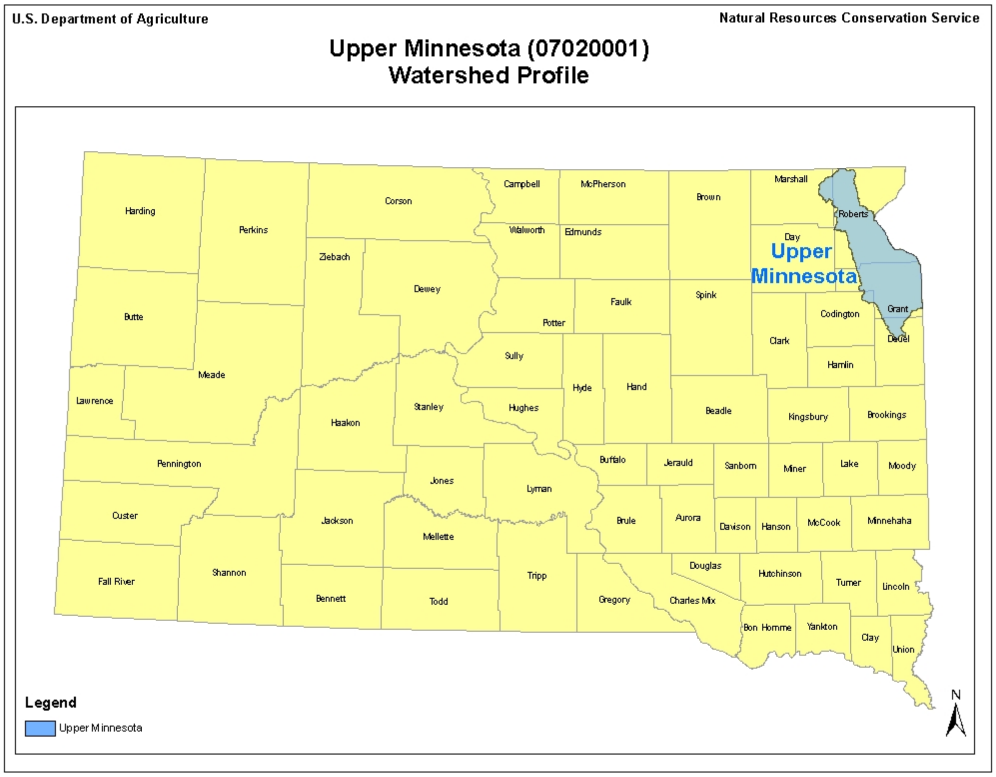
UPPER MINNESOTA RIVER WATERSHED

FIVE YEAR STRATEGIC PLAN



In Cooperation With:
East Dakota Water Development District
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 Upper Minnesota River watershed drains an area of approximately 1,637 square miles, slightly over one million acres, within the Level III Ecoregion of the Northern Glaciated Plains in northeastern South Dakota (SD). The watershed begins in the Coteau Des Prairies, near the town of Veblen in Marshall County, as the Little Minnesota River. The river flows southward, through Roberts and Grant Counties for approximately 30 miles to Big Stone Lake. The Minnesota River begins at the outlet of Big Stone Lake and forms the state boundary between South Dakota and Minnesota. The Minnesota River is reported as the most polluted river from phosphorous loading in the State of Minnesota. The Federal Water Pollution Control Administration identified surface runoff from the surrounding Big Stone Lake watershed to be the main source of nutrients and sediment in a 1967 report. The watershed is shared by the two States; as the Little Minnesota River ends when it empties into Big Stone Lake and the drainage continues at the outlet of Big Stone Lake into Minnesota as the Minnesota River. Specifically, the study identified animal feedlots, septic systems from residences along the lake shoreline, livestock watering within the lake, and poor agricultural practices as delivering nutrient and sediment loads to the lake.

Water quality efforts intensified in the early 1980's when citizens of both South Dakota and Minnesota requested assistance from both State governments and EPA to begin efforts to clean up Big Stone Lake. These citizens' efforts resulted in the Phase I study of the Little Minnesota River and Big Stone Lake in 1983. Since that date the U.S. Army Corps of Engineers (USACE) spent more than $12 million in the early 1980's to construct a new outlet control structure and sediment barrier to reduce sediment loadings to Big Stone Lake. State, federal, and local funds of approximately $3.6 million have also been spent in the Big Stone Lake watershed to help improve water quality. In addition, a series of EPA Section 314 and Section 319 grants and USDA-NRCS PL-566 and Environmental Quality Incentives Program (EQIP) funding have provided monies for local lake and watershed restoration projects. The water quality efforts continue today with the Mississippi River Basin Healthy Watersheds Initiative sponsored by the USDA-NRCS, and the Upper Minnesota River EPA 319 project sponsored by SDDENR, Day County Conservation District and their conservation partners.

The 2012 SDDENR Integrated Report list of 303(d) impaired water bodies within the Upper Minnesota River Basin included Big Stone Lake, Punished Woman Lake, the Little Minnesota River, the North Fork of the Whetstone River, the South Fork of the Whetstone River, the North Fork of the Yellow Bank River, and the South Fork of the Yellow Bank River. The causes of the 303(d) impaired listings were temperature, high pH, dissolved oxygen, and *Escherichia coli* bacteria.

The subwatershed of Punished Woman Lake was investigated by the Water Quality Assessment Phase I study completed in 1991 to identify, prioritize, and present alternatives to correct nonpoint pollution sources. This Phase I report was used by SDDENR in 2000 to established

Total Maximum Daily Loads for Punished Woman Lake. The watershed had been evaluated by the use of The Agricultural Nonpoint Source Pollution Model (AGNPS) identifying land uses in critical cells as delivering excessive coliform, nutrients, and sediments to water bodies. The importance of this study and those of other nearby watersheds is that the use of AGNPS can identify critical cells that contribute significant loading. These critical cells can be isolated and treated with Best Management Practices to reduce nutrient and sediment loading.

More recently, the North and South Forks of the Yellow Bank River were studied in the years 2010 and 2011 and reported on in the 2012 SDDENR TMDL report. The purpose of the study was to locate and evaluate sources of pollution in the watersheds of both the Yellow Bank and Whetstone Rivers. The study evaluated the possible point sources of pollution, which were municipalities with National Pollution Discharge Elimination System (NPDES) permits and private human sewage systems. The resulting determination from the Yellow Bank River was that the municipalities did not violate their NPDS permits and individual human sewage systems had very minimal effects on total nutrient and coliform bacteria loadings. Data from the Whetstone River has not been evaluated at this time. The identified nonpoint sources of pollution were mainly agricultural in nature resulting from animal feeding operations, overgrazing pastures, excessive grazing in riparian zones, direct livestock access to water bodies, livestock trampling of shorelines, and excessive erosion on cropland fields.

Nonpoint source pollution management measures have been installed and reported on by Jensen in 2007 for the Little Minnesota River / Big Stone Lake project. Best Management Practices that were identified as successful in reducing nutrient loadings were animal waste storage facilities, nutrient management plans, prescribed grazing systems, managed grazing on riparian areas, cropland conservation no-till, grassed waterways, stream bank stabilization, wetland restoration, pond construction, and the conversion of cropland to grass land. The BMPs need to be implemented on sites identified through AGNPS evaluation as critical cells. These BMP practices and their costs of implementation were calculated to reduce loadings and attain TMDL criteria for the impaired water bodies. This Strategic Implementation Plan for the Upper Minnesota River Basin details these selected BMPs and the necessary administrative costs to implement the practices and achieve the load reductions needed to improve water quality in the watershed.

1.0 INTRODUCTION

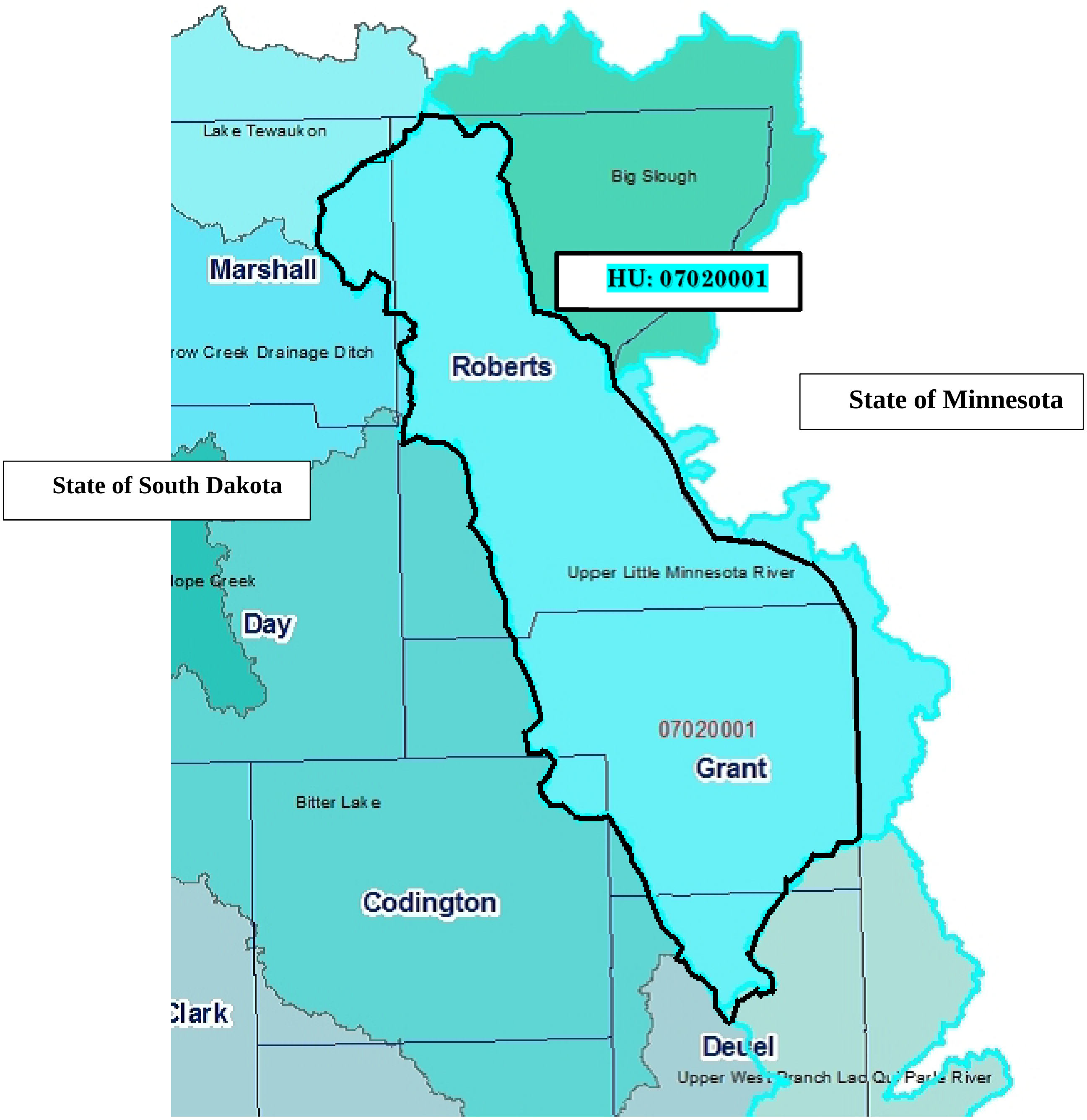
1.1 Project Background and Scope

This project encompasses the portion of the Upper Minnesota River watershed, Hydrological Unit (HU) 07020001 that lies within the northeast corner of the State of South Dakota and includes portions of the counties of Marshall, Roberts, Grant, Codington, and Deuel. The drainage system is in the Level III Northern Glaciated Plains Ecoregion and begins in South Dakota as the Little Minnesota River. The Little Minnesota River arises as an intermittent stream from the Coteau des Prairies in Marshall County, near the town of Veblen, and flows generally southeastward through Roberts County. Near the Minnesota state line, it passes within a mile of Lake Traverse and enters Minnesota at the town of Browns Valley. The river then travels southward where it flows into Big Stone Lake. From its headwaters to Big Stone Lake, a distance of 30 miles, the river drops 1,100 feet in elevation. The Little Minnesota River continues as the Minnesota River at the outlet of Big Stone Lake, eventually flowing into the Mississippi River near Saint Paul, Minnesota, outletting into the Gulf of Mexico. In the remaining 1,600 river miles from Big Stone Lake to the Gulf, the river system only drops an additional 966 feet in elevation. The region between Lake Traverse and Big Stone Lake is known as the Traverse Gap. Traverse Gap is an ancient river channel occupied by Lake Traverse, Big Stone Lake, and the valley connecting them. Traverse Gap has an unusual distinction for a valley, as it is crossed by a continental divide that separates water that flows northward to Hudson Bay, via the Red River, from waters that flow south, via the Minnesota River, to the Gulf of Mexico.

The Minnesota River begins at the outlet of Big Stone Lake and delineates the state boundary between South Dakota and Minnesota. Other tributaries of the Minnesota River that drain this HU include the North Fork and South Fork of the Whetstone Rivers' and the North Fork and South Fork of the Yellow Bank Rivers'. These tributaries flow east-northeast, crossing the South Dakota and Minnesota border, entering the Minnesota River in the State of Minnesota. The Minnesota River basin drains an area of 1,637 square miles within South Dakota. See Figure 1-1 for the HU watershed area.

The climate of the Upper Minnesota River basin in South Dakota is classified as Sub-humid Continental. The high mean temperature at Sisseton in July is 83.7 degrees Fahrenheit (^{o}F), while the low mean in January is -1.3 ^{o}F, with the average annual temperature at 54.43 ^{o}F. The high mean temperature at Milbank in July is 85.1 ^{o}F, while the low mean in January is -1.1 ^{o}F, with the average annual temperature being 54.79 ^{o}F at Milbank. The annual precipitation in Sisseton and Milbank is 23.16 and 21.24 inches, respectively. Climate conditions are relatively uniform throughout the watershed basin, which experiences all of the conditions of the 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 region experiences severe weather episodes such as tornadoes, hail storms, and blizzards in their respective seasons.

Figure 1-1. Upper Minnesota River HU 07020001 in South Dakota



The watershed is largely rural in nature with the City of Milbank having the largest population with 3,353 residents. The second largest city is Sisseton with a population of 2,470 residents. There are 17 incorporated and unincorporated cities and villages within the watershed. Table 1-1 lists the cities with populations over 200 and the county populations in the watershed. A map of the cities and counties locations and State boundaries is shown in Figure 1-2.

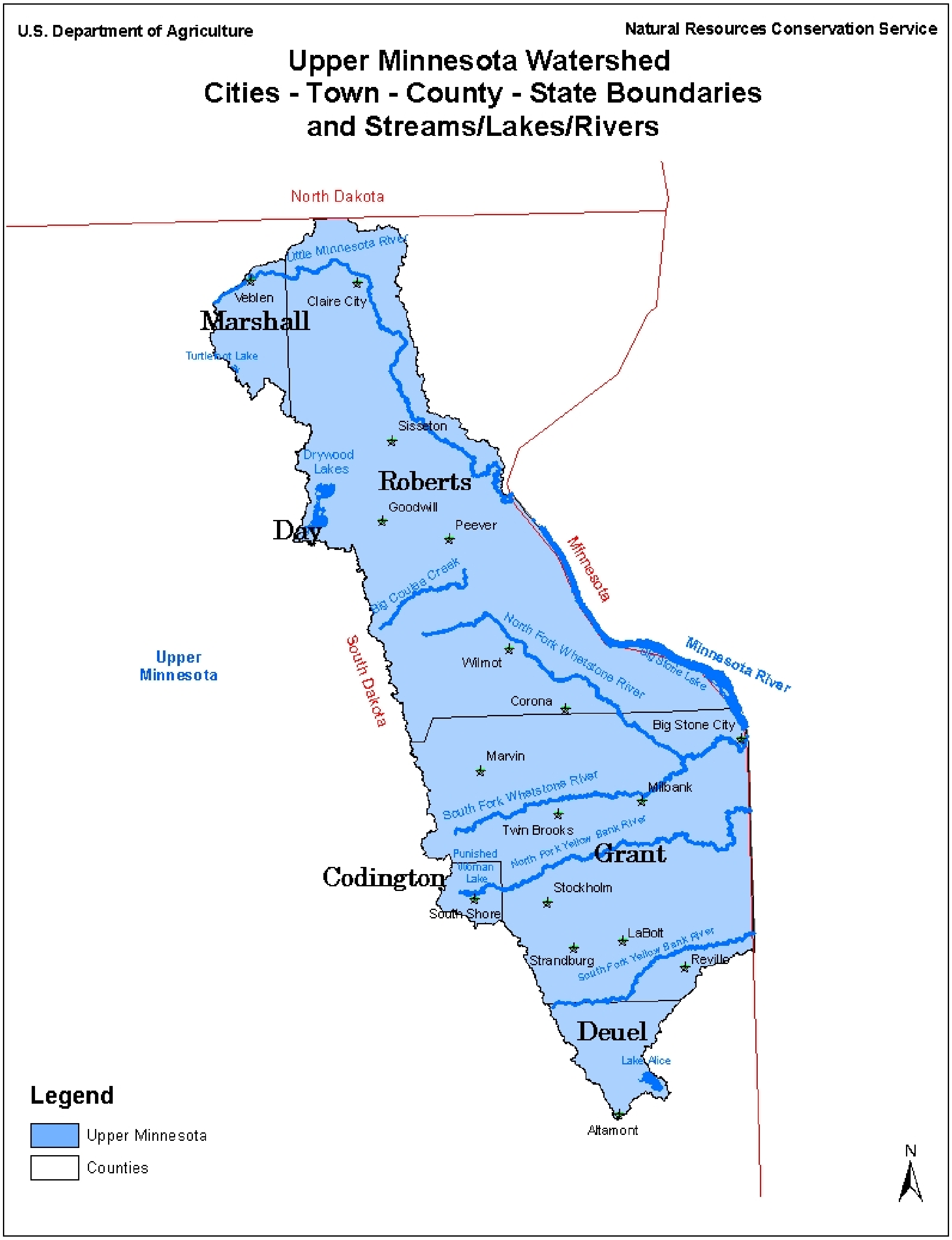
Table 1-1. Population Statistics of the Upper Minnesota River Basin in SD

Population Statistics of the Upper Minnesota River Basin in SD					
Cities with Populations Over 200 - U.S Census Bureau 2010 Census					
City	County	Population		Total County Populations	
Milbank	Grant	3,353		County	Population
Sisseton	Roberts	2,470		Codington	27,227
Wilmot	Roberts	492		Deuel	4,364
Big Stone City	Grant	467		Grant	7,356
Summit	Roberts	288		Marshall	4,655
Veblen	Marshall	281		Roberts	10,149
South Shore	Codington	227		Total	53,751

1.2 Upper Minnesota River Watershed History

The Minnesota River originates in west central Minnesota at the Minnesota-South Dakota border. It drains 16,770 square miles in Minnesota, South Dakota, North Dakota and Iowa and flows 335 miles to join the Mississippi River at Mendota, Minnesota, just south of St. Paul, Minnesota. A series of flood control dams have been built on the river beginning with the Big Stone Lake Dam constructed in 1937 as a Works Progress Administration (WPA) project during the Great Depression. The Marsh Lake Dam and the Lac qui Parle Dam were also both built as WPA projects in 1939. The U.S. House of Representatives authorized studies in May of 1962 to determine the advisability of further improvements in the Minnesota River basin for navigation, flood risk management, recreation, low-flow augmentation, and other related water and land resources. The Highway 75 Dam was finished in 1975 and is part of the U. S. Fish & Wildlife Big Stone National Wildlife Refuge. Two additional privately constructed dams for power generation are the Granite Falls Dam and the Minnesota Falls Dam, constructed in the late 1800's and 1905, respectively.

Figure 1-2. Cities, Counties, Water Bodies of the Upper Minnesota River HU in South Dakota.



The land use activities of the watershed of the Upper Minnesota River are of importance due to the emphasis placed on the water quality of the Minnesota River and its tributaries. The Minnesota River is the most polluted river from phosphorous loading in the State of Minnesota. Citizens of South Dakota and Minnesota requested assistance from both State governments and EPA in the 1980's to begin an effort to restore Big Stone Lake. The governor of Minnesota, Arnie Carlson, made a proclamation in 1992 to make the Minnesota River "swimmable and fishable in 10 years". The primary concerns then were poor water quality, excessive algae blooms, sedimentation, rooted aquatic vegetation, and the reduced recreation potential. The U.S. Army Corps of Engineers (USACE) spent more than $12 million in the early 1980's to construct a new outlet control structure and sediment barrier to reduce sediment loadings to Big Stone Lake. State, federal, and local funds of approximately $3.6 million have also been spent in the Big Stone Lake watershed to help improve water quality. Flood risk management activities have had a direct impact on flood responses in the downstream communities. The USACE has calculated that the Big Stone Lake flood control structure has prevented flood damages to the extent of $2,969,116 since its construction.

In addition, a series of EPA section 314 and section 319 grants beginning in 1983 have provided funding for local lake and watershed restoration projects. The U.S. Department of Agriculture (USDA) Environmental Quality Incentives Program (EQIP) funding is also being used to implement additional conservation practices in all watershed counties. The key partners in the Big Stone Lake Restoration Project were watershed landowners; lake residents; local county boards of supervisor, conservation districts, and municipalities; Upper Minnesota River Watershed District; East Dakota Water Development District; Citizens for Big Stone Lake; South Dakota Department of Environment and Natural Resources; Minnesota Pollution Control Agency; U.S. Environmental Protection Agency; U.S. Natural Resources Conservation Service; U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service.

Various conservation and restoration Best Management Practices (BMP) have been implemented through the Big Stone Lake restoration projects since 1987. Conservation practices in the lake's watershed include the installation of animal waste management systems, no-till planting of crops, construction of multiple-use wetlands, grassed waterways through cropland fields, stream buffer strips, stream bank stabilization, and implementation of the USDA Conservation Reserve Program. In addition, six municipal wastewater treatment facilities in the watershed have been built or upgraded.

A new lake outlet control structure and debris barrier were also constructed at the south end of Big Stone Lake. The main purpose of the structure was to divert the majority of flow from the Whetstone River away from Big Stone Lake. The Whetstone River was diverted into the lake in the 1930s to augment lake levels, but the diversion resulted in excessive nutrients and sediment being deposited in the lake. The new control structure diverted these contaminants away from the lake in accordance with the original river flow pattern. Lake area residents have continually monitored this structure and have made contact (2012) with the USACE for improvements in the structure. The results of the Big Stone Lake Restoration Project are beginning to be realized in improved water quality. Water sampling results have shown a gradual but steady improvement in recent years. The trophic status of the lake has changed from hypereutrophic (extremely nutrient-rich) to eutrophic (nutrient-rich). As a result, algae blooms are less extensive and shorter in duration.

The USACE and the State of Minnesota Environmental Quality Board entered into a feasibility cost share agreement in 2008 to study land and water management measures in the watershed. An interagency study team has been formed to coordinate the initial study activities and oversee technical analysis of the basin. The USACE plans to build hydrologic models of several sub-watersheds in 2012 within the Minnesota River basin. These models will evaluate how various land and water management measures could be used effectively throughout the basin. The Secretary of South Dakota-Department Environment and Natural Resources (SDDENR), Steve Pirner, gave written support to the USACE for these joint activities in October, 2011.

1.3 Upper Minnesota River Watershed Water Quality Studies

Water quality testing has been historically conducted on the various lakes and streams in the Upper Minnesota River basin. Analysis has revealed water quality issues of temperature, pH, dissolved oxygen, fecal coliform bacteria, total suspended solids, total phosphorous, and sedimentation. The South Dakota Department of Environment and Natural Resources Integrated Report (SDDENR-IR) 2012 shows that of the twelve water bodies identified in the report only five have approved Total Maximum Daily Loads (TMDL). The remaining water bodies either have no available data or insufficient data to make a TMDL determination. A short synopsis of the studies are as follows:

- The Punished Woman Lake watershed in Codington County was investigated and reported in *Punished Woman's Lake Watershed, Codington County, South Dakota, April 2000*, SD Department of Environment & Natural Resources, Water Resources Assistance Program, Total Maximum Daily Load. This report identified the TMDL pollutants as sediment and nutrients. Recommendations from the report were to (1) reduce in-lake sedimentation by 50 percent and (2) to reduce aquatic vegetation 50 percent by reducing in-lake nutrient rich sediment by 15 percent. The in-lake sediment deposition was a result of shoreline erosion and bank sloughing caused by construction of an eight-inch cap placed on the outlet structure in 1971 that elevated the water levels. Water quality analysis showed that the tributary waters did not exceed water quality standards of total solids, suspended solids, or dissolved solids. The 2012 SD-DENR Integrated Report listed the 303(d) impairment as high pH.

- Lake Alice was studied in the *Phase I, Watershed Assessment and Final Report, Lake Alice, Deuel County, SDDENR, July 2002*. Water quality monitoring identified this lake as fully supporting its beneficial uses without watershed or in-lake treatments to control nutrient loading. Modeling indicated that the watershed is composed primarily of grass and pastureland with approximately 96% of the total acres accounted for in hay, Conservation Reserve Program (CRP), or pasture. Prior to the inception of the CRP Program, this watershed was composed of 30% to 40% cropland. The cropland component is now less than 2% of the total watershed acres. The computer model BATHTUB calculated the Trophic State Index (TSI) for Lake Alice at 61.5; which is a eutrophic state. Forty percent of the phosphorous load entering the lake was from atmospheric deposition. The computer model indicated a 95% reduction in phosphorous levels reduced the TSI to only a 55-58 rating. It would be very unrealistic to achieve a 95% reduction in phosphorous when 40% of it is delivered by atmospheric deposition. The SDDENR-IR for the year 2000 listed Lake Alice as partially supporting the TSI and the water quality trend as 'downward'. The 2002 TMDL recommended that Lake Alice be removed from the 303(d) list; it was not listed as 303(d) impaired in the 2004 SDDENR-IR; and currently the SDDENR 2012 IR lists it as fully supporting all beneficial uses assigned to the lake.

- Big Stone Lake had historically been plagued with severe algal blooms as reported in the *Phase I Diagnostic/Feasibility Study* (SDDENR 1983). A very early EPA study (1967) reported the bloom in 1966 as being one of the worst to that date. Corrective actions recommended from that 1967 study were better agricultural tillage and rotation practices, treatment of wastes from cattle feedlots, central collection and treatment of sewage wastes from lakefront homes, and removal of livestock access to lake shore line for watering. A series of EPA section 314 and section 319 grants, beginning in 1983, have provided funding for lake and watershed restoration projects. The Environmental Quality Incentives Program funding (EQIP) is also being used to implement additional conservation practices in Roberts and Grant Counties.

- The North and South Forks of the Yellow Bank River were investigated and reported in the document *Escherichia coli Bacteria Total Maximum Daily Load Evaluations for the North and South Forks of the Yellow Bank River – Grant, Codington, and Deuel Counties, South Dakota* (SDDENR 2012). These rivers were listed as 303(d) impaired for *Escherichia coli* bacteria with the source being identified as manure from livestock. Approximately 30% of the manure was derived from animal feedlots and 70% from livestock grazing on pastures adjacent to water bodies. The results of this TMDL data are new and no implementation projects have been installed based on this TMDL report. Water quality sampling data has also been completed for the North Fork and South Fork of the Whetstone River and a TMDL will be set after the data has been analyzed.

1.4 Goals of the Upper Minnesota River Basin Strategic Plan

The goal of the strategic plan for the Upper Minnesota River Basin watershed in the State of South Dakota 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 eliminate or reduce the nutrient, sediment and fecal coliform bacteria loadings to the Minnesota River from its watershed and tributaries. In addition to the 303(d) delisting, the implementation of this plan will improve water quality, conserve the diverse characteristics of Minnesota River's waters, restore and maintain healthy aquatic ecosystems, and provide diverse recreational opportunities.

2.0 CAUSES AND SOURCES OF IMPAIRMENTS

2.0.1 Geography, Soils, and Land Use

The Upper Minnesota River Watershed basin lies with the Central Feed Grains and Livestock Region of USDA 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. Uniquely, region M is second in the total amount of water used in the U.S. Eco-regions; with about 87 percent of the use from surface water sources and 13 percent from ground water sources. Most of this watershed is in the Western Lake Section of the Central Lowland Province of the Interior Plains. The center of the Prairie Coteau, in northeastern South Dakota, is in the Dissected Till Plains section of the same province and division.

The large MRLA's are subdivided into smaller more homogeneous resource areas referred to a Common Resource Area's (CRA). The Upper Minnesota Basin watershed is entirely in the Rolling Till Prairie CRA 102A; see Figure 2-1. "Prairie pothole" lakes and ponds are common in the gently sloping areas with steeper slopes occurring on the sides of drainages and on breaks adjacent to some of the larger tributaries. Elevation generally ranges from 1,000 to 1,350 feet above sea level in the lowlands and from 1,350 to 1,650 feet on the uplands. There are isolated highs at elevations of more than 2,000 feet on the Prairie Coteau, in northeastern South Dakota. The Prairie Coteau is one of the more prominent landforms in North America with lakes, ponds, and marshes common in the area. The eastern edge of the Central Bird Migratory Flyway and the western edge of the Atlantic Bird Migratory Flyway are in this MLRA and numerous migrating waterfowl occur in the area. The watershed has many publicly owned wildlife land management areas.

The dominant landforms in this MLRA area are stagnation moraines, end moraines, glacial outwash plains, terraces, and flood plains with nearly level to rolling topography. The area is dominated by till-covered moraines. The stagnation moraines are gently undulating to steep and have many depressions with poorly defined drainages. The steepest slopes are on escarpments adjacent to some of the larger tributaries. Small outwash areas are adjacent to the watercourses. The Cretaceous Pierre Shale underlies the till in most of the area. Precambrian rocks also occur at depth. Granite is quarried at Milbank, South Dakota.

The dominant soil order in this MLRA is Mollisols. The soils in the area dominantly have a frigid soil temperature regime, an aquic or udic soil moisture regime, and mixed mineralogy. They generally are very deep, well drained to very poorly drained, and loamy. Hapludolls formed in loamy till (Barnes, Forman, and Hokans series), in loess or silty drift over till (Kranzburg, Poinsett, and Waubay series), in eolian deposits. The predominant soil associations in the watershed 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://websoilssurvey.nrcs.usda.gov for official and current USDA soil information as viewable maps and tables.

The soils are predominantly loamy, with landscapes having a complex mixture of well and poorly drained soils. The poorly drained soils developed on glacial till and loess, and tend to be clay rich with limited infiltration potential. Drainage of depressional areas is often poor and tile drainage is common. Depressional wetlands are the primary source for recharge of shallow aquifers in many areas. More than 90 percent of runoff trapped in prairie potholes is typically lost to evapotranspiration (ET). Annual potential ET exceeds precipitation in most years, which explains why most prairie wetlands undergo a wet-dry cycle each year. The land surface is a nearly level to gently sloping, dissected glaciated plain. The major soil resource concerns are water erosion, wetness, and maintenance of the content of organic matter and productivity of the soils. Wind erosion is a hazard in some of the northern parts of the region where the lighter textured soils occur. The soils and climate favor agriculture. Land use capability classes of soil are presented in Table 2-1. There are 394,900 acres of Prime Farmland in the Upper Minnesota River watershed (USDA-NRCS 1997 NRI). Protecting wildlife habitat and preserving the quality of surface water and ground water are additional concerns in many parts of this watershed.

Figure 2-1. Common Resource Area Rolling Till Area, 102A

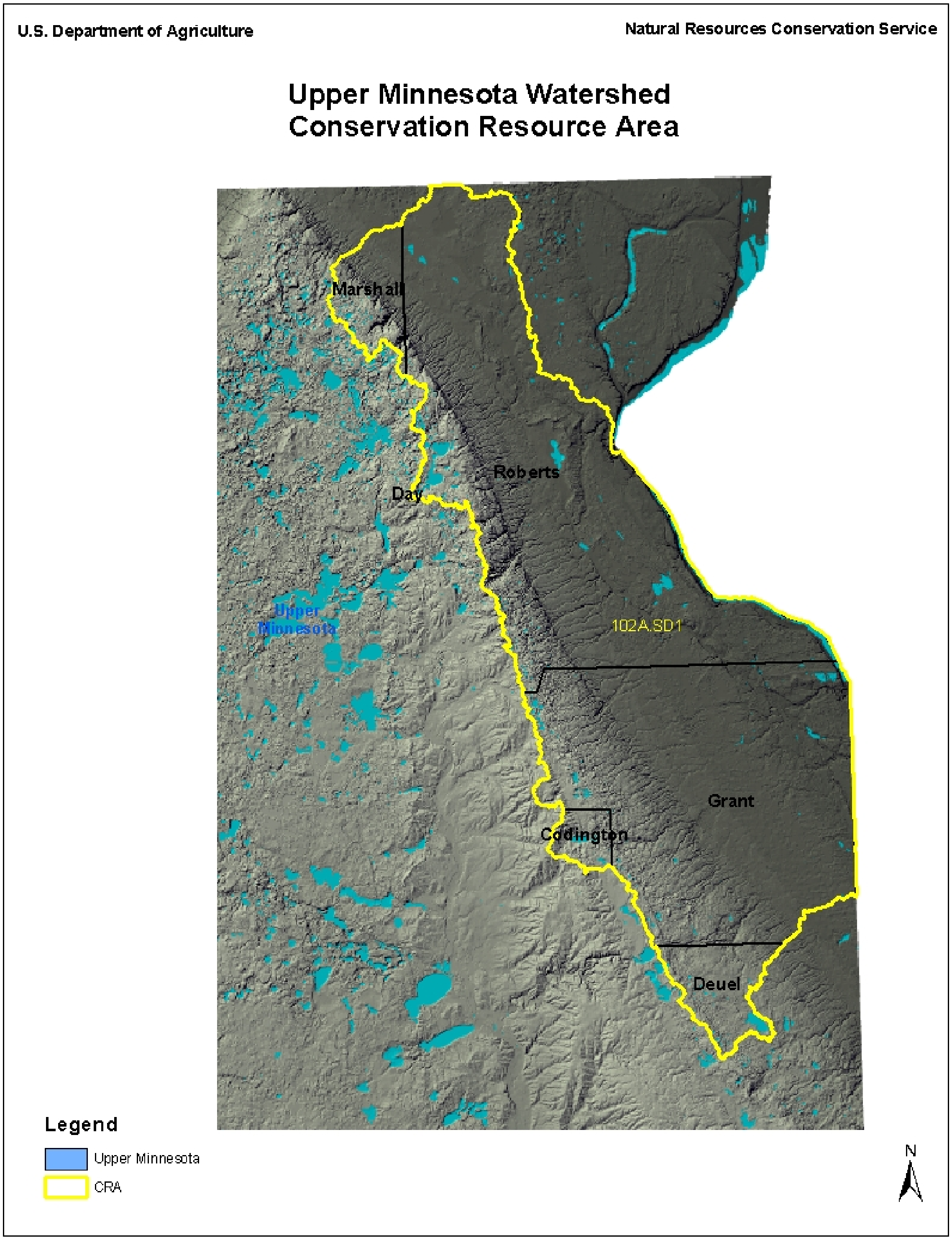


Figure 2-2 General Soils Map of the Upper Minnesota Watershed

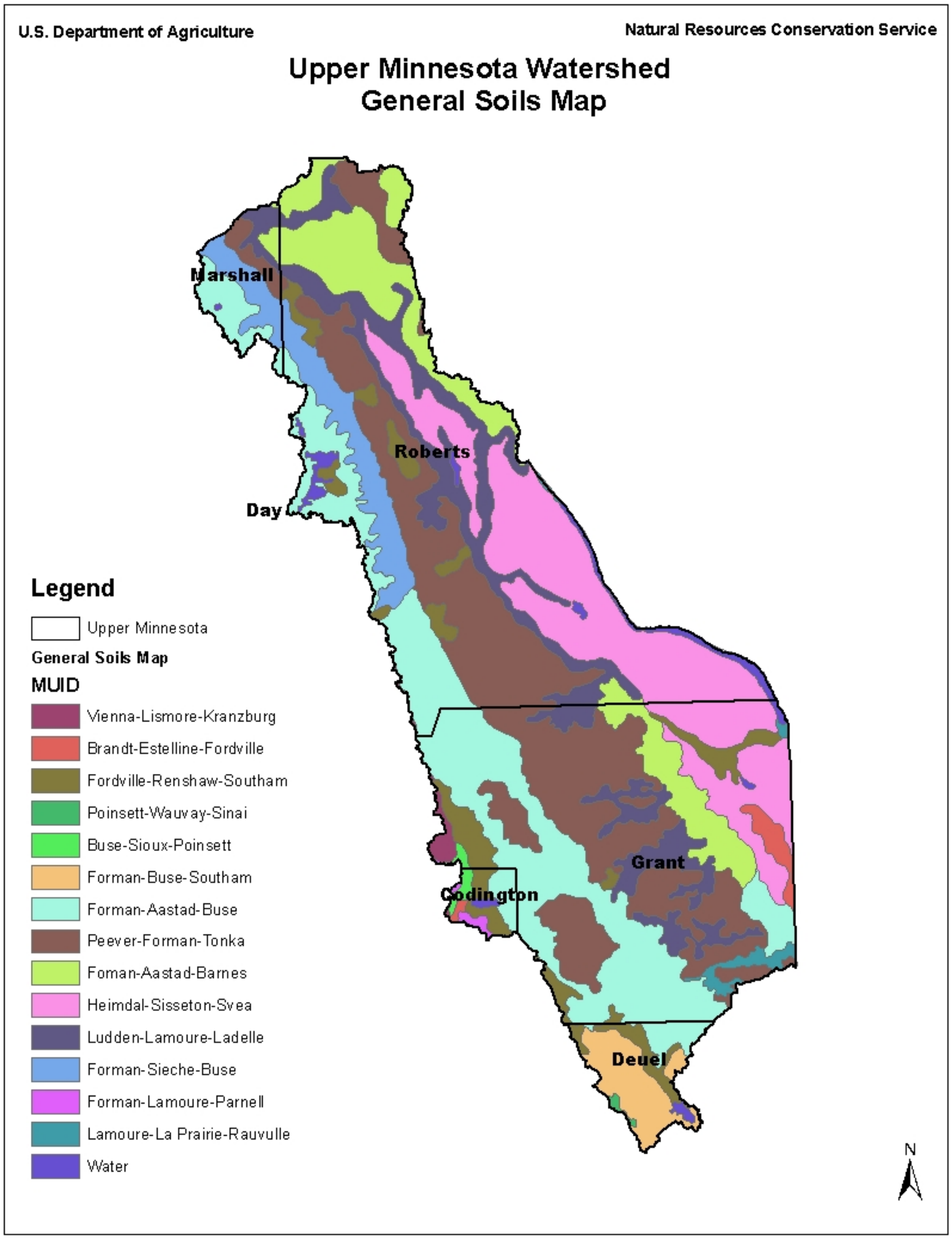


Table 2-1. Land Use Capability Classes

Land Capability Class (1997 Natural Resource Inventory Estimate)	**Acres**	**Percent**
I - Slight limitations	85,900	10%
II - moderate limitations	283,200	34%
III - severe limitations	197,000	24%
IV - very severe limitations	80,900	10%
V - no erosion hazard, but other severe limitations	16,800	2%
VI - very severe limitations, unsuited for cultivation, limited to pasture, range, forest	49,100	6%
VII - very severe limitations, unsuited for cultivation, limited to grazing, forest, wildlife	69,400	8%
VIII – misc. areas have limitations, limited to recreation, wildlife, and water supply	6,600	1%
Other Acres Not Determined	47,700	6%
Total Acres	**836,600**	**100%**

Most of this watershed area is in farms with about two-thirds of the cropland used for crops grown for sale or for feeding livestock. The principal crops are corn, soybeans, alfalfa, spring wheat, and oats. See Table 2-2 for the agricultural data for the two counties that comprise most of the acres in the watershed. The Preauthorization Report for the Little Minnesota-Big Stone Lake Watershed (1994) listed 61% of that portion of the watershed as cropland, 20% as rangeland, 10% as pasture and hayland, 4% as woodland, and 5% as urban, roads, state and federal lands. The most current watershed land use data from the 1997USDA National Resource Inventory is presented in Table 2-3. The grains and hay grown in the region commonly are fed to beef cattle. Cropland and Rangeland productivity maps are presented in Figures 2-3 and 2-4, respectively. Wooded areas generally occur as narrow bands along streams and rivers or as shelterbelts around farmsteads. Recreational hunting and fishing are important land uses around the many natural lakes in the northern part of the area. The major soil resource concerns are wind erosion, water erosion, maintenance of the content of organic matter and productivity of the soils, soil wetness, and management of soil moisture. Conservation practices on cropland generally include systems of crop residue management, especially no-till or other conservation tillage systems that conserve moisture and contribute to soil quality. Other conservation practices include terraces, grassed waterways, and cropland nutrient management.

Table 2-2. Agricultural Data for Grant and Roberts Counties

Agricultural Data for Two Major Counties in Watershed*			
	Grant	**Roberts**	**Data Year**
Land Area Acres	436,818,	704,856	2007
Number of Farms	555	887	2007
Total Cropland Acres	263,680	412,361	2007
Corn Acres	98,000	143,500	2011
Soybean Acres	95,000	154,000	2011
Small Grain Acres	34,500	37,900	2011
Pasture/Range Acres	91,869	149,766	2007
Cattle	55,000	55,000	2011
Swine	3,117	21,460	2007
Sheep	2,320	5,875	2007

*Data from USDA Agricultural Statistics Service

Table 2-3. Land Use Cover Data from 1997 USDA-NRCS NRI

Land Use Cover 1997 NRI	**Acres**	**Percent**
Cropland	428,400	51%
Rangeland	222,300	27%
Pastureland	23,600	3%
Hayland	19,000	2%
Forestland	14,400	2%
CRP	44,800	5%
Farmsteads	24,600	3%
Wetlands	4,400	1%
Water	12,100	1%
Urban	8,700	1%
Rural Transportation	17,600	2%
Minor land uses/cover	16,700	2%
Total	836,600	100%

Figure 2-3. Cropland Productivity in the Upper Minnesota River Watershed

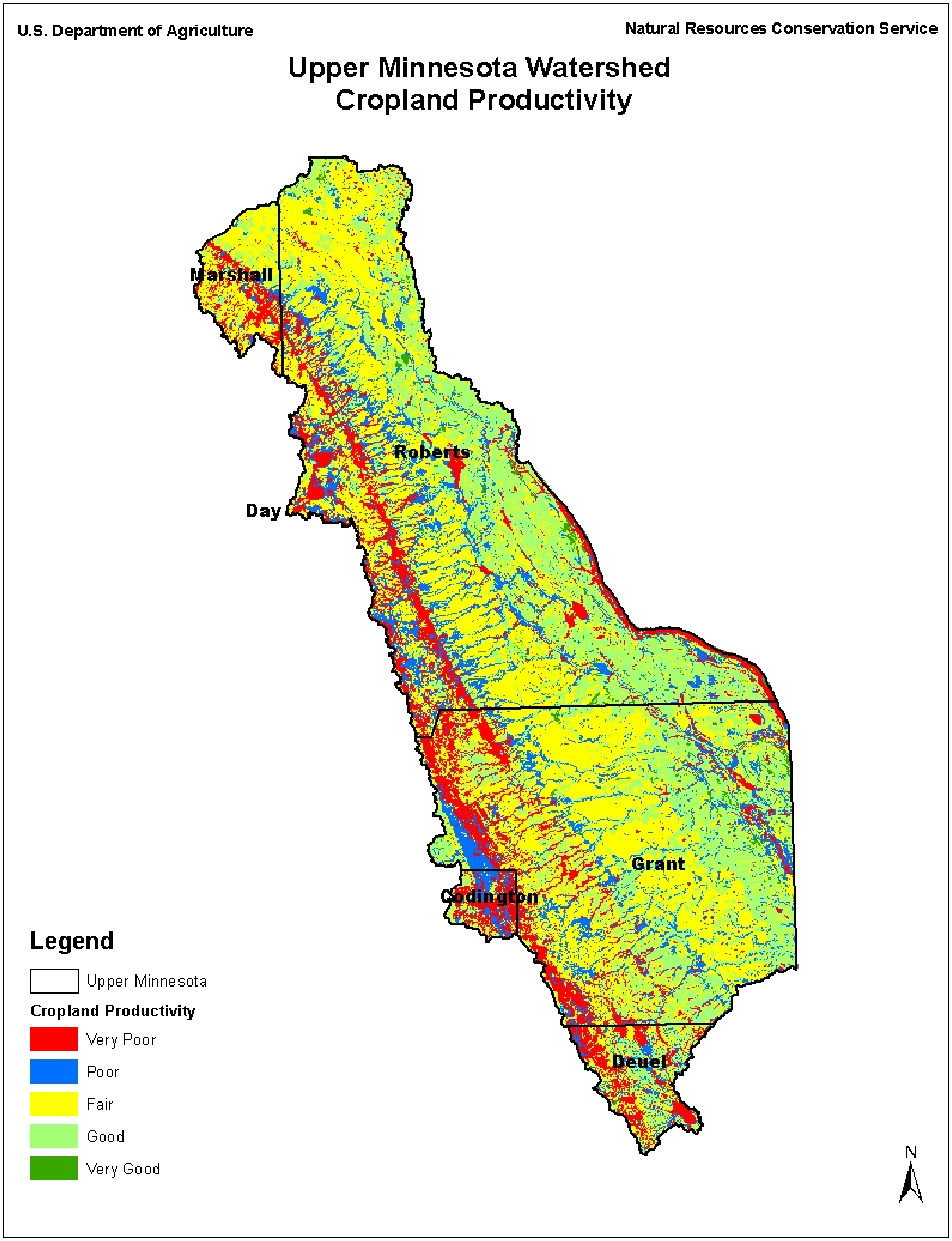
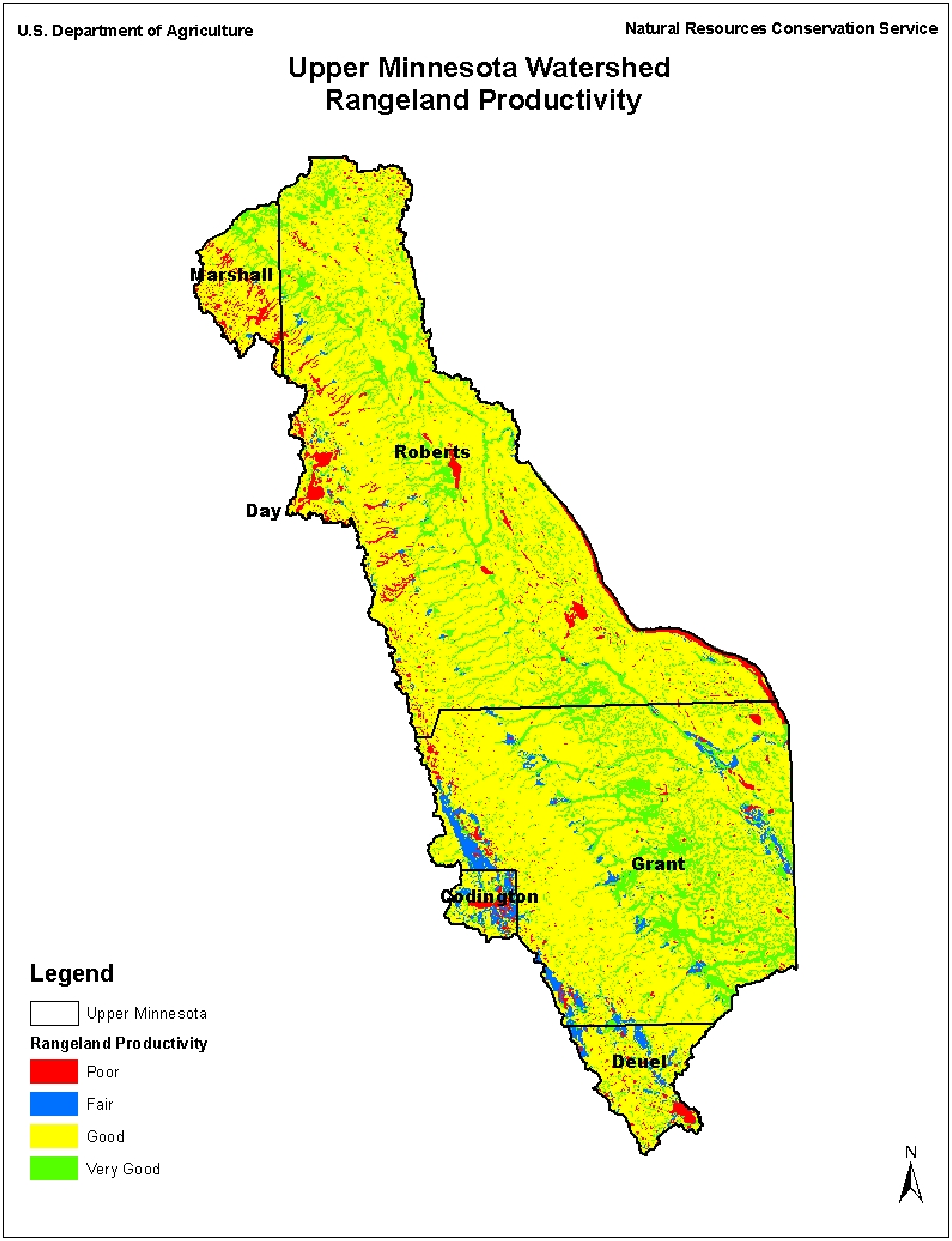


Figure 2-4. Rangeland Productivity in the Upper Minnesota River Watershed



2.0.2 Water Bodies Studies and Current Status

The Roberts County Soil and Water Conservation District (USDA 1994) identified the following resource concerns, based on two Hydrologic Unit public planning meetings and mail surveys, as top priorities for conservation and cost sharing efforts:

- Water Erosion from Cropland.
- Pollution control from Animal Feedlots.
- Quality of Rangeland.
- Fertilization and Pesticide Management on Cropland.

The Phase I Diagnostic/Feasibility Study (SDDENR 1983) identified the nonpoint sources of nutrients from fertilizers applied to cropland, animal wastes, and sediment carried into streams by runoff from agricultural land. The Little Minnesota River watershed was determined to be the major source of the nutrient and sediment reaching Big Stone Lake in this study. Most of the land is privately owned; however the watershed includes the Sisseton-Wahpeton Ovate and the Bureau of Indian Affairs administered lands.

The *2012 South Dakota-DENR Integrated Report for Surface Water Quality Assessment* for the Upper Minnesota River reported that dissolved oxygen (DO), high pH, temperature, and *Escherichia coli* bacteria were the identified impairments listed within the Upper Minnesota River basin. This report of water bodies with designated beneficial uses, impairments, and causes of impairments is presented in Table 2-4. The 303(d) listed water bodies are summarized in Table 2-5. Figure 1-2 on page 11 shows the watershed areas and locations of the Little Minnesota River, the North and South Forks of the Whetstone Rivers, and the North and South Forks of the Yellow Bank Rivers. Figure 2-5 shows the locations of the reaches for the listed water bodies in the Upper Minnesota River Basin.

Water quality investigations began with the U.S. Department of Interior in 1967 that identified pollution sources in the Little Minnesota and Big Stone Lake watersheds as runoff from cattle feedlots, septic systems from lakeside residences, heavily fertilized agricultural land, and waste deposition along the shoreline by self-watering livestock. A study conducted in 1983 to assess the trophic status of Big Stone Lake concluded that the lake had reached an extreme trophic status called "hypereutrophic," the most severe form of cultural lake aging or eutrophication. As a result of this study, the Big Stone Lake Restoration Project was developed. Implementation of the project began in 1985 with the overall objective being to maintain or increase the recreational potential and lifespan of Big Stone Lake by altering the trophic status from hypereutrophic to eutrophic. These Phase I (SDDENR 1983) and Phase II (SDDENR 1985) Diagnostic/Feasibility reports identified nonpoint sources of nutrients (fertilizer residue and animal wastes) and sediments from runoff from agricultural land as the largest contributors to the decline in water quality.

Table 2-4. Upper Minnesota River Watershed 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	EPA CATEGORY	303(d) Priority
Lake Alice	**Deuel**	**L1**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**		**1***	**NO**
SD-MN-L-ALICE_01	**County**			**Immersion Recreation**	**FULL**			
				Limited Contact Recreation	**FULL**			
				Warmwater Semipermanent Fish Life	**FULL**			
Big Stone Lake SD-MN-L-BIG_STONE_01	**Roberts**	**L2**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**		**5***	**Yes - 2**
	County			**Immersion Recreation**	**FULL**			
				Irrigation Waters	**FULL**			
				Limited Contact Recreation	**FULL**			
				Warmwater Permanent Fish Life	**NON**	**Temperature**		
Lake Drywood North	**Roberts**	**L4**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**INS**		**3**	**NO**
SD-MN_L-DRYWOOD_	**County (Formerly SD-**			**Immersion Recreation**	**NA**			
NORTH_01	**BS-**			**Limited Contact Recreation**	**NA**			
	L-DRYWOOD_			**Warmwater Marginal Fish Life**	**INS**			
	NORTH_01)							
Punished Woman	**Codington**	**L9**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**		**5***	**YES-2**
Lake	**County**			**Immersion Recreation**	**FULL**			
SD-MN-L-PUNISHED_				**Limited Contact Recreation**	**FULL**			
WOMAN_01				**Warmwater Semipermanent Fish Life**	**NON**	**pH (high)**		
Turtle Foot Lake	**Marshall**	**L10**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**		**1**	**NO**
SD-MN-L-TURTLE_	**County**			**Immersion Recreation**	**FULL**			
FOOT-01				**Limited Contact Recreation**	**FULL**			
				Warmwater Marginal Fish Life	**FULL**			
Big Coulee Creek	**Near Peever**	**R1**	**USGS**	**Fish/Wildlife Prop, Rec, Stock**	**INS**		**3**	**NO**
SD-MN-R-COULEE-01				**Irrigation Waters**	**INS**			

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.

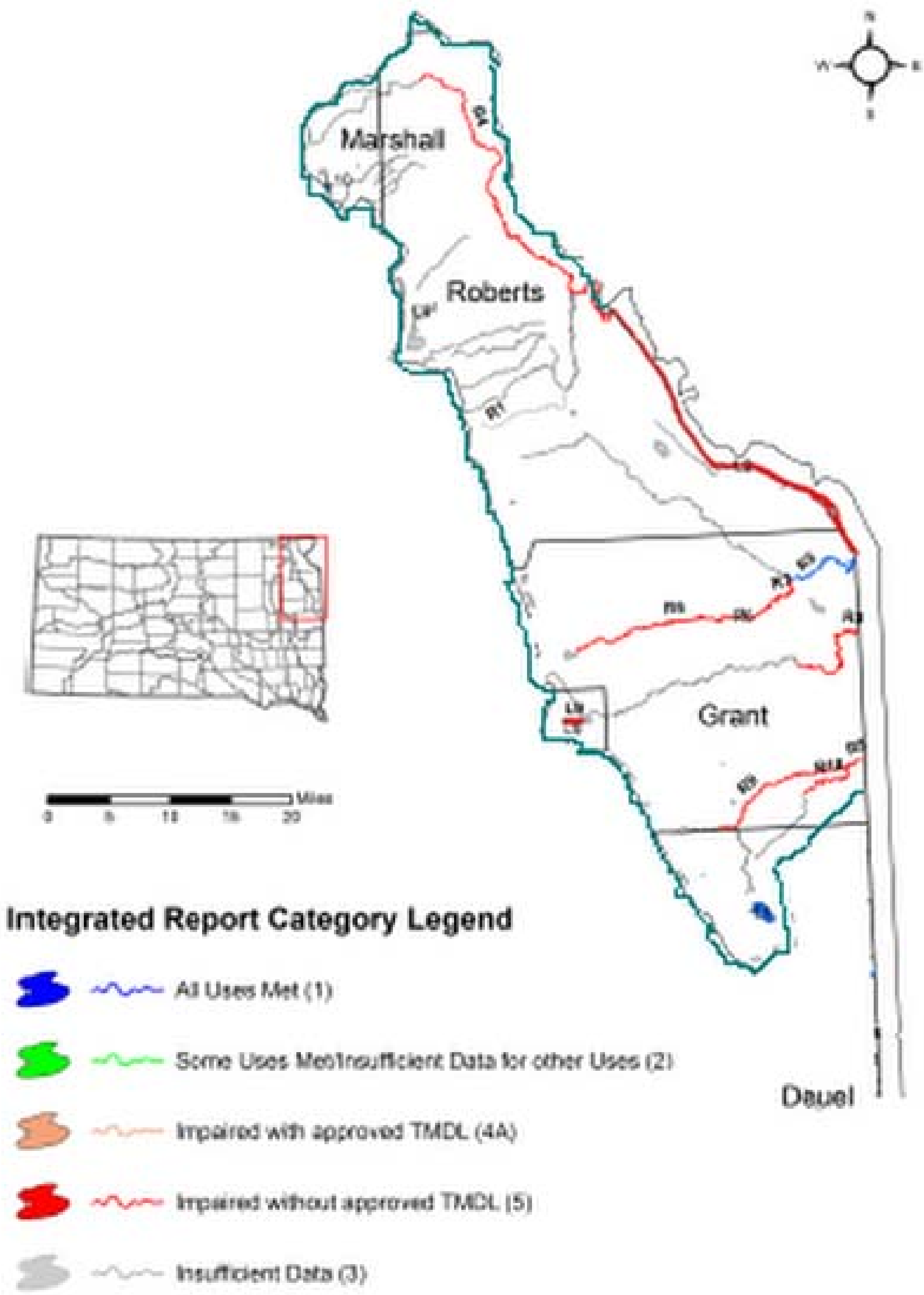
WATERBODY AUID	LOCATION	MAP ID	BASIS	USE	SUPPORT	CAUSE	EPA CATEGORY	303(d) Priority
Little Minnesota River	**Big Stone Lake**	**R4**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**		**5**	**YES-2**
SD-MN-R-LITTLE_	**to S15**			**Irrigation Waters**	**FULL**			
MINNESOTA _01	**T128N-R52W**			**Limited Contact Recreation**	**NON**	**Oxygen, Dissolved**		
				Warmwater Semipermanent Fish Life	**NON**	**Oxygen, Dissolved**		
Whetstone River SD-MN-R-WHETSTONE_01	**SD/MN Border to confluence with North and South Forks**	**R5**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**		**1**	**NO**
				Irrigation Waters	**FULL**			
				Limited Contact Recreation	**FULL**			
				Warmwater Semipermanent Fish Life	**FULL**			
South Fork	**Headwaters**	**R6**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**		**5**	**YES-1**
Whetstone River	**to**			**Irrigation Waters**	**FULL**			
SD-MN-R-WHETSTONE	**Lake Farley**			**Limited Contact Recreation**	**NON**	**Escherichia coli**		
S_FORK-01				**Warmwater Marginal Fish Life**	**FULL**			
South Fork	**Lake Farley**	**R7**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**		**5**	**YES-1**
Whetstone River	**to**			**Irrigation Waters**	**FULL**			
SD-MN-R-WHETSTONE	**Mouth**			**Limited Contact Recreation**	**NON**	**Escherichia coli**		
S_FORK-02				**Warmwater Marginal Fish Life**	**FULL**			
North Fork	**SD/MN Border to**	**R8**	**DENR**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**		**5**	**YES-1**
Yellow Bank River	**S27**			**Irrigation Waters**	**FULL**			
SD-MN-R-YELLOW_BANK	**T120N-R48W**			**Limited Contact Recreation**	**NON**	**Escherichia coli**		
N_FORK-01				**Warmwater Permanent Fish Life**	**FULL**			
South Fork	**SD/MN Border to**	**R9**	**DENR**	**Coldwater Marginal Fish Life**	**FULL**		**5**	**YES-1**
Yellow Bank River	**S33**		**USGS**	**Fish/Wildlife Prop, Rec, Stock**	**FULL**			
SD-MN-R-YELLOW_BANK	**T118N-R49W**			**Irrigation Waters**	**FULL**			
S_FORK-01				**Limited Contact Recreation**	**NON**	**Escherichia coli**		

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 2-5: Summary of Upper Minnesota River Watershed Water bodies Listed as 303(d) Impaired, Source of Impairment, and Cause. (Data from "*The 2012 SD Integrated Report for Surface Water Quality Assessment*".)

Water Body Impaired	Beneficial Use Impaired	Listed Cause of Impairment
Big Stone Lake -L2	Warmwater Permanent Fish Life	Temperature
Punished Woman Lake - L9	Warmwater Semipermanent Fish Life	High pH
Little Minnesota River - R4	Limited Contact Recreation	Dissolved Oxygen
	Warmwater Semipermanent Fish Life	Dissolved Oxygen
North Fork Whetstone River - 6	Limited Contact Recreation	*Escherichia coli*
South Fork Whetstone River - R7	Limited Contact Recreation	*Escherichia coli*
North Fork Yellow Bank River -R8	Limited Contact Recreation	*Escherichia coli*
South Fork Yellow Bank River -R9	Limited Contact Recreation	*Escherichia coli*

Figure 2-5. Upper Minnesota River Watershed 303(d) Listed Water Bodies, SD-DENR IR 2012



Two other major watersheds in this HU are the Whetstone and Yellow Bank Rivers. Although previously not studied as intensively, TMDL's have been set for the North and South Forks of the Yellow Bank Rivers (SDDENR June 2012); however, data still needs to be analyzed for the North and South Forks of the Whetstone Rivers. All four rivers have been listed as 303(d) impaired due to *Escherichia coli* bacteria. The East Dakota Water Development District in South Dakota conducted a two year water quality assessment in 2010 whose purpose was; (a) to determine the condition of water bodies in the Upper Minnesota River watershed (Whetstone and Yellow Bank Rivers) and record changes over a period of time; (b) to document bacterial, sediment and/or nutrient loadings to the river systems, and by extension, Big Stone Lake and the Minnesota River; and (c) to support the development of total maximum daily loads (TMDL) as necessary. The TMDL established for the North Fork and South Fork of the Yellow Bank River, resulting from this study (SDDENR 2012), found that the *E. coli* bacteria impairment source was manure from livestock feedlots and pastures.

The Minnesota Pollution Control Agency (MPCA 2004) reported that "among the nutrients, phosphorus is a pollutant of major concern to the water quality of the Minnesota River and its tributaries. Any strategy to restore the Minnesota River will require each major watershed to take part in reducing phosphorus loadings to the main stem. Eventually, through basin management, a basin-wide phosphorus loading reduction goal can be established. Through a collaborative process involving local, state and federal government, in addition to watershed residents and other stakeholders, this whole-basin load-reduction goal can be allocated among the 13 major watersheds. Within each major watershed, in turn, the total watershed load-reduction goal can be further allocated among point and nonpoint sources". Along these guidelines the two States are cooperating with each other at the County, State, and Federal levels of government to achieve the end goal of water quality improvement.

2.1.0 Description of the Impairments for 303(d) Water Body Listings in the Upper Minnesota River Basin

2.1.1 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 (^{o}F) increase in water temperature. Water temperature can influence oxygen concentration, metabolism (body functions), reproduction and growth. Each species of aquatic organism has its own optimum water temperature. If the water temperature shifts too far from the optimum, the organism suffers. Cold-blooded animals cannot survive temperatures below 32 ^{o}F, and only rough fish can tolerate temperatures much warmer than about 97 ^{o}F. The water temperatures at which fish growth ceases are 82 ^{o}F for Northern pike, 90 ^{o}F for channel catfish, and 97 ^{o}F for carp. The Northern pike and channel catfish die when water temperatures exceed

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

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

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

2.1.2 pH Levels

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

High pH can also occur when plants use carbon dioxide (CO2) during photosynthesis to produce carbohydrates. Although highly soluble in water, most carbon dioxide in lakes is formed as an end product of respiration. When the rate of atmospheric CO2 diffusing into the water is less than the rate of photosynthesis, aquatic plants use dissolved carbonates as their source of carbon. As they produce carbon dioxide in water, it forms a series of compounds, including carbonic acid, bicarbonate, and carbonate. The process of photosynthesis also consumes protons which contribute to raising the pH. The resulting carbonate chemistry, along with the hydroxide (OH-) anion, contributes to the alkalinity and buffering capacity of water. This hydroxyl ion is responsible for the increase in lake water pH during photosynthesis. Alkalinity is a conservative parameter in that it does not change readily in well-buffered lakes. However, pH values may vary both temporally and spatially within a lake. During intense photosynthesis in the euphotic zone, carbon dioxide and its dissociation product, carbonic acid, can become less abundant. 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 pH standard set by South Dakota DENR 303(d) is a pH of 9.0.

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 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 Table 2-6 below gives some special effects of pH on fish and aquatic life.

Table 2-6. Effects of pH Levels and Minimum/Maximum Temperature Tolerances

Minimum	Maximum	Effects of pH and Minimum/Maximum Levels
3.8	10.0	Fish eggs could be hatched, but deformed young are often produced
4.0	10.1	Limits for the most resistant fish species
4.1	9.5	Range tolerated by trout
---	4.3	Carp die in five days
4.5	9.0	Trout eggs and larvae develop normally
4.6	9.5	Limits for perch
---	5.0	Limits for stickleback fish
5.0	9.0	Tolerable range for most fish
---	8.7	Upper limit for good fishing waters
5.4	11.4	Fish avoid waters beyond these limits
6.0	7.2	Optimum (best) range for fish eggs
---	1.0	Mosquito larvae are destroyed at this pH value
3.3	4.7	Mosquito larvae live within this range
7.5	8.4	Best range for the growth of algae

2.1.3 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 (DO) 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 a lot of 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 both produce and consume oxygen, gaining 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 changes 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 difficult time surviving 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.

2.1.4 *Escherichia coli* Bacteria

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

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

2.2.0 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 the Upper Minnesota River watershed by SDDENR to identify the main sources of these impairments.

2.2.1 Point Sources of Impairment

Point sources of impairment were cited in earlier water quality studies in the Upper Minnesota River basin as contributing an estimated 10-20% of the total phosphorous load to the Little Minnesota River. Since that time, municipal wastewater treatment facilities were constructed during earlier funding projects for the communities of Peever, Veblen, and Sisseton in South Dakota and for Browns Valley, Minnesota. These four facilities reduced the phosphorus loading to the Little Minnesota River and Big Stone Lake by an estimated 6,700 pounds annually (SDDENR 1995).

The most current water quality report for the Upper Minnesota River Basin was compiled during a two year investigation by East Dakota Water Development District (EDWDD) for the Whetstone and Yellow Bank Rivers. The results for the North and South Forks of the Yellow Bank River were reported in the TMDL (SDDENR 2012). Data collected for the North and South Forks of the Whetstone River has not been analyzed at this date. Point sources of pollutants were investigated and no direct point source dischargers were identified within the drainage area of the impaired segments of the North Fork and South Fork of the Yellow Bank River. All communities in the North Fork watershed utilize retention pond systems as a mechanism to treat municipal wastewater. The facilities are regulated by National Pollution Discharge Elimination System (NPDES) Surface Water Discharge permits (Table 2-7) and all NPDES permits allow no discharge except for an emergency. No Waste Load Allocation (WLA) was required in the TMDL for the impaired segment of the North Fork of the Yellow Bank River.

There are five communities within the South Fork of the Yellow Bank River watershed of which only two communities require NPDES permits (Table 2-7). The town of LaBolt is the only community in the South Fork of the Yellow Bank watershed authorized to discharge wastewater.

However, it was determined that the town of LaBolt's discharge is not impacting the impaired segment of the South Fork and the city was not given a WLA for the *Escherichia coli* TMDL.

Table 2-7. NPDES Permit and Waste Load Status of Communities in the North and South Fork Yellow Bank River Watershed.

Watershed	Community	Population	NPDES permit status	WLA
North Fork Yellow Bank	South Shore	270	NPDES permit-no discharge	no
North Fork Yellow Bank	Stockholm	105	NPDES permit-no discharge	no
North Fork Yellow Bank	Strandburg	69	NPDES permit-no discharge	no
South Fork Yellow Bank	Altamont	34	No NPDES permit	no
South Fork Yellow Bank	Tunerville	0	No NPDES permit	no
South Fork Yellow Bank	Albee	10	No NPDES permit	no
South Fork Yellow Bank	Revillo	147	NPDES permit-no discharge	no
South Fork Yellow Bank	LaBolt	76	NPDES permit-discharge	yes

The TMDL for the Yellow Bank River found that community wastewater treatment systems served 711 of the approximate 4,600 people in the North Fork and South Fork watersheds of the Yellow Bank River. Septic systems were assumed to be the primary human source for the rural population in both watersheds. When included in the total load, this population produces less than 0.5% of all fecal coliform produced in both watersheds. The human fecal bacteria produced should all be delivered to a septic system, which if functioning correctly would result in no bacteria entering the river systems. Septic system failure was not identified as a source of concern during the field investigation conducted in the North and South Forks of the Yellow Bank River watersheds. See Tables 2-8 and 2-9 for *Escherichia coli* bacterial sources in the Yellow Bank River.

Table 2-8. North Fork Yellow Bank Watershed E. Coli Bacteria Sources

Species	#/acre	Bacteria /Animal/Day	Bacteria/Acre	Percent
Dairy cow3	2.05E-02	1.01E+11	2.07E+09	15.7%
Beef3	1.04E-01	2.08E+11	1.09E+10	82.2%
Hog3	7.14E-03	1.08E+10	7.71E+07	0.6%
Sheep3	6.09E-03	1.20E+10	7.30E+07	0.6%
Horse3	1.11E-03	4.20E+08	4.66E+05	0.004%
All Wildlife	Sum of all wildlife		9.89E+07	0.7%
Human3	1.68E-02	2.00E+09	3.37E+07	0.3%

Table 2-9. South Fork Yellow Bank Watershed *E .coli* Bacteria Sources

Species	#/acre	Bacteria/Animal/Day	Bacteria/Acre	Percent
Dairy cow3	2.19E-03	1.01E+11	2.21E+08	13.8%
Beef3	1.29E-02	1.04E+11	1.34E+09	83.6%
Hog3	4.47E-04	1.08E+10	4.83E+06	0.3%
Sheep3	9.47E-04	1.20E+10	1.14E+07	0.7%
Horse3	1.65E-04	4.20E+08	6.92E+04	0.004%
All Wildlife	Sum of all wildlife		2.18E+07	1.4%
Human3	1.682E-03	2.00E+09	3.36E+06	0.2%

The NPDES status of the other communities and potential point pollution discharges in the Upper Minnesota River are listed below in Table 2-10. The NPDES permit discharges of concern are for the City of Milbank and the industry of Valley Queen Cheese. These two discharge sources are being addressed by SDDENR and the Waste Load Allocations will be set for them when the TMDLs are finalized.

Table 2-10. NPDES Status of Other Potential Point Pollution Discharges

Watershed	Community	Population	NPDES Permit Status	WLA
North Fork Whetstone	Marvin	34	No Discharge	No
South Fork Whetstone	Twin Brooks	69	No Discharge	No
North Fork Whetstone	Corona	109	NPDES Permit-No Discharge	No
South Fork Whetstone	Milbank	3,353	NPDES Permit - Discharge	No
Little Minnesota	Peever	168	NPDES Permit - Discharge	No
Little Minnesota	Sisseton	2,470	NPDES Permit - Discharge	No
North Fork Whetstone	Summit	288	NPDES Permit - Discharge	No
South Fork Whetstone	Valley Queen Cheese	Industry	NPDES Permit - Discharge	No
Little Minnesota	Veblen	281	NPDES Permit - Discharge	No
North Fork Whetstone	Wilmot	492	NPDES Permit - Discharge	No

The conclusions repeated by the other TMDL watershed studies in South Dakota on potential point sources of loadings did not identify human fecal bacteria as being significant; James River, Yankton County (SDDENR 2011); Alexandria (SDDENR 2011) Dawson Creek study (SDDENR 2011). The municipalities had either (1) zero discharge NPDES permits, (2) discharges that were NPDES permitted were 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 for the James River

(SDDENR 2011) as represented in Table 2-11. Similarly, the percent of human contamination of 0.3% in the James River was almost identical to that in the North and South Forks of the Yellow Bank River at 0.3% and 0.2%, respectively. Although the data for the North and South Forks of the Whetstone River has not been evaluated, similar results are expected, with no point sources of bacterial loading to be found.

Table 2-11: Nonpoint Sources of Bacteria, James River, Yankton County, DENR 2011

Species	#/mile	#/acre	FC/Animal/Day	FC/Acre	Percent
Dairy cow	0.00	0.0E+00	4.46E+10	0	0.0%
Beef	73.00	1.1E-01	3.90E+10	4448437500	83.8%
Hog	34.00	5.3E-02	1.08E+10	573750000	10.8%
Sheep	4.00	6.3E-03	1.96E+10	122500000	2.3%
Horse	0.25	3.9E-04	5.15E+10	20109375	0.4%
Poultry	100.00	1.6E-01	1.36E+08	21250000	0.4%
Humans1	5.85	9.1E-03	1.95E+09	17824219	0.3%

There were no lakes listed as 303(d) impaired for *Escherichia coli* bacteria in the 2012 SDDENR-IR. Big Stone Lake was not listed as impaired for bacteria although it has numerous residences along it's approximately 52 miles of shoreline; presumably with each having their own septic system. However, individual household septic systems can be a source of point pollution. A septic leachate survey of Enemy Swim Lake, in adjacent Day County, was conducted during a period of peak wastewater loading during the summer of 1998. The purpose for the survey of the developed shoreline areas was to locate and qualitatively characterize septic plumes emanating from malfunctioning on-lot sanitary systems.

Over forty potential septic leachate plumes were identified in front of shoreline cabins on Enemy Swim Lake, with water samples from twenty six stations being analyzed. The laboratory analyses of water samples collected from plume locations demonstrated the existence of a significant number of malfunctioning systems. The presence of elevated nutrients and fecal contamination indicated that many systems are releasing poorly treated wastewater effluent. It was assumed likely that rapid dilution / flushing of septic leachate plumes occurs from the combination of the excessively drained and poor filtering capacity of the Sioux (SbB) gravelly loam sand soil and the wind generated wave action present throughout much of the survey. The conclusion of the study found the soils and the high ground water level were not conducive for proper operation of septic systems. The consultant, ECOSCIENCE Inc. from Moscow, Pennsylvania, recommended constructing a centralized sewer system for the lake cabins and also implementing an information and education program for detergent and water use. Based on this preliminary base-line information, Big Stone Lake may need further analysis of its adjacent lake shoreline residences for potential nutrient loadings.

2.2.2 Non Point Sources of Impairment

Non point sources have not been identified for all designated water bodies in the Upper Minnesota River basin 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. Phase I Watershed Assessment and TMDL Final Reports have been completed for Lake Alice in Deuel County. The Lake Alice TMDL (2001) concluded that the major source of phosphorous was from atmospheric loading and there were minimal sources of sediment and nutrient loadings from other sources. Lake Alice has met the 303(d) criteria of all its designated beneficial uses per SDDENR IR 2012. Turtle Foot Lake and the Whetstone River also met all the 303(d) criteria for their beneficial uses.

The water bodies of Lake Drywood North and Big Coulee Creek were reported in the 2012 SDDENR IR to have insufficient water quality data to ascertain whether they meet the supporting criteria of their designated beneficial uses. These water bodies are not listed as having any priority under the 303(d) listing in this report. The future status of these water bodies' evaluations is unknown.

Water quality studies on the Little Minnesota River and Big Stone Lake, the North and South Forks of the Yellow Bank Rivers have concluded that agricultural activities were the major nonpoint source of excessive nutrients to the watershed and that all other potential sources were minimal. The following pollutants, as identified by the SDDENR 2012 Integrated Report, are discussed by each listed 303(d) impairment for the described water bodies:

2.2.3 Temperature Impairment – Big Stone Lake, L2

Big Stone Lake is listed 303(d) as temperature impaired for the support of Warm Water Permanent Fish Life in the 2012 DENR-IR. Big Stone Lake covers 12,360 acres of surface area, stretches 26 miles in length, averages approximately 1 mile wide, and has 62 miles of shoreline. Its maximum depth is 16 feet with an average depth of 8 feet. Results from the water quality monitoring part of the Phase I study (SDDENR 1983) indicated that the Little Minnesota River Watershed contributes approximately 121, 000 tons of sediment each year to Big Stone Lake. The study also indicated that 80 percent of the sediment and nutrient loads in the Little Minnesota River were from agricultural nonpoint sources such as cropland erosion, stream bank erosion, range and pasture erosion, and confined livestock operations. One hundred and thirty-five (135) feedlots were identified in the 1983 report with 63 feedlots having a Feedlot Rating Model score of greater than 50.

This shallow average depth and influx of nutrient loads have also led to an extensive littoral zone of the lake. The littoral zone is that area of a lake, generally the area near the shoreline that is shallow where sunlight penetrates all the way to the bottom sediments and allows aquatic plants to grow. Light levels of about 1% or less of surface values usually define this depth. The littoral zone of Big Stone encompasses 12,000 acres, approximately 99 percent of the lakes surface acres. Essentially, during the peak period times of summer aquatic plant growth, Big Stone Lake has 1 percent or less of open water (limnetic) zone. This rooted aquatic plant growth is stimulated by the increased supply of nutrients and the creation of additional shallow growing areas by the accumulation of sediments, silt, and organic matter. These factors have led to increased eutrophication. A study completed by RMB Environmental Laboratories for the Minnesota Pollution Control Agency (2010) has Big Stone Lake meeting the criteria as a eutrophic lake for chlorophyll-*a*, transparency, and as hyper eutrophic for phosphorous. The high Trophic State Index (TSI) of phosphorous indicates that not all the phosphorus is being utilized by the algae and the phosphorus loading from the numerous tributaries is so high that it overloads the system. See Table 2-12. Since the Big Stone Lake acts like a large river, this phosphorus is carried through the lake and into the Minnesota River. This study concluded that phosphorous appears to be the main problem in Big Stone Lake as shown by the lake's tropic status index analysis.

Table 2-12. Trophic State Index for Big Stone Lake. RMB Environmental Laboratories, MWPCA 2010.

Trophic State Index	Big Stone Lake TSI	Trophic State
TSI Total Phosphorus	76-80	Hypereutrophic
TSI Chlorophyll-a	55-61	Eutrophic
TSI Transparency	52-62	Eutrophic

Numbers represent the mean TSI range for 2007-2010 across all 6 monitoring sites.

The length of Big Stone Lake and its narrow width associated with a northwest to southeast geographical orientation are conducive to wind energy that breaks down a lake's vertical stratification. Wind energy transports phosphorus from bottom sediments and resuspends it into all water levels. The resuspending of sediments can lead to an earlier warming of water temperatures above normal, as the suspended particles near the surface facilitate the absorption of heat from sunlight. This internal loading of phosphorus can accelerate an early growth of algae and aquatic plants and the resulting plant problems associated with human induced cultural eutrophication.

Jensen (2008) reported a reduction of 45,836 tons of sediment delivered to Big Stone Lake per year. This is a 32% reduction that has occurred since the beginning of concentrated effort to install Best Management Practices (BMP) in the mid-1980s. However, Jensen still reported that

Big Stone Lake has the water quality problems of hyper eutrophic lake conditions; excessive algal blooms, an overabundance of rooted aquatic plants, and decreasing lake depth. He listed the causes of the poor water quality conditions as primarily non-point sources of nutrients and sediment loading from crop land erosion, fertilizer runoff, animal feedlot runoff, poor rangeland condition, lakeshore erosion, and stream bank erosion. He also indicated that point sources of pollution may be occurring from inadequate lakeside septic systems.

The high temperatures of Big Stone Lake may result from the combined physical characteristics of a shallow lake, geographical orientation, increased sedimentation from erosion in the watershed, stream bank and shoreline erosion, and resuspension of bottom sediments. The Big Stone Power Plant and an nearby ethanol plant obtain their cooling water from Big Stone Lake; however, both do not discharge into its waters. The Big Stone Power Plant utilizes a condenser cooling system that uses a 340-acre closed-cycle cooling pond which eliminates any potential problems created by plant thermal discharges to public bodies of water. No other sources of industrial thermal pollution are known to discharge into the lake. Big Stone Lake does support a stable population of game fish including walleye, yellow perch, largemouth bass, northern pike, crappie, and bluegill. A fishing league held May 2, 2012, reported the best catches in league history (Schmidt's Landing Resort 2012). The exceedance of temperature criteria for warm water permanent fish life propagation may be a seasonal occurrence during the summer months that appears to not be detrimental to the existing permanent warm water fisheries.

2.2.4 High pH – Punished Woman Lake, L9

Punished Woman Lake is listed 303(d) as High pH impaired for the support of Warm Water Semi-Permanent Fish Life in the 2012 SDENR-IR. Punished Woman's Lake is a 477 acre lake located in northeastern Codington County, South Dakota, immediately north of the town of South Shore, and approximately 25 miles northeast of Watertown, South Dakota. The Punished Woman's Lake watershed is comprised of 12,280 acres of generally hilly terrain. Recreational uses of fishing, swimming, and boating were reduced because excess sediment had caused a loss of water depth, an increase of nutrients, and an increase of aquatic macrophytes. A sediment survey conducted during the winter of 1987-88 found approximately 2.7 million cubic yards of soft sediment in the lake with the deepest sediment (greater than 10 feet) located in the middle of the lake. The average water depth prior to implementation of a 319 project was 5.4 feet with a maximum water depth of 8 feet. Sediment depth averaged 5.2 feet with greater than 10 feet of sediment located in the middle of the lake with the deepest sediment located at the east end of the lake. Two major tributaries enter the lake, at the southwest and northeast ends, and five smaller intermittent streams enter the lake at various locations. Water inflows are generally limited to periods of runoff associated with snowmelt or rainstorm events. The lake outlet is located at the east end of the lake.

Before the 319 project implementation (SDDENR 1991) the designated beneficial uses of warm water semi-permanent fish life propagation, immersion recreation, and limited contact recreation were impaired by shallow water due to the accumulated sediment and to an increase in aquatic vegetation from excessive nutrients. The in-lake sediment deposition was a result of shoreline erosion and bank sloughing caused by construction of an eight-inch cap placed on the outlet structure in 1971. The lake mimicked a prairie slough more than a lake. The restoration activity of removal of the outlet cap from the outlet structure and dredging to remove nutrient-laden sediment was completed in 1988. After the cap was removed, the bank sloughing ceased and natural vegetation became reestablished along most bank areas previously devoid of cover; minimizing future sloughing and deposition of sediment into the lake. Water quality analysis from the Phase I Diagnostic/Feasibility study showed that the tributary waters did not exceed water quality standards for total solids, suspended solids, or dissolved solids.

The removal of 421,000 cubic yards of nutrient-rich lake sediment had a dramatic effect on designated beneficial uses and has led to better water quality. The dredging deepened the selected mid-lake area water depth by 12 to 15 feet, which alone improved immersion and limited contact recreational uses. As a result of the dredging, lake water clarity improved and suspended solids were reduced. Deepening large parts of the lake also had the effect of reducing the exposure of bottom sediments to wind and wave action, thereby reducing inorganic water turbidity; which was formerly a major detriment to water clarity in Punished Woman's Lake. It is anticipated that dissolved oxygen levels will increase and overall water temperatures decrease, thereby enhancing the lake's fishery. Water clarity also increased as shallow vegetation was eliminated and nutrient-bound sediment (primarily phosphorus) was removed. The local project coordinator observed that approximately 75 percent of the submergent vegetation was removed from the lake as a result of the implementation project. The dredging activity also opened previously plugged groundwater connections as witnessed by the lake's continuous discharge without any inflow during extended dry climatic periods.

As a component of the Phase I Diagnostic/Feasibility study, the AGNPS Model was used to assess the condition of the Punished Woman Lake watershed with respect to nutrient and sediment outputs and the effects of feedlots on those parameters. The AGNPS model results indicated 34 non-feedlot cells as potentially significant in terms of nutrient and/or sediment yield. Additionally, four feedlots were identified as potentially significant. The study suggested conservation practices such as conservation tillage, contour farming, contour strip-cropping, crop rotation, terraces, grassed waterways, animal waste management systems, and range and pasture management may be the most appropriate Best Management Practices to implement in this watershed. Bank stabilization efforts may also be required on isolated areas that have not yet stabilized and have yet to be vegetated naturally.

2.2.5 Dissolved Oxygen – Little Minnesota River, R4

The Little Minnesota River is listed as 303(d) impaired for Dissolved Oxygen (DO) for the support of both Limited Contact Recreation and Warm Water Semi-Permanent Fish Life in the 2012 DENR-IR. The DO standard for the recreational uses serves as an indicator for those causes that can contribute to low DO levels. There are several other potential sources of oxygen demand in a river system (MWPCA 2004):

- nitrogen oxygen demands derived by the nitrogen cycle (i.e. when ammonia is converted into nitrate/nitrate chemically binding the oxygen);
- sediment oxygen demand combining diffusion gradients with organic and/or chemical and mineral oxygen demands (i.e. when oxidized iron reenters an aerated water column it uses up oxygen as it reforms ferric compounds;
- bacterial uptake of dissolved oxygen in ground water;
- organic sources directly discharged to the water (e.g. BOD); and
- BOD from eutrophication caused by high levels of nutrients producing excess algae. When the algae dies and decays, it exerts an oxygen demand leading to low dissolved oxygen.

These last two sources exert most of the BOD during low flow conditions in the lower Minnesota River and deserve further discussion. The Phase I 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. The water quality monitoring data indicated that the Little Minnesota River carries a very substantial load of sediment and nutrients, with 80 percent of this load come from agricultural nonpoint sources such as commercial fertilizers and manure. The sampling data found that total phosphorus levels almost always exceeded the level that is recommend for the lake. 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. The result of low DO can be fish kills and undesirable recreational value.

The DO impairment, resulting from high BOD caused by this excess phosphorus, especially manifests itself during low stream flow conditions. These high levels of available nutrients during low flows encourage intense algal blooms to occur during the warmer summer months. Under low stream flow conditions, streams become quiescent as a result of reduced flow. The slow-moving water provides sufficient residence time for algae to settle out, die, and decay; such that oxygen demand is greater than oxygen production. Decay of excessive levels of algae can cause severe oxygen depressions which results in reduced dissolved oxygen concentrations. The SDDENR standard for DO levels is a minimum of 5 Mg/L for a warm water fisheries beneficial use.

2.2.6 *Escherichia coli* – North and South Forks Whetstone Rivers, R6 & R7 North and South Forks Yellow Bank Rivers, R8 & R9

The North and South Forks of the Whetstone Rivers and the North and South Forks of the Yellow Bank Rivers are listed as 303(d) impaired for *Escherichia coli* for the support of Limited Contact Recreation in the 2012 SDDENR-IR. Fecal coliform bacteria are usually not harmful, but they can indicate the presence of other harmful bacteria, viruses and/or parasites. Examples include the pathogenic strain of *E. coli* that is often linked to food borne illnesses, as well as giardia and cryptosporidium. Recreational contact, especially swimming, is not recommended when high concentrations of fecal coliform bacteria are present. Water quality data was collected from these watersheds in 2010 and 2011. The purpose of the study (SDDENR 2012) was to locate and document sources of nonpoint source pollution in the watersheds of the Whetstone and Yellow Bank Rivers through water quality sampling and stage and discharge measurements. The study was completed for the Yellow Bank Rivers and result in Total Daily Maximum Load (TMDL) limits set for the identified impairments. The data for the Whetstone Rivers has not been analyzed at this date.

The SDDENR report identified manure from predominantly beef and dairy cattle livestock as the potential source of *E. coli* bacteria to the North and South Fork Yellow Bank watersheds. Bacteria movement from small feeding areas and upland grazing most likely occurred during major run-off events. The most likely source of bacteria at low flows was from livestock defecating while wading in the stream. Cattle can also contribute while grazing on rangelands as their manure and bacteria is washed into streams during precipitation events. Table 2-13 allocates nonpoint sources of bacteria production in both watersheds into three primary categories. Feedlot numbers were also analyzed in this study as the sum of all dairy, hog, and the USDA-National Agriculture Statistics Service (NASS) estimate of beef in feeding areas. All remaining livestock numbers were assumed to be on grass. There were five permitted Concentrated Animal Feeding Operations (CAFO's) in the North Fork and no permitted CAFO's in the South Fork watershed. The main source of *E. coli* bacteria in the North and South Fork Yellow Bank watersheds was determined to be livestock grazing. Evidence of this is available in the load duration curves which indicated that elevated counts of *E. coli* occurred throughout different flow regimes. Beef and dairy cattle were found to contribute the most significant amount of bacteria to the North and South Fork Yellow Bank watersheds; refer to Tables 2-8 and 2-9, pages 35 and 36.

Table 2-13. Bacteria Source Allocations for the North and South Fork of the Yellow Bank River Watersheds, SDDENR 2012.

	Percentage	
Source	North Fork	South Fork
Feedlots	32%	29%
Livestock on Grass	67%	70%
Wildlife	1%	1%

Wenck Associates, Inc. (2012) had similar findings in a water quality study of the lower reaches of the Yellow Bank River in Minnesota. Their information identified *E. coli* bacteria loadings were the result of; (a) over-grazed riparian pastures and noncompliant septic systems; which had a high likelihood of being major contributors of bacteria loading during dry conditions (low flow) during all seasons; this is because they can contribute bacteria load to receiving waters when other sources do not due to minimal or no runoff; and (b) surface applied manure, over-grazed pastures, and feedlots without runoff controls appeared likely to be the biggest contributors of bacteria loading during high runoff conditions across all seasons. Loads from these sources are generally transported entirely or in large part by runoff from high precipitation events.

Studies of adjacent and similar watersheds with 303(d) *E. coli* impairment listings in South Dakota have also identified the sources of *E. coli* bacteria (Blue Dog Lake, 2000). The computer model Agricultural Nonpoint Source Pollution Model (AGNPS) version 3.65 was selected in order to assess the nonpoint source (NPS) loadings throughout the drainage. AGNPS modeling predicts runoff volume and peak rate, eroded and delivered sediment, nitrogen, phosphorus, chemical oxygen demand (COD) concentrations in the runoff, and sediment. The AGNPS model was then used to objectively compare different subwatersheds and individual 40 acre cells within the watershed to other watersheds within the drainage basin.

The AGNPS model rated 25 feedlots in the watershed, 12 of which had rankings over 50. The model showed that removal of nutrients from these 12 animal feeding areas should reduce the phosphorus to Blue Dog Lake by 17%. The AGNPS model identified that the major sources of nutrients and bacteria in the Blue Dog Lake watershed were animal feeding areas, summer-long grazing, and poor manure management.

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. 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 Evan et al. 2003/2008.

BMP SYSTEM/TYPE	NRCS PRACTICE CODE	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%

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 designed for the full containment of animal wastes by the proper handling, storage, and utilization of wastes generated from animal confinement operations. The waste storage facility should reduce any discharge of animal wastes into the waters of the State. Therefore, the potential nutrient reduction in loading should be significant. Wastes would only be applied, through a Nutrient Management Plan (NMP), when growing crops can use the accompanying nutrients and soil and weather conditions are appropriate.

Study results in the Upper Minnesota Basin and adjacent watersheds indicated that the most likely sources of the nutrient loading were animal feeding operations and cattle grazing adjacent to water bodies. Feedlots were scored and ranked for implementation assessment. The analysis in Blue Dog Lake (SDDENR 1999) found that if the animal feeding areas, with an AGNPS rating over 55 were treated, the phosphorus load would be reduced by 17 percent and the nitrogen by 7.5 percent. The water quality samples also had fecal coliform bacteria in the majority of the samples collected, pointing to animal feeding areas as sources of bacterial contamination.

Similarly, the AGNPS computer model in the Clear Lake study (SDDENR 1999) indicated that major nutrient sources were streamside animal feeding operations and runoff from fertilized cropland. Compared to other watersheds in eastern South Dakota, the density of potentially critical feeding areas found in the Clear Lake drainage was high. Twenty-five animal feeding areas were evaluated as part of the study. Of these, 16 were found to have an AGNPS rank of 50 or more and 10 had an AGNPS rank of 60 or more on a scale of zero (no impact) to 100 (severe).

AWMS's are very effective in eliminating nutrient loading as the source of the nutrients is contained in a closed system. Eighteen AWMS reported as installed in the Lake Mitchell - Firesteel Creek watershed by Kringen (2010) reduced nitrogen by 49,409 pounds/year and phosphorous by 11,117 pounds per year.

3.2 NUTRIENT MANAGEMENT SYSTEM. NRCS PRACTICE CODE 590A

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.

3.3 GRAZING – RIPARIAN AREAS. NRCS PRACTICE CODE 528

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. Evan etal, (2008), estimated a 34% reduction in phosphorous and a 43% reduction in nitrogen through proper grazing management. Proper grazing management would include utilizing stocking rates to better manage grass height; grazing riparian pastures timely when ground conditions are not conducive (wet) to excessive bank and shoreline damage; and rotational use of pastures to allow periods of grass rest and recovery. Kringen reported (2010) rotational grazing systems on 14,421 acres to have reduced nitrogen by 2,575 pounds/year, phosphorous by 342.9 pounds/year, and sediment by 151 tons/year.

Rotational grazing and exclusion of livestock from critical areas (steep slopes adjacent to the lake and stream) also provides benefits that are difficult to simulate in modeling. Phosphorus was reported to be reduced by 0.4 tons/year in the Firesteel Creek 319 Phase I Summary

(Kringen 2006) by improved grazing management on 13,000 acres of grassland. The estimated P load reduction used for grazing management systems was 0.06 pounds of phosphorus reduction per acre per year improved. Application of this practice basin wide would manipulate the intensity, frequency, duration, and season of grazing to: (1) improve water infiltration, (2) maintain or improve riparian and upland area vegetation, (3) protect stream banks from erosion, (4) manage for deposition of fecal material away from water bodies.

The Rosehill/Sand Creek study (SDDENR 2002) reported that shoreline erosion occurred where the bank vegetation had been reduced or removed by domestic livestock. Banks that were void of vegetative cover were prone to erosion even by small waves. Livestock use of the riparian area also erodes portions of the bank into the lake. Restoring the shoreline vegetation along these sections would reduce the suspended solids in the lake and improve the water clarity. Lake reduction response modeling (Rosehill Lake) was conducted with BATHTUB, an Army Corps of Engineers Eutrophication Response Model. System responses were calculated using reductions in the loading of phosphorus to the lake from Sand Creek. Loading data for Sand Creek was taken directly from the results obtained from the FLUX modeling data calculated for the inlet to the lake. A large portion of the total phosphorus load was produced where bank erosion problems occurred along the creek and the shoreline of the lake. These areas had the highest discharge coefficient and the highest percentage of dissolved phosphorus, which indicated expected reductions in phosphorus of 20% to 40%. However, the authors felt these percentages were high, suggesting there were additional sources of phosphorus located in this area. To make a conservative estimate, they predicted bank stabilization practices to reduce loads by at least 10%.

Grazing along shoreline could be restricted by fencing the stream corridors off and keeping cattle out of the stream channel area or by limiting grazing to drier periods of the season, like late summer or early fall during low flow periods. 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 along 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 (329) applies to all cropland and includes both no-till and tillage methods commonly referred to as mulch tillage; where the soil surface is disturbed by tillage operations. Mulch tillage includes vertical tillage, chiseling, disking, and also includes tillage/planting systems with relatively minimal soil disturbance. No Till or Strip Till applies to limiting the soil disturbing activities to only those necessary to place nutrients, condition residue, and plant crops. Surface residue is left evenly distributed and no full width tillage is implemented.

Several studies adjacent to the Upper Minnesota River basin utilized the Agricultural Nonpoint Source Model (AGNPS) to evaluate their watersheds. The Blue Dog Lake watershed was divided up into 1,421 equally sized cells of 40 acres. Fifty-five cells had erosion rates of greater than 5 ton/acre/year and represented only 4% of the entire Blue Dog Lake drainage area. The targeted or “critical” cells were identified by the amount of nutrients that they produced and that ultimately reached the outlet of the watershed. Forty-one cells were identified as needing reduced tillage, which represented 2.9 % of the total watershed acres in this study. By implementing no-till cropping practices on these cells, the AGNPS showed an 18% reduction in phosphorus, a 35% reduction in sediment, and an 8% reduction in nitrogen delivered to Blue Dog Lake.

Similarly, the Little Minnesota/Big Stone Lake Project Implementation Report (Jensen 2007) found a savings for converting from conventional tillage systems to no-till planting systems of 8,844.6 tons of soil erosion reduction, 3,537.8 tons of sediment load reduction, and 6,721.7 pounds of phosphorous load reduction on 11,056 acres of cropland during the years of 2000 to 2006.

The emphasis for BMPs should be targeted to cropland identified in the critical AGNPS cells as the critical cells are located in close proximity to delivery systems and on steeper more erosive slopes.

3.5 STREAMBANK STABILIZATION. NRCS PRACTICE CODE 580

Stream bank 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. Severely eroded banks are usually back sloped 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.

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 Little Minnesota River (Jensen 2007) reductions for grassed waterways were documented with RUSLE II software using average values for the dominant soil types for the area. Total sediment delivery from the contributing waterways was reduced for the years 2000 to 2006 by 3,073.2 tons and phosphorous was reduced by 5,839.08 tons. His calculations were based on 39 grassed waterways which totaled 112 constructed acres and represented 9,978 total contributing watershed acres. The Sand Creek TMDL (SDDENR 2002) identified specific critical cells where the construction of grassed waterways and/or buffer strips would be the most effective treatment to reduce nutrient loadings from these cells. 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, 600, 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 also 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 (Jensen 2007) project. Sediment and phosphorous reductions were reported as 91,579 tons/pond lifespan and 174,000 lbs./pond lifespan, respectively. For this reason, wetland restoration, pond construction, water and sediment control structures, and structures for water control will be part of the Upper Minnesota River's 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

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.

The conversion to grassland was reported to reduce total soil erosion by approximately 1.6 tons/acre/year in the Little Minnesota River (Jensen 2007) study. This equated to a sediment delivery reduction to the Little Minnesota River watershed of approximately 0.6 tons/acre/year (37.5%). Reductions were calculated for each field in this study with RUSLE II using the dominant soil type.

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 Upper Minnesota River basin and evaluating them before BMP's are installed.

3.9 CONSERVATION CROP ROTATION AND CONSERVATION COVER CROPS. NRCS PRACTICE CODES 328 & 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. Convention tillage on soybean fields 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% to 65% and accompanying soil losses from 42% to 92%. The results from the TMDL study on Clear Lake (SDDENR 1999) found that runoff from fertilized cropland was a significant source of water soluble nutrients to Clear Lake. Conservation cover crop treatment use will provide both soil erosion benefits and the reduction of water runoff that carries the fertilizers and pesticides.

3.10 UPLAND WILDLIFE HABITAT MANAGEMENT. NRCS PRACTICE CODE 645

The objectives of upland wildlife habitat management (UWHM 645) are to provide and manage upland habitats and give connectivity within the landscape habitats for wildlife. During a comprehensive conservation planning process, any upland wildlife habitat concerns identified need to be treated. The objectives would be to enable movement and to provide shelter, cover, food in proper amounts, locations, and times to sustain wild animals that inhabit uplands during a portion of their life cycle. Although UWHM is not specifically related to reducing the pollutant sources identified in the 303(d) listing, this BMP may be beneficial in reducing pollutants in that it requires the establishment of permanent vegetative with minimal use or management.

Upland wildlife habitat management typically consists of grass and forb plantings enhanced with shrubs and trees that have minimal disturbance except for periodic management to maintain the quality of the existing cover. UWHM may be used to seed wildlife areas around wetland restorations and to provide riparian habitat adjacent to stream channels. This practice will also allow both herbaceous and woody plantings to be used.

3.11 NUTRIENT MANAGEMENT PLAN - CROPLAND. NRCS PRACTICE CODE 590

This nutrient management practice (590) 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 non-point 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 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 fallow. The potential exists for accelerated nutrient loss when essential nutrient amounts exceed crop uptake needs. Nutrient reactions and pathways in the soil-water system are complex. Nutrient flow to surface water and groundwater vary from nutrient to nutrient as do the threats to water quality. Potential surface water impacts include sedimentation, eutrophication and overall water quality degradation. Evans et al. (2003/2008) estimated nutrient management plans at efficiencies at 70% reduction for nitrogen and a 28% reduction for phosphorous.

4.0 LOAD REDUCTIONS

4.1 ANIMAL WASTE STORAGE FACILITIES

The Little Minnesota River/Big Stone Lake Phase I Diagnostic Feasibility Study (SDDENR 1983) identified 135 animal feeding operations with 63 of the feedlots ranked with an index value greater than 50 by the 'Feedlot Rating Model'. Since that time, approximately, 80 feedlots have had Animal Waste Storage Facilities (AWSF) constructed. The Mississippi River Nutrient Reduction and Water Quality Improvement Project for South Dakota (MRBI – 2012) reported approximately 52 animal feeding operations within the Upper Minnesota River watershed. The CD/NRCS field offices that have land in the Upper Minnesota River watershed were contacted for the number of Animal Waste Storage Facilities (AWSF) that are needed in each county. Their estimated need was for 20 AWSF to be constructed. Refer to Table 4-1 for projected load reductions and yearly applications.

Table 4-1. Estimated N and P Load Reductions Associated with AWSF

Estimated Nitrogen (N) and Phosphorous (P) Load Reductions (LR) Associated with Animal Waste Storage Facilities (AWSF)						
Year	# Goal	AU	N #/AU/YR	Total N #/YR LR	P #/YR/AU	Total P #/YR LR
1	1	300	16.5	4,950	3.7	1,110
2	4	1,200	16.5	19,800	3.7	4,440
3	5	1,500	16.5	24,750	3.7	5,550
4	8	2,400	16.5	39,600	3.7	8,880
5	2	600	16.5	9,900	3.7	2,220
Totals	20	6,000		99,000		22,200

Nutrient reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010

4.2 NUTRIENT MANAGEMENT SYSTEM LOAD REDUCTIONS FOR ANIMAL WASTES

The NMPs are designed to spread the manure from the Animal Waste Storage Facilities. The NMPs need approximately one acre 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. Ten facilities with 300 animal units constructed each year would require 3,000 acres in the NMPs; however, only 300 acres would receive the manure each year. See Table 4-2 for the estimated nitrogen and phosphorous load reductions associated with NMPs.

Table 4-2. Estimated N and P Load Reductions for NMP with AWSFs

Estimated Nitrogen (N) and Phosphorous (P) Load Reductions (LR) for Nutrient Management Plans Associated with Animal Waste Storage Facilities (AWSF)						
Year	# Goal	Acre	N #/AC/YR	Total N #/YR LR	P #/YR/AC	Total P #/YR LR
1	1	30	9.8	294	0.6	18
2	4	120	9.8	1,177	0.6	72
3	5	150	9.8	1,472	0.6	90
4	8	240	9.8	2,354	0.6	144
5	2	60	9.8	589	0.6	36
Totals	20	600		5,886		360

Nutrient reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010

4.3 PRESCRIBED GRAZING SYSTEMS

The CD/NRCS field offices that have land in the Upper Minnesota River watershed were contacted for the number of acres of grazing lands that need a grazing management system for each county. The estimated need was for 17,900 acres of prescribed grazing systems to be planned and implemented. Load reductions are presented in Table 4-3 using nitrogen load reduction estimates by Firesteel Creek/Lake Mitchell Watershed Project, (Kringen 2010) and phosphorous, and sediment load reduction estimates by Jensen (2007). Prescribed grazing systems are figured on 500 acres per system, with a rural water hook-up, one tank, water pipeline footage of 2,000 feet, and 2,500 feet of fencing per system.

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

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Prescribed Grazing on Pasture and Rangeland								
Year	Goaled	Acres	N #/Ac/Yr	Total #N/YR-LR	P #/Ac/YR	Total #P/YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	4	2,500	1.33	3,325.0	0.18	450.0	0.08	200.00
2	4	3,500	1.33	4,655.0	0.18	630.0	0.08	280.00
3	4	4,000	1.33	5,320.0	0.18	720.0	0.08	320.00
4	4	4,000	1.33	5,320.0	0.18	720.0	0.08	320.00
5	4	3,900	1.33	5,187.0	0.18	702.0	0.08	312.00
	20	17,900		23,807.0		3,222.0		1,432.00

Phosphorous and Sediment Load Reduction Estimates from Jensen 2007
Nitrogen reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010

4.4 RIPARIAN AREAS

Grazing management systems will be implemented on 17,050 acres of riparian areas to reduce nutrient and sediment transport to water bodies. These acres were estimated by CD/NRCS field office staff in the watershed counties. This grazing management plan can be as simple as fencing off the riparian zones to isolate grazing periods during less erosive periods. The Continuous CRP will 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 4-4 presents the load reductions for nitrogen, phosphorous, and sediment for 17,050 acres of riparian management for the Upper Minnesota River Basin.

Table 4-4. Riparian Area Management Program and Conservation Reserve Program Load Reductions

Riparian Area Management Program and Conservation Reserve Program Load Reductions							
Year	Acres Planned	N Reduction Lbs/Acre	Total N Reduction Lbs/Year	P Reduction Lbs/Acre	Total P Reduction Lbs/Year	Sediment Reduction Tons/Acre	Total Sediment Tons/Year
1	1,000	3.65	3,650.0	1.04	1,043.0	0.550	550.0
2	3,000	3.65	10,950.0	1.04	3,129.0	0.550	1,650.0
3	5,000	3.65	18,250.0	1.04	5,215.0	0.550	2,750.0
4	6,000	3.65	21,900.0	1.04	6,258.0	0.550	3,300.0
5	2,050	3.65	7,482.5	1.04	2,138.2	0.550	1,127.5
	17,050		62,232.5		17,783.2		9,377.5

Nitrogen reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010
Phosphorous and Sediment Load Reduction Estimates from Jensen 2007

4.5 RESIDUE & TILLAGE MANAGEMENT ON CROPLAND

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 average annual rate of sheet and rill erosion for cropland in the Little Minnesota/Big Stone project area (USDA-SCS 1994) was estimated at 3.6 tons/acre/year over 136,160 acres of cropland. However, more recent studies using AGNPS to analyze individual 40 acre cells has identified critical cells as contributing most of the erosion. In the Blue Dog Lake study (SDDENR 1999), the AGNPS model (version 3.65) identified 55 critical cells (4%) out of a total of 1,421 cells where erosion exceeded the 5 ton/acre/year rate. These 55 critical cells averaged 7.0 tons/acre/year of soil erosion. Applying Evans estimate of soil reductions by conservation tillage practices to the Blue Dog Lake data; soil loss could be reduced by 64 percent to 2.5 ton/acre/year; saving 4.5 tons/acre/year. This is a sediment load reduction of 1.9 tons/acre/year using an estimated 40 percent delivery rate to a water course. Most importantly, the studies using AGNPS modeling have identified that most of the erosion is coming from a small percentage of the AGNPS cells as in the case of Blue Dog Lake which was 4%.

Since the Little Minnesota/Big Stone Implementation Project (Jensen 2007) was within the Upper Minnesota River Basin, the values calculated by Jensen will be used to estimate sediment and phosphorous load reductions. These values also represent an average load reduction over all the watershed acres, not just the critical cells identified by AGNPS. Jensen’s average calculated erosion reduction for the implementation of No-till on cropland was 0.8 tons/acre/year. The deliver rate of eroded soil to the drainage systems was estimated at 40% or 0.32 tons/acre/year of sediment load reduction. This is somewhat higher than the sediment delivery of 0.026 tons/acre/year in the Blue Dog Lake study; however, they reported this delivery rate as quite low compared to other watersheds in northeast South Dakota. The Firesteel Creek 319 Application (2006) reported P load reduction for cropland was 0.5 pounds of phosphorus reduction per ton of soil saved; saving 2.75 pounds of P per acre. Jensen’s estimate of 0.61 lbs./acre/year phosphorous delivery was fairly similar to both Firesteel Creek at 0.50 lbs/acre/year and the Blue Dog Lake delivery rate of 0.59 lbs./acre/year. Jensen’s did not analyze nitrogen load delivery; therefore the rates of nitrogen delivery used in the Blue Dog Lake study of 2.42 lbs./acre/year will be used to project estimates in Table 4-5.

Table 4-5. 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	N #/Ac/Yr	Total #/YR-LR	P #/Ac/YR	Total #YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	10,000	2.42	24,200.0	0.61	6,100.0	0.32	3,200.0
2	12,000	2.42	29,040.0	0.61	7,320.0	0.32	3,840.0
3	12,000	2.42	29,040.0	0.61	7,320.0	0.32	3,840.0
4	12,000	2.42	29,040.0	0.61	7,320.0	0.32	3,840.0
5	12,000	2.42	29,040.0	0.61	7,320.0	0.32	3,840.0
Totals	58,000		140,360.0		35,380.0		18,560.0

Nitrogen reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010
Phosphorous and Sediment Load Reduction Estimates from Jensen 2007

4.6 STREAMBANK STABILIZATION

The planned bank stabilization footages were estimated by field office staff as 3,700 linear feet of stream bank stabilization. Table 4-6 presents load reductions for nitrogen as calculated using STEPL for projects installed in the Firesteel Creek project and reported by Kringen in 2010. Kringen noted that the STEPL estimates were on-site reductions and not necessarily delivered reductions, because it is difficult to estimate a percent delivered from BMPs installed. Load reductions of phosphorous and sediment on stream bank stabilization along severely eroded banks on the Little Minnesota River (Jensen 2007) are also reported in Table 4-6.

Table 4-6. Stream Bank Stabilization Load Reductions

Stream Bank Stabilization and Load Reductions Per Linear Foot (LF)							
Year	Linear Feet Planned	N Reduction Lbs/LF	Total N Reduction Lbs/LF	P Reduction Lbs/LF	Total P Reduction Lbs/LF	Sediment Reduction Tons/LF	Total Sediment Tons/LF
1	500	0.00884	4.4	0.360	180.00	0.190	95.0
2	700	0.00884	6.2	0.360	252.00	0.190	133.0
3	850	0.00884	7.5	0.360	306.00	0.190	161.5
4	850	0.00884	7.5	0.360	306.00	0.190	161.5
5	800	0.00884	7.1	0.360	288.00	0.190	152.0
Totals	3,700		32.7		1,332.0		703.0

Nitrogen reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010
Phosphorous and Sediment Load Reduction Estimates from Jensen 2007

4.7 GRASSED WATERWAYS

Planned linear feet (LF) for grassed waterways are based on estimates by field office personnel. Phosphorous and sediment load reduction estimates used were the calculations by Jensen (2007) for load reductions in the Little Minnesota/Big Stone Lake watershed implementation project final report. Jensen did not calculate the nitrogen load reductions and those nitrogen load reductions calculated by Kringen (2010) were used. This data is presented in Table 4-7.

Table 4-7. Grassed Waterway Load Reductions for N, P, and Sediment

Grassed Waterway Load Reductions for Nitrogen, Phosphorous, Sediment							
Year	Linear Feet (LF) Planned	N Reduction Lbs/LF	Total N Reduction Lbs/Year	P Reduction Lbs/LF	Total P Reduction Lbs/Year	Sediment Reduction Tons/LF	Total Sediment Tons/Year
1	5,000	0.15900	795.0	0.07680	384.00	0.04042	202.1
2	15,175	0.15900	2,412.8	0.07680	1,165.44	0.04042	613.4
3	15,500	0.15900	2,464.5	0.07680	1,190.40	0.04042	626.5
4	15,500	0.15900	2,464.5	0.07680	1,190.40	0.04042	626.5
5	15,000	0.15900	2,385.0	0.07680	1,152.00	0.04042	606.3
Totals	66,175		10,521.8		5,082.2		2,674.8

Nitrogen reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010
Phosphorous and Sediment Load Reduction Estimates from Jensen 2007

4.8 WETLAND RESTORATION AND POND CONSTRUCTION

Planned restoration of wetlands and pond construction numbers were estimated by field office personnel. See Table 4-8. Calculated total sediment and phosphorous load reductions data expected from the constructed ponds/basins and restored wetlands are from multi-purposed ponds constructed in the Little Minnesota River/Big Stone implementation project (Jensen 2007). The phosphorous and sediment load reductions were based on five acres of watershed protection (WSAc) around the restored wetlands/ponds over an estimated 20 year lifespan.

Table 4-8. Wetland Restoration, Pond, Basin Construction Load Reductions

Wetland Restoration and Pond Construction Load Reductions						
Year	No. Ponds Wetlands Planned	Watershed Acres Restored	P Reduction Lbs/WS Ac Lifespan	Total Lbs P Reduction Lifespan	Sed Reduct Lifespan Tons/ WS Ac	Total Sediment Reduction
1	10	50	29.76	1,488.0	15.67	783.5
2	30	150	29.76	4,464.0	15.67	2,350.5
3	30	150	29.76	4,464.0	15.67	2,350.5
4	40	200	29.76	5,952.0	15.67	3,134.0
5	30	150	29.76	4,464.0	15.67	2,350.5
Totals	140	700		20,832.0		10,969.0

Phosphorous and Sediment Load Reduction Estimates from Jensen 2007

4.9 CONVERSION OF CROPLAND TO FORAGE AND BIOMASS PLANTINGS

The amount of acres needed to convert the highest eroding cropland to vegetative species suited to pasture, hayland, or biomass production was estimated by field office staff to be 1,925 acres for the Upper Minnesota River basin. The calculated load reductions of phosphorous and sediment for were those reported by Jensen (2007) in the Little Minnesota/Big Stone Lake implementation project. Nitrogen load reductions were not calculated by Jensen and the numbers used for nitrogen load reduction are those reported in the Firesteel Creek project by Kringen (2010) using STEPL. This data is presented in Table 4-9.

Table 4-9. 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	N #/Ac/Yr	Total #N/YR-LR	P #/Ac/YR	Total #P/YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	200	4.01	802.0	1.203	240.6	0.633	126.6
2	400	4.01	1,604.0	1.203	481.2	0.633	253.3
3	400	4.01	1,604.0	1.203	481.2	0.633	253.3
4	550	4.01	2,205.5	1.203	661.7	0.633	348.3
5	375	4.01	1,503.8	1.203	451.1	0.633	237.5
Totals	1,925		7,719.3		2,315.8		1,218.9

Nitrogen reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010
Phosphorous & Sediment Load Reductions from Jensen 2007

4.10 CONSERVATION CROP ROTATION AND CONSERVATION COVER CROP ON CROPLAND ACRES

The effectiveness in using cover crops to reduce soil erosion and rainfall runoff was demonstrated by Hargrove (1991). However, the sediment and nutrient delivery on cropland acres has not been analyzed in the Upper Minnesota River basin. The adjacent watershed study of Clear Lake (SDDENR 1999) reported the sediment transport and deliverability throughout the watershed indicated that for an average year, approximately 3,084 tons (0.121 tons/acre) of sediment enter the lake. The AGNPs data indicated that the Clear Lake sub watersheds had a total nitrogen (soluble+sediment bound) deliverability rate of 22.1 lbs./acre/yr., and a total phosphorus (soluble+sediment bound) deliverability rate of 5.2 lbs./acre/yr. to the lake. The results also indicated that runoff from fertilized cropland was a significant source of water soluble nutrients to Clear Lake.

Hargrove (1991) found the use of cover crops reduced average annual runoff from 31% to 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% to 6.85 lbs./ac/year and 5.2 lbs. of phosphorous/acre/year could be reduced by 31% to 1.6 lb./ac/year.

The analysis of the sediment transport and deliverability throughout the watershed to Clear Lake indicated that for an average year, approximately 3,084 tons (0.121 tons/acre) of sediment entered the lake. Hargrove's report found soil losses to be reduced from 42% to 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 0.051 ton/acre/year. These load reductions from the use of a cover crop are applied in Table 4-10. The winter cover crop treatment produced results similar to a meadow rotation treatment (Hargrove 1991); therefore the load reductions reported in Table 4-10 may be higher if a crop rotation that incorporates meadow or hayland is included.

Table 4-10. Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Cover Crops on Cropland

Estimated Nitrogen (N), Phosphorous (P), and Sediment (S) Load Reductions (LR) for Cover Crops on Cropland							
Year	Acres	N #/Ac/Yr	Total #/YR-LR	P #/Ac/YR	Total #YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	1,250	6.85	8,562.5	1.61	2,012.5	0.051	63.8
2	1,250	6.85	8,562.5	1.61	2,012.5	0.051	63.8
3	1,250	6.85	8,562.5	1.61	2,012.5	0.051	63.8
4	1,250	6.85	8,562.5	1.61	2,012.5	0.051	63.8
5	1,250	6.85	8,562.5	1.61	2,012.5	0.051	63.8
Totals	6,250		42,812.5		10,062.5		318.8

Projected Estimates from Hargrove 1991 and TMDL Clear Lake SDDENR 1999

LR Estimates are for Cover Crop Use Only. The Addition of Crop Rotation with a Cover Crop May Give Higherr LR (Hargrove 1991)

4.11 WATER AND SEDIMENT CONTROL BASIN AND STRUCTURES FOR WATER CONTROL

Planned numbers of water and sediment control basin numbers were estimated by field office personnel at twenty-one. Calculated total sediment and phosphorous load reductions data expected from the constructed ponds/basins and restored wetlands are from multi-purposed ponds constructed in the Little Minnesota River/Big Stone Lake implementation 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 in Jensen's load reduction calculation. However, the water and sediment basins should result in similar control of the sediment delivery and sediment attached phosphorous. The phosphorous and sediment load reductions were based on five acres of watershed protection (WS Ac) around the restored watershed acres over an estimated 20 year lifespan and are presented in Table 4-11.

Table 4-11. Water and Sediment Control Basin Load Reductions

Water and Sediment Control Basin & Structure for Water Control Load Reductions								
Year	No. Ponds Wetlands Planned	Watershed Acres Restored	P Reduct Lbs/Ac/Yr	P Reduct Lbs/WS Ac 20 Yr Life	Total Lbs P Reduct Life Span	Sediment Reduction Ton/Ac/Yr	Sed Reduct Ton/ Ws Ac 20 Yr Life	Total Sed Reduct Life Span
1	2	10	1.489	29.78	297.8	0.784	15.68	156.8
2	4	20	1.489	29.78	595.6	0.784	15.68	313.6
3	5	25	1.489	29.78	744.5	0.784	15.68	392.0
4	5	25	1.489	29.78	744.5	0.784	15.68	392.0
5	5	25	1.489	29.78	744.5	0.784	15.68	392.0
Totals	21	105			3,126.9			1,646.4

Phosphorous and Sediment Load Reduction Estimates from Jensen 2007

4.12 UPLAND WILDLIFE HABITAT MANAGEMENT

Upland wildlife habitat management typically consists of grass and forb plantings enhanced with shrubs and trees. Jensen reported (2007) a riparian forest buffer was installed on a tributary of the Little Minnesota River consisting of a four acre buffer of 885 rod rows of trees and shrubs. A 5.4 acre filter strip of native grasses was also planted adjacent to the trees to reduce sediment delivery from an adjoining crop field. Sediment delivery from the field was reduced by approximately 1.623 tons/acre/year and phosphorous was reduced by 3.08 pounds/acre/year. Kringen (2010) reported riparian projects of 349 acres within the Firesteel Creek Riparian Area Management Program averaged a nitrogen load reduction at 3.65 pounds/acre/year, phosphorus at 2.52 pounds/acre/year, and sediment at 0.08 tons/acre/year. Estimated load reductions for the Upper Minnesota River are presented in Table 4-12.

Table 4-12. Nitrogen, Phosphorous, and Sediment Load Reductions on Upland Wildlife Habitat

Estimated Nitrogen (N), Phosphorous (P), and Sediment (Sed) Load Reductions (LR) for Cropland Conversion to Upland Wildlife Habitat							
Year	Acres	N #/Ac/Yr	Total #N/YR-LR	P #/Ac/YR	Total #P/YR-LR	Sed T/Ac/YR	Total T/YR-LR
1	30	3.65	109.5	3.080	92.4	1.623	48.7
2	30	3.65	109.5	3.080	92.4	1.623	48.7
3	30	3.65	109.5	3.080	92.4	1.623	48.7
4	30	3.65	109.5	3.080	92.4	1.623	48.7
5	30	3.65	109.5	3.080	92.4	1.623	48.7
Totals	150		547.5		462.0		243.5

Nitrogen reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010
Phosphorous and Sediment Load Reduction Estimates from Jensen 2007

4.13 NUTRIENT MANAGEMENT PLAN - CROPLAND.

This nutrient management practice (590) 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 manures. 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 can be developed to manage the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments necessary to sustain plant growth and production goals. The NMP should minimize agricultural nonpoint source pollution of surface waters and result in reduced nutrient loading from manure spread on fields as discussed in section 3.2, page 46, and presented in Table 3-1 of this document. Estimated load reductions for NMP are presented in Table 4-13.

Table 4-13. 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	Acre	N #/AC/YR	Total N #/YR LR	P #/YR/AC	Total P #/YR LR
1	2,500	9.8	24,525	0.6	1,500
2	3,500	9.8	34,335	0.6	2,100
3	4,000	9.8	39,240	0.6	2,400
4	4,000	9.8	39,240	0.6	2,400
5	3,500	9.8	34,335	0.6	2,100
Totals	17,500		171,675		10,500

Nutrient reduction estimates from STEPL: Spreadsheet Tool for the Estimation of Pollutant Load v. 4.0. Kringen 2010

5.0 TECHNICAL AND FINANCIAL ASSISTANCE NEEDED

The Northeast Glacial Lakes Watershed Improvement & Protection Project (NEGLW) will be administratively responsible for the project implementation and will be the lead sponsor. A project coordinator will manage all water quality project activities among the watershed counties which will include all the local, state and federal conservation personnel. The counties supporting the project will appoint members to serve on a steering committee. The Conservation District Managers and NRCS District Conservationists will assist the project coordinator with cost-share reimbursement, file maintenance, and other financial transactions. Technical expertise from these offices will be necessary to implement the BMPs in each local county. Both financial programs and technical expertise will be provided through existing partnerships with Marshall, Roberts, Deuel, Codington, Grant, and Day County Conservation Districts; East Dakota Water Development District; James River Water Development District; South Dakota Lakes and Streams Association; Sisseton-Wahpeton Oyate Office of Environmental Protection; Pheasants Forever; Prairie Coteau Habitat Partnership; Nature Conservancy in South Dakota; SD Association of Conservation Districts; SD Game, Fish and Parks (SD GF&P); SDDENR; SD Department of Agriculture (SDDOA); SD Extensions Service; US Environmental Protection Agency; US Fish and Wildlife Service; USDA Farm Service Agency; and USDA NRCS. Additional funding for the implementation of the BMPs will be solicited from these partners through their programs such as; the NRCS Environmental Quality Incentive Program and Wetland Reserve Program; FSA Conservation Reserve Program and Conservation Reserve Enhancement Program; SD GF&P Wildlife Partnership Program and Wetland and Grassland Habitat Program; and US-FWS Grassland and Wetland Easement Programs and Private Land Programs.

Funding and technical assistance needs for BMP implementation are based on extrapolations of several detailed completed sub watershed analyses. The Upper Minnesota River Basin land use is fairly homogenous and the impairment problems have been consistently identified as agricultural in nature for both cropland and animal uses. The extrapolations have been conservative and the expected outcome to be consistent. The assistance needed is intended to fund the first segment of the watershed need through a Five Year Strategic Plan. The estimated costs are based on the 2012 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.

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	1	$ 20,000	Grazing System, EA	$ -	5	$ -
	AWSF	$200,000	1	$ 200,000	Rural Water, EA	$ 2,000	5	$ 10,000
	Const Mgmt	$ 18,750	1	$ 18,750	Pipeline, LF	$ 5	10,000	$ 50,000
	NMP	$ 2,500	0	$ -	Tanks, EA	$ 1,000	5	$ 5,000
	Cultural Study	$ 500	1	$ 500	Fencing, LF	$ 1	12,500	$ 12,500
				$ 239,250				$ 77,500
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	1,000	$ -	Rock, Fabric/LF	$ 110	500	$ 55,000
	Fencing LF	$ 1	5,000	$ 5,000				$ -
				$ 5,000				$ 55,000
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	10,000	$ 100,000	Dirt Work, Seed/ LF	$ 1.70	5,000	$ 8,500
				$ 100,000				$ 8,500
Year	BMP - Wetland Restoration and Pond Construction				BMP - Cropland Conversion to Forage Plantings			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 1,000	50	$ 50,000	Tillage/Seeding AC	$ 100	200	$ 20,000
				$ 50,000				$ 20,000
Year	BMP - Cover Crop on Cropland				BMP - Water & Sediment Basin			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,250	$ 47,500	Dirt Work/Seed EA	$ 4,500	2	$ 9,000
				$ 47,500				$ 9,000
Year	BMP - Nutrient Manage Plan, Non AWMS				BMP - Wildlife Habitat Manage			
1	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 3.58	2,500	$ 8,950	Cost Incentive/AC	$ 91	75	$ 6,825
				$ 8,950				$ 6,825
		TOTAL BMP COSTS			$ 627,525			

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, EA	$ -	7	$ -
	AWSF	$200,000	4	$ 800,000	Rural Water, EA	$ 2,000	7	$ 14,000
	Const Mgmt	$ 18,750	4	$ 75,000	Pipeline, LF	$ 5	14,000	$ 70,000
	NMP	$ 2,500	2	$ 5,000	Tanks, EA	$ 1,000	7	$ 7,000
	Cultural Study	$ 500	4	$ 2,000	Fencing, LF	$ 1	17,500	$ 17,500
				$ 962,000				$ 108,500
Year	BMP - Riparian Areas				BMP	- Bank Stabilization		
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	3,000	$ -	Rock, Fabric/LF	$ 110	700	$ 77,000
	Fencing LF	$ 1	15,000	$ 15,000				$ -
				$ 15,000				$ 77,000
Year	BMP - Residue & Tillage Manage				BMP -	Grassed Waterways		
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	12,000	$ 120,000	Dirt Work, Seed/ LF	$ 1.70	15,175	$ 25,798
				$ 120,000				$ 25,798
Year	BMP - Wetland Restoration and Pond Construction				BMP - Cropland Conversion to Forage Plantings			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 1,000	30	$ 30,000	Tillage/Seeding AC	$ 100	400	$ 40,000
				$ 30,000				$ 40,000
Year	BMP - Cover Crop on Cropland				BMP - Water & Sediment Basin			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,250	$ 47,500	Dirt Work/Seed EA	$ 4,500	4	$ 18,000
				$ 47,500				$ 18,000
Year	BMP - Nutrient Manage Plan, Non AWMS				BMP - Wildlife Habitat Manage			
2	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 3.58	3,500	$ 12,530	Cost Incentive/AC	$ 91	75	$ 6,825
				$ 12,530				$ 6,825
		TOTAL BMP COSTS			$ 1,463,153			

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	5	$ 100,000	Grazing System, EA	$ -	8	$ -
	AWSF	$200,000	5	$1,000,000	Rural Water, EA	$ 2,000	8	$ 16,000
	Const Mgmt	$ 18,750	5	$ 93,750	Pipeline, LF	$ 5	16,000	$ 80,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,000	8	$ 8,000
	Cultural Study	$ 500	5	$ 2,500	Fencing, LF	$ 1	20,000	$ 20,000
				$1,208,750				$ 124,000
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	5,000	$ -	Rock, Fabric/LF	$ 110	850	$ 93,500
	Fencing LF	$ 1	25,000	$ 25,000				$ -
				$ 25,000				$ 93,500
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	12,000	$ 120,000	Dirt Work, Seed/ LF	$ 1.70	15,500	$ 26,350
				$ 120,000				$ 26,350
Year	BMP - Wetland Restoration and Pond Construction				BMP - Cropland Conversion to Forage Plantings			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 1,000	30	$ 30,000	Tillage/Seeding AC	$ 100	400	$ 40,000
				$ 30,000				$ 40,000
Year	BMP - Cover Crop on Cropland				BMP - Water & Sediment Basin			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,250	$ 47,500	Dirt Work/Seed EA	$ 4,500	5	$ 22,500
				$ 47,500				$ 22,500
Year	BMP - Nutrient Manage Plan, Non AWMS				BMP - Wildlife Habitat Manage			
3	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 3.58	4,000	$ 14,320	Cost Incentive/AC	$ 91	75	$ 6,825
				$ 14,320				$ 6,825
		TOTAL BMP COSTS			$ 1,758,745			

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	8	$ 160,000	Grazing System, EA	$ -	8	$ -
	AWSF	$200,000	8	$1,600,000	Rural Water, EA	$ 2,000	8	$ 16,000
	Const Mgmt	$ 18,750	8	$ 150,000	Pipeline, LF	$ 5	16,000	$ 80,000
	NMP	$ 2,500	8	$ 20,000	Tanks, EA	$ 1,000	8	$ 8,000
	Cultural Study	$ 500	8	$ 4,000	Fencing, LF	$ 1	20,000	$ 20,000
				$1,934,000				$ 124,000
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	6,000	$ -	Rock, Fabric/LF	$ 110	850	$ 93,500
	Fencing LF	$ 1	30,000	$ 30,000				$ -
				$ 30,000				$ 93,500
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	12,000	$ 120,000	Dirt Work, Seed/ LF	$ 1.70	15,500	$ 26,350
				$ 120,000				$ 26,350
Year	BMP - Wetland Restoration and Pond Construction				BMP - Cropland Conversion to Forage Plantings			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 1,000	40	$ 40,000	Tillage/Seeding AC	$ 100	550	$ 55,000
				$ 40,000				$ 55,000
Year	BMP - Cover Crop on Cropland				BMP - Water & Sediment Basin			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,250	$ 47,500	Dirt Work/Seed EA	$ 4,500	5	$ 22,500
				$ 47,500				$ 22,500
Year	BMP - Nutrient Manage Plan, Non Manure				BMP - Wildlife Habitat Manage			
4	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 3.58	4,000	$ 14,320	Cost Incentive/AC	$ 91	75	$ 6,825
				$ 14,320				$ 6,825
		TOTAL BMP COSTS			$ 2,513,995			

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	2	$ 40,000	Grazing System, EA	$ -	8	$ -
	AWSF	$200,000	2	$ 400,000	Rural Water, EA	$ 2,000	8	$ 16,000
	Const Mgmt	$ 18,750	2	$ 37,500	Pipeline, LF	$ 5	14,000	$ 70,000
	NMP	$ 2,500	5	$ 12,500	Tanks, EA	$ 1,000	8	$ 8,000
	Cultural Study	$ 500	2	$ 1,000	Fencing, LF	$ 1	20,000	$ 20,000
				$ 491,000				$ 114,000
Year	BMP - Riparian Areas				BMP - Bank Stabilization			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Grazing AC	$ -	2,050	$ -	Rock, Fabric/LF	$ 110	800	$ 88,000
	Fencing LF	$ 1	10,000	$ 10,000				$ -
				$ 10,000				$ 88,000
Year	BMP - Residue & Tillage Manage				BMP - Grassed Waterways			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 10	12,000	$ 120,000	Dirt Work, Seed/ LF	$ 1.70	15,000	$ 25,500
				$ 120,000				$ 25,500
Year	BMP - Wetland Restoration and Pond Construction				BMP - Cropland Conversion to Forage Plantings			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Dirt Work/Seed EA	$ 1,000	30	$ 30,000	Tillage/Seeding AC	$ 100	375	$ 37,500
				$ 30,000				$ 37,500
Year	BMP - Cover Crop on Cropland				BMP - Water & Sediment Basin			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 38	1,250	$ 47,500	Dirt Work/Seed EA	$ 4,500	5	$ 22,500
				$ 47,500				$ 22,500
Year	BMP - Nutrient Manage Plan, Non AWMS				BMP - Wildlife Habitat Manage			
5	Components	Costs	Quantity	Total Costs	Components	Costs	Quantity	Total Costs
	Cost Incentive/AC	$ 3.58	3,500	$ 12,530	Dirt Work/Seed EA	$ 91	75	$ 6,825
				$ 12,530				$ 6,825
		TOTAL BMP COSTS			$ 1,005,355			

TABLE 5-6. SUMMARY OF 5 YEAR COSTS UPPER MINNESOTA RIVER						
BMP IMPLEMENTATION COSTS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TASK TOTAL
Animal Waste Management System	$239,250	$962,000	$1,208,750	$1,934,000	$491,000	$4,835,000
Prescribed Grazing	$77,500	$108,500	$124,000	$124,000	$114,000	$548,000
Riparian Area	$5,000	$15,000	$25,000	$30,000	$10,000	$85,000
Bank Stabilization	$55,000	$77,000	$93,500	$93,500	$88,000	$407,000
Residue & Tillage Manage	$100,000	$120,000	$120,000	$120,000	$120,000	$580,000
Grassed Waterways	$8,500	$25,798	$26,350	$26,350	$25,500	$112,498
Wetland/Pond Restoration	$50,000	$30,000	$30,000	$40,000	$30,000	$180,000
Cropland Conversion to Grass	$20,000	$40,000	$40,000	$55,000	$37,500	$192,500
Conservation Cover Crop	$47,500	$47,500	$47,500	$47,500	$47,500	$237,500
Water & Sediment Basin	$9,000	$18,000	$22,500	$22,500	$22,500	$94,500
Nutrient Manage Plan, Non AWMS	$8,950	$12,530	$14,320	$14,320	$12,530	$62,650
Wildlife Habitat Manage	$6,825	$6,825	$6,825	$6,825	$6,825	$34,125
BMP TOTAL COST IMPLEMENTATION	$627,525	$1,463,153	$1,758,745	$2,513,995	$1,005,355	$7,368,773
PERSONNEL SUPPORT						
Project Coordinator	$60,000	$60,000	$60,000	$60,000	$60,000	$300,000
OPERATIONS						
Vehicle, Fuel, Travel, Insurance	$10,000	$10,000	$10,000	$10,000	$10,000	$50,000
ADMINISTRATION						
Computer, Supplies, Telephone, Offce, Postag	$6,000	$6,000	$6,000	$6,000	$6,000	$30,000
PERSONNEL SUPPORT TOTAL COSTS	$76,000	$76,000	$76,000	$76,000	$76,000	$380,000
YEARLY TOTALS	$703,525	$1,539,153	$1,834,745	$2,589,995	$1,081,355	$7,748,773

6.0 PUBLIC OUTREACH

Historically, efforts for public outreach have been ongoing since a 1967 study of Big Stone Lake was completed jointly by the States of Minnesota and South Dakota to address citizens' concerns about the decline in aesthetics and water quality of the lake. A report was completed by the U.S. Army Corps of Engineers on siltation and water quality problems in Big Stone Lake in 1975. A Diagnostic and Feasibility Study of the Lower Little Minnesota River and Big Stone Lake watersheds project sponsored by the Roberts and Marshall County Conservation Districts was completed in 1983. Jensen reported (2007) that alternative conservation practices acceptable to the public in the watershed were identified through four public meetings and two mail-in surveys. The Marshall County and Roberts County Conservation Districts developed a survey for residents in each sub watershed. The survey listed practices proposed by a planning team. Participants were asked to rank the practices in order of priority for achieving a reduction in phosphorus delivered to the lake. The survey also requested that landowners and operators identify other conservation practices that they would like to implement if the project was funded. In order to reach as many people as possible, brief overviews of the project and the surveys were presented at agricultural meetings held in the watershed. Surveys were also mailed to all township board chairmen for board members to complete. Based on survey results, the top five practices ranked from the highest to lowest priority were minimum tillage, critical area treatment, grassed waterways, no-till planting, and animal waste management systems.

Public involvement continued through the use of Local Work Groups (LWG). These LWGs are sponsored by each of the five counties Soil and Water CDs' encompassed by the implementation projects. Phase I and Phase II implementation projects have utilized participant local match, State funding, EPA 319, USDA EQIP and PL-566 funds. 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. This outreach momentum continued when, in 2012, the project was combined with the Northeast Glacial Lakes Improvement and Protection Project sponsored by the Grant County Conservation District. The Northeast Glacial Lakes Watershed Protection and Improvement Project includes the northeast South Dakota counties of Day, Grant, Marshall, and Roberts.

The USDA NRCS offices are usually co-located with the CD and staff from these offices will be utilized to disseminate the information to producers. Updates and achievements will be emailed to these field offices on a quarterly basis by the project coordinator. Annual meetings with be held by the NEGLW Project Coordinator and the District Managers of each CD to provide them with information on the BMPs available to each county.

A project steering committee will meet twice each year to provide input for project management and coordination of resources. The committee will consist of representatives from Codington, Deuel, Grant, Marshall, and Roberts CDs; County Commissions; SD GF&P; SD DENR; SD

DOA; SDACD, SDSU Extension Service; USDA NRCS and FSA County Field Offices; US FWS; and the projects sponsor, the East Dakota Water Development District, and the James River Water Development District. Watershed assessment needs are determined by Local Work Groups (LWG).

Public outreach will come through:

- A "Friendship Tour" was held between the States of South Dakota and Minnesota touring the Upper Minnesota Watershed on July 11, 2012. Over 100 people were in attendance. The tour was sponsored by the Lac qui Parle-Yellow Bank Watershed District, the Upper Minnesota River Watershed District, and the East Dakota Water Development District.
- Newsletters from the CDs
- Articles in the local newspapers of Sisseton, Milbank, Britton, Clear Lake, and Wilmot
- Contact with the Citizens for Big Stone Lake Association
- Postcards sent to landowners along tributaries for CRP
- WEB page articles by several CDs
- Personal contact of landowners by Project staff
- Development of display for the local county fairs

7.0 IMPLEMENTATION SCHEDULE

The implementation of this project will be through voluntary programs over a five county-wide watershed area and will be coordinated by the project coordinator. The implementation of the practices is targeted at the agricultural sector. The unique delivery systems of the South Dakota Conservation Districts 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 in the county. 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, and project reports is detailed semi-annually in Table 7-1.

Table 7-1: Implementation Schedule for Upper Minnesota River Basin Project

Task	Group	Quantity	Year 1		Year 2		Year 3		Year 4		Year 5	
			Jan - June	June - Dec	Jan - June	June - Dec	Jan - June	June - Dec	Jan - June	June - Dec	Jan - June	June - Dec
OBJECTIVE 1: BMP IMPLEMENTATION												
Task 1: Animal Waste Manage Systems (#)												
Product 1: Animal Waste Manage Systems	1,2,3											
Engineering Studies		20		1	1	3	2	3	3	5	1	1
Animal Waste Storage Facilities		20		1	1	3	2	3	3	5	1	1
Construction Management		20		1	1	3	2	3	3	5	1	1
Nutrient Management Plan		20		0	1	1	2	3	3	5	1	4
Cultural Resource Study		20		1	1	3	2	3	3	5	1	1
Task 2: Grassland Management	1,2,4											
Product 2: Prescribed Grazing Systems (Ac)		17,900		2,500		3,500		4,000		4,000		3,900
Product 3: Riparian Areas (Ac)		17,050		1,000		3,000		5,000		6,000		2,050
Task 3: Streambank Stabilization	2,4											
Product 4: Streambank Stablization (LF)		3,700		500		700		850		850		800
Task 4: Cropland Management	1,2,4											
Product 5: Residue & Tillage Manage (Ac)		58,000		10,000		12,000		12,000		12,000		12,000
Product 6: Grassed Waterways (LF)		66,175		5,000		15,175		15,500		15,500		15,000
Product 7: Wetland & Pond Construct (WsAc)		700		50		150		150		200		150
Product 8: Conversion of Crop to Grass (Ac)		1,925		200		400		400		550		375
Product 9: Convservation Cover Crop (Ac)		6,250		1,250		1,250		1,250		1,250		1,250
Product 10: Water & Sediment Basin (#)		21		2		4		5		5		5
Product 11: Cropland NMP (Ac)		17,500		2,500		3,500		4,000		4,000		3,500
Product 12: Wildlife Habitat (Ac)		375		75		75		75		75		75

Table 7-1 Continued: Implementation Schedule for Upper Minnesota River Basin Project

Task	Group	Quantity	Year 1		Year 2		Year 3		Year 4		Year 5	
			Jan - June	June - Dec	Jan - June	June - Dec	Jan - June	June - Dec	Jan - June	June - Dec	Jan - June	June - Dec
OBJECTIVE 2: INFORMATION OUTREACH												
Task 5: Information Distribution												
Product 10: 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		5		1		1		1		1		1
Fair Demonstrations		10		2		2		2		2		2
WEB Site Listing		25	5		5		5		5		5	
OBJECTIVE 3: PROJECT REPORTS												
Task 6: Semi-annual, Annual, Final												
Product 11: Reports	1,2											
Semi-Annual		5	1		1		1		1		1	
Annual		5		1		1		1		1		1
Final		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 BMP’s 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 bacteria, nutrients, pH, temperatures, 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 Upper Minnesota River Watershed basin. 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 steering team will examine the achievements to determine if adequate progress has been made by the current BMP implementations. If they determine that adequate progress has not been made, they can readjust the implementation projects in order to achieve the five year BMP goals.

Table 8-1. Shortterm Criteria & Milestones BMP or Activity	Quantity	Year 1	Year 2	Year 2 Subtotal	Year 3	Year 3 Subtotal	Year 4	Year 4 Subtotal	Year 5	Final Totals
Engineering Studies - AWMS	20 No.	1	4	5	5	10	8	18	2	20
Animal Waste Storage Facilities	20 No.	1	4	5	5	10	8	18	2	20
Construction Management - AWMS	20 No.	1	4	5	5	10	8	18	2	20
Nutrient Management Plan	20 No.	0	2	2	5	7	8	15	5	20
Cultural Resource Study - AWMS	20 No.	1	4	5	5	10	8	18	2	20
Prescribed Grazing Systems	17900 Ac	2,500	3,500	6,000	4,000	10,000	4,000	14,000	3,900	17,900
Riparian Areas	17,050 Ac	1,000	3,000	4,000	5,000	9,000	6,000	15,000	2,050	17,050
Streambank Stabilization	3,700 LF	500	700	1,200	850	2,050	850	2,900	800	3,700
Residue & Tillage Manage	58,000 Ac	10,000	12,000	22,000	12,000	34,000	12,000	46,000	12,000	58,000
Grassed Waterways	66,175 Lf	5,000	15,175	20,175	15,500	35,675	15,500	51,175	15,000	66,175
Wetland & Pond Construction	700 WSAc	50	150	200	150	350	200	550	150	700
Conversion of Crop to Grass	1,925 Ac	200	400	600	400	1,000	550	1,550	375	1,925
Conservation Cover Crop	6,250 Ac	1,250	1,250	2,500	1,250	3,750	1,250	5,000	1,250	6,250
Water & Sediment Control Structures	21 No	2	4	6	5	11	5	16	5	21
Nutrient Management Plan	17,500 Ac	2,500	3,500	6,000	4,000	10,000	4,000	14,000	3,500	17,500
Wildlife Habitat Management	375 Ac	75	75	150	75	225	75	300	75	375
CD Newsletters	15	5	5	10	5	15	5	20	5	25
Newspaper Articles	10	2	2	4	2	6	2	8	2	10
Radio Spots	5	1	1	2	1	3	1	4	1	5
Fair Demonstrations	10	2	2	4	2	6	2	8	2	10
WEB Site Listing	25	5	5	10	5	15	5	20	5	25
Semi-Annual Reports	5	1	1	2	1	3	1	4	1	5
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. The SDDENR also maintains ambient water quality monitoring stations at eight sites located in Grant and Roberts Counties within the Upper Minnesota River Basin. Two stations are located in the Little Minnesota River are sampled monthly and one in the Little Minnesota River is sampled quarterly; two are in the South Fork of the Whetstone River and one in the Whetstone River that are sampled quarterly; and one is in the South Fork and one in the North Fork of the Yellow Bank River that are sampled quarterly. Data sampling from these 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 anticipated.

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, and STEPL models. The AnnAGNPS model will be used for changes in loadings due to BMP installation, while STEPL will be used to estimate annual load reductions in the watershed. 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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