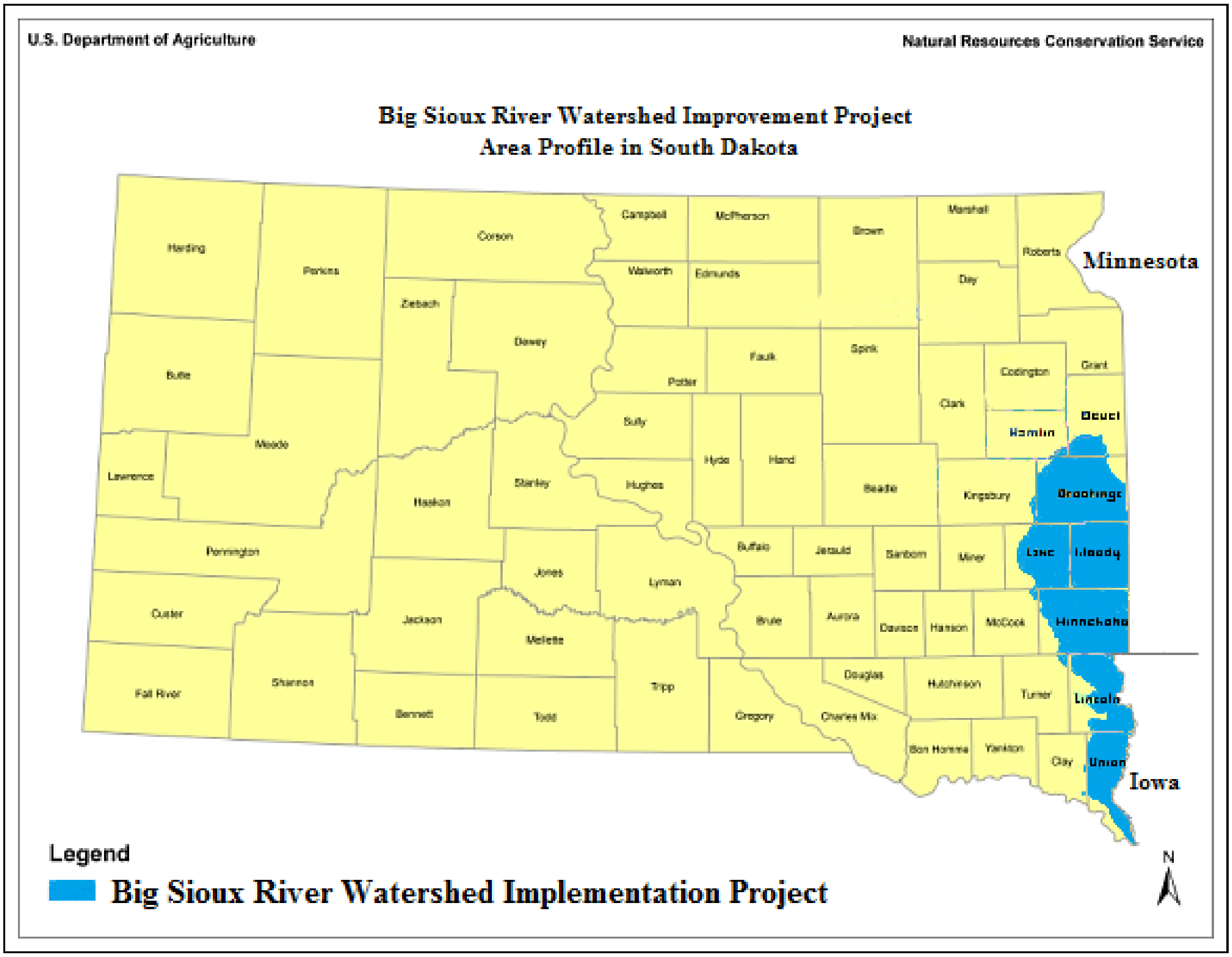

BIG SIOUX RIVER WATERSHED STRATEGIC PLAN

In Cooperation With:
South Dakota Conservation Districts
South Dakota Association of Conservation Districts
South Dakota Department of Environment and Natural Resources
USDA Natural Resources Conservation Service

Date: June 2016

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ABBREVIATIONS

AFOs	Animal Feeding Operations
AGNPS	Agricultural Non Point Source Computer Model
AWMS	Animal Waste Management System
AWSF	Animal Waste Storage Facility
BSLC	Bacteria Source Load Calculator
BMP	Best Management Practice
BOD	Biological Oxygen Demand
BSRWIP	Big Sioux River Watershed Implementation Project
CBSRWIP	Central Big Sioux River Watershed Implementation Project
CD	Conservation District
CFS	Cubic Feet per Second
CFU	Colony Forming Units
CEAP	Conservation Effects Assessment Project by NRCS 2012
CRA	Conservation Resource Area
CRP	Conservation Reserve Program
DO	Dissolved Oxygen
E. coli	*Escherichia coli* bacteria
EDWDD	East Dakota Water Development District
EQIP	Environmental Quality Incentive Program
ET	Evapo-Transpiration
^{o}F	Degrees Fahrenheit
FSA	Farm Service Agency - USDA
FLUX	Computer model designed for estimating the loadings of suspended solids transported at a point in a stream during a given period of time.
GRTS	Grant Reporting and Tracking System
HSPF	Hydrologic Simulation Program-Fortran
HU	Hydrological Unit
IR	Immersion Recreation
LBSRWIP	Lower Big Sioux River Watershed Implementation Project
LCRWS	Lewis & Clark Rural Water System
LCR	Limited Contact Recreation
MCD	Minnehaha County Conservation District
MCCD	Moody County Conservation District
mgp	Million Gallons per Day
Mg/L	Milligrams per Liter

MIP	Model Implementation Project
MLRA	Major Land Resource Area
MOS	Margin of Safety
msl	Mean Sea Level
NASS	National Agricultural Statistics Service
NCBSR	North-Central Big Sioux River
NMP	Nutrient Management Plan
NPDES	National Pollution Discharge Elimination System
NPPR	Northern Prairie Pothole Region
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service - USDA
MS4	Municipal Storm Sewers Discharge Permit
NWQI	National Water Quality Initiative
PIP	Project Implementation Plan
RAM	Riparian Area Management
RCPP	Regional Conservation Partnership Program
RCWP	Rural Clean Water Program
RWS	Rural Water Systems
SD	South Dakota
SDACD	South Dakota Association of Conservation Districts
SDDENR	South Dakota Department of Environment and Natural Resources
SDDENR-IR	SDDENR-Integrated Report on Surface Water Quality
SDGFP	South Dakota Department of Game Fish & Parks
SDGS	South Dakota Geological Survey
SDSU	South Dakota State University
SPF	Strategic Prevention Framework
SRAM	Seasonal Riparian Area Management
STEPL	Spreadsheet Tool for Estimating Pollutant Load
TMDL	Total Maximum Daily Load
TSI	Trophic State Index
TSS	Total Suspended Solids
UBSRWIP	Upper Big Sioux River Watershed Project
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
WLA	Waste Load Allocations
WIP	Watershed Implementation Project
WQ	Water Quality
WRI	Wetland Resource Institute
WWTP	Waste Water Treatment Plant

Executive Summary

The Big Sioux River drains approximately 8,282 square miles in eastern South Dakota, southwestern Minnesota, and northwestern Iowa. The river begins near the town of Summit in northeastern South Dakota and flows south for 420 miles to its confluence with the Missouri River near Sioux City, Iowa. The river drops in elevation from 1,826 feet at Summit to 1,085 feet above sea level at the Missouri River. The river is the second largest river basin in South Dakota and provides the drainage system for the land formation call the Coteau des Prairies, or more commonly, the Prairie Coteau. The Big Sioux River is the heaviest populated river basin in the state and provides drinking water from its surface water and aquifer to approximately 40% of the population of South Dakota. The river has an average annual discharge of 246 cubic feet per second and on average exceeds bank full stage every 2-3 years. However, periods of low flow are common in the late summer to winter seasons, with a low flow of 0.1 cubic feet per second having been recorded. During these low flow drought periods, the river does not provide an adequate sustainable source of surface water for the residents of Sioux Falls.

As the population of Sioux Falls increased from 33,362 in 1930 to its present population of over 170,000 people, the demands on the river's surface water and aquifer resources has increased. The first of large diameter wells were constructed by the City of Sioux Falls in 1906 and, as the city grew, a total of nine public wells had been constructed by 1934. To meet the present day population needs, ground water is pumped from fifty-five wells and additional surface water can be obtained from one pumping station on the Big Sioux River. The dependency on ground water increased, while the surface water decreased as the population grew. Surface water use has been as high as 71% since 1997, but has decreased since that date to an average of 33%. No surface water was used in 2014 and 2015, as Sioux Falls began obtaining water from the Lewis & Clark Regional Water System in 2012.

Concerns over water quantity were initiated in 1947 when state geologist, E.P. Rothrock, began studying the Big Sioux River water flows and the Big Sioux River aquifer. Because of the aquifer's consistency in providing water, the unconfined, one thousand square mile aquifer became a water source for the communities along the Big Sioux River as the water flowed southward. Recharge of the aquifer from the Big Sioux River provided about 75% of the pumping needs while the surrounding river valleys only provided 25% of the pumping needs at that time. Thus the importance of the Big Sioux River in its recharge of the aquifer was made apparent. The cities of Watertown, Brookings, Flandreau, Sioux Falls, Canton, and the six rural water systems of Brookings-Deuel, King-Brook, Big Sioux, Minnehaha, South Lincoln, and Clay all pump water from the Big Sioux Aquifer; providing water to approximately 300,000 South Dakota residents.

Water quality became of concern in 1973 when the U.S. Environmental Protection Agency completed water quality investigations of the Big Sioux River near Sioux Falls. The report identified low oxygen levels, excessive concentrations of NH3-N, and fecal bacteria contamination of the Big Sioux River downstream of Sioux Falls. Water quality of the Big Sioux River watershed lakes also became a concern for lake users and residents along the lakes. This was especially a concern for Lake Kampeska, which also served as a water source for the City of Watertown. Watershed studies and assessments were initiated in the 1980s within the Big Sioux River watershed as: the Lake Kampeska Watershed project, which developed into the Upper Big Sioux River Watershed Project; the North-Central Big Sioux River Watershed Project; the Central Big Sioux River Watershed Project; and the Lower Big Sioux River Watershed Project. These watershed projects have now been combined into the current Big Sioux River Watershed Improvement Project, for which this Strategic Plan was written, and the Upper Big Sioux River Watershed Project. Specific lake watershed improvement projects were completed on the Lake Herman, Brant Lake, Lake Madison, Lake Campbell, Oakwood Lakes, and Wall Lake.

The *2014 South Dakota-DENR Integrated Report for Surface Water Quality Assessment* for water bodies in the BSRWIP area identified Chlorophyll-*a*, *Escherichia coli*, Fecal Coliform Bacteria, Total Suspended Solids, and Mercury as impairments listed within the watershed area. Water bodies that did not meet the 303(d) criteria for all or some of all their designated beneficial uses, per the 2014 SDDENR-IR, were Lake Alvin; East Oakwood Lake; Lake Herman; North Island Lake; Lake Madison; Twin lakes/W. Hwy #81; Twin Lakes/Minnehaha County; West Oakwood Lake; Beaver Creek; Brule Creek; East Brule Creek; Flandreau Creek; Pipestone Creek; Six Mile Creek; Skunk Creek; Split Rock Creek; Spring Creek; Union Creek; and the following segments of the Big Sioux River: R9-R10, Volga to Brookings/Moody County line; and R12 to R20, Section 2-T104N-R49W to confluence with the Missouri River.

No significant point discharges of pollutants into the water bodies were identified. The TMDL studies found that municipalities had either zero discharge NPDES permits, discharges that were NPDES permitted and controlled, or the discharges were so minor and/or infrequent as to be negligible, and the remaining human produced fecals not delivered to a municipal treatment facility had a minimal impact on total loading**.** However, lakes with numerous residences and without a centralized sanitary sewer system were recommended to form sanitary sewer districts and install centralized sanitary sewer systems.

The nonpoint sources of pollutants for these water bodies listed as 303(d) impaired were also investigated and the following recommendation made: 1) reduce the use of lawn fertilizers around the lakes; 2) construct animal waste management systems for the identified animal feeding operations; 3) implement crop tillage systems, crop rotations, and cropland Best Management Practices in identified critical cropland fields; 4) livestock access to streams should be reduced, and livestock should be provided sources of water away from streams; 5) unstable stream banks should be protected by enhancing the riparian vegetation that provides erosion control and filters runoff of pollutants into the stream; 6) Filter strips should be installed along streams bordering cropland and pastureland; 7) prescribed grazing systems established on riparian pastures; and 8) a terrace maintenance program should be implemented to repair or replace failing terracing systems.

Water bodies that have met the 303(d) criteria of all their designated beneficial uses, per SDDENR IR 2014, were Brant Lake, Lake Campbell; Covell Lake, Goldsmith Lake, Wall Lake, Big Ditch Creek, and the following segments of the Big Sioux River: R8, Stray Horse Creek to Volga and R11, Brookings County line to section 22-T104N-R52W. The water bodies of: Lake Sinai, Unnamed tributary R4, Jack Moore Creek, and North Deer Creek were reported in the 2014 SDDENR IR to have insufficient water quality data to ascertain whether they met the supporting criteria of all the designated beneficial uses.

The Moody Conservation District is the current BSRWIP project sponsor and the lead agency responsible for the completion of the goals, objectives, and tasks. The Moody Conservation District has entered into a cooperative agreement with the Brookings, Lake, Moody, Minnehaha, Lincoln, and Clay Conservation Districts, and the Cities of Brookings and Sioux Falls to help advise the project sponsor, develop priorities, practice manuals, work plans, and strategies for the BSRWIP. The goal of this strategic plan is to identify the pollutant sources for the 303(d) listed water bodies; to find suitable Best Management Practices that, when implemented, will result in the delisting of the 303(d) water bodies; and to identify practice and administrative costs and goals over a five year period. The Best Management Practices in this Strategic Plan have been selected based on the identified 303(d) pollutants and their success at achieving load reductions. The implementation of these BMPs should achieve delisting of the identified water bodies by eliminating or reducing the nutrient, sediment, and fecal coliform bacteria loadings in the BSRWIP area.

1. INTRODUCTION

1.1 Project Background and Scope

The Big Sioux River watershed drains approximately 5,282 square miles in eastern South Dakota and an additional 3,000 square miles in southwestern Minnesota and northwestern Iowa. See Figure 1-1 for the BSRWIP watershed boundary. The river's headwaters start near Summit, South Dakota and flow southward for approximately 420 miles to its confluence with the Missouri River near Sioux City, Iowa. Its elevation above mean sea level is 1,826 feet near Summit and 1,085 feet at its mouth near Sioux City. The river is the second largest of the three major river basins in eastern South Dakota that drain into the Missouri River. The Big Sioux River watershed is comprised of three Hydrological Units (HU): the Upper Big Sioux HU 10170201, the Middle Big Sioux HU 10170202, and the Lower Big Sioux HU 10170203. See Figure 1-2 for Big Sioux River HU boundaries in South Dakota.

The river provides the drainage system for the unique land formation called the Coteau des Prairies or Hill of the Prairies. This north-pointing, flatiron-shaped Coteau des Prairie is the most conspicuous land form of the Mid-continental United States; some 200 miles long and 100 miles wide, rising some 300-700 feet above the prairie. Elevations in feet above mean sea level (msl) range from 2,000 feet msl on the north to about 1,600 feet msl on the south. Approximately 12,000 years ago during the Wisconsin glaciation, two streams of glacial ice, the James Lobe on the west and the Des Moines Lobe on the east, formed this arc-moraine as they parted at the stream divide and moved southward. They further deepened the flanking lowlands forming a plateau. As the glacier ice stagnated, fragmented, and melted, it left behind large blocks of ice buried in the melt water outwash. The melting of these ice blocks left thousands of depressions as wetlands and lakes in the topography of the Coteau des Prairie and the watershed of the Big Sioux River.

The Big Sioux River basin's primary source of income is agriculture. It is also the heaviest populated river basin in the state. The Big Sioux River controls both surface and shallow groundwater movement in the numerous aquifers and provided drinking water to one-third the population of South Dakota in 2005 (Watertown, UBSRWS, 2005). Population increases in the BSRWIP since 2005 have now increased this usage to approximately 40% of the state's population. The Sioux City Journal (May 7, 2012) reported that the advocacy group, Environment America, ranked the Big Sioux River as the nation's 13th dirtiest river. To address the pollution in the Big Sioux River, the SDDENR originally divided the stream into four large assessment projects: the Upper Big Sioux, running from its source near Summit to Watertown; the North Central Big Sioux, near its confluence with Mud Creek to near Volga at the confluence of North Deer Creek; the Central Big Sioux, from Volga to State Highway 38 east of Sioux Falls; and the Lower Big Sioux, from Highway 38 to its mouth at the Missouri River. The BSRWIP includes all the 12 digit HUs from north of Brookings to the outlet of the Big Sioux River at the Missouri River. The twelve counties within the present BSRWIP boundary are Brookings, Deuel, Hamlin, Kingsbury, Lake, Lincoln, McCook, Minnehaha, Moody, Turner, Clay, and Union. The major tributaries to the lower Big Sioux River in South Dakota are Peg Munky Run, North Deer Creek, Skunk Creek, Beaver Creek, and Brule Creek. However, outside the BSRWIP boundary area the tributaries of Beaver Creek, Pipestone Creek, Split Rock Creek, Rock River, Six Mile Creek, Indian Creek, and Broken Kettle Creek contribute to the lower Big Sioux River from the states of Iowa and Minnesota. There are one hundred 12 digit HUCs within the BSRWIP with a total of 2,107,000 acres or 3,292 square miles.

1.2 Climate

The climate of the BSRWIP area is classified as sub-humid continental. The highest mean temperature in the northern part for the city of Brookings in July is 81.6 degrees Fahrenheit (^{o}F), while the lowest mean temperature in January is 2.9 ^{o}F; the average mean temperature is 43.1 ^{o}F. The average high temperature at the south end for Sioux City, Iowa, in July is 85 ^{o}F, while the average low in January is 10 ^{o}F; the average temperature is 48.5 ^{o}F. The annual precipitation in Brookings and Sioux City is 24.31 and 27.73 inches, respectively. The weather data references are from the South Dakota State University, South Dakota Climate and Weather, Normal Statistics 1981-2010 and U.S Climate Data. Climate conditions are relatively uniform throughout the watershed, which experiences all of the conditions of the temperate continental climate classification: pronounced seasonality with long, cold winters, hot summers, mid-latitude cyclonic storms, and variable precipitation. Strong surface winds patterns across the watershed persist principally blowing from the north and northwest during the colder part of the year.

1.3 Population

The population of South Dakota in 2010 was 814,180 (2010 U.S. Census). Although the BSRWIP area is largely rural in nature, 39.5% of the state’s population live in the BSRWIP area. The City of Sioux Falls has the largest population at 153,888 residents (2010 U.S. Census). The second largest city is Brookings with a population of 22,056 residents. There are approximately 46 incorporated and unincorporated cities and villages within the watershed. Table 1-1 lists the cities with populations over 1,000 and the counties’ populations in the watershed. A map of the cities and counties locations and watershed boundaries is shown in Figure 1-3.

Figure 1-1. BSRWIP Entire Watershed in Iowa, Minnesota, South Dakota

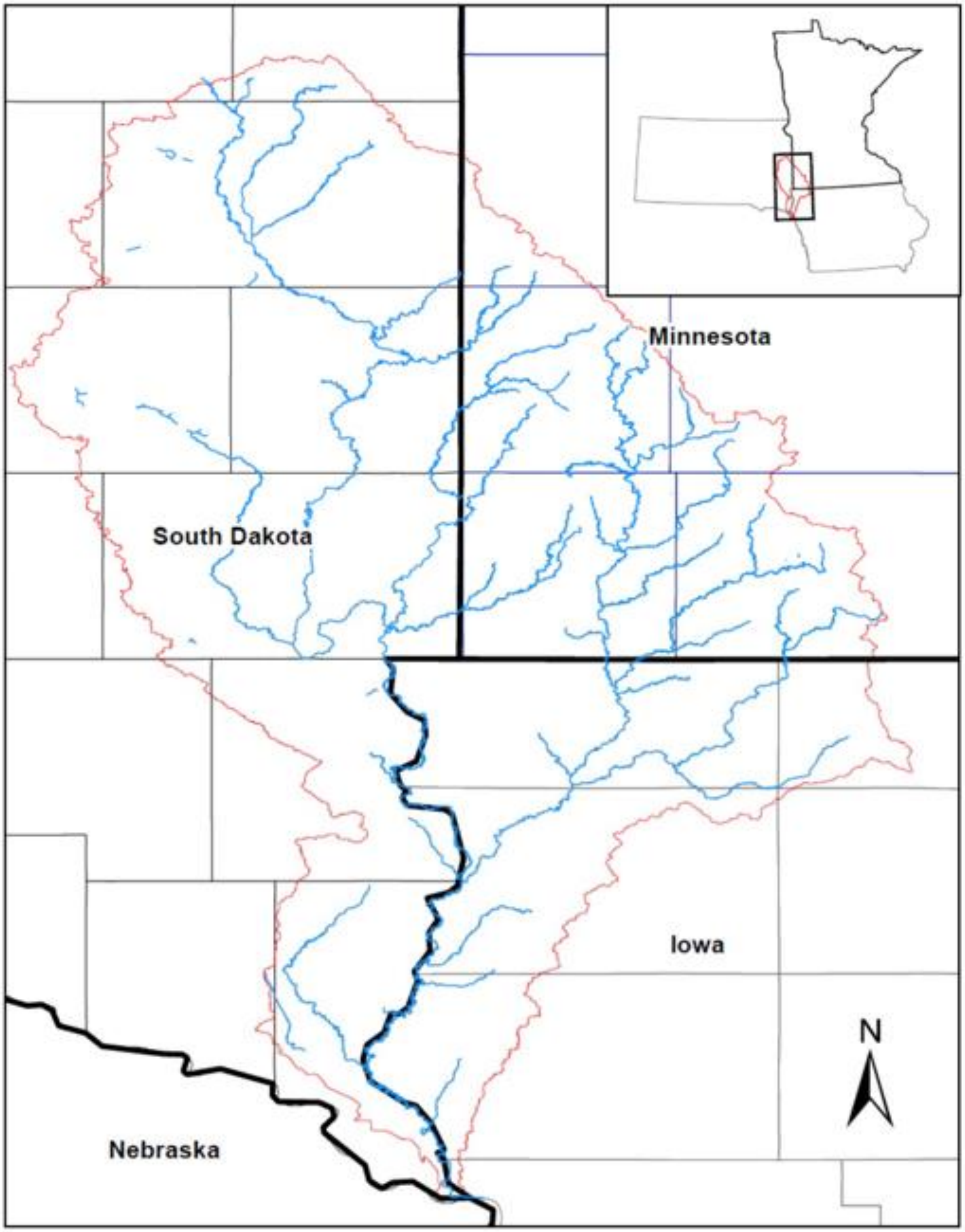


Figure 1-2. Big Sioux River HU Boundaries in South Dakota

Table 1-1: Population Statistics of the Big Sioux River WIP. US Census Bureau 2010 Census					
Cities with Populations Over 1,000				Total County Population	
City	County	Population		County	Population
Sioux Falls	Minnehaha	153,888		Minnehaha	169,468
Brookings	Brookings	22,056		Lincoln	44,828
Brandon	Minnehaha	8,785		Brookings	31,965
Madison	Lake	6,474		Union	14,399
Harrisburg	Lincoln	4,084		Clay	13,864
Tea	Lincoln	3,806		Lake	11,200
Dell Rapids	Minnehaha	3,633		Turner	8,347
Canton	Lincoln	3,057		Moody	6,486
Hartford	Minnehaha	2,534		Hamlin	5,903
North Sioux City	Union	2,530		McCook	5,618
Flandreau	Moody	2,341		Kingsbury	5,148
Beresford	Minnehaha	2,005		Deuel	4,364
Elk Point	Union	1,963			
Volga	Brookings	1,768			
Crooks	Minnehaha	1,269			
Garretson	Minnehaha	1,166			
Baltic	Minnehaha	1,089		Total	321,590

1.4 Geography

The majority of the BSRWIP watershed is located in the Level III Northern Glaciated Plains with a small portion at the southeastern end of the watershed in the Western Corn Belt Plains ecoregion (NRCS 2006). The Northern Glaciated Plains ecoregion was historically dominated by transitional grassland containing both tall grass and short grass prairie communities. Drift plains, large glacial lake basins, and shallow river valleys, with level to undulating surfaces and deep soils, provide the basis for a crop agriculture. The young geologic age has left an immature drainage system leaving the ecoregion dotted with substantial numbers of wetland depressions, ranging in size and permanence. This moderately high concentration of semi-permanent and seasonal wetlands is commonly referred to as Prairie Potholes. The poorly drained soils developed on glacial till and loess east of the Missouri River tend to be clay rich with limited infiltration potential. More than 90 percent of runoff trapped in prairie potholes is typically lost to evapotranspiration (ET). Annual potential ET exceeds precipitation in most years, which explains why most prairie wetlands undergo a wet-dry cycle each year. The land surface is a nearly level to gently sloping, dissected glaciated plain. There are also sub-regional concentrations of glacial formed permanent lakes. Cropland, grassland, wetland, and surface water form the general mosaic of land covers within the Northern Glaciated Plains ecoregion. There are also sub-regional concentrations of glacial formed permanent lakes. Cropland,

Figure 1-3: Cities and Towns Over Population of 1,000 in Big Sioux River WIP

grassland, wetland, and surface water form the general mosaic of land covers within the Northern Glaciated Plains ecoregion.

The Western Corn Belt Plains ecoregion was once a tall grass prairie covered with little bluestem, big bluestem, Indiangrass, switchgrass, numerous forbs, and with small areas of bur oak and oak-hickory woodlands; the region has nearly all been converted to agricultural land. There are intermittent and perennial streams, many of which have been channelized, and a few natural lakes. The topography consists of nearly level to gently rolling glaciated till plains and hilly loess plains. Thick loess and glacial till cover the Mesozoic and Paleozoic shale, sandstone, and limestone. Mollisol soils are dominant with mesic soil temperatures and udic soil moisture. Over 75 percent of the Western Corn Belt Plains is now used for cropland agriculture, and much of the remainder is in forage for livestock.

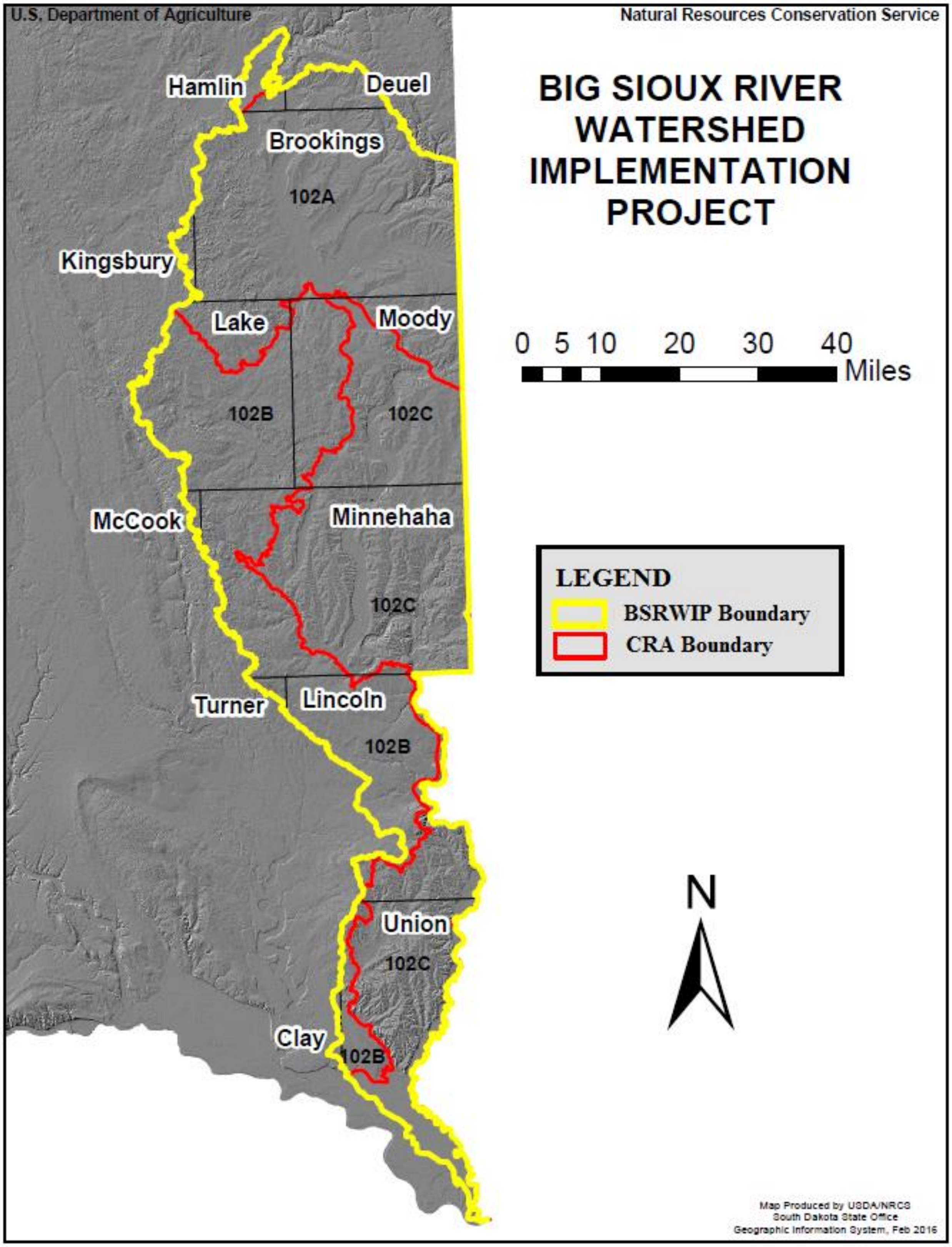
The BSRWIP lies in the Central Feed Grains and Livestock Region, Land Resource Region M. The Major Land Resource Areas (MLRA) are part of a USDA classification system that defines land as a resource for farming, ranching, forestry, engineering, and other uses (NRCS 2006). The MLRA is a broad-based geographic area characterized by a uniform pattern of soils, elevation, topography, climate, water resources, potential natural vegetation, and land use. The large MRLAs are subdivided into smaller more homogeneous resource areas referred to a Common Resource Areas (CRA). The BSRWIP area is within three CRAs; the Rolling Till Prairie 102A, the Till Plains 102B, and the Loess Uplands 102C. See Figure 1-4 Common Resources Areas.

The dominant landforms in this MLRA are stagnation moraines, end moraines, glacial outwash plains, terraces, and flood plains. The MLRA is dominated by till covered moraines. The stagnation moraines are gently undulating to steep and have many depressions and poorly defined drainages. The steepest slopes are on escarpments adjacent to the water courses. Small outwash areas are adjacent to the watercourses. Cretaceous Pierre Shale underlies the till in most of the area.

1.5 Soils

The dominant soil order in this MLRA is Mollisols (NRCS 2006). The soils in CRA 102A dominantly have a frigid soil temperature regime, an aquic or udic soil moisture regime, and mixed mineralogy. They generally are very deep, well drained to very poorly drained, and loamy. Hapludolls formed in loamy till (Barnes, Forman, and Hokans series), in loess or silty drift over till (Kranzburg, Poinsett, and Waubay series), in eolian deposits (Egeland and Embden series), and in glacial outwash (Arvilla, Fordville, and Renshaw series) on till plains and moraines. Calciudolls (Buse and Balaton series) formed in loamy till on rises and ridges.

Figure 1-4: Common Resource Areas of the BSRWIP



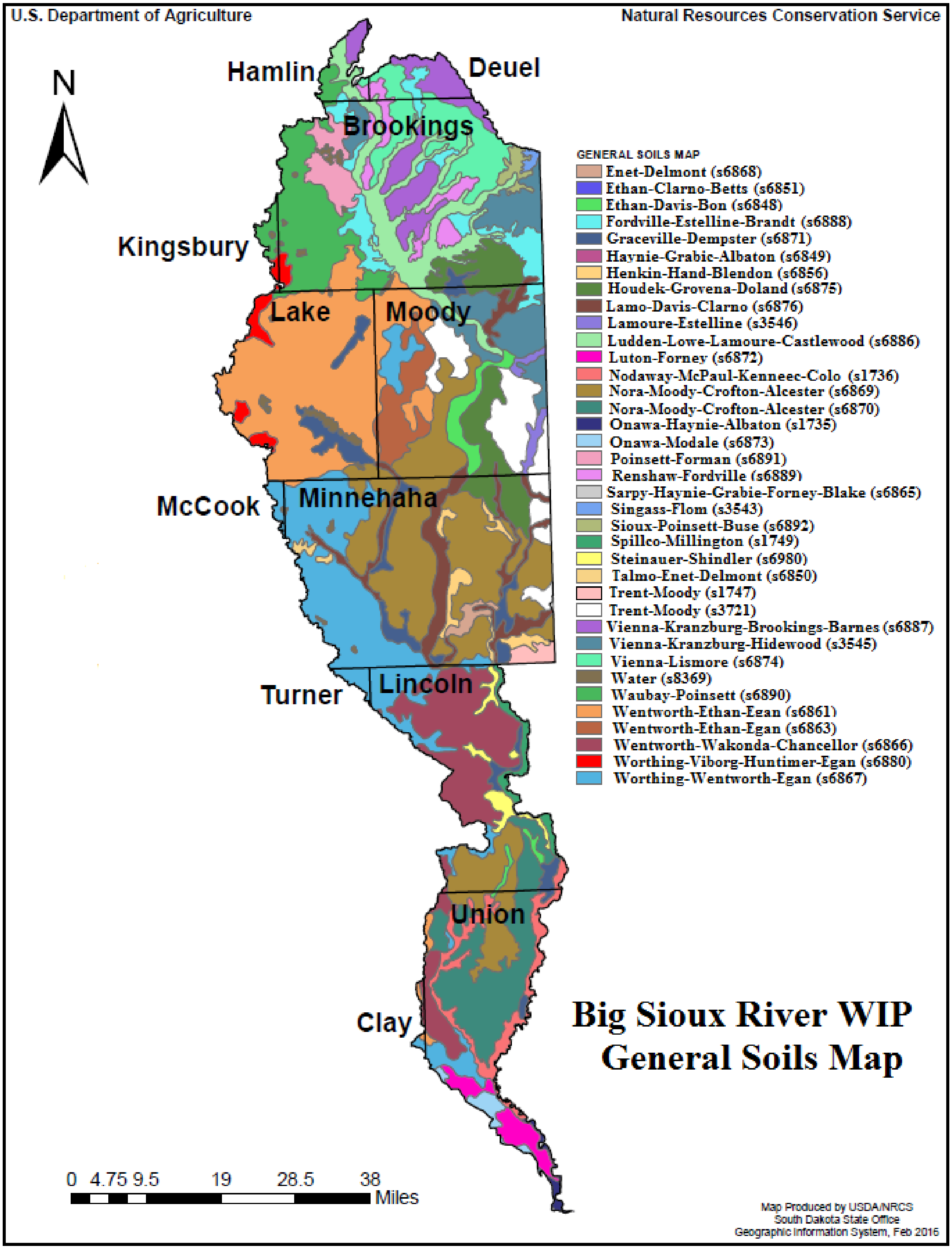
Argiaquolls (Parnell and Badger series) formed in loamy till and colluvial and alluvial sediment in swales and depressions. Argialbolls (Tonka series) and Endoaquolls formed in colluvial and alluvial sediment in depression (Quan series) and in alluvial sediment on flood plains (Lamoure and Rauville series). Calciaquolls (Marysland and Moritz series) formed in alluvial sediment on flood plains.

The soils in CRA 102B dominantly have a mesic soil temperature regime, an ustic soil moisture regime that borders on udic, and mixed mineralogy. They generally are very deep, well drained to poorly drained, and clayey or loamy. Calciustolls (Ethan series) and Calciustepts (Betts series) formed in till on the steeper slopes on moraines. Calciaquolls formed in silty drift (Wakonda series) and glacial till (Davison series) in areas characterized by upward water movement. Haplustolls formed in lacustrine sediments (Huntimer series), silty drift (Wentworth and Trent series), silty drift over glacial till (Egan and Viborg series), or glacial till (Clarno series). They also formed in glaciofluvial deposits on outwash plains (Dempster, Graceville, Delmont, and Enet series). Argiaquolls (Chancellor series) formed in alluvium in wet drainageways. The soils that formed in alluvium in depressions include Argialbolls (Tetonka series), Argiaquolls (Worthing series), and Endoaquolls (Baltic series). Soils that formed in stream alluvium include Haplustolls (Bon, Davis, and Roxbury series), Endoaquolls (Lamo, Clamo, and Salmo series), Calciaquolls (Arlo and Storla series), and Fluvaquents (Chaska series).

The soils in CRA 102C dominantly have a mesic soil temperature regime, an ustic soil moisture regime, and mixed or smetitic mineralogy. They are shallow to very deep, moderately well drained to somewhat excessively drained, and loamy or clayey. Haplustolls formed in loess on uplands (Belfore, Moody, and Nora series), in loess over outwash on uplands (Dempster and Graceville series), in colluvium and alluvium on footslopes (Alcester series), and in eolian deposits on uplands (Flandreau, Grovena, and Thurman series). Endoaquolls (Colo, Gibbon, and Zook series) formed in alluvium on flood plains. Ustorthents (Crofton series) formed in loess in steep areas on uplands. Fluvaquents (Albaton series) and Udifluvents (Blake and Grable series) formed in alluvium on the Missouri River flood plain.

The predominant soil associations in the watershed area are shown on Figure 1-5. Official Soil Series Descriptions or a Series Extent Map can be retrieved using the following link: https://soilseries.sc.egov.usda.gov/osdname.asp**.** Soil survey data can be obtained by visiting the online Web Soil Survey at http://websoilsurvey.nrcs.usda.gov for official and current USDA soil information as viewable maps and tables.

Figure 1-5: General Soils Map of the BSRWIP



1.6 Land Use

The BSRWIP area lies in the highly productive glaciated soils region in east central South Dakota. The land use of the watershed is estimated at about 71% cropland (USDA-NASS 2012) with the production of row crops and hay land as the primary cropland uses. The principal crops are corn, soybeans, alfalfa, spring wheat, and oats. Grazing lands used for livestock operations make up approximately 11% of the acres. See Table 1-2 for the agricultural data of the counties containing the majority of the land areas within the BSRWIP watershed.

Cropland and Rangeland productivity maps are presented in Figures 1-6 and 1-7, respectively. Wooded areas generally occur as narrow bands along streams and rivers or as shelterbelts around farmsteads. Recreational hunting and fishing are important land uses around the many natural lakes within the watershed. The major resource concerns are water erosion, soil wetness, wind erosion on lighter textured soils, maintenance of the content of organic matter and productivity of the soils, irrigation, and management of soil moisture. Conservation practices on cropland generally include systems of crop residue management, especially no-till or other conservation tillage systems that conserve moisture and contribute to soil quality. Other conservation practices include terraces, grassed waterways, and cropland nutrient management. Preserving the quality of surface water and ground water is an additional concern in this region.

1.7 Water Resources

The total daily gallons of freshwater withdrawal in the Rolling Till Prairie (102A) CRA averages about 145 million gallons, of which about 39% is from surface water sources and 61% from ground water sources; the Till Prairie (102B) CRA averages about 61 million gallons, of which about 22% is from surface water sources and 78% is from ground water sources; and the Loess Upland (102C) CRA that averages about 61 million gallons per day, of which about 32% is from surface water sources and 68% is from ground water sources (USDA 2006). Precipitation is the principal source of moisture for crops, although in some years it is inadequate for maximum crop production. Shallow wells in glacial outwash deposits, primarily sand and gravel, provide water for livestock, domestic use, and irrigation in this area. The water is hard but is of good quality with the median level of total dissolved solids at about 350 parts per million (ppm) in the Rolling Till Prairie and Loess Upland CRAs. Water in the Till Prairie CRA averages about 670 ppm total dissolve solids, which exceeds the national secondary standard for drinking water.

Table 1-2: Agricultural Data for Counties in BSWIP Watershed. NASS 2012

Agricultural Data for Six Counties in BSRWIP							
	Brookings	Lake	Lincoln	Minnehaha	Moody	Union	Data Year
Land Area Acres	508,490	360,491	370,009	517,873	332,611	294,659	2012
Number of Farms	1,023	502	899	1,157	513	527	2012
Total Cropland Acres	327,406	207,264	329,906	322,386	208,768	259,279	2012
Corn Acres	142,000	130,000	147,000	173,000	146,000	130,000	2014
Soybean Acres	125,000	110,000	128,000	139,000	92,000	105,000	2014
Small Grain Acres	6,100	2,300	800	0	0	0	2014
Hayland	21,000	10,100	6,900	18,600	9,720	10,650	2014
Pasture/Range Acres*	95,412	41,954	22,630	63,281	34,211	19,675	2012
Cattle	79,000	33,000	36,000	69,000	36,500	23,000	2012
Swine	46,580	30,880	35,377	55,741	18,181	20,291	2012
Sheep	11,251	2,150	4,719	2,728	1,095	896	2012
Data from SDDA 2015 Bulletin	*USDA-NASS-2012						

Ground water obtained from the Big Sioux and Skunk Creek aquifers and several other minor aquifers are the sources of most good quality potable water used in the BSRWIP. In some areas these aquifers can support the production of 1,000 gallons per minute capacity (Rockroth 1947). Water in these surficial aquifers is easily susceptible to contamination from barnyards, feedlots, dump grounds, septic disposal fields, and crop fertilizers because they are near the land surface and covered with permeable material. Six rural water systems (RWS) provide service to the counties within the project area: Brookings-Deuel, Kingbrook, Big Sioux, Minnehaha, South Lincoln, and Clay.

The Prairie Coteau is the next deep aquifer buried beneath the clay till. Its water is generally of poor quality, and many tested wells were high in nitrates. The most deeply buried aquifer in the glacial drift, lying directly on top of the bedrock surface, is the Altamont aquifer, which is saline, very hard, and high in sulfate. The deeper Dakota Formation is the only bedrock aquifer, but its water is high in boron, fluoride, sodium, sulfate, and, in some areas, chloride.

1.8 Big Sioux River Watershed Improvement Project History

One of the initial Big Sioux River water quality investigations was conducted by the Environmental Protection Agency (USEPA) in 1973. The report identified restricted oxygen levels, downstream of Sioux Falls from the waste water treatment plants activated sludge facilities, were organically overloaded. Despite abnormally high flows, NH3-N concentrations were found to be excessive because of oxygen-demanding carbonaceous and nitrogenous materials. The study also demonstrated that bacteria from the Sioux Falls waste water treatment plant (WWTP) was impairing water quality downstream.

Figure 1-6: Cropland Productivity in the BSRWIP Area

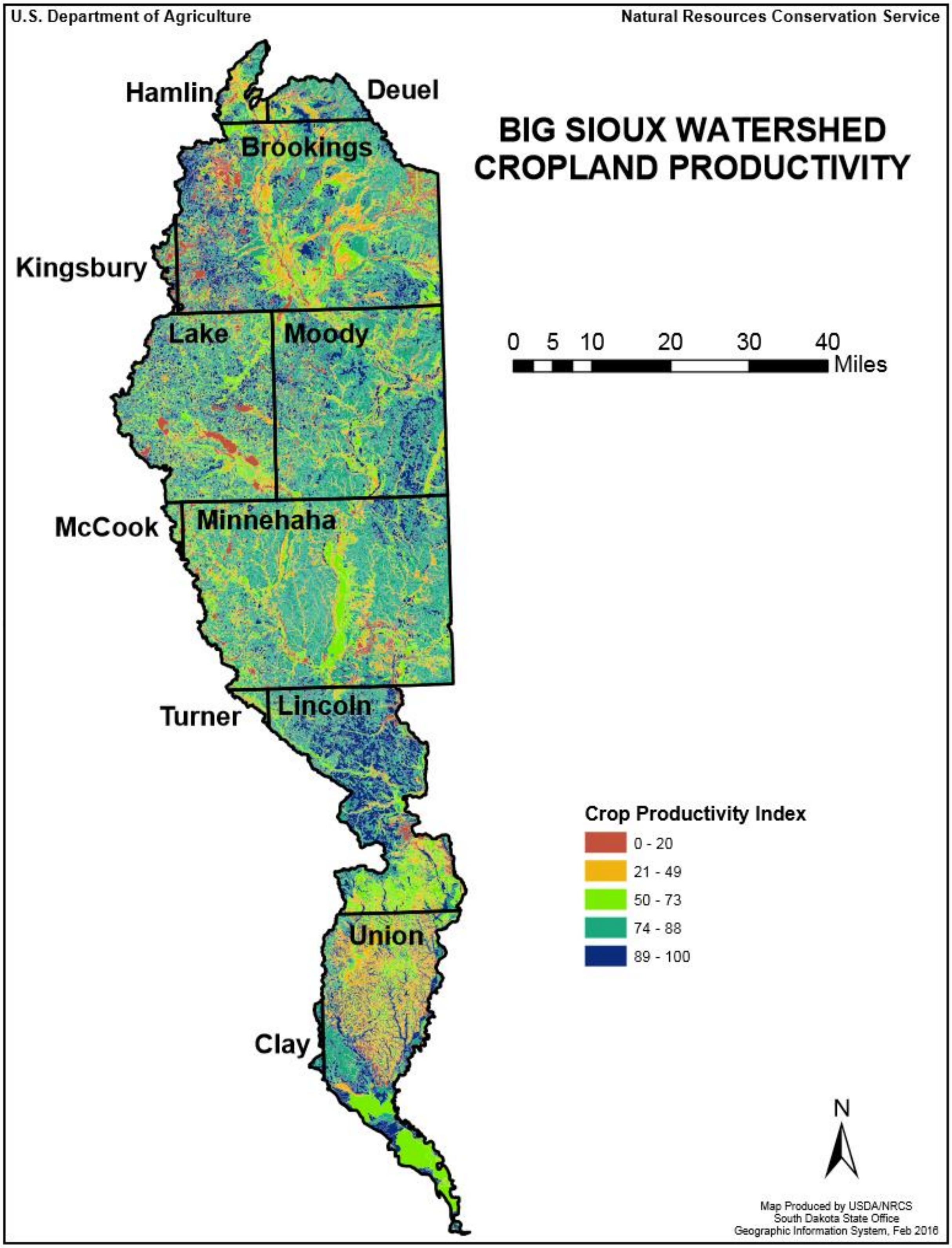
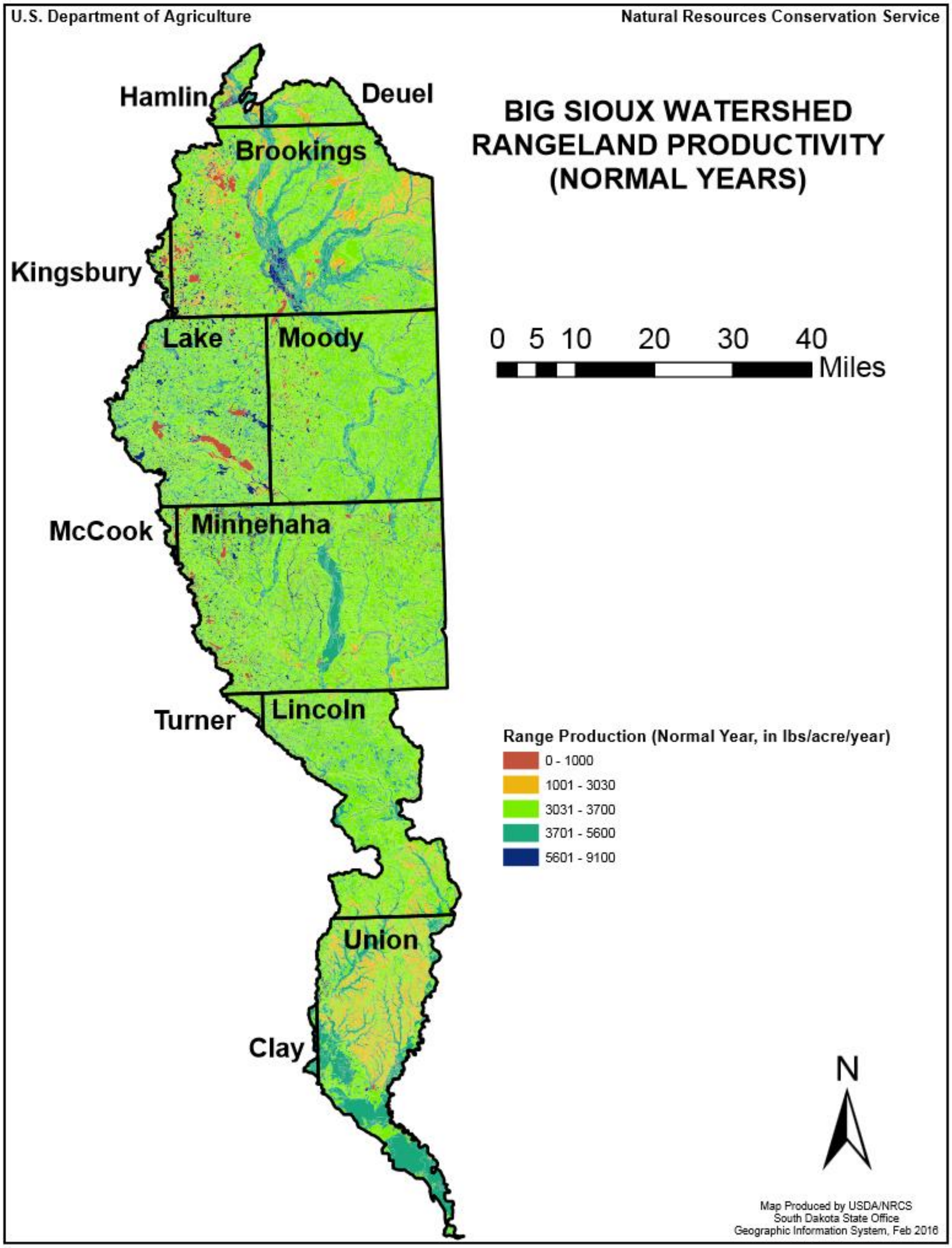


Figure 1-7: Rangeland Productivity in the BSRWIP

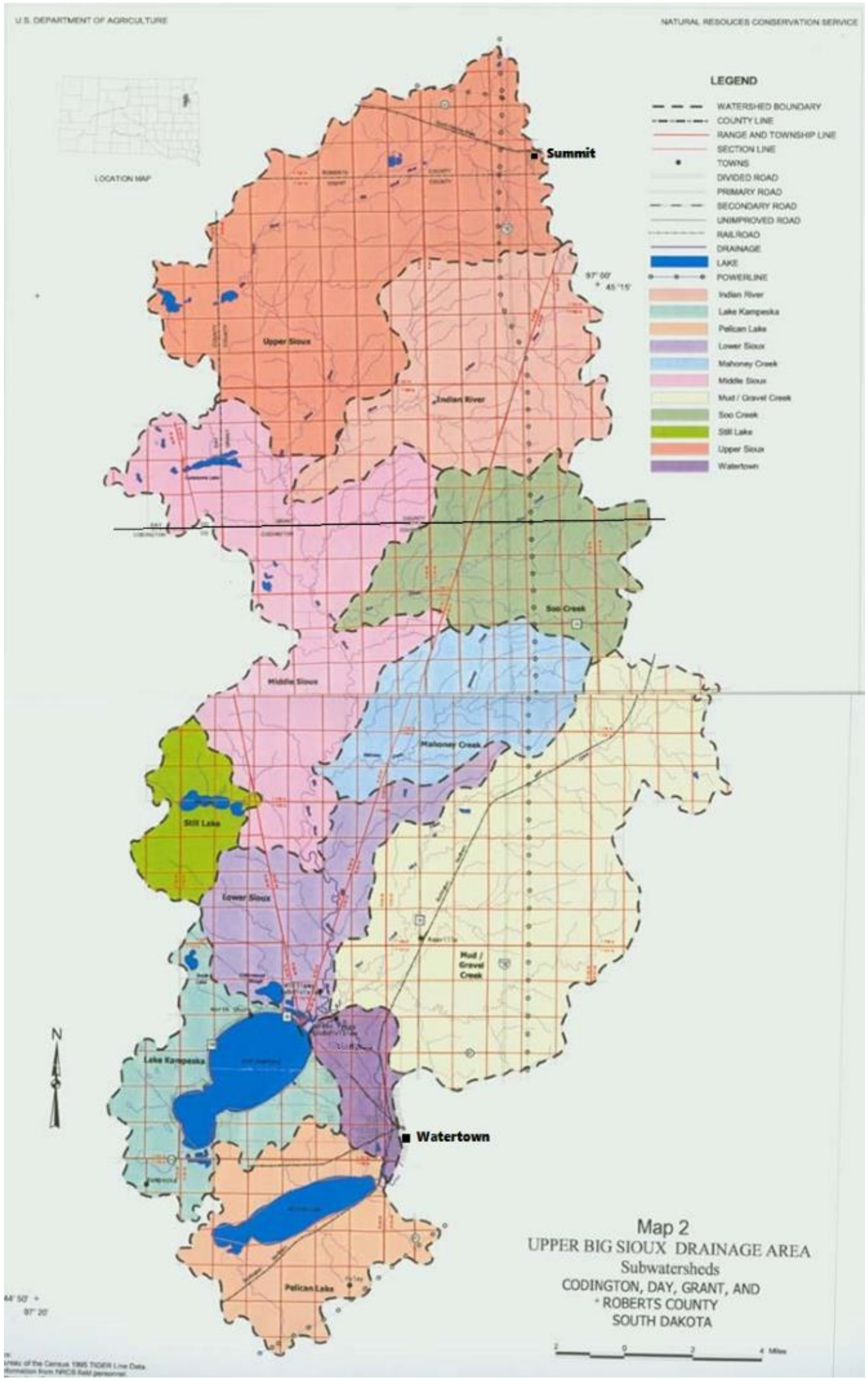


1.8.1 Upper Big Sioux River Watershed

The Upper Big Sioux River Watershed Project (UBSRWP) was a continuation of the original Lake Kampeska Watershed Project that resulted from a SDDENR diagnostic/feasibility study in 1992. See Figure 1-8 for UBSRWP boundary. The Lake Kampeska Watershed Project was an early water quality study in the upper reaches of the Big Sioux River conducted from 1989 through 1995 on Lake Kampeska, near Watertown. Lake Kampeska was an important drinking water resource utilized by the City of Watertown until 2006; it also had a surface water connection to the Big Sioux River (Watertown 2005). The name was changed to the Upper Big Sioux River Watershed Project when the Lake Pelican Water Project District joined the project following the completion of the SDDENR Lake Pelican Diagnostic/Feasibility Study in 1995. The Upper Big Sioux River Basin Study (Watertown 2005) was used to evaluate nutrient and sediment contributions from cropland and Animal Feeding Operations (AFOs). The major conclusions of this study were: 1) ephemeral and classic gully erosion was the primary source of sediment. Additionally, streambank erosion in some subwatersheds was a major source of sediment that contributed directly into the stream system; 2) sheet and rill erosion and classic gully erosion contributed the majority of the phosphorus. Animal feeding operations, classic gully erosion, and rangeland were the major sources of dissolved phosphorus; 3) the deterioration of riparian areas along channels and streambanks, a result of livestock grazing pressure or the intensity of cropping practices, accelerated gully formation and reduced the sediment and nutrient filtering effects of vegetation.

Best Management Practices (BMP) were funded and installed through the UBSRWP from 1994 through 2005. The 2005 Final Report for the UBSWP reported the following Best Management Practices (BMPs) were installed: 19,432 feet of Grassed Waterways; 2,368 acres of Grazing Management; 8 Animal Nutrient Management Systems; 3,921 feet of Lake Shoreline Stabilization; Manure Application Management with 5 cooperators; 132 Small Ponds/Dams; and 1,960 feet of Shoreline Stabilized. The UBSRWP had a segment 5 study that ran from April, 2008, to December, 2012. The final report for this study was issued in December 2012 by the City of Watertown.

Figure 1-8: Upper Big Sioux River WIP Boundary. Watertown 2005



1.8.2 North-Central Big Sioux River Watershed

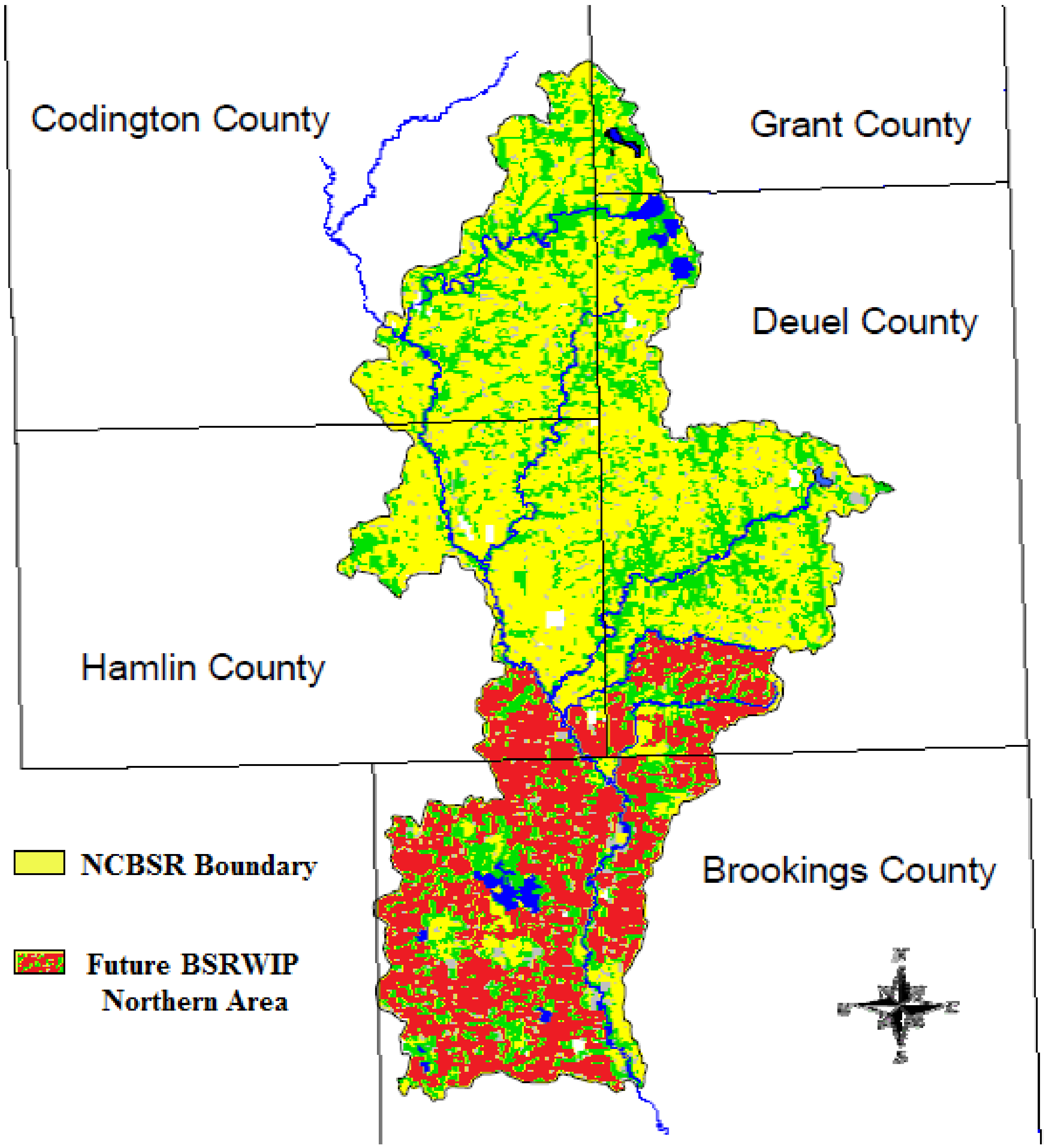
The North-Central Big Sioux River (NCBSR) watershed assessment project (SDDENR 2005) began in 2001 and continued through 2005. The purpose of this assessment was to determine sources of impairment and develop restoration alternatives for the NCBSR and its major tributaries. The North-Central portion of the Big Sioux River was listed as partially supporting its designated uses because of excess total suspended solids, pathogens, nutrients, and organic enrichment in the 1998 and 2000 South Dakota 305(b) Water Quality Assessment Report. The NCBSR was also listed as not supporting its designated uses due to excessive suspended solids, fecal coliform bacteria, and nitrates in the 2004 SDDENR Integrated Report for Surface Water Quality Assessment. The NCBSR project was intended to be one of the initial phases of watershed-wide studies, to be analyzed with other Big Sioux River watershed assessments, and restoration implementation projects.

The NCBSR Watershed Project extended from the USGS gaging station north of Watertown, near the confluence with Mud Creek, to southeast of Volga, near the confluence of North Deer Creek. The southern end of the project, Estelline-South Area from Estelline to Volga, would later become a part of the BSRWIP. See Figure 1-9. The assessment was a result of this reach of the Big Sioux River being placed on the 1998 303(d) list for Total Suspended Solids (TSS) exceedance. In the Estelline-South Area, fecal coliform bacteria exceeded the water quality criteria on two of the four river/tributary sampling sites. The monitoring data showed high fecal concentration during runoff events and non-event flows. Potential non-background, non-point sources of fecal coliform bacteria were failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. According to the feedlot inventory, 43 of the 130 animal feeding operations (89% were cattle operations) analyzed with AGNPS in this area rated 50 or greater on a 0 to 100 scale.

1.8.3 Central Big Sioux River Watershed 2004

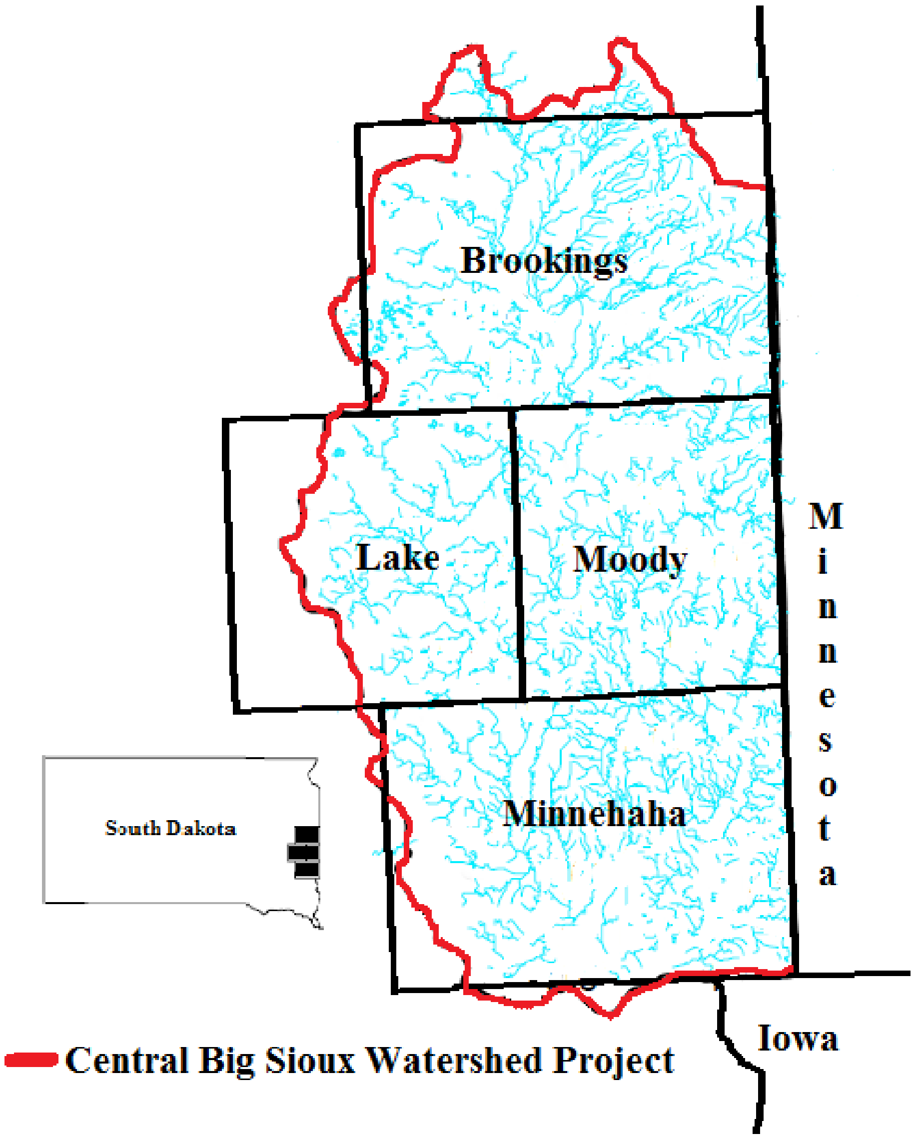
Formal watershed assessment of the Central Big Sioux River (CBSR), later to be part of the BSRWIP, began in 1999 and lasted through 2003 (SDDENR March 2004). The Phase 1 Watershed Assessment Final Report and TMDLs for the CBSR in Brookings, Lake, Moody, and Minnehaha Counties was published in March 2004, by SDDENR. Impairments cited in the 1998, 2000, and 2004 305(b) Water Quality Assessment Reports for the CBSR watershed were excessive pathogens (fecal coliform bacteria) and suspended solids. The goals of this assessment project were to: (1) locate and document sources of non-point pollution impairments to the central portion of the CBSR; (2) identify feasible restoration alternatives to support watershed implementation projects to improve water quality impairments; (3) develop TMDLs based on identified pollutants impairments cited in the 305(b) Water Quality Assessment Reports. The assessment also developed feasible restoration alternatives to improve water quality problems

Figure 1-9: Boundary of NCBSR Watershed Study. SDDENR 2005



within the watershed of the Big Sioux River between the communities of Volga and Sioux Falls and included the major tributaries in Brookings, Lake, Moody, and Minnehaha counties. See Figure 1-10. The EDWDD sponsored a project implementation plan for the identified water quality impairments as Segment 1 of the CBSRWP. Best Management Practices (BMPs) were implemented from 2005 through 2010 for the Big Sioux River and its tributaries between the communities of Watertown and Brandon.

Figure 1-10: Central Big Sioux River Watershed Project Boundaries (SDDENR 2004)



Direct runoffs to the river, as well as permanent and intermittent tributaries, contributed loadings of sediment, nutrients, and fecal coliform bacteria and were primarily related to seasonal snow melt or rainfall events. The assessment was conducted as a result of being placed on the 1998 303(d) list for fecal coliform bacteria and TSS problems. The Segment 1 of this project was completed by the EDWDD from August 2005 to September 2010. The final report for Segment 1 of the CBSRWP (Strom EDWDD 2010) reported on Best Management Activities implemented in the watershed counties of Lake, Brookings, Moody, and Minnehaha. These counties would later be combined with the Lower Big Sioux River project.

An Interim Implementation Project for the CBSR extended BMP implementation from 2010 through 2011 to serve as a transition from the first and second project segments. Berg (2012) wrote an Interim Report for the CBSRWIP, summarizing the activities of 2010 and 2011. Completed BMP projects were 2 livestock nutrient management systems engineered; 11,275 linear feet of stream bank stabilization, and 39 water samples tested. The interim project was a transition between the first and second segments of several planned implementation projects design to implement BMPs in the Big Sioux River watershed. BMPs completed during this time were 230 acres riparian conservation reserve program; 561.5 acres riparian rural easements; 25,000 linear feet bank stabilization; 16 waste storage facilities designed and planned; 12 waste storage facilities built; and 1,080 water quality samples were taken.

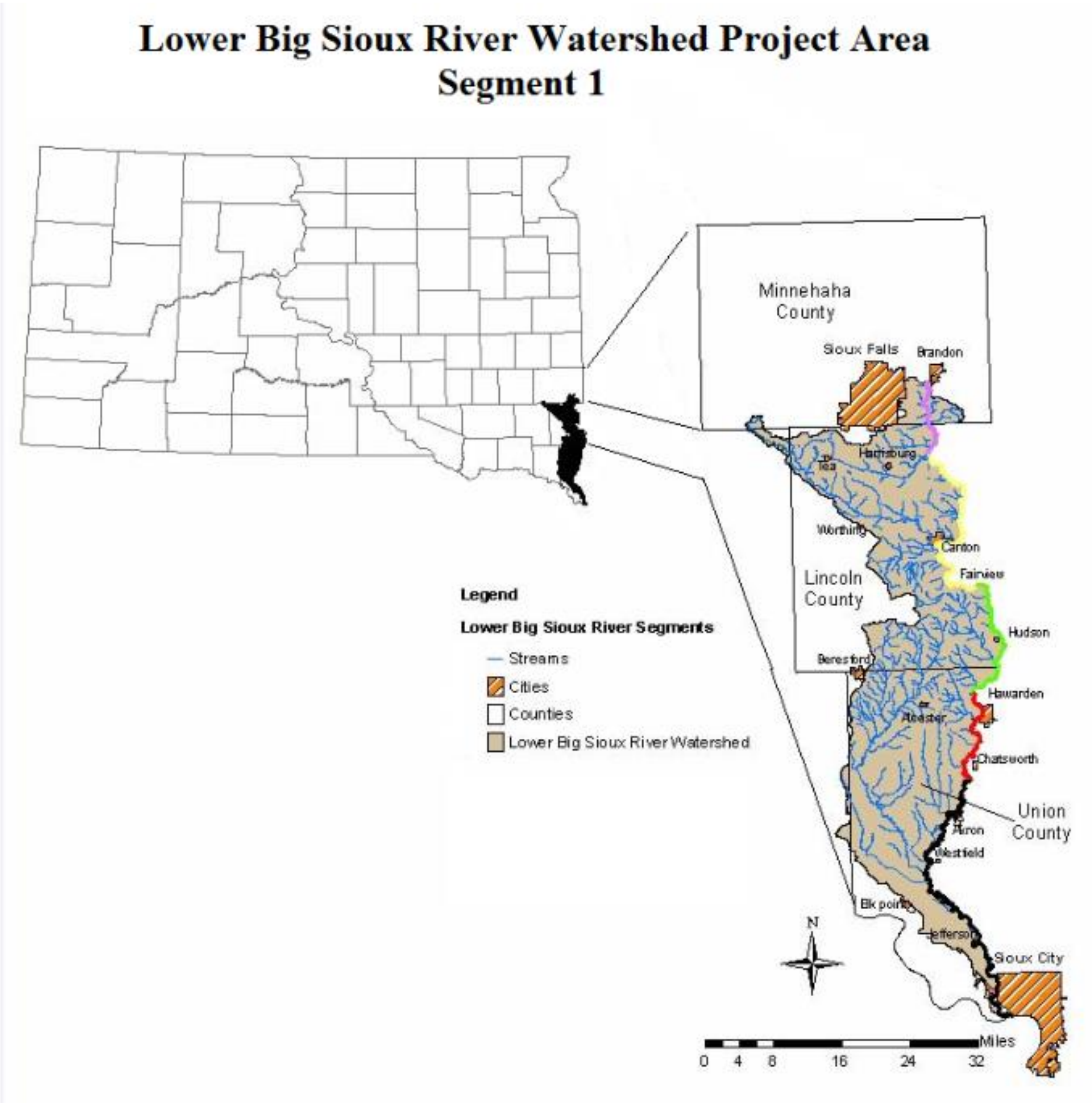
1.8.4 Lower Big Sioux River 2002

The Lower Big Sioux River (LBSR) watershed assessment was initiated in 2002 to document impairments and collect water quality criteria from its confluence with Beaver Creek, near the city of Brandon, to its mouth with the Missouri River. The majority of the watershed was located in Lincoln and Union Counties, in southeast South Dakota, with only a small portion in Minnehaha County. See Figure 1-11. During the 2002 watershed assessment, 572 livestock operations were located and analyzed using the Agricultural Non-Point Source (AGNPS) pollution feedlot model.

Initial water quality data indicated high levels of fecal coliform bacteria and TSS in both the lower Big Sioux River and its tributaries, which resulted in the placement of all of LBSRWIP project area on the 303d waterbody list as impaired in 2004. The first Project Implementation Plan (PIP) was developed during October, 2007, and initiated a watershed project to install BMPs designed to reduce fecal coliform bacteria and TSS loading into the river. The proposal was based on preliminary data from the assessment project and the draft TMDL report for the Big Sioux River, which was approved by EPA in January, 2008. The project goals were to "Improve the water quality of the Lower Big Sioux River by implementing TMDLs developed for this section of the river" (Berg 2010).

The LBSRWIP – Segment 1 Final Report (Berg 2010) summarized projects activities of the LBSRWIP in 2008 and 2010. The project area included the southern portion of Minnehaha County to the mouth of the Big Sioux River. The project was sponsored by the Lincoln County Conservation District. BMPs completed during this time were 1,382 acres conservation tillage; 51 acres grass seeding; 13.9 acres filter strips; 5,568 linear feet grass waterways; 19.4 acres riparian buffers; 2 waste storage facilities; 2 nutrient management plans.

Figure 1-11: Lower Big Sioux River Watershed Project Area, Segment 1. Berg 2010



The Segment 2 Final Report for the LBSRWIP (Berg, August, 2013) summarized two years of BMP implementation from July 2010 to July 2012. The project sponsor was the Lincoln County Conservation District. Project boundaries were the same as in the Segment 1, 2010, report. BMPs completed during this time were 43,363 linear feet terrace restoration; 3,172 acres conservation tillage; 219.6 acres grass seeding; 76.7 acres filter strips; 11,670 linear feet grass waterways; 19.4 acres riparian buffers; 154 acres rotational grazing systems; 6 acres riparian rotational grazing systems; 3,054 linear feet fencing; 2 waste storage facilities; 2 waste storage feasibility studies.

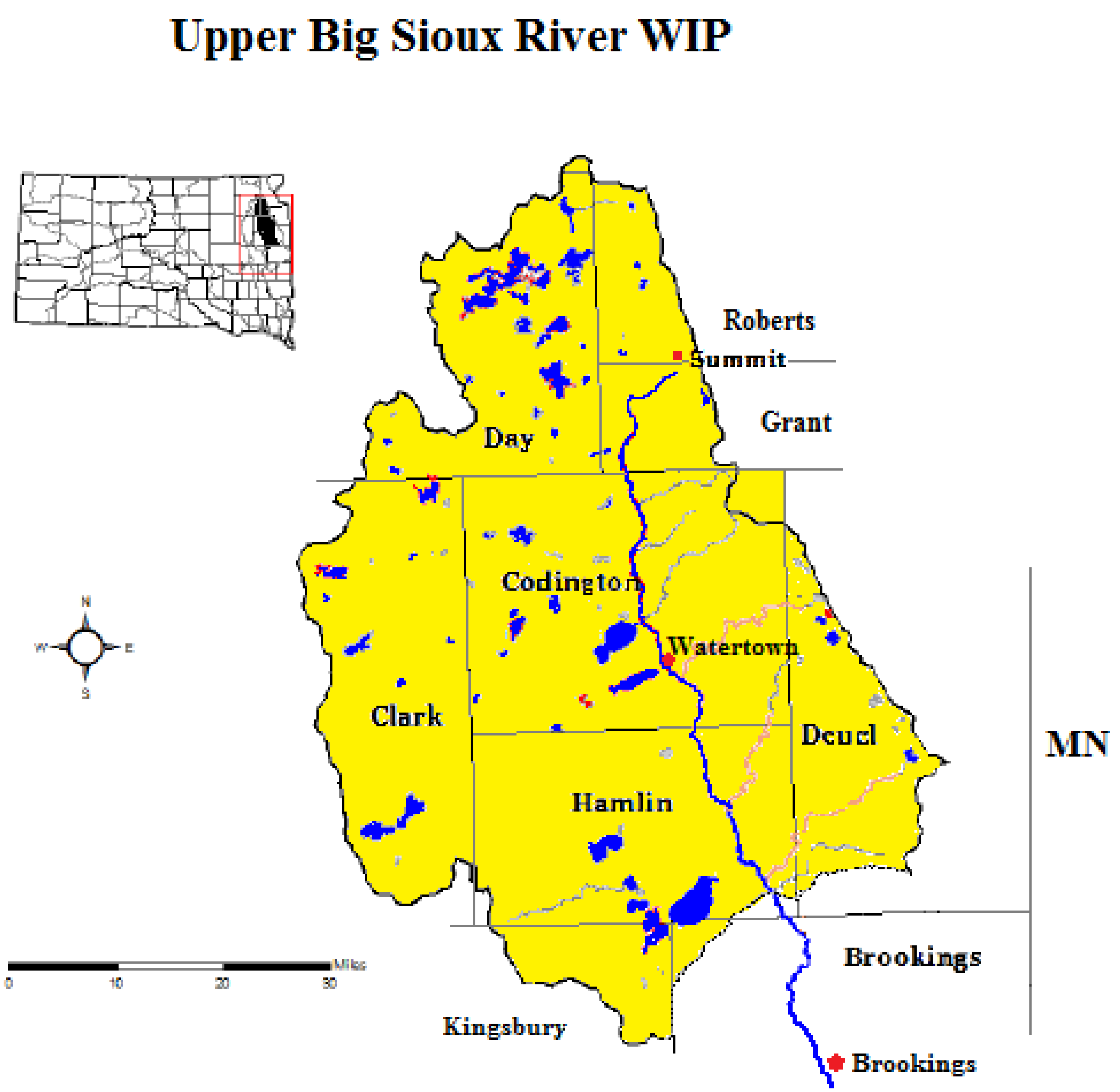
During Segment 2 of the LBSRWIP the project was merged with the CBSRWIP Segment 2 in September of 2012. The merged CBSRWIP was later changed to the Big Sioux River Watershed Implementation Project (BSRWIP). A final report for the CBSRWIP Segment 2 activities from July 2011 to July 2015 was summarized in February 2016 (Berg 2016). BMPs focused on the installation of animal waste management systems, cropland management, grassland management, water quality monitoring, and bank stability testing. BMPs completed during this time were 6,647 linear feet terrace restoration; 138.1 acres CRP/RAM; 11,043 linear feet grass waterways; 79.2 acres filter strips; 16.8 acres easements; 1,270 linear feet bank stabilization; 585 acres SRAM; 6 rotational grazing systems; 14 waste storage facilities designed and 7 constructed. The BSRWIP is currently in its third segment of implementation from 2015 to 2020.

1.8.5 Summary of Past Big Sioux River Segment Projects

These final assessment and project reports for the Upper, North-Central, Central, and Lower Big Sioux River segments served as the foundation for the implementation and restoration projects that were later developed to meet the designated uses and water quality standards of the Big Sioux River and its tributaries. These projects were intended to be the initial phases of a series of watershed-wide restoration implementation projects within the Big Sioux River watershed. Since that time, the boundaries of the North-Central, Central, and the Lower Big Sioux River implementation projects were combined into the BSRWIP. The Upper Big Sioux River watershed and a portion of the North-Central Big Sioux River watershed, from the town of Summit to Watertown, were combined into the UBSRWP. See Figure 1-12. A final report on Segment 5 of the UBSRWP was published in December, 2012.

This Strategic Plan will deal with the Big Sioux River Watershed Implementation Plan project boundaries from the Hamlin-Brookings counties line, south to the Big Sioux River's confluence with the Missouri River. See Figure 1-13.

Figure 1-12: Current Upper Big Sioux River Watershed Project Boundaries



1.8.6 Big Sioux River Watershed Implementation Project – Current Status

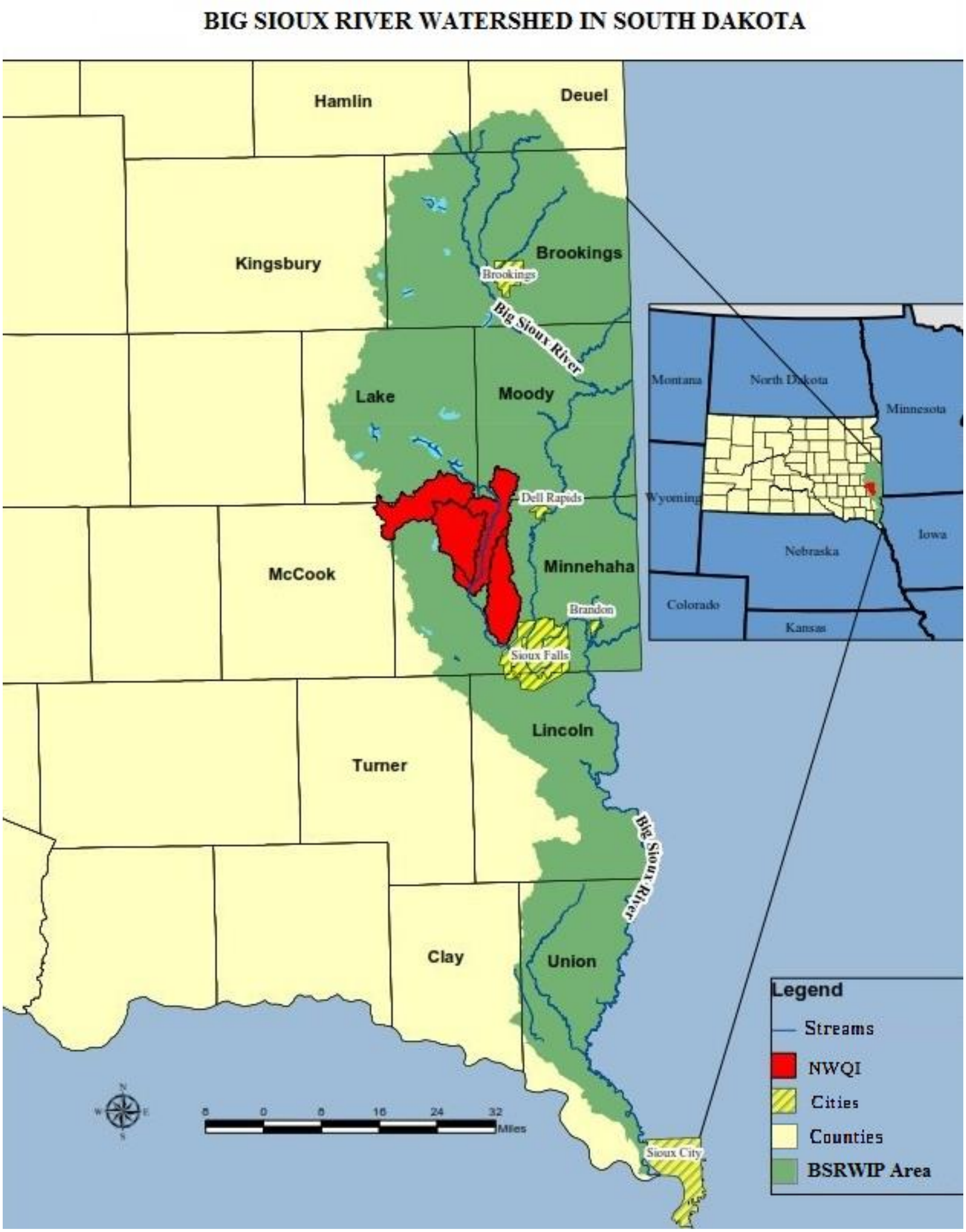
In 2014, a Project Implementation Plan (PIP) was submitted that would change the Big Sioux River project boundaries to include portions of the watershed in southeast Hamlin and southwest Deuel counties, Brookings, Lake, Moody, McCook, Minnehaha, Turner, Lincoln, Clay, and Union counties to the mouth of the river near North Sioux City, South Dakota. The Moody County Conservation District took the lead sponsorship for this southern portion.

This BSRWIP would run from July 2015 to June of the year 2020. This PIP would address installing BMPs to address the high levels of fecal coliform bacteria and TSS and meet the 30 separate TMDLs developed for the river, several of its tributaries, and the lakes within the watershed. A public education and outreach campaign was initiated to inform landowners, stakeholders, and area residents on water quality issues and BMPs important to the lower Big Sioux River Basin Watershed. BMPs were targeted towards identified high priority sub-watersheds. BMPs focused on the installation of animal waste management systems, cropland management, grassland management, water quality monitoring, and bank stability testing. The BSRWIP is currently in its third segment of implementation, which is projected to end in 2020. A USDA-NRCS Regional Conservation Partnership Program (RCPP) was also approved to allocate special EQIP funding in the project area.

1.8.7 National Water Quality Initiative

The National Water Quality Initiative (NWQI) program was selected for four HUs in the Skunk Creek watershed of the Big Sioux River in 2014, 2015, and 2016. See Figure 1-13. The southern portions of Lake and Moody Counties, the northeast corner of McCook County, and a large part of Minnehaha County were designated as a NWQI. The NWQI watershed boundary includes the subwatersheds of Jensen Creek (35,204 acres), Buffalo Creek (31,422 acres), Colton Creek (31,935 acres), and Willow Creek (30,282 acres). These are tributaries within the Skunk Creek Watershed, which ultimately feed into the Big Sioux River. There are special funds allocated within the NWQI designation, by which the Natural Resources Conservation Service (NRCS) offers financial assistance through the Environmental Quality Incentive Program (EQIP). Technical assistance is also provide to agricultural producers interested in improving water quality and aquatic habitats in priority watersheds with impaired streams. The NRCS will help producers implement conservation and management practices through a system approach to control and trap nutrient and manure runoff.

Figure 1-13: Big Sioux River Watershed Implementation Project. Berg 2016



1.9 Lakes within the Lower Big Sioux River Water Improvement Project

1.9.1 Oakwood Lakes

The USDA administered Rural Clean Water Program (RCWP) implemented BMPs in the watersheds of Oakwood Lakes (West Oakwood Lake and East Oakwood Lake) and Lake Poinsett over a ten year period between 1981 and 1991. Although Lake Poinsett is out of the BSRWIP area, both west and east Oakwood Lakes are within the project boundaries. A 1977 EPA study had reported that the water quality of 90% of the drainage basins in the Corn Belt were affected by pollution (Little 1989), and that by far the most common nonpoint source of pollution reported by States was agricultural runoff. The RCWP was a government funded program that cost-shared agricultural BMPs that would improve the water quality of recreational lakes and ground water resources. The Oakwood Lakes-Lake Poinsett RCWP project made significant contributions to the science of nonpoint source pollution by monitoring inputs of pollutants to groundwater from crop fields, evaluating inputs of nutrient to lakes from surface and ground water, and evaluating the transient movement of agricultural chemicals in the vadose zone.

SDDENR conducted the Oakwood Lakes watershed assessment project, which began in 2001 and continued through 2005, in conjunction with the NCBSRWP Assessment. The final report was published in 2005. The Oakwood Lakes watershed assessment was conducted as a result of East Oakwood Lake being placed on the 1998 South Dakota 303(d) impaired waterbody list. Excess nutrients, siltation, and noxious aquatic plants were cited as the primary problems. According to the report, surface water monitoring indicated that all tributaries to the Oakwood Lakes supplied excess amounts of nitrogen and phosphorus to the system. The lakes could sustain large algal blooms even in low flow years because much of the bottom sediments are saturated with phosphorus. This report concluded that the Oakwood Lakes system is operating as phosphorus sink with a 70 to 100% trapping efficiency. The report recommended any future goals to improve water quality in these lakes would need to include in-lake restoration measures due to their nutrient saturated in-lake sediments.

West Oakwood Lake was listed on the 2002 South Dakota 303(d) Waterbody List for not supporting its beneficial uses due to Trophic State Index (TSI) impairment. Both East Oakwood Lake and West Oakwood Lake have been identified as impaired on subsequent impaired waterbody lists including the most recent 2014 SDDENR-IR for Surface Water Quality Assessment. The long term goal for this project was to locate and document sources of non-point source pollution in the Oakwood Lakes watershed and provide feasible restoration alternatives for the improvement of water quality.

1.9.2 Lakes Madison and Brant

Lake Madison and Brant Lake were studied by SDDENR in 1989. Both lakes were targeted for a 50% reduction in phosphorus loadings as they were 303(d) listed for Warmwater Permanent Fish Life and TSI in the 2004 SDDENR-IR. AGNPS program analysis of the watershed in 40-acre cells indicated that BMPs be installed where cells had a rate of erosion greater than 7.0 tons per acre. Forty-one Animal Feeding Operations (AFOs) were evaluated in the watershed. Twenty-four had an AGNPS ranking greater than 30 and three were greater than 50. The study recommended that: 1) AFOs with a ranking over 20 should be evaluated for operational or structural modifications to reduce phosphorus loadings; 2) the City of Madison storm sewers should be rerouted, reduced, or eliminated from outletting into Silver Creek; and 3) a centralized sewage system should be installed on Brant Lake for the homes.

1.9.3 Lake Herman

Lake Herman was studied in the mid-1970s through a special water quality project called the Model Implementation Project (MIP). The MIP Project was a joint effort between the USDA and the USEPA designed to coordinate between the various soil conservation and water quality management programs available in the two agencies (SDDENR March 2004). Through the MIP, BMPs were installed on agricultural lands and three sediment control structures were installed above the lake to trap sediment before it entered the lake. In 1992 the Lake Herman Phase III Post-Implementation project was initiated to a quantify reduction in loadings and change in water quality in the lake and watershed as a result of the 1977 Lake Herman MIP. A secondary goal was to assess the effectiveness of the BMPs implemented in the Lake Herman Watershed during the MIP project. From the data collected from 1992-1993, the following recommendations were made: 1) construct two Animal Waste Management Systems (AWMS); 2) increase the number of BMPs installed in the watershed; 3) implement streambank stabilization and riparian vegetation management of areas along tributaries damaged by flooding; 4) increase the retention time of the three sediment control structures; 5) continue to monitor the riprap installed along the Lake Herman shoreline through the MIP. A PIP was implemented, based on these findings from 2000-2006, during which time 8 AWMSs were built, 11 grassed waterways, 4 terrace systems, 6 multi-purpose dams, 9 grazing systems, 89 acres of wetlands restored or created, 650 feet of bank stabilization, a City of Madison storm sewer study, a Bourne Slough sediment study, and the Bourne Slough berm restored (Strom 2006).

1.9.4 Lake Campbell

Concerned homeowners around Lake Campbell began collecting water quality samples due to the declining water quality of their lake. This interest materialized into a water quality assessment conducted by the SDDENR in 1983; where it was determined the major problem of

Lake Campbell was an excess of nitrogen and phosphorus. In 1986 the Water Resources Institute (WRI) did a more detailed water quality assessment to determine the amount of nutrients entering the lake from agricultural land. The study reported that 1.19 million cubic yards of sediment had also accumulated in Lake Campbell. The Lake Campbell project dredged sediment from the lake from 1987 to 1989; during which time 220,000 cubic yards of sediment were removed from two locations in Lake Campbell. The WRI conducted another study in 1989 to identify critical nonpoint nutrient and sediment loading areas within the Lake Campbell watershed. SDDENR followed-up with a diagnostic and feasibility study in 1993. During the diagnostic and feasibility study (Madison and Wax 1993), water quality monitoring and watershed modeling resulted in the identification of nutrient and sediment loadings to the lake. Nutrients and sediment were believed to be coming from two specific watershed areas through Battle Creek, from shoreline erosion, faulty septic systems, and in-lake sediment. Eighty-seven lakeshore homes had their sanitary septic systems surveyed during the 1993 diagnostic/feasibility study of Lake Campbell. The survey found 10% of the systems were out of compliance with current construction specification and were thought to be contributing to the degradation of the water quality. The study identified several septic systems that were potentially affecting the water quality of the lake. A Sanitary District was established in 1994; however, a centralized wastewater collection and treatment facility was not constructed at that time. A later comparison survey of 77 systems in 2008 found that the septic systems were getting older and many of the tanks and fields were still in need improvement.

This study recommended several restoration activities to be implemented that included an information and education program to promote BMPs that reduce sediment and nutrient loads; feedlot runoff control on approximately 12 feedlots; 1,365 feet of shoreline erosion control; the establishment of a sanitary district to address failing systems; wetland restoration; and the dredging of 100 surface acres of the lake to an average depth of 10-11 feet, approximately 1,000,000 cubic yards.

The Brookings County Conservation District conduced a PIP from 1995 to 1999 implementing BMPs within the watershed. During this time 1 AWMS was installed; 3,800 aces of no-till farming; 1 wetland was created; 1,500 acres of conservation tillage; 5 acres of tree plantings; 3 grazing systems; 19,459 linear feet of grassed waterways; 8,000 feet of streambank stabilization; and 2,400 feet of shoreline stabilization. The water control structure at the outlet on the north end of the lake was also restored.

In 2007, the EDWDD began a post-assessment of the Lake Campbell watershed (SDDENR 2009). The purpose of this assessment was to check the condition of the lake and evaluate whether previous restoration activities positively impacted the water quality of the lake. The results of this second assessment were that the inlet was still contributing a fair amount of nutrients to the lake. As of 2008, the modeled TSI for this lake was 78, which warranted a continuing the installation of best management applications by revisiting the areas that were identified for BMPs.

1.9.5 Lake Alvin

Lake Alvin is a 107 acre reservoir in northeastern Lincoln County owned and managed by South Dakota Game, Fish and Parks (SDGFP). Lake Alvin has a watershed of 28,013 acres with the primary land use being agriculture. It is drained by Nine Mile Creek and includes the cities of Harrisburg and the eastern portion of Tea (SDDENR 2001). Lake Alvin has had problems with high fecal coliform counts and public swimming beach closures. Lake Alvin was last listed on the 303(d) waterbody list for elevated fecal coliform bacteria and increasing TSI trend in the SDDENR-IR 2006. From 2008 to 2014 the lake has been listed for high water Temperature – Warmwater Permanent Fish Life.

During the SDDENR 2001 study, there were no water quality standards exceedances for Nine Mile Creek downstream or upstream of Lake Alvin. However, three upstream tributary sites had fecal coliform counts in excess of 1,000 colonies/100 ml. SDGFP reported most beach closures at Lake Alvin occurred after heavy rains, suggesting runoff from the watershed was a major factor in increased fecal coliform counts. Implementing BMPs on select tributaries was recommended to reduce fecal coliform counts from livestock and reduce the number of beach closures.

The study reported the increasing TSI trend observed in Lake Alvin from 1989 through 1999 was a result of increased nutrients by in-lake loading and delivered loads. To improve the water quality and lower the TSI values, erosional sediments, nitrogen, and phosphorus inputs from Nine Mile Creek and the ungauged portion of the watershed would need to be decreased. This could be accomplished by implementing tributary and in-lake BMPs on critical cells and priority areas identified by watershed assessment and AGNPS pollution model. A fecal coliform load reduction of 25% was determined to be needed to meet water quality standards using AWMSs to control waste. Additional reductions in fecal coliform concentrations could also be achieved by riparian management and buffer strips. An information and education program was recommended to educate the public on fecal coliform and ways to prevent local beach contamination by humans and dogs. Watershed improvements have been made (SDDENR 2001), including the construction of total retention wastewater treatment ponds for the City of Harrisburg in 1999, and improvements to the City of Tea wastewater treatment ponds in 1998.

The implementation of BMPs has improved the water quality of Lake Alvin as it has not been listed for fecal coliform since 2006 and TSI since 2008. The SDDENR-IR 2014 303(d) listing is for water temperature. Lake Alvin has been proposed for delisting in the SDDENR-IR 2016 as it is fully meeting its beneficial uses.

1.9.6 Wall Lake

An initial water quality assessment of Wall Lake was conducted by SDDENR from 1979 to 1984. Problems documented before the restoration activities included excessive nutrients, algae problems, and lack of depth. The goal for the assessment project was to locate and document sources of nonpoint source pollution in the Wall Lake watershed and to provide feasible restoration alternatives for the improvement of water quality. According to the initial assessment (SDDENR 1985), Wall Lake was identified as being hypereutrophic due to high concentrations of total phosphorus and elevated total nitrogen levels from agriculture and other human activities. The results of the assessment findings were that the lake be dredged and other restoration activities, including BMPs, were to be implemented. During the initial assessment, water quality monitoring and watershed modeling resulted in the identification of a nutrient impairment. Excessive nutrients were believed to be coming from faulty septic systems, fertilizer runoff, feedlot runoff, and in-lake sediment. The sources of impairment were addressed through dredging operations and BMPs, such as installing a centralized sewer system, feedlot management, wetland restoration, shoreline buffers, and riparian management. The dredging project was completed between 1989 and 1993 while other BMPs were installed through 1995. Dredging efforts removed approximately 1.5 million cubic yards of sediment from the lake bottom. A centralized sewer system was implemented in 1992 on which all lake residents, as well as the Girl Scout Camp and beach facilities, were hooked to the system.

A reassessment of the initial project was conducted from October 2001 to December 2004. The purpose of the reassessment was to assess the post implementation condition of the lake and its watershed and compare those results with the initial assessment results. Efforts to improve the quality of the lake were successful and accomplished the goal of improving water quality as shown by the results of the reassessment project. However, the tributary sites were still contributing high levels of nutrients to the lake, and from the water quality data, Wall Lake was still receiving much of its nutrients from its watershed. The comparison showed that the average concentrations of phosphorus and nitrates within Wall Lake have decreased since dredging. However, nutrients in the tributaries have shown little or no change since the initial assessment period.

Wall Lake also exhibited a longer water residence time than what might typically be found in other lakes. Nutrient recycling from sediments can be a significant problem in lakes with long residence times. More improvement may occur over time, as nutrient reductions in lakes with large amounts of phosphorus locked in the sediments take a significant amount of time. A study of nutrient levels in Sheridan Lake, South Dakota, indicated that it would take approximately 55 years for the lake to see a 90% recovery to the necessary target TSI level (Swanson 2004). Recommendations from the reassessment were that water quality in the lake could be enhanced by activities to reduce/remove biological nutrients once all external BMPs were installed. The activities could be using aeration, microbial augmentation, or actual physical removal. Wall

Lake tends toward nitrogen-limited conditions and was considered a eutrophic lake. Results showed that more improvements would be needed within the watershed in order for Wall Lake to maintain its TSI level of < 63.4.

1.10 Big Sioux River Watershed Improvement Project Water Quality Studies

In general the portion of the Big Sioux River, upstream of Volga to Summit, has been in full support of its designated uses. However, reaches of the lower Big Sioux River in the BSRWIP area have been listed in the SDDENR-IR's of 1998, 2000, 2002, 2004, 2006, 2008, 2010, 2012, and 2014 as only partially meeting some of their designated beneficial uses for either TSS, TSI, Fecal Coliform, *Escherichia coli*, and Ammonia. Lakes within the BSRWIP have also been listed for not meeting certain designated beneficial use for either Fecal Coliform, TSI, Temperature, pH, Chlorophyll-*a*, and Mercury. Besides the water quality data collected by SDDENR, data was also obtained from U.S. Geological Survey (USGS), the cities of Watertown and Sioux Falls, and the EDWDD.

The main causes of nonsupport within the Big Sioux River basin in streams are due to fecal coliform, *Escherichia coli*, and total suspended solids (SDDENR 2014). The presence of bacteria in the Big Sioux basin was mainly due to runoff from livestock operations, wet weather discharges, and storm sewers within municipal areas. Sediment sources are overland runoff from near-by croplands, inflow from tributaries, and streambank erosion. Lakes in the Big Sioux River basin are highly productive due to algae, nutrient enrichment, and siltation with nearly 50% of the monitored lakes considered hypereutrophic. The moderate size and shallow depth of most lakes makes them more susceptible to changes produced by large nutrient and sediment loads from the surrounding agricultural watersheds. This plus the erodibility of the glacial soils contributes to their hypereutrophic conditions.

There are numerous water quality studies and implementation projects within the Big Sioux River watershed upstream of the BSRWIP. However, only the studies dealing specifically with the water quality of the lower Big Sioux River watershed within the project area will be given. Short synopses of these reports are as follows. Other studies may be found in the bibliography.

- The *Big Sioux River Watershed Implementation Project Segment 2 Final Report* (Berg 2016) was a project implementation plan, from July 2011 to July 2015, to implement TMDLs and restore the water quality of the Big Sioux River from its confluence with Stray Horse Creek in Hamlin County to its mouth with the Missouri River. Preliminary data from the draft TMDL showed fecal coliform bacteria and total suspended solids in high concentrations for all 5 segments of the lower Big Sioux River main stem. During the Central and Lower Big Sioux River Watershed Assessments, 1,525 livestock operations were analyzed with AGNPS. Of these, 492 operations were ranked over 50. Fourteen AWMS were built; 1,270 feet of streambanks were stabilized; a drain tile bioreactor was installed; 99,869 feet of terraces; 602 acres of RAM/SRAM (Seasonal Riparian Area Management); 6 grazing systems; and a Water Quality Credit Trading Plan is in the final stages of development. EDDWD collected 993 water samples throughout the watershed for analysis. During this Segment 2 the LBSRWIP was merged with the CBSRWIP.

- The *Lower Big Sioux River Watershed Implementation Project Segment 2 Final Report* (Berg 2013) was a project implementation plan to implement TMDLs and restore the water quality of the lower Big Sioux River and Lake Alvin in Minnehaha, Lincoln, and Union counties. Preliminary data from the draft TMDL showed fecal coliform bacteria and total suspended solids in high concentrations for all 5 segments of the lower Big Sioux River main stem. The levels increased downstream resulting in nonsupport of immersion recreation, limited contact recreation, and warm water semi-permanent fish life propagation. The most likely sources of the impairments were reported as runoff from confined animal feedlots, feeding areas in close proximity to drainages, grazing livestock standing in, crossing or heavily grazing riparian areas, improper application and handling of manure, and intense row cropping practices.

- The *Central Big Sioux River Watershed Implementation Project, Interim Final Report* (Berg 2012) was a ten year Total Maximum Daily Load implementation strategy on reaches of the river that failed to meet designated used due to impairments from total suspended solids, dissolved oxygen, and/or fecal coliform bacteria. The south boundary was located in Minnehaha County along county road 38 southeast of Sioux Falls and the North boundary was located in Codington County at the outlet of Lake Kampeska. Project goals were to reduce bacteria and sediment loadings to the Big Sioux River by the improvement of existing animal feeding operations, limiting animal access to streams, shoreline stabilization, and to develop a master plan for the Central Big Sioux River watershed.

- *Segment 1 of the Central Big Sioux River Watershed Project* (Strom 2010) was an implementation project to restore the Big Sioux River and its tributaries in South Dakota from Watertown to Brandon. The project start date was in 2005 and ended in September of 2010. The work completed was the renovation and improvement of existing high-priority animal feeding operations; reduction of livestock access to water bodies; stabilizing banks along critical reaches of Skunk Creek and the Big Sioux River; and restoration of riparian areas.

- The *Lower Big Sioux River Watershed Implementation Project Segment 1 Final Report* summarized projects in the Big Sioux River watershed from the confluence of Beaver Creek in southeastern Minnehaha County and extends to the mouth at the Missouri River (Berg 2010). The majority of the watershed was located in Lincoln and Union Counties with only a small portion in Minnehaha County. Preliminary data from the draft TMDL showed fecal coliform bacteria and total suspended solids in high concentrations for all 5 mainstem segments of the lower Big Sioux River. The levels increased downstream resulting in nonsupport of immersion recreation, limited contact recreation, and warm water semi-permanent fish life propagation. The most likely sources of the impairments were reported as runoff from confined animal feedlots, feeding areas in close proximity to drainages, grazing livestock standing in, crossing or heavily grazing riparian areas improper application and handling of manure, and intense row cropping practices.

- A survey was completed through Iowa State University Extension Service for the Big Sioux River watershed in Iowa (Morton-Wright 2007). The Soil and Water Conservation Districts in Iowa mailed 4,439 surveys to landowners (farmers, rural acreage owners, town dwellers) living in eleven tributaries of the Big Sioux River watershed. Just slightly over 1,100 responses were returned. Approximately one-third felt they had a water quality problem. Eighty-six percent either had no knowledge of any community group that set water quality goals for their watershed and 96% did not know of any water quality goals for their watershed.

- A study the *Attitudes Toward the Water Quality of the Big Sioux River: An Executive Summary* (Stover et al, 2007) interviewed producers and their spouses living within the basin of the Big Sioux River. The results were that producers felt they bore some of the responsibility for water quality; producers also felt non-producers contributed to pollution; some producers were strong environmentalists, some moderate, and some indifferent; few wanted the Federal government to involved in decisions on how to protect the Big Sioux River, but rather have local level control.

- A *Rapid Watershed Assessment for the Lower Big Sioux River HUC 10170203* was completed by the Iowa Natural Resources Conservation Service (USDA-NRCS 2009) profiling data from 2007 on soils, farm operators, climate, land use, land capabilities, population statistics, and resource concerns. The main resource concerns were the high concentration of open feedlots and confined animal feeding operations.

- The *Phase I Watershed Assessment Final Report and TMDLs, North-Central Big Sioux River, Brookings, Hamlin, Deuel, and Codington Counties, South Dakota*, 2005 studied the water quality in the Big Sioux River (Segments R7 & R8), Willow Creek, Stray Horse Creek, and Hidewood Creek from 2001-2006 (SDDENR 2005). The goals of this assessment were to determine the sources of impairments, identify feasible restoration alternatives, and to develop TMDLs on the identified pollutants. Segment R7 of the Big Sioux River was listed as 303(d) impaired for Limited Contact Recreation because of *Escherichia coli* and Fecal Coliform bacteria, and the watersheds of Willow Creek, Stray Horse Creek, and Hidewood Creek were listed as 303(d) impaired for Limited Contact Recreation due to Fecal Coliform bacteria in the SDDENR Integrated Report of 2012.

- The *Upper Big Sioux River Watershed Project Continuation Final Report*, 2005, was a continuation of the original Lake Kampeska Watershed Project that resulted in a diagnostic/feasibility study by SDDENR (1992). The major conclusions of this study were that ephemeral and classic gully erosion and streambank erosion were the primary sources of sediment; sheet and rill erosion, classic gully erosion, animal feeding operations, and rangeland were the major sources of dissolved phosphorus; and the deterioration of riparian areas, as a result of livestock grazing or intense cropping practices, accelerated gully formation and reduced the sediment and nutrient filtering effects of vegetation.

- The *North Central Big Sioux River Phase 1 Watershed Assessment Final Report and TMDLs*, 2005, was a continuation of the original Lake Kampeska Watershed Project that resulted from a diagnostic/feasibility study by SDDENR in 1992. The major conclusions of this study (Watertown 2005) were that ephemeral and classic gully erosion and stream bank erosion were the primary sources of sediment; sheet and rill erosion, classic gully erosion, animal feeding operations, and rangeland were the major sources of dissolved phosphorus; and the deterioration of riparian areas, as a result of livestock grazing or intense cropping practices, accelerated gully formation and reduced the sediment and nutrient filtering effects of vegetation.

- *The Phase I Watershed Assessment and Final Report and TMDL, Central Big Sioux River, Brookings, Lake, Moody, and Minnehaha Counties, South Dakota, March* 2004. The Central Big Sioux River watershed assessment project began in April of 1999 and lasted through December of 2003 when data analysis and compilation into a final report was completed (SDDENR 2004). The purpose of this assessment was to determine the sources of impairment and develop restoration alternatives for the central portion of the Big Sioux River (between the communities of Volga and

Sioux Falls) and major tributaries in Brookings, Lake, Moody and Minnehaha counties of South Dakota. The south boundary was located in Minnehaha County along county road 38 southeast of Sioux Falls and the north boundary was located in Codington County at the outlet of Lake Kampeska. Direct runoffs to the river, as well as permanent and intermittent tributaries, contributed loadings of sediment, nutrients, and fecal coliform bacteria primarily related to seasonal snow melt or rainfall events. The assessment was conducted as a result of being placed on the 303(d) list for due to impairments from TSS, dissolved oxygen, and/or fecal coliform bacteria. The long term goal for this project was to locate and document sources of nonpoint source pollution in the Big Sioux River watershed and provide feasible restoration alternatives to improve water quality problems within the watershed.

- Marvin E. Hora completed a Master's Thesis on the *Nutrient Sources and Transport in the Central Region of the Big Sioux River, South Dakota* (Hora 1973). His objective was to determine the amount of phosphate, organic nitrogen, and organic carbon transported by the Big Sioux River. He compared three agricultural drainage areas for the amount of nutrients lost: Six Mile Creek, North Deer Creek, a subwatershed of the Big Sioux River Basin, and the city of Brookings. The three agricultural watersheds combined contributed 16% of the total annual phosphate load, 17 % of the total annual organic nitrogen load, and 15% of the total annual water discharged transported by the Big Sioux River. The city of Brookings contributed 10% of the total annual phosphate load, 2% of the total annual organic nitrogen load, 1% of the total annual organic carbon load, 75% of the ammonia load, and 1% of the total annual water discharge of the Big Sioux River. He concluded the total amount of nutrients lost from a watershed depended on the size of the watershed, but the nutrient loss per square kilometer of drainage area appeared to depend on the amount of water discharged per square kilometer of drainage area.

- During the fall of 1972 and winter of 1973, the USEPA conducted studies to assess the water quality in the Big Sioux River Basin, which including drainage from Iowa, Minnesota, and South Dakota (EPA 1973). The major sources of pollution was from John Morrell, Spencer Foods Inc., and waste water discharge from the Sioux Falls Wastewater Treatment Plant (WWTP). During the fall, nitrogen was the growth-limiting nutrient upstream of the WWTP. There was sufficient nitrogen in the water downstream of the WWTP to sustain algal growth; however, the algal growth was reduced downstream resulting from the toxic chlorine and chloramines in the effluent.

1.11 Goals of the BSWIP Strategic Plan

The goals of this strategic plan for the Big Sioux Watershed Implementation Project are to: (1) review all water quality assessments, studies, TMDLs, and project implementation achievements; (2) provide a source of summary's and bibliography's of the research and implementation activities; (3) identify the pollutant sources for the 303(d) listed water bodies and the most effective Best Management Practices that will result in the delisting of the 303(d) water bodies; (4) provide an estimate on BMPs and administrative costs for a five year project period; and (5) provide a document to guide an implementation project to meet the 41 separate TMDL standards set for the Big Sioux River, its tributaries, and lakes. The end result of the implementation this plan would be the 303(d) delisting by elimination or reduction of the nutrient, sediment, and fecal coliform bacteria loadings to the BSRWIP from its watershed and tributaries. In addition to the 303(d) delisting, the implementation of this plan will allow the continued use of the water bodies for flood control, drinking water, livestock water, swimming, boating, recreation, irrigation, commerce, wildlife, and residential living.

2. CAUSES AND SOURCES OF IMPAIRMENTS

2.1 Water Bodies Current Status

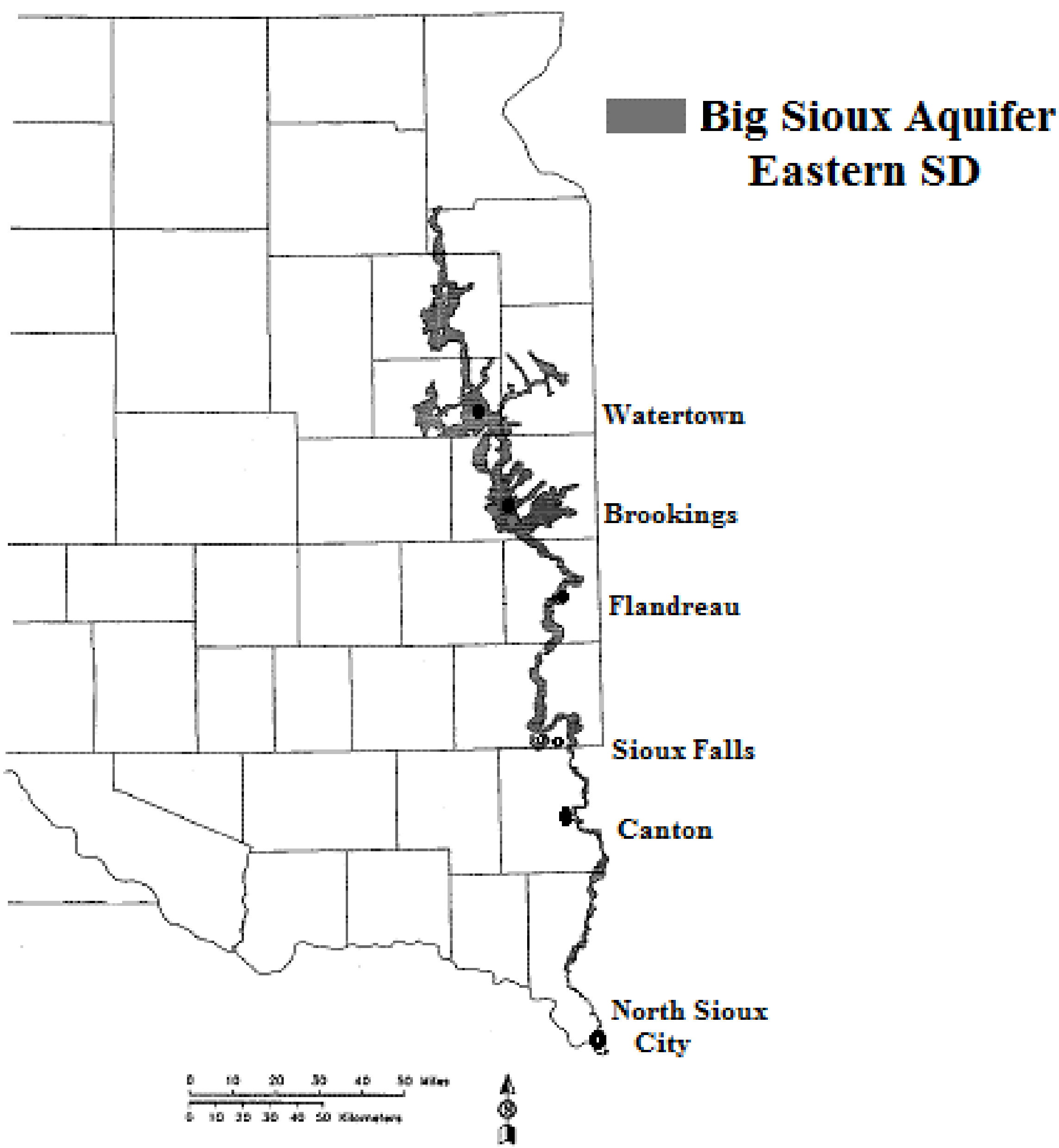
The interest in the water quality of the Big Sioux River had its beginnings around the unique formation of the river falls near Sioux Falls. Around 14,000 years ago, melting from the last glacial ice sheet exposed the underlying Sioux quartzite bedrock, forming the falls. These 'falls' have been a lure and meeting placing for past ancient peoples who lived in the area. Native American tribes of the Lakota and Dakota also used the falls as a rendezvous place to trade with other tribes and white explorers who appeared around the eighteenth century. Eventually, two groups of speculative land developers, the Western Town Company of Dubuque, Iowa, and the Dakota Land Company of St. Paul, claimed the land around the falls as a promising town site in 1856 and 1857, respectively. This location provided a water supply, a source of drinking water, and a place of beauty. The population of this early claim grew to near 40 in 1858. As Sioux Falls grew in importance and population, it was incorporated as a village in 1876 and a city charter was granted in 1883

Residents of Sioux Falls began using dug wells as a source of drinking water in 1890 (USGS 1973) when it had a population of 10,177 residents. Rothrock (1947) reported that "the Big Sioux River has an average annual discharge of 246 cubic feet per second and on the average exceeds bank full stage every 2-3 years. Periods of low flow are common in the late summer, fall, and winter with and a low flow of 0.1 cubic foot per second has been recorded." The low flow periods during drought cycles or late summer did not provide an adequate sustainable source of surface-provided water for Sioux Falls residents. The first of large diameter dug wells were constructed in 1906 as the city grew and the need for water increased. These new public wells tapped into the Big Sioux River aquifer as a source of ground water. The city continued to grow to 10,266 residents in 1900 and 14,094 residents in 1910. A total of nine public supply wells were constructed prior to 1934, fulfilling the water demands of a population which had grown to 33,362 in 1930.

The aquifer under the Big Sioux River runs along the river's entire length in eastern South Dakota. See Figure 2-1. It is a shallow, unconfined aquifer covering approximately 1,000 square miles in the Big Sioux River basin. The glacial outwash aquifer averages 20 feet in thickness but ranges from a few feet thick to over 100 feet thick. Because of the aquifer's consistency in providing water, the city of Sioux Falls became more dependent on the aquifer underlying the Big Sioux River as the city grew. The Big Sioux Ground Water Reservoir, between Dell Rapids and Sioux Falls, represents a body of sand and gravel averaging 40 feet deep, 2 miles wide, 18 miles long, and covering approximately 36 square miles. This naturally formed trough is sealed with a clay bottom and clay sides. This segment of the Big Sioux aquifer was created by two large quartzite bed rock dams buried deep, west-to-east, across the river valley forming this trough. One dam is at Dell Rapids and one crosses the Big Sioux River valley near Madison Avenue in Sioux Falls. The aquifer butts up against these bed rock dams at its upper and lower ends. The quartzite bedrock under this aquifer is a sandstone so solid that its pore space has been filled with cement leaving pore spaces as low as 2% of the rock, making the quartzite very impermeable (Rothrock 1947).

The number of wells and the amount of water withdrawn from this aquifer have increased rapidly as the population of Sioux Falls increased. As of January 1969, the city well field consisted of 28 operating wells (Jorgensen & Ackroyd 1973), by 1970 the resident population had increased to 72,488. In addition to the water supply from wells, 6 million gallons per day (mgd) of Big Sioux River water could have been withdrawn directly from intakes in the flood-diversion channel (Rothrock 1947). The existing water treatment plant in Sioux Falls was constructed in 1956 and designed to treat up to 24 mgd per day. Later upgrades to this facility have increased the capacity to treat and deliver up to 75 mgd. By 1989 the population of Sioux Falls had grown to 101,000 and the average daily pumping rate was 17.3 mgd (SDGS 1989). The 1989 water supply study by SDGS estimated the population of Sioux Falls to be 137,000 by the year 2030. Sioux Falls exceeded this population estimate in 2004. Currently records (2015) show the city is pumping an average of 19.6 mgd for an estimated population of over 170,000. The ground water supply is pumped via 55 water wells located in the Big Sioux River and the Middle Skunk Creek aquifers. Any additional needed drinking water that is needed can be pumped from the one surface water pumping station in the Big Sioux River.

Figure 2-1: Aquifer Map of the Big Sioux River. South Dakota's Ground Water Quality Monitoring Network Project Completion Report 2001. SDDENR



Sioux Falls has historically balanced both surface water from the Big Sioux River and well water from its aquifer to meet their water demands. However, Sioux Falls used 100% well water in 2014 and 2015 with the most recent year of surface water pumping from the river being 2013 (personal communication, G. Graverson, Sioux Falls Water Division). The average natural recharge to the Big Sioux aquifer was estimated to be 11.9 mgd (Hedges 1982), while the daily average use was about 20 mgd. The difference between the daily water use and the estimated daily natural recharged is balanced by induced recharge to the aquifer from the Big Sioux River. As long as the Big Sioux River continued to flow, water use could continue at this rate. Koch (USGS 1983) calculated that at a pumping rate of 25 mgd from the aquifer could only be sustained for 248 days. The SDGS study determined that without pollution control practices near the Sioux Falls city wells and control on additional consumptive uses upstream from Dell Rapids, the Sioux Falls management unit of the Big Sioux aquifer would not be adequate to meet the city's increasing water demand. One of their recommendations was to compare local options of obtaining water to a cost of a Missouri River pipeline. Since that time the Missouri River pipeline recommendation has developed into the Lewis & Clark Regional Water System (LCRWS). The City of Sioux Falls has joined the LCRWS project and when it is completed an additional 27 mgd of water per day can be delivered to the City of Sioux Falls. The city began purchasing water from LCRWS in 2012 and has purchased water all years through 2015.

Jorgensen stated the differences between the quality of water in the river and water in the aquifer at the well field were not that great. However, the differences necessitated variations in methods of treating the water. Well water pumped largely from aquifer storage was more mineralized and cost more to treat than water taken directly from the river. Raw ground water from the wells near Sioux Falls was classified as a hard bicarbonate water with high quantities of iron and manganese. River water, although generally softer, had objectionable tastes and odors that were often associated with surface water. Water from wells located near the river had no objectionable odor or taste and were relatively economical to treat.

One of the most significant conclusions from Rothrock's studies was that the pumping from the Sioux Falls well field greatly exceeded the capacity of the river valley's deposits to transmit water from the upper watershed. The valleys provided about 25% of the pumping needs at that time, while the remaining volume (75%) was provided by the Big Sioux River recharging the well field. It was determined that the Big Sioux River was important because the river delivered water to the aquifer, thus recharging the well fields and meeting the pumping demands of Sioux Falls. The water quality studies along the entire Big Sioux River aquifer have emphasized the importance of improving water conditions along the Big Sioux River, as about 40% of South Dakota's population drinks the water from the Big Sioux River watershed. The cities of Watertown, Brookings, Flandreau, Sioux Falls, Canton, and rural water systems of King-Brook, Big Sioux, Minnehaha, and South Lincoln all draw water from the Big Sioux aquifer and can impact total water available to each downstream entity, as the water in the unconfined aquifer flows southward along the river.

The construction of dams has been considered as a water source for Sioux Falls. Sites were investigated just west of Sioux Falls, four miles downstream of Sioux Falls, and at Rowena four miles south of Brandon. Other sites investigated were the valley of Skunk Creek above the town of Ellis and the valley of Split Rock Creek in the vicinity of Corson (Rothrock 1947). The U.S. Army Corps of Engineers also evaluated a proposed dam site on Skunk Creek near Hartford and a proposed dam site on the Big Sioux River near Flandreau. The U.S. Bureau of Reclamation (1969) finished a reconnaissance report on the feasibility of another reservoir on Slip Up Creek in 1969. However, no major dams were ever constructed for a water supply.

The EWDD implemented a comprehensive local groundwater protection project in eleven counties along the Big Sioux River. The main project objective was to protect water supplies and shallow groundwater resources through local county zoning ordinances. A secondary objective was to reduce potential groundwater contamination from ground water/surface water interchange and nonpoint pollution sources. Protection was provided mainly by restricting land use through local zoning ordinances. Education, land use conversion, and supplemental projects also helped protect groundwater resources. The model ordinance established two protective zones: Zone A, where new facilities or land uses that have the potential to contaminate groundwater were prohibited; and Zone B, where most facilities were allowed to build as long as performance standards were met, such as secondary containment for all storage tanks. Eleven counties were covered in this project that served approximately one-third of South Dakota’s population: Brookings, Clark, Codington, Deuel, Grant, Hamlin, Kingsbury, Lake, Miner, Minnehaha, and Moody.

2.2 2014 SDDENR - Integrated Report Status on Water Body Listings

The *2014 South Dakota-DENR Integrated Report for Surface Water Quality Assessment* for both lakes and streams in the Big Sioux River Watershed Improvement Project area reported that Chlorophyll-*a*, *Escherichia coli* and Fecal Coliform Bacteria, Total Suspended Solids, and Mercury were the identified impairments listed within the watershed project area. Figures 2-2 and 2-3 show the locations of the reaches for the identified water bodies in the BSRWIP. The report of stream water bodies with designated beneficial uses, impairments, and causes of impairments is presented in Table 2-1. The 303(d) listed water bodies are summarized in Table 2-2.

Figure 2-2: Upper Big Sioux River Basin. SDDENR IR 2014

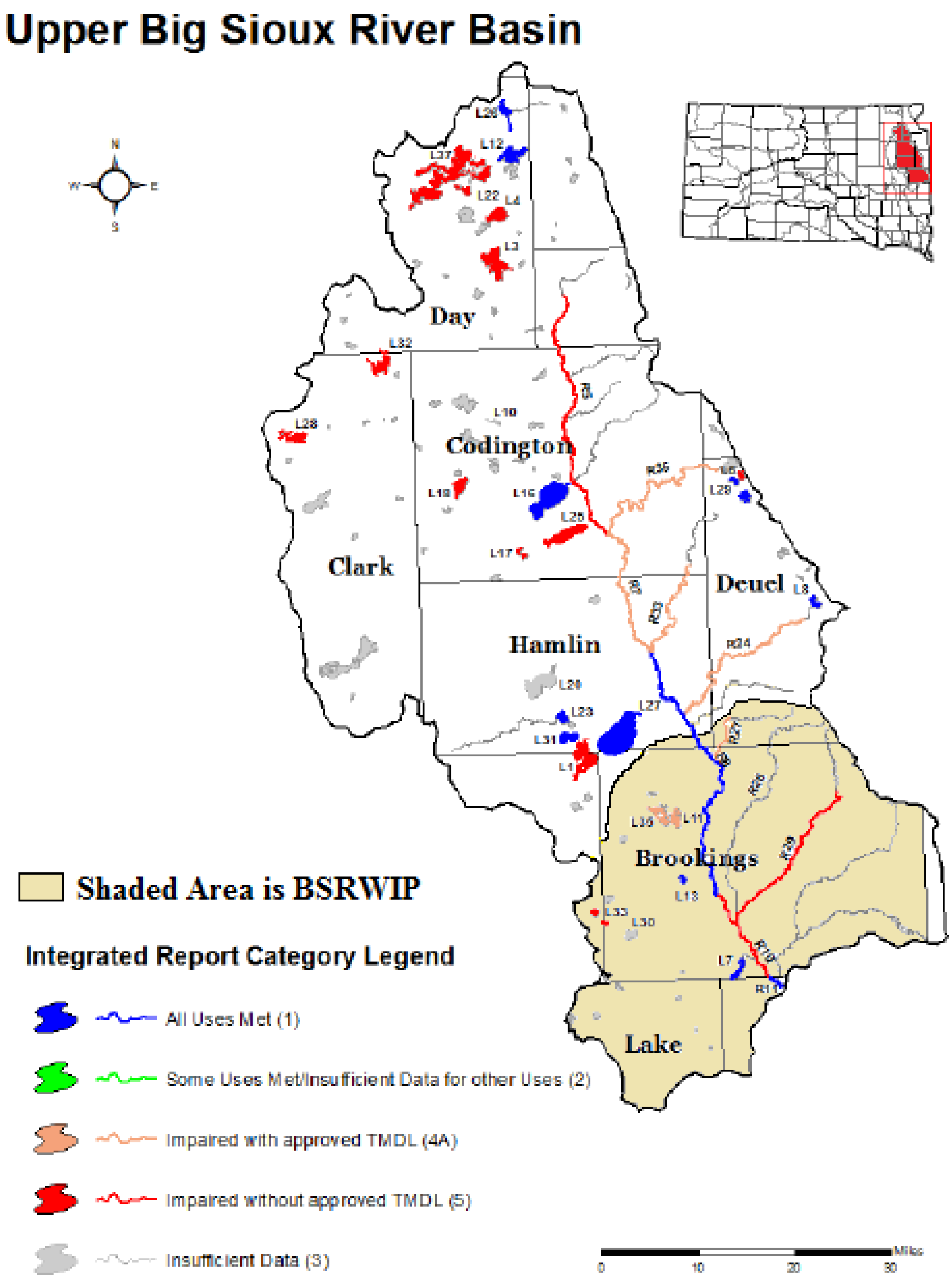


Figure 2-3: Lower Big Sioux River Basin. SDDENR IR 2014

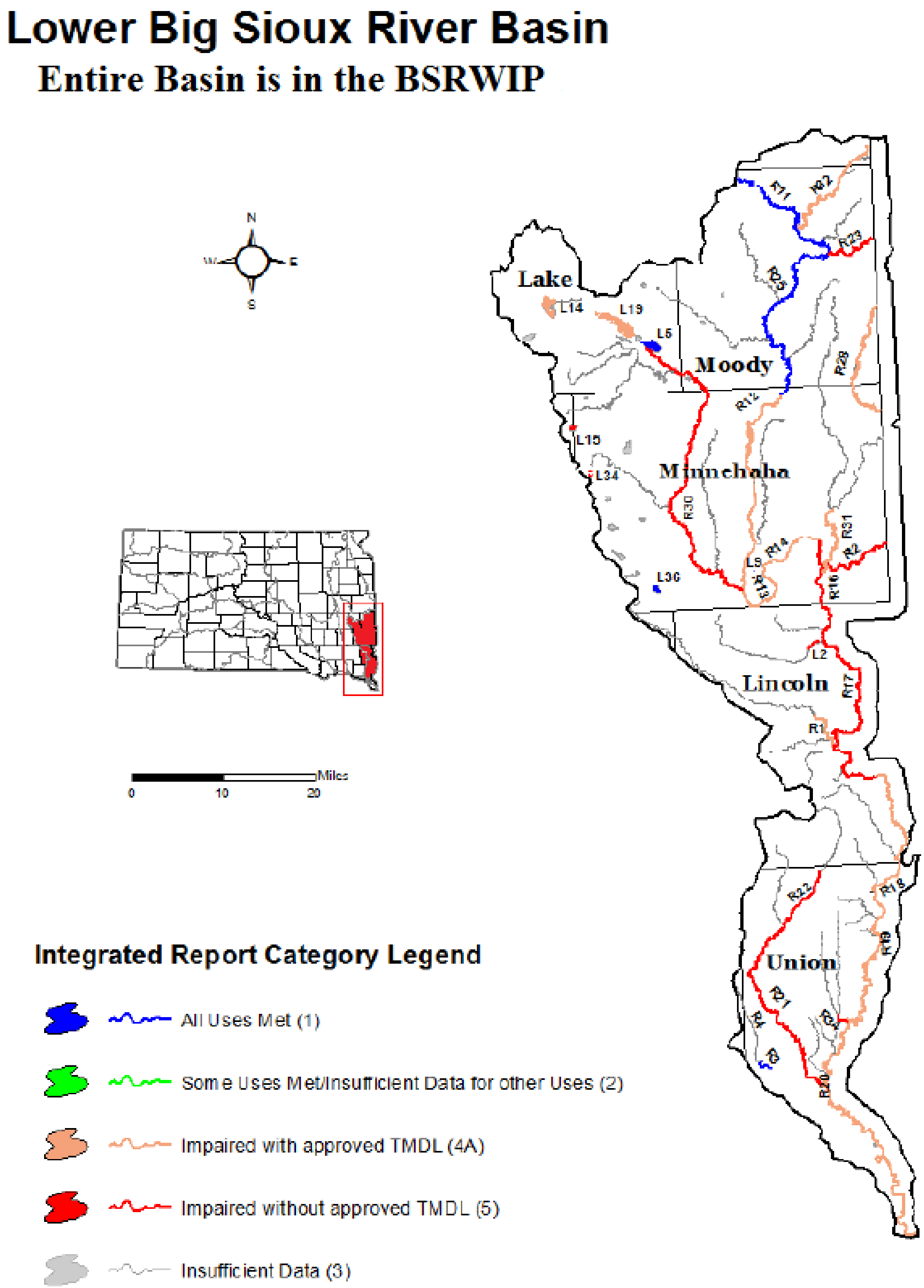


Table 2-1. BSRWIP Stream Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. Data from *The 2014 SD Integrated Report for Surface Water Quality Assessment*

WATERBODY Streams/AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Beaver Creek	Big Sioux River	R1	DENR	Fish/Wildlife Prop, Rec, Stock	INS			4A*	NO
SD-BS-R-Beaver_01	to		MCPA	Irrigation Waters	INS				
	S9, T98N, R49W			Limited Contact Recreation	NON	Fecal Coliform	Livestock		
				Warmwater Marginal Fish Life	INS				
Beaver Creek	Split Rock Creek	R2	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5*	YES-1
SD-BS-R-Beaver_02	to			Irrigation Waters	FULL				
	SD-MN Border			Limited Contact Recreation	NON	Escherichia coli			
						Fecal Coliform			
				Warmwater Marginal Fish Life	NON	Total Suspended Solids			
Big Ditch Creek	Headwaters	R3	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	NO
SD-BS-R-Big_Ditch_01	to			Irrigation Waters	FULL				
	S21, T92N, R50W								
Unamed Tributary	Headwaters	R4	DENR	Fish/Wildlife Prop, Rec, Stock	INS			3	NO
to Big Ditch Creek	to			Irrigation Waters	INS				
SD-BS-R-BIG_DitchTrib_01	Big Ditch Creek								
Big Sioux River	Stray Horse Creek	R8	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	NO
SD-BS-R-Big_Sioux_04	to		USGS	Irrigation Waters	FULL				
	near Volga		EDWDD	Limited Contact Recreation	FULL				
				Warmwater Semipermanent Fish Life	FULL				
Big Sioux River	Near Volga	R9	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5	YES-1
SD-BS-R-Big_Sioux_05	to		EDWDD	Irrigation Waters	FULL				
	Brookings			Limited Contact Recreation	FULL				
				Warmwater SemiPermanent Fish Life	NON	Total Suspended Solids			

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired, requires a TMDL. *Waterbody has an EPA approved TMDL. D**-TMDL development in Discussion with to EPA.

Table 2-1 Continued: BSRWIP Stream Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. Data from *The 2014 SD Integrated Report for Surface Water Quality Assessment*

WATERBODY Streams/AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Big Sioux River	Brookings to	R10	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5	YES-1
SD-BS-R-Big_Sioux_06	Brookings/Moody			Irrigation Waters	FULL				
	County Line			Limited Contact Recreation	FULL				
				Warmwater SemiPermanent Fish Life	NON	Total Suspended Solids			
Big Sioux River	Brookings/Moody	R11	DENR	Domestic Water Supply	FULL			1*	NO
SD-BS-R-Big_Sioux_07	County Line		USGS	Fish/Wildlife Prop, Rec, Stock	FULL				
	to		EDWDD	Irrigation Waters	FULL				
	S2, T104N, R49W			Limited Contact Recreation	FULL				
				Warmwater SemiPermanent Fish Life	FULL				
Big Sioux River	S2, T104N, R49W	R12	DENR	Domestic Water Supply	FULL			4A*	NO
SD-BS-R-Big_Sioux_08	to		USGS	Fish/Wildlife Prop, Rec, Stock	FULL				
	Interstate 90		Sioux Falls	Immersion Recreation	NON	Escherichia coli	Livestock		
			EDWDD			Fecal Coliform			
				Irrigation Waters	FULL				
				Limited Contact Recreation	FULL				
				Warmwater SemiPermanent Fish Life	NON	Total Suspended Solids	Cropping		
Big Sioux River	Interstate 90	R13	DENR	Domestic Water Supply	FULL			4A*	NO
SD-BS-R-Big_Sioux_10	to		USGS	Fish/Wildlife Prop, Rec, Stock	FULL				
	Diversion Return		EDWDD	Immersion Recreation	NON	Escherichia coli	Livestock		
						Fecal Coliform			
				Irrigation Waters	FULL				
				Limited Contact Recreation	NON	Escherichia coli	Municipal		
						Fecal Coliform			
				Warmwater SemiPermanent Fish Life	NON	Total Suspended Solids			
Big Sioux River	Diversion Return	R14	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	NO
SD-BS-R-Big_Sioux_11	to		USGS	Immersion Recreation	NON	Escherichia coli	Livestock		
	Sioux Falls		Sioux Falls			Fecal Coliform	Municipal		
	WWTF		EDWDD	Irrigation Waters	FULL				
				Limited Contact Recreation	NON	Escherichia coli			
						Fecal Coliform			
				Warmwater Semipermanent Fish Life	NON	Total Suspended Solids			

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired, requires a TMDL. *Waterbody has an EPA approved TMDL. D-TMDL development in Discussion with to EPA.**

Table 2-1 Continued: BSRWIP Stream Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. Data from *The 2014 SD Integrated Report for Surface Water Quality Assessment*

WATERBODY Streams/AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Big Sioux River	Sioux Falls	R15	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	No
SD-BS-R-Big_Sioux_12	WWTF		Sioux Falls	Immersion Recreation	NON	Escherichia coli			
	to					Fecal Coliform	Livestock		
	above Brandon			Irrigation Waters	FULL				
				Limited Contact Recreation	NON	Escherichia coli			
						Fecal Coliform			
				Warmwater Semipermanent Fish Life	NON	Total Suspended Solids			
Big Sioux River	Above Brandon	R16	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5A*	YES-1
SD-BS-R-Big_Sioux_13	to		EDWDD	Immersion Recreation	NON	Escherichia coli	Livestock		
	Nine Mile Creek					Fecal Coliform	Grazing		
				Irrigation Waters	FULL				
				Limited Contact Recreation	NON	Escherichia coli			
						Fecal Coliform			
				Warmwater Semipermanent Fish Life	NON	Total Suspended Solids			
Big Sioux River	Nine Mile Creek	R17	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5*	YES-1
SD-BS-R-Big_Sioux_14	to near			Immersion Recreation	NON	Escherichia coli			
	Fairview					Fecal Coliform	Livestock		
				Irrigation Waters	FULL				
				Limited Contact Recreation	NON	Escherichia coli			
						Fecal Coliform			
				Warmwater Semipermanent Fish Life	NON	Total Suspended Solids			
Big Sioux River	Fairview to	R18	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	NO
SD-BS-R-Big_Sioux_15	near Alcester			Immersion Recreation	NON	Escherichia coli			
						Fecal Coliform	Grazing		
				Irrigation Waters	FULL				
				Limited Contact Recreation	NON	Escherichia coli	Grasing		
				Warmwater Semipermanent Fish Life	NON	Total Suspended Solids	Grazing		
							Crop		

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired, requires a TMDL. *Waterbody has an EPA approved TMDL. D**-TMDL development in Discussion with to EPA.

Table 2-1 Continued: BSRWIP Stream Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. Data from *The 2014 SD Integrated Report for Surface Water Quality Assessment*

WATERBODY Streams/AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Big Sioux River	Near Alcester	R19	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	NO
SD-BS-R-Big_Sioux_16	to			Immersion Recreation	NON	Escherichia coli	Livestock		
	Indian Creek					Fecal Coliform	Grazing		
				Irrigation Waters	FULL				
				Limited Contact Recreation	NON	Escherichia coli	Livestock		
						Fecal Coliform	Grazing		
				Warmwater Semipermanent Fish Life	NON	Total Suspended Solids	Streambank		
							Crop		
Big Sioux River	Indian Creek	R20	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	NO
SD-BS-R-Big_Sioux_17	to			Immersion Recreation	NON	Escherichia coli			
	Mouth					Fecal Coliform	Livestock		
				Irrigation Waters	FULL		Grazing		
				Limited Contact Recreation	NON	Escherichia coli			
						Fecal Coliform	Grazing		
				Warmwater Semipermanent Fish Life	NON	Total Suspended Solids	Streambank		
							Grazing		
							Crop		
Brule Creek	Big Sioux River	R21	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5*	YES-1
SD-BS-R-Brule_01	to confluence of			Irrigation Waters	FULL				
	its east and			Limited Contact Recreation	NON	Escherichia coli			
	west forks			Warmwater Marginal Fish Life	FULL				
East Brule Creek	Confluence with	R22	DENR	Fish/Wildlife Prop, Rec, Stock	INS			5*	YES-1
SD-BS-R-East_Brule_01	Brule Creek to			Irrigation Waters	INS				
	S3, T95N, R49W			Limited Contact Recreation	NON	Fecal Coliform	Grazing		
				Warmwater Marginal Fish Life	NON	Total Suspended Solids			
Flandreau Creek	Big Sioux River	R23	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5*	YES-1
SD-BS-R-Flandreau_01	to		USGS	Irrigation Waters	FULL				
	Minnesota Border		MPCA	Limited Contact Recreation	NON	Escherichia coli			
				Warmwater Marginal Fish Life	FULL				

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired, requires a TMDL. *Waterbody has an EPA approved TMDL. D**-TMDL development in Discussion with to EPA.

Table 2-1 Continued: BSRWIP Stream Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. Data from *The 2014 SD Integrated Report for Surface Water Quality Assessment*

WATERBODY Streams/AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Jack Moore Creek	Big Sioux River	R25	DENR	Fish/Wildlife Prop, Rec, Stock	INS			3*	NO
SD-BS-R-Jack_Moore_01	to			Irrigation Waters	INS				
	S33, T107N, R49W			Limited Contact Recreation	INS				
				Warmwater Marginal Fish Life	INS				
North Deer Creek	Six Mile Ceek	R26	DENR	Fish/Wildlife Prop, Rec, Stock	INS			3*	NO
SD-BS-R-North_Deer_01	to			Irrigation Waters	INS				
	US Highway 77			Limited Contact Recreation	INS				
				Warmwater Marginal Fish Life	INS				
Peg Munky Run	Big Sioux River	R27	DENR	Fish/Wildlife Prop, Rec, Stock	INS				
SD-BS-Peg_Munky_Run 01	to			Irrigation Waters	INS				
	S17, T113N, R50W			Limited Contact Recreation	NON	Fecal Coliform	Grazing	4A*	NO
				Warmwater Marginal Fish Life	INS				
Pipestone Creek	Split Rock Creek	R28	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	NO
SD-BS-R-Pipestone_01	to		USGS	Immersion Recreation	NON	Fecal Coliform			
	Minnesota Border		MCPA			Escherichia coli	Grazing		
				Irrigation Waters	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Semipermanent Fish Life	FULL				
Six Mile Creek	Big Sioux River	R29	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5*	YES-2
SD-BS-R-Sixmile_01	to S30			Irrigation Waters	FULL				
	T112N, R48W			Limited Contact Recreation	NON	Escherichia coli			
						Fecal Coliform			
				Warmwater Marginal Fish Life	NON	Total Suspended Solids			

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired, requires a TMDL. *Waterbody has an EPA approved TMDL. D**-TMDL development in Discussion with to EPA

Table 2-1 Continued: BSRWIP Stream Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. Data from *The 2014 SD Integrated Report for Surface Water Quality Assessment*

WATERBODY Streams/AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Skunk Creek	Brant Lake	R30	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5*	YES-2
SD-BS-R-Skunk_01	to		USGS	Irrigation Waters	FULL				
	Big Sioux River		Sioux Falls	Limited Contact Recreation	NON	Escherichia coli			
			EDWDD			Fecal Coliform			
				Warmwater Marginal Fish Life	NON	Total Suspended Solids			
Split Rock Creek	At Corson, SD	R31	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	NO
SD-BS-R-Split_Rock_01			USGS	Immersion Recreation	NON	Fecal Coliform	Livestock		
USGS				Irrigation Waters	FULL				
				Limited Contact Recreation	FULL-TH	Fecal Coliform			
				Warmwater Semipermanent Fish Life	FULL				
Spring Creek	Big Sioux River	R32	DENR	Fish/Wildlife Prop, Rec, Stock	INS			4A*	NO
SD-BS-R-Spring_01	to S22			Irrigation Waters	INS				
	T109N, R47W			Limited Contact Recreation	INS-TH	Fecal Coliform	Livestock		
				Warmwater Marginal Fish Life	INS				
Union Creek	Big Sioux River	R34	DENR	Fish/Wildlife Prop, Rec, Stock	INS			5	YES-1
SD-BS-R-Union_01	to			Irrigation Waters	INS				
	confluence with			Limited Contact Recreation	INS-TH	Fecal Coliform	Livestock		
	East & West Forks			Warmwater Marginal Fish Life	INS-TH	Total Suspended Solids			

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired, requires a TMDL. *Waterbody has an EPA approved TMDL. D**-TMDL development in Discussion with to EPA

Table 2-2. Summary of Big Sioux River WIP Areas Stream Water Bodies Listed as 303(d) Impaired			
Water Body Impaired	**Reach**	**Beneficial Use Impaired**	**Listed Cause of Impairment**
Big Sioux River	R12, R13, R14, R15, R16, R17, R18, R19, R20,	Immersion Recreation	E. coli , Fecal Coliform
	R13, R14, R15, R16, R17, R18, R19, R20,	Limited Contact Recreation	E. coli , Fecal Coliform
	R9, R10, R12, R13, R14, R15, R16, R17, R18, R19, R20,	Warmwater Semipermanent Fish Life	Total Suspended Solids
Beaver Creek	R1, R2	Limited Contact Recreation	Fecal Coliform
	R2	Warmwater Marginal Fish Life	Total Suspended Solids
Brule Creek	R21	Limited Contact Recreation	Escherichia coli
East Brule Creek	R22	Limited Contact Recreation	Fecal Coliform
		Warmwater Marginal Fish Life	Total Suspended Solids
Flandreau Creek	R23, R24	Limited Contact Recreation	Escherichia coli
Pipestone Creek	R28	Immersion Recreation	E. coli , Fecal Coliform
Six Mile Creek *	R29	Limited Contact Recreation	E. coli , Fecal Coliform
		Warmwater Marginal Fish Life	Total Suspended Solids
Skunk Creek *	R30	Limited Contact Recreation	Escherichia coli
		Warmwater Marginal Fish Life	Total Suspended Solids
Split Rock Creek	R31	Immersion Recreation	Fecal Coliform
		Limited Contact Recreation	Fecal Coliform
Spring Creek	R32	Limited Contact Recreation	Fecal Coliform
Union Creek	R34	Limited Contact Recreation	Fecal Coliform
		Warmwater Marginal Fish Life	Total Suspended Solids

* Proposed for Delisting in SDDENR-IR 2016

Table 2-3: BSRWIP Lake Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. Data from *The 2014 SD Integrated Report for Surface Water Quality Assessment*

WATERBODY Lakes/AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Lake Alvin	Lincoln County	L2	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			5*	YES-2
SD-BS-L-Alvin_01				Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Permanent Fish Life	NON	Temperature, Water			
Brant Lake	Lake County	L5	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1*	NO
SD-BS-L-Brant_01				Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Permanent Fish Life	FULL				
Lake Campbell	Brookings County	L7	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	NO
SD-BS-L-Campbell_01				Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Marginal Fish Life	FULL				
Covell Lake	Minnehaha County	L9	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	NO
SD-BS-L-Covell_01				Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Marginnal Fish Life	FULL				
East Oakwood Lake	Brookings County	L11	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	NO
SD-BS-L-E_Oakwood_01				Immersion Recreation	NON	Chlorophyll-a			
				Limited Contact Recreation	NON	Chlorophyll-a			
				Warmwater Semipermanent Fish Life	NON	Chlorophyll-a			
						pH (high)			
Goldsmith Lake	Brookings County	L13	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	NO
SD-BS-L-Goldsmith_01				Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater Marginal Fish Life	FULL				

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired, requires a TMDL. *Waterbody has an EPA approved TMDL. D**-TMDL development in Discussion with to EPA

Table 2-3 Continued: BSRWIP Lake Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. Data from *The 2014 SD Integrated Report for Surface Water Quality Assessment*

WATERBODY Streams/AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
Lake Herman	Lake County	L14	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	NO
SD-BS-L-Herman_01				Immersion Recreation	NON	Chlorophyll-a			
				Limited Contact Recreation	NON	Chlorophyll-a			
				Warmwater SemiPermanent Fish Life	NON	Chlorophyll-a			
North Island Lake	Minnehaha/McCook	L15	DENR	Fish/Wildlife Prop, Rec, Stock	NA			5	YES-2
SD-BS-L-Island_N_01	Counties (formerly			Immersion Recreation	NA				
	SD-VM-L-Island_			Limited Contact Recreation	NA				
	N_01)			Warmwater SemiPermanent Fish Life	INS-TH	Mercury in Fish Tissue	Non-Point		
Lake Madison	Lake County	L19	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	NO
SD-BS-L-Madison_01				Immersion Recreation	NON	Chlorophyll-a			
				Limited Contact Recreation	NON	Chlorophyll-a			
				Warmwater Permanent Fish Life	NON	Chlorophyll-a			
Lake Sinai	Brookings County	L30	DENR	Fish/Wildlife Prop, Rec, Stock	INS			3	NO
SD-BS-L-Sinai_01				Immersion Recreation	NA				
				Limited Contact Recreation	NA				
				Warmwater Permanent Fish Life	INS				
Twin Lakes/W. Hwy 81	Kingsbury County	L33	DENR	Fish/Wildlife Prop, Rec, Stock	INS-TH	Mercury in Fish Tissue	Non-Point	5	YES-2
SD-BS-L-Twin_01									
Twin Lakes	Minnehaha County	L34	DENR	Fish/Wildlife Prop, Rec, Stock	INS-TH	Mercury in Fish Tissue	Non-Point	5	YES-2
SD-BS-L-Twin_02				Immersion Recreation	NA				
				Limited Contact Recreation	NA				
				Warmwater Permanent Fish Life	NA				

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired, requires a TMDL. *Waterbody has an EPA approved TMDL. D**-TMDL development in Discussion with to EPA

Table 2-3 Continued: BSRWIP Lake Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. Data from *The 2014 SD Integrated Report for Surface Water Quality Assessment*

WATERBODY Streams/AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	SOURCE	EPA CATEGORY	303(d) Priority
West Oakwood Lake	Brookings County	L35	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			4A*	No
SD-BS-L-W_Oakwood_01				Immersion Recreation	NON	Chlorophyll-a			
				Limited Contact Recreation	NON	Chlorophyll-a			
				Warmwater SemiPermanent Fish Life	NON	Chlorophyll-a			
Wall Lake	Minnehaha County	L36	DENR	Fish/Wildlife Prop, Rec, Stock	FULL			1	NO
SD-BS-L-Wall_01				Immersion Recreation	FULL				
				Limited Contact Recreation	FULL				
				Warmwater SemiPermanent Fish Life	FULL				

Category (1) All uses met, (2) Some uses met but insufficient data to determine support of other uses, (3) Insufficient data, (4a) Water impaired but has an approved TMDL, (5) Water impaired, requires a TMDL. *Waterbody has an EPA approved TMDL. D**-TMDL development in Discussion with to EPA

Table 2-4. Summary of Big Sioux River WIP Areas Lake Water Bodies Listed as 303(d) Impaired		
Water Body Impaired	**Beneficial Use Impaired**	**Listed Cause of Impairment**
Lake Alvin *	Warmwater Permanent Fish Life	Temperature, Water
East Oakwood Lake	Immersion Recreation	Chlorophyll-a
	Limited Contact Recreation	Chlorophyll-a
	Warmwater Semipermanent Fish Life	Chlorophyll-a
Lake Herman	Immersion Recreation	Chlorophyll-a
	Limited Contact Recreation	Chlorophyll-a
	Warmwater Semipermanent Fish Life	Chlorophyll-a
North Island Lake *	Warmwater Semipermanent Fish Life	Mercury in Fish Tissue
Lake Madison	Immersion Recreation	Chlorophyll-a
	Limited Contact Recreation	Chlorophyll-a
	Warmwater Permanent Fish Life	Chlorophyll-a
Twin Lakes/W.Hwy 81 *	Fish/Wildlife Prop, Rec, Stock	Mercury in Fish Tissue
Twin Lakes *	Fish/Wildlife Prop, Rec, Stock	Mercury in Fish Tissue
West Oakwood Lake	Immersion Recreation	Chlorophyll-a
	Limited Contact Recreation	Chlorophyll-a
	Warmwater Semipermanent Fish Life	Chlorophyll-a

*** Proposed for 303(d) Delisting in SDDENR-IR 2016**

2.3 Descriptions of the Impairments for 303(d) Water Body Listings in the BSRWIP

2.3.1 *Escherichia coli* and Fecal Coliform

Fecal coliform are bacteria that are found in the waste of warm-blooded animals. Common types of bacteria associated with livestock, wildlife, and human feces are *E. coli*, Salmonella, and Streptococcus. These fecal indicators are microbes whose presence indicates that the water is contaminated with human or animal wastes. Fecal coliform, enterococci, and *E. coli* bacteria are not usually disease-causing agents themselves; however, high concentrations may suggest the presence of disease-causing organisms.

Of the coliforms, *E. coli* is generally the most sensitive to environmental stresses and rarely grows outside the human or animal gut. *E. coli* bacteria are normally excreted by the billions in animal wastes, and their survival time in the environment generally lasts only four to twelve weeks. The inability of *E. coli* to grow in water, combined with its short survival time in water environments, means that the detection of *E. coli* in a water body is a good indicator that fecal contamination from sewage or animal waste recently entered the system. Thus, *E. coli* is used to indicate the probability of finding other pathogenic organisms in a stream. The pathogenic microbes in these wastes can cause short-term health effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They also pose a special health risk for infants, young children, some of the elderly, and people with severely compromised immune systems. Sources of fecal contamination to surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and storm runoff. The presence of elevated levels of fecal bacteria can also cause cloudy water, unpleasant odors, and an increased oxygen demand.

2.3.2 Total Suspended Solids (TSS)

Solids present in water are addressed separately as total solids, dissolved solids, suspended solids, and volatile suspended solids. The TSS are the sum of all forms of material including suspended and dissolved solids that will not pass through a filter. The TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life by blocking light from reaching submerged vegetation. As the amount of light passing through the water is reduced, photosynthesis slows down. Reduced rates of photosynthesis causes less DO to be released into the water by plants. If light is completely blocked from bottom dwelling plants, the plants will stop producing oxygen and die. Bacteria uses up additional oxygen from the water as the plants decompose resulting in lower DO which can lead to fish kills. High TSS can also cause an increase in surface water temperature because the suspended particles absorb heat from sunlight. This can cause DO levels to fall even further as warmer waters hold less DO.

The decrease in water clarity caused by TSS can affect the ability of fish to see and catch food. Suspended sediment can also clog fish gills, reduce growth rates, decrease resistance to disease, and prevent egg and larval development. When suspended solids settle to the bottom of a waterbody, they can smother the eggs of fish and aquatic insects, as well as suffocate newly hatched insect larvae. Settling sediments can fill in spaces between rocks which could have been used by aquatic organisms. High TSS in a waterbody can mean high concentrations of bacteria, nutrients, pesticides, and metals in the water. These pollutants attach to sediment particles on the land, are carried into water bodies with storm events, and are then released from the sediment or travel farther downstream.

2.3.3 Chlorophyll-*a*

Chlorophyll-*a* is the primary photosynthetic pigment found in oxygen producing plants and blue-green algae. The measurement of Chlorophyll-*a* is an indirect indicator of the nutrient levels in a lake, the lake's productivity, and its state of eutrophication. Waters that have high chlorophyll conditions are typically high in nutrients, generally phosphorus and nitrogen. These two nutrients cause the algae to grow or bloom. High levels of nitrogen and phosphorus are indicators of pollution from man-made sources, such as animal wastes, septic system leakage, poorly functioning wastewater treatment plants, soil erosion, or fertilizer runoff. Chlorophyll measurement is utilized as an indirect indicator of these nutrient levels.

Nitrogen is difficult to limit in aquatic environments because of its highly soluble nature. Due to the many environmental sources of nitrogen (atmospheric, soil, fertilizer, and fecal matter), nitrogen is difficult to remove from a water system. Blue green algae can also convert nitrogen for their own growth making it even more difficult to control. For these reasons, the focus on nutrient reduction is usually on phosphorus instead of nitrogen. Phosphorus is easier to control in the environment, making it the primary nutrient targeted for reduction when attempting to control lake eutrophication. The large algal blooms in studied lakes typically coincided with large phosphorus concentrations. Chlorophyll levels significantly increase due to algae blooms that occur during periods of higher water temperature. Levels may also increase due to the stratification of the water column which may cause anoxic conditions in the hypolimnion. The anoxia is accompanied by low pH values and results in the release of nutrients, particularly phosphorus, from the bottom sediments. This release of total nitrogen, total phosphorous, and total dissolved phosphorous concentration can result in the algal blooms that persist throughout the summer.

When algae populations bloom and then die in response to changing environmental conditions, they deplete DO levels, a primary cause of most fish kills. Methods to eliminate the existing nutrients by artificial oxygenation of lake bottoms could result in fewer and less intense algal blooms. However, little data exists on circulators, oxygenators, and other types of equipment that eliminate stratification of the water column and the affect they have on the frequency or intensity of nuisance algal blooms. The reduction of nutrient inputs, primarily phosphorus, into the BSRWIP water bodies would be the preferred method to prevent algal blooms, reduce Chlorophyll-*a* concentrations, and meet 303(d) impairment standards

Scientists from the U.S. Geological Survey (USGS 2010), studying the effects of harmful algal blooms on lake water quality, found that blooms of blue-green algae (cyanobacteria) in Midwestern lakes also produced mixtures of cyanotoxins and taste-and-odor causing compounds such as geosmin. Cyanotoxins can be toxic to mammals, including humans, causing allergic and/or respiratory issues, attacking the liver and kidneys, or affecting the nervous system. The findings of this study were significant because studies assessing toxicity and risk of cyanotoxin exposure have historically focused on only one class of toxins (microcystins). The World Health Organization has established the highest risk threshold for human exposure to cyanotoxins at >50 mg/L with the range of 10-50 mg/L considered as a moderate exposure risk. It was recommended that lakes having a chlorophyll-*a* level within this range should be sampled for cyanobacteria and microcystin levels. After examining various thresholds and approaches, Region 8 of the USEPA set a maximum threshold average of 30 mg/L during the growing season of May 1 to September 30 as the 303(d) listing criteria.

2.3.4 pH Levels

The pH of water has a strong effect on which fish, amphibians, invertebrates, and plants can live in a community. The pH of water affects most chemical and biological processes in water, and it is one of the most important environmental factors limiting the distribution of species in aquatic habitats. The pH is the measure of hydrogen ions or acidity in a water solution. The pH scale ranges from 0 (most acidic) to 14 (most basic). A pH of 7 is considered neutral. The pH scale is logarithmic, and it changes by the power of ten; as a change of one whole number in the pH equals a tenfold change in the amount of acidity. Changes of two whole numbers indicate a 100-fold change in acidity. Naturally occurring pH levels typically fall between 6.5 and 9.0. The pH of a stream or lake is dependent on the water source and the kinds of rocks and soil that the water contacts. Certain dissolved minerals, such as calcium carbonate, can combine with the extra hydrogen or hydroxyl ions that alter the water's pH. When water percolates through these soils, these minerals dissolve, and their buffering quality is passed along to the water. This buffering effect on the water does not allow the pH to change easily when acids or bases are added to the water.

High pH can also occur when plants use carbon dioxide (CO2) during photosynthesis to produce carbohydrates. Although highly soluble in water, most carbon dioxide in lakes is formed as an end product of respiration. When the rate of atmospheric CO2 diffusing into the water is less than the rate of photosynthesis, aquatic plants use dissolved carbonates as their source of carbon. As they produce carbon dioxide in water, it forms a series of compounds, including carbonic acid, bicarbonate, and carbonate. The process of photosynthesis also consumes protons which contribute to raising the pH. The resulting carbonate chemistry, along with the hydroxide (OH-) anion, contributes to the alkalinity and buffering capacity of water. This hydroxyl ion is responsible for the increase in lake water pH during photosynthesis. Alkalinity is a conservative parameter in that it does not change readily in well-buffered lakes. However, pH values may vary both temporally and spatially within a lake. During intense photosynthesis in the euphotic zone, carbon dioxide and its dissociation product, carbonic acid, can become less abundant. The pH values may rise to as high as 9 with less of this acid. The combination of these effects can result in pH exceeding 10 in the late afternoon in lakes undergoing photosynthesis by phytoplankton.

The most significant environmental impact of pH involves its synergistic effects, as the pH of a solution also influences the amount of substances like heavy metals that dissolve in it. This process is especially important in surface waters as runoff from agricultural, domestic, and industrial areas which all may contain iron, aluminum, ammonia, mercury, or other elements. Ammonia is relatively harmless to fish in water that is neutral or acidic; however, as the water becomes more basic and the pH increases, ammonia becomes increasingly toxic.

A change in the pH can alter the behavior of other chemicals in the water. These dissolved metals may also interfere with body functions. They can influence developing eggs and larvae which can lead to lower natural reproduction. Ultimately the population declines, the food chain collapses, and the community suffers. Developing eggs and larvae also have specific, narrower pH requirements. Perch can tolerate a pH of between 4.6 to 9.5 and remain relatively healthy. However, even at the high and low ends of this pH tolerance level, fish become stressed. Aquatic invertebrates with external skeletons or shells made of calcium are extremely sensitive to pH below neutral. These organisms are important members of aquatic food chain. A pH range of 6.0 to 9.0 appears to provide protection for the life of freshwater fish and bottom dwelling invertebrates. The pH upper limit set by South Dakota DENR 303(d) is a pH of 9.0.

2.3.5 Temperature

Fish and most aquatic organisms are cold-blooded and are unable to control their internal body temperature except by behavior. Their metabolism increases two to three times per 18 degrees Fahrenheit (°F) increase in water temperature. Water temperature can influence oxygen concentration, metabolism (body functions), reproduction, and growth. Each species of aquatic organism has its own optimum water temperature. If the water temperature shifts too far from the optimum, the organism suffers. Most cold-blooded animals cannot survive temperatures below 32 °F, and only rough fish can tolerate temperatures much warmer than about 97 °F. The water temperatures at which fish growth ceases are 82 °F for Northern pike, 90 °F for channel catfish, and 97 °F for carp. The Northern pike and channel catfish die when water temperatures exceed

86 ^{o}F and 95 ^{o}F, respectively. The South Dakota standard for water temperature for Warm Water Permanent Fish Life is 80 ^{o}F.

Fish are not the only organisms requiring specific temperatures. Diatoms grow best at a temperature of 59-77 ^{o}F, green algae at 77-95 ^{o}F, and blue-green algae at 86-104 ^{o} F. While temperature changes can cause mortality, it can also cause sub-lethal effects by altering the physiology of aquatic organisms. Temperatures outside of an acceptable window affect the ability of aquatic organisms to grow, reproduce, escape predators, and compete for habitat. Warm water also makes some substances like heavy metals, phenol, xylene, and zinc more toxic for aquatic animals. When high water temperatures are combined with low dissolved oxygen levels, the toxicity is increased.

Water temperature is also influenced by the seasons, the amount of sunlight reaching the water, amount and speed of the water, the source of the water (springs or runoff), and the amount of material suspended in the water. The color of the water also affects its temperature as most heat warming for surface waters comes from the sun, so water bodies with dark-colored water or those with high turbidity absorb heat best. The depth of the water also influences the water temperature as deeper waters usually are colder than shallow waters simply because they require more time to warm up. Shallow waters open to wind currents also mix more thoroughly, and temperatures are generally the same from surface to the bottom. This happens because the shallow waters are mixed by air currents which do not allow them to stratify into thermal layers, and they therefore do not develop colder layers of water.

2.3.6 Mercury

Many of the fish in the lakes in the Big Sioux River basin contain mercury in their tissue. A significant factor of mercury accumulation is the expansion of surface water that has flooded new areas. In the early 1980s and again in the late 1990s, increased precipitation and snowmelt turned small wetlands into larger lakes. Without natural outlets, many lakes in the BSRWIP continue to gain surface area inundating wetlands and surrounding landscape. Water depth, substrate, and increased organic decay influence the rate that elemental mercury is methylated and converted to the biologically available form of methylmercury. The concentration of mercury in the water column is typically very low and similar to other lakes in the basin. However, the methylation rate is typically higher and results in a greater bioavailability of mercury. This mercury then moves up the food chain and results in excessive mercury in larger, older predator fish.

Mercury is a hazardous chemical that occurs naturally in the environment and is used in industrial applications. Exposure to mercury, even in small amounts, is a great danger to humans and wildlife acting as a neurotoxin interfering with the brain and nervous system. Mercury exposure is especially dangerous to pregnant women and young children. Frequent exposure during childhood can damage the central nervous system and affect neurological functions with possible effects on learning, muscle development, motor function, and attention. Mercury poisoning in adults can harm the kidneys and brain and increase the risk of cardiovascular disease. It can also adversely affect fertility, blood pressure regulation, cause memory and vision loss, cause tremors, and numbness of the fingers and toes.

In lakes and other bodies of freshwater, bacteria converts naturally occurring inorganic mercury into its organic form, methyl mercury. Methyl mercury binds with particles and sediments eaten by smaller fish. Larger game fish prey on these smaller, mercury contaminated fish. Because fish eliminate mercury at a very slow rate, it accumulates in their tissues and organs where it cannot be removed by filleting or cooking, unlike organic contaminants that concentrate in the skin and fat. From the bacterial level, each step-up of consumption in the food chain leads to higher concentrations of the methyl mercury in larger, older predator fish; a process called "bio-magnification."

The mercury contamination is strongly linked to atmospheric pollution from coal-fired power plants. However, the natural cycle of wet and dry periods incorporated the mercury into South Dakota lakes (Stone et al. 2011). When the flooding from above average rainfall years occurred, it killed the grass and vegetation; the mercury that was bound to the plants was dissolved in the water and reincorporated into the aquatic food web (Selch 2008, Chipps 2009). Many lakes did not have natural outlets and continued to gain surface area inundating wetlands and surrounding landscapes (SDDENR 2014). Water depth, substrate, and increased organic decay influence the rate that elemental mercury is methylated and converted to the biologically available form of methylmercury. The concentration of mercury in the lakes' water column is typically very low and similar to other lakes in the basin. However, the methylation rate is typically higher because of shallow water depth, newly flooded substrate, and increased organic decay influence the rate that elemental mercury is methylated and converted to the biologically available form of methylmercury. This process results in a greater bioavailability of mercury to the fish.

Some South Dakota lakes with elevated mercury concentrations also did not have very good natural reproduction in walleyes and perch. There was a steep decline in fertilization success as mercury concentrations increased. Laboratory experiments (Hayer et al. 2011) have shown that high levels of mercury in water reduced the fertilization success of fish eggs, thus having a negative effect on fish reproduction.

2.4 Defining the Sources of Impairments for 303(d) Listed Water Bodies

The general sources of impairment have been listed in the 2014 SDDENR-IR, see Table 2-3; however, further identification of the physical sources is required for the land application of BMPs to be successful. The implementation of BMPs that address the impairments of the listed water bodies would more specifically solve the water quality issues. Investigations of both point and nonpoint sources were completed within portions of the BSRWIP area by SDDENR to identify the main sources of these impairments.

2.4.1 Point Sources of Impairment – Streams

Point sources of pollutants were investigated for the water bodies listed as 303(d) impaired in the 2014 SDDENR-IR: Big Sioux River (R9-R10 and R12 through R20), Beaver Creek (R1, R2), Brule Creek (R21), East Brule Creek (R22), Flandreau Creek (R23, R24), Pipestone Creek (R28), Six Mile Creek (R29), Skunk Creek (R30), Split Rock Creek (R31), Spring Creek (R32), and Union Creek (R34). The Big Sioux River (Segment R8) as it enters the boundaries of the BSRWIP, is in full support of its designated uses: see Table 2-2, page 69. Although the reaches R6 and R7 immediately north of R8 and outside the BSRWIP boundaries are 303(d) listed for *E. coli* and DO, the Big Sioux River enters the BSRWIP area meeting all of its designated beneficial uses.

2.4.1.1 Lower Big Sioux River in Minnehaha County

The lower Big Sioux River in Minnehaha County has several permitted *E. coli* and TSS point source discharges. These are the Dell Rapids WWTP and the Baltic WWTP in R-8; the Sioux Falls MS4 (Municipal Storm Sewers) permit in R-10; the John Morrell & Company in R-10; and the Sioux Falls WWTP in R-11 (RESPEC 2012). The point sources were found to be negligible in their load contributions, and they were in compliance with their discharge permits. The Baltic WWTP has not discharged in the last 5 years while the Dell Rapids WWTP usually discharges in May and November each year (RESPEC 2012). The Sioux Falls WWTP and John Morrell & Company used disinfectants to control bacterial in their discharge and accounted for less than 0.1 percent of the bacterial loadings. However, findings by an Augustana College study (Spencer et al. 1997) stated the total biomass of all marcroinvertebrates were significantly lower at three sample sites downstream of the John Morrell plant. Suggesting that the impacts on the invertebrate community were caused by toxicity problems in the effluent rather than changes in food availability. The John Morrell plant had satisfied requirements for water quality monitoring and effluent discharge standards during the time period of their study.

2.4.1.2 Big Sioux River from Brandon to Mouth

TMDLs on the Big Sioux River were established through a Phase 1 approach by USEPA, Iowa Department of Natural Resources (DNR), and SDDENR (USEPA 2007). There were 5 reaches of the Big Sioux River reviewed starting from above Brandon, SD, southward to the mouth of the Big Sioux River, near North Sioux City. The watershed area included the drainages of the Big Sioux and the Rock Rivers in the states of Minnesota, Iowa, and South Dakota. The Rock River flows into the Big Sioux River in Sioux County, 6 miles north of Hawarden, Iowa. Phase 1 was the beginning of the development of a project to improve water quality by analyzing the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based on the resources and informtion available. The Phase 1 evaluation process will continue as more data and resources become available.

South Dakota had 4 permitted point sources actively discharging, while Iowa had 19 permitted sources and 17 NPDES permitted animal feeding operation facilities. The South Dakota permittees were the cities of Brandon, Canton, Alcester, and the Coffee Cup Fuel Stop. An implementation plan was a component of the Phase 1 evaluation. The South Dakota data analysis showed only a few small point source discharges were located in the project area on the South Dakota side of the Big Sioux River. Data also showed that the implementation plan needed to focus on controlling livestock manure runoff and cattle in streams in order to restore the recreational uses of the river (USEPA 2007).

2.4.1.3 Big Sioux River, Fairview to Mouth

Point sources were investigated along a 97 mile stretch of the Big Sioux River (SDDENR 2009) from Fairview, South Dakota, to the mouth of the Big Sioux River, near North Sioux City. Fairview is approximately 35 miles south of Sioux Falls. The approximately 2.4 million acre watershed included drainage from the Big Sioux River in Iowa, Minnesota, and South Dakota, and the Rock River in Iowa and Minnesota. South Dakota had 28.4% of the total watershed acres, Iowa had 36.6%, and Minnesota had 35.0%. This reach of the lower Big Sioux River has had a history of exceedance of the South Dakota TSS water quality criterion of warmwater semipermanent beneficial use impairment. The river was initially listed in 1998 SDDENR-IR due to the TSS impairment and was consistently listed in the 2002, 2004, 2006, 2008, 2010, 2012, and 2014 SDDENR-IRs.

Three point sources were located directly on the river: (1) the City of Hudson, SD, which although an NPDES permitted facility, it does not discharge; (2) the City of Hawarden, SD, which is an NPDES permitted facility whose outfall discharges directly into the Big Sioux River, its TSS contribution is insignificant at less than 1.0 percent; and (3) the City of Akron, Iowa, which is an NPDES permitted facility that is only permitted to discharge in the spring and fall.

Total TSS contribution from the Akron facility to the Big Sioux River was insignificant at less than 1.0%. These three WWTFs are directly located on the Big Sioux River, and although the most significant point sources of TSS loading on the river, their total contributions were considered insignificant.

2.4.1.4 East Brule Creek

Investigations on East Brule Creek (SDDENR 2011) found one permitted facility, the city of Alcester, that discharges. The facility was upgraded in 2003 following numerous violations of ammonia, Biological Oxygen Demand (BOD), TSS, total residual chlorine, and fecal coliform bacteria. With the upgraded facility, it was felt that the city of Alcester would be able to meet the current chronic and acute fecal coliform standard, and it was not a large contributor to the fecal coliform bacteria impairment.

2.4.1.5 Summary of Other Tributaries

SDDENR water quality studies on tributaries Peg Munky Run Creek, SDDENR 2011; Brule Creek, SDDENR 2011; Beaver Creek, SDDENR 2011; Flandreau Creek, EDWDD 2004; Pipestone Creek, SDDENR 2011; Skunk Creek, EDWDD 2004; Split Rock Creek, EDWDD 2004; Spring Creek, EDWDD 2004; and Union Creek, SDDENR 2011; did not identify any significant point source discharges. Although the tributary of Six Mile Creek was 303(d) listed in the 2014 SDDENR IR for *E. coli*, fecal coliform, and TSS; a draft TMDL (SDDENR 2004) did not identify any significant point sources of pollution. Jack Moore Creek and North Deer Creek had insufficient data and a 303(d) listing was not able to be determined. The following conclusions have been supported by other TMDL watershed studies in South Dakota that evaluated potential point sources of loading. The TMDL studies found that municipalities had either (1) zero discharge NPDES permits, (2) discharges that were NPDES permitted and controlled or the discharges were so minor and/or infrequent as to be negligible, and (3) the remaining human produced fecals not delivered to a municipal treatment facility had a minimal impact on total loading**.**

2.4.2 Point Sources – Lakes

Lake watershed studies did not identify point sources of pollution, as pollution sources identified were mostly nonpoint sources. There are currently no water quality assessment studies on Covell Lake, Goldsmith Lake, North Island Lake, Lake Sinai, Twin Lake West Highway 81, and Twin Lakes in Minnehaha County.

2.4.3 Nonpoint Sources of Impairment – Streams; *E. coli* and Fecal Coliform

The Big Sioux River (R12-20), Beaver Creek (R1, R2), Brule Creek, (R21, East Brule Creek (R22), Flandreau Creek (R23, R24), Pipestone Creek (R28), Six Mile Creek (R29), Skunk Creek

(R30), Split Rock Creek (R31); Spring Creek (R32), and Union Creek (R34) are listed as 303(d) impaired for *Escherichia coli* and/or Fecal Coliform for the support of Limited Contact Recreation in the 2014 SDDENR-IR. The beneficial use periods of Immersion Recreation (IR) and Limited Contact Recreation (LCR) are effective during the recreation season, May 1-September 30 (SDDENR April 2014). The *E. coli* criteria for IR requires that water samples not exceed 235 Colony Forming Units (CFU) per 100 milliliters (cfu/ml) and the geometric mean of a minimum of five samples collected during separate 24-hour periods must not exceed 126 cfu/100ml during any 30-day period. The *E. coli* criteria for LCR requires that water samples not exceed 1,178 Colony Forming Units per 100 milliliters (cfu/ml) and the geometric mean of a minimum of five samples collected during separate 24-hour periods must not exceed 630 cfu/100ml during any 30-day period. Non point sources of impairment have not been identified for all designated water bodies in the BSRWIP area either because the water body met all of its 303(d) designated beneficial uses or because of insufficient water quality data to make a determination.

Fecal coliform bacteria are usually not harmful, but they can indicate the presence of other harmful bacteria, viruses and/or parasites. Examples include the pathogenic strain of *E. coli* that is often linked to food borne illnesses, as well as giardia and cryptosporidium. Recreational contact, especially swimming, is not recommended when high concentrations of fecal coliform bacteria are present. The FLUX program was used to determine total nutrient loads; the AGNPS was used to rank feedlots on a scale of 0-100, with a score of 50 identifying those most likely to deliver pollutant loads. The AGNPS model is a GIS-integrated water quality model that predicts nonpoint source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze feedlots and their pollution potential. Watersheds dominated by agricultural land uses, pasturing cattle in stream drainages, runoff from manure application, and runoff from concentrated animal feeding operations can influence fecal coliform bacteria concentrations. The AGNPS feedlot assessment assumed the probable sources of fecal coliform bacteria loadings were related to agricultural land use (upland and riparian), use of streams for stock watering, and animal feeding operations. The Central Big Sioux River Phase 1 Watershed Assessment Final Report (SDENR March 2004) identified 827 Animal Feeding Operations within these subwatersheds with 254 having an AGNPS score of 50 or greater.

Rural household septic system contributions were estimated, as a direct accounting of the number of septic systems in use in the watershed were unavailable. It was assumed that 20% of all rural septic systems in the North-Central Big Sioux River watershed were failing (SDDENR 2005). This percentage did not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It was assumed that failing septic systems constituted a very small amount of the overall contribution because not all of the failing systems would reach the receiving waters. It was implied that comparatively, failing septic systems were having an insignificant effect on the excess fecal coliform loading but were included in the margin of safety portion of the established TMDLs.

Water quality studies in the BSRWIP area have concluded that agricultural activities were the major nonpoint source of excessive nutrients to the watershed by sheet and rill erosion from the agricultural lands, manure from livestock feedlots, livestock defecating while wading in water bodies, and defecating while grazing on rangeland and stream bed and bank. The following pollutants, as identified by the SDDENR 2014 Integrated Report, are discussed by each listed 303(d) impairment for the described water bodies.

2.4.3.1 *Escherichia coli* – Fecal Coliform. Big Sioux River (R12-R20), Beaver Creek (R1 & R2), Brule Creek (R21), East Brule Creek (R22), Flandreau Creek (R23 & R24), Pipestone Creek (R28), Six Mile Creek (R29), Skunk Creek(R30), Split Rock Creek (R31), Spring Creek (R32), and Union Creek (R34).

Segments R12 through R20 of the Big Sioux River, from approximately one mile northeast of Dell Rapids to its confluence with the Missouri River, are listed as 303(d) impaired for *E.coli* and/or Fecal Coliform bacteria. Also included, with the same impairments, are Beaver Creek (R1,R2), Flandreau Creek (R23, R24), Pipestone Creek (R28), Six Mile Creek (R29), and Skunk Creek (R31); these sub-watersheds are included in this section as they were assessed in the Central Big Sioux River Assessment (SDDENR March 2004) along with the Big Sioux River direct drainage.

SDDENR studied the upper reaches of the Big Sioux River in Brookings, Lake, Moody, and Minnehaha counties in March 2004. See Figure 2-4. This reach of the central Big Sioux River flows from near Volga to County Road 38, southeast of Sioux Falls, and includes reaches R9 through R16. Approximately 65% of the area is cropland consisting primarily of corn and soybeans with 30% in grassland and pastureland. Eight hundred twenty-seven animal feed lots were rated using the AGNPS feedlot model within the central Big Sioux River watershed (SDDENR March 2004). Of the 827 feedlots, 254 (31%) rated ≥ 50 on a scale from 0 to 100. There were a total of 262 animal feeding operations in the Big Sioux direct drainage area, with approximately 85% of the livestock being cattle. The monitoring data showed high fecal concentration during runoff events and base flows. Potential nonpoint sources of fecal coliform bacteria were failing septic systems, pastured livestock, poor riparian areas, instream livestock, inadequate manure application, feedlot runoff, and urban runoff. Livestock waste contributed the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contributed to the low flows. The priority management watersheds are shown in Figure 2-5.

Figure 2-4: CBSR Assessment Boundary, SDDENR March 2004

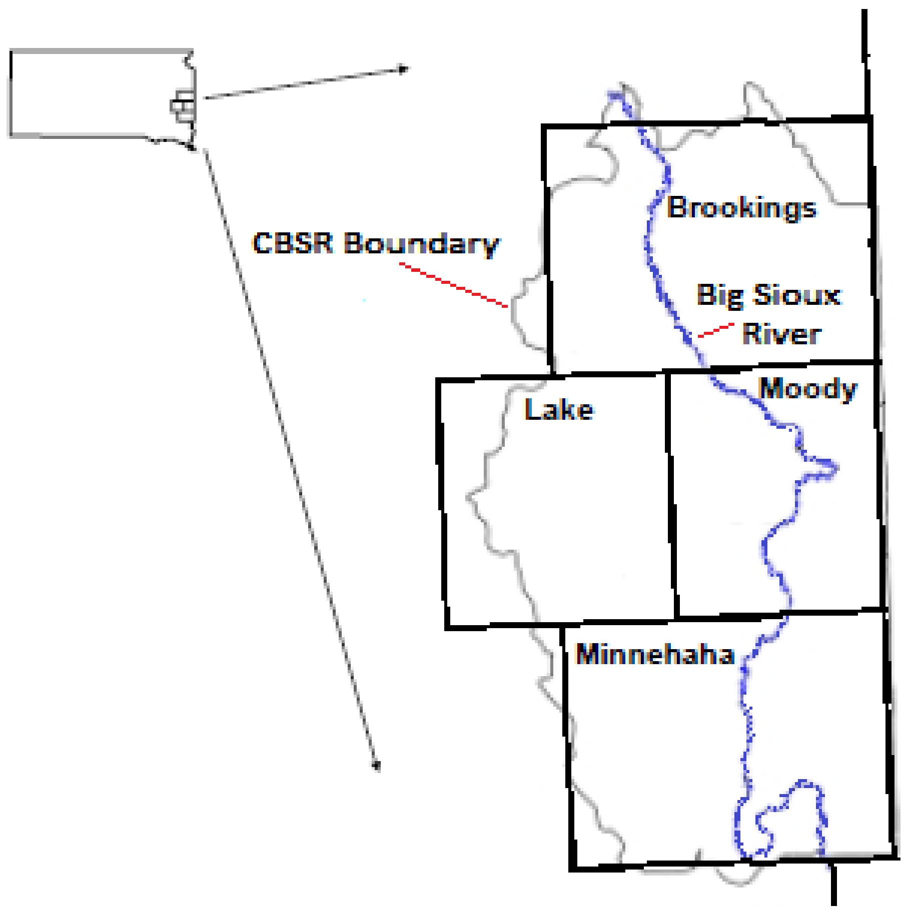
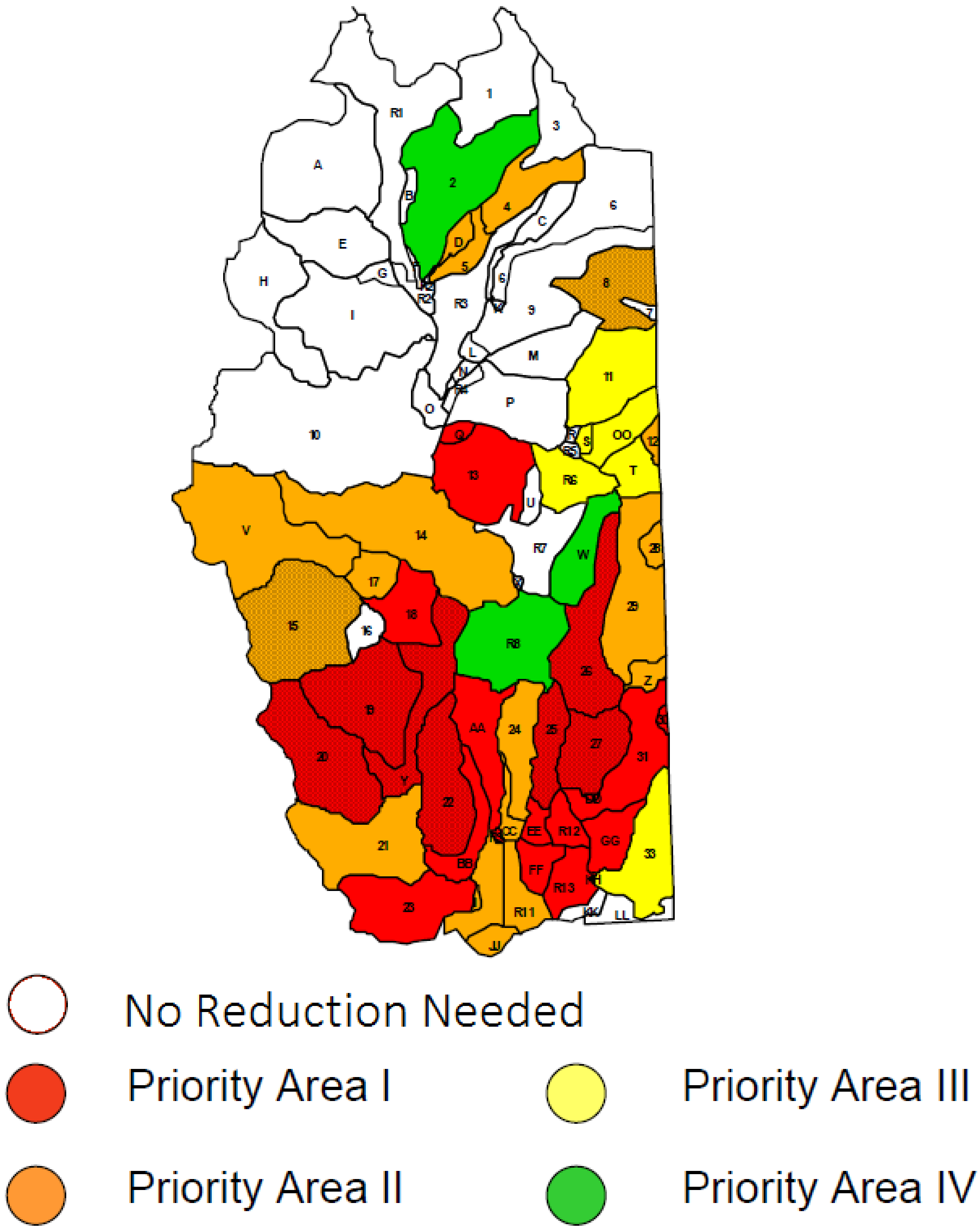


Figure 2-5: Consolidated Priority Management Areas for Fecal Coliform Bacteria.
Central Big Sioux River Watershed Assessment - SDDENR March 2004



2.4.3.2 Big Sioux River 5 TMDL Pathogens

The Federal Clean Water Act required the Iowa Department of Natural Resources (DNR) and SDDENR to develop *E. coli* and Fecal Coliform Bacteria TMDLs for five segments of their bordering Big Sioux River that were listed as 303(d) impaired. The TMDL evaluation was an iterative process that required re-evaluation of the existing information, analysis of new data, and the refinement of analytical procedures; a process referred to as “phasing” (USEPA 2007). The project area for this report had a watershed in South Dakota of 661,418 acres and 919,040 acres in Iowa. See Figure 2-6 for the project area. The Big Sioux River was divided into five impaired segments running from the City of Brandon, South Dakota, to the confluence of the Big Sioux River with the Missouri River.

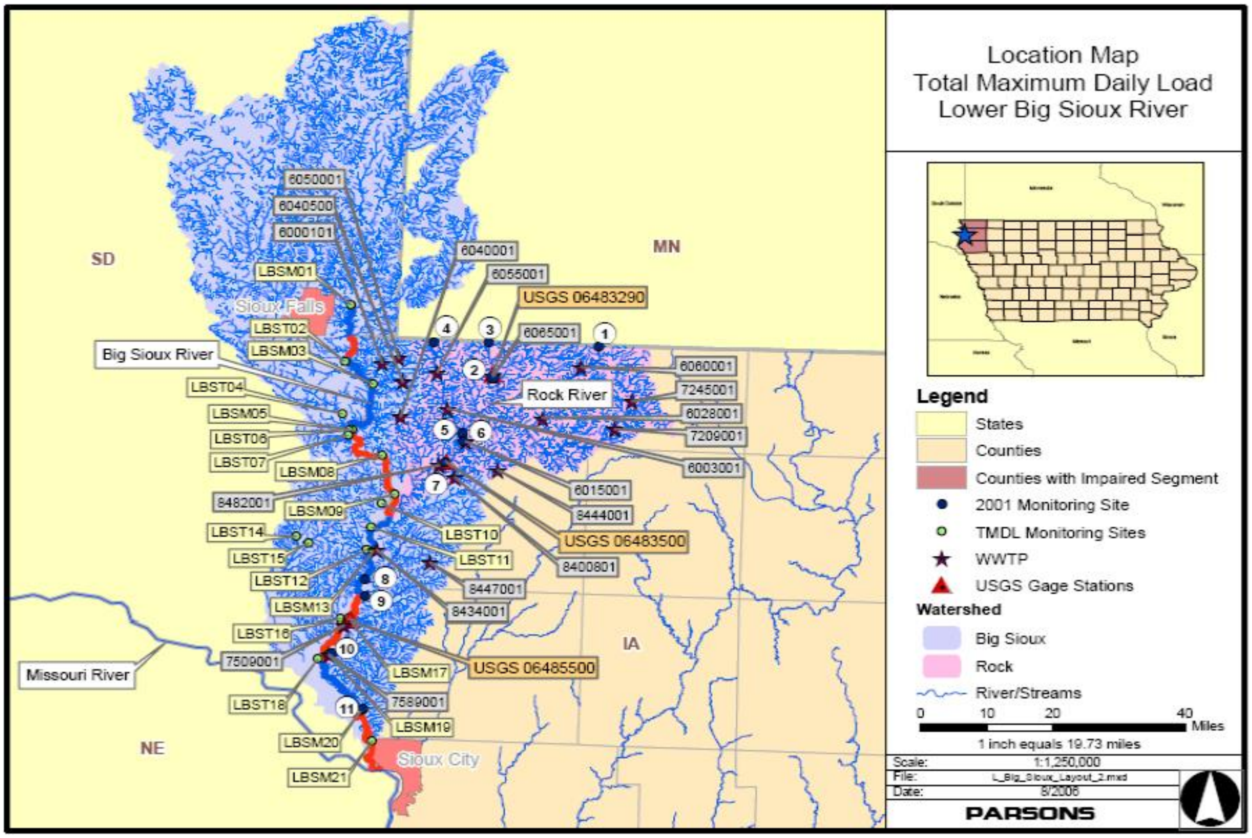
There two types of point source potential evaluated that could potentially discharge fecal coliform bacteria and *E. coli* into the Big Sioux River were continuous point discharges (WWTP and AFOs) and Municipal Separate Storm Sewer Systems (MS4). There were no MS4 discharge areas within the project area. Iowa had 19 permitted point sources, and South Dakota had 4 discharging permits. Nonpoint sources of pathogen for both states were similar and included livestock and wildlife fecal material, leaking septic tank treatment systems, manure from cattle in and near streams, agricultural activities, manure land application fields, urban runoff, and pets.

Controlling livestock manure runoff and cattle in streams was determined to be a significant part of any plan to reduce bacterial loading of the Big Sioux River in both Iowa and South Dakota. BMPs included feedlot runoff control; fencing off livestock from streams; alternative livestock watering supply; and vegetative buffer strips along the river and tributary corridors to slow and divert runoff. Additional BMPs would be to repair failed septic tank systems and for WWTPs to control the bacteria in their effluent. Based on this joint project (USEPA 2007), TMDLs for pathogen indicators were approved for these five segments of the Big Sioux River by EPA in 2008.

2.4.3.3 Big Sioux River, Dell Rapids to Brandon

The consulting firm RESPEC completed TMDL documentation focusing on *E. coli* and fecal coliform bacteria impairments on the Big Sioux River for impaired reaches SD-BS-R-BIG_SIOUX_08, SD-BS-R-BIG_SIOUX_10, SD-BS-R-BIG_SIOUX_11, and SD-BS-RBIG_SIOUX_12. The segments begin near Dell Rapids at the Moody/Minnehaha county line and end downstream above Brandon, South Dakota. Permitted point sources in these reaches included the Dell Rapids WWTP, the Baltic WWTP, the Sioux Falls MS4 permit, John Morrell & Company, and the Sioux Falls WWTP. The facilities did not currently have *E. coli* effluent limits; however, the collected *E. coli* criteria were used to calculate the WLAs for these facilities (RESPEC 2012). SDDENR will include the *E. coli* limits to each of these permits when reissued. The point sources were in compliance with their individual NPDES permits and did not require reductions to current loadings. Their load contributions were negligible accounting for <0.1% of the loadings within the given reach. Potential nonpoint sources of bacteria were identified as human, domestic animals, agricultural livestock, and wildlife.

Figure 2-6: Project Area for TMDL Iowa and South Dakota. USEPA 2007



The Sioux Falls MS4 contributed significantly to impairment in reach SD-BS-BIG_SIOUX_10. Four of the eight storm water outfalls flowing into this segment reached 100% exceedance of the daily maximum criteria of the receiving Big Sioux River. The other four storm water outfalls had a minimum exceedance of 79%. The average median *E. coli* concentration at the eight outfalls was over 8,000 cfu/100 mL, which was over 50 times the *E. coli* criteria for the Big Sioux River in the project area. Current BMPs within the study area, such as detention ponds and constructed wetland channels/basins, focused on sediment control and did not appear to significantly decrease bacteria concentrations.

The control measures recommended to be implemented in Sioux Falls were expected to reduce exceedances of the acute *E. coli* criteria from 74% to 3% in Reach SD-BS-R-BIG_SIOUX_08; from 90% to 4% in Reach SD-BS-RBIG_SIOUX_10; from 80% to 4% in Reach SD-BS-R-

BIG_SIOUX_11; and from 76% to 6% in Reach SD-BS-R-BIG_SIOUX_12. These load reductions would assist in reaching projected TMDL goals.

Seven management scenarios were simulated for each bacteria-impaired reach and are presented in Table 2-5 and are listed as follows: (1) future land use, (2) the city's planned BMPs, (3) Big Sioux River upstream of Dell Rapids and Skunk Creek compliance with the current limited recreation acute water quality standard, (4) Big Sioux River upstream of Dell Rapids and Skunk Creek compliance with the immersion recreation acute water-quality standard, (5) change of flow routing down the Big Sioux River and the diversion (minimum flow through the city maintained at 400 cfs), (6) 90% load reduction on agricultural land within the project area boundary north of Sioux Falls local to the Big Sioux River and Silver Creek, and (7) an *E. coli* reduction of 75% to 100% of the MS4.

It was determined the baseline conditions of bacteria exceedances in the Big Sioux River study area could be reduced from a range of 74% to 90% to a range of 3% to 6% with the cumulative implementation of all seven scenarios and would be an effective way to achieve maximum *E. coli* reduction in the Big Sioux River throughout the project area. These goals were felt to be achievable with the proper planning between local, state, and federal governmental agencies implementing BMPs provided they had adequate funding sources (RESPEC 2012.

2.4.3.4 Beaver Creek

Beaver Creek has a watershed of 67,672 acres in southeast South Dakota and drains into the Big Sioux River north of Elk Point, South Dakota. The land use of the watershed is primarily agriculture consisting of 73.6% row crops, 10.8% grass, 1.3% small grains, and the remaining acres developed lands and open spaces. SDDENR set the fecal coliform bacteria TMDL for Beaver Creek in May 2011.

Nonpoint sources of fecal coliform bacteria in Beaver Creek came primarily from agricultural sources (SDDENR 2011). Manure from hogs and beef cattle was a potential source of fecal coliform to the stream. See Table 2-6. Livestock can contribute fecal coliform bacteria directly to the stream by defecating while wading in the stream. They also contributed by defecating while grazing on rangelands that get washed off during precipitation events. There were no point sources within the Beaver Creek watershed. Septic systems were assumed to be the primary human source for the remaining 1,733 people in the watershed. When included as a total load in the table, the remaining human population produced fecal coliform bacteria accounting for approximately 0.18% of all fecal coliform bacteria in the watershed. These bacteria should all be delivered to a septic system, which if functioning correctly, would result in no fecal coliform bacteria entering Beaver Creek.

Table 2-5: Summary of Load and Exceedance Reductions for *E. coli* BMPs. RESPEC, September 2012

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

Table 2-6: Fecal Coliform Allocations for Beaver Creek

Area	Percentage
Feeding Areas	51.30%
Grazing Areas	46.42%
Wildlife	2.28%

2.4.3.5 Brule Creek

Brule Creek has a watershed of 81,863 acres in South Dakota and drains into the Big Sioux River north of Elk Point, South Dakota. The land use of the watershed is primarily agriculture consisting of 71% row crops, 21% grass, 1.4% small grains, and the remaining acres developed lands and open spaces. SDDENR set the fecal coliform bacteria TMDL for Brule Creek in March 2011.

Nonpoint sources of fecal coliform bacteria in Brule Creek came primarily from agricultural sources (SDDENR 2011). See Table 2-7. Manure from hogs and beef cattle was a potential source of fecal coliform to the stream. Livestock can contribute fecal coliform bacteria directly to the stream by defecating while wading in the stream. They also contribute by defecating while grazing on rangelands that get washed off during precipitation events.

Table 2-7: Fecal Source Allocation for Brule Creek

Source	Percentage
Feedlots	81.2%
Livestock on Grass	18.0%
Wildlife	0.8%

2.4.3.6 East Brule Creek

East Brule Creek has a watershed of 44,608 acres in southeast South Dakota and drains into the Big Sioux River north of Elk Point, South Dakota. The land use of the watershed is primarily agriculture consisting of 86% row crops, 6% grass, 1% small grains, and the remaining acres developed lands and open spaces. The fecal coliform bacteria TMDL was established by SDDENR for East Brule Creek in January, 2011. The main source of fecal coliform bacteria in the watershed was from overland runoff from livestock feedlots and livestock grazing in pastures. See Table 2-8. This was evidenced by elevated bacteria counts that occurred throughout different stream flow regimes but mainly during storm events.

There was only one permitted point source located in the East Brule Creek watershed, the city of Alcester, which accounted for about 885 residents in the watershed. The remaining population produced fecals accounting for about 1.4% of all fecal coliforms produced in the watershed. These bacteria should all be delivered to a septic system, which if functioning correctly would result in no fecal coliforms entering the creek.

Table 2-8: Fecal Source Allocation for East Brule Creek

Source	Percentage
Feedlots	63.0%
Livestock on Grass	36.5%
Wildlife	0.5%

2.4.3.7 Flandreau Creek

Flandreau Creek has a watershed of 13,166 acres in Moody County, South Dakota; however, 90% of its watershed is located in Minnesota. The watershed was assessed for TMDLs in the Central Big Sioux River Assessment Project (SDDENR 2004) by the EDWDD, and the TMDL was approved by EPA in 2008. Land use in the watershed was primarily agricultural with 98% of the area as grassland or cropland. One municipality, the town of Lake Benton, is located in the Minnesota portion of the watershed. There were no identified NPDES facilities or point sources located within the South Dakota portion of the watershed. The waste load allocation component of the TMDL was zero. Total contribution from the facility during the study period was zero, due to either the facility not discharging or fecal coliform data not being recorded. Flandreau Creek was identified as not supporting its limited contact recreation beneficial use because of fecal coliform bacteria. The creek experienced fecal coliform loading due to poor riparian areas, in-stream livestock, feedlots/manure runoff, storm water runoff, and NPDES systems. Willow Creek, a sub-tributary that joins Flandreau Creek within Minnesota, was identified as a possible source of fecal coliform bacteria. Although 90% of this watershed resided in Minnesota, no water quality information from either the portion of Flandreau Creek in Minnesota or Willow Creek was used to establish the TMDL. Data collected from this study indicated that the fecal coliform problem most likely originated in the Minnesota portion of the watershed. Flandreau Creek required reducing the fecal coliform counts per day by 91% during high to moist stream flow conditions. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events. The study revealed additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this stream.

2.4.3.8 Pipestone Creek

Pipestone Creek originates in Minnesota and has a watershed of 45,993 acres in South Dakota. The creek flows back into Minnesota and joins Split Rock Creek, which eventually flows back into South Dakota. The land use of the watershed is primarily agriculture consisting of 82% row crops, 17% grass, and the remaining acres developed lands and open spaces. The *E. coli* bacteria TMDL was established by SDDENR for Pipestone Creek in November, 2011. Nonpoint pollution of fecal coliform in Pipestone Creek came primarily from agricultural livestock sources; predominantly hogs and beef cattle. See Table 2-9 for source allocations. Livestock can contribute *E. coli* bacteria directly to the stream by defecating while wading in the stream. They also can contribute by defecating while grazing on rangelands that get washed off during precipitation events. There were no point sources within the Pipestone Creek watershed.

Table 2-9: Fecal Coliform Source Allocation for Pipestone Creek

Source	Percentage
livestock on range	56.80%
feedlots	42.15%
wildlife	0.80%
human	0.25%

2.4.3.9 Six Mile Creek – TMDL Not Final

Six Mile Creek has a watershed of 24,423 acres in east-central Brookings County and originates in the northern part of the county. Land use in the watershed was primarily agricultural with 56% of the area as cropland and 39% as grassland. The municipalities of White and Brookings are located within this watershed (Andrew Kopp, SDDENR, personal communication). There are two NPDES facilities within this segment of Six Mile Creek: South Dakota State University and the City of White. Total contributions from these facilities during the study period was insignificant at 0.00006%. The City of Brookings was also investigated for discharges associated with medium municipal separate storm sewer systems.

The watershed was assessed for TMDLs in the Central Big Sioux River Assessment (SDDENR 2004) by the EDWDD; however, the TMDL for Fecal Coliform was not completed per this assessment and was listed as 'draft' stage. The stream segment of concern was located between the City of White and the City of Brookings, where Six Mile Creek (T04 and T05) was found to carry fecal coliform bacteria. This segment of stream was considered impaired because more than 10% of the values exceeded the numeric criteria of ≤ 2,000 counts per 100 milliliters for fecal coliform bacteria (SDDENR 2014). This tributary experienced fecal coliform loading due to absent or poor riparian areas, pastured livestock, manure, feedlot runoff, storm water, and

NPDES systems. It was determined Six Mile Creek would need to reduce the fecal coliform counts per day by 12% during stream high flows/moist conditions. Six Mile Creek was not addressed in SDDENR Integrated Reports until 2008, when it was included but noted with insufficient sampling information and limited sample data. In the 2010 and 2012 SDDENR-IR Six Mile Creek was listed for Fecal Coliform Bacteria. The most recent 2014 SDDENR-IR has the creek listed for both TSS and Fecal Coliform Bacteria. The TMDL assessment for Six Mile Creek is currently being conducted.

2.4.3.10 Skunk Creek

Skunk Creek has a watershed of 372,571 acres in Lake, Moody, and Minnehaha counties and originates at the outlet of Brant Lake. The watershed was assessed for TMDLs in the Central Big Sioux River Assessment (SDDENR 2004) by the EDWDD and the TMDL approved by EPA in 2008. Skunk Creek is influenced by the tributaries of North Buffalo Creek, Brant Lake Outlet, Buffalo Creek, Willow Creek, West Branch Skunk Creek, and Colton Creek. Land use in the watershed was primarily agricultural with 94% of the area as grassland or cropland. The municipalities of Hartford, Crooks, Colton, Chester, and Humboldt are located within this watershed. Skunk Creek was found to carry fecal coliform bacteria which degraded water quality.

The NPDES facilities assessed in this watershed were Dakota Ethanol; Tri-Valley School District; City of Crooks Water and Sewer; Wall Lake Sanitary District; and the Cities of Colton, Chester, Humboldt, and Hartford. The City of Hartford was the only facility that contributed to the fecal coliform load during the study period; however, its contribution was insignificant at 0.00001% of the fecal load. The City of Colton and Crooks Water and Sewer discharged during the study period but no fecal data was recorded. The remaining facilities either did not discharge during the study period or maintained total retention.

Skunk Creek's potential fecal coliform loadings from nonpoint sources were from surface runoff, wildlife, livestock, pets, and leaking septic tanks. Sixty-eight animal feedlots were assessed using AGNPS that rated 50 or greater on a scale of 0-100. The Brant Lake outlet was supporting its assigned beneficial uses at the current numeric standard and did not require a reduction. North Buffalo Creek needed reductions during high flows/moist conditions and mid-range/dry stream conditions. Buffalo Creek was not assigned a numeric standard, nor did it need a reduction in fecal coliform loading. Colton Creek needed reductions during high flows/moist conditions and dry/low flow stream conditions. Both Willow Creek and West Branch Skunk Creek needed reductions throughout their overall respective flow zones. Improvements to the water quality in these tributary streams was stated to be critical, as reduction of fecal coliform loads to these tributaries would greatly reduce the fecal coliform bacteria loading to Skunk Creek. It was determined a 95% reduction in fecal coliform counts per day would be needed from nonpoint sources during high flow conditions to achieve the applicable water quality standards and meet the TMDL goal. It was also felt additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment.

2.4.3.11 Split Rock Creek

Split Rock Creek has a watershed of 168,728 acres in Moody and Minnehaha counties and originates in Minnesota, near the town of Pipestone. The creek is also the receiving waters for West Pipestone Creek, Pipestone Creek, and Beaver Creek. The watershed was assessed for TMDLs in the Central Big Sioux River Assessment (SDDENR 2004) by the EDWDD and the TMDL approved by USEPA in 2008. Land use in the watershed was primarily agricultural with 99% of the area as grassland or cropland. The municipalities of Brandon, Sherman, Corson, Garretson, and Valley Springs are located in this watershed. Four NPDES facilities were assessed within this area: the USGS-Earth Resources Observation System (EROS) Data Center, the City of Garretson, the Corson Village Sanitary District, and the City of Valley Springs. Total contribution from these facilities during the study period was zero, due to either the facilities not discharging or fecal coliform data not being recorded. Split Rock Creek was found to carry fecal coliform bacteria. This creek experienced fecal coliform loading due to absent or poor riparian areas, urban storm water, pastured livestock, manure/feedlot runoff, and urban runoff. Excessive fecal coliform loadings occurred mainly during mid-range to high flow conditions. Split Rock Creek required reducing the fecal coliform counts per day by 96% for all flow conditions. It was felt additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment.

2.4.3.12 Spring Creek

Spring Creek has a watershed of 31,743 acres in Brookings and Moody counties. Another 10% of its watershed also lies within the State of Minnesota. The watershed was assessed for TMDLs in the Central Big Sioux River Assessment (SDDENR 2004) by the EDWDD and the TMDL approved by USEPA in 2008. Land use in the watershed was primarily agricultural with 98% of the area as grassland or cropland. Urban areas made up approximately 1% of the watershed. The City of Elkton was the only identified NPDES facility in the watershed. Total contribution from this facility during the study period was insignificant at 0.00016%. Spring Creek would require reducing the fecal coliform counts per day by 45% for all stream flow conditions.

2.4.3.13 Union Creek

Union Creek has a watershed of 23,217 acres in southeast South Dakota and flows into the Big Sioux River near Alcester. The land use of the watershed is primarily agriculture consisting of 81% row crops, 14% grass, and the remaining acres developed lands and open spaces. The fecal coliform bacteria TMDL was established by SDDENR for Union Creek in April, 2011.

Nonpoint pollution of fecal coliform in Union Creek comes primarily from agricultural livestock sources; predominantly hogs and beef cattle. See Table 2-10 for source allocations. Livestock can contribute *E. coli* bacteria directly to the stream by defecating while wading in the stream. They also can contribute by defecating while grazing on rangelands that get washed off during precipitation events. There were no point sources within the Union Creek watershed.

Table 2-10: Fecal Source Allocation for Union Creek

Source	Percentage
Feedlots	81.2%
Livestock on Grass	18.0%
Wildlife	0.8%

2.4.4 Total Suspended Solids (TSS)

Big Sioux River, R9-10 and R12-20; Beaver Creek, R2; East Brule Creek, R22; Six Mile Creek, R29; Skunk Creek, R30; Union Creek, R34.

The following stream segments of the Big Sioux River are listed in the SDDENR-IR 2014 as 303(d) impaired for TSS under the beneficial use of Warmwater Semipermanent Fish Life. Segments R9 and R10 are reaches of the Big Sioux River that flow southward from near Volga to the Brookings/Moody County line. Segments R12 through R20, of the Big Sioux River, flow from approximately one mile northeast of Dell Rapids to the rivers confluence with the Missouri River. The tributaries of Beaver Creek, R2; East Brule Creek, R22; Six Mile Creek, R29; Skunk Creek, R30; Union Creek, R34; are also 303(d) listed for TSS in the SDDENR-IR 2014 for the impairment of Warmwater Marginal Fish Life.

2.4.4.1 Big Sioux River: Brookings, Lake, Moody, Minnehaha Counties

SDDENR assessed the upper reaches of the Big Sioux River in Brookings, Lake, Moody, and Minnehaha counties in March 2004. Approximately 65 % of the area was cropland consisting primarily of corn and soybeans with 30% in grassland and pastureland.

Total mass of the sediments was calculated using the FLUX model. Two subwatersheds were identified as delivering 72% of the total sediment loadings while only representing 25.6% of the total watershed acres. The most significant loading was from one subwatershed that delivered 53% of the loading and constituted only 18.6% of the total watershed. It averaged a soil loss of 20 tons of sediment per acre for the months that were monitored. (SDDENR March 2004). See Figure 2-7 for TSS priority areas. To achieve the desired TSS levels, required reductions ranged from 0-72% per priority area and averaged 25%. BMPs to reduce TSS were stream buffers, contour buffers, no-till, and conservation tillage.

2.4.4.2 Big Sioux River in Minnehaha County

The consulting firm RESPEC reported on the TSS - TMDL Daily Load for the Big Sioux River Minnehaha County, South Dakota, in September 2012. Permitted point source discharges located within the watershed were the Dell Rapids WWTP, the Baltic WWTP, the Sioux Falls MS4 permit, John Morrell & Company, and the Sioux Falls WWTP. Nonpoint source pollution generally comes from surface runoff, bed and bank erosion, cropland erosion, and construction erosion (RESPEC 2012).

The TSS loads in the Big Sioux River within Sioux Falls were determined to be a chronic issue. Eroding stream banks, the river bed, and poor riparian areas were the dominant sources of sediment. Fine materials from the river's bed and bank were able to be transported by the Big Sioux River and routinely exceeded the chronic standard during non-storm events. Six management scenarios were simulated for each TSS impaired reach. The scenarios and potential load reductions are presented in Table 2-11.

It was felt that implementing all six scenarios would decrease the 30-day average criterion percent average exceedance of baseline conditions of 18% to 33%; to 1%, 0%, 5%, and 10% exceedance in Reaches 8, 10, 11, and 12, respectively. There was reasonable assurance that TSS exceedances could be reduced from a range of 18 to 33% to a range of 0 to 22%. These goals were felt to be achievable with the proper planning between local, state and federal governmental agencies implementing BMPs provided they had adequate funding sources (RESPEC September 2012).

Figure 2-7: TSS Priority Areas in the Central Big Sioux River, SDDENR March 2004

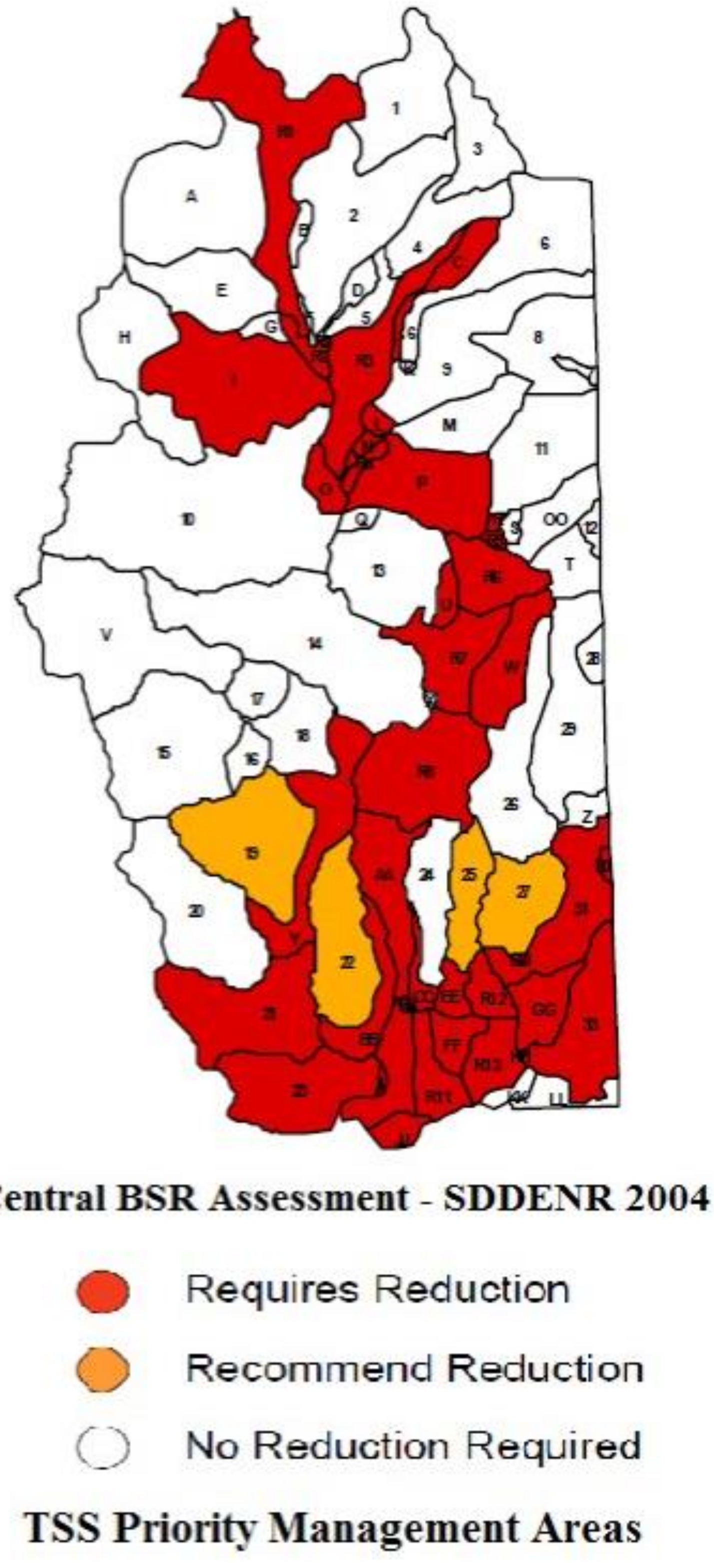


Table 2-11: Big Sioux River BMP Modeled Percent TSS Exceedance of the 30-Day Average Criterion and BMP Reduction. RESPEC, September 2012

	Baseline	Scenario 1 (Future Land Use)	Scenario 2 (Sioux Falls Planned BMPs)	Scenario 3 (90% Load Reduction on Agriculture Land[a])	Scenario 4 (Big Sioux River and Skunk Creek Boundaries at Current TSS Criteria (90 mg/L and 150 mg/L, respectively)	Scenario 5 (Big Sioux River and Skunk Creek Boundaries at Warm-Water Semipermanent Criteria (90 mgL)	Scenario 6 (50% Reduction of Instream Scour on Big Sioux River and Skunk Creek Within the Project Area)
Big Sioux River (TMDL Endpoint of Reach 08)							
Modeled % Exceedance (30-day average)[b]	18%	18%	18%	18%	11%	11%	1%
Individual BMP Percent Load Reduction[c]	–	0%	0%	0%	25%	0%	28%
Cumulative BMP Percent Load Reduction	–	0%	0%	0%	25%	25%	53%
Big Sioux River (TMDL Endpoint of Reach 10)							
Modeled % Exceedance (30-day average)[b]	24%	24%	24%	24%	2%	0%	0%
Individual BMP Percent Load Reduction[c]	–	-2%	2%	0%	45%	6%	16%
Cumulative BMP Percent Load Reduction	–	-2%	0%	0%	45%	51%	67%
Big Sioux River (TMDL Endpoint of Reach 11)							
Modeled % Exceedance (30-day average)[b]	31%	31%	31%	31%	18%	17%	5%
Individual BMP Percent Load Reduction[c]	–	0%	0%	0%	23%	1%	31%
Cumulative BMP Percent Load Reduction	–	0%	0%	0%	23%	24%	55%
Big Sioux River (TMDL Endpoint of Reach 12)							
Modeled % Exceedance (30-day average)[b]	33%	33%	33%	33%	22%	22%	10%
Individual BMP Percent Load Reduction[c]	–	-1%	0%	0%	19%	1%	34%
Cumulative BMP Percent Load Reduction	–	-1%	0%	0%	19%	20%	54%

(a) Agricultural BMPs for Scenario 3 were on lands within the project area boundary north of Sioux Falls local to the Big Sioux River and Silver Creek.
(b) Modeled percent exceedance represents the percent of samples that exceeded the 30-day average concentration based on the results of the HSPF model application.
(c) Individual load reduction is the reduction in average annual load from water year 2005–2009 that corresponds to a single BMP (not cumulative BMP effects).

2.4.4.3 Beaver Creek

Beaver Creek has a watershed of 39,548 acres in Minnehaha County; however, it originates in Minnesota where 60% of its watershed is located. Beaver Creek accepts drainage inflow from three tributaries located in Minnesota: Little Beaver Creek, Springwater Creek, and Four Mile Creek, before it eventually flows into Split Rock Creek. The watershed was assessed for TMDLs in the Central Big Sioux River Assessment (SDDENR 2004) by the EDWDD and the TMDL approved by EPA in 2008. Land use in the watershed was primarily agricultural with 98% of the area as grassland or cropland.

The municipalities of Valley Springs, South Dakota, and Beaver Creek, Minnesota are located in this watershed. The City of Valley Springs is the only NPDES permitted facility associated with this watershed in South Dakota. Total contribution from this facility during the study period is insignificant, at less than 0.000001%.

Beaver Creek was found to carry excessive sediment which degrades water quality. The tributary experiences instream TSS loading from bed/bank erosion and also external TSS loading from its watershed. Natural background sources constituted 2% of the total, and the remainder was assigned to those land uses likely to contribute sediment at rates above natural background, such as cropland, pastureland, bed/bank erosion, and residential areas. Any remaining excess sediment was likely from bed and bank erosion. Stream bank stabilization has shown to improve sediment reduction by 75% to 100%. Beaver Creek was identified as not supporting its warm water marginal fish life propagation beneficial use. Excessive sediment loadings were occurring during the high flow conditions. Beaver Creek would require reducing the TSS concentrations by 79% under high flow conditions. Additional controls were thought to be needed in order to achieve the applicable water quality standards

2.4.4.4 Six Mile Creek

Six Mile Creek has a watershed of 24,423 acres in Brookings and Deuel Counties and empties into Deer Creek near Brookings. Land use in the watershed was primarily agricultural with 56% of the area as cropland and 39% as grassland. The municipalities of White and Brookings are located within this watershed. NPDES facilities taken into consideration within this segment of Six Mile Creek included SDSU and the City of White. The City of Brookings was also covered for discharges associated with medium municipal separate storm sewer systems (SDDENR 2004; TMDL Draft Six Mile Creek).

The watershed was assessed for TMDLs in the Central Big Sioux River Assessment (SDDENR 2004) by the EDWDD; however, the TMDL for TSS was not completed per this assessment and was listed as ‘draft’ stage. Six Mile Creek was not addressed in SDDENR-IRs until 2008 when it was included but noted with insufficient sampling information and limited sample data. In the

2010 and 2012 SDDENR-IR, Six Mile Creek was listed for Fecal Coliform Bacteria. The most recent SDDENR-IR of 2014 has the creek listed for both TSS and Fecal Coliform Bacterial.

In 2012 an assessment was conducted to estimate the relative pollutant loading from the City of Brookings to Six Mile Creek. The results from 2012 suggested that the highest concentrations of bacteria and sediment runoff were occurring in the northern portion of the city (Kopp, SDDENR, Personal Communication). This was because storm water outflows, within the southern portion, first flowed through man-made and constructed wetlands, which allowed the pollutants time to settle out in the wetlands. The sample site upstream of Brookings had lower concentrations of TSS and bacteria relative to the same site downstream of the city of Brookings; which was not expected. This suggested substantial loading of bacteria originating within the City of Brookings and prompted a follow-up study to determine what caused the drop in pollutant levels as the creek flowed through Brookings.

A follow-up study was conducted in 2015 on Six Mile Creek to determine if a feedlot and the SDSU ponds were contributing factors. The fact that the upstream sample site was adjacent to a small feedlot may have led to elevated bacteria and sediment levels. Six Mile Creek also flowed into the SDSU ponds which potentially lowered pollutant levels and may have influenced the results. The 2015 assessment confirmed that water entering the SDSU ponds was higher in pollution concentration relative to water flowing out of the SDSU ponds. In the 2012 study, the upstream sample site may have been poorly positioned immediately next to a small feedlot and may have made sample concentrations appear to improve as Six Mile Creek flowed through the City of Brookings. It was determined the SDSU ponds played a large role in reducing sediment by acting as a settling basin for sediment and bacteria as water entering the ponds was generally worse in terms of water quality than water exiting the ponds. The City of Brookings also did not appear to significantly contribute large sediment loads to Six Mile Creek. The TMDL assessment for Six Mile Creek is currently being conducted by SDDENR. Six Mile Creek has been proposed for delisting in the SDDENR-IR for 2016 as the TSS water quality standard has been achieved.

2.4.4.5 Skunk Creek

Skunk Creek has a watershed of 372,571 acres in Lake, McCook, Moody, and Minnehaha counties and originates at the outlet of Lake Brant northwest of Chester. Skunk Creek also receives drainage from the tributaries of North Buffalo Creek, Brant Lake Outlet, Buffalo Creek, Willow Creek, West Branch Skunk Creek, and Colton Creek. The municipalities of Hartford, Crooks, Colton, Chester, and Humboldt are located within this watershed. The watershed was assessed for TMDLs in the Central Big Sioux River Assessment (SDDENR 2004) by the EDWDD; however, the TMDL for TSS was not completed per this assessment. Skunk

Creek met the water quality criteria for TSS at the time of this assessment; however, it was not meeting the standards for fecal coliform bacteria. See TSS % Exceedances, Table 2-12.
Land use in the watershed was primarily agricultural with 65% of the area as cropland and 29% as grassland and pastureland. There were a total of 213 animal feeding operations in the watershed with 66% of the livestock being cattle. There were 11 NPDES permitted facilities. The cities of Colton, Crooks, and Hartford were the only identified point source contributors to TSS; however, their total contribution was less than 1% of the combined TSS load in Skunk Creek. The City of Hartford was the only identified point source that discharged during the sampling period. Their contribution was calculated to be insignificant, although it was noted that they had some very high daily maximums.

Total phosphorus summer mean concentrations for monitoring sites T16, T19, T20, T21, T22, and T23 were greater than the ecoregion mean of 0.30 mg/L. These higher numbers were attributed to sources such as livestock and human waste, commercial fertilizers, inadequate manure application, instream livestock, poor riparian areas, and septic failure. Table 2-13 shows the index values for bugs, fish, and stream habitat degradation as being moderate to severe for eight of the nine monitoring sites. The monitoring and modeling results indicated the Skunk Creek watershed accounts for 2% of the total TSS loading to the Big Sioux River (R13). Based on the water quality criteria during the assessment (SDDENR 2014), a TSS reduction of 10% was needed at one monitoring site, T21. SDDENR-IR 2012 and 2014 had Skunk Creek 303(d) listed for TSS. Currently a TMDL assessment for TSS has been initiated. SDDENR has proposed that Skunk Creek be delisted for TSS in the SDDENR-IR 2016, as the applicable water quality standard has been attained.

Table 2-12: TSS % Exceedance in the Skunk Creek Watershed. SDDENR 2014

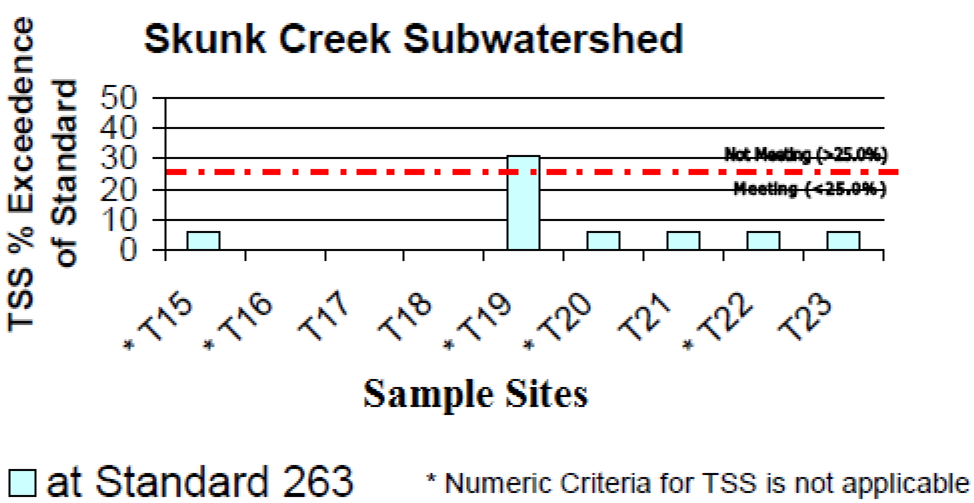


Table 2-13: Index Values for Skunk Creek Watershed

Final Index Values for Bugs, Fish, and Habitat for the Skunk Creek Watershed. SDDENR March 2004. TSS Evaluation.

Site	Macroinverts	Fish	Habitat	Suggested Impairment
T15	67	49	50	Moderate to Severe
T16	NA	24	62	Severe
T17	51	36	46	Severe
T18	54	56	40	Severe
T19	62	54	31	Severe
T20	71	60	67	Minimal to Moderate
T21	79	69	61	Minimal to Moderate
T22	64	52	39	Severe
T23	73	80	75	Minimal

2.4.4.6 Split Rock Creek

Split Rock Creek has a watershed of 168,525 acres in Moody and Minnehaha counties and originates near Pipestone, Minnesota. The creek is also the receiving waters for West Pipestone Creek, Pipestone Creek, and Beaver Creek. The watershed was assessed for TMDLs in the Central Big Sioux River Assessment (SDDENR 2004) by the EDWDD and the TMDL approved by EPA in 2008. Land use in the watershed was primarily agricultural with 99% of the area as grassland or cropland. The municipalities of Brandon, Sherman, Corson, Garretson, and Valley Springs are located in this watershed. Four NPDES facilities were assessed within this area: the USGS-EROS Data Center, the City of Garretson, the Corson Village Sanitary District, and the City of Valley Springs. Identified point sources in this watershed were found to contribute an insignificant amount to the total suspended solids loading and the "waste load allocation" component was of no consequence. Split Rock Creek was found to carry excessive sediment. This tributary experienced instream TSS loading from bed and bank erosion and also external TSS loading from its watershed. Natural background sources constituted only 2% of the total load with the remainder assigned to land uses likely to contribute sediment at rates above natural background; these included cropland, pastureland, bed/bank erosion, and residential areas. Split Rock Creek would require reducing the TSS concentrations by 67% under high flow conditions. Additional controls may be needed in order to achieve the applicable water quality standards.

2.4.4.7 Union Creek

Union Creek has a watershed of 23,217 acres in southeast South Dakota and discharges to the Big Sioux River near Alcester, South Dakota. During the assessment (SDDENR 2011), data was collected indicating the creek experienced periods of degraded water quality as a result of

TSS loads. The impaired reach of Union Creek lies within Union County. Land use in the watershed was primarily agricultural with 81% of the area as cropland and 14% as grassland. Nonpoint sources of TSS in Union Creek came primarily from agricultural sources.

Union Creek was not addressed in the SDDENR-IRs until 2008 when it was first listed for TSS and Fecal Coliform. It was again listed in 2010 for the same beneficial uses. The recent SDDENR-IRs of 2012 and 2014 have the creek listed for TSS and Fecal Coliform.

2.4.4.8 East Brule Creek

East Brule Creek currently has a TSS-TMDL assessment initiated.

2.4.4.9 Big Sioux River: Fairview to Mouth

TSS - TMDLs were established in 2009 for three segments of the lower Big Sioux River: Fairview to Alcester; Alcester to Indian Creek; Indian Creek to its Mouth; segments R18, R19, R20, respectively, per SDDENR-IR 2014. The watershed area of these segments is 2,396,661 acres; with 36.6%, 35%, and 28.4% of the acres in Iowa, Minnesota, and South Dakota, respectively. The overall objective of this study (SDDENR 2009) was to determine rates and loading of sediment from streambank erosion along main-stem reaches of the Big Sioux River. The TMDL used a review of available information, water quality and discharge data, FLUX loadings, Annualized-AGNPS modeling results, Rapid Geomorphic Assessments (RGAs), literature values, and load duration curves to identify nonpoint sources of sediment. The primary nonpoint sources of TSS for all three segments of the Big Sioux River watershed included: 1) sheet and rill erosion from the agriculturally dominated landscape, and 2) bed and bank erosion from the various tributaries as well as the Big Sioux River main stem. Other possible sources of TSS were identified as urban runoff and construction site erosion. The TSS loadings from streambank erosion were calculated between 10% – 25% of the total suspended sediment river load.

The three point source WWTPs of the cities of Hudson and Hawarden, South Dakota, and Akron, Iowa, are located directly on the Big Sioux River and contributed an insignificant point source of TSS loading to the Lower Big Sioux River. There were other permitted facilities located in the watershed but were not included because: 1) they were located in subwatersheds that require individual TSS or Pathogen TMDLs, or 2) they were located so far up in the watershed that their cumulative impact on the TSS loadings to segments of the Big Sioux River were insignificant relative to the nonpoint source contributions.

Several types of BMPs were recommended in the development of a water quality management implementation plan for the impaired segments of the Lower Big Sioux River. The results of the FLUX loadings indicated that an estimated 25% or greater of the TSS load originated from bank erosion in varying flow zones. The types of control measures recommended were: 1) livestock access to streams should be reduced, and livestock should be provided sources of water away from streams; 2) unstable stream banks should be protected by enhancing the riparian vegetation that provides erosion control and filters runoff of pollutants into the stream; 3) filter strips should be installed along the stream bordering cropland and pastureland; 4) animal confinement facilities should implement proper animal waste management systems; 5) a terrace maintenance program should be implemented to repair or replace failing terracing systems; 6) an assessment of the effect of tiling on peak flows and bank erosion should be completed for the tributaries draining into these three segments of the Big Sioux River (SDDENR 2009).

2.4.5 Nonpoint Sources of Impairment - Lakes

Lake water bodies that have met the 303(d) criteria of all their designated beneficial uses, per SDDENR IR 2014, were Brant Lake, Lake Campbell, Covell Lake, Goldsmith Lake, and Wall Lake. The following lakes did not meet their beneficial uses: Lake Alvin impaired for high temperatures; East and West Oakwood Lakes, Lake Herman, and Lake Madison for Chlorophyll-*a*; North Island Lake, Twin Lakes/W. Hwy #81, and Twin Lakes in Minnehaha County for high levels of mercury. The following lakes had insufficient data to make determinations on some of their designated beneficial uses: North Island Lake, Lake Sinai, Twin Lakes/W. Hwy #81, and Twin Lakes/Minnehaha County.

2.4.5.1 Lakes Herman and Madison.

Lake Herman and Lake Madison were listed 303(d) as Chlorophyll-*a* impaired for the support of Immersion Recreation, Limited Contact Recreation, and Warm Water Permanent Fish Life in the 2014 SDDENR IR. Lake Herman is the first lake in a chain of lakes at the headwaters of Silver Creek, which flows into Lake Madison, Round Lake, Brant Lake, and then into Skunk Creek; which is tributary of the Big Sioux River. See Figure 2-8. Lake Herman has a surface area of 1,350 acres with a watershed of approximately 43,000 acres and an average depth of 5.6 feet. Lake Madison has a surface area of 2,799 acres, a watershed of 29,191 acres, and a mean depth of 9.7 feet (SDDENR 1998). Agricultural land use in the watersheds was approximately 84% cropland and 15% grass or pasture. Both lakes have the water as the central focus for state parks and are fully equipped for the recreational activities of swimming, boating, picnicking, hiking, and fishing. Fish species include northern pike, walleye, yellow perch, and black bullhead.

In September 1977 the USDA and the USEPA initiated a joint water quality land management effort called the Model Implementation Project (MIP). The program was devised to demonstrate the effectiveness of soil conservation programs in cooperation with the local Lake Conservation District, SDDENR, USDA, and USEPA. Under the MIP, three sediment control structures and twelve types of BMPs were installed in the watershed. A Lake Herman Phase III Post-Implementation study was initiated in 1992 to determine the long-term effects of the land treatments on water quality. The mean and median of total phosphorus and chlorophyll-*a* levels were way into the hyper-eutrophic level of the water quality index. The Secci depth TSI was high into the eutrophic scale. These high indexes were both indicative of excessive amounts of nutrients. The mean trophic status of Lake Madison over the years was 73, which again was in the hyper-eutrophic range.

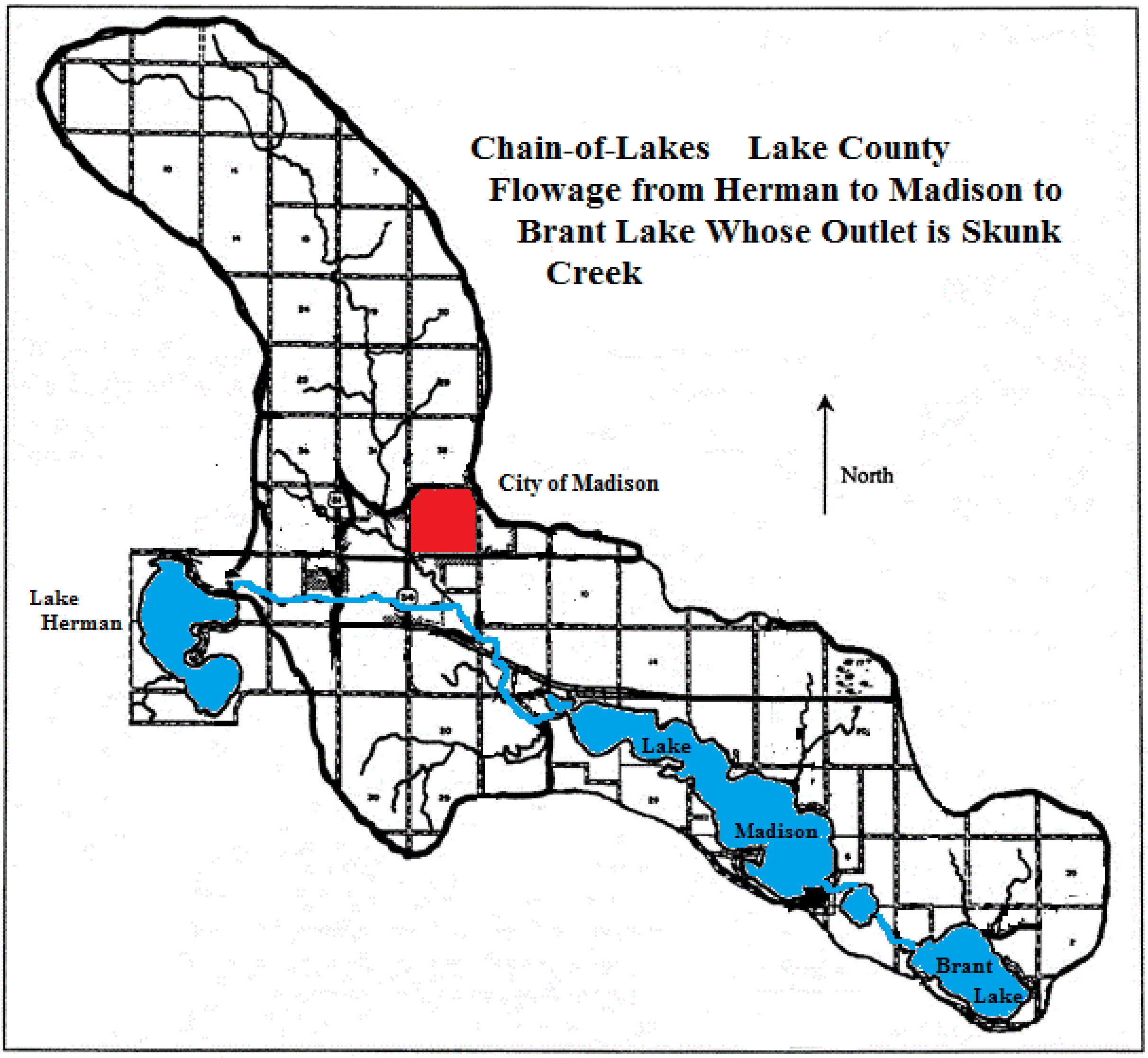
There were no point sources of pollution identified in the Lake Herman watershed. A watershed improvement project was initiated from 2000 through 2006 (Strom 2006). The project goal was to decrease the phosphorous loading of Lake Herman/Lake Madison/Brant Lake complex by 50% to be in compliance with the TMDL. To achieve the reduction, nutrient and sediment loads originating from critical areas were reduced by installing BMPs. Critical areas were those identified during the Lake Madison/Brant Lake Watershed Assessment and Lake Herman Post Implementation Investigation and in-field assessments completed as part of the project.

Activities selected to attain the project goal were divided among four objectives: Reduce Phosphorus Loading, Erosion Control, Storm Sewer Mitigation, and an Education Program. The PIP was amended during 2004 to achieve a better balance between the milestones and the needs of the producers. Activities completed to reduce phosphorus loading included construction of 8 AWMS located around Lake Herman. The tests were not able to show that there was a need to make alterations in the current practices. The northeast area of the lake was occupied by 8 summer cabins, and it was recommended that the septic systems be checked to ensure they were in compliance with regulations and did not discharge directly into the lake. Erosion control practices installed included 11 grassed waterways, 4 terraces, 6 multipurpose dams, and 1 bank stabilization project.

2.4.5.2 Lake Alvin - Temperature

Lake Alvin is a 107 acre reservoir completed in 1954 in northeastern Lincoln County that is owned and managed by SDGFP. See Figure 2-9. The dam was constructed in 1954 and the primary spillway was repaired in 1994. The lake has an average depth of 11 feet with a maximum depth 23 feet (Schelhaas 2009). The lake's water is continually replenished by Nine Mile Creek. Lake Alvin has a watershed of 28,013 acres and includes the cities of Harrisburg and the eastern portion of Tea, South Dakota. Since the TMDL report was completed in 2001, urban sprawl from the two major municipalities has accelerated

Figure 2-8: Lake County Chain of Lakes



resulting in the conversion of a portion of the pasture land into residential areas (Schelhaas 2009). Several watershed improvements have been made with the construction of a total retention wastewater treatment ponds for the City of the Harrisburg in 1999 and improvements to the City of Tea wastewater treatment ponds in 1998. Lake Alvin has had problems with high fecal coliform counts and swimming beach closures in the past.

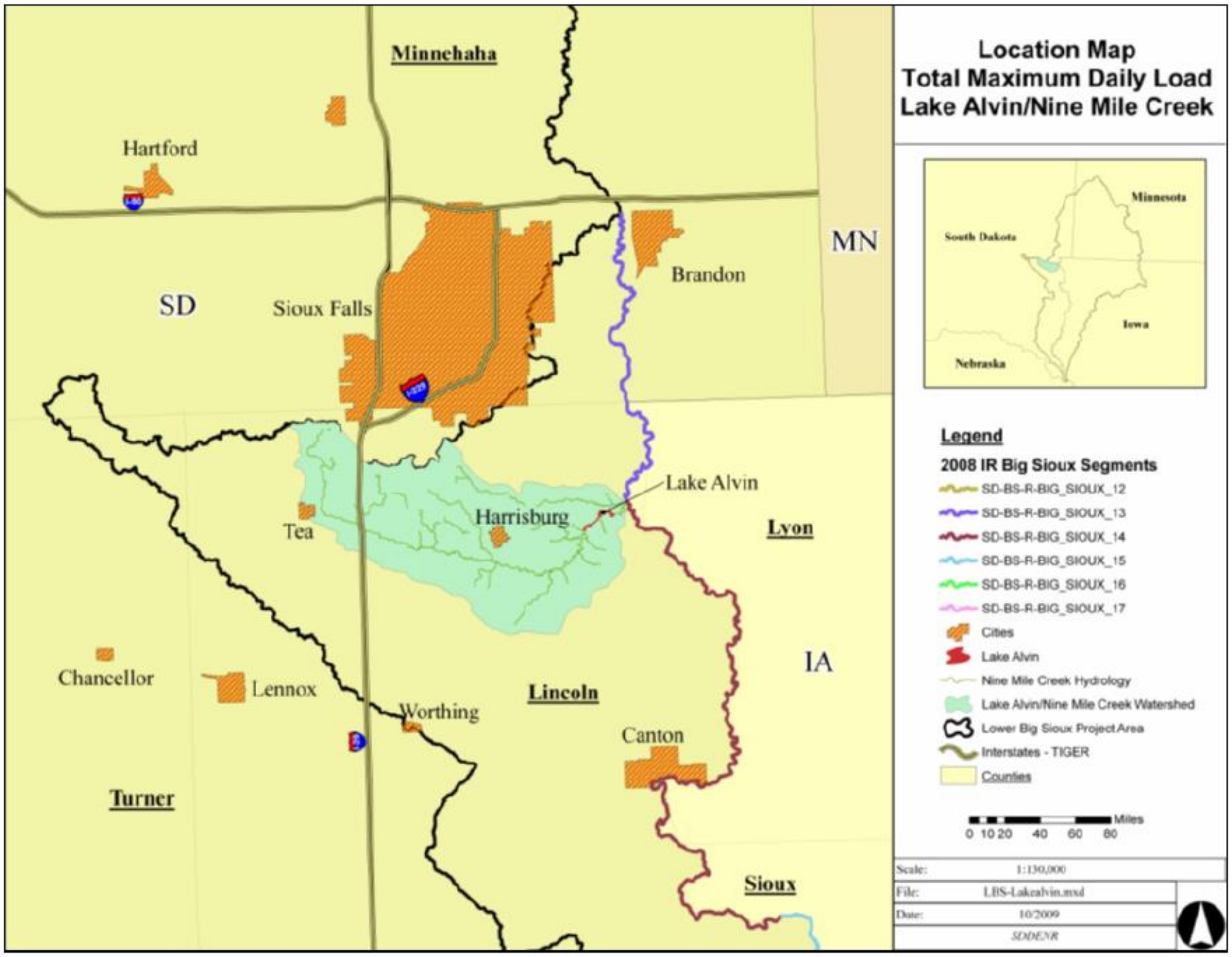
Lake Alvin was ranked as a high priority watershed after being listed in the 1998 SDDENR-IR for fecal coliform bacteria, fecal water quality standard violations, and increasing TSI trend. SDDENR completed a Phase 1 Watershed Assessment on the lake in January of 2001. During this study, there were no water quality standards exceedances for Nine Mile Creek downstream or upstream of Lake Alvin (SDDENR 2001). The increasing TSI trend observed in Lake Alvin was the result of increased nutrients by in-lake and delivered loads. Ten livestock feeding operations were documented within the watershed, and it was recommended to implement select BMPs to reduce fecal contamination from the livestock. It was felt this would result in a reduction of beach closures, while decreasing sediment erosion and nutrient inputs, and improve TSI levels. To reach the recommended goals (SDDENR 2001) the phosphorus load will have to be reduced by 67%. The recommended target for an average TSI value in Lake Alvin was 64.95. After implementing both tributary and in-lake BMPs, an average reduction in current loadings of approximately 67% was expected.

Lake Alvin has a southwest to northeast geographical orientation which is conducive to wind energy that can help break down a lake's vertical stratification. Wind energy transports phosphorus from bottom sediments and resuspends it into all water levels. The resuspension of sediments can also lead to an earlier warming of water temperatures above normal, as the suspended particles near the surface facilitate the absorption of heat from sunlight. This internal loading of phosphorus and early warming can accelerate an early growth of algae and aquatic plants and the resulting plant problems associated with human induced cultural eutrophication. The TMDL for temperature impairment has not been initiated at this time. SDDENR has proposed delisting Lake Alvin for the 2016 SDDENR-IR as it has fully met all its beneficial uses.

2.4.5.3 Mercury in Fish Tissue. North Island Lake; Twin Lakes/W. Hwy 81; Twin Lakes/Minnehaha County

South Dakota Department of Health (SDDH 2016) samples at least 10 lakes each year for a panel of 25 contaminants including mercury. Prior to the current state testing program, only one other body of water was found with mercury levels above the FDA's action level of 1 ppm. The SDGFP issued a human health advisory for the consumption of fish as follows: North Island Lake for Walleye 18 inches in length or larger and Smallmouth Bass 18 inches or larger; Twin Lakes/W. Hwy 81 for Walleye 18 inches or larger and Northern Pike 19 inches or larger; Twin Lakes/Minnehaha County for Walleye of all sizes. The BSRWIP is not able to address the 303(d) listing of mercury for this lake because the pollution is a combination of the above normal precipitation runoff into the lake, pollution from atmospheric deposition of mercury from sources outside the BSRWIP area, and bio-magnification of the pollutant via the food web. SDDENR has proposed delisting North Island Lake, Twin Lakes/W. Hwy81, and Twin Lakes/Minnehaha County for Mercury in Fish Tissue for the 2016 SDDENR-IR. These lakes will no longer be on the 303(d) listing. Agricultural BMPs therefore will not be discussed for this pollutant.

Figure 2-9: Lake Alvin – Nine Mile Creek Watershed



3. NONPOINT SOURCE MANAGEMENT MEASURES

The management measures needed to address the causes and sources of pollution impairments are strongly interrelated. The nonpoint impairments have been identified as agricultural activities linked to livestock feeding operations, nutrients from livestock manure, direct use of water bodies by livestock, and soil erosion from both adjacent cropland and pasture. Practice effectiveness will overlap in many instances, and these nonpoint measures will result in load reductions that affect several sources. Evans et al. (2003/2008) studied predicted load reductions for NRCS Best Management Practices.

The Phase 1 Watershed Assessment final Report and TMDLs for the Central Big Sioux River (SDDENR March 2004) completed a review of the BMPs with the pollutant they are effective on and their potential load reductions. Table 3-1 presents the effectiveness of each BMP, and Table 3-2 lists its range of achievable load reductions. Table 3-3 presents the BMPs most suited to the five hydrologic stream conditions and the recommended management practices to help reduce loads. High flow is representative of conditions when precipitation intensity exceeds the rate of water infiltration into the soil and may cause flooding. Moist conditions are representative of those periods when the soils are already saturated and runoff is occurring. Mid-range flows are representative of subsequent rain events and of a time when saturation is beginning to lessen. Dry conditions are representative of those times when rain is sparse. Low flows are representative of conditions when rain is absent, and there is a drought situation. The Nonpoint Source Measures will be described and referenced to BMPs as defined by the NRCS. A comparison of load reduction data are also presented in Table 3-4 by Evan's et al. (2003/2008), as he studied predicted load reductions for NRCS BMPs. Any related NRCS practices may also be selected and added to supplement these identified BMPs as necessary to achieve load reductions.

Table 3-1. BMPs, Pollutants Affected, Potential Load Reductions, SDDENR 2004

BMP	Fecal	Nutrients	Potential Reduction
(1) Feedlot Runoff Containment	X	X	High
(2) Manure Management	X	X	High
(3) Grazing Management	X	X	Moderate
(4) Alternative Livestock Watering	X	X	Moderate
(5) Contour Farming		X	Moderate
(6) Contour Strip Farming		X	High
(7) Terracing		X	High
(8) Conservation Tillage (30% residue)		X	Moderate
(9) No Till		X	High
(10) Grassed Waterways		X	Moderate
(11) Buffer/Filter Strips	X	X	Moderate
(12) Commercial Fertilizer Management		X	Moderate
(13) Streambank Stabilization		X	High
(14) Urban Runoff Controls			
(14a) Pet Waste Control	X	X	High
(14b) Lawn Fertilizer Control		X	High
(14c) Construction Erosion Control		X	High
(14d) Street Sweeping		X	High
(14e) Stormwater Ponds	X	X	High
(15) Wetland Restoration or Creation	X	X	High
(16) Riparian Vegetation Restoration	X	X	High
(17) Conservation Easements	X	X	High
(18) Livestock Exclusion	X	X	High

Note: approximate range of reductions:
Low = 0-25% Moderate = 25-75% High = 75-100%

Table 3-2: BMP Benefits and Achievable Reductions in BSRWIP. SDDENR March 2004

BMP	Benefits	Achievable Reduction
Manure Management	• Reduces Nutrient Runoff • Significant Source of Fertilizer	50-100% reduction of nutrient runoff
Buffer/Filter Strips	• Controls sediment, phosphorus, nitrogen, organic matter, and pathogens	50% sediment and nutrient delivery reduction
Conservation Tillage	• Reduces runoff • Reduces wind erosion • More efficient in use of labor, time, fuel, and equipment	30-70% pollutant reduction 50% nutrient loss reduction (depends on residue and direction of rows and contours)
Contouring	• Control erosion of cropland and pasture • Reduces runoff and conserves moisture • Can increase yields	30-50% erosion reduction 25% nutrient reduction 10-50% runoff reduction (based on 2-12 % slope)
Confinement Ponds	• Sediment/nutrient reduction • Reduction in peak flow runoff • Increase in wildlife habitat	60-90% sediment trapping 10-40% nutrient trapping
Fencing	• Reduces erosion • Increases vegetation • Stabilized banks • Improves aquatic habitat	Up to 70% erosion reduction
Grassed Waterways	• Reduces gulleys and channel erosion • Reduces sediment associated nutrient runoff • Increases wildlife habitat	10-50% sediment delivery reduction (broad) 0-10% sediment deliver reduction (narrow)
Strip Cropping	• Reduces erosion and sediment loss • Reduces field loss of sediment associated nutrients	High quality sod strips filter out 75% of eroded soil from cultivated strips
Terraces with Contours	• High reduction of erosion • Reduces loss of sediment associated nutrients	50-100% sediment reduction 25-45% nutrient reduction (2-12 degree slopes)

Table 3-3. Fecal Coliform Bacteria BMP Recommendation by Hydrologic Condition. SDDENR March 2004

Hydrologic Condition	Source of Pollutant	Possible Contributing Source Areas	Recommended Management Practices
High Flows (0-10)	*Nonpoint Source*	Absent/Poor Riparian Areas	**Riparian buffers-** riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Sewer System Overflows/Stormwater	Sewer and NPDES Inspection
		Manure Runoff/Concentrated Feedlots	Feedlot Runoff Containment
Moist Conditions (10-40)	*Nonpoint Source*	Absent/Poor Riparian Areas	**Riparian buffers-** riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Incorrect Land Application of Livestock waste	Fertilizer Management
		Livestock In-stream	Alternative Livestock Watering
		Manure Runoff/Concentrated Feedlots	Feedlot Runoff Containment
		Pastured Livestock	Fencing, Channel crossing, Grazing Management
		Sewer System Overflows/Stormwater	Sewer and NPDES Inspection
		Urban Runoff	Pet Waste Management
Mid-range Flows (40-60)	*Nonpoint Source*	Absent/Poor Riparian Areas	**Riparian buffers-** riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Incorrect Land Application of Livestock Waste	Fertilizer Management
		Livestock In-Stream	Fencing, Channel crossing, Alternative Livestock Watering
		Manure Runoff/Concentrated Feedlots Pastured Livestock	Feedlot Runoff Containment Grazing Management
		Urban Runoff	Pet Waste Management
Dry Conditions (60-90)	*Nonpoint/Point Source*	Absent/Poor Riparian Areas	**Riparian buffers-** riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Discharge from Wastewater Treatment Plants or Industries	Point Source Inspection
		Incorrect Land Application of Livestock Waste	Fertilizer Management
		Livestock In-Stream	Fencing, Channel Crossing, Alternative Livestock Watering
		Manure Runoff/Concentrated Feedlots	Feedlot Runoff Containment
		Pastured Livestock	Grazing Management
		Septic System Failure	Septic System Inspection
Low Flows (90-100)	*Point Source*	Discharge from Wastewater Treatment Plants or Industries	Point Source Inspection
		Livestock In-Stream	Fencing, Channel Crossing, Alternative Livestock Watering
		Manure Runoff/Concentrated Feedlots	Feedlot Runoff Containment
		Pastured Livestock	Grazing Management
		Septic System Failure	Septic System Inspection
		Straight-Pipe Septic Systems	Septic System Replacement

Table 3-4. Estimated BMP Reduction Efficiencies by Pollutant Type. Evans 2003/2008

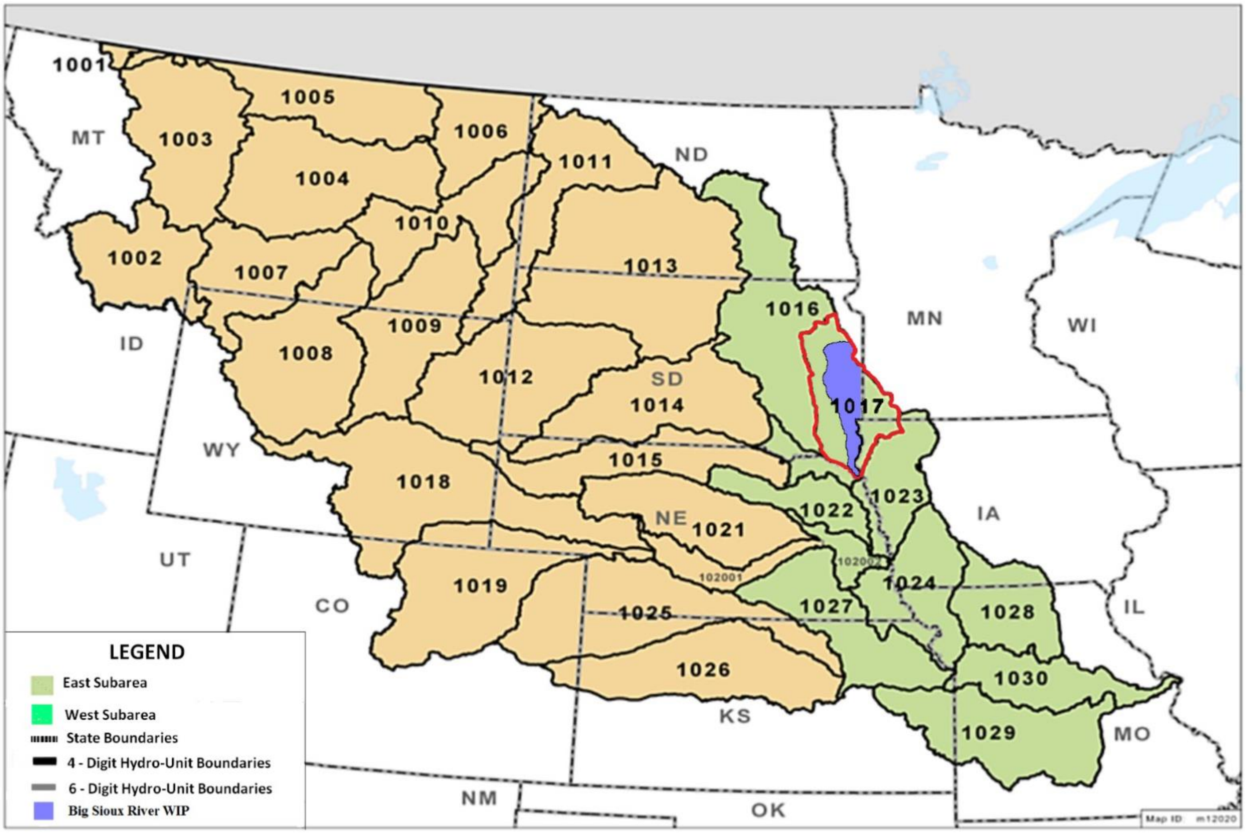
BMP SYSTEM/TYPE	NRCS PRACTICE	NITROGEN	PHOSPHOROUS	SEDIMENT	FECAL
Crop Residue Manage	329 & 345	50%	38%	64%	-
Vegetated Buffer	390	54%	52%	58%	70%
Grazing Land Manage	528	43%	34%	13%	-
Streambank Protect	580	65%	78%	76%	-
Nutrient Manage Plan	590	70%	28%	-	-
Grassed Waterways	428	54%	52%	58%	-
Constructed Ponds/Wetlands	378 & 657	88%	53%	51%	71%
Waste Storage Facility	313	75%	75%	-	75%

A thorough evaluation of the effects of conservation practices on cultivated cropland from 2003 to 2006 in the Missouri River Basin was completed by NRCS in 2012 in the Conservation Effects Assessment Project (CEAP). See Figure 3-1 for the watersheds covered in the study. The goals of CEAP were to estimate conservation benefits, to establish the scientific understanding of the effects and benefits of conservation practices at the watershed scale, and to provide research and assessment on how to best use conservation practices in managing agricultural landscapes to protect and enhance environmental quality. The studied subregion included in the BSRWIP area is the Missouri-Big Sioux-Lewis-Clark Lake (code 1017) with approximately 66.8% percent of its watershed in cultivated cropland and 21.6 percent in permanent grass.

The CEAP study used the computer model HUMUS/SWAT to evaluate conservation practices in use on cultivated cropland. The model estimated that conservation practices reduced sediment, nutrient, and atrazine loads delivered to rivers and streams from cultivated cropland sources per year, on average, by 54% for nitrogen, 60% for phosphorus, 76% for sediment, and 36% for atrazine.

A Field-Level Cropland Model called APEX, used to simulate the effects of conservation practices at the field level, showed that adoption of additional erosion control and nutrient management practices on the 15.3 million under-treated acres would further reduce field losses in the region by 37% for sediment loss due to water erosion, 24% for nitrogen lost with surface runoff, 12% for nitrogen loss in subsurface flows, 20% for phosphorus lost to surface water (sediment-attached and soluble), and 22% for wind erosion.

Figure 3-1. Subregions Studied in the Missouri River Basin, CEAP. NRCS 2012



3.1 Animal Waste Management System. NRCS Practice Code 313, Waste Storage Facility

A Waste Storage Facility is part of an AWMS and is designed for the full containment of animal wastes by the proper handling, storage, and utilization of wastes generated from animal confinement operations. The waste storage facility should reduce any discharge of animal wastes into the waters of the state. Therefore, the potential nutrient reduction in loading should be significant. Wastes would only be applied, through a NMP, when growing crops can use the accompanying nutrients and soil and weather conditions are appropriate.

During the Central and Lower Big Sioux River Watershed Assessments, 1,525 livestock operations were located and analyzed using the AGNPS pollution feedlot model. Of the 1,525 operation assessed, 492 operations (32%) were ranked at or above 50. Load reductions per system reported for the CBSRWIP Final Report Segment 2 for installed AWMSs were 7,329 pounds of nitrogen; 1,553.4 pounds of phosphorus; and 13.0 tons of sediment (Berg February 2016).

3.2 Nutrient Management Plan System. NRCS Practice Code 590

A Nutrient Management Plan (NMP) is a required component of the AWMS. The purpose of an NMP is to utilize manure or organic byproducts as a plant nutrient source and minimize agricultural nonpoint source pollution of surface and ground water resources. A nutrient budget is developed for nitrogen, phosphorus, and potassium that considers all potential sources of nutrients including, but not limited to, animal manure and organic by-products, waste water, commercial fertilizer, crop residues, legume credits, and irrigation water. This should result in reduced nutrient loading from manure spread on fields as estimated by Evans (2003, 2008) of 70% for nitrogen and 28% for phosphorous.

The assessment of conservation practices for the entire Missouri River Basin (NRCS 2012) found the second highest percentage of cropped acres with manure applied for all subregions was the Missouri-Big Sioux-Lewis-Clark Lake (code 1017), as it had manure applied to 16% of its total cropland acres. The CBSWIP Segment 2 Final Report (Berg February 2016) reported that the high fecal coliform levels were associated with animal livestock feeding operations, livestock use of riparian areas, and the lack of prescribed grazing systems, which may include both excess application rates and not incorporating manure applied in areas subject to high runoff rates.

3.3 Prescribed Grazing – Riparian Areas. NRCS Practice Code 528

Prescribed Grazing may be applied on all lands where grazing and/or browsing animals are managed. Removal of herbage by the grazing animals will be in accordance with production limitations, plant sensitivities, and management goals. Frequency of defoliations and season of grazing is based on the rate of growth and physiological condition of the plants. Duration and intensity of grazing is based on desired plant health and expected productivity of the forage species to meet management objectives. In all cases enough vegetation is left to prevent accelerated soil erosion. Proper grazing management would include practices such as: (1) utilizing stocking rates to better manage grass height, (2) grazing riparian pastures timely when ground conditions are not conducive (wet) to excessive bank and shoreline damage, and (3) rotational use of pastures to allow periods of grass rest and recovery.

SDDENR watershed studies within the BSRWIP that have identified livestock grazing as an additional source of nutrients and fecal bacteria were the Big Sioux River TMDL (SDDENR 2011), North-Central Big Sioux River (SDDENR 2005) and TMDL Big Sioux Segment 3 (SDDENR 2009). Load reductions for Segments 1 and 2 of the LBSRWIP (Berg 2013) for grazing management were 2.0 pounds of nitrogen/acre/year, 0.43 pounds of phosphorus per acre, and 0.28 tons of sediment per acre on 154 acres of grazing management. The SRAM practice (Berg 2016) had load reductions of 8.0 pounds of nitrogen/acre/year, 1.9 pounds of phosphorous/acre/year, and 0.4 tons of soil/acre/year on 585.3 acres of riparian restoration. The

Kingsbury Lakes study (Strom 2008) reported load reductions of 8.63 pounds of nitrogen/acre/year, 1.57 pounds of phosphorous/acre/year, and 0.93 tons of sediment/acre/year on 1,337 acres of grazing land management. Rotational grazing and exclusion of livestock from critical riparian areas (steep slopes adjacent to the lake and stream) also provides benefits that are difficult to simulate in modeling.

The application of prescribed grazing basin wide would manipulate the intensity, frequency, duration, and season of grazing to: (1) improve water infiltration, (2) maintain or improve riparian and upland area vegetation, (3) protect stream banks from erosion, and (4) manage for deposition of fecal material away from water bodies. Management of livestock should include prescribed grazing, constructing fences or other barriers to control concentrated livestock access to riparian areas, livestock crossing structures, and alternative water supply. Other alternatives include seasonal access or rotational grazing to reduce the intensity and duration of access to riparian zones and uplands. Grazing along shorelines could be restricted by fencing the stream corridors off and keeping cattle out of the stream channel area. Since livestock may have direct contact with water bodies during hotter weather, grazing should be limited to cooler and less erosive periods of the year. Conservation Reserve Program (CRP) vegetative buffer strips could also be enrolled to protect streams and stream banks. Current CRP buffer practices allow up to 120 feet of perennial herbaceous vegetation to be protected from grazing adjacent to intermittent streams to benefit water quality. Other practices along riparian areas would be Stream Bank Restoration and Riparian Forest Buffers.

3.4 Residue & Tillage Management on Cropland. NRCS Practice Code 329

Residue and Tillage Management BMPs applies to all cropland and includes both no-till and tillage methods commonly referred to as mulch tillage, where the soil surface is disturbed by tillage operations. Mulch tillage includes vertical tillage, chiseling, disking, and also includes tillage/planting systems with relatively minimal soil disturbance. No Till or Strip Till applies to limiting the soil disturbing activities to only those necessary to place nutrients, condition residue, and plant crops. Surface residue is left evenly distributed, and no full width tillage is implemented.

The NRCS CEAP study (2012) found some acres required additional conservation treatment on only one of the five resource concerns, while other acres required additional treatment for two or more resource concerns. The five resource concerns evaluated for the Missouri River Basin were: (1) sediment loss due to water erosion, (2) nitrogen loss with surface runoff (nitrogen attached to sediment and in solution), (3) nitrogen loss in subsurface flows, (4) phosphorus lost to surface water (phosphorus attached to sediment and in solution, including soluble phosphorus in subsurface lateral flow pathways), and (5) wind erosion.

After accounting for the acres that need treatment for multiple resource concerns, the evaluation of treatment needs for the Missouri River Basin determined the following:

- 1% of cropped acres (1.1 million acres) have a 'High Level' of need for additional conservation treatment,
- 17% of cropped acres (14.2 million acres) have a 'Moderate Level' of need for additional conservation treatment, and
- 82% of cropped acres (68.3 million acres) have a 'Low Level' of need for additional treatment and were considered to be adequately treated.

Land acres that required treatment for two or more resource concerns were considered 'under-Treated'; these acres were the high and moderate levels that needed additional conservation treatments. The Missouri-Big Sioux-Lewis/Clark Lake subregion (code 1017) had 5.2% of its subregion acres listed as under-treated. The delivery rates of nitrogen, phosphorus, and sediment per acre in this subregion was 6.52 lbs/ac/year, 0.38 lbs/ac/year, and 0.11 ton/ac/year, respectively. The Missouri River basin-wide averages were 5.82 nitrogen lbs/ac/year, 0.38 Phosphorus lbs/ac/year, and 0.17 Sediment tons/ac/year, respectively. Cropland management load reductions for Segments 1 and 2 of the LBSRWIP (Berg 2013) were 10.7 pounds of nitrogen/acre/year, 3.8 pounds of phosphorus per acre, and 2.8 tons of sediment per acre on 3,172 cropland acres.

Eighty-two percent of the cropped acres in the Missouri River Basin that had a 'low level' of conservation treatment need were considered to be 'adequately treated'. This is in part due to the relatively lower vulnerability potential for most cropped acres in this region as compared to other regions of the United States. Additional conservation treatment for these acres with a 'low' need for treatment is expected to provide small per-acre reductions in erosion and nutrient losses, requiring a large number of acres to be treated in order to have a significant impact at the subregional and regional levels. The emphasis recommended in the NRCS-CEAP study was to identify and target the lands that needed Moderate and High Levels of conservation treatment needs and concentrate work efforts on these priority areas. Load reductions for Segments 1 and 2 of the LBSRWIP (Berg 2013) for cropland management were 10.7 pounds of nitrogen/acre/year, 3.8 pounds of phosphorus per acre, and 2.8 tons of sediment per acre on 3,171.7 acres of cropland management.

3.5 Stream Bank & Channel Stabilization. NRCS Practice Code 580

Stream bank stabilization is a treatment used to stabilize and protect the banks of streams and the shorelines of lakes or reservoirs. The purpose is to prevent the loss of land or damage to land use or facilities adjacent to the banks of streams or lakes. Stabilization efforts also reduce the offsite or downstream effects of sediment deposition resulting from bank erosion. The treatment of severely eroded banks usually involves back-sloping with heavy earth moving equipment to a stable grade. The area is then protected with a geotextile fabric and covered with stone rip-rap according NRCS standards. This practice is quite costly and is typically used as a last resort to stabilize a bank and protect valuable facilities adjacent to the bank.

Berg used STEPL to evaluate the reduction of TSS and other nutrients from implementation of bank stabilization. Calculations for load reductions were based on 11,275 linear feet of bank stabilized with an average bank height of 8 feet and a lateral recession of 5 foot per year. Streambank stabilization projects installed on the Big Sioux River, as reported by Berg (2012), reduced nitrogen by 2.4 pounds/linear foot (lbs/LF), reduced phosphorus by 0.9 lbs/LF, and reduced sediment by 1.8 tons/LF for 11,275 LF of stream bank.   Strom reported similar load reductions on 15,400 LF of stream bank stabilization projects installed on the Big Sioux River (2010) as reducing nitrogen by 2.6 lbs/LF, phosphorus by 1.0 lbs/LF, and sediment by 1.8 tons/LF.

Bank failure along streams has been linked to livestock use of the riparian areas and the loss of riparian vegetation from cattle grazing. Properly functioning riparian areas can significantly reduce nonpoint source pollution by intercepting surface runoff, filtering and storing sediment and associated pollutants, and stabilizing banks. Stream bank stability is directly related to the species composition of the riparian vegetation and the distribution and density of these species (Sheffield 1997). Proposed BMPs to address riparian area degradation in this study included livestock use exclusion, stream bank stabilization and protection, and reseeding or manual planting of native plant species.

3.6 Grassed Waterways. NRCS Practice Code 412

Grassed waterways are shaped or graded channels that are established with suitable vegetation to carry surface water at a non-erosive velocity to a stable outlet. They are used to control gully erosion formed in fields where added water conveyance capacity and vegetative protection are needed to control erosion resulting from concentrated runoff. AnnAGNPS (Yuan et al. 2006) estimated that ephemeral gully erosion accounted for approximately 85% of the total landscape erosion in that watershed, while sheet and rill erosion amounted to the remaining 15%. The simulation of ephemeral gullies for delivery of sediments and associated nutrients is an important process captured in AnnAGNPS, which is not an element of many other watershed models and highlights the importance of grassed waterways and buffer strips in load reductions. The PRediCT model, Evans et al. (2008), estimates a 54% reduction in nitrogen, a 52% reduction in phosphorus, and a 58% reduction in sediment by installing grassed waterways.

Load reductions for Segments 1 and 2 of the BSRWIP (Berg 2013) for grassed waterways were 28.3 pounds of nitrogen/acre/year, 41.9 pounds of phosphorus/acre/year, and 28.3 tons of sediment/acre/year on 11,043 linear feet. Smith (2007) reported grassed waterways to reduce phosphorus by 2.45 pounds/acre/year and sediment by 4.9 tons/acre/year in the Lake Poinsett watershed project. Other projects have reported higher savings, as Kringen, (2010), in the James

River watershed, reported nitrogen load reductions of 124.3 pounds/acre/year; phosphorous by 32.6 pounds/acres/year; and sediment by 16.7 tons/acre/year. Gullies are some of the more serious forms of erosion on slight to moderate slopes where contour farming and terraces are not practical. Grassed waterways need to be implemented basin wide in the identified critical cells in conjunction with conservation tillage and no-till.

3.7 Wetland Restoration, Pond Construction, Water & Sediment Control Basins, and Structures for Water Control. NRCS Practice Codes 657, 378, 638, 587, Respectively

Concave slopes, often occupied by wetlands, serve as sediment traps on the landscape and act as a filter for adjacent aquatic systems (NDSU 2006). Excessive deposition in wetland landscapes, where erosion has been accelerated substantially, has reduced the wetlands capabilities to store sediments. The problem of sedimentation is then passed downstream, eventually impacting aquatic systems such as lakes and streams. Wetlands have evolved to transform the soluble and adsorbed chemical load delivered in surface runoff into nontoxic forms that allow diverse biotic conditions to flourish. When wetlands are removed from the landscape, soluble and adsorbed chemicals are delivered directly to aquatic systems. Streams, rivers, and lakes have not evolved the capacity to withstand increased chemical inputs, particularly at the rates delivered due to accelerated erosion. The result is hyper-eutrophic conditions and chemical toxicity that reduces the biotic diversity and value of aquatic water resources.

Nitrogen levels in Northern Prairie Pothole Region (NPPR) wetlands, lakes and tributaries have been observed to vary seasonally. Generally the highest concentrations of nitrites and nitrates are found during spring runoff from agricultural activities. These concentrations subside substantially by biological activity as temperatures increase later in the spring and summer. Total nitrogen concentrations in NPPR lakes are lowest in the fall, increase in the winter, remain the same or decrease in the spring, and increase in the summer. The periods of highest total nitrogen concentrations are the summer and winter. In the summer, the predominant form of nitrogen is organic due to flourishing populations of aquatic organisms. In the winter, the predominant form of nitrogen is ammonia. This is because decomposition of organic material only proceeds through the ammonification step of mineralization due to the reduced environment. By the end of winter, toxic levels of ammonia may become a water quality problem, particularly in smaller lakes.

Phosphorus is distinctly less mobile in the environment, compared with nitrogen. An important aspect of phosphorus control is related to the release of PO4 -3 from lake sediments, known as internal nutrient loading. Anoxic or low redox potentials in lake or wetland sediments will contribute to environmental conditions that maintain soluble PO4 -3 in the water at relatively high levels. The oxidation state of iron in iron oxides is reduced when the redox potential is lowered. Under these conditions PO4-3 is not readily adsorbed to iron oxide surfaces and is released to solution. Mineralization also continues to release PO4 -3 from organic matter.

Therefore, aquatic systems that have accumulated a significant layer of eroded sediment likely will not see much reduction in PO4 -3 concentrations for extended periods after the implementation of management practices.

The School/Bullhead Lakes study within the upper Big Sioux River watershed (SDDENR 2005) removed 1,833 acres of impoundments, 10 acres or larger, and ran the AnnAGNPS computer model with the scenario of ‘no impoundments’ to compare with the existing watershed conditions. The removal of the impoundments caused an increase loading of mass nitrogen by 41%, of mass phosphorus by 21%, and a 98% increase in sediment loading; demonstrating the importance of impoundments in filtering nutrients, which is especially true of wetland areas.

Smith (2007) reported a phosphorus savings of 2.5 pounds/acre/year and 5.0 tons of sediment/acre/year for sediment retention dams installed in the Lake Poinsett Watershed Improvement Project. Load reductions for sediment and phosphorus were also documented in both restored wetlands with vegetated buffers and constructed ponds during the Little Minnesota River (Jensen 2007) project. Total phosphorus and sediment reductions on 51 multi-purposed ponds with 5,846 acres of watershed were reported as load reductions of 1.49 pounds/acre/year and 0.78 tons/acre/year, respectively, for the expected 20 year pond lifespan. For this reason, wetland restoration, pond construction, water and sediment control structures, and structures for water control will be part of the BSRWIP strategic plan. The purpose for these practices is to create multi-purpose ponds in the watershed to trap sediment, phosphorus, nitrogen, benefit wildlife, and serve as an alternative water source for grazing management systems.

3.8 Conversion of Cropland to Forage and Biomass Plantings. NRCS Practice Code 512

The AnnAGPS model (Yuan et al. 2006) estimated a suspended sediment loading reduction of 54% with a conversion of 10% of the highest eroding cropland to grassland. A 60% reduction was achieved for a combined management scenario involving conservation tillage, conversion of crop to grassland, and improved nutrient management. One scenario, which converted 25% of the highest eroding cropland in the watershed to grassland, reduced the sediment loads at the watershed outlet by 80%. Converting the highest eroding cropland cells to grassland was more efficient in sediment reductions than converting the highest eroding cropland cells from reduced tillage to no tillage practice (Yuan et al. 2006). The data clearly implies the importance of utilizing AGNPS programs that identified the critical cells throughout the North-Central, Central, and Lower Big Sioux River Basin during assessments and evaluate them before BMPs are installed. Berg (2013) reported a savings of 13.4 pounds/acre/year of nitrogen, 5.3 pounds/acre/year of phosphorus, and 3.9 tons/acre/year of sediment for grass establishment on 219.6 acres in the Big Sioux River watershed. Smith reported a savings of 3.7 pounds/acre/year of nitrogen, 1.14 pounds/acre/year of phosphorus and 0.79 tons/acre/year of sediment for grass establishment in the Lake Poinsett Watershed Improvement Project (2007). An alternative to conservation residue management within critical watershed cells would be the conversion of cropland to vegetative species suited to pasture, hayland, or biomass production. This would be a conversion without retiring the land from production completely, as with the Conservation Reserve Program. The benefits would be to reduce erosion and improve soil and water quality, while increasing forage production or energy production and improving livestock nutrition.

3.9 Conservation Crop Rotation and Conservation Cover Crops. NRCS Practice Codes 328 & 340

3.9.1 Conservation Crop Rotation 328

A Conservation Crop Rotation that meets NRCS practice standards is the growing of crops in a planned sequence on the same field with at least one-third of the planned crop rotation, on a time basis, planted to annual crops. A planned crop rotation must consist of a minimum of two "crop types." Crop types in South Dakota are defined as follows: warm-season grasses, examples: corn, sorghum, millet, warm season perennial grasses; cool-season grasses, examples: winter and spring wheat, barley, oats, cool-season perennial grasses; warm-season broadleaf, examples: soybean, sunflower, dry beans, potatoes, alfalfa, and other warm season perennial broadleaf crop; and cool-season broadleaf, examples: field pea, flax, canola, mustard.

This practice consists of growing different crops in a planned rotation to manage nutrient and pesticide inputs, enhance soil quality, or reduce soil erosion. Including hay or a close grown crop in rotations with row crops can have a pronounced effect on long-term average field losses of sediment and nutrients, as well as enhancement of soil quality.

In the Missouri River Basin study (USDA 2012) crop rotations that meet NRCS criteria occurred on about 88% percent of the cropped acres. The BSRWIP would require an additional resource-conserving crop in the producer's rotation that reduces soil erosion, improves soil fertility and tilth, interrupts pest cycles, and reduces depletion of soil moisture or otherwise reduces the need for irrigation. A resource-conserving crop is one of the following: perennial grass; legume grown for use as forage, seed for planting, or green manure; legume-grass mixture; or a small grain grown in combination with a grass or legume green manure crop whether inter-seeded or planted in rotation.

3.9.2 Conservation Cover Crop 340

A conservation cover crop includes grasses, legumes, and forbs for seasonal cover that are planted on lands requiring vegetative cover for natural resource protection. A cover crop is also considered a crop in the rotation and does meet the standard for a Conservation Crop Rotation (328). Generally, the cover crop may be planted late in another crop's growing season or soon after harvest for over wintering protection. A cover crop can provide multiple conservation benefits several being (1) to reduce erosion from wind and water, (2) to capture and recycle or redistribute nutrients in the soil profile thus preventing leaching, and (3) encourage the deposition of sediment to reduce sediment delivery to water bodies.

Studies (Hargrove 1991) have shown that cover crops are very effective at reducing soil erosion and the runoff from precipitation events. Conventional tillage on a soybean field had a soil loss of 3.34 tons/acre/year; the incorporation of a cover crop into the rotation reduced the soil loss to 0.75 tons/acre/year. Utilizing both a no-till system and a cover crop further reduced the soil erosion loss to 0.04 tons per acre. Soil loss reductions were more pronounced when a cover crop was used with conventional tillage systems. The winter cover crop treatment produced results similar to a meadow rotation treatment. Use of the cover crop reduced average annual runoff from 31% - 65% and accompanying soil losses from 42% - 92%. Conservation cover crop treatment use will provide both soil erosion benefits and the reduction of water runoff that carries the fertilizers and pesticides.

The two most important functions of cover crops (NRCS 2012) from a water quality perspective are (1) to provide soil surface cover and reduce soil erosion and (2) to utilize and convert excess nutrients remaining in the soil from the preceding crop into plant biomass, thereby reducing nutrient leaching and minimizing the amount of soluble nutrients in runoff during the non-crop growing season. In the Missouri River Basin study (NRCS 2012), cover crops were not commonly used as a conservation practice, as less than one percent of the acres met the criteria for cover crop use in the basin.

3.10 Nutrient Management Plan - Cropland. NRCS Practice Code 590

This Nutrient Management Practice is intended for cropland acres where animal manures are not used on cropland fields. The use of animal manures may be impractical because of the distances involved in hauling manure to all crop fields, the lack of the quantities of manure needed to meet the needs of all fields, or the lack of livestock production, and thus the lack of available manure. Nutrient management utilizes farm practices that permit efficient crop production while controlling nonpoint source water pollutants. A NMP is a written, site-specific plan that addresses these issues. The plan must be tailored to specific soils and crop production systems. The goal of the plan is to minimize detrimental environmental effects, primarily on water quality, while optimizing farm profits. Nutrient losses will occur with the plan but will be controlled to an environmentally acceptable level. Nutrient management programs emphasize how proper planning and implementation will improve water quality and enhance farm profitability through reduced input costs. These plans incorporate soil test results, manure test results, yield goals, and estimates of residual nitrogen to generate field-by-field recommendations.

The efficient use of nutrients in agricultural production systems has important environmental implications. Crops are not efficient at removing fertilizer and manure nitrogen from the soil during the growing cycle. Unused or residual nitrogen is vulnerable to leaching prior to the start of the next cropping year especially during the fall and winter months if precipitation occurs when fields lay dormant. The potential exists for accelerated nutrient loss when essential nutrient amounts exceed crop uptake needs. Nutrient reactions and pathways in the soil-water system are complex. Nutrient flow to surface water and groundwater vary from nutrient to nutrient as do the threats to water quality. Potential surface water impacts include sedimentation, eutrophication, and overall water quality degradation. Evans et al. (2003/2008) estimated nutrient management plan efficiency at 70% reduction for nitrogen and a 28% reduction for phosphorus.

Although nutrient management practices were widely used on cropped acres in the Missouri River Basin (NRCS 2012), few producers met the management criteria for application rate, timing of application, and method of application. Only 24% of the cropped acres met all three criteria for both nitrogen and phosphorus applications. The importance for the promotion of nutrient management plans on cropland is obvious and will be used as a BMP in the BSRWIP.

3.11 Terraces - NRCS Practice Code 600

A terrace is an earth embankment, or a combination or a ridge and channel, constructed across the field slope usually on the contour. The terrace is generally applied as part of a resource management system to reduce erosion by reducing slope length, thus soil erosion, and retaining runoff for moisture conservation. The length of a hill's slope is reduced by constructing the terraces perpendicular to the slope. Both soil erosion and channel erosion are reduced further because the terraces force the field to be farmed on the contour between the terraces (Foster 1983). Although terraces are generally constructed on the contour, channel grades are sometimes increased to facilitate water storage for terraces with tile outlets in an effort to keep terraces parallel to each other to facilitate farming. Contouring farming alone is very effective in reducing soil erosion by approximately 50% (Czapar 2005), but it does have limits of application. Generally, as slope increases, the maximum slope length decreases, and when erosion is most severe, such as slopes exceeding 9%, much of the effectiveness of contouring is lost. Thus, terraces are needed for controlling slope length, managing water flow, and reducing soil erosion on the more erodible steeper and longer field slopes.

Terraces have a negligible effect on crop yields, but a major effect on sediment delivery (Czapar, etal. 2005). Estimated annual soil and nutrient losses under various erosion control practices in a Central Iowa climate, showed conventional tilled non-terraced soils with soil losses at 7.8 tons/acre/year compared to terracing with 2.3 tons/acre/year (averaged over ten soils, a 73 foot long slope of 9%, and a 300 foot long slope of 5%). Terraces in an Iowa corn/small grain rotation reduced soil loss from 7.6 kilograms/square-meter to 2.7 kilograms/square-meter (Foster 1983). Soil losses in these two examples were reduced 70.5% and 65.5%, respectively, by the installation of a terrace system.

Terraces may discharge their water through surface channels or by infiltration in a pond area through underground drain lines. Terraces that drain by surface channels are designed to have no erosion in the terrace channels. Terraces that drain through underground outlets are very effective at reducing sediment delivery of eroded material. It is estimated that about 95% of material eroded between terraces was deposited in pond areas around the underground intakes (Czapar, etal. 2005). However, terraces drained by tile outlets may deliver more nitrogen than fields that are not tiled. Total nitrogen yields in the Corn Belt region varied greatly but were typically less than 10 lbs/acre/year in non-tiled drained watersheds and greater than 20 lbs/acre/year in tile-drained watersheds. Terraces may be used in the BSRWIP on steeper and longer field slopes when other BMPs do not bring soil losses down to acceptable levels or as needed to control rill and gully erosion. Berg (2016) reported a savings of 33.0 pounds/acre/year of nitrogen, 12.9 pounds/acre/year of phosphorus, and 9.4 tons/acre/year of sediment for terraces constructed in the BSRWIP area.

3.12 Filter Strips - Non CRP

Areas adjacent to streams were evaluated in section 3.3 as riparian areas. Grassed filter strips can also be installed adjacent to other water bodies (wetland, ponds) or serve as filters for smaller animal waste facilities or tile outlets. A non CRP option would allow the haying or grazing of the filter strips without severe use restrictions and still provide resource protection. Haying would not impose much reduction in the conservation effects of grass cover, but grazing could and would need to be managed. Management of livestock may be needed which allows only seasonal access, rotational grazing, and/or time limitations, to reduce the intensity and duration of grazing. The SRAM practice (Berg 2016) had load reductions of 8.0 pounds of nitrogen/acre/year, 1.9 pounds of phosphorus/acre/year, and 0.4 tons of soil/acre/year on 585.3 acres of riparian restoration. These rates will be used for the non-CRP filter strips. Load reductions on grazed buffer strips were reported in Segment 2 of the Lake Poinsett Watershed Implementation Plan at the rates of 8.62 lbs/acre/year of nitrogen, 3.64 lbs/acre/year of phosphorus, and 2.42 tons/acre/year for sediment.

4. LOAD REDUCTIONS

4.1 Animal Waste Storage Facilities

The Big Sioux River Watershed Improvement Project area identified over 1,595 animal feeding operations. Based on the percentages of AFOs analyzed by the computer model AnnAGNPS in other studies, as many as 492 feedlots were determined to be potential priority operations requiring the construction of an animal waste management system. Since that assessment, approximately 28 feedlots have had Animal Waste Storage Facilities (AWSF) constructed under various programs, and some priority lots have ceased operations. It is estimated that 400 AWSF would need to be built, with an average yearly construction rate of 5 AWSF per year; it will take additional years beyond this Strategic Plan to complete the needed AWSF. Load reductions of nitrogen were those calculated from AWSF installed in the Big Sioux River watershed (Berg 2016) that averaged reductions of 7,329 pounds of nitrogen per system; 1,553 pounds of phosphorus; and 13 tons of sediment per system. Refer to Table 4-1 for projected load reductions and yearly applications.

Table 4-1. Estimated N and P Load Reductions Per AWSF System

Estimated Nitrogen (N), Phosphorous (P), Sediment (Sed) Load Reductions (LR) Associated with Animal Waste Storage Facilities (AWSF) (# = Pounds, T = Tons)								
Year	No. Goal	% Goal	N #/System	Total #N	P #/System	Total #P	Sed/T/Syst	Total T Sed
1	5	1.0	7,329	36,645	1,553	7,765	13.0	65
2	5	1.0	7,329	36,645	1,553	7,765	13.0	65
3	5	1.0	7,329	36,645	1,553	7,765	13.0	65
4	5	1.0	7,329	36,645	1,553	7,765	13.0	65
5	5	1.0	7,329	36,645	1,553	7,765	13.0	65
Subtotal	25	5.0		183,225		38,825		325
6-10	25	10.0	7,329	183,225	1,553	38,825	13.0	325
11-15	25	15.0	7,329	183,225	1,553	38,825	13.0	325
15-Plus	325	85.0	7,329	2,381,925	1,553	504,725	13.0	4,225
Total	400	100.0		2,931,600		621,200		5,200

Nutrient reduction estimates from Berg PIP 2016.

4.2 Nutrient Management Plan Load Reductions for Animal Wastes

The NMPs for animal wastes are designed to manage the manure from the Animal Waste Storage Facilities. The NMPs need approximately one acre of land per animal unit to safely spread the manure over time. The manure is spread on approximately 10 percent of these acres annually to meet crop nutrient needs. The average BSRWIP facility has 500 animal units and would require approximately 500 acres in the NMPs; however, only about 50 acres (10%) would receive the manure each year. Load reductions used will be those of Kringen's (2010), in the James River watershed, where he calculated 9.8 pounds of nitrogen/acre/year and 0.6 pounds of phosphorus/acre/year for an applied NMP. See Table 4-2 for the estimated nitrogen and phosphorus load reductions associated with NMPs.

Table 4-2. Estimated N and P Load Reductions by NMP System

Estimated Nitrogen (N) and Phosphorous (P) Load Reductions (LR) for Nutrient Management Plans Associated with Animal Waste Storage Facilities (AWSF)						
Year	# Goal	% Goal	N #/YR	Total N #/YR	P #/YR	Total P #/YR
1	5	0.8	2,450	12,250	400	2,000
2	5	0.8	2,450	12,250	400	2,000
3	5	0.8	2,450	12,250	400	2,000
4	5	0.8	2,450	12,250	400	2,000
5	5	0.8	2,450	12,250	400	2,000
Subtotal	25	4.0		61,250		10,000
6-10	25	4.0	2,450	61,250	400	10,000
11-15	25	4.0	2,450	61,250	400	10,000
15-Plus	325	88.0	2,450	796,250	400	130,000
Total	400	100.0		980,000		160,000

Nutrient reduction estimates from Kringen 2010

4.3 Prescribed Grazing Systems

4.3.1 Upland Prescribed Grazing Systems

The estimated need for prescribed grazing plans to be implemented in the BSRWIP was for 300,000 acres. The estimated yearly average implementation rate was 300 acres per year. At the end of this five year Strategic Plan, only 1,500 acres (0.5%) would be implemented. Additional years of planning to meet the projected grazing plan goals would be needed. Load reductions are presented in Table 4-3-1 using nitrogen load reduction estimates as documented in the Big Sioux River watershed of 2.0 pounds of nitrogen/acre/year; 0.43 pounds of phosphorus/ acre/year; and 0.28 tons of sediment/acre/year. Prescribed grazing systems are figured on approximately 100 acres per system, with a rural water hook-up, two tanks, water pipeline footage of 1,000 feet, and 1,000 feet of fencing per system.

Table 4-3-1. Estimated N, P, and Sediment Load Reductions for Prescribed Grazing on Pasture and Rangeland

Estimated Nitrogen (N), Phosphorous (P), and Sediment (Sed) Load Reductions (LR) for Prescribed Grazing								
Year	Acres	% Goal	N #/Ac/Yr	Total #N/Yr	P #/Ac/Yr	Total #P/Yr	Sed T/Ac/Yr	Total T/Yr
1	300	0.1	2.00	600	0.43	129	0.28	84.00
2	300	0.1	2.00	600	0.43	129	0.28	84.00
3	300	0.1	2.00	600	0.43	129	0.28	84.00
4	300	0.1	2.00	600	0.43	129	0.28	84.00
5	300	0.1	2.00	600	0.43	129	0.28	84.00
Subtotal	1,500	0.5		3,000		645		420.00
6-10	1,500	0.5	2.00	3,000	0.43	645	0.28	420.00
11-Plus	297,000	99.0	2.00	594,000	0.43	127,710	0.28	83,160.00
TOTAL	300,000	100.0		600,000		129,000		84,000.00

Nutrient and Sediment Load Reduction estimates from Berg 2013.

4.3.2 Riparian Area Grazing Management

Riparian area grazing management systems were estimated to be needed on 30,000 acres throughout the BSRWIP area to reduce nutrient and sediment transport to water bodies. At a rate of 300 acres per year implementation, additional years would be needed to resolve resource problems. Load reductions were calculated from filter strips installed in the BSRWIP. A grazing management plan can be as simple as fencing off the riparian zones to schedule grazing periods during cooler and less erosive periods. The Continuous CRP can also be used to provide landowners an incentive to establish buffer strips along streams to improve the water quality. This program will assist landowners with exclusion of livestock from the riparian areas through planning and installation of grazing systems that utilize 10-15 year land use agreements. Table 4-3-2 presents the load reductions for nitrogen, phosphorous, and sediment for riparian management in the BSRWIP are during the first five years of the Strategic Plan.

Table 4-3-2. Riparian Area Management Program and CRP Load Reductions

Riparian Area Management Load Reductions of Nitrogen, Phosphorous, and Sediment								
Year	Acres Planned	% Goal	N Reduction Lbs/Ac	Total N Reduction Lbs/Year	P Reduction Lbs/Ac	Total P Reduction Lbs/Year	Sediment Reduction Tons/Ac	Total Sediment Tons/Year
1	300	0.7	8.0	2,400.0	1.9	570.0	0.4	120.0
2	300	0.7	8.0	2,400.0	1.9	570.0	0.4	120.0
3	300	0.7	8.0	2,400.0	1.9	570.0	0.4	120.0
4	300	0.7	8.0	2,400.0	1.9	570.0	0.4	120.0
5	300	0.7	8.0	2,400.0	1.9	570.0	0.4	120.0
Subtotal	1,500	3.5		12,000.0		2,850.0		600.0
6-10	1,500	3.5	8.0	12,000.0	1.9	2,850.0	0.4	600.0
11 Plus	27,000	93.0	8.0	216,000.0	1.9	51,300.0	0.4	10,800.0
TOTAL	30,000	100.0		240,000.0		57,000.0		12,000.0

Nutrient and Sediment Load Reduction estimates from Berg 2016.

4.4 Residue & Tillage Management on Cropland

It was estimated 400,000 acres of conservation tillage would be needed to solve resource concerns. At the rate of 1,000 acres per year, additional years would be necessary to achieve this targeted goal. The sediment, nitrogen, and phosphorous load delivery rates vary per watershed depending on soil erodibility, tillage practices, rotations, steepness of the slope, and slope length. The Big Sioux River project reported a load reduction using conservation tillage on cropland of 10.7 pounds of nitrogen per acre; 3.8 pounds of phosphorus; and 2.8 tons of soil saved per acre. These load reduction values are presented in Table 4-4.

Table 4-4. Estimated Nitrogen, Phosphorous, and Sediment Load Reductions for Cropland Conservation Tillage on Cropland Acres

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Cropland Conservation Tillage								
Year	Acres	% Goal	N #/Ac/Yr	Total #/Yr	P #/Ac/Yr	Total #/Yr	Sed T/Ac/Yr	Total T/Yr
1	1,000	0.25	10.7	10,700.0	3.8	3,800.0	2.8	2,800.0
2	1,000	0.25	10.7	10,700.0	3.8	3,800.0	2.8	2,800.0
3	1,000	0.25	10.7	10,700.0	3.8	3,800.0	2.8	2,800.0
4	1,000	0.25	10.7	10,700.0	3.8	3,800.0	2.8	2,800.0
5	1,000	0.25	10.7	10,700.0	3.8	3,800.0	2.8	2,800.0
Subtotal	5,000	1.25		53,500.0		19,000.0		14,000.0
6-10	5,000	1.25	10.7	53,500.0	3.8	19,000.0	2.8	14,000.0
11-15	5,000	1.25	10.7	53,500.0	3.8	19,000.0	2.8	14,000.0
16- PLUS	385,000	96.25	10.7	4,119,500.0	3.8	1,463,000.0	2.8	1,078,000.0
TOTAL	400,000	100.00		4,280,000.0		1,520,000.0		1,120,000.0

Nutrient and Sediment Load Reduction estimates from Berg 2013

4.5 Stream Bank Stabilization

The planned stream bank stabilization footages needed in the BSRWIP area were 4,000 linear feet. Approximately 2,000 LF would be installed each year in years two and three. The expense of stream bank stabilization limits its use to unique application. Table 4-5 presents load reductions for nitrogen as calculated using STEPL from stream bank restoration installed along the Big Sioux River (Berg 2012).

Table 4-5. Stream Bank Stabilization Load Reductions by Linear Feet

Stream Bank Stabilization and Load Reductions								
Year	Linear Feet (LF) Planned	% Total Goal	N Reduction Lbs/LF	Total N Reduction Lbs/LF	P Reduction Lbs/LF	Total P Reduction Lbs/LF	Sediment Reduction Tons/LF	Total Sediment Tons/LF
1	0	0.0	2.4	0.0	0.9	0.0	1.8	0.0
2	2,000	50.0	2.4	4,800.0	0.9	1,800.0	1.8	3,600.0
3	2,000	50.0	2.4	4,800.0	0.9	1,800.0	1.8	3,600.0
4	0	0.0	2.4	0.0	0.9	0.0	1.8	0.0
5	0	0.0	2.4	0.0	0.9	0.0	1.8	0.0
TOTAL	4,000	100.0		9,600.0		3,600.0		7,200.0

Nutrient and Sediment Load Reduction estimates from Berg 2012.

4.6 Grassed Waterways

The constructed acres of grassed waterways estimated by field offices for the total treatment of gullies were 10,000. At 5 acres per year, 25 acres will be completed in the five years of the Strategic Plan, which is 0.25% of the needed estimate. More years will be needed to complete the necessary linear feet of grassed waterways. Nitrogen, phosphorus, and sediment load reduction estimates were the waterway calculations used from Berg (2016). This data is presented in Table 4-6.

Table 4-6. Grassed Waterway Load Reductions for N, P, and Sediment

Grassed Waterway Load Reductions for Nitrogen, Phosphorous, Sediment								
			N	Total N	P	Total P	Sediment	Total
Year	Acres	% Goal	Reduction	Reduction	Reduction	Reduction	Reduction	Sediment
	Planned		Lbs/Ac	Lbs/Year	Lbs/Ac	Lbs/Year	Tons/Ac	Tons/Year
1	5	0.05	28.3	141.5	41.9	209.5	28.3	141.5
2	5	0.05	28.3	141.5	41.9	209.5	28.3	141.5
3	5	0.05	28.3	141.5	41.9	209.5	28.3	141.5
4	5	0.05	28.3	141.5	41.9	209.5	28.3	141.5
5	5	0.05	28.3	141.5	41.9	209.5	28.3	141.5
Subtotal	25	0.25		707.5		1,047.5		707.5
6-10	25	0.25	28.3	707.5	41.9	1,047.5	28.3	707.5
11-15	25	0.25	28.3	707.5	41.9	1,047.5	28.3	707.5
16-20	9,925	99.25	28.3	280,877.5	41.9	415,857.5	28.3	280,877.5
Total	10,000	100.00		283,000.0		419,000.0		283,000.0

Nutrient and Sediment Load Reduction estimates from Berg 2016.

4.7 Wetland Restoration, Pond, and Basin Construction

Planned restoration numbers of wetlands, pond construction, and water and sediment control basin numbers were estimated to be 200 to meet estimated load reductions. With an average of five basins restored or constructed each year, this goal will not be met at the end of the Strategic Plan. See Table 4-7.

Water and sediment control basins are typically an 'open basin' and are drained with a tile outlet to control the water flow. This is unlike the closed systems of a wetland restoration or pond load reductions. However, the water and sediment basins should result in similar control of the sediment delivery and sediment attached phosphorous. The average size of the restored wetland basins in the BSRWIP as reported by field offices in 2015 was 7.2 acres. Calculated load reductions used in Table 4-7 are from the adjacent Vermillion River project for wetland restorations (Ward 2010). Load Reductions were 4.06 lbs/ac/year of nitrogen, 1.3 lbs/ac/year of phosphorous; and 0.86 tons/ac/year for sediment per project.

Table 4-7. Wetland Restoration, Pond, Basin Construction Load Reductions

Wetland Restoration and Pond Construction Load Reductions									
Year	No. Ponds Wetlands Planned	% Goal	Wetland Acres Restored	N Reduction Lbs/Wet Ac Year	Total Lbs N Reduction Year	P Reduction Lbs/Wet Ac Year	Total Lbs P Reduction Year	Sed Reduct Tons/ Wet Ac Year	Total Tons Sed/Reduct Year
1	5	2.5	36	4.06	146	1.30	46.80	0.86	30.96
2	5	2.5	36	4.06	146	1.30	46.80	0.86	30.96
3	5	2.5	36	4.06	146	1.30	46.80	0.86	30.96
4	5	2.5	36	4.06	146	1.30	46.80	0.86	30.96
5	5	2.5	36	4.06	146	1.30	46.80	0.86	30.96
Subtotal	25	12.5	180		730.80		234.00		154.80
6-10	25	12.5	180	4.06	730.80	1.30	234.00	0.86	154.80
11-15	25	12.5	180	4.06	730.80	1.30	234.00	0.86	154.80
16 Plus	125	62.5	900	4.06	3,654.00	1.30	1,170.00	0.86	774.00
Total	200	100.0	1,440.0		5,846.40		1,872.00		1,238.40

Nutrient and Sediment Load Reduction estimates from Ward 2010.

4.8 Conversion of Cropland to Forage and Biomass Plantings

The conversion of the highest eroding cropland to vegetative species suited to pasture, hayland, or biomass production was estimated to be 15,000 acres for the BSRWIP area. Two hundred and fifty acres were estimated to be completed each year. The total goal would not be met at the end of the five year strategic plan. The BSRWIP had estimated the calculated load reductions of 3.7 pounds/acre for nitrogen, phosphorous at 1.14 pounds/acre, and sediment load reductions at 0.79 tons/acre (Berg 2013). This data is presented in Table 4-8.

Table 4-8. Estimated N, P, and Sediment Load Reductions for Cropland Conversion to Perennial Vegetation

Estimated Nitrogen (N), Phosphorous (P), and Sediment (Sed) Load Reductions (LR) for Cropland Conversion to Perennial Vegetation								
Year	Acres	% Goal	N #/Ac/Yr	Total #N/Yr	P #/Ac/Yr	Total #P/Yr	Sed T/Ac/Yr	Total T/Yr
1	250	1.0	13.4	3,350.0	5.3	1,325.0	3.9	975.0
2	250	1.0	13.4	3,350.0	5.3	1,325.0	3.9	975.0
3	250	1.0	13.4	3,350.0	5.3	1,325.0	3.9	975.0
4	250	1.0	13.4	3,350.0	5.3	1,325.0	3.9	975.0
5	250	1.0	13.4	3,350.0	5.3	1,325.0	3.9	975.0
Subtotal	1,250	5.0		16,750.0		6,625.0		4,875.0
6-10	1,250	5.0	13.4	16,750.0	5.3	6,625.0	3.9	4,875.0
11-Plus	12,500	90.0	13.4	167,500.0	5.3	66,250.0	3.9	48,750.0
Total	15,000	100.0		201,000.0		79,500.0		58,500.0

Nutrient and Sediment Load Reduction estimates from Berg 2013.

4.9 Conservation Crop Rotation and Conservation Cover Crop on Cropland Acres

The need of Conservation Crop Rotations and/or Cover Crops on cropland acres was estimated to be 400,000 acres for the BSRWIP area. An estimated 1,000 acres would be installed each year resulting in only 1.25% of this goal being achieved at the end of the five year Strategic Plan. This goal will only be met with additional project implementation years. The effectiveness in using cover crops to reduce soil erosion and rainfall runoff was demonstrated by Hargrove (1991). However, the sediment and nutrient delivery on cropland acres has not been analyzed in the BSRWIP. The watershed study of Clear Lake (SDDENR 1999) reported the sediment transport and deliverability throughout the watershed indicated that for an average year, approximately 3,084 tons (0.121 tons/acre) of sediment enter the lake. The AGNPs data indicated that the Clear Lake subwatersheds had a total nitrogen (soluble+sediment bound) deliverability rate of 22.1 lbs./acre/yr., and a total phosphorus (soluble+sediment bound) deliverability rate of 5.2 lbs./acre/yr. to the lake. The results also indicated that runoff from fertilized cropland was a significant source of water soluble nutrients to Clear Lake.

Hargrove (1991) found the use of cover crops reduced average annual runoff from 31% - 65%. Applying his data to the Clear Lake study, nitrogen and phosphorous could be reduced conservatively by 31%. Therefore, 22.1 lbs. of delivered total nitrogen/acre/year could be reduced by 31% or 6.85 lbs./ac/year and 5.2 lbs. of delivered total phosphorous/acre/year could be reduced by 31% or 1.6 lb./ac/year.

The analysis of the sediment transport and deliverability throughout the watershed to Clear Lake indicated that for an average year approximately 3,084 tons (0.121 tons/acre) of sediment entered the lake. Hargrove's report found soil losses to be reduced from 42% - 92%, again a conservative application to the Clear Lake study would be a 42% reduction in soil loss and resultant 42% in sediment load delivery. The load reduction is estimated at 0.121 tons/acre/year multiplied by 42% reduction equals a load reduction of 0.05 ton/acre/year. These load reductions from the use of a cover crop are applied in Table 4-9. The winter cover crop treatment produced results similar to a meadow rotation treatment (Hargrove 1991), therefore, the load reductions reported in Table 4-9 may be higher if a crop rotation incorporates meadow or hayland.

Table 4-9. Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Crop Rotations and Cover Crops on Cropland

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Conservation Crop Rotation and Cover Crops on Cropland								
Year	Acres	% Goal	N #/Ac/Yr	Total #/YR	P #/Ac/YR	Total #YR	Sed T/Ac/YR	Total T/YR
1	1,000	0.25	6.85	6,850.00	1.61	1,610.00	0.05	50.00
2	1,000	0.25	6.85	6,850.00	1.61	1,610.00	0.05	50.00
3	1,000	0.25	6.85	6,850.00	1.61	1,610.00	0.05	50.00
4	1,000	0.25	6.85	6,850.00	1.61	1,610.00	0.05	50.00
5	1,000	0.25	6.85	6,850.00	1.61	1,610.00	0.05	50.00
Subtotal	5,000	1.25		34,250.00		8,050.00		250.00
6-10	5,000	1.25	6.85	34,250.00	1.61	8,050.00	0.05	250.00
11- Plus	390,000	97.50	6.85	2,671,500.00	1.61	627,900.00	0.05	19,500.00
Totals	400,000	100.00		2,740,000.0		644,000.0		20,000.0
Hargrove 1991 and TMDL Clear Lake SDDENR 1999								

Projected Estimates from Hargrove 1991 and TMDL Clear Lake SDDENR 1999

4.10 Nutrient Management Plan - Cropland

This nutrient management practice is intended for cropland acres where animal manures are not used on cropland fields, and the fields are fertilized with commercial fertilizers. There is an estimated a total need of 100,000 acres of nutrient management plans on cropland where manure is not applied in the BSRWIP. With approximately 5,000 NMP acres targeted annually, it will require additional years of project implementation to meet their goal. A NMP will be developed for nitrogen, phosphorus, and potassium that considers all potential sources of nutrients including commercial fertilizer, crop residues, and legume credits. The NMP would also require that NRCS practice standards be met for Conservation Tillage. Load reductions for NMPs were computed from the Vermillion River Basin project load deliveries for conservation tillage and multiplied by Evans (2003/2008) estimated load reduction percentages of nitrogen (70%) and phosphorus (28%). These estimated load reductions attributed solely to the NMP for the BSRWIP are presented in Table 4-10.

Table 4-10. Nitrogen and Phosphorous Load Reductions on Nutrient Management Plans on Non-Manure Applied Cropland

Estimated Nitrogen (N) and Phosphorous (P) Load Reductions (LR) for Nutrient Management Plans Associated Non-Manured Cropland						
Year	Acres	% Goal	N #/AC/YR	Total N #/YR	P #/YR/AC	Total P #/YR
1	5,000	5.0	1.04	5,200	0.10	500
2	5,000	5.0	1.04	5,200	0.10	500
3	5,000	5.0	1.04	5,200	0.10	500
4	5,000	5.0	1.04	5,200	0.10	500
5	5,000	5.0	1.04	5,200	0.10	500
Subtotal	25,000	25.0		26,000		2,500
6-10	25,000	25.0	1.04	26,000	0.10	2,500
11-Plus	50,000	50.0	1.04	52,000	0.10	5,000
Total	100,000	100.0		104,000		10,000

Nutrient Load Reduction Estimates from Vermillion River Project (Ward 2010).

4.11 Terraces

Erosion concerns on cropland can be addressed with tillage and crop rotations; however, terraces may be needed on steeper slopes. There was estimated to be a need of 2,000,000 LF of terrace construction to address the steeper slopes in the BSRWIP area; completing 40,000 LF per year would require additional years to accomplish this goal. Soil loss calculations projected before and after terrace construction were based on average soil losses computed from the Revised Universal Soil Loss Equation. However, calculating load reductions of nitrogen and phosphorous are more complicated. The dominant path for nitrate loss is leaching, and nitrate concentrations in runoff are usually low compared to subsurface (tile) drainage waters. The impacts of increased losses of dissolved phosphorus and decreased losses of particulate phosphorus due to the widespread adoption of conservation tillage systems make estimates less certain. In some settings, dissolved inorganic phosphorus is likely to be more biologically available than sediment bound phosphorus. In other settings, dissolved phosphorus may become sediment bound and relatively unavailable. Sediment bound phosphorus can also become released in anaerobic environments, and thus become more biologically available for phytoplankton. Load reductions for nitrogen and phosphorous were based on load reductions losses with associated soil erosion and sediment yields. Czapar reported loss reductions of nitrogen from 32.8 lbs/acre/year to 7.4 lbs/acre/year, a savings of 25.4 lbs/acre/year (77.4%) and phosphorous from 12.7 lbs/acre/year to 2.9 lbs/acre/year, a savings of 9.8 lbs/acre/year (77.2%). The load reductions presented in Table 4-11 were calculated from terraces installed in the BSRWIP (Berg 2016). The acres of cropland protected are based on terrace length times an estimated 180 feet of protected cropping area.

Table 4-11. Terrace Load Reductions for N, P, and Sediment

Terrace Load Reductions for Nitrogen, Phosphorous, and Sediment									
Year	Linear Feet Planned	Acres Protected	% Goal	N Reduction Lbs/Acre	Total N Reduction Lbs/Year	P Reduction Lbs/Acre	Total P Reduction Lbs/Year	Sediment Reduction Tons/Acre	Total Sediment Tons/Year
1	40,000	110.0	3.1	33.0	3,630.0	12.9	1,419.0	9.4	1,034.0
2	40,000	110.0	3.1	33.0	3,630.0	12.9	1,419.0	9.4	1,034.0
3	40,000	110.0	3.1	33.0	3,630.0	12.9	1,419.0	9.4	1,034.0
4	40,000	110.0	3.1	33.0	3,630.0	12.9	1,419.0	9.4	1,034.0
5	40,000	110.0	3.1	33.0	3,630.0	12.9	1,419.0	9.4	1,034.0
Subtotal	200,000	550.0	15.5		18,150.0		7,095.0		5,170.0
6-10	200,000	550.0	15.5	33.0	18,150.0	12.9	7,095.0	9.4	5,170.0
11-Plus	1,600,000	550.0	69.0	33.0	18,150.0	12.9	7,095.0	9.4	5,170.0
Total	2,000,000	1,650.0	100.0		54,450.0		21,285.0		15,510.0

N, P, and Sediment Load Reductions from Berg 2016

4.12 Filter Strips - Non-CRP

The need for Non-CRP filter strips was estimated be 50,000 acres within the BSRWIP area. Installing 40 acres annually would require additional years to meet the estimated goal. It is unknown whether the non-CRP filter strips will be harvested for hay or grazed; therefore, the load reduction calculations will be based on the more severe land use of grazing. The load reduction for nitrogen, phosphorous, and sediment for grassed filter strips were calculated from 585 acres of rotational grazing installed and reported in the Segment 2 CBSRWIP (Berg 2016). The load reduction estimates are presented in Table 4-13.

Table 4-12. N, P, and Sediment Load Reduction of Non-CRP Filter Strips

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Non CRP Filter Strips								
Year	Acres	% Goal	N #/Ac/Yr	Total #N/Yr	P #/Ac/Yr	Total #P/Yr	Sed T/Ac/Yr	Total T/Yr
1	40	0.08	8.0	320.0	1.9	76.0	0.4	16.0
2	40	0.08	8.0	320.0	1.9	76.0	0.4	16.0
3	40	0.08	8.0	320.0	1.9	76.0	0.4	16.0
4	40	0.08	8.0	320.0	1.9	76.0	0.4	16.0
5	40	0.08	8.0	320.0	1.9	76.0	0.4	16.0
SubTotal	200	0.40		1,600.0		380.0		80.0
6-10	200	0.40	8.0	1,600.0	1.9	380.0	0.4	80.0
11-Plus	49,600	99.20	8.0	396,800.0	1.9	94,240.0	0.4	19,840.0
TOTAL	50,000	100.0		400,000.0		95,000.0		20,000.0

N, P, and Sediment Load Reductions from Berg 2016.

5. TECHNICAL AND FINANCIAL ASSISTANCE NEEDED

The Moody County Conservation District (MCCD) is the lead sponsor and administratively responsible for the BSRWIP. A project coordinator will manage all water quality project activities among the watershed counties and cooperate with all the local, state, and federal conservation personnel. The counties supporting the project will appoint members to serve on a steering committee. The Conservation District Managers and NRCS District Conservationists will assist the project coordinator with cost-share reimbursement, file maintenance, and other financial transactions. Technical expertise from these offices will be necessary to implement the BMPs in each local county. This expertise has been and will continue to be provided through existing partnerships with the local Conservation Districts, the Cities of Sioux Falls and Brookings, Ducks Unlimited, Pheasants Forever, EDWDD, the SDACD, SDDENR, SD Department of Agriculture, SDGFP, SD Extension Service, FSA, NRCS, USFWS, and USEPA.

Funding sources for the implementation of the BMPs will be solicited from the MCCD; SD Department of Agriculture; SDGFP Wildlife Partnership Program and Wetland and Grassland Habitat Program; SDDENR; USFWS Grassland and Wetland Easement Program and Private Land Program; USEPA 319 Funding; the NRCS Environmental Quality Incentive Program, Wetland Reserve Program, National Water Quality Incentive Program, and Regional Conservation Partnership Program; and the FSA Conservation Reserve Program.

Funds expended in past BMP implementation projects for the RCWP, Central BSRWIP, Lower BSRWIP, and the current BSRWIP came from the SD Department of Agriculture, SD Soil and Water Conservation Grant awarded through the SD Conservation Commission; SDGFP, State Acres for Wildlife Enhancement; SDDENR, Consolidated Water Facilities Construction Fund Program and State 319 Program Funds; City of Sioux Falls State Revolving Fund Nonpoint Source Funds; NRCS, Environmental Quality Incentive, Wildlife Habitat Incentive, Wetland Reserve Program; and FSA Conservation Reserve Program.

The Big Sioux River Watershed Implementation Project area land use is fairly homogenous, and the impairment problems have been consistently identified as agricultural in nature for both cropland and animal uses. The financial extrapolations have been conservative with the BMP goals estimated by field personnel. This Five Year Strategic Plan is intended to describe and detail the funding needed for the proposed BMPs and the administrative costs needed to implement them. The estimated costs are based on the 2015 NRCS cost share docket and actual costs from similar local projects. Tables 5-1 through 5-5 summarize the costs of the BMP and associated practice components per each year. Table 5-6 presents an annual summary of both BMPs and administrative costs which includes personnel, office equipment, and supplies for the project years.

Table 5-1. Technical and Financial Resources Needed					Year 1			
Year 1	BMP - Animal Waste management System				BMP - Prescribed Grazing			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -		$ -
	AWSF	$250,000	5	$ 1,250,000	Rural Water, EA	$ 2,500	3	$ 7,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	3,000	$ 15,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	6	$ 9,000
	Cultural Study	$ 500	5	$ 2,500	Fencing, LF	$ 2.50	3,000	$ 7,500
				$ 1,458,750				$ 39,000
Year 1	BMP - Riparian Areas - SRAM				BMP - Cropland Conversion to Forage Plantings			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC/15 Years	$ 900	50	$ 45,000	Tillage/Seeding AC	$ 80	250	$ 20,000
	Fencing LF	$ 2.50	7,500	$ 18,750	Forgone Income AC	$ 125	250	$ 31,250
	Pipeline	$ 5	5,000	$ 25,000				
	Tank	$ 1,500	2	$ 3,000				
	Rural Water	$ 2,500	5	$ 12,500				
				$ 104,250				$ 51,250
Year 1	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	1,000	$ 10,000	Dirt Work, Seed/AC	$ 2,500	5	$ 12,500
				$ 10,000				$ 12,500
Year 1	BMP - Wetlands, Ponds, Sed Basins				BMP - Bank Stabilization			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 3,000	5	$ 15,000	Rock, Fabric/LF	$ 110	0	$ -
				$ 15,000				$ -
Year 1	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,000	$ 38,000	Cost Incentive/AC	$ 15	5,000	$ 75,000
				$ 38,000				$ 75,000
Year 1	BMP - Filter Strips, Non-CRP				BMP - Terraces			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 80	40	$ 3,200	Dirt Work/LF	$ 3	40,000	$ 120,000
				$ 3,200				$ 120,000
					TOTAL BMP COSTS			$ 1,926,950

Table 5-2. Technical and Financial Resources Needed					Year 2			
Year 2	BMP - Animal Waste management System				BMP - Prescribed Grazing			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -		$ -
	AWSF	$250,000	5	$ 1,250,000	Rural Water, EA	$ 2,500	3	$ 7,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	3,000	$ 15,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	6	$ 9,000
	Cultural Study	$ 500	6	$ 3,000	Fencing, LF	$ 2.50	3,000	$ 7,500
				$ 1,459,250				$ 39,000
Year 2	BMP - Riparian Areas - SRAM				BMP - Cropland Conversion to Forage Plantings			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC/15 Years	$ 900	50	$ 45,000	Tillage/Seeding AC	$ 80	250	$ 20,000
	Fencing LF	$ 2.50	7,500	$ 18,750	Forgone Income AC	$ 125	250	$ 31,250
	Pipeline	$ 5	5,000	$ 25,000				
	Tank	$ 1,500	2	$ 3,000				
	Rural Water	$ 2,500	5	$ 12,500				
				$ 104,250				$ 51,250
Year 2	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	1,000	$ 10,000	Dirt Work, Seed/AC	$ 2,500	5	$ 12,500
				$ 10,000				$ 12,500
Year 2	BMP - Wetlands, Ponds, Sed Basins				BMP - Bank Stabilization			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 3,000	5	$ 15,000	Rock, Fabric/LF	$ 110	2,000	$ 220,000
				$ 15,000				$ 220,000
Year 2	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,000	$ 38,000	Cost Incentive/AC	$ 15	5,000	$ 75,000
				$ 38,000				$ 75,000
Year 2	BMP - Filter Strips, Non-CRP				BMP - Terraces			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 80	40	$ 3,200	Dirt Work/LF	$ 3	40,000	$ 120,000
				$ 3,200				$ 120,000
					TOTAL BMP COSTS			$ 2,147,450

Table 5-3. Technical and Financial Resources Needed					Year 3			
Year 3	BMP - Animal Waste management System				BMP - Prescribed Grazing			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -		$ -
	AWSF	$250,000	5	$ 1,250,000	Rural Water, EA	$ 2,500	3	$ 7,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	3,000	$ 15,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	6	$ 9,000
	Cultural Study	$ 500	8	$ 4,000	Fencing, LF	$ 2.50	3,000	$ 7,500
				$ 1,460,250				$ 39,000
Year 3	BMP - Riparian Areas - SRAM				BMP - Cropland Conversion to Forage Plantings			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC/15 Years	$ 900	50	$ 45,000	Tillage/Seeding AC	$ 80	250	$ 20,000
	Fencing LF	$ 2.50	7,500	$ 18,750	Forgone Income AC	$ 125	250	$ 31,250
	Pipeline	$ 5	5,000	$ 25,000				
	Tank	$ 1,500	2	$ 3,000				
	Rural Water	$ 2,500	5	$ 12,500				
				$ 104,250				$ 51,250
Year 3	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	1,000	$ 10,000	Dirt Work, Seed/AC	$ 2,500	5	$ 12,500
				$ 10,000				$ 12,500
Year 3	BMP - Wetlands, Ponds, Sed Basins				BMP - Bank Stabilization			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 3,000	5	$ 15,000	Rock, Fabric/LF	$ 110	2,000	$ 220,000
				$ 15,000				$ 220,000
Year 3	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,000	$ 38,000	Cost Incentive/AC	$ 15	5,000	$ 75,000
				$ 38,000				$ 75,000
Year 3	BMP - Filter Strips, Non-CRP				BMP - Terraces			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 80	40	$ 3,200	Dirt Work/LF	$ 3	40,000	$ 120,000
				$ 3,200				$ 120,000
					TOTAL BMP COSTS			$ 2,148,450

Table 5-4. Technical and Financial Resources Needed					Year 4			
Year	BMP - Animal Waste management System				BMP - Prescribed Grazing			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -		$ -
	AWSF	$250,000	5	$ 1,250,000	Rural Water, EA	$ 2,500	3	$ 7,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	3,000	$ 15,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	6	$ 9,000
	Cultural Study	$ 500	4	$ 2,000	Fencing, LF	$ 2.50	3,000	$ 7,500
				$ 1,458,250				$ 39,000
Year	BMP - Riparian Areas - SRAM				BMP - Cropland Conversion to Forage Plantings			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC/15 Years	$ 900	50	$ 45,000	Tillage/Seeding AC	$ 80	250	$ 20,000
	Fencing LF	$ 2.50	7,500	$ 18,750	Forgone Income AC	$ 125	250	$ 31,250
	Pipeline	$ 5	5,000	$ 25,000				
	Tank	$ 1,500	2	$ 3,000				
	Rural Water	$ 2,500	5	$ 12,500				
				$ 104,250				$ 51,250
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	1,000	$ 10,000	Dirt Work, Seed/AC	$ 2,500	5	$ 12,500
				$ 10,000				$ 12,500
Year	BMP - Wetlands, Ponds, Sed Basins				BMP - Bank Stabilization			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 3,000	5	$ 15,000	Rock, Fabric/LF	$ 110	0	$ -
				$ 15,000				$ -
Year	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,000	$ 38,000	Cost Incentive/AC	$ 15	5,000	$ 75,000
				$ 38,000				$ 75,000
Year	BMP - Filter Strips, Non-CRP				BMP - Terraces			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 80	40	$ 3,200	Dirt Work/LF	$ 3	40,000	$ 120,000
				$ 3,200				$ 120,000
					TOTAL BMP COSTS			$ 1,926,450

Table 5-5. Technical and Financial Resources Needed					Year 5			
Year 5	BMP - Animal Waste management System				BMP - Prescribed Grazing			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Engineer Design	$ 20,000	5	$ 100,000	Grazing System, EA	$ -		$ -
	AWSF	$250,000	5	$ 1,250,000	Rural Water, EA	$ 2,500	3	$ 7,500
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	3,000	$ 15,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,500	6	$ 9,000
	Cultural Study	$ 500	2	$ 1,000	Fencing, LF	$ 2.50	3,000	$ 7,500
				$ 1,457,250				$ 39,000
Year 5	BMP - Riparian Areas - SRAM				BMP - Cropland Conversion to Forage Plantings			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC/15 Years	$ 900	50	$ 45,000	Tillage/Seeding AC	$ 80	250	$ 20,000
	Fencing LF	$ 2.50	7,500	$ 18,750	Forgone Income AC	$ 125	250	$ 31,250
	Pipeline	$ 5	5,000	$ 25,000				
	Tank	$ 1,500	2	$ 3,000				
	Rural Water	$ 2,500	5	$ 12,500				
				$ 104,250				$ 51,250
Year 5	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	1,000	$ 10,000	Dirt Work, Seed/AC	$ 2,500	5	$ 12,500
				$ 10,000				$ 12,500
Year 5	BMP - Wetlands, Ponds, Sed Basins				BMP - Bank Stabilization			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 3,000	5	$ 15,000	Rock, Fabric/LF	$ 110	0	$ -
				$ 15,000				$ -
Year 5	BMP - Rotation/Cover Crop on Cropland				BMP - Nutrient Manage Plan			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,000	$ 38,000	Cost Incentive/AC	$ 15	5,000	$ 75,000
				$ 38,000				$ 75,000
Year 5	BMP - Filter Strips, Non-CRP				BMP - Terraces			
	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 80	40	$ 3,200	Dirt Work/LF	$ 3	40,000	$ 120,000
				$ 3,200				$ 120,000
					TOTAL BMP COSTS			$ 1,925,450

TABLE 5-6. SUMMARY OF 5 YEAR COSTS - BIG SIOUX RIVER WIP						
BMP IMPLEMENTATION COSTS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TASK TOTAL
Animal Waste Manage System	$1,458,750	$1,459,250	$1,460,250	$1,458,250	$1,457,250	$7,293,750
Prescribed Grazing	$39,000	$39,000	$39,000	$39,000	$39,000	$195,000
Riparian Area	$104,250	$104,250	$104,250	$104,250	$104,250	$521,250
Bank Stabilization	$0	$220,000	$220,000	$0	$0	$440,000
Residue & Tillage Manage	$10,000	$10,000	$10,000	$10,000	$10,000	$50,000
Grassed Waterways	$12,500	$12,500	$12,500	$12,500	$12,500	$62,500
Wetland/Pond/Basin Restoration	$15,000	$15,000	$15,000	$15,000	$15,000	$75,000
Cropland Conversion to Grass	$51,250	$51,250	$51,250	$51,250	$51,250	$256,250
Conservation Cover Crop & Rotation	$38,000	$38,000	$38,000	$38,000	$38,000	$190,000
Nutrient Manage Plan	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Terraces	$120,000	$120,000	$120,000	$120,000	$120,000	$600,000
Filter Strips Non-CRP	$3,200	$3,200	$3,200	$3,200	$3,200	$16,000
BMP SUB TOTAL COSTS	$1,926,950	$2,147,450	$2,148,450	$1,926,450	$1,925,450	$10,074,750
PERSONNEL SUPPORT						
Project Coordinator	$50,000	$51,500	$53,045	$54,636	$56,275	$265,457
Admin. Assistant	$45,000	$46,350	$47,741	$49,173	$50,648	$238,911
Clerical Assistant	$4,000	$4,120	$4,244	$4,371	$4,502	$21,237
OPERATIONS						
Water Quality Tests	$1,000	$1,000	$1,000	$1,000	$1,000	$5,000
Vehicle, Fuel, Travel, Insurance	$19,000	$19,570	$20,157	$20,762	$21,385	$100,874
ADMINISTRATION						
Computer, Supplies, Telephone,	$10,000	$10,300	$10,609	$10,927	$11,255	$53,091
RC&D Office, Postage						
PERS/ADMIN SUB TOTAL COSTS	$129,000	$132,840	$136,795	$140,869	$145,065	$684,569
YEARLY TOTALS	$2,055,950	$2,280,290	$2,285,245	$2,067,319	$2,070,515	$10,759,319

6. PUBLIC OUTREACH

The Big Sioux River has long been the main source of drinking water from early settlement in 1856 until its current growth in 2016 to the present population of over 170,000 residents. The river and its aquifer provides water to roughly 40% of South Dakota's human population. From a prairie "stream of clear, swift running water" in 1838 (Nicollet et al. 1993), it was cited by the advocacy group Environment America (2012) as the 13th dirtiest river and 14th dirtiest watershed in America for total toxic discharges in 2010. One of the earliest concerns of its water quality was a report on the river by USEPA (1973) that identified urban, agricultural, and industrial pollutions sources that degraded the water quality from Estelline, South Dakota, to Sioux City, Iowa. Since that time numerous assessments, TMDLs, and project implementation plans have been completed along the reaches of the Big Sioux River and the watersheds of the major recreational lakes in the area. The implementation projects have incorporated public outreach activities in their campaign to install BMPs as presented in Table 6-1.

Table 6-1: Public Outreach Activities of Past Watershed Projects

PUBLIC OUTREACH ACTIVITIES					
Activities	Central BSWWP 2010	Central BSWWP 2012	Lower BSRWIP 2012	BSRWIP 2016	Lakes Herman Madison, Brant 2006
Field Tours	2				5
I&E Meeting/Workshops	8	4	1	66	
Service Announcements	8		1	21	
News Releases	7	4	3		
WEB Sites			1		
Brochures					10,170
Public Awareness Activities					140
Special Programs					Zero Phosphorus
Signs					4

The mayor of Sioux Falls, Mike Huether, has been very supportive of public awareness efforts to publicize the status of the Big Sioux River. The Mayor has held two Big Sioux River Water Quality Summits in Sioux Falls and one in Brookings in the last three years to create an opportunity to bring watershed stakeholders together to work to improve and conserve the Big Sioux River as a natural resource. The event usually features a key note speaker with presentation workshops on issues such as storm water and urban environments, agriculture, recreation, flood control, fisheries, and water quality initiatives throughout the region. The Summit helps to ensure transparency between the public and the City and allows the public to be involved in the various water quality improvement projects.

EDWDD funded a telephone survey in 2006 in effort to gauge public opinion regarding pollution within the Big Sioux River Watershed. Telephone interviews were conducted among two groups: one that represented rural property owners adjacent to the Big Sioux River between Watertown and Brandon, and another that represented adults over the age of 25 residing in the towns of Watertown, Brookings, Sioux Falls, and Brandon. A total of 149 individuals were asked about their beliefs and attitudes concerning pollution in the Big Sioux River. Most of the respondents believed the Big Sioux River was polluted and were generally willing to support water quality protection measures. However, they did not know how the clean-up restoration should be done or what measures they should take to support it. Another survey was conducted in 2007 and 2008 to investigate the environmentally related attitudes of residents living within the Big Sioux River Basin (Stover et.al 2008). Twenty-one families living within the basin, who were farming or had been farming, were interviewed on a face-to-face basis. The survey revealed that most of these families acknowledged that land owner/producers bear at least some of the responsibility and obligation to protect the water quality of the Big Sioux River. In September 2007, the Soil and Water Conservation Districts Plymouth, Sioux, and Lyon Counties in Iowa mailed 4,439 surveys on water quality issues to landowners living in 11 tributaries of the Big Sioux River watershed (ISU 2007). One-third of the participants were farm residences and 2/3's were rural acreages or town residences. Approximately 54% of those surveyed felt people in the watershed believed there was a water quality problem. However, 72% did not know there was any group that set water quality goals for their watershed and 97% did not know if there were any water quality goals for their watershed. Over 91% of the participants had not participated in a public discussion about their watershed in the last two years. Of the farmer operators, 48.3% felt they were doing a 'really good' job with conservation measures on their farm, 38.4% felt they were doing an 'okay' job, and about 13% felt there was room for improvement in their conservation measures.

The MCD is currently the BSRWIP sponsor and is responsible for the completion of the goals, objectives, and tasks. The MCD has entered into a cooperative agreement with the Brookings, Lake, Minnehaha, Lincoln, and Union County Conservation Districts and signed a joint powers agreement with the City of Sioux Falls. These county Conservation Districts regularly attend steering committee meetings with the City of Sioux Falls, City of Brookings, SDDENR, and EDWDD. This steering committee will advise the project sponsor in developing priorities, practice manuals, work plans, and strategies for the project. They will meet at least two times each year to provide input for project management and coordination of resources to the Moody Conservation District. The NRCS offices are usually co-located with the CDs. Staff from these offices will be utilized to disseminate the information to producers. Updates and achievements will be given to steering committee meeting members at quarterly meetings.

Other local, state and federal agencies, and organizations providing technical and financial assistance are the Lake Associations' of Campbell, Herman, Madison, Brant, and Wall; Lake

Campbell, Herman, Madison, Brant Lakes' Sanitary Districts; EDWDD; SDGFP; SDDENR; SD Department of Agriculture; SDACD; SDSU Extension Service; NRCS; FSA; and the USFWS.

Public involvement is encouraged through the participation in Local Work Groups (LWG). These LWGs are sponsored by each of the county's Soil and Water Conservation Districts in the BWRWIP. The LWGs meet annually gathering input on critical resource concerns and BMP solutions within each county. The LWGs then come together on a watershed basis to share their priorities and recommendations on the needs of the watershed. Other outreach activities will be through notice in WEB sites, conservation district newsletters, information presentations, and newspaper and radio advertisements.

7. IMPLEMENTATION SCHEDULE

The implementation of this project will be through voluntary programs with producers and landowners over a six county-wide watershed area and will be coordinated by the project coordinator. The implementation of the practices is targeted at the agricultural sector. The unique delivery systems of the South Dakota Conservation Districts to this sector will be utilized to implement the voluntary tasks scheduled. The County Conservation Districts have a field office located in each county that does business with the landowners and agricultural producers. The implementation schedule for BMPs, project outreach, task assignments, and project reports is detailed semi-annually in Table 7-1.

Table 7-1: Implementation & Task Assignment			Year 1		Year 2		Year 3		Year 4		Year 5	
Objectives, Tasks, Products	Group	Quantity	Jan - Jun	Jul-Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec	Jan - Jun	Jul - Dec
OBJECTIVE 1: BMP IMPLEMENTATION												
Task 1: Animal Waste Manage Systems (#)												
Product 1: Animal Waste Manage Systems	1,2,3											
Engineering Studies		25		5		5		5		5		5
Animal Waste Storage Facilities		25		5		5		5		5		5
Construction Management		25		5		5		5		5		5
Nutrient Management Plan		25		5		5		5		5		5
Cultural Resource Study		25		5	3	3	3	5	2	2	2	0
Task 2: Grassland Management	1,2,4											
Product 2: Prescribed Grazing Systems (Ac)		1,500		300		300		300		300		300
Product 3: Riparian Areas (Ac)		1,500		300		300		300		300		300
Task 3: Streambank Stabilization	2,4											
Product 5: Streambank Stabilization (LF)		4,000				2,000		2,000				
Task 4: Cropland Management	1,2,4											
Product 6: Residue & Tillage Manage (Ac)		5,000		1,000		1,000		1,000		1,000		1,000
Product 7: Grassed Waterways (AC)		25		5		5		5		5		5
Product 8: Wetland & Pond Construct (No)		49		5		5		5		5		29
Product 9: Conversion of Crop to Grass (Ac)		1,250		250		250		250		250		250
Product 10: Conservation Rotation/Cover Crop (Ac)		5,000		1,000		1,000		1,000		1,000		1,000
Product 11: Cropland NMP (Ac)		25,000		5,000		5,000		5,000		5,000		5,000
Product 13: Terraces (LF)		200,000		40,000	10,000	30,000	10,000	30,000	10,000	30,000	10,000	30,000
Product 14: Filter Strips, Non-CRP (Ac)		200		40	10	30	10	30	10	30	10	30
OBJECTIVE 2: INFORMATION OUTREACH												
Task 5: Information Distribution												
Product 15: Articles, Newsletter, Radio, WEB	1,2,3,4											
CD Newsletters		30	3	3	3	3	3	3	3	3	3	3
Newspaper Articles		15	2	1	2	1	2	1	2	1	2	1
I & E Workshops & Meetings		25	2	3	2	3	2	3	2	3	2	3
New Releases		15	2	1	2	1	2	1	2	1	2	1
Field Tours		15	1	2	1	2	1	2	1	2	1	2
WEB Site Maintained		1	1	1	1	1	1	1	1	1	1	1
OBJECTIVE 3: PROJECT REPORTS												
Task 6: Annual, Final												
Product 16: Reports	1,2											
Annual		5		1		1		1		1		1
Final		1										1

8. SHORT-TERM CRITERIA AND MILESTONES FOR BMP IMPLEMENTATION PROGRESS

The implementation schedule will be used as a comparative measurement to determine progress of the Strategic Plan. The BMPs in this Strategic Plan have been selected based on the identified 303(d) pollutants and their success at achieving load reductions. These BMPs have been documented by previous research as reducing fecal coliform bacteria, *Escherichia coli*, TSS, and Chlorophyll-*a*. Although this method of measuring progress is not the same as testing water quality, it is assumed that the successful implementation of the practices will have a positive impact on water quality of the Big Sioux River Watershed Improvement Project. However, water quality testing is currently being conducted at 33 water quality monitoring sites in the project watershed. The short-term progress of the project will be measured annually in the last quarter of each project year. The project coordinator will be responsible for tabulating the number of BMPs installed, the number of acres treated, and the public outreach campaign efforts made in each county as identified in Table 8-1. This information will be submitted annually to USEPA and the information will be made available to the public on SDDENRs website. The project steering team will examine the achievements to determine if adequate progress has been made by the current BMP implementations. If they determine that adequate progress has not been made, they can adjust the implementation projects in order to achieve the five year BMP goals.

Table 8-1. Short-term Criteria & Milestones				Year 2		Year 3		Year 4		Year 5
BMP or Activity	Quantity	Year 1	Year 2	Subtotal	Year 3	Subtotal	Year 4	Subtotal	Year 5	Subtotal
Engineering Studies - AWMS	25	5	5	10	5	15	5	20	5	25
Animal Waste Storage Facilities	25	5	5	10	5	15	5	20	5	25
Construction Management - AWMS	25	5	5	10	5	15	5	20	5	25
Nutrient Management Plan	25	5	5	10	5	15	5	20	5	25
Cultural Resource Study - AWMS	25	5	6	11	8	19	4	23	2	25
Prescribed Grazing Systems	1,500	300	300	600	300	900	300	1,200	300	1,500
Riparian Areas	1,500	300	300	600	300	900	300	1,200	300	1,500
Streambank Stabilization	4,000	0	2,000	2,000	2,000	4,000	0	4,000	0	4,000
Residue & Tillage Manage	5,000	1,000	1,000	2,000	1,000	3,000	1,000	4,000	1,000	5,000
Grassed Waterways	25	5	5	10	5	15	5	20	5	25
Wetland/Pond/Basin Construction	25	5	5	10	5	15	5	20	5	25
Conversion of Crop to Grass	1,250	250	250	500	250	750	250	1,000	250	1,250
Conservation Cover & Crop Rotation	5,000	1,000	1,000	2,000	1,000	3,000	1,000	4,000	1,000	5,000
Nutrient Management Plan Crop	25,000	5,000	5,000	10,000	5,000	15,000	5,000	20,000	5,000	25,000
Terraces	200,000	40,000	40,000	80,000	40,000	120,000	40,000	160,000	40,000	200,000
Filter Strips Non-CRP	200	40	40	80	40	120	40	160	40	200
CD Newsletters	30	6	6	12	6	18	6	24	6	30
Newspaper Articles	15	3	3	6	3	9	3	12	3	15
I&E Workshop & Meetings	25	5	5	10	5	15	5	20	5	25
News Releases	15	3	3	6	3	9	3	12	3	15
Field Tours	15	3	3	6	3	9	3	12	3	15
WEB Site Maintained	5	1	1	2	1	3	1	4	1	5
Annual Reports	5	1	1	2	1	3	1	4	1	5
Final	1								1	1

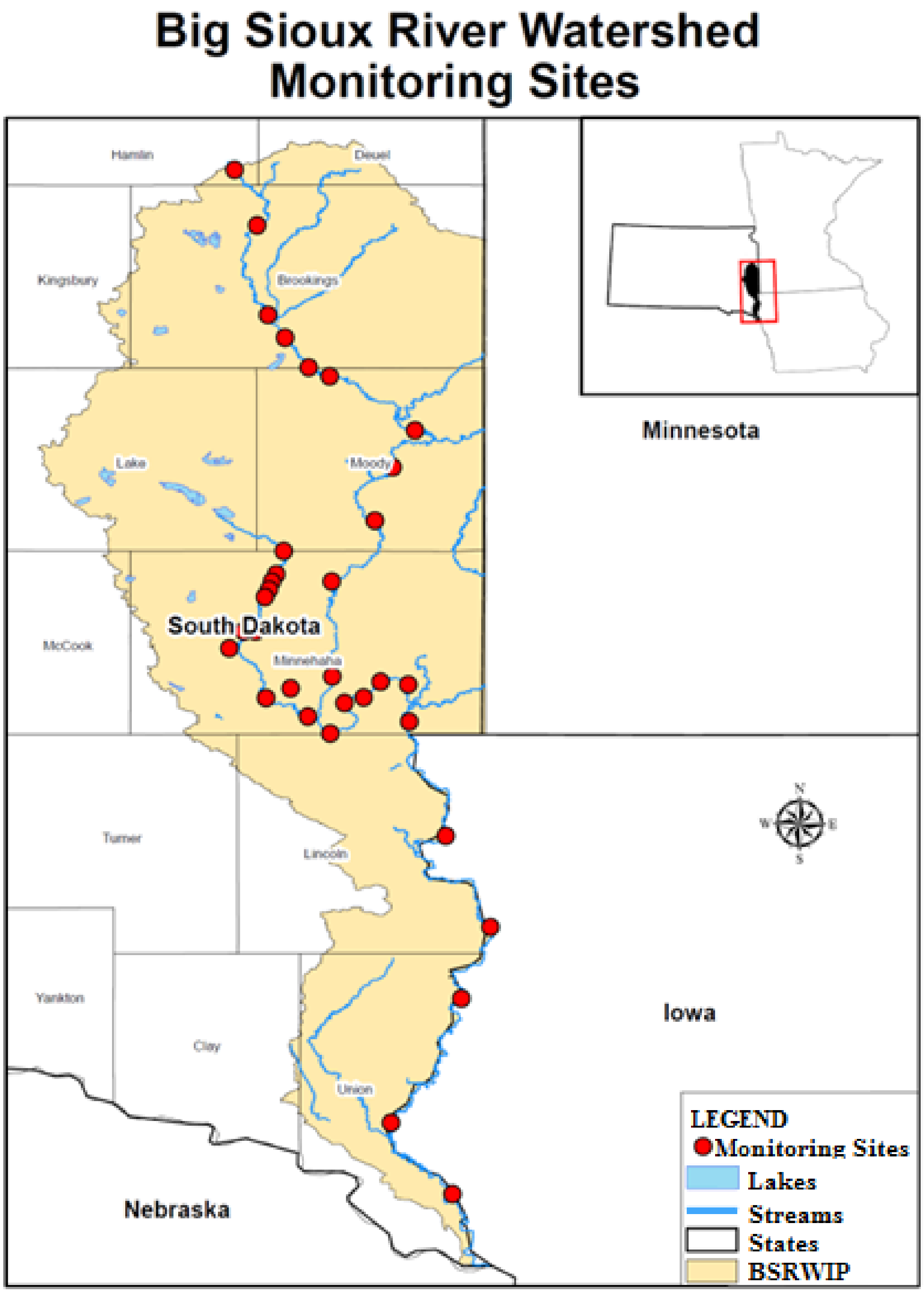
9. MONITORING AND EVALUATION PLAN

Monitoring and evaluation efforts will include analyzing water quality changes from BMP installation compared to water quality changes since the most recent watershed assessments on selected sites. The completion of the TMDL studies cited in Section 1.2 of this document has also provided a solid baseline of water quality data to use as BMPs are installed. Several computer analysis programs will be used to identify specific critical pollution sources, evaluate and determine source loading, and quantify load reductions such as: Hydrologic Simulation Program-Fortran (HSPF), Strategic Prevention Framework (SPF), Bacteria Source Load Calculator (BSLC), Spreadsheet Tool for Estimating Pollutant Load (STEPL), and the AGNPS-Feedlot Model.

The USGS and SDENR maintain 22 water quality monitoring (WQM) monitoring stations along the Big Sioux River from the town of Bruce south to its mouth and 11 WQM sites on its tributaries. See Table 9-1. The data from these 33 WQM stations can also be used by the project director to make comparisons of installed practices. This data can be collected from SDDENR and USGS on an annual basis as BMPs are installed and results evaluated.

The effectiveness of BMPs installed relative to the improvement in water quality will be evaluated using the appropriate tools and models available such as AGNPS-Feedlot, RUSLE2, STEPL, HSPF, and BSLC models. The AGNPS-Feedlot model can be used to identify specific feeding operations or cropland practices where the BMPs should be implemented, and the models can again be used to quantify the changes in load reductions. Any water sampling, testing and test result evaluations for water quality changes will be completed with technical assistance from DENR. They will also assist to develop a sampling and analysis plan, train project staff, and help in data storage and evaluation. Sampling will be completed according to the *Standard Operating Procedures for Field Samplers, Volumes I & II, Tributary and In-Lake Sampling Techniques*, SD DENR, 2005.

Table 9-1. Water Quality Monitoring Stations in BSRWIP



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