
# NORTHEAST GLACIAL LAKES 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**

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## Executive Summary

The glacier lakes of northeastern South Dakota were formed in the Coteau des Prairies as the last glaciers retreated across the landscape. The lakes were formed as the glaciers melted away and left large blocks of ice. The remaining holes or 'kettles' filled up with water forming the larger glacial lakes and thousands of small prairie pothole wetlands across the Coteau. Big Stone Lake and Lake Traverse, two of the larger lakes in the eastern Coteau, were formed from the Des Moines Lobe of the glacier when it retreated. The glacier melt water sent torrents of water southward forming the Little Minnesota River, draining Big Stone Lake into the Gulf of Mexico, and northward forming the Bois des Sioux River draining Lake Traverse north to the Red River and into the Arctic Ocean. Along the drier western flank of the Coteau, cut by the James Lobe, the James River was carved as flood waters drained glacial Lake Dakota. The James River flows south into the Missouri River.

The current Northeast Glacial Lake Watershed Protection and Improvement Project Segment 2 (NEGL) encompasses four counties in northeast South Dakota: Day, Grant, Marshall, and Roberts. Water quality studies of glacial lakes began as early as 1999 for Pickerel Lake, Enemy Swim in 2005, and Blue Dog Lake in 2006. The assessments identified the main sources of pollution as nonpoint sources from agricultural lands that included fecal coliform bacteria, nutrients, and sediments. These contaminants to the water bodies led to severe algal blooms, excessive beds of macrophytic vegetation, decreased water depths, increased water temperatures, and low dissolved oxygen levels.

The earlier Segment 1 implementation project included twelve water bodies as follows:

- Big Sioux River Basin: Blue Dog Lake, Enemy Swim Lake, Minnewasta Lake, and Pickerel Lake (Upper Big Sioux HUC #10170201)
- James River Basin: Amsden Dam and Pierpont (Mud HUC #10160005); and Buffalo Lake, Clear Lake, Nine Mile Lake, and Red Iron Lake South (Upper James HUC #10160003)
- Red River Basin: Lake Traverse (Bois De Sioux HUC 09020101) and White Lake Dam (Western Wild Rice HUC #09020105).

The Segment 1 project terminated in December 2010 and was followed by the current Segment 2 project which added Roy Lake in the Upper James HUC and the Little Minnesota River Basin (Upper Minnesota HUC #07020001). This strategic plan does not include the Little Minnesota River Basin as that was addressed in the 2012 document, the Upper Minnesota River Watershed Five Year Strategic Plan. The total watershed project in Segment 2 NEGL project is approximately 362,211 acres, excluding the Little Minnesota River Basin.

The *2012 South Dakota-DENR Integrated Report for Surface Water Quality Assessment* for water bodies in the NEGL project area reported that High pH, low Dissolved Oxygen, and High Temperature were the identified impairments for the 303(d) listings. Blue Dog Lake and Nine

Mile Lake were 303(d) listed due to High pH; Buffalo Lake South was listed due to low Dissolved Oxygen; and Pierpont Lake was listed for the exceedance of High Temperature. The remaining water bodies met the 303(d) criteria for all their designated beneficial uses.

The Day County Conservation District agreed to sponsor Segment 2 of the NEGL project in 2010 to improve and protect the water quality of several northeast South Dakota lakes by implementing Best Management Practices (BMP). An Advisory Council of local, state, tribal, and federal partners was formed to manage the NEGL project and oversee the implementation of BMPs. A memorandum of understanding that defines the responsibilities and obligations of each conservation district was signed by the Day, Grant, Marshall, and Roberts Conservation Districts.

Recommendations to reduce nutrient and sediment inflow to the water bodies were the installation of a centralized sanitary sewer systems on Blue Dog Lake and Enemy Swim Lake, installation of a water control structures, reduction of the use of lawn fertilizers around the lake, shoreline stabilization, aeration pumps to maintain DO levels, selective dredging, construction of animal waste management systems for identified animal feeding operations, installation of grass buffer strips and critical area grass seedings, grazing land management, and implementation of crop residue management in critically identified agricultural fields.

Central sewage collection systems may be needed around the larger lakes in the future as the development of permanent and summer homes increases. Blue Dog Lake had a central sewage system installed in 1992 connecting lake homes to City of Waubay's wastewater treatment plant eliminating the concern that sewage effluent from lake homes could enter the waters of Blue Dog Lake. However, as homes and cabins develop around other recreational glacial lakes, wastewater generated by individual septic tanks and drain field systems could leach into lake waters and become a source of increased chlorophyll-*a*, resulting in a decrease in water quality. The leachate survey data conducted in 1998 on Enemy Swim Lake indicated that the lake had become more eutrophic over the previous decade. Soils adjacent to many of the lake shorelines are unsuitable for septic system absorption fields and should be thoroughly evaluated as they may contribute to sewage leachate entering lake waters.

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 (BMP) that, when implemented, will result in the delisting of the 303(d) water bodies; and to identify practice and administrative costs, and set goals over the 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 NEGL project area.

# 1.0 INTRODUCTION

## 1.1 Project Background and Scope

The watershed of the project area includes seven counties in northeast South Dakota: Clark, Codington, Day, Deuel, Grant, Marshall, and Roberts; and portions of four major river basins: the Big Sioux, James, Little Minnesota, and Red Rivers. This area is included in portions of six Hydrologic Unit Code (HUC) areas: the Bois De Sioux, HUC-09020101; the Mud, HUC-10160005; the Upper Big Sioux, HUC-10170201; the Upper James, HUC-10160003; Western Wild Rice, HUC-09020105; and the Upper Minnesota, HUC-07020001. See Figure 1-1 for HUCs.

The boundaries of the Northeast Glacial Lake Watershed Protection and Improvement Project (NEGL) encompass four of these northeast South Dakota counties: Day, Grant, Marshall, and Roberts, and portions of four major river basins: the Big Sioux, James, Little Minnesota, and Red Rivers (Skadsen 2010). Many of the selected lakes are on 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 U.S. Midcontinent; 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.

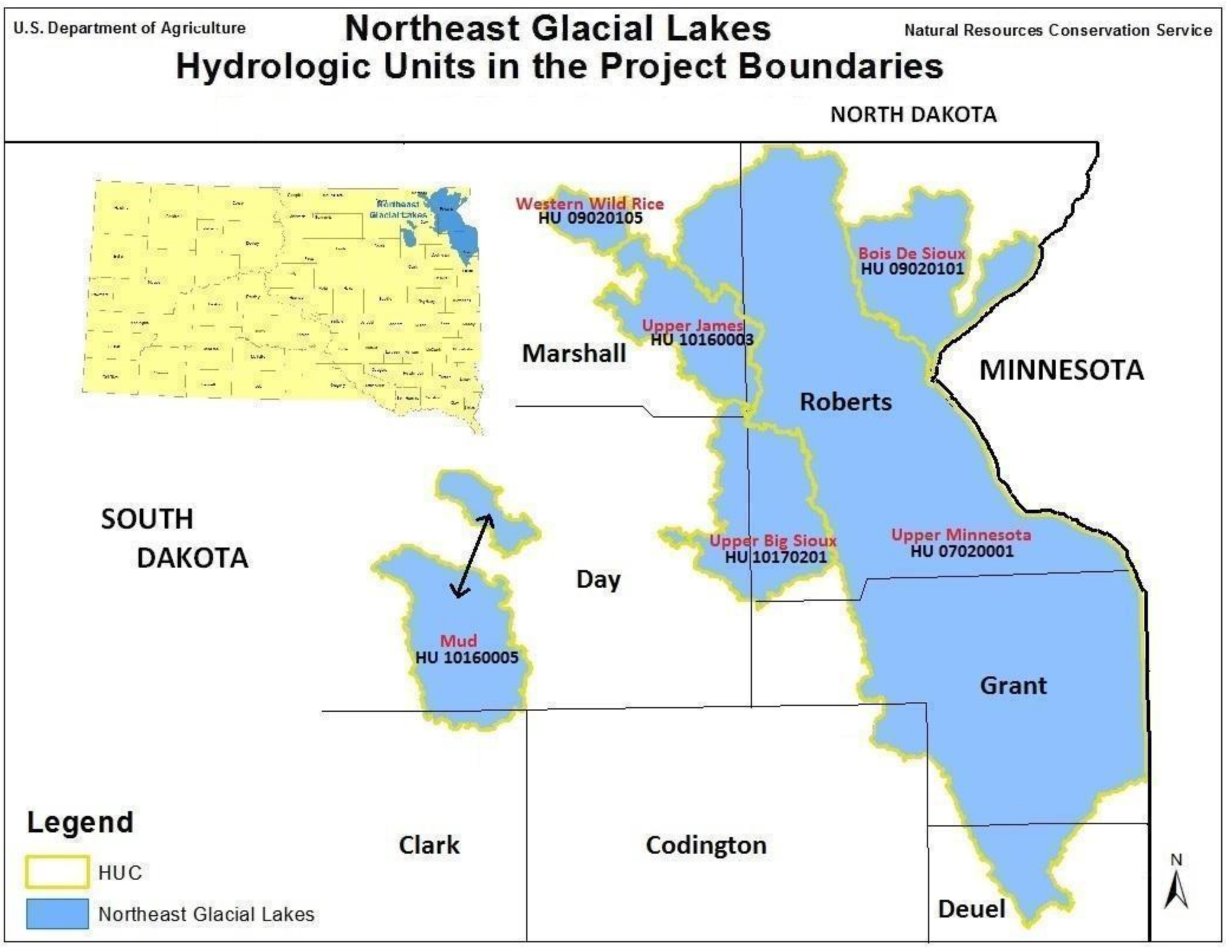
Melt water from the top of the Coteau also cut deep channels along the eastern and western slopes of the Coteau as the glaciers retreated northward. These channels formed small perennial streams on the east side of the Coteau that are the headwaters of the Red River that flow north into Hudson Bay and the Minnesota River that flows east into the Mississippi River. The watershed on the west side of the Coteau flowed west and southward to the James River, which empties into the Missouri River.

The Red River watershed portion of the NEGL includes the White Lake reservoir located on the Wild Rice River that drains to the Red River Basin system and Lake Traverse which lies in the main channel of the remains of the Glacial River Warren. Lake Traverse drains into the Bois De Sioux River, a tributary of the Red River, with ninety percent of its watershed in Minnesota.

Many of the lakes within the eastern portion of the Coteau des Prairie are situated within closed basins. Although many are closed, the potential exists for these lakes to eventually drain to the Big Sioux River Basin. This potential was realized in the 1990's when greater than normal precipitation and less than normal evaporation caused many of the lower lakes in the subsystem to rise twenty feet above normal lake level elevations (Skadsen 2010). Many of the lakes are also hydraulically connected by aquifers and surface drainages.

The Little Minnesota River basin is comprised of the Little Minnesota River, the Jorgenson River, the North Fork Whetstone River, the South Whetstone River, the North Fork Yellow Bank River, the South Fork Yellow Bank River, and their smaller tributaries. The Little Minnesota River drains the majority of Roberts County and a portion of east central Marshall County beginning near Veblen, South Dakota. The rivers flows into Big Stone Lake south of Browns Valley, Minnesota, and as it outlets Big Stone Lake, it begins as the Minnesota River.

**Figure 1-1. Hydrological Units in the NEGL Watershed.**



The climate of the Northeast Glacial Lake region is classified as sub-humid continental. The highest mean temperature in the northern part of the basin for Sisseton in July is 77.0 degrees Fahrenheit (F), while the lowest mean temperature in January is -3.17 ° F; the average median temperature is 43.8 ° F. The highest mean temperature at the south end of the basin for Webster in July is 76.3° F, while the lowest mean in January is -3.3° F; the average median temperature is 43.0° F. The annual precipitation in Sisseton and Webster is 22.08 and 22.06 inches, respectively. The weather data references are from the South Dakota State University, South Dakota Climate and Weather, Normal Statistics 1971-2000. Climate conditions are relatively uniform throughout the watershed basin, 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.

The Northeast Glacial Lake project area is largely rural in nature with the City of Milbank having the largest population at 3,347 residents. The second largest city is Sisseton with a population of 2,469 residents. There are approximately 21 incorporated and unincorporated cities and villages within the watershed. Table 1-1 lists the cities and the counties' populations in the watershed. A map of the cities and counties locations and project area is shown in Figure 1-2.

**Table 1-1. Population Statistics of the NEGL Project Area**

| Populations Statistics of the NEGL. US Census Bureau 2010 Census | | | | | | |
|---|---|---|---|---|---|---|
| **City** | **Populations** | **County** | | **City** | **Populations** | **County** |
| Milbank | 3,347 | Grant | | Claire City | 76 | Roberts |
| Sisseton | 2,469 | Roberts | | Strandburg | 72 | Grant |
| Wilmot | 599 | Roberts | | Twin Brooks | 69 | Grant |
| Big Stone City | 479 | Grant | | LaBolt | 68 | Grant |
| Veblen | 331 | Marshall | | Ortley | 65 | Roberts |
| Peever | 228 | Roberts | | Lake City | 51 | Marshall |
| South Shore | 225 | Codington | | Altamont | 34 | Duel |
| Revillo | 111 | Grant | | Butler | 24 | Day |
| Corona | 109 | Roberts | | Lily | 17 | Day |
| Marvin | 105 | Grant | | Albee | 16 | Grant |
| Stockholm | 100 | Grant | | | | |

## 1.2 Northeast Glacial Lakes Watershed History

The Northeast Glacial Lakes Watershed Protection and Improvement Project (NEGL) Segment 2 encompasses four northeast South Dakota counties: Day, Grant, Marshall, and Roberts, and portions of four major river basins: the Big Sioux, James, the Little Minnesota River, and the Red

Rivers (Skadsen 2010). Prior to 2007 watershed assessments and improvement projects were funded by Environmental Protection Agency (EPA) and SDDENR for the lakes and reservoirs located in the project area (Skadsen 2010). Additional monies were obtained from both the United States Department of Agricultures (USDA) Natural Resources Conservation Service (NRCS) and the Farm Service Agency (FSA). The South Dakota State University Water Resources Institute (WRI) assisted the Day County Conservation District in the collection and analysis of water quality samples.

Earlier watershed implementation projects were completed for Pickerel Lake in 1996, Enemy Swim Lake in 2005, and Blue Dog Lake in 2006. The town of Pierpont funded a two year study of Pierpont Dam Reservoir's water quality that was completed in 2009. Water quality studies of Clear Lake, Enemy Swim Lake, and Pickerel Lake were also funded by local lake associations, conservation districts, and sanitary sewer districts. In 2007 the Day County Conservation District agreed to sponsor the Segment 1 of the Northeast Glacial Lake Watershed Improvement and Protection Project (NEGL) to improve and protect the water quality of several northeast South Dakota lakes. This project extended into December of 2010 and included a cooperative partnership with the Marshall and Roberts County Conservation Districts. See Figure 1-3 for Segment 1 NEGL project boundaries from 2007-2010.

The main nonpoint source pollutants identified in these assessments that impaired the water quality of the project lakes were fecal coliform bacteria, nutrients, and sediments carried from agricultural lands located in the watersheds. The goal of the Segment 1 project was to continue protecting and improving water quality of the northeast South Dakota glacial lakes by implementing Best Management Practices (BMP). Segment 1 was immediately followed by Segment 2 of the NEGL project which began 2011 and will continue to June 2014. The NEGL project was again sponsored by the Day County Conservation District.

**Figure 1-2. Cities, Counties, Water Bodies of the NEGL Project**

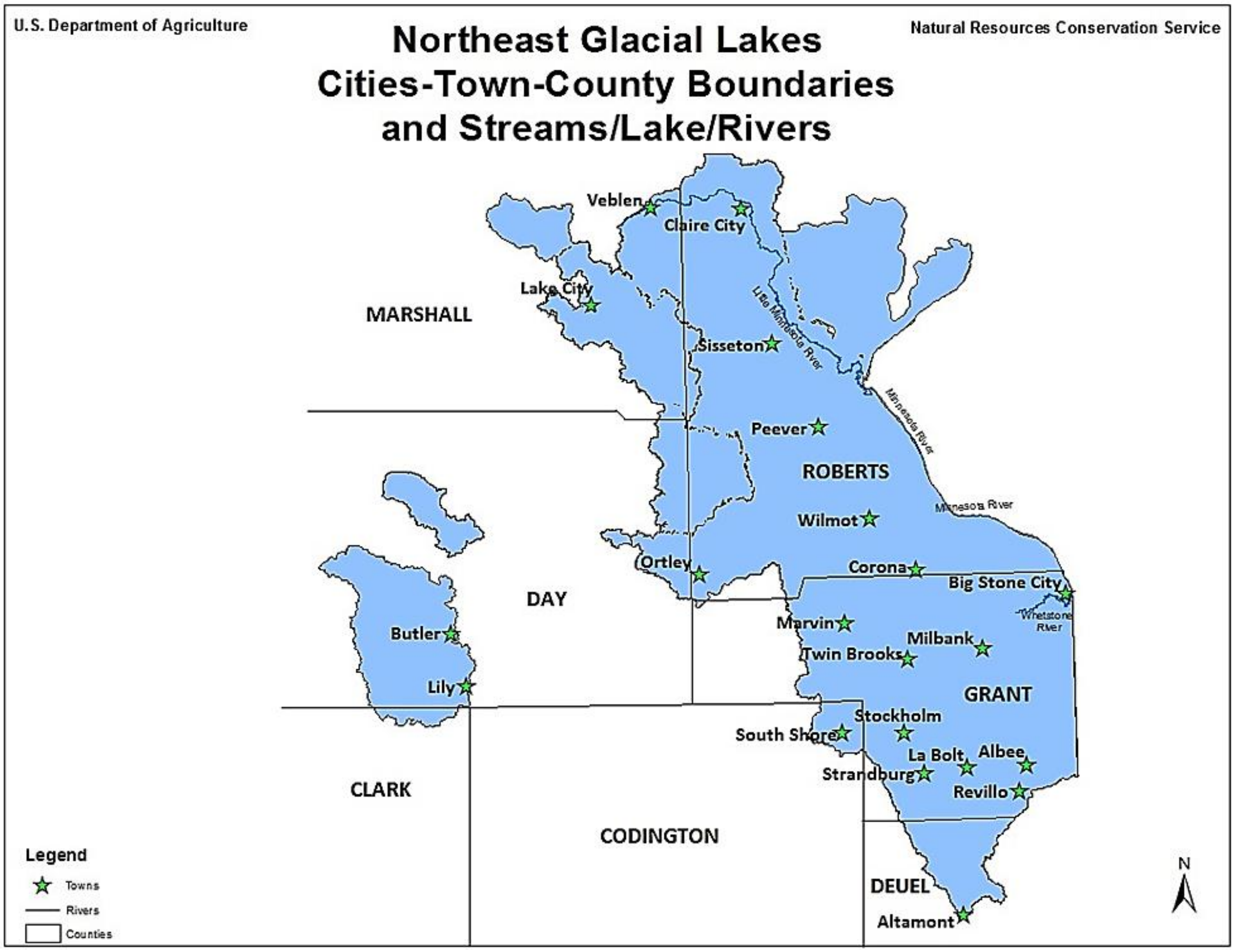
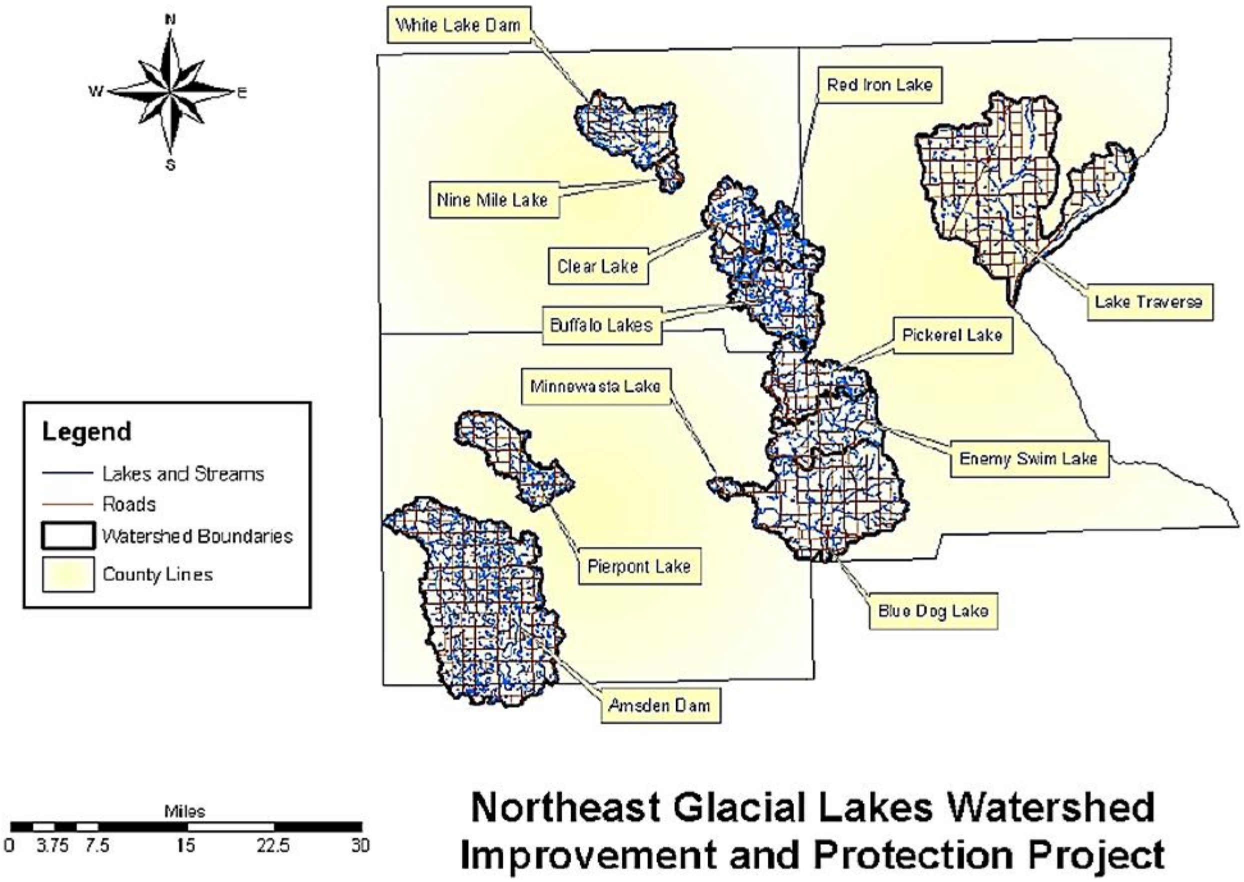


**Figure 1-3. Segment 1 Boundaries of the NEGL Project 2007-2010**




## 1.3 Northeast Glacial Lakes Water Quality Studies

The water bodies in the northeastern South Dakota were assessed and studied through a variety of funding projects from both governmental and private sources. These assessments provided the foundation of baseline data for future water quality activities and project implementations. The main sources of pollution were nonpoint from agricultural lands located in the lake watersheds. These pollutants had been identified as fecal coliform bacteria, nutrients, and sediments. Segment 1 of the NEGL project was a multi-year locally led effort to implement best management practices recommended by previous watershed assessments and studies.

Segment 2 of the NEGL project was amended to include the Little Minnesota River watershed in 2011 and will be completed in June 2014. A Five Year Strategic Plan was written for the Upper Minnesota River Watershed in 2012 which detailed the work completed in this basin and the Best Management Practices (BMP) necessary for the 303(d) listed water bodies to meet their designated beneficial uses. Therefore, the Upper Minnesota River HUC 07020001 will be referenced, but not duplicated, in the Strategic Plan for the Northeast Glacial Lakes project. The water bodies included in Segment 2 are presented in Table 1-2, excluding the Little Minnesota River watershed.

**Table 1-2. Water Bodies in the Segment 2 NEGL Project Area**

| Water Bodies in Segment 2 NEGL Project | | | |
|---|---|---|---|
| Amsden Lake | Minnewasta Lake | Roy Lake | Red Iron Lake North |
| Blue Dog Lake | Nine Mile Lake | Buffalo Lake South | Lake Traverse |
| Clear Lake | Pickerel Lake | Buffalo Lake North | White Lake |
| Enemy Swim Lake | Pierpont Lake | Red Iron Lake South | |

Seven water bodies in the Upper Minnesota River were listed for Temperature, High pH, Dissolved Oxygen, and *Escherichia coli* bacteria. These were: Big Stone Lake, Punished Woman Lake, Little Minnesota River, North and South Fork Whetstone Rivers, and North and South Fork Yellow Bank Rivers. Data for these water bodies can be found in the Five Year Strategic Plan for the Upper Minnesota River Watershed (Lebeda 2012).

The water bodies in the NEGL project area listed in the SDDENR Integrated Report (IR) as fully meeting all of their designated beneficial uses were: Amsden Dam, Buffalo Lake North, Clear Lake, Enemy Swim Lake, Lake Traverse, Minnewasta Lake, Pickerel Lake, Red Iron Lake South, Roy Lake, and White Lake. The following lakes were 303(d) listed as impaired in the SDDENR-IR 2012: Blue Dog Lake and Nine Mile Lake were listed due to High pH; Buffalo Lake South was listed due to low Dissolved Oxygen; and Pierpont Lake was listed for the exceedance of High Temperature. A short synopsis of each study within the Northeast Glacial Lakes is as follows:

**Amsden Dam Reservoir:**

- The *Phase I Watershed Assessment Final Report for Amsden Dam Reservoir* was completed in 2007. Data collection began in September of 2004 and ended in October of 2005. Amsden Dam is a man-made reservoir completed in 1936 as a Works Program Administration (WPA) project on Pickerel Creek, a small perennial stream and the lake's main tributary. The reservoir is located in west central Day County on the west slope of the Coteau des Prairies within the James River watershed. It has a surface area of 235 acres, a 32,000 acre watershed, a maximum depth of 27 feet, and a mean depth of 12.7 feet. A sediment survey indicated an average sediment depth of 2.4 feet. Land use in the watershed is mainly agricultural with cropland planted to corn, soybeans, and wheat rotations. The majority of Amsden's shoreline is grazed to the water's edge or cropped with very little riparian buffer. The lake was listed in the 2012 SDDENR Integrated Report as meeting all of its designated beneficial uses.

- The *Total Maximum Daily Load Evaluation (TMDL) for Amsden Dam Reservoir Hydrologic Unit Code (HUC) 10160005, Day County, South Dakota*, was published in December 2006. There were no point sources of pollutants of concern in this watershed.

**Blue Dog Lake:**

- Blue Dog Lake was initially assessed in the *Phase 1 Watershed Assessment Final Report, Blue Dog Lake, Day County, South Dakota*, in 1999. Blue Dog Lake is a 1,502 acre natural lake located on the eastern central border of Day County, approximately 10 miles east of Webster. It has a maximum depth of 8 feet and a mean depth of 6.2 feet when the lake elevation reaches the crest of the outlet structure. The main tributaries are Owens Creek, which begins in Roberts County, and the outlet of Enemy Swim Lake/Campbell Slough. The lake's watershed is approximately 56,840 acres with an agricultural land use of 35.2% rangeland, 25.4% crop, and 31.2% hay land (SDDENR 1999). Blue Dog Lake was 303(d) listed in the 2012 DENR Integrated report for High pH. The assessment found that animal feeding operations and the handling of the animal manure were the most likely source of nutrients to Blue Dog Lake. Nutrients and soil erosion delivered from croplands, targeted by the AGNPS model as having slopes greater than 7%, also needed treatment with Best Management Practices (BMPs). The shoreline and emergent vegetation around Blue Dog Lake should also be managed to reduce shoreline erosion, re-suspension of bottom sediments, and to provide better fish habitat.

- The *Total Maximum Daily Load Evaluation (TMDL) for Blue Dog Lake, Day County, South Dakota*, was published in April 2000. There were no reported point sources of pollutants of concern. Nonpoint sources of pollutants were animal feeding operations, crop fields with land slopes of 7% or greater, and shoreline erosion. It was recommended that a reduction goal of 30% of phosphorus inputs should be attained.

- The *Blue Dog Lake Watershed Improvement Project Final Report* was published in July 2006. This was a project implementation plan developed to install best management practices designed to reduce the phosphorus loading to the lake by 35% and move the lake's Trophic State Index (TSI) from a hypereutrophic state to eutrophic. During the project 1,573 acres of cropland were enrolled in the Conservation Reserve Program and 7,684 acres of pasture and rangeland were improved. The targeted TSI for the project was 63.75 and the project goal was attained with a final TSI of 63.33.

**Buffalo Lake – North:**

- The Marshall County Lake Assessment Project *Final Report for North Buffalo Lake* was completed in November 2008. North Buffalo Lake is a 107.6 acre natural lake located in Marshall County nine miles northeast of Lake City. The average depth of the lake is 10 feet with a maximum depth of 12 feet. The lake has an 18,733 acre watershed with one small unnamed tributary that flows into the lake. A sediment survey showed an average sediment depth of 8.4 feet. The lake may at times be connected to South Buffalo Lake, with water usually flowing from South Buffalo Lake into North Buffalo Lake. North Buffalo Lake drains into Almos Lake and then into South Red Iron Lake. During the study, Dissolved Oxygen (DO) levels were below the acceptable standard of 5.0 milligrams/liter (mg/l); however, no dead fish were found, and SDDENR had not reported fish kills in previous ten years. Several pH readings were above 9.0, but it was determined that these pH levels were not considered problematic for this lake. The lake was meeting its target Trophic State Index of 63.4 and did not need extensive watershed conservation practices although it was recommended that Best Management Practices and Animal Waste Management Systems be promoted in the watershed. The lake was listed in the 2012 SDDENR Integrated Report as meeting all of its designated beneficial uses.

**Buffalo Lake – South:**

- The Marshall County Lake Assessment Project *Final Report for South Buffalo Lake* was completed in November 2008. The lake is approximately 9 miles southeast of Lake City and 5 miles east of Eden. South Buffalo Lake is a 1,780 acre lake located in Marshall County with an average depth of 6 feet and a maximum depth of 12 feet. The lake has a 16,781 acre watershed that drains primarily grazing lands with some cropland acres. The lake was listed in the 2012 SDDENR Integrated Report as not meeting the designated beneficial use of Dissolved Oxygen (DO) for Warmwater Semipermanent Fish Life. Twenty-seven percent of the DO levels were below the 5.0 milligram/liter (mg/l) criterion for maintaining Warmwater Semipermanent Fish Life Propagation. The most likely cause of low DO levels was bacteria using oxygen during the decomposition of organic matter in the lake. It was recommended that reducing phosphorus loadings to the lake would improve DO concentrations and overall water quality.

**Clear Lake:**

- Results of the SDDENR sampling of Clear Lake in 1979, 1989, 2001, and 2005 are reported in the document *Clear Lake Water Quality 1979-2005*. The South Dakota Water Resources Institute (WRI) conducted studies from 1991-1995 and as part of an undergraduate research project in 2006. Water quality in Clear Lake declined in the period from 1979 to 1992 and then improved to a mesotrophic TSI condition by 1994. However, Clear Lake shifted to more eutrophic conditions again by 2005. Water quality is a reflection of the watersheds that discharge water to them, and the data indicated that Clear Lake is sensitive to phosphorus loadings. The conclusion was that if the Conservation Reserve Program lands are returned to crop production and lake shore line development increases, the water quality of Clear Lake will most likely decline if phosphorus loadings from these sources are not reduced. The lake was listed in the 2012 SDDENR Integrated Report as meeting all of its designated beneficial uses.

- Phil George reported to the Clear Lake Betterment Association (CLBA) on *Understanding Pollution Sources and Protecting Water Quality in Clear Lake* in June 2009. The original articles of incorporation for the CLBA stated the purpose of the organization was to 'promote good recreation and water safety' and undertake water studies to improve the lake and lake shore property. The CLBA roster showed 209 lake residents which included 32 full-time residents. A 1977 report on northeastern South Dakota lakes recommended that a sewer district be formed, and a public sewer system be built around Clear Lake. Two attempts to incorporate a public sewage district on the lake were narrowly defeated in 2007 and 2008. The CLBA board reported it would continue to look at sources of pollution and to take steps to keep Clear Lake water quality at the highest level possible.

**Enemy Swim Lake:**

- The *Phase 1 Watershed Assessment Final Report on Enemy Swim Lake, Day County, South Dakota* was published in May 2000. Enemy Swim Lake is a 1,209 acre glacial lake located in northeast Day County with a watershed of 22,310 acres located mostly in Roberts County. Results from the study indicated Enemy Swim Lake has become more eutrophic over time with a marked increase in chlorophyll-*a* in the last decade. The identified sources of nutrients, via a Septic Leachate Survey conducted in 1998, were grain fields, animal feeding areas, over grazed pastures, and septic leachate from lake homes. The lake was listed in the 2012 SDDENR Integrated Report as meeting all of its designated beneficial uses.

- A report to the Day County Conservation District, *Enemy Swim Lake Wastewater Collection and Treatment Feasibility Study* was completed in 2004 by Clark Engineering Corporation, Aberdeen, South Dakota. Septic tank effluent collection systems and opinions of probable cost were provided for the wastewater collection for all areas of the lake, which included approximately 260 homes, resort cabins, and recreational facilities.

- Enemy Swim Lake was reported on in the *Invertebrate and Aquatic Plant Studies of Two Mesotrophic Lakes in South Dakota* by David R. German with the South Dakota Water

Resources Institute from March 2004 to February 2005. The objectives of this study were to prepare lists of: aquatic macro-invertebrates and their abundance; aquatic plants and their general abundance; and to assess the current trophic state of the lakes. Enemy Swim Lake exhibited characteristics of a mesotrophic to early eutrophic lake in 2004.

- The *Watershed Project Final Report for the Enemy Swim Lake Watershed Improvement Project* (ESLWIP) was compiled by Dennis R. Skadsen, Project Coordinator, in July 2005. The ESLWIP ran from March 2001 to March 2005 with a goal to reduce in-lake phosphorus by 31%. During the project in-lake phosphorous concentrations were reduced by 37%, the lake Trophic State Index (TSI) moved from eutrophic to mesotrophic, and the water clarity was improved.

**Lake Traverse:**

- A six year investigation to describe and quantify the water resources of the Lake Traverse Reservation was documented in the 2001 report, *Water Resources of the Lake Traverse Reservation, South and North Dakota, and Roberts County, South Dakota,* by the U.S. Geological Survey in cooperation with the SDDENR, the Sisseton-Wahpeton Sioux Tribe, and Roberts County. The report described the quantity, quality, and availability of surface and ground water, the extent of the major glacial and bedrock aquifers and named outwash groups, and surface and ground water uses. Historically, nearly all potable water was supplied by the users because no municipal or rural water systems existed. Municipalities and rural water systems currently provide most of the water used with nearly all of it from ground water sources. Surface water use is limited to livestock watering. Irrigation accounted for 10% of the total water use.

- The Lake Traverse-Roberts County Rural Water System requested the SD Geological Survey (SDGS) to delineate the areal extent and define the water quality of aquifers in portions of Roberts, Marshall, and Day Counties which might serve as a water source for the rural water system. The report *Investigation of Ground Water Resources in Portions of Roberts County, South Dakota*, was completed in 1996 by SDGS. It was recommended that the rural water system examine the possibility of using the Veblen aquifer as its water source.

- Lake Traverse was listed in the 2012 SDDENR Integrated Report as meeting all of its designated beneficial uses.

**Minnewasta Lake:**

- Minnewasta Lake was reported on in the *Phase I Watershed Assessment Final Report for Amsden Dam Reservoir & Minnewasta Lake, Day County, South Dakota*, January 2007. The assessment ran from September 2004 to October 2005. Minnewasta Lake is a natural lake with a surface area of 601 acres, a maximum depth of 14 feet, a mean depth of 10.5 feet, and a watershed of 2,564 acres. Modeling and sampling found significant nonpoint pollution sources to Minnewasta Lake. There were two Animal Feeding Operations (AFOs) nearby and a small development with nine cabins on the lake shore. No overall water quality trend was indicated from 1989 to 2005, but the lake exhibited a pattern of gradual change from hyper-eutrophic to eutrophic and back.

- The *Total Maximum Daily Load Evaluation (TMDL) for Minnewasta Lake (HUC 10160010), Day County, South Dakota*, was published in December 2006. The lake was listed in the 2012 SDDENR Integrated Report as meeting all of its designated beneficial uses.

**Nine Mile Lake:**

- The *Final Report for Nine Mile Lake, Marshall County, South Dakota*, was completed in March 2007 by SDDENR. The report was part of the Marshall County Lakes Assessment Project. Nine Mile Lake is a 282 acre natural lake with a watershed of 2,722 acres, an average depth of 6.6 feet, and a maximum depth of 10 feet. The lake is four miles west of Lake City and has historically been plagued by nuisance aquatic plants, siltation, and nutrients. The lake was found to have 43% of its volume filled in with silt; however, the lake's Trophic State Index (TSI) of 50.86 was meeting its target TSI of 63.4. Nine Mile Lake was 303(d) listed as having a High pH for Fish and Wildlife Propagation, Recreation, and Stock Watering and Warmwater Semipermanent Fish Life in the 2012 SDDENR Integrated Report.

- The *TMDL Summary for Nine Mile Lake, Marshall County, South Dakota*, was established in March 2007 and published as Appendix B in the *Final Report for Nine Mile Lake, Marshall County, South Dakota*, March 2007, by SDDENR.

**Pickerel Lake**:

- *A Review of Pickerel Lake Water Quality* was completed by David German and Dennis Skadsen in 2010. The South Dakota State University Water Resources Institute (WRI) began water quality monitoring in 1991 as part of the Nonpoint Source Task Force lakes' protection strategy. The purpose is to provide a data set for assessing long-term and year-to-year variations in algal productivity of Pickerel Lake. The lake was listed in the 2012 SDDENR Integrated Report as meeting all of its designated beneficial uses.

**Pierpont Lake:**

- The *Pierpont Lake In-Lake Water Quality Study 2007-2008* was published in January 2010 by David R. German and Dennis R. Skadsen, from SDSU-WRI and Day County Conservation District, respectively. Pierpont Lake dam was built in 1939 on Mud Creek. The reservoir has 77.3 surface acres, a watershed of 5,885 acres, with an average depth of 7.8 feet, and a maximum depth of 16 feet. The Pierpont Lake In-Lake Water Quality Study found the basin characteristics contributed to a macrophytic plant dominance which limits storm damage to the macrophytes beds and resuspension of sediment, thus helping to maintain clear water conditions. Recommendations for macrophytic plant management were: that a low water drain be installed to allow more active management of the lake water levels; possible sediment removal; and the mechanical harvesting of macrophytes. Pierpont Lake was 303(d) listed for Temperature as nonsupport for Warmwater Permanent Fish Life in the 2012 SDDENR Integrated Report.

- An engineering report was conducted for the South Dakota Office of School and Public Lands by Clark Engineering Corporation in 2008 that assessed the current condition of the dam and recommended repairs be made to the dam structure.

**Red Iron Lake - South:**

- South Red Iron Lake was reported on in the *Final Report for South Red Iron Lake, Marshall, County, South Dakota*, as part of the Marshall County Lakes Assessment Project and published in November 2008 by SDDENR. The lake is a 610 acre natural lake located in Marshall with a watershed of 26,477 acres. The average depth of the lake is 8.3 feet with a maximum depth of 15 feet. The lake is connected to North Red Iron Lake, and water can flow back and forth between the two lakes when high water conditions exist. South Red Iron Lake was 303(d) listed for Dissolved Oxygen as nonsupport for Warmwater Semipermanent Fish Life in the 2012 SDDENR Integrated Report.

**Red Iron Lake – North:** No data available.

**Roy Lake:**

- The *Phase I Watershed Assessment Final Report for Roy Lake, Marshall County, South Dakota*, was completed by SDDENR in March of 2009. Roy Lake has 2,054 surface acres with a watershed of 9,614 acres, a maximum depth of 20.6 feet, and a mean depth of 10.0

feet.  The goal of the Phase 1 project was to locate and document sources of nonpoint source pollutants in the watershed.  The assessment determined that the lake was meeting all of its beneficial uses, although high fecal coliform bacteria counts were found after several severe runoff events which indicated the need for nutrient management and riparian buffers.  The assessment served as a benchmark for future water quality studies and as a basis to maintain or improve water quality.  Roy Lake had been 303(d) listed for Trophic State Index (TSI) in the SDDENR-IR's for 2006 and 2008; however, it was delisted in 2010 and listed as fully supporting all designated beneficial uses in 2012.

**White Lake Dam:**

- The sources of impairment to White Lake were studied in the June 2005 *Watershed Assessment/TMSL Final Report, White Lake, Marshall County, South Dakota.* The lake is a man-made 186.8 acre reservoir constructed as a Works Progress Administration (WPA) project.  It has a watershed of 22,348 acres, an average depth of eight feet, and a maximum depth of twenty feet.  The report recommended that a realistic TSI target of 70 be set based on the social and economic limitations in the watershed.  It was 303(d) listed for TSI in the SDDENR-IR's for 2004, 2006, 2008, and reported as fully supporting all designated beneficial uses in the 2010 and 2012 reports.

**Upper Minnesota River Basin:**

- The Upper Minnesota River Basin is within the boundaries of the Segment 2 of the Northeast Glacial Lake Water Quality Improvement Project.  A detailed five year Strategic Plan was completed for the Upper Minnesota River Basin in August of 2012 (Lebeda 2012).  That Strategic Plan detailed the water quality status and needs of the water bodies in the watershed.  Water bodies in that report not meeting their 303(d) designated beneficial uses were Big Stone Lake, Punished Woman Lake, Little Minnesota River, North Fork Whetstone River, South Fork Whetstone River, North Fork Yellow Bank River, and the South Fork Yellow Bank River.  Details of the Upper Minnesota River Basin watershed will not be included in the Strategic Plan for Northeast Glacial Lake WIP but will be referenced to the Upper Minnesota River Watershed Five Year Strategic Plan.

## 1.4 Goals of the Northeast Glacial Lakes Project Strategic Plan

The goal of the strategic plan for the NEGL is to identify the pollutant sources for the 303(d) listed water bodies and to find suitable Best Management Practices (BMP) that, when implemented, will result in the delisting of the 303(d) water bodies.  The implementation of the BMPs will coincide with the goals of the Northeast Glacial Watershed Improvement and Protection Project to improve and protect the water quality of northeast South Dakota lakes through the implementation of best management practices that reduce bacteria, nutrient, and sediment loads to these lakes. 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.

# 2.0 CAUSES AND SOURCES OF IMPAIRMENTS

## 2.1 Geography

The NEGL project is located in the Level III Northern Glaciated Plains ecoregion. 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 crop agriculture. The young geologic age has left an immature drainage system, and the ecoregion is 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 the Prairie Pothole Region. 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.

The NEGL project lies in the Northern Great Plains Spring Wheat Region, Land Resource Region F; and 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. 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 MLRAs are subdivided into smaller more homogeneous resource areas referred to as Common Resource Areas (CRA). The NEGL project includes the following CRAs: the Rolling Till Prairie 102A, in Region M; the Central Black Glaciated Plains 55B, and a small portion of the Red River Valley of the North 56, in Region F. See Figure 2-1.

The dominant landforms in the Rolling Till Prairie, 102A, are stagnation, moraines, end moraines, glacial outwash plains, terraces, and flood plains, which 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 some of the larger tributaries. Small outwash areas are adjacent to the watercourses. “Prairie pothole” lakes and ponds are common.

The Central Black Glaciated Plains, 55B, are covered by glacial till plains that include glacial lacustrine deposits. Glacial deposits in kettle holes, kames, and moraines break up the till plain.

One of the major river systems in this area is the James River, which was carved by floodwaters draining glacial Lake Dakota. Its valley is filled with glacial outwash and alluvial deposits. A high terrace scarp separates the valley floor from the surrounding land. The Red River Valley of the North, 56, is the bed of glacial Lake Agassiz and is a glacial lake plain with remnants of gravelly beaches.

## 2.2 Soils

The dominant soil order in Rolling Till Prairie, 102A, is Mollisols. The soils dominantly have a frigid soil temperature regime, and 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 (Krazburg, 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. 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 depressions (Quam series) and in alluvial sediment on flood plains (Lamoure and Rauville series). Calciaquolls (Marysland and Moritz series) formed in alluvial sediments on flood plains.

The dominant soil order in the Central Black Glaciated Plains, 55B, is Mollisols. The soils in the area dominantly have a frigid soil temperature regime, udic or aquic soil moisture regime, and mixed or smectitic mineralogy. They generally are very deep, well drained to poorly drained, and loamy or clayey. Hapludolls and Argiudolls formed in glacial till on till plains and moraines (Barnes, Emrick, and Forman series), in sandy sediments on lake plains and outwash plains (Arvilla and Hecla series), in silty lacustrine deposits on lake plains (Great Bend, Beotia, and Harmony series), in mixed till and alluvium on till plains (Svea serues), and in loamy sediments on uplands (Swenoda series). Calciudolls (Buse series) formed in glacial till on till plains and moraines. Calciaquolls formed on lake plains (Bearden and Hegne series) and on till plains (Hamerly and Vallers series). Argiaquolls (Parnell series) and Argialbolls (Tonka series) formed in local alluvium in depressions on till plains. The dominant soil orders in the Red River Valley of the North, 56, are Mollisols and Vertisols. They are very deep, somewhat poorly drained to very poorly drained, and loamy or clayey.

The predominant soil associations in the project area are shown on Figure 2-2. 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 2-1. Common Resource Areas of the NEGL Project Area.**

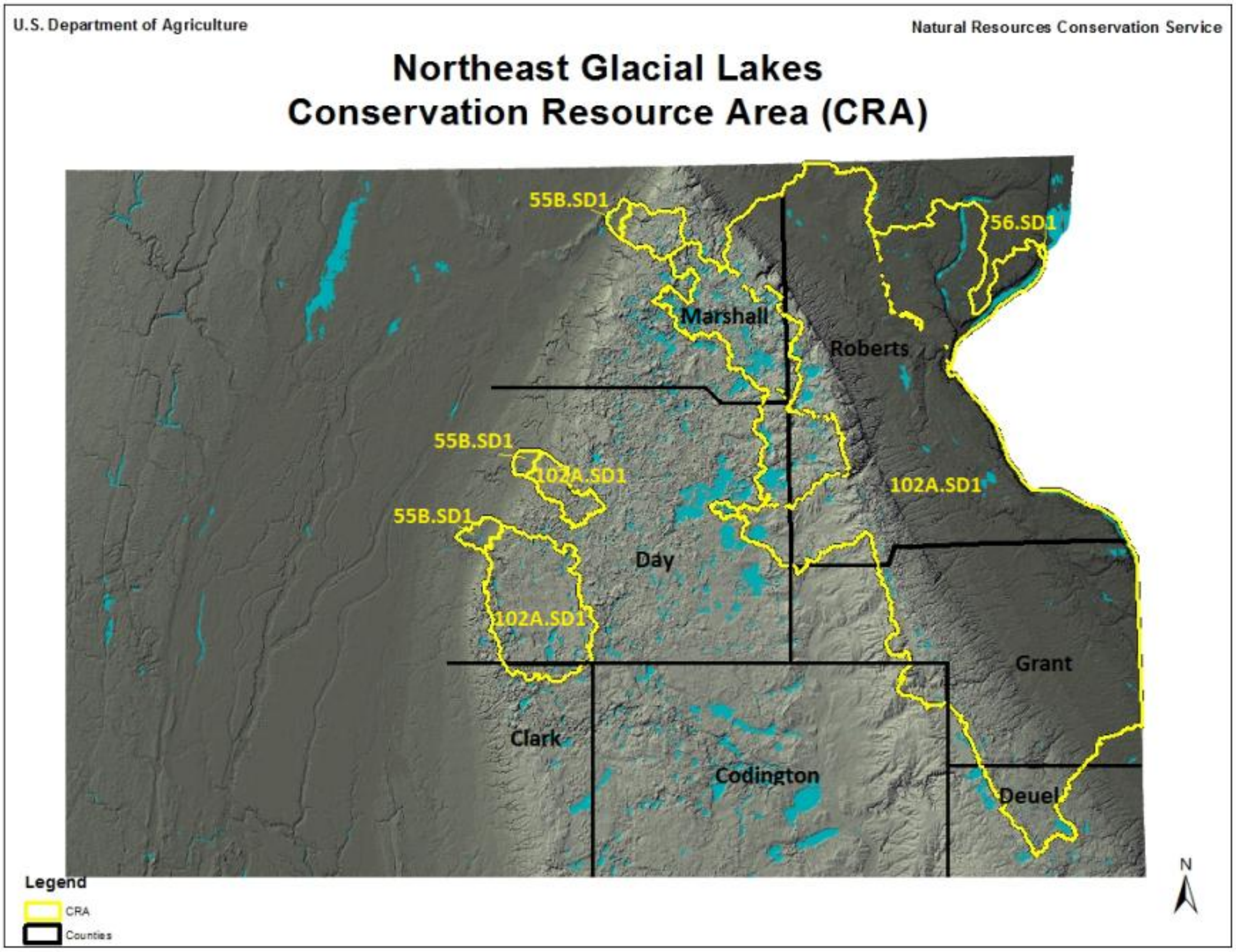
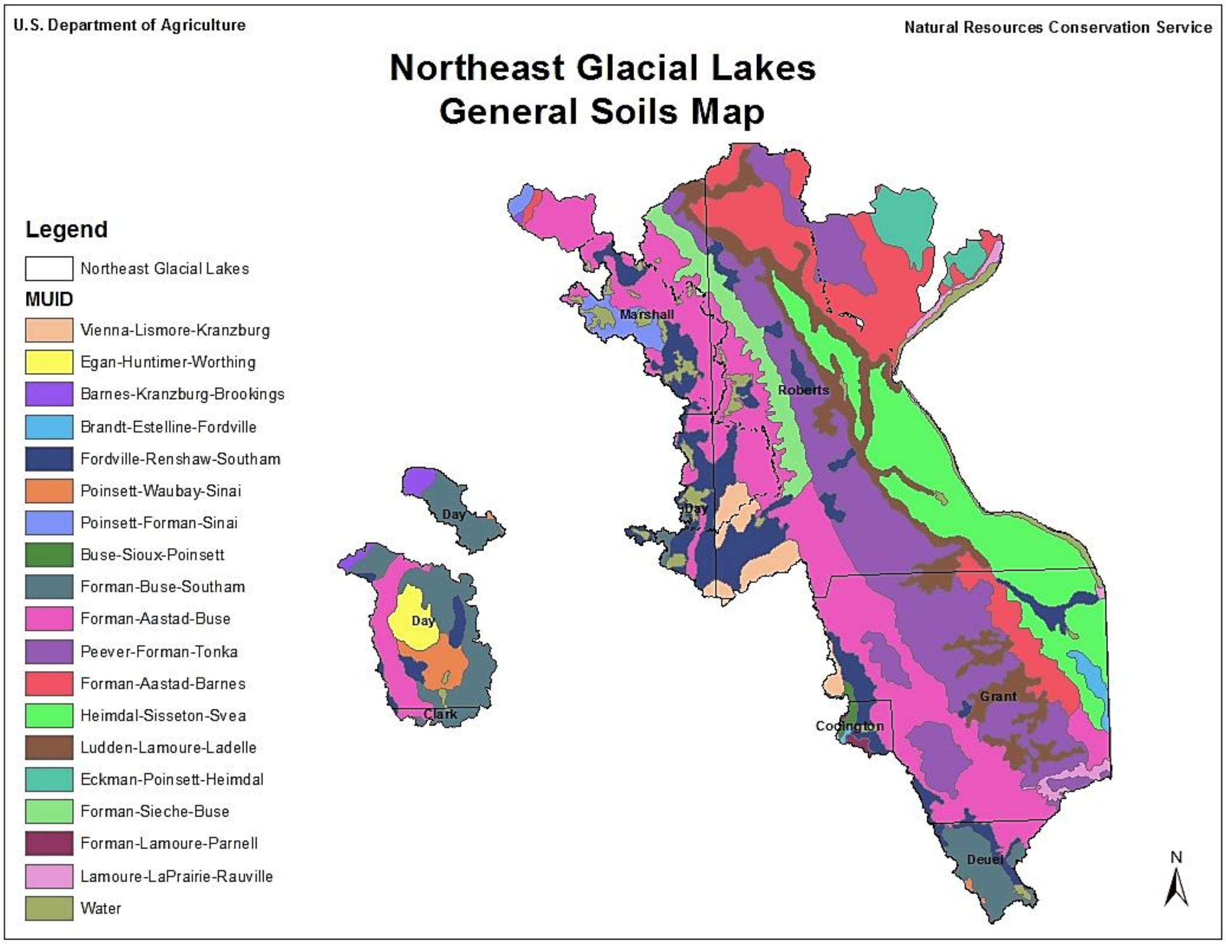


**Figure 2-2. General Soils Map of the NEGL Project Area**




## 2.3 Land Use

Most of the area in Rolling Till Prairie, 102A, is farmland, with about two-thirds of the cropland used for growing crops for sale or for feeding livestock. The principal crops are corn, soybeans, alfalfa, spring wheat, and oats. 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 in the area.

About three-fourths of the Central Black Glaciated Plains, 55B, is dry-farmed cropland. Cash-grain production is the principal enterprise on many farms. Less than one-fifth of the area, consisting of the more sloping and shallower soils, is used for livestock production on native range or woodland. The dry-farmed crops are principally: small grains, such as wheat, barley; corn for grain; and soybeans. Flax, canola, peas, dry edible beans, sunflowers, forage crops, and corn for silage also are grown.

Refer to Table 2-1, and Figures 2-3 and 2-4 for the Agricultural Data on the NEGL counties, the Cropland Productivity, and the Rangeland Productivity of the NEGL project area, respectively. The major soil resource concerns are wind erosion, water erosion, maintenance of the content of organic matter and productivity of the soils, management of soil moisture, and salinity around wetland borders. Conservation practices on cropland generally include crop residue management, no-till and other conservation tillage systems, conservation cropping systems that eliminate the need for fallowing, cover crops, nutrient management, and pest management. Other practices include contouring, strip cropping, field tree windbreaks, and grassed waterways.

### 2.4 Water Resources

The total withdrawals for the entire Rolling Till Prairie, 102A, average 145 million gallons per day. About 61 percent is from ground water sources, and 39 percent is from surface water sources. Precipitation is the principal source of moisture for crops; however, in some years it is inadequate for maximum crop production and crop irrigation accounts for 65.1% of the water use. Public drinking water accounts for 14.1% of the use, livestock for 11.5%, and other water uses account for 9.3%. Small ponds and shallow wells are the principal sources of water for livestock. Many natural glacial lakes are in the northern part of the area, and many of the larger ones are used for recreation. The water in the lakes and larger streams is generally suitable for all uses. The quality of the water in the smaller streams is generally poor with the water slightly saline at low flows.

Shallow wells in glacial outwash deposits, primarily sand and gravel, provide water for livestock, domestic use, and irrigation in this area. This water is hard but is of good quality. The median level of total dissolved solids is 350 parts per million. Ground water also is available in deep wells in the Precambrian bedrock in this area or in the Dakota Sandstone. These aquifers are seldom utilized in this area because of an abundance of shallow glacial deposits and surface water.

The total withdrawals from the entire Central Black Glaciated Plains, 55B, average 685 million gallons per day. About 7 percent is from ground water sources and 93 percent is from surface water sources. In some years precipitation is inadequate for maximum crop production; however, only 7.2% is used for crop irrigation. Public drinking water accounts for 3.5% of the use, livestock for 0.8%, and other water uses account for 88.5%. Most of the water in this MLRA is used as cooling water in the generation of electricity from burning fossil fuels. Perennial streams are few and widely spaced and are little used for irrigation. Water for livestock is stored in ponds and small reservoirs on individual farms and ranches. The surface water is of fair to good quality but at times is limited in quantity. Irrigation uses mostly surface water. Water from the Dakota Newcastle aquifer is used only for livestock.

**Table 2-1. Agricultural Data for Northeast Glacial Lakes Counties**

| Agricultural Data for Counties in the NE Glacial Lakes | | | | | |
|---|---|---|---|---|---|
| | Day | Grant | Marshall | Roberts | Data Year |
| Land Area Acres | 658,329 | 436,818, | 536,888 | 704,856 | 2007 |
| Number of Farms | 675 | 555 | 523 | 887 | 2007 |
| Total Cropland Acres | 386,994 | 263,680 | 328,243 | 412,361 | 2007 |
| Corn Acres | 83,900 | 98,000 | 74,900 | 143,500 | 2010 |
| Soybean Acres | 144,000 | 95,000 | 75,000 | 176,000 | 2010 |
| Small Grain Acres | 59,300 | 34,500 | 11,900 | 37,800 | 2010 |
| Hayland | 38,000 | 29,500 | 39,500 | 139,000 | 2010 |
| Pasture/Range Acres | 144,307 | 91,869 | 205,891 | 55,000 | 2007 |
| Cattle | 46,500 | 55,000 | 77,000 | 21,460 | 2011 |
| Swine | 1,581 | 3,117 | 10,810* | 5,875 | 2007 |
| Sheep | 732 | 2,320 | 1,177 | 5,377 | 2007 |
| Data from USDA Agricultural Statistics Service | | | * 2002 Data | | |

**Figure 2-3. Cropland Productivity in the NEGL Project Area**

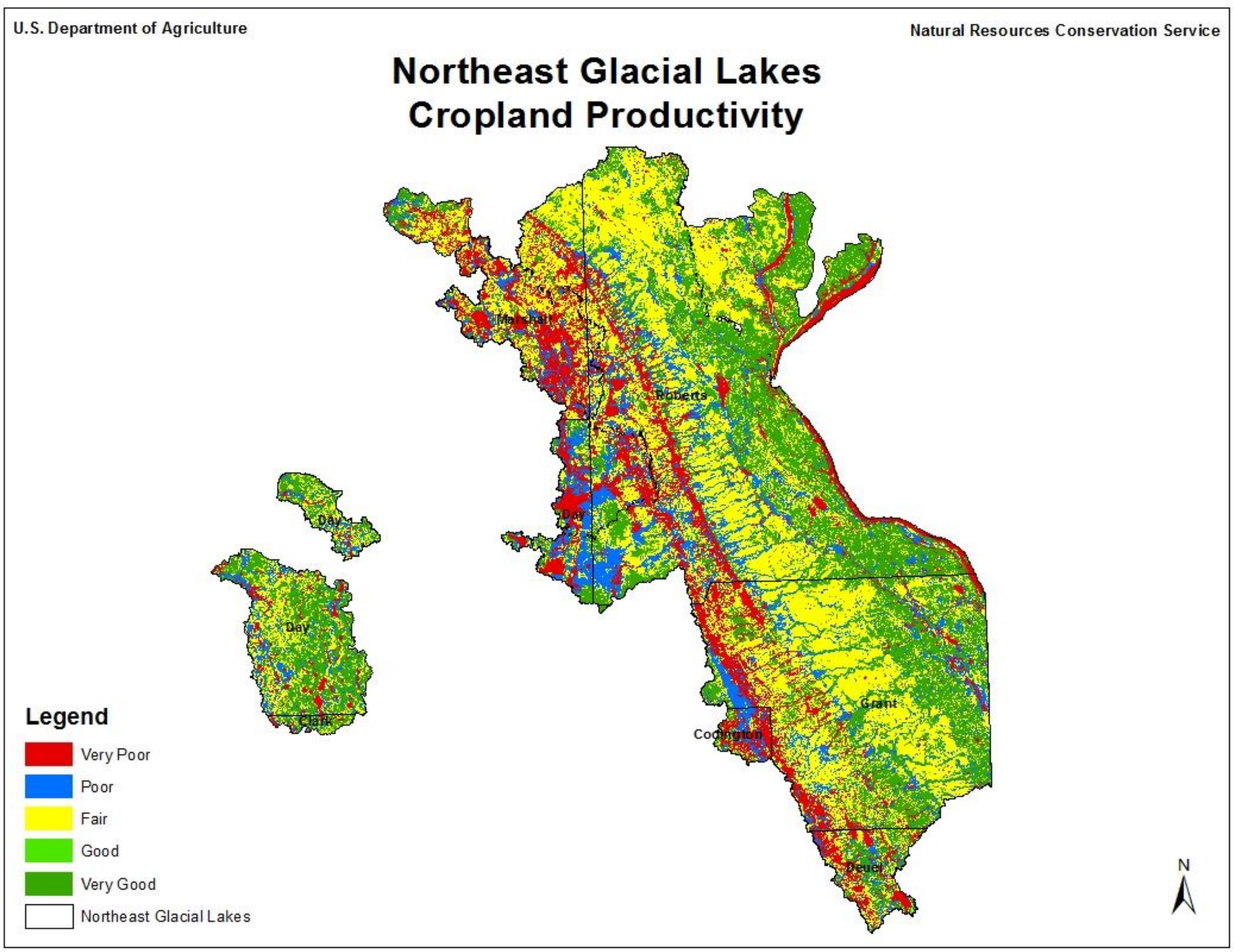
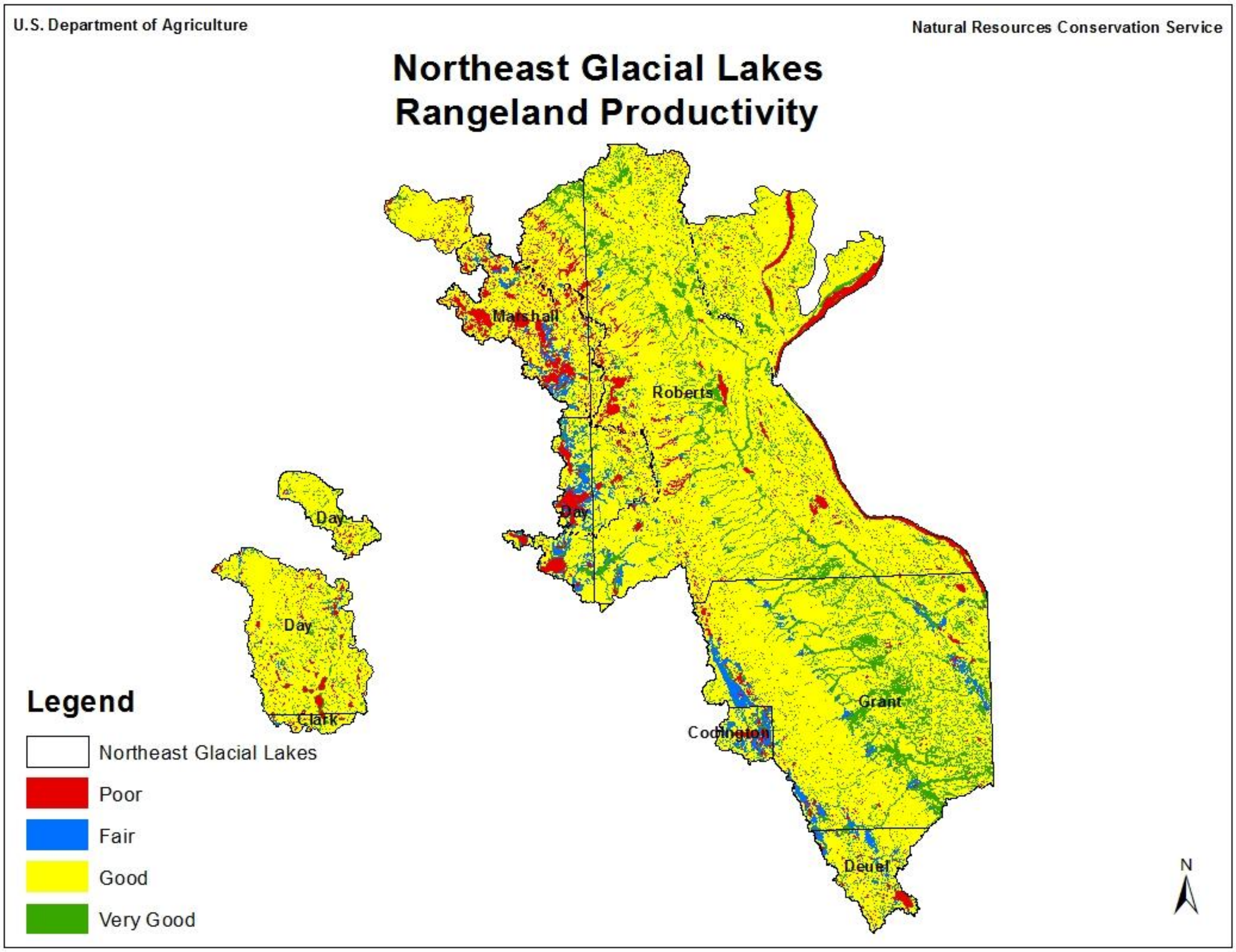


**Figure 2-4. Rangeland Productivity in the NEGL Project Area**




There are six rural water systems (RWS) that serve the NEGL watershed area. These RWSs are listed in Table 2-2. The source of the water for these systems is mostly groundwater from local aquifers; however, the WEB RWS does pump surface water to its customers. The particular modes of drift deposition on the Coteau des Prairies produced three distinct groups of glacial outwash aquifers: basal, intermediate, and surficial (SDGS 1988, 1996). The basal aquifers were deposited directly upon shale bedrock and generally are the deepest aquifers. The intermediate aquifers are outwash sands and gravels deposited in lenses between the bedrock and the drift surface. They are often concentrated on surfaces of buried drift sheets and may cover areas of several square miles. There are also innumerable small pods or lenses of outwash within the individual drift sheets that may cover on a few square feet of area. The surficial aquifers are deposits of sand and gravel found in large sheets as outwash plains or as deposits around the edges of the many lakes and are often recharge areas for the deeper systems and lakes. The water from these aquifers, the Missouri River, and the rural water systems that deliver this water is critical to the quality of life and economic development by providing a high-quality, reliable domestic water supply to people residing in the NEGL region.

**Table 2-2. Rural Water Systems Serving the NEGL Watershed Counties**

| Rural Water Systems Serving the NEGL Watershed - Source SDDENR WEB Site | | | | | |
|---|---|---|---|---|---|
| RWS | Customers | Population Served | Gallons/Day | Water Source | Contamination Risk |
| Brookings-Deuel | 5,275 | 6,500 | 1,410,000 | Groundwater | MEDIUM |
| Brown-Day-Marshall | 5,375 | 8,350 | 1,290,000 | Groundwater | LOW |
| Clark | 2,130 | 3,967 | 767,100 | Groundwater | LOW |
| Grant-Roberts | 4,857 | 5,400 | 786,000 | Groundwater | HIGH |
| Sioux | 4,000 | 4,958 | 941,000 | Groundwater | MEDIUM |
| WEB | 14,000 | 30,500 | 5,600,000 | Surface | MEDIUM |
| TOTALS | 35,637 | 59,675 | 10,794,100 | | |

## 2.5 Water Bodies Studies and Current Status

The interest in the northeast South Dakota glacial lakes began when the South Dakota Clean Lakes Program received grant funds to conduct lake water quality assessments. The Clean Lakes Program was established in 1972 as Section 314 of the Federal Water Pollution Control Act (the Clean Water Act) to provide financial and technical assistance to States in restoring publicly owned lakes. The Clean Lakes Program was created to stop or slow down the cultural eutrophication of lakes that is contributed to humans. Eutrophication of lakes occurs naturally by the accumulation of nutrients and silt, a process normally taking hundreds of years. However, the human contribution of pollutants to lakes has destroyed lakes within a decade. States could receive financial assistance from the United States Environmental Protection Agency (EPA) through four types of cooperative agreements: Lake Water Quality Assessments; Phase I Diagnostic Feasibility Studies; Phase II Implementation Projects; and Phase III Post-Implementation Monitoring Studies.

The South Dakota Clean Lakes Program lake water quality assessments were conducted in the years 1979, 1989, 1991, 1992, 1993, and 1994 and summarized in the *1995 South Dakota Lakes Assessment Final Report* by SDDENR. Additional water quality data was included in this report from Phase I assessments, Phase II Implementation Projects, Phase III post-implementation studies, and special sampling circumstances (SDDENR 1995). The purpose of the 1995 report was to provide water quality information for the 305(b) Report to Congress, to update the South Dakota Lakes Survey, and to serve as a repository of historical water quality data. The document was intended to be a database containing morphological and water quality information on 112 selected South Dakota lakes with the following three criteria: significant public access, publicly owned, and having over 100 surface acres.

Segment 1 of the Northeast Glacial Lake Watershed Improvement and Protection Project was implemented in May 2007 and primarily focused on lakes in Day and Marshall Counties within the Upper Big Sioux River Basin, the Upper James River Basin, and Red River Basin. Segment

1 was completed in December of 2010 and was followed by Segment 2, which added the Upper Minnesota River Basin and Roy Lake into the NEGL project area. Segment 2 of the implementation project is scheduled to end in June 2014.

The *2012 South Dakota-DENR Integrated Report for Surface Water Quality Assessment* for NEGL reported that Dissolved Oxygen (DO), High pH, and Temperature were the identified impairments listed within the watershed project area for this Strategic Plan. The Upper Minnesota River Basin is included in the NEGL project, and several water bodies in the Upper Minnesota River Basin were also listed for *Escherichia coli* bacteria. However, the data for the Upper Minnesota River Basin was reported in the document the *Upper Minnesota River Watershed Five Year Strategic Plan* and will not be detailed in this Strategic Plan.

The designated beneficial uses, impairments, and causes of impairments for the water bodies listed in the 2012 SDDENR-IR for this Northeast Glacial Lakes Strategic Plan are presented in Table 2-3. The 303(d) listed water bodies are summarized in Table 2-4. Figures 2-5, 2-6, and 2-7 shows the locations of the reaches for the identified water bodies in the Big Sioux River, James River, and Red River Basins, respectively.

**Table 2-3. NE Glacial Lakes Water Bodies: Beneficial Uses, Listed as 303(d) Impaired, Source of Impairment, and Priority. (Data from "*The 2012 SD Integrated Report for Surface Water Quality Assessment*".)**

| WATERBODY AUID | LOCATION | MAP ID | BASIS | USE | SUPPORT | CAUSE | SOURCE | EPA CATEGORY | 303(d) Priority |
|---|---|---|---|---|---|---|---|---|---|
| **Amsden Dam** | Day | L1 | DENR | Fish/Wildlife Prop, Rec, Stock | FULL | | | 1 | No |
| SD-JA-L-Amsden_01 | County | | | Immersion Recreation | FULL | | | | |
| | | | | Limited Contact Recreation | FULL | | | | |
| | | | | Warmwater Permanent Fish Life | FULL | | | | |
| **Blue Dog Lake** | Day | L4 | DENR | Fish/Wildlife Prop, Rec, Stock | INS | | | 5* | Yes-2 |
| SD-BS-L-Blue_Dog_01 | County | | | Immersion Recreation | INS | | | | |
| | | | | Limited Contact Recreation | INS | | | | |
| | | | | Warmwater Permanent Fish Life | NON | High pH | | | |
| **Buffalo Lake - North** | Marshall | L25 | DENR | Fish/Wildlife Prop, Rec, Stock | FULL | | | 1 | No |
| SD-JA-L-N_Buffalo_01 | County | | | Immersion Recreation | FULL | | | | |
| | | | | Limited Contact Recreation | FULL | | | | |
| | | | | Warmwater Permanent Fish Life | FULL | | | | |
| **Buffalo Lake - South** | Marshall | L36 | DENR | Fish/Wildlife Prop, Rec, Stock | FULL | | | 5 | Yes-2 |
| SD-JA-L-S_Buffalo_01 | County | | | Immersion Recreation | FULL | | | | |
| | | | | Limited Contact Recreation | FULL | | | | |
| | | | | Warmwater Semipermanent Fish Life | NON | Oxygen, Dissolved | | | |
| **Clear Lake** | Marshall | L9 | DENR | Fish/Wildlife Prop, Rec, Stock | FULL | | | 1 | No |
| SD-JA-L-Clear_M_01 | County | | | Immersion Recreation | FULL | | | | |
| | | | | Limited Contact Recreation | FULL | | | | |
| | | | | Warmwater Permanent Fish Life | FULL | | | | |
| **Enemy Swim** | Day | L12 | DENR | Fish/Wildlife Prop, Rec, Stock | FULL | | | 1 | No |
| SD-BS-L-Enemy_Swim_01 | County | | | Immersion Recreation | FULL | | | | |
| | | | | Limited Contact Recreation | FULL | | | | |
| | | | | Warmwater Permanent 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. ^EPA added cause. D** TMDL development deferred to EPA.

## Table 2-3: Continued

| WATERBODY AUID | LOCATION | MAP ID | BASIS | USE | SUPPORT | CAUSE | SOURCE | EPA CATEGORY | 303(d) Priority |
|---|---|---|---|---|---|---|---|---|---|
| **Lake Traverse** | **Roberts** | **L1** | **DENR** | **Fish/Wildlife Prop, Rec, Stock** | **FULL** | | | **1** | **No** |
| SD-RD-L-Traverse_01 | **County** | | | **Immersion Recreation** | **FULL** | | | | |
| | | | | **Limited Contact Recreation** | **FULL** | | | | |
| | | | | **Warmwater Permanent Fish Life** | **FULL** | | | | |
| | | | | | | | | | |
| **Minnewasta Lake** | **Day** | **L19** | **DENR** | **Fish/Wildlife Prop, Rec, Stock** | **FULL** | | | **1** | **No** |
| SD-BS-L-Minnewasta_01 | **County** | | | **Immersion Recreation** | **FULL** | | | | |
| | | | | **Limited Contact Recreation** | **FULL** | | | | |
| | | | | **Warmwater Semipermanent Fish Life** | **FULL** | | | | |
| | | | | | | | | | |
| **Nine Mile Lake** | **Marshall** | **L26** | **DENR** | **Fish/Wildlife Prop, Rec, Stock** | **NON** | **pH High** | | **5** | **Yes-2** |
| SD-JA-L-Nine_Mile_01 | **County** | | | **Immersion Recreation** | **FULL** | | | | |
| | | | | **Limited Contact Recreation** | **FULL** | | | | |
| | | | | **Warmwater Semipermanent Fish Life** | **NON** | **pH High** | | | |
| | | | | | | | | | |
| **Pickerel Lake** | **Day** | **L23** | **DENR** | **Fish/Wildlife Prop, Rec, Stock** | **FULL** | | | **1** | **No** |
| SD-BS-L-Pickerel_01 | **County** | | | **Immersion Recreation** | **FULL** | | | | |
| | | | | **Limited Contact Recreation** | **FULL** | | | | |
| | | | | **Warmwater Permanent Fish Life** | **FULL** | | | | |
| | | | | | | | | | |
| **Pierpont** | **Day** | **L28** | **DENR** | **Fish/Wildlife Prop, Rec, Stock** | **FULL** | | | **5** | **Yes-2** |
| SD-JA-L-Pierpont_01 | **County** | | | **Immersion Recreation** | **INS** | | | | |
| | | | | **Limited Contact Recreation** | **INS** | | | | |
| | | | | **Warmwater Permanent Fish Life** | **NON** | **Temperature** | | | |
| | | | | | | | | | |
| **Red Iron Lake - South** | **Marshall** | **L35** | **DENR** | **Fish/Wildlife Prop, Rec, Stock** | **FULL** | | | **1** | **No** |
| SD-JA-L-S_Red_Iron_01 | **County** | | | **Immersion Recreation** | **FULL** | | | | |
| | | | | **Limited Contact Recreation** | **FULL** | | | | |
| | | | | **Warmwater Permanent 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. ^EPA added cause. D** TMDL development deferred to EPA.

**Table 2-3: Continued**

| WATERBODY AUID | LOCATION | MAP ID | BASIS | USE | SUPPORT | CAUSE | SOURCE | EPA CATEGORY | 303(d) Priority |
|---|---|---|---|---|---|---|---|---|---|
| Roy Lake | | L34 | DENR | Fish/Wildlife Prop, Rec, Stock | FULL | | | 1 | No |
| SD-JA-L-Roy_01 | | | | Immersion Recreation | FULL | | | | |
| | | | | Limited Contact Recreation | FULL | | | | |
| | | | | Warmwater Permanent Fish Life | FULL | | | | |
| | | | | | | | | | |
| White Lake | Marshall | L2 | DENR | Fish/Wildlife Prop, Rec, Stock | FULL | | | 1* | No |
| SD-RD-L-White_01 | County | | | Immersion Recreation | FULL | | | | |
| | | | | Limited Contact Recreation | FULL | | | | |
| | | | | Warmwater Permanent Fish Life | FULL | | | | |

**Table 2-4. Summary of Northeast Glacial Lakes Project Water Bodies: Beneficial Uses and Listed as 303(d) Impaired**

| Water Body Impaired | Beneficial Use Impaired | Listed Cause of Impairment |
|---|---|---|
| Blue Dog Lake - L4 | Warmwater Permanent Fish Life | High pH |
| Buffalo Lake- South - L36 | Warmwater Semipermanent Fish Li | Dissolved Oxygen |
| Nine Mile Lake - L26 | Fish & Wildlife Propagation | High pH |
| | Warmwater Semipermanent Fish Li | High pH |
| Pierpont Lake - L28 | Warmwater Permanent Fish Life | Temperature |

**Figure 2-5. 303(d) Listed Water Bodies in the Big Sioux River Basin, NEGL**

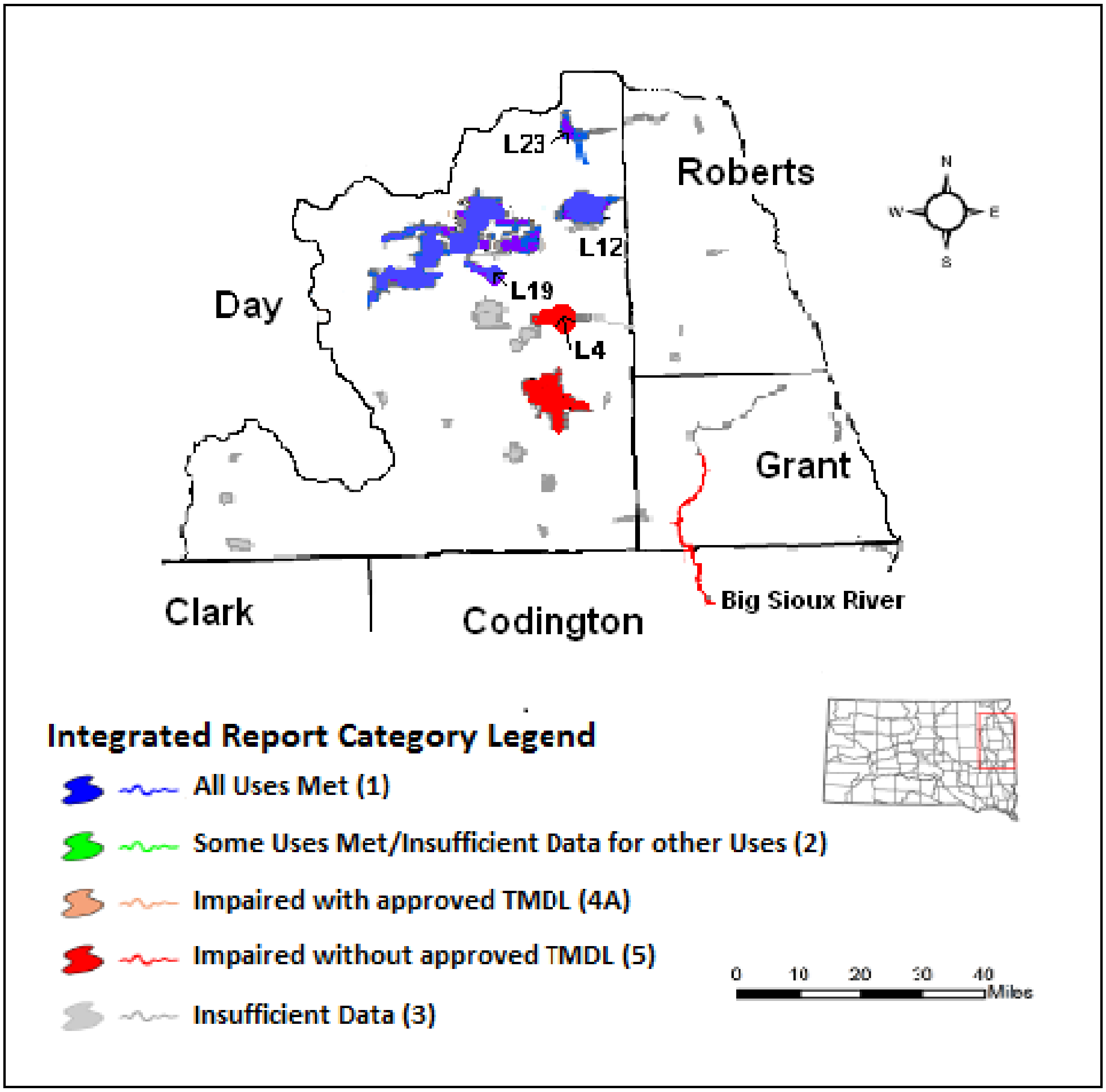


**Figure 2-6. 303(d) Listed Water Bodies in the James River Basin, NEGL**

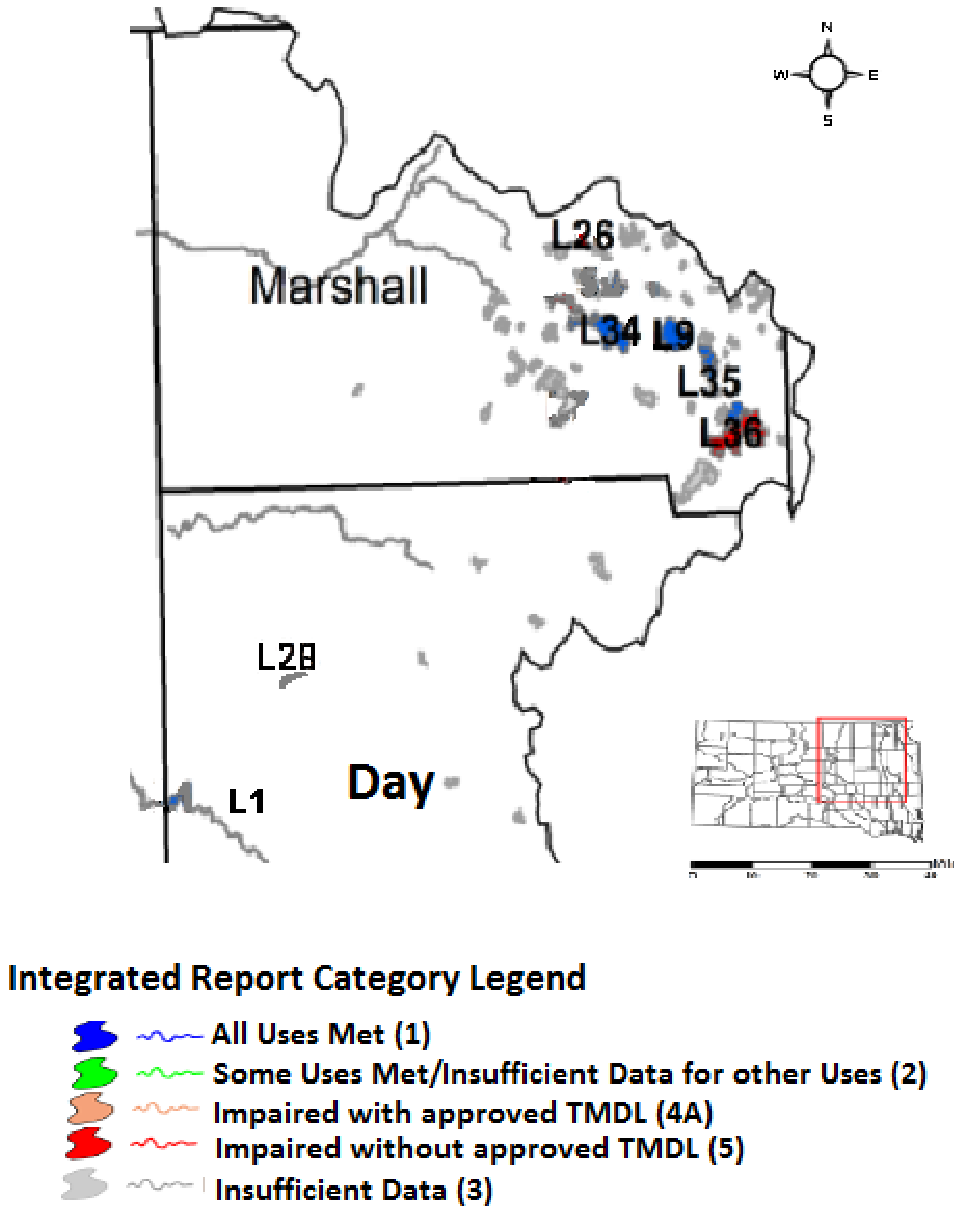
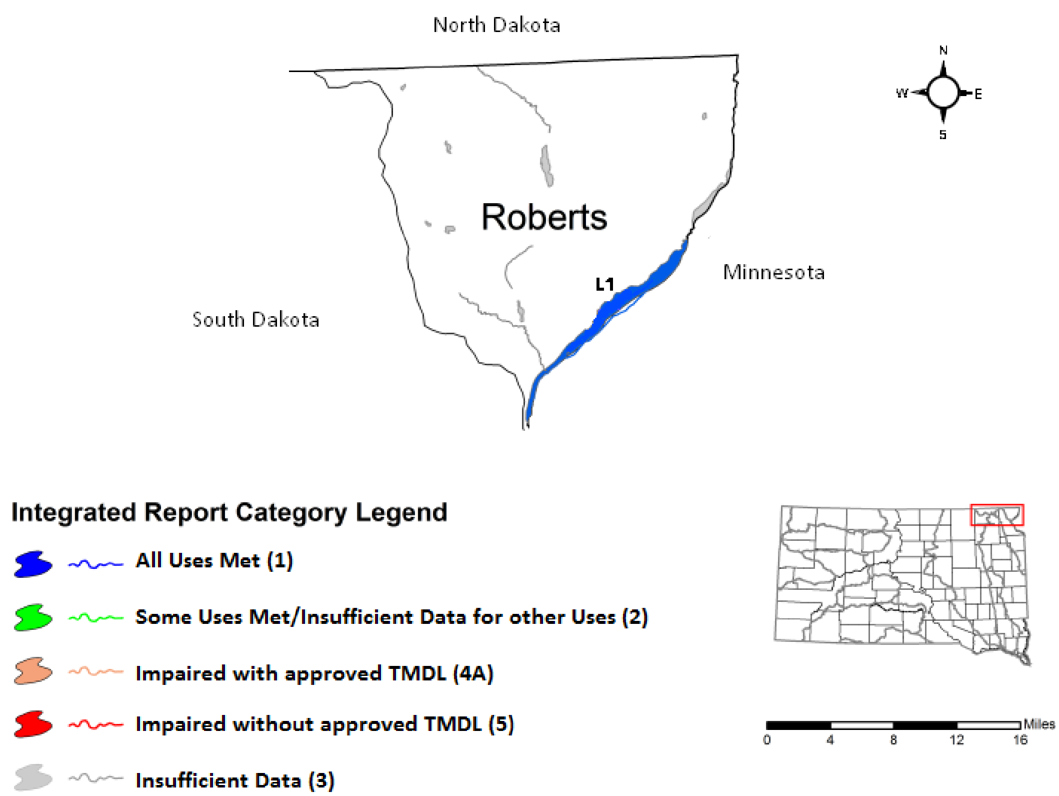


**Figure 2-7. 303(d) Listed Water Bodies in the Red River Basin, NEGL**




## 2.6 Description of the Impairments for 303(d) Water Body Listings in the NEGL

### 2.6.1 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 ($CO_2$) 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 $CO_2$ 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 standard set by South Dakota DENR 303(d) is a pH of 9.0.

### 2.6.2 Dissolved Oxygen

The amount of oxygen in water, Dissolved Oxygen (DO), is expressed as a concentration in milligrams per liter of water (mg/l) and can also be expressed as parts per million (ppm). Aquatic organisms use oxygen for metabolic processes and require concentrations above a certain level to survive and grow. Energy production is dependent on the availability of oxygen. When dissolved oxygen is less than 3 or 4 mg/l for warm water fish or 7 mg/l for cold-water fish, they are unable to extract sufficient oxygen from the water to support physiological functions. Their ability to catch prey is reduced, reproduction is negatively impacted, and a variety of other adverse physiological effects occur.

Hypoxia, the condition of low dissolved oxygen, is a significant problem for waters that receive runoff that contains nutrients like nitrogen, phosphorous, animal wastes, and other oxygen-demanding biological wastes. Excessive nutrients in aquatic systems stimulate algal growth, which in turn uses up the oxygen needed to maintain healthy fish and shellfish populations. Water bodies produce and consume oxygen, gain oxygen from the atmosphere, and from plants as a result of photosynthesis. DO levels in lakes are most likely to vary vertically in the water column as compared to running water that mixes and dissolves more oxygen because of its churning. Therefore, DO levels in rivers and streams change more horizontally along the course of the waterway than vertically, as in lakes or reservoirs. This is especially true in smaller, shallower streams. The DO levels in and below riffle areas, waterfalls, or dam spillways are typically higher than those in pools and slower-moving stretches. Dams may pose an oxygen supply problem when they release waters from the bottom of their reservoirs into streams and rivers. Although the water on the bottom may be cooler than the warm water on top, it may also be low in oxygen when large amounts of organic matter has fallen to the bottom and is decomposed by bacteria.

Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen. Wastes from sewage treatment plants, animal feedlots, farmland, storm water from urban streets, and failing septic systems often contains organic materials that are decomposed by microorganisms that use oxygen in this process. The amount of oxygen consumed by these organisms in breaking down the waste is known as the biochemical oxygen demand (BOD). BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen as aquatic organisms become stressed, suffocate, and die.

Aquatic life can have a hard time in stagnant water that has a lot of rotting, organic material in it, especially in summer. The concentration of dissolved oxygen is inversely related to water temperature, as cold water can hold more DO than warm water. During the summer months with hotter water, lower DO, and high BOD, conditions may become especially serious resulting in the death of many fish. The concentration of dissolved salts has a synergistic effect on DO levels and reduces the amount of oxygen held in water. The SDDENR standard for DO levels is a minimum of 5 mg/l for a warm water fisheries beneficial use.

### 2.6.3 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 ($^oF$) 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 $^oF$, and only rough fish can tolerate temperatures much warmer than about 97 $^oF$. The water temperatures at which fish growth ceases are 82 $^oF$ for Northern pike, 90 $^oF$ for channel catfish, and 97 $^oF$ for carp. The Northern pike and channel catfish die when water temperatures exceed 86 $^oF$ and 95 $^oF$, respectively. The South Dakota standard for water temperature for Warm Water Permanent Fish Life is 80 $^oF$.

Fish are not the only organisms requiring specific temperatures. Diatoms grow best at a temperature of 59-77 $^oF$, green algae at 77-95 $^oF$, and blue-green algae at 86-104 $^oF$. 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.

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

The general sources of impairment have been listed in the 2012 South Dakota Integrated Report for Surface Water Quality Assessment (SDDENR), see Table 2-4; however, further identification of the physical sources is required for the land application of Best Management Practices (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 Northeast Glacial Lakes project watershed by SDDENR to identify the main sources of these impairments.

#### 2.7.1 Point Sources of Impairment

Point sources of pollutants were investigated for the four water bodies listed as 303(d) impaired in the 2012 SDDENR Integrated Report: Blue Dog Lake (L4), Buffalo Lake-South (L36), Nine Mile Lake (L26), and Pierpont Lake (L28). No known point sources were identified in the TMDL SDDENR documents for Blue Dog Lake and Nine Mile Lake, in 2000 and 2007 respectively.

Buffalo Lake South had a Final Report completed under the Marshall County Lakes Assessment Project (SDDENR 2008). The cause of the lake not meeting its targeted beneficial uses in the assessment was not attributed to point source pollution. Buffalo Lake South is listed as needing a TMDL in the 2012 SDDENR-Integrated Report.

Pierpont Lake had an in-lake water quality study (German and Skadsen 2010) that intended to compare the current water quality data that was reported in the SDDENR 1996 South Dakota Lakes Assessment Final Report. Point source pollution was not addressed in the 2010 assessment. Pierpont Lake is listed as needing a TMDL in the 2012 SDDENR-Integrated Report.

TMDL investigations generally have not identified any significant point discharges in other South Dakota watersheds that were evaluated for potential point sources of loading. The TMDL studies have found that point sources/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. Any discharges under the NPDES permits were also required to meet the chronic water quality standards in the NPDES permit.

### 2.7.2 Nonpoint Sources of Impairment

Nonpoint sources (NPS) of impairment have not been identified for all designated water bodies in the NEGL 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. Water bodies that have met the 303(d) criteria of all their designated beneficial uses, per SDDENR IR 2012, were Amsden Dam, Buffalo Lake North, Clear Lake, Enemy Swim, Lake Traverse, Minnewasta Lake, Pickerel Lake, Red Iron Lake-South, Roy Lake, and White Lake.

The water bodies of Blue Dog Lake and Pierpont Lake were reported in the 2012 SDDENR IR to have insufficient water quality data to ascertain whether they met the supporting criteria of all the designated beneficial uses. However, both lakes were 303(d) listed for the nonsupport of Warmwater Permanent Fish Life. The Blue Dog Lake Total Maximum Daily Load (TMDL) listed the nonpoint source of impairment as coming from animal feeding operations (AFOs) and manure management practices. The Enemy Swim Lake TMDL cited the nonpoint source pollutants as AFOs, manure management practices, and cattle grazing in the riparian zones. A combination of factors were listed as potential nonpoint sources in the White Lake TMDL such as cattle grazing in the riparian zones, human septic systems adjacent to the lake, nutrients from steeper crop fields, and wildlife.

Water quality TMDL studies in the NEGL area have concluded that agricultural activities were the major nonpoint source of excessive nutrients to the watershed. Potential NPSs were 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 erosion. The following pollutants, as identified by the SDDENR 2012 Integrated Report, are discussed by each listed 303(d) impairment for the described water bodies.

#### 2.7.2.1 High pH: Blue Dog Lake L4 and Nine Mile Lake L26

#### L4 - Blue Dog Lake

The beneficial use of Warmwater Permanent Fish Life requires that the pH values in the lake remain between the values of 6.5 and 9.0. Algal and macrophyte photosynthesis acts to increase a lake's pH, while respiration and the decomposition of organic matter will reduce the pH. It is assumed that the algae influences pH as high concentrations of algae can be the cause of high pH levels because photosynthesis from algae and macrophytes acts to increase the pH of water. Blue Dog Lake experienced the typical lake pH scenario as during the winter the pH was slightly lower than the pH concentration in the summer samples (SDDENR 1999). The higher algae production in the spring and summer months most likely increased the pH concentration; however, the relatively high alkalinity concentrations in the lake worked to buffer dramatic pH changes. Since increases in decomposition decreases pH, increases in pH can be an indication of increased organic matter in a lake over time.

Blue Dog Lake is listed 303(d) for High pH impaired for the support of Warmwater Permanent Fish Life in the 2012 SDENR-IR. Data from the 1999 *Phase I Watershed Assessment Final Report, Blue Dog Lake, Day County, South Dakota,* indicated that Blue Dog Lake was a hypereutrophic lake with excessive nutrients and shoreline erosion but with relatively low sedimentation from its tributaries. The major sources of nutrients in the watershed were from animal feeding areas, summer-long grazing, and poor manure management. There were 25 animal feeding areas identified in the watershed, twelve of which had an AGNPS rating greater than 55 (SDDENR 1999). These livestock operations were responsible for 17% of the phosphorus loading and 7.5% of the nitrogen loading to Blue Dog Lake. The AGNPS model predicted very little overall sediment coming from the watershed; however, a few cultivated areas were losing higher than acceptable amounts of soil. These areas had very little residual crop cover and slopes greater than 7%. These critical cells accounted for approximately 18% of the total phosphorus load and 8% of the nitrogen loading to Blue Dog Lake. Nutrient loads from the watershed were greatest in the spring with snowmelt and spring rains.

Blue Dog Lake had a central sewage system installed in 1992 connecting lake homes to the City of Waubay's wastewater treatment plant. Sewage effluent from lake homes should no longer be a concern about entering the waters of Blue Dog Lake. However, as homes and cabins develop around the recreational glacial lakes, wastewater generated by individual septic tanks and drain field systems can leach into lake waters and become a source of increased chlorophyll-a resulting in a decrease in water quality (Skadsen, Enemy Swim Lake 2005). The data on Enemy Swim indicated that the lake had become more eutrophic over the previous decade. Soils adjacent to many of the lake shorelines are unsuitable for septic system absorption fields (SDDENR, Roy Lake 2009) and contribute to sewage leachate entering lake waters.

The lake elevations during the study reached record heights at 1892.9 feet above mean sea level (msl). These high water levels were responsible for severe shoreline erosion along the banks of the lake. During the summer of 1998, it was estimated an average of ten feet of soil (735,000 cubic feet) was lost along approximately seven miles of the lake's 8.7-mile shoreline. Suspended solids from shoreline bank erosion and re-suspension of bottom solids by wind and wave action, decreased the amount of photosynthesis and algae in the non-ice periods of spring, summer, and fall. The periods of ice formation on the lake eliminated the re-suspension of sediment from wave action and allowed for higher dissolved phosphorus in the winter months. Chlorophyll-*a* concentrations in Blue Dog Lake were relatively low with respect to the nutrient concentrations. The phosphorus concentrations in Blue Dog Lake were four times greater than the amount needed for an algal bloom, which was high enough to produce prolonged nuisance algal blooms if favorable conditions would occur.  It was felt that the production of chlorophyll-*a* in Blue Dog Lake was limited by light-blocking sediments which prevented large algal blooms.

SDDENR (1999) recommended that a 30% reduction of incoming phosphorus load was needed to meet a total phosphorus Trophic State Level (TSI) level of 63.75.  To meet this goal the following BMPs were recommended: eliminate discharge from twelve animal feeding areas with an AGNPS score of 55 or greater, improve both manure and crop management, target the 41 critical cropland cells with slopes greater than 7%, and establish shoreline vegetation around the perimeter of Blue Dog lake  to reduce shoreline erosion.  The Blue Dog Lake Watershed Improvement Project (BDLWIP) was implemented in March 2000 and extended to July 2006. The BDLWIP had a project goal (Skadsen 2006) of moving the total phosphorus TSI from a hypertrophic state to a eutrophic state.  This TSI was attained by the BDLWIP with a TSI of 63.33; which was slightly below the targeted phosphorus TSI of 63.75.

**L26 – Nine Mile Lake**

Nine Mile Lake is 303(d) listed for High pH impaired for the support of Fish and Wildlife Propagation, Recreation, and Stock Watering Waters; and Warmwater Semipermanent Fish Life in the 2012 SDENR-IR.  The beneficial use of Fish and Wildlife Propagation, Recreation, and Stock Watering Waters requires that pH values in the lake remain between 6.5 to 9.5; while the pH value for Warmwater Semipermanent Fish Life requires the values to remain between 6.5 to 9.0.

Two primary nutrients are required for cellular growth in organisms: phosphorus and nitrogen. Nitrogen is difficult to limit in aquatic environments due to its highly soluble nature and the algal uptake of nitrogen from the atmosphere.  Phosphorus is easier to control, making it the primary nutrient targeted for reductions when attempting to control eutrophication.  The average total nitrogen (TN) to total phosphorus (TP) ratio collected from Nine Mile Lake was 29.66, indicating it was phosphorus limited (SDDENR 2007).

Nine Mile Lake had relatively low chlorophyll-*a* concentrations throughout the study by SDDENR (2007).  This was felt to be due to the large number of macrophytes in the lake that presumably out-competed the algae for nutrients.  The chlorophyll-*a* concentration averaged 5.62 milligrams per liter (mg/l) during the growing season, which indicated mesotrophic conditions. The phosphorus limiting conditions helped create conditions favorable for a good phosphorus-chlorophyll-*a* relationship.  Light limitation for algae growth was thought not to be a factor because the lake was usually clear and the bottom of the lake visible allowing for good light penetration.  The lake was plagued with extensive beds of macrophytes, to the extent that operating a motorized boat in the lake was difficult.  There were few areas of open water and users of the lake reported difficulties with fishing and other recreational uses due to extensive beds of submerged macrophytes.

The 2007 study found that 11.3% of the dissolved oxygen (DO) readings were below the 5.0 mg/l criterion for maintaining warmwater semipermanent fish life propagation. This was felt most likely due to elevated water temperatures during the late summer and from bacteria using oxygen during the decomposition of organic matter in the lake.

A sediment survey was conducted on Nine Mile Lake during 2003. The water depth of the lake averaged 8 feet, while the sediment depth averaged 6 feet. Because there were no disruptive sources in the watershed, it was assumed that the sedimentation of the lake was a natural process of this "pothole" lake, and it would eventually fill in and become a marsh. However, the lake depth could be increased by 43% if the sediment was removed extending the life of the lake and maintaining lake conditons related to lake depth and volume. The secondary benefits of sediment removal would be the removal of phosphorus rich sediments that release nutrients to the lake and the removal of the macrophytes.

The TMDL study of 2007 recommended increasing the DO to State standards of 5.0 mg/l; maintaining the total phosphorus loading at 376.2 kilograms/year (kg/yr); decreasing the macrophyte coverage by 30%; maintaining an average Secchi chlorophyll-*a* TSI of $\leq$ 63.4 during the growing season; and achieving a pH standard of 9.0 or less. A summary of the recommended lake restoration techniques for Nine Mile Lake are presented in Table 2-5.

**Table 2-5: Summary of Recommended Lake Restoration Techniques for Nine Mile Lake**

| Restoration Technique | Action | Targets | Comments |
|---|---|---|---|
| Macrophyte control by mechanical means (weed harvester). | Remove macrophytes in center areas of the lake or other small localized areas. | Decrease percent macrophyte coverage by 30%. | Not recommended as a long term solution. As needed only. |
| Macrophyte control by chemical means. | Remove macrophytes in center areas of the lake or other small localized areas. | Decrease percent macrophyte coverage by 30%. | Not recommended as a long term solution. As needed only. |
| Macrophyte control with sediment covers. | Cover lake bottom in localized areas. | Decrease macrophytes by 100% in small areas near boat ramp or lakeside homes. | As needed only. |
| Aeration/circulation. | Aerate until DO concentration is at least 5.0 mg/l. | DO concentration of 5.0 mg/l. | Frequent monitoring of DO recommended for initiation and continuation of aeration. |
| Best Management Practices and Animal Waste Management. | Promote use of BMPs and AWMs in the watershed. | TSI target of 63.4<br>DO of 5.0 mg/l | Used to maintain TSI target. May help alleviate low DO concentrations. |

### 2.7.2.2 Dissolved Oxygen: Buffalo Lake – South, L36

South Buffalo Lake was 303(d) listed for low Dissolved Oxygen (DO) impaired for the support of Warmwater Semipermanent Fish Life in the 2012 SDENR-IR. The DO standard for Warmwater Semipermanent Fish Life requires the values to remain $\geq$ 5.0 mg/l. The SDDENR Final Report for South Buffalo Lake (2008) found the standards for nitrate, unionized ammonia, conductivity, total suspended solids, and fecal coliform bacteria were not exceeded. Aquatic macrophytes were also not found to be a major problem in the lake. The lake was considered to be eutrophic.
The 1996, 1998, 2000, and 2002 SDDENR-IR listed South Buffalo Lake as not meeting its fish life propagation use because of pH and TSI. The cause of the problem was thought to be nonpoint source pollution.

Dissolved oxygen level depletion was not limited to the lake bottom but occurred throughout the water column. Twenty-six out of ninety-six (27%) had DO levels below 5.0 mg/l. This was most likely due to bacteria using oxygen during the decomposition of organic matter in the lake. The Little Minnesota River/Big Stone Lake Phase 1 study (SDDENR 1983) determined that the most detrimental factors affecting water quality were nutrients and sedimentation runoff from agricultural practices on land in the watershed. High feedlot run-off and high algae biomass can result in low DO levels because of the high Biological Oxygen Demand (BOD) when organic matter decays. Decay of excessive levels of algae can cause severe oxygen depressions which results in reduced dissolved oxygen concentrations.

All of the TN:TP ratios calculated for the lake were greater than 10:1 with an average of 31.94, indicating phosphorus limitation. The data indicated relatively low concentrations of chlorophyll-*a* with the growing season concentration averaging 10.34 mg/l. During the study, the average growing season TSI numerical value for South Buffalo Lake was 58.22 based on total phosphorus, Secchi transparency, and chlorophyll-*a* which placed the lake in the eutrophic category.

The BATHTUB model produced good agreement between the observed and predicted total phosphorus (TP) concentration and TP TSI. The predicted average Secchi/chlorophyll-*a* TSIs were also similar. Based on the BATHTUB model results, the total annual phosphorus load can be set at 357.9 kg/yr to ensure the target TSI of 63.4. South Buffalo Lake had a total phosphorus retention of 253.8 kg/yr with a total inflow of 306.7 kg/yr and a total outflow of 52.9 kg/yr.

A sediment survey was also conducted in March 2003 with nine test holes being drilled through the ice. The average sediment depth was 3.4 feet and the water depth averaged 10.8 feet with a maximum depth of 15.0 feet. The average sediment depth was not considered unusually high, but the lake volume could be increased up to 24% by sediment removal.

The recommendations that were rejected for lake restoration and control of algal biomass and aquatic macrophytes are as follows: dilution/flushing; lake drawdown/harvesting; biological controls; surface sediment covers; hypolimnetic withdrawal; macrophytes/algae control by herbicides and algaecides; phosphorus inactivation and bottom sealing with aluminum sulfate; sediment removal for nutrient/organics control; and sediment removal for lake longevity. Two techniques recommended for consideration were: (1) watershed best management practices including animal waste management systems, and (2) aeration and circulation where oxygen is pumped into the lake during periods of low DO. These recommendations supported South Dakota's approach to accepted watershed strategies to treat the sources of nutrients and reduce or eliminate nutrient loads to impaired waters, rather than treat the symptoms of low dissolved oxygen. The reduction of the phosphorus loading to the lake will improve dissolved oxygen concentrations and overall water quality in South Buffalo Lake.

#### 2.7.2.3 Temperature: Pierpont Lake L28

Pierpont Lake is listed as 303(d) impaired for temperature for the support of Warm Water Permanent Fish Life in the 2012 DENR-IR. The Pierpont Lake In-Lake Water Quality Study was conducted in 2007 and 2008 and is the only complete study on the lake. During 1989, 1991, and 1993 the SDDENR collected in-lake water quality samples in Pierpont Lake and this data was published as part of a statewide lake assessment project in 1996. There were no homes or commercial developments along the shoreline except for a small park operated by the City of Pierpont.

The Statewide Lake Assessment (SWLA) data collected in 2004 and 2010 had five water samples out of twenty-eight water column profile measurements exceed the Warm Water Permanent Fish Life standard of 80 $^{o}$F, which is an 18% violation rate. Violation rates that exceed 10% constitute an impairment based on the 2012 SDDENR-IR listing methodology (Paul Lorenzen, DENR, personal communication).

Dissolved oxygen levels in Pierpont Lake ranged from 7.0 mg/l to 11.4 mg/l on the surface and from 1.6 mg/l to 7.9 mg/l on the bottom (German and Skadsen 2010). Low DO levels were observed in bottom samples during a weak thermal stratification in August 2008. Low concentrations near the bottom probably resulted from the decomposition of organic matter in the sediments and the decay of excess aquatic plants. Observed pH values ranged from 7.96 in the bottom sample to 8.69 on the surface sample. No violations of the pH standard were recorded during 2007 to 2008. Pierpont Lake is a well buffered lake which protects it from any dramatic pH changes.

## 3.0 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. Load reduction predictions from other studies are presented in Table 3-1 (Evan et al. 2003/2008). The Nonpoint Source Measures will be described and referenced to Best Management Practices (BMPs) as defined by the Natural Resources Conservation Service (NRCS), USDA; however, any related NRCS practices may be added to supplement these identified BMPs.

**Table 3-1. Estimated BMP Reduction Efficiencies by Pollutant Type**

| 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 USDA-NRCS in 2012 in the Conservation Effects Assessment Project (CEAP). This included the Big Sioux, James, and Little Minnesota Rivers' in the NEGL project area. See Figure 3-1 for the NEGL area 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 subregions included in the NEGL watershed were the James River Basin (code 1016) with approximately 55.0% of its watershed in cultivated cropland and 37.1% in permanent grass, and the Missouri-Big Sioux-Lewis-Clark Lake (code 1017) with approximately 68.6% of its watershed in cultivated cropland and 21.6% in permanent grass. Of the thirty subregions studied, these two subregions ranked in the top ten for sediment, nitrogen, phosphorus, and atrazine loads delivered from cultivated cropland to rivers and streams. These top ten subregions also had 83% of the acres with a "high need" for additional conservation treatment.

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 Animal Waste Management Systems (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. Through a Nutrient Management Plan (NMP), wastes would only be applied when growing crops can use the accompanying nutrients and when soil and weather conditions are appropriate.

Seven watershed studies completed from 1999 to 2010 identified 82 Animal Feeding Operations (AFO) in the NEGL project area. These studies represented approximately 75% of the NEGL watershed acres; extrapolating this data to the entire NEGL watershed would estimate approximately 110 AFOs throughout the NEGL watershed. AFOs that were evaluated in these studies using AGNPS computer modeling found approximately 35% AFOs (17 of 49) had a ranking score at or equal to 50. This percentage estimate is similar to other South Dakota studies as during the Turkey Ridge Creek Assessment (DENR 2005), 129 AFOs were identified and 35% had an AGNPS rating of over 50. Similarly, the Lake Thompson Watershed Final Report (Strom 2008) identified 33% of the 84 AFOs in its watershed to have a rating of over 50. Extrapolating the estimated 35% to the 110 potential AFOs would project approximately 38 AFOs with a ranking score at or equal to 50 in the NEGL project. Examining the completed NEGL implementation project reports in the NEGL revealed approximately 10 AFOs were either abandoned, relocated, or had an AWMS constructed. This leaves an estimated 28 AFOs in needed of an AWMS; a number fairly close to the 25 that were estimated by local field offices. The AFOs with a rating above 50 will be subjected to further evaluation, and the higher rated ones may be targeted for the installation of an Animal Waste Management System (AWMS) to reduce fecal coliform impacts to the water bodies.

### 3.2 Nutrient Management 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 in Table 3-1 of 70% for nitrogen and 28% for phosphorous.

The assessment of conservation practices for the entire Missouri River Basin (NRCS 2012) found the 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 James River Basin (code 1016) had considerable less acres treated with manure at 6%. The main nonpoint source pollutants impairing the water quality of NEGL project lakes (Skadsen 2010) were fecal coliform bacteria, nutrients, and sediments carried by runoff from agricultural lands located in their watersheds. High fecal coliform levels can be associated with the land application of manure, including both excess application rates and not incorporating manure applied in areas subject to high runoff rates.

### 3.3 Prescribed Grazing – 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. Evan etal, (2008), estimated a 34% reduction in phosphorous and a 43% reduction in nitrogen through proper grazing management. 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.

#### 3.3.1 Prescribed Grazing – Pasture Lands

The application of prescribed grazing on pasture lands 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 rotational grazing, constructing fences or other barriers to control concentrated livestock access to riparian areas, livestock crossing structures, and alternative water supply.

#### 3.3.2 Prescribed Grazing – Riparian Areas

Other grazing management techniques along water bodies would include seasonal access or rotational grazing to reduce the intensity and duration of access to riparian zones**.** 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. The NEGL Segment 1 Final Report (Skadsen 2010) reported riparian buffers in riparian pasture as having load reductions of 3.4 pounds of nitrogen/acre/year, 1.1 pounds of phosphorous/acre/year, and 0.77 tons of soil/acre/year on 92.1 acres of grazing land. Skadsen also reported riparian buffers in cropland as having load reductions of 12.2 pounds of nitrogen/acre/year, 3.3 pounds of phosphorous/acre/year, and 2.17 tons of soil/acre/year on 53.4 acres of cropland.

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 Yellow Bank TMDL (SDDENR 2012), Blue Dog Lake (SDDENR 1999), and the MWPCA (2010) analysis of their watersheds indicated that the most likely source of the nutrient loading, in addition to the animal feeding operations, was cattle grazing and their access to streams and lakes. 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 apply to all cropland and include 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 considered 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 with the delivery rates of nitrogen, phosphorous, and sediment per acre in this subregion at 6.52 lbs/acre/year, 0.38 lbs/acre/year, and 0.11 ton/acre/year, respectively. The James River subregion (code 1016) had 9.2% of it subregion acres listed as under-treated with the delivery rates of nitrogen, phosphorous, and sediment per acre in this subregion at 4.63 lbs/acre/year, 0.26 lbs/acre/year, and 0.11 ton/acre/year, respectively. Both subregion watersheds were in the top ten percent of regional totals by subregion for sediment, nitrogen, and phosphorus delivered from cultivated cropland to rivers and streams. The Missouri River basin-wide averages were 5.82 N lbs/acre/year, 0.38 P lbs/acre/year, and 0.17 Sediment ton/acre/year, respectively.

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 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.

### 3.5 Streambank & Channel Stabilization. NRCS Practice Code 580

Streambank stabilization is a treatment used to stabilize and protect banks of streams and shoreline 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 USDA-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.

The suspected cause of bank failure 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). Additional 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 phosphorous, and a 58% reduction in sediment by installing grassed waterways.

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.

Load reductions for sediment and phosphorus were documented in both restored wetlands with vegetated buffers and constructed ponds during the Little Minnesota River Watershed project (Jensen 2007). 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. Jensen reported sediment and phosphorous reductions as 91,579 tons/pond lifespan and 174,000 lbs./pond lifespan, respectively.

The School/Bullhead Lakes study (SDDENR 2005) removed 1,833 acres of impoundments, 10 acres or larger, to run the AnnAGNPS scenario of ‘no impoundments’ to compare to 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. For this reason, wetland restoration, pond construction, water and sediment control structures, and structures for water control will be part of the NEGL strategic plan. The purpose for these practices is to create multi-purpose ponds in the watershed to trap sediment, phosphorous, 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 percent. 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 identifying critical cells throughout the NEGL watershed project area and evaluating them before BMPs are installed.

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 (WSGs), examples - corn, sorghum, millet, warm season perennial grasses; cool-season grasses: (CSGs), examples - winter and spring wheat, barley, oats, cool-season perennial grasses; warm-season broadleaf (WSB), examples - soybean, sunflower, dry beans, potatoes, alfalfa, and other warm season perennial broadleaf crop; and cool-season broadleaf (CSB), 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% of the cropped acres. The NEGL project 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.

The results from the TMDL study on Clear Lake in Marshall County (SDDENR 1999) found that runoff from fertilized cropland was a significant source of water soluble nutrients to Clear Lake. The suspected source of sediment loading was from agricultural lands having slopes of 4% and greater. The study recommended that the implementation of appropriate BMPs be targeted to critical cells within critical subwatersheds.

Nutrient and sediment loading from cropland runoff has been identified in other NEGL water bodies as contributing to water quality degradation in the following SDDENR water quality reports and assessments: Blue Dog Lake 1999, Enemy Swim 2000, Pickerel Lake 2010, Little Minnesota River/Big Stone Lake 2007, Punished Woman Lake 2000, and White Lake 2005.

### 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 crops 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 CEAP study, 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 Windbreak/Shelterbelt Establishment. NRCS Practice Code 380

The objectives of Windbreak/Shelterbelt Establishment are to reduce soil erosion from wind; provide shelter for structures, animals, and people; enhance wildlife habitat; improve air quality by reducing and intercepting air borne particulate matter, chemicals and odors; improve irrigation efficiency; increase carbon storage in biomass and soils; and reduce energy use.

During a comprehensive conservation planning process, the conservation resource needs of the land and producer are evaluated and addressed. The windbreak/shelterbelt practice also protects the land that is planted to trees and/or shrub species in that it requires the establishment of permanent woody vegetation with minimal use or only periodic management. Load reductions for tree planting were not reported in the NEGL; however, Strom reported (2008) on converting 25.1 acres of cropland to trees in nearby Kingsbury county. Strom's data will be used in estimated load reductions for the NEGL.

### 3.11 Nutrient Management Plan - Cropland. NRCS Practice Code 590

This Nutrient Management Practice, unlike section 3.2, 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 nutrient management plan 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 (N) 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. The nutrient flow to surface water and groundwater varies 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 plans at efficiencies at 70% reduction for nitrogen and a 28% reduction for phosphorous.

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 percent of the cropped acres met all three criteria for both nitrogen and phosphorous applications. The importance for the promotion of nutrient management plans on cropland is obvious and will be used as a BMP in the NEGL project.

### 3.12 Filter Strips - Non CRP. NRCS Practice Code 393

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 might and would need to be managed. Management of livestock may be needed allowing only seasonal access, rotational grazing, and/or time limitations to reduce the intensity and duration of grazing. Load reduction for nitrogen, phosphorous, and sediment for grassed filter strips were calculated from 92 acres of riparian buffers in pasture and reported by Skadsen (2010) in the NEGL.

### 3.13 Brush Management – NRCS Practice Code 314

One of the most striking land cover changes on rangelands worldwide over the past 150 years has been the proliferation of trees and shrubs at the expense of perennial grasses (Archer et al. 2011). Brush encroachment has long been considered one of the major management problems confronting managers of rangeland as a dense stand of brush usually minimizes grass cover (Welch 2000). The reduced grass cover results in increased soil erosion, inefficient use of rainfall with increased runoff, and loss of livestock production. Brush Management, NRCS conservation practice code 314, is the management or removal of invasive and noxious woody (nonherbaceous or succulent) plants to create the desired plant community consistent with the ecological site. The practice is designed to restore or release desired vegetative cover to protect soils, control erosion, reduce sediment, improve water quality, or enhance stream flow, and improve forage accessibility, quality, and quantity for livestock and wildlife. Brush includes woody half-shrubs, shrubs, and trees that invade areas on which they are not part of the natural plant community or that occur in amounts significantly in excess of what is natural to the site.

A study by Zhang et al. (2012) found that dramatic increases in runoff and soil loss were attributed to the increase in the frequency and intensity of extreme events for plant communities in three scenarios, since there was no significant increase in mean annual precipitation. The projected mean annual runoff and soil loss approximately doubled and predicted erosion from shrub communities increased more than for other plant communities under the three scenarios. Greater increases of soil loss indicated that soil erosion was more sensitive to changes in storm patterns than runoff. A predicted future of increasing runoff and soil erosion appeared to accelerate the transitions of grassland to shrub lands or to more eroded states than what already had been occurring on the study area over the past century. The prediction of more soil erosion on shrub lands in the future (Westoby et al. 1989) could mean significant shifts from shrubs to the eroded state. This may imply that it may be difficult to restore historical plant communities over time frames relevant to ecosystem management. The option of woody plant control and removal through brush management is a technique that could be considered to reduce soil erosion on rangelands.

Brush management is designed to achieve the desired plant community based on species composition, structure, density, and canopy (or foliar) cover or height. Brush management is applied in a manner to achieve the desired control of the target woody species and protection of desired species. This can be accomplished by mechanical, chemical, or biological methods either alone or in combination. However, this practice should be completed in conjunction with a planned prescribed grazing management system, NRCS practice code 528.

# 4.0 LOAD REDUCTIONS

## 4.1 Animal Waste Storage Facilities

Conservation field offices in the NEGL estimated the need for 25 AFOs requiring the construction of an animal waste management system. The NEGL Final Report (Skadsen 2010) calculated that an AWMS constructed in the Amsden Dam watershed had a nitrogen reduction of 7,664 pounds per year and a phosphorous reduction of 1,724 pounds per year. The average estimated Animal Units (AU) per Animal Waste Storage Facility (AWSF) by field offices was 375 with a yearly construction rate of 2 AWSFs per year. At this construction rate it will take additional years to complete the needed AWSFs. Load reductions used in Table 4-1 are those calculated by Skadsen. 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) and Phosphorous (P) Load Reductions (LR) Associated with Animal Waste Storage Facilities (AWSF) | | | | | | |
|---|---|---|---|---|---|---|
| Year | # Goal | % Goal | N #/System | Total N #/Syst | P #/System | Total P #/Syst |
| 1 | 2 | 8.0 | 7,664 | 15,328 | 1,724 | 3,448 |
| 2 | 2 | 8.0 | 7,664 | 15,328 | 1,724 | 3,448 |
| 3 | 2 | 8.0 | 7,664 | 15,328 | 1,724 | 3,448 |
| 4 | 2 | 8.0 | 7,664 | 15,328 | 1,724 | 3,448 |
| 5 | 2 | 8.0 | 7,664 | 15,328 | 1,724 | 3,448 |
| Subtotal | 10 | 40.0 | | 76,640 | | 17,240 |
| 6-10 | 10 | 40.0 | 7,664 | 76,640 | 1,724 | 17,240 |
| 11-15 | 5 | 20.0 | 7,664 | 38,320 | 1,724 | 8,620 |
| Total | 25 | 100.0 | | 191,600 | | 34,480 |

Nutrient Load Reduction Estimates from NEGL Final Report Segment 1, Skadsen 2010

## 4.2 Nutrient Management System 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. An average of two facilities constructed each year with 375 animal units each would require approximately 750 acres in the NMPs; however, only about 75 acres (10%) would receive the manure each year. Load reductions used will be those of Kringens (2010), in the James River watershed, where he calculated 9.8 pounds of nitrogen/acre/year and 0.6 pounds of phosphorous/acre/year for an applied NMP. See Table 4-2 for the estimated nitrogen and phosphorous 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 #/Ac/Yr | Total N #/Yr | P #/Ac/Yr | Total P #/Yr |
| 1 | 2 | 8.0 | 367.5 | 735.0 | 22.5 | 45.0 |
| 2 | 2 | 8.0 | 367.5 | 735.0 | 22.5 | 45.0 |
| 3 | 2 | 8.0 | 367.5 | 735.0 | 22.5 | 45.0 |
| 4 | 2 | 8.0 | 367.5 | 735.0 | 22.5 | 45.0 |
| 5 | 2 | 8.0 | 367.5 | 735.0 | 22.5 | 45.0 |
| Subtotal | 10 | 40.0 | | 3,675.0 | | 225.0 |
| 6-10 | 10 | 40.0 | 367.5 | 3,675.0 | 22.5 | 225.0 |
| 11-15 | 5 | 20.0 | 367.5 | 1,837.5 | 22.5 | 112.5 |
| Total | 25 | 100.0 | | 9,187.5 | | 562.5 |

Nutrient Load Reduction Estimates from Kringen 2010

## 4.3 Prescribed Grazing Systems

### 4.3.1 Upland Prescribed Grazing Systems

The field offices in the NEGL project area were contacted for the number of acres of grazing lands that need a grazing management system for each county. The estimated need was for 82,500 acres of prescribed grazing systems to be planned and implemented. The estimated average implementation rate was 2,900 acres per year. At the end of this five year Strategic Plan only 14,500 acres (17.5%) 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 NEGL Segment 1 Final Report (Skadsen 2010) of 0.86 pounds of nitrogen/acre/year, 0.14 pounds of phosphorous/acre/year, and 0.07 tons of sediment/acre/year. Prescribed grazing systems are figured on 420 acres per system with a rural water hook-up, two tanks, a water pipeline footage of 2,000 feet, and 5,000 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 | 2,900 | 3.5 | 0.86 | 2,494 | 0.14 | 406 | 0.07 | 203.0 |
| 2 | 2,900 | 3.5 | 0.86 | 2,494 | 0.14 | 406 | 0.07 | 203.0 |
| 3 | 2,900 | 3.5 | 0.86 | 2,494 | 0.14 | 406 | 0.07 | 203.0 |
| 4 | 2,900 | 3.5 | 0.86 | 2,494 | 0.14 | 406 | 0.07 | 203.0 |
| 5 | 2,900 | 3.5 | 0.86 | 2,494 | 0.14 | 406 | 0.07 | 203.0 |
| Subtotal | 14,500 | 17.5 | | 12,470 | | 2,030 | | 1,015.0 |
| 6-10 | 14,500 | 17.5 | 0.86 | 12,470 | 0.14 | 2,030 | 0.07 | 1,015.0 |
| 11-Plus | 53,500 | 65.0 | 0.86 | 46,010 | 0.14 | 7,490 | 0.07 | 3,745.0 |
| TOTAL | 82,500 | 100.0 | | 70,950 | | 11,550 | | 5,775.0 |

N, P, and Sediment Load Reduction Estimates from NEGL Final Report Segment 1, Skadsen 2010

### 4.3.2 Riparian Area Grazing Management

Riparian area grazing management systems were estimated to be needed on 190 acres throughout the NEGL project area by field offices to reduce nutrient and sediment transport to water bodies. At a rate of 10 acres per year implementation, additional years would be needed to resolve resource problems. 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 NEGL watershed during the first five years of the Strategic Plan. Load reduction estimates are from the NEGL Segment 1 final report (Skadsen 2010) for riparian buffers established in pastures.

**Table 4-3-2. Riparian Area Management Program and Conservation Reserve Program 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 | 10 | 5.0 | 3.40 | 34 | 1.10 | 11 | 0.77 | 7.7 |
| 2 | 10 | 5.0 | 3.40 | 34 | 1.10 | 11 | 0.77 | 7.7 |
| 3 | 10 | 5.0 | 3.40 | 34 | 1.10 | 11 | 0.77 | 7.7 |
| 4 | 10 | 5.0 | 3.40 | 34 | 1.10 | 11 | 0.77 | 7.7 |
| 5 | 10 | 5.0 | 3.40 | 34 | 1.10 | 11 | 0.77 | 7.7 |
| Subtotal | 50 | 25.0 | | 170 | | 55 | | 38.5 |
| 6-10 | 50 | 25.0 | 3.40 | 170 | 1.10 | 55 | 0.77 | 38.5 |
| 11 Plus | 90 | 50.0 | 3.40 | 306 | 1.10 | 99 | 0.77 | 69.3 |
| TOTAL | 190 | 100.0 | | 646 | | 209 | | 146.3 |

N, P, and Sediment Load Reduction estimates from NEGL Segment 1 Final Report, Skadsen 2010

## 4.4 Residue & Tillage Management on Cropland

Field Offices estimated 132,300 acres of conservation tillage would be needed to solve resource concerns. At the rate of 9,900 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 NEGL project did not report on cropland residue and tillage management. However, the Vermillion River (Ward 2013) project reported a load reduction using conservation tillage on cropland of 7.69 pounds of nitrogen per acre. Segment 1 of the Lake Poinsett Watershed Improvement Project (LPWIP) reported 1.75 pounds of phosphorus, and 3.5 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 | 9,900 | 7.5 | 7.69 | 76,131 | 1.75 | 17,325 | 3.5 | 34,650.0 |
| 2 | 9,900 | 7.5 | 7.69 | 76,131 | 1.75 | 17,325 | 3.5 | 34,650.0 |
| 3 | 9,900 | 7.5 | 7.69 | 76,131 | 1.75 | 17,325 | 3.5 | 34,650.0 |
| 4 | 9,900 | 7.5 | 7.69 | 76,131 | 1.75 | 17,325 | 3.5 | 34,650.0 |
| 5 | 9,900 | 7.5 | 7.69 | 76,131 | 1.75 | 17,325 | 3.5 | 34,650.0 |
| Subtotal | 49,500 | 37.5 | | 380,655 | | 86,625 | | 173,250.0 |
| 6-10 | 49,500 | 37.5 | 7.69 | 380,655 | 1.75 | 86,625 | 3.5 | 173,250.0 |
| 11 Plus | 33,300 | 25.0 | 7.69 | 256,077 | 1.75 | 58,275 | 3.5 | 116,550.0 |
| TOTAL | 132,300 | 100.0 | | 1,017,387 | | 231,525 | | 463,050.0 |

**N load reductions are the Vermillion River, Ward 2013; P and Sediment are LPWIP, Smith 2010**

### 4.5 Streambank Stabilization

The planned streambank stabilization footages needed in the NEGL project area were estimated by field office staff as 28,000 linear feet (LF). Approximately 2,640 LF would be installed each year which would require additional years to achieve. Shoreline stabilization projects installed on Lake Poinsett, as reported by Smith (2007), reduced phosphorus by 0.4 pounds/linear foot (lbs/LF) and reduced sediment by 10.0 tons/LF. Load reductions for nitrogen were calculated at 2.6 lbs/LF by Strom (2010) for streambank restoration installed along the Big Sioux River. Table 4-5 presents estimated load reductions for NEGL.

**Table 4-5. Streambank 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 | P Reduction Lbs/LF | Total P Reduction Lbs | Sediment Reduction Tons/LF | Total Sediment Tons |
| 1 | 2,640 | 9.0 | 2.6 | 6,864 | 0.4 | 1,056 | 10.0 | 26,400.0 |
| 2 | 2,640 | 9.0 | 2.6 | 6,864 | 0.4 | 1,056 | 10.0 | 26,400.0 |
| 3 | 2,640 | 9.0 | 2.6 | 6,864 | 0.4 | 1,056 | 10.0 | 26,400.0 |
| 4 | 2,640 | 9.0 | 2.6 | 6,864 | 0.4 | 1,056 | 10.0 | 26,400.0 |
| 5 | 2,640 | 9.0 | 2.6 | 6,864 | 0.4 | 1,056 | 10.0 | 26,400.0 |
| Subtotal | 13,200 | 45.0 | | 34,320 | | 5,280 | | 132,000.0 |
| 6-10 | 13,200 | 45.0 | 2.6 | 34,320 | 0.4 | 5,280 | 10.0 | 132,000.0 |
| 11-15 | 1,600 | 10.0 | 2.6 | 4,160 | 0.4 | 640 | 10.0 | 16,000.0 |
| TOTAL | 28,000 | 100.0 | | 72,800 | | 11,200 | | 280,000.0 |

N Load Reduction Estimates Strom 2010; P and Sediment from Smith 2007

### 4.6 Grassed Waterways

One hundred and three (103) constructed acres of grassed waterways were estimated to be needed by the field offices for full treatment of gullies. At a construction rate of 18 acres per year, 90 acres will be completed in the five years of the Strategic Plan, which is 87.5% of the needed estimate. More years will be needed to complete the necessary linear feet of grassed waterways to control gully erosion.

The Little Minnesota River (Jensen 2007) load reductions for constructed grassed waterways were 52.2 pounds/acre/year of phosphorus and 27.5 tons/acre/year of sediment per acre of constructed grassed waterway. Other implementation projects have reported higher savings, as Kringen, in the James River watershed (2010), reported nitrogen load reductions of 123.8 pounds/acre/year; phosphorous by 32.6 pounds/acres/year; and sediment by 16.7 tons/acre/year. Smith (2007) reported grassed waterways to reduce phosphorus by 2.45 pounds/acre/year and sediment by 4.9 tons/acre/year in the LPWIP.

Nitrogen load reduction estimates used in Table 4-6 are from the waterway calculations used by Kringen. Phosphorous and sediment load reductions are from Jensen. No waterway load reduction data is available for the NEGL project. 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 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Acres (AC) 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 | 18 | 17.5 | 123.8 | 2,228.4 | 52.2 | 939.6 | 27.5 | 495.0 |
| 2 | 18 | 17.5 | 123.8 | 2,228.4 | 52.2 | 939.6 | 27.5 | 495.0 |
| 3 | 18 | 17.5 | 123.8 | 2,228.4 | 52.2 | 939.6 | 27.5 | 495.0 |
| 4 | 18 | 17.5 | 123.8 | 2,228.4 | 52.2 | 939.6 | 27.5 | 495.0 |
| 5 | 18 | 17.5 | 123.8 | 2,228.4 | 52.2 | 939.6 | 27.5 | 495.0 |
| Subtotal | 90 | 87.5 | | 11,142.0 | | 4,698.0 | | 2,475.0 |
| 6-10 | 13 | 12.5 | 123.8 | 1,609.4 | 52.2 | 678.6 | 27.5 | 357.5 |
| Total | 103 | 100.0 | | 12,751.4 | | 5,376.6 | | 2,832.5 |

N Load Reductions from Kringen 2010 . P and Sediment Reduction Estimates from Jensen 2007

## 4.7 Wetland Restoration, Pond, and Basin Construction

Planned restoration numbers of wetlands, pond construction, and water and sediment control basin numbers were estimated by field office personnel to be 27 to meet estimated load reductions. An average of four basins are restored or constructed each year. At the end of the Strategic Plan, approximately 74% of the basin construction estimates will be completed. More years will be needed to meet the estimates of the FO personnel.

Load reduction data was not available for restored wetlands or sediment ponds for the NEGL. Jensen (2007) reported an average of 1.50 lbs/ac/year of phosphorous, and 0.78 ton/acre/year for sediment per restored wetland acre in the Little Minnesota River Watershed. The average size of the restored wetlands in the Little Minnesota River Watershed Project was 5.0 acres. Since Jensen did not calculate nitrogen load reductions, nitrogen load reductions of 6.05 lbs/acre/year for sediment traps as reported in the Vermillion River Basin (Ward 2013) and will be used for nitrogen estimates in Table 4-7.

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

| Wetland Restoration and Pond Construction Load Reductions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | No. Ponds Wetlands Planned | % Goal | Acres Per Wetland | 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 | 4 | 14.8 | 5 | 6.05 | 121.00 | 1.50 | 30.0 | 0.78 | 15.6 |
| 2 | 4 | 14.8 | 5 | 6.05 | 121.00 | 1.50 | 30.0 | 0.78 | 15.6 |
| 3 | 4 | 14.8 | 5 | 6.05 | 121.00 | 1.50 | 30.0 | 0.78 | 15.6 |
| 4 | 4 | 14.8 | 5 | 6.05 | 121.00 | 1.50 | 30.0 | 0.78 | 15.6 |
| 5 | 4 | 14.8 | 5 | 6.05 | 121.00 | 1.50 | 30.0 | 0.78 | 15.6 |
| Subtotal | 20 | 74.0 | | | 605.00 | | 150.0 | | 78.0 |
| 6-10 | 7 | 26.0 | 5 | 6.05 | 211.75 | 1.50 | 52.5 | 0.78 | 27.3 |
| Total | 27 | 100.0 | | | 816.75 | | 202.5 | | 105.3 |

N from Ward 2013. P and Sediment Load Reduction Estimates from Jensen 2007.

## 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 by field office staff to be 2,200 acres for the NEGL project area. One hundred and eighty acres (180) were estimated to be completed each year. At the end of the five year plan only 41% of this estimate would be completed requiring additional years to meet the goal. The calculated load reductions of nitrogen, phosphorous, and sediment were those reported by Skadsen (2010) in the NEGL watershed. He reported the savings of 12.20 pounds/acre/year of nitrogen, 3.28 pounds/acre/year of phosphorous, and 2.17 tons/acre/year of sediment converting cropland to grass riparian buffers. 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 | 180 | 8.2 | 12.20 | 2,196 | 3.28 | 590.4 | 2.17 | 390.6 |
| 2 | 180 | 8.2 | 12.20 | 2,196 | 3.28 | 590.4 | 2.17 | 390.6 |
| 3 | 180 | 8.2 | 12.20 | 2,196 | 3.28 | 590.4 | 2.17 | 390.6 |
| 4 | 180 | 8.2 | 12.20 | 2,196 | 3.28 | 590.4 | 2.17 | 390.6 |
| 5 | 180 | 8.2 | 12.20 | 2,196 | 3.28 | 590.4 | 2.17 | 390.6 |
| Subtotal | 900 | 41.0 | | 10,980 | | 2,952.0 | | 1,953.0 |
| 6-10 | 900 | 41.0 | 12.20 | 10,980 | 3.28 | 2,952.0 | 2.17 | 1,953.0 |
| 11-Plus | 400 | 18.0 | 12.20 | 4,880 | 3.28 | 1,312.0 | 2.17 | 868.0 |
| Total | 2,200 | 100.0 | | 26,840 | | 7,216.0 | | 4,774.0 |

N, P and Sediment Reduction Estimates from NEGL Segment 1, Skadsen 2010

## 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 by field office staff to be 130,250 acres for the NEGL at 8,760 acres installed each year; this goal will only be achieved through 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 was not analyzed in the NEGL project area. The adjacent watershed study of Clear Lake, Marshall County, (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 entered the lake. The AGNPs data indicated that the Clear Lake sub watersheds had a total nitrogen (soluble+sediment bound) deliverability rate of 22.1 lbs./acre/year. and a total phosphorus (soluble+sediment bound) deliverability rate of 5.2 lbs./acre/year. 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%. Applying this estimate to the Clear Lake data, 22.1 lbs. nitrogen/acre/year could be reduced by 31% or 6.85 lbs./acre/year and 5.2 lbs. of phosphorous/acre/year could be reduced by 31% or 1.61 lb./acre/year.

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 that incorporates meadow or hayland is included.

**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 | 8,760 | 6.7 | 6.85 | 60,006.0 | 1.61 | 14,103.6 | 0.05 | 438.0 |
| 2 | 8,760 | 6.7 | 6.85 | 60,006.0 | 1.61 | 14,103.6 | 0.05 | 438.0 |
| 3 | 8,760 | 6.7 | 6.85 | 60,006.0 | 1.61 | 14,103.6 | 0.05 | 438.0 |
| 4 | 8,760 | 6.7 | 6.85 | 60,006.0 | 1.61 | 14,103.6 | 0.05 | 438.0 |
| 5 | 8,760 | 6.7 | 6.85 | 60,006.0 | 1.61 | 14,103.6 | 0.05 | 438.0 |
| Subtotal | 43,800 | 33.5 | | 300,030.0 | | 70,518.0 | | 2,190.0 |
| 6-10 | 43,800 | 33.5 | 6.85 | 300,030.0 | 1.61 | 70,518.0 | 0.05 | 2,190.0 |
| 11- Plus | 42,650 | 33.0 | 6.85 | 292,152.5 | 1.61 | 68,666.5 | 0.05 | 2,132.5 |
| Totals | 130,250 | 100.0 | | 892,212.5 | | 209,702.5 | | 6,512.5 |

Projected Estimates from Hargrove 1991 and TMDL Clear Lake SDDENR 1999

## 4.10 Windbreak/Shelterbelt Establishment

Windbreak or Shelterbelt Establishment typically consists of trees and/or shrub plantings designed to solve a conservation resource concern. Field offices estimated the need for 270 acres of trees to address resource concerns in the NEGL project. At the rate of 40 acres annually, 74% of this goal will be reached in five years. Strom (2008) reported load reductions gained by converting cropland to trees within the Lake Thompson watershed averaged a nitrogen load reduction at 9.20 pounds/acre/year, phosphorus at 3.17 pounds/acre/year, and sediment at 2.37 tons/acre/year. Estimated load reductions are presented in Table 4-10.

**Table 4-10. Nitrogen, Phosphorous, and Sediment Load Reductions on Tree Plantings**

| Estimated Nitrogen (N), Phosphorous (P), and Sediment (Sed) Load Reductions (LR) for Cropland Conversion to Tree Plantings | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Acres | % Goal | N #/Ac/Yr | Total #N/Yr | P #/Ac/Yr | Total #P/Yr | Sed T/Ac/Yr | Total T/Yr |
| 1 | 40 | 14.8 | 9.20 | 368.0 | 3.17 | 126.8 | 2.37 | 94.8 |
| 2 | 40 | 14.8 | 9.20 | 368.0 | 3.17 | 126.8 | 2.37 | 94.8 |
| 3 | 40 | 14.8 | 9.20 | 368.0 | 3.17 | 126.8 | 2.37 | 94.8 |
| 4 | 40 | 14.8 | 9.20 | 368.0 | 3.17 | 126.8 | 2.37 | 94.8 |
| 5 | 40 | 14.8 | 9.20 | 368.0 | 3.17 | 126.8 | 2.37 | 94.8 |
| Subtotal | 200 | 74.0 | | 1,840.0 | | 634.0 | | 474.0 |
| 6-10 | 70 | 26.0 | 9.20 | 644.0 | 3.17 | 221.9 | 2.37 | 165.9 |
| TOTAL | 270 | 100.0 | | 2,484.0 | | 855.9 | | 639.9 |

**Load Reduction Estimates from Lake Thompson, Strom 2008**

## 4.11 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. The field offices estimated a total need of 53,000 acres of nutrient management plans on cropland where manure is not applied in the NEGL project. With approximately 5,100 NMP acres targeted annually, it will require additional years of project implementation to meet their goal. A nutrient management plan (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 should minimize agricultural nonpoint source pollution of surface waters and result in reduced nutrient loading. Estimated load reductions for NMP are presented in Table 4-11. Nitrogen and phosphorus load reductions were calculated from Vermillion River Basin project data (Ward 2013). Load reduction benefits derived from the implementation of a nutrient management plan were calculated and separated from those benefits derived from conservation tillage.

**Table 4-11. 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 | 5,100 | 9.6 | 1.04 | 5,304.0 | 0.10 | 510.0 |
| 2 | 5,100 | 9.6 | 1.04 | 5,304.0 | 0.10 | 510.0 |
| 3 | 5,100 | 9.6 | 1.04 | 5,304.0 | 0.10 | 510.0 |
| 4 | 5,100 | 9.6 | 1.04 | 5,304.0 | 0.10 | 510.0 |
| 5 | 5,100 | 9.6 | 1.04 | 5,304.0 | 0.10 | 510.0 |
| Subtotal | 25,500 | 48.0 | | 26,520.0 | | 2,550.0 |
| 6-10 | 25,500 | 48.0 | 1.04 | 26,520.0 | 0.10 | 2,550.0 |
| 11 Plus | 2,500 | 4.0 | 1.04 | 2,600.0 | 0.10 | 250.0 |
| Total | 53,500 | 100.0 | | 55,640.0 | | 5,350.0 |

Nutrient reduction estimates from Vermillion River, Ward 2013

### 4.12 Filter Strips - Non-CRP

The need for Non-CRP filter strips was estimated by Field Offices to be 1,700 acres within the NEGL project watershed. Installing 20 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 intense land use of grazing. Load reduction rates used are those reported by Skadsen (2010) on grazed riparian buffer strips at the rates of 3.4 lbs/acre/year of nitrogen, 1.10 lbs/acre/year of phosphorous, and 0.78 tons/acre/year for sediment. 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 | 20 | 1.2 | 3.40 | 68.0 | 1.10 | 22.0 | 0.78 | 15.6 |
| 2 | 20 | 1.2 | 3.40 | 68.0 | 1.10 | 22.0 | 0.78 | 15.6 |
| 3 | 20 | 1.2 | 3.40 | 68.0 | 1.10 | 22.0 | 0.78 | 15.6 |
| 4 | 20 | 1.2 | 3.40 | 68.0 | 1.10 | 22.0 | 0.78 | 15.6 |
| 5 | 20 | 1.2 | 3.40 | 68.0 | 1.10 | 22.0 | 0.78 | 15.6 |
| SubTotal | 100 | 6.0 | | 340.0 | | 110.0 | | 78.0 |
| 6-10 | 100 | 6.0 | 3.40 | 340.0 | 1.10 | 110.0 | 0.78 | 78.0 |
| 11-Plus | 1,500 | 88.0 | 3.40 | 5,100.0 | 1.10 | 1,650.0 | 0.78 | 1,170.0 |
| TOTAL | 1,700 | 100.0 | | 5,780.0 | | 1,870.0 | | 1,326.0 |

Load Reductions data from NEGL Segment 1, Skadsen 2010.

## 4.13 Brush Management

Zhang et al. (2012) evaluated the climate change impacts on soil erosion and surface runoff in southeastern Arizona with the Rangeland Hydrology and Erosion Model (RHEM). Data from the 1970 -1999 conditions was compared to future conditions in 2050s and 2090s. The results suggested no changes in annual precipitation across the region under the three scenarios, but projected annual runoff and soil loss increased significantly, ranging from 78.7% - 91.7% and from 127.3% - 157.1%, respectively, relative to the baseline years 1970-1999**.** The baseline annual mean runoff was 0.09 inches/year with the projected future scenarios annual mean runoff of 0.21 inches. Estimated reduction in annual runoff is the difference of these two figures; 0.12 inches/year. Zhang's average annual soil loss rates were 0.09 ton/acre/year during 1970 to 1999 and 0.23 ton/acre/year for all the combinations in future scenarios. Soil loss estimates use in Table 4-13 were 0.23 ton/acre/year minus 0.09 ton/acre/year, which equaled 0.14 ton/acre/year.

Field offices in the NEGL project area estimated a need of 1,450 acres of brush management at an implementation rate of 100 acres per year. The installation rate of 100 acres annually would require additional years to meet the estimated goal.

**Table 4-13. Mean Annual Runoff/ Sediment Load Reductions for Brush Management**

| Mean Annual Runoff Depth and Mean Annual Sediment Loading Reductions for Brush Management | | | | | | |
|---|---|---|---|---|---|---|
| Year | Acres Planned | % Goal | Reduction Runoff Depth Inches | Total Runoff Reduction Inches/Year | Sediment Reduction Tons/Acre | Total Sediment Tons/Year |
| 1 | 100 | 6.9 | 0.12 | 12.0 | 0.14 | 14.0 |
| 2 | 100 | 6.9 | 0.12 | 12.0 | 0.14 | 14.0 |
| 3 | 100 | 6.9 | 0.12 | 12.0 | 0.14 | 14.0 |
| 4 | 100 | 6.9 | 0.12 | 12.0 | 0.14 | 14.0 |
| 5 | 100 | 6.9 | 0.12 | 12.0 | 0.14 | 14.0 |
| Subtotal | 500 | 34.5 | | 60.0 | | 70.0 |
| 6-10 | 500 | 34.5 | 0.12 | 60.0 | 0.14 | 70.0 |
| 11-Plus | 450 | 31.0 | 0.12 | 54.0 | 0.14 | 63.0 |
| Total | 1,450 | 100.0 | | 174.0 | | 203.0 |

Load Reductions Calculations Data Based on Zhang 2012

## 5.0 TECHNICAL AND FINANCIAL ASSISTANCE NEEDED

The Day Conservation District is the lead sponsor and administratively responsible for the project implementation. The 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 other counties supporting the project (Grant, Marshall, Roberts) will appoint members to serve on the Advisory Council. 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; James River Water Development District; East Dakota Water Development District; the SD Association of Conservation Districts; Pickerel Lake Conservancy; South Dakota Lakes and Streams Association; SD Department of Agriculture Resource Conservation and Forestry Divisions; SD Department of Environment and Natural Resources; US Environmental Protection Agency; US Fish & Wildlife Service – Waubay National Wildlife Refuge; Sisseton Wahpeton Oyate Office of Environmental Protection; Pheasants Forever; Prairie Coteau Habitat Partnership; Nature Conservancy in South Dakota; and the US Natural Resources Conservation Service.

The Greater Pickerel Lake Association, Clear Lake Betterment Association, Enemy Swim Sanitary Sewer District, and the City of Pierpont provided local cash for water quality studies of Clear Lake, Enemy Swim Lake, Pickerel Lake, and Pierpont Dam. The James River Water Development District (WDD) provided a one-to-one match for local cash generated by the Marshall Conservation District. The East Dakota WDD has provided funding for the Segment 2 implementation and proposed Segment 3. The East Dakota WDD also assisted with water quality studies in the Upper Minnesota River Basin which became part of the NEGL project in 2010.

Best Management Practices (BMPs) were funded by the SD Department of Environment and Natural Resources through Environmental Protection Agency 319 funds, and they provided oversight of all project activities. The SD Department of Agriculture also provided funding and technical assistance through the SD Coordinated Soil and Water Conservation Commission Grant. The SD Department of Game, Fish, and Parks provided technical advice and cost-share funds through their Private Lands Technical Assistance Programs and their Wildlife Partnership and Wetland and Grassland Habitat Programs. SD-GF&P also provided additional land rental payments for producers enrolled in the Conservation Reserve program (CRP) through the Conservation Reserve Enhancement Program (CREP) in the James River watershed. The South Dakota State University Water Resources Institute (WRI) provided technical advice for water quality testing, analysis of water samples, personnel for water sampling and the Lakes-Are-Cool Program, and funding of water festivals and ecology workshops.

Additional funding sources for the implementation of the BMPs will be solicited from other programs such as the: USDA-FSA, Conservation Reserve and Continuous Conservation Reserve Programs (CRP and CCRP); USDI-FWS - Annual appropriation for SD habitat projects; USDI-EPA Clean Water Act Section 319 Implementation Project grants; USDA-NRCS Environmental Quality Incentive Program and Wetland Reserve Program; USDI-FWS Grassland and Wetland Easement Programs and Partners for Fish and Wildlife Program; and SD Extension Service.

The Northeast Glacial Lakes watershed impairments 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 the local county field offices. 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 2013 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 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. The tables in Section 5 do not include the BMPs needed or the costs associated with the BMPs for the Little Minnesota River Basin. The BMP data for the Little Minnesota River Basin are presented in the Upper Minnesota River Watershed Five Year Strategic Plan (Lebeda 2012).

| Table 5-1. Technical and Financial Resources Needed | | | | | Year 1 | | | |
|---|---|---|---|---|---|---|---|---|
| Year | BMP - Animal Waste management System | | | | BMP - Prescribed Grazing | | | |
| 1 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Engineer Design | $ 20,000 | 2 | $ 40,000 | Grazing System, AC | $ 5 | 2,900 | $ 14,500 |
| | AWSF | $200,000 | 2 | $ 400,000 | Rural Water, EA | $ 2,500 | 7 | $ 17,500 |
| | Const Mgmt | $ 18,750 | 2 | $ 37,500 | Pipeline, LF | $ 2 | 14,000 | $ 28,000 |
| | NMP | $ 2,500 | 1 | $ 2,500 | Tanks, EA | $ 1,000 | 14 | $ 14,000 |
| | Cultural Study | $ 500 | 2 | $ 1,000 | Fencing, LF | $ 1 | 10,000 | $ 10,000 |
| | | | | $ 481,000 | | | | $ 84,000 |
| Year | BMP - Riparian Areas | | | | BMP - Bank Stabilization | | | |
| 1 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Grazing AC | $ 83 | 10 | $ 830 | Rock, Fabric/LF | $ 35 | 2,640 | $ 92,400 |
| | Fencing LF | $ 1 | 2,640 | $ 2,640 | | | | $ - |
| | | | | $ 3,470 | | | | $ 92,400 |
| Year | BMP - Residue & Tillage Manage | | | | BMP - Grassed Waterways | | | |
| 1 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 24 | 9,900 | $ 237,600 | Dirt Work, Seed/AC | $2,100 | 18 | $ 37,800 |
| | | | | $ 237,600 | | | | $ 37,800 |
| Year | BMP - Wetlands, Ponds, Sed Basins | | | | BMP - Cropland Conversion to Forage Plantings | | | |
| 1 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Dirt Work/Seed EA | $ 4,900 | 4 | $ 19,600 | Tillage/Seeding AC | $ 65 | 180 | $ 11,700 |
| | | | | $ 19,600 | | | | $ 11,700 |
| Year | BMP - Rotation/Cover Crop on Cropland | | | | BMP - Nutrient Manage Plan, Non AWMS | | | |
| 1 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 35 | 8,760 | $ 306,600 | Cost Incentive/AC | $ 4.00 | 5,100 | $ 20,400 |
| | | | | $ 306,600 | | | | $ 20,400 |
| Year | BMP - Windbreak/Shelterbelt | | | | BMP - Filter Strips, Non-CRP | | | |
| 1 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $545 | 40 | $ 21,800 | Cost Incentive/AC | $ 65 | 20 | $ 1,300 |
| | | | | $ 21,800 | | | | $ 1,300 |
| Year | | | | | Brush Management | | | |
| 1 | | | | | Components | Costs | Quantity | Total Costs |
| | | | | | Cost Incentive/AC | $ 325 | 100 | $ 32,500 |
| | | | | | | | | $ 32,500 |
| | | | | | TOTAL BMP COSTS | | | $ 1,350,170 |

| Table 5-2. Technical and Financial Resources Needed | | | | | Year 2 | | | |
|---|---|---|---|---|---|---|---|---|
| Year | BMP - Animal Waste management System | | | | BMP - Prescribed Grazing | | | |
| 2 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Engineer Design | $ 20,000 | 4 | $ 80,000 | Grazing System, AC | $ 5 | 2,900 | $ 14,500 |
| | AWSF | $200,000 | 2 | $ 400,000 | Rural Water, EA | $ 2,500 | 7 | $ 17,500 |
| | Const Mgmt | $ 18,750 | 2 | $ 37,500 | Pipeline, LF | $ 2 | 14,000 | $ 28,000 |
| | NMP | $ 2,500 | 2 | $ 5,000 | Tanks, EA | $ 1,000 | 14 | $ 14,000 |
| | Cultural Study | $ 500 | 4 | $ 2,000 | Fencing, LF | $ 1 | 10,000 | $ 10,000 |
| | | | | $ 524,500 | | | | $ 84,000 |
| Year | BMP - Riparian Areas | | | | BMP - Bank Stabilization | | | |
| 2 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Grazing AC | $ 83 | 10 | $ 830 | Rock, Fabric/LF | $ 35 | 2,640 | $ 92,400 |
| | Fencing LF | $ 1 | 2,640 | $ 2,640 | | | | $ - |
| | | | | $ 3,470 | | | | $ 92,400 |
| Year | BMP - Residue & Tillage Manage | | | | BMP - Grassed Waterways | | | |
| 2 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 24 | 9,900 | $ 237,600 | Dirt Work, Seed/AC | $2,100 | 18 | $ 37,800 |
| | | | | $ 237,600 | | | | $ 37,800 |
| Year | BMP - Wetlands, Ponds, Sed Basins | | | | BMP - Cropland Conversion to Forage Plantings | | | |
| 2 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Dirt Work/Seed EA | $ 4,900 | 4 | $ 19,600 | Tillage/Seeding AC | $ 65 | 180 | $ 11,700 |
| | | | | $ 19,600 | | | | $ 11,700 |
| Year | BMP - Rotation/Cover Crop on Cropland | | | | BMP - Nutrient Manage Plan, Non AWMS | | | |
| 2 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 35 | 8,760 | $ 306,600 | Cost Incentive/AC | $ 4.00 | 5,100 | $ 20,400 |
| | | | | $ 306,600 | | | | $ 20,400 |
| Year | BMP - Windbreak/Shelterbelt | | | | BMP - Filter Strips, Non-CRP | | | |
| 2 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $545 | 40 | $ 21,800 | Cost Incentive/AC | $ 65 | 20 | $ 1,300 |
| | | | | $ 21,800 | | | | $ 1,300 |
| Year | | | | | Brush Management | | | |
| 2 | | | | | Components | Costs | Quantity | Total Costs |
| | | | | | Cost Incentive/AC | $ 325 | 100 | $ 32,500 |
| | | | | | | | | $ 32,500 |
| | | | | | TOTAL BMP COSTS | | | $ 1,393,670 |

| Table 5-3. Technical and Financial Resources Needed | | | | | Year 3 | | | |
|---|---|---|---|---|---|---|---|---|
| Year | BMP - Animal Waste management System | | | | BMP - Prescribed Grazing | | | |
| 3 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Engineer Design | $ 20,000 | 2 | $ 40,000 | Grazing System, AC | $ 5 | 2,900 | $ 14,500 |
| | AWSF | $200,000 | 2 | $ 400,000 | Rural Water, EA | $ 2,500 | 7 | $ 17,500 |
| | Const Mgmt | $ 18,750 | 2 | $ 37,500 | Pipeline, LF | $ 2 | 14,000 | $ 28,000 |
| | NMP | $ 2,500 | 3 | $ 7,500 | Tanks, EA | $ 1,000 | 14 | $ 14,000 |
| | Cultural Study | $ 500 | 2 | $ 1,000 | Fencing, LF | $ 1 | 10,000 | $ 10,000 |
| | | | | $ 486,000 | | | | $ 84,000 |
| Year | BMP - Riparian Areas | | | | BMP - Bank Stabilization | | | |
| 3 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Grazing AC | $ 83 | 10 | $ 830 | Rock, Fabric/LF | $ 35 | 2,640 | $ 92,400 |
| | Fencing LF | $ 1 | 2,640 | $ 2,640 | | | | $ - |
| | | | | $ 3,470 | | | | $ 92,400 |
| Year | BMP - Residue & Tillage Manage | | | | BMP - Grassed Waterways | | | |
| 3 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 24 | 9,900 | $ 237,600 | Dirt Work, Seed/AC | $2,100 | 18 | $ 37,800 |
| | | | | $ 237,600 | | | | $ 37,800 |
| Year | BMP - Wetlands, Ponds, Sed Basins | | | | BMP - Cropland Conversion to Forage Plantings | | | |
| 3 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Dirt Work/Seed EA | $ 4,900 | 4 | $ 19,600 | Tillage/Seeding AC | $ 65 | 180 | $ 11,700 |
| | | | | $ 19,600 | | | | $ 11,700 |
| Year | BMP - Rotation/Cover Crop on Cropland | | | | BMP - Nutrient Manage Plan, Non AWMS | | | |
| 3 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 35 | 8,760 | $ 306,600 | Cost Incentive/AC | $ 4.00 | 5,100 | $ 20,400 |
| | | | | $ 306,600 | | | | $ 20,400 |
| Year | BMP - Windbreak/Shelterbelt | | | | BMP - Filter Strips, Non-CRP | | | |
| 3 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $545 | 40 | $ 21,800 | Cost Incentive/AC | $ 65 | 20 | $ 1,300 |
| | | | | $ 21,800 | | | | $ 1,300 |
| Year | | | | | Brush Management | | | |
| 3 | | | | | Components | Costs | Quantity | Total Costs |
| | | | | | Cost Incentive/AC | $ 325 | 100 | $ 32,500 |
| | | | | | | | | $ 32,500 |
| | | | | | TOTAL BMP COSTS | | | $ 1,355,170 |

| 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 | 1 | $ 20,000 | Grazing System, AC | $ 5 | 2,900 | $ 14,500 |
| | AWSF | $200,000 | 2 | $ 400,000 | Rural Water, EA | $ 2,500 | 7 | $ 17,500 |
| | Const Mgmt | $ 18,750 | 2 | $ 37,500 | Pipeline, LF | $ 2 | 14,000 | $ 28,000 |
| | NMP | $ 2,500 | 2 | $ 5,000 | Tanks, EA | $ 1,000 | 14 | $ 14,000 |
| | Cultural Study | $ 500 | 1 | $ 500 | Fencing, LF | $ 1 | 10,000 | $ 10,000 |
| | | | | $ 463,000 | | | | $ 84,000 |
| Year | BMP - Riparian Areas | | | | BMP - Bank Stabilization | | | |
| 4 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Grazing AC | $ 83 | 10 | $ 830 | Rock, Fabric/LF | $ 35 | 2,640 | $ 92,400 |
| | Fencing LF | $ 1 | 2,640 | $ 2,640 | | | | $ - |
| | | | | $ 3,470 | | | | $ 92,400 |
| Year | BMP - Residue & Tillage Manage | | | | BMP - Grassed Waterways | | | |
| 4 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 24 | 9,900 | $ 237,600 | Dirt Work, Seed/AC | $2,100 | 18 | $ 37,800 |
| | | | | $ 237,600 | | | | $ 37,800 |
| Year | BMP - Wetlands, Ponds, Sed Basins | | | | BMP - Cropland Conversion to Forage Plantings | | | |
| 4 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Dirt Work/Seed EA | $ 4,900 | 4 | $ 19,600 | Tillage/Seeding AC | $ 65 | 180 | $ 11,700 |
| | | | | $ 19,600 | | | | $ 11,700 |
| Year | BMP - Rotation/Cover Crop on Cropland | | | | BMP - Nutrient Manage Plan, Non AWMS | | | |
| 4 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 35 | 8,760 | $ 306,600 | Cost Incentive/AC | $ 4.00 | 5,100 | $ 20,400 |
| | | | | $ 306,600 | | | | $ 20,400 |
| Year | BMP - Windbreak/Shelterbelt | | | | BMP - Filter Strips, Non-CRP | | | |
| 4 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $545 | 40 | $ 21,800 | Cost Incentive/AC | $ 65 | 20 | $ 1,300 |
| | | | | $ 21,800 | | | | $ 1,300 |
| Year | | | | | Brush Management | | | |
| 4 | | | | | Components | Costs | Quantity | Total Costs |
| | | | | | Cost Incentive/AC | $ 325 | 100 | $ 32,500 |
| | | | | | | | | $ 32,500 |
| | | | | | TOTAL BMP COSTS | | | $ 1,332,170 |

| Table 5-5. Technical and Financial Resources Needed | | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Year | BMP - Animal Waste management System | | | | BMP - Prescribed Grazing | | | |
| 5 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Engineer Design | $ 20,000 | 1 | $ 20,000 | Grazing System, AC | $ 5 | 2,900 | $ 14,500 |
| | AWSF | $200,000 | 2 | $ 400,000 | Rural Water, EA | $ 2,500 | 7 | $ 17,500 |
| | Const Mgmt | $ 18,750 | 2 | $ 37,500 | Pipeline, LF | $ 2 | 14,000 | $ 28,000 |
| | NMP | $ 2,500 | 2 | $ 5,000 | Tanks, EA | $ 1,000 | 14 | $ 14,000 |
| | Cultural Study | $ 500 | 1 | $ 500 | Fencing, LF | $ 1 | 10,000 | $ 10,000 |
| | | | | $ 463,000 | | | | $ 84,000 |
| Year | BMP - Riparian Areas | | | | BMP - Bank Stabilization | | | |
| 5 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Grazing AC | $ 83 | 10 | $ 830 | Rock, Fabric/LF | $ 35 | 2,640 | $ 92,400 |
| | Fencing LF | $ 1 | 2,640 | $ 2,640 | | | | $ - |
| | | | | $ 3,470 | | | | $ 92,400 |
| Year | BMP - Residue & Tillage Manage | | | | BMP - Grassed Waterways | | | |
| 5 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 24 | 9,900 | $ 237,600 | Dirt Work, Seed/AC | $2,100 | 18 | $ 37,800 |
| | | | | $ 237,600 | | | | $ 37,800 |
| Year | BMP - Wetlands, Ponds, Sed Basins | | | | BMP - Cropland Conversion to Forage Plantings | | | |
| 5 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Dirt Work/Seed EA | $ 4,900 | 4 | $ 19,600 | Tillage/Seeding AC | $ 65 | 180 | $ 11,700 |
| | | | | $ 19,600 | | | | $ 11,700 |
| Year | BMP - Rotation/Cover Crop on Cropland | | | | BMP - Nutrient Manage Plan, Non AWMS | | | |
| 5 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $ 35 | 8,760 | $ 306,600 | Cost Incentive/AC | $ 4.00 | 5,100 | $ 20,400 |
| | | | | $ 306,600 | | | | $ 20,400 |
| Year | BMP - Windbreak/Shelterbelt | | | | BMP - Filter Strips, Non-CRP | | | |
| 5 | Components | Costs | Quantity | Total Costs | Components | Costs | Quantity | Total Costs |
| | Cost Incentive/AC | $545 | 40 | $ 21,800 | Cost Incentive/AC | $ 65 | 20 | $ 1,300 |
| | | | | $ 21,800 | | | | $ 1,300 |
| Year | | | | | Brush Management | | | |
| 5 | | | | | Components | Costs | Quantity | Total Costs |
| | | | | | Cost Incentive/AC | $ 325 | 100 | $ 32,500 |
| | | | | | | | | $ 32,500 |
| | | | | | TOTAL BMP COSTS | | | $ 1,332,170 |

| TABLE 5-6. SUMMARY OF 5 YEAR COSTS - NORTHEAST GLACIAL LAKES | | | | | | |
|---|---|---|---|---|---|---|
| BMP IMPLEMENTATION COSTS | YEAR 1 | YEAR 2 | YEAR 3 | YEAR 4 | YEAR 5 | TASK TOTAL |
| Animal Waste Manage System | $481,000 | $524,500 | $486,000 | $463,000 | $463,000 | $2,417,500 |
| Prescribed Grazing | $84,000 | $84,000 | $84,000 | $84,000 | $84,000 | $420,000 |
| Riparian Area | $3,470 | $3,470 | $3,470 | $3,470 | $3,470 | $17,350 |
| Bank Stabilization | $92,400 | $92,400 | $92,400 | $92,400 | $92,400 | $462,000 |
| Residue & Tillage Manage | $237,600 | $237,600 | $237,600 | $237,600 | $237,600 | $1,188,000 |
| Grassed Waterways | $37,800 | $37,800 | $37,800 | $37,800 | $37,800 | $189,000 |
| Wetland/Pond/Basin Restoration | $19,600 | $19,600 | $19,600 | $19,600 | $19,600 | $98,000 |
| Cropland Conversion to Grass | $11,700 | $11,700 | $11,700 | $11,700 | $11,700 | $58,500 |
| Conservation Cover Crop & Rotation | $306,600 | $306,600 | $306,600 | $306,600 | $306,600 | $1,533,000 |
| Nutrient Manage Plan, Non AWMS | $20,400 | $20,400 | $20,400 | $20,400 | $20,400 | $102,000 |
| Windbreak/Shelterbelt | $21,800 | $21,800 | $21,800 | $21,800 | $21,800 | $109,000 |
| Filter Strips Non-CRP | $1,300 | $1,300 | $1,300 | $1,300 | $1,300 | $6,500 |
| Brush Management | $32,500 | $32,500 | $32,500 | $32,500 | $32,500 | $162,500 |
| BMP SUB TOTAL COSTS | $1,350,170 | $1,393,670 | $1,355,170 | $1,332,170 | $1,332,170 | $6,763,350 |
| | | | | | | |
| PERSONNEL SUPPORT | | | | | | |
| Project Coordinator | $60,000 | $61,800 | $63,700 | $65,600 | $67,600 | $318,700 |
| Admin. Assistant | $40,000 | $41,200 | $42,400 | $43,700 | $45,000 | $212,300 |
| OPERATIONS | | | | | | |
| Vehicle, Fuel, Travel, Insurance | $12,000 | $13,300 | $14,700 | $16,000 | $17,300 | $73,300 |
| ADMINISTRATION | | | | | | |
| Computer, Supplies, Telephone, | $8,700 | $9,300 | $10,000 | $10,700 | $11,300 | $50,000 |
| RC&D Office, Postage | | | | | | |
| PERS/ADMIN SUB TOTAL COSTS | $120,700 | $125,600 | $130,800 | $136,000 | $141,200 | $654,300 |
| | | | | | | |
| YEARLY TOTALS | $1,470,870 | $1,519,270 | $1,485,970 | $1,468,170 | $1,473,370 | $7,417,650 |

## 6.0 PUBLIC OUTREACH

The Northeast Glacial Lake Watershed Improvement and Protection Project, Segment 1, was initiated in May, 2007 to restore and protect the water quality of northeast South Dakota glacial lakes. The main nonpoint water quality concerns were fecal coliform bacteria, nutrients, and sediments carried by runoff from agricultural lands located in the watersheds. Segment 1 was the first segment of a multi-year locally led effort to implement best management practices to build on previous watershed assessments and water quality improvements realized from previous implementation projects (Skadsen 2010).

The Day Conservation District is currently the project sponsor and will be responsible for the completion of the goals, objectives, and tasks of the NEGL project. An Advisory Council was developed consisting of local, state, tribal, and federal partners to oversee project activities, develop a project strategy, implement Best Management Practices, implement a public outreach program, and to tract project milestones and progress.

Public involvement was sought by the local Soil and Water Conservation Districts, who encouraged the public to be participants in Local Work Groups (LWG). These LWGs are sponsored by each of the four counties' Soil and Water Conservation Districts in the NEGL watershed. 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.

A project website (http://www.neglwatersheds.org) was developed and maintained to inform and educate the public on project opportunities and activities. This website will be continually updated with a goal of 1,200 hits for the current Segment 2 project. Eight news articles and four radio/television interviews were completed in Segment 1, with 20 being planned for Segments 2 and 3. The "Lakes Are Cool" program was attended by five area schools for 5th and 6$^{th}$ grade students to allow students to experience hands-on water testing and assessment of a lake ecosystem and to learn water based recreational skills. This program was also made available to the Ne-So-Dak Environmental Learning Center located on Enemy Swim Lake.

Project brochures were published and handed out to producers at USDA field offices located in Britton, Sisseton, and Webster. Eight project fact sheets were written for this project and included topics titled: Shoreline Restoration Procedures and Permits; Riparian Buffers for Lakes, Streams, and Rivers; On-Site-Septic Systems Along Shoreline Properties; Surface Water Pollution from Livestock; Reducing Nonpoint Source Pollution – Protection Tips for Lake Property Owners; Water Wise Boating –Tips for Reducing Nonpoint Source Pollution from Boats and Jet Skis; and facts on Pickerel and Enemy Swim Lakes. These brochures were made available at six county farm and home shows in Day County, Sisseton Winter Show, and the

Britton Winter Festival during 2008 and 2009. Four of these brochures will be updated and four new brochures developed in Segment 2. The NRCS offices are usually co-located with the CD, and staff from these offices will be utilized to disseminate this information to producers

## 7.0 IMPLEMENTATION SCHEDULE

The implementation of this project will be through voluntary programs with producers and landowners over the four county-wide NEGL watershed area and will be managed 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 an office located in each county that does business with the landowners and agricultural producers. The BMPs will be implemented with funding as available from local funding sources, South Dakota Conservation Commission funds, South Dakota Consolidated Funds, the USDA programs, and EPA 319 funds. The implementation schedule for BMPs, project outreach, task assignments, and project reports is detailed semi-annually in Table 7-1. The Section 7 table does not include the schedules associated with the BMPs, Information Outreach, or Project Reports for the Upper Minnesota River Basin.

| 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 | | 10 | | 2 | 2 | 2 | | 2 | | 1 | 1 | |
| Animal Waste Storage Facilities | | 10 | | 2 | | 2 | | 2 | | 2 | | 2 |
| Construction Management | | 10 | | 2 | | 2 | | 2 | | 2 | | 2 |
| Nutrient Management Plan | | 10 | | 1 | | 2 | 1 | 2 | | 2 | | 2 |
| Cultural Resource Study | | 10 | | 2 | 2 | 2 | 1 | 1 | | 1 | | 1 |
| Task 2: Grassland Management | 1,2,4 | | | | | | | | | | | |
| Product 2: Prescribed Grazing Systems (Ac) | | 14,500 | | 2,900 | | 2,900 | | 2,900 | | 2,900 | | 2,900 |
| Product 3: Riparian Areas (Ac) | | 50 | | 10 | | 10 | | 10 | | 10 | | 10 |
| Product 4: Brush Management (Ac) | | 500 | | 100 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Task 3: Streambank Stabilization | 2,4 | | | | | | | | | | | |
| Product 5: Streambank Stabilization (LF) | | 13,200 | | 2,640 | | 2,640 | | 2,640 | | 2,640 | | 2,640 |
| Task 4: Cropland Management | 1,2,4 | | | | | | | | | | | |
| Product 6: Residue & Tillage Manage (Ac) | | 49,500 | | 9,900 | 4,900 | 5,000 | 4,900 | 5,000 | 4,900 | 5,000 | 4,900 | 5,000 |
| Product 7: Grassed Waterways (AC) | | 90 | | 18 | | 18 | | 18 | | 18 | | 18 |
| Product 8: Wetland & Pond Construct (No) | | 20 | | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Product 9: Conversion of Crop to Grass (Ac) | | 900 | | 180 | | 180 | | 180 | | 180 | | 180 |
| Product 10: Conservation Rotation/Cover Crop (Ac) | | 43,800 | | 8,760 | | 8,760 | | 8,760 | | 8,760 | | 8,760 |
| Product 11: Cropland NMP (Ac) | | 25,500 | | 5,100 | 3,000 | 2,100 | 3,000 | 2,100 | 3,000 | 2,100 | 3,000 | 2,100 |
| Product 12: Windbreak/Shelterbelt (Ac) | | 200 | | 40 | | 40 | | 40 | | 40 | | 40 |
| Product 14: Filter Strips, Non-CRP (Ac) | | 100 | | 20 | | 20 | | 20 | | 20 | | 20 |
| OBJECTIVE 2: INFORMATION OUTREACH | | | | | | | | | | | | |
| Task 5: Information Distribution | | | | | | | | | | | | |
| Product 15: Articles, Newsletter, Radio, WEB | 1,2,3,4 | | | | | | | | | | | |
| CD Newsletters | | 15 | | 3 | | 3 | | 3 | | 3 | | 3 |
| Newspaper Articles | | 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Radio Spots | | 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| OBJECTIVE 3: PROJECT REPORTS | | | | | | | | | | | | |
| Task 6: Semi-annual, Annual, Final | | | | | | | | | | | | |
| Product 16: Reports | 1,2 | | | | | | | | | | | |
| Monthly/Semi Monthly Progress/Financial Report | | 60 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Annual Reports | | 5 | | 1 | | 1 | | 1 | | 1 | | 1 |
| Final Report | | 1 | | | | | | | | | | 1 |

# 8.0 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*, nutrients, Chlorophyll-*a*, pH, TSS, and dissolved oxygen. 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 NEGL 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 published in an annual report sent to all cooperating agencies and made available to residents of the watershed. The project Advisory Council 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. The Short-term Criteria and Milestones presented in Table 8-1 does not include the goals associated with the BMPs or Activities for the Upper Minnesota River Basin.

| Table 8-1. Short-term Criteria & Milestones | | | | Year 2 | | Year 3 | | Year 4 | | Project |
|---|---|---|---|---|---|---|---|---|---|---|
| BMP or Activity | Quantity | Year 1 | Year 2 | Subtotal | Year 3 | Subtotal | Year 4 | Subtotal | Year 5 | Totals |
| Engineering Studies - AWMS | 10 No. | 2 | 4 | 6 | 2 | 8 | 1 | 9 | 1 | 10 |
| Animal Waste Storage Facilities | 10 No. | 2 | 2 | 4 | 2 | 6 | 2 | 8 | 2 | 10 |
| Construction Management - AWMS | 10 No. | 2 | 2 | 4 | 2 | 6 | 2 | 8 | 2 | 10 |
| Nutrient Management Plan | 10 No. | 1 | 2 | 3 | 3 | 6 | 2 | 8 | 2 | 10 |
| Cultural Resource Study - AWMS | 10 No. | 2 | 4 | 6 | 2 | 8 | 1 | 9 | 1 | 10 |
| Prescribed Grazing Systems | 14,500 Ac. | 2,900 | 2,900 | 5,800 | 2,900 | 8,700 | 2,900 | 11,600 | 2,900 | 14,500 |
| Riparian Areas | 50 Ac. | 10 | 10 | 20 | 10 | 30 | 10 | 40 | 10 | 50 |
| Brush Management | 500 Ac. | 100 | 100 | 200 | 100 | 300 | 100 | 400 | 100 | 500 |
| Streambank Stabilization | 13,200 Ac. | 2,640 | 2,640 | 5,280 | 2,640 | 7,920 | 2,640 | 10,560 | 2,640 | 13,200 |
| Residue & Tillage Manage | 49,500 Ac. | 9,900 | 9,900 | 19,800 | 9,900 | 29,700 | 9,900 | 39,600 | 9,900 | 49,500 |
| Grassed Waterways | 90 Ac. | 18 | 18 | 36 | 18 | 54 | 18 | 72 | 18 | 90 |
| Wetland/Pond/Basin Construction | 20 No. | 4 | 4 | 8 | 4 | 12 | 4 | 16 | 4 | 20 |
| Conversion of Crop to Grass | 900 Ac. | 180 | 180 | 360 | 180 | 540 | 180 | 720 | 180 | 900 |
| Conservation Cover & Crop Rotation | 43,800 Ac. | 8,760 | 8,760 | 17,520 | 8,760 | 26,280 | 8,760 | 35,040 | 8,760 | 43,800 |
| Nutrient Management Plan Crop | 25,500 Ac. | 5,100 | 5,100 | 10,200 | 5,100 | 15,300 | 5,100 | 20,400 | 5,100 | 25,500 |
| Windbreak/Shelterbelt | 200 Ac. | 40 | 40 | 80 | 40 | 120 | 40 | 160 | 40 | 200 |
| Filter Strips Non-CRP | 100 Ac. | 20 | 20 | 40 | 20 | 60 | 20 | 80 | 20 | 100 |
| CD Newsletters | 15 | 3 | 3 | 6 | 3 | 9 | 3 | 12 | 3 | 15 |
| Newspaper Articles | 5 | 1 | 1 | 2 | 1 | 3 | 1 | 4 | 1 | 5 |
| Radio Spots | 10 | 2 | 2 | 4 | 2 | 6 | 2 | 8 | 2 | 10 |
| Semi-Montly/Monthly Reports | 60 | 12 | 12 | 24 | 12 | 36 | 12 | 48 | 12 | 60 |
| Annual Reports | 5 | 1 | 1 | 2 | 1 | 3 | 1 | 4 | 1 | 5 |
| Final | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

## 9.0 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. The AGNPS 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. In-lake water quality sampling was completed during Segment 1 (Skadsen 2010) with 32 water samples taken and analyzed. Seventy comprehensive water samples are planned to be taken in the current Segment 2 NEGL and 32 additional samples to be taken in the proposed Segment 3.

The SDDENR maintains four ambient water quality monitoring (WQM) sites within the NEGL watershed: **Brown County:** James River WQM-112, WQM-33, and WQM-34; and **Grant County:** Big Sioux River WQM-BSA1. Eight additional WQM sites are located within the Upper Minnesota River Basin. The data from these water quality monitoring stations can also be used by the project director to make comparisons of installed practices. This data can be collected from DENR on an annual basis as BMPs are installed and results evaluated. This Monitoring and Evaluation Plan presented in Section 9.0 does not include the goals associated with the Upper Minnesota River Basin.

The effectiveness of BMPs installed relative to the improvement in water quality will be evaluated using the appropriate tools and models available such as AnnAGNPS, RUSLE2, STEPL models, and GIS. The AnnAGNPS 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.

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