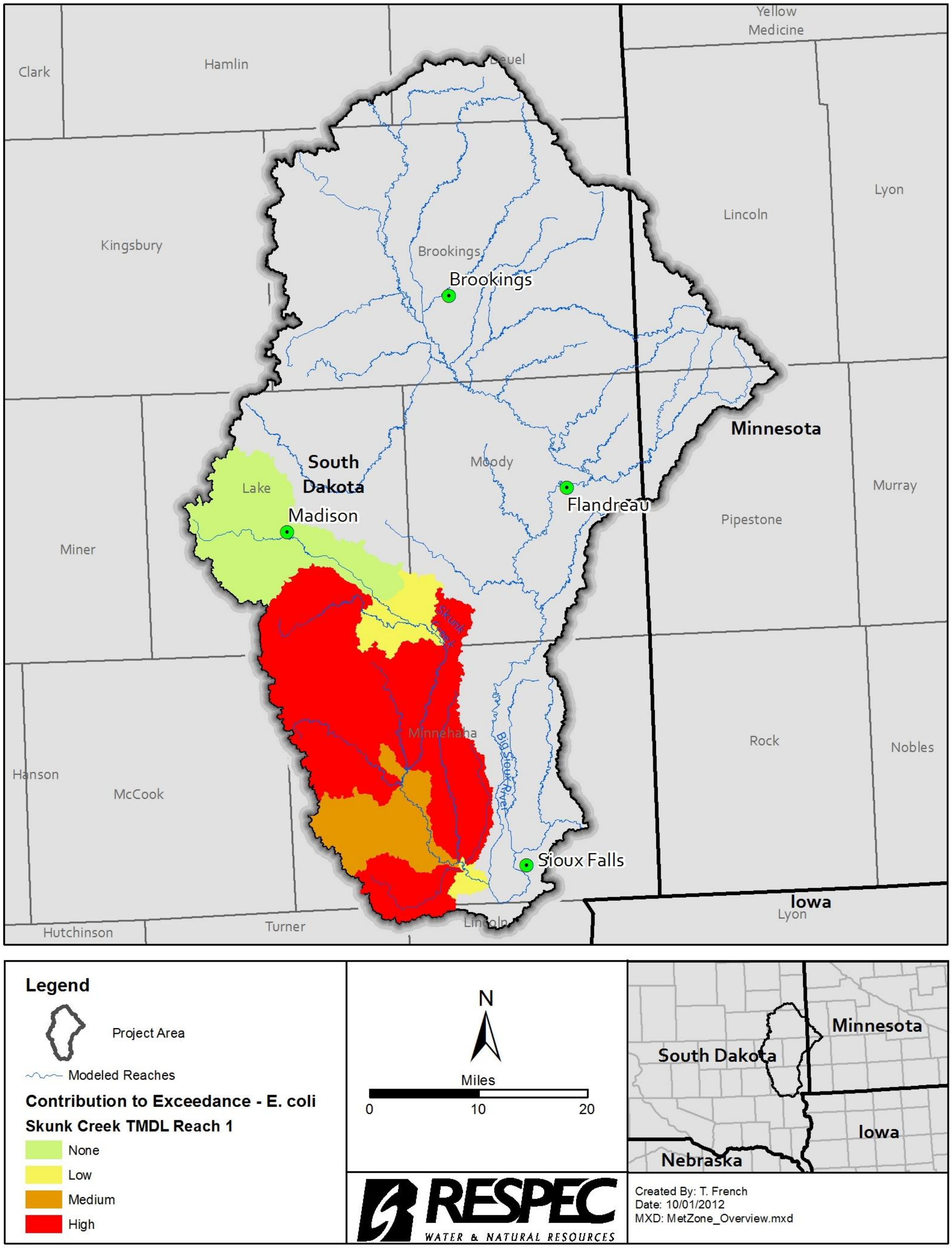

Figure A-6. Priority Areas Representing Contributions to the Number of *E. coli* Exceedances in Skunk Creek.

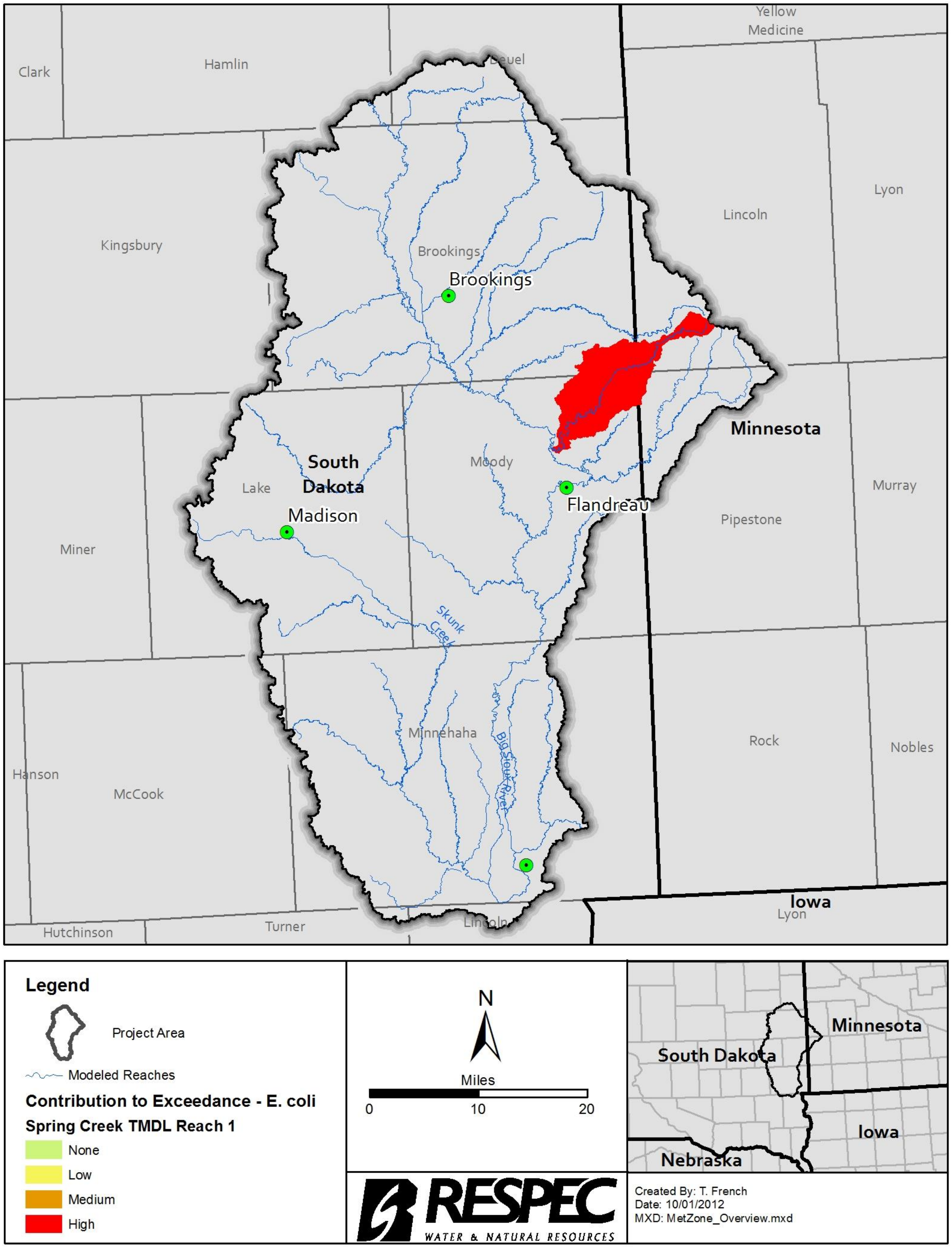

Figure A-7. Priority Areas Representing Contributions to the Number of *E. coli* Exceedances in Spring Creek.