Silver Lake Watershed Management Plan

Submitted by: Dickinson Soil & Water Conservation District

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1. Project Mission

The goal of the Silver Lake Watershed Project is to work to improve the water quality of Silver Lake to support multiple uses, to benefit fish and wildlife resources, and to maximize the quality of life for those who use it. To achieve these results, the watershed project must reduce sediment and phosphorous from reaching Silver Lake.

Previously, the Osceola Soil & Water Conservation District (SWCD), the Dickinson Soil & Water Conservation District (SWCD), the Dickinson County Clean Water Alliance (CWA), and the Silver Lake Park Improvement Association (SLPIA) have jointly participated in a Water Quality Assessment for the Silver Lake Watershed in an effort to determine where the water quality concerns for Silver Lake could be determined. These organizations have jointly pursued the protection and improvement of water quality in the Silver Lake Watershed since 1999.

The Dickinson SWCD has developed an intensive plan to reduce sediment and phosphorous loading to Silver Lake. The Osceola SWCD has already implemented the first phase of this plan. This includes a Watershed Improvement Review Board (WIRB) project focused on restoring 5% of the watershed to wetland and upland habitat. The 319/WSPF grant is the 2nd part of the plan. This project will assist landowners in the watershed with implementation of best management practices in key locations in the watershed. By using the combination of these two programs, it is hoped we will be able to reduce phosphorous loading into the lake by 58%, which will be enough to remove this lake from the impaired waters list.

Dickinson County Water Quality Commission was established in 2001 to provide a steady funding source, using local money as a match to state and federal revenues for water quality projects for lakes in Dickinson County. This one-of-a-kind organization in the state is comprised of 18 commissioners who represent the county and its ten municipalities. Among the many objectives of the WQC are: to bring a minimum of $3 in federal, state and private matching funds to communities that are looking for money to improve water quality. In the first year of operation in 2001, the WQC had a pool of $100,000 to grant to water quality projects to improve lakes in Dickinson County. In each subsequent year, the WQC has administered $200,000 in water quality projects. To date the Water Quality Commission has awarded nearly 1 million dollars in grant funds that have been matched with over 14 million dollars by the grantees. The 28-E agreement that created the WQC is in effect until 2009, and automatically renews for a two-year period thereafter.

Dickinson County Clean Water Alliance coordinates the efforts of governmental agencies, non-profit and private organizations through the help of a branch of the Dickinson County Soil and Water Conservation District (SWCD). Its slogan is, “united to keep our lakes alive.” The CWA is an uncommon federation of over 60 groups working in harmony to protect the water resources of the area. The CWA was formed in 1990 by the Dickinson County SWCD and the INHF, the area lake protective associations and the Iowa DNR. They continue to coordinate activities for water quality.

The long-range strategic plan developed by the CWA has identified four main watershed goals for lakes in Dickinson County:

- Native biological diversity is respected and encouraged
- Infiltration practices are promoted throughout the watershed
- Impaired waters are protected and improved
- High quality waters are maintained and improved

The Alliance recognizes that a successful watershed approach to protecting and enhancing the water quality in the Great Lakes region requires clearly identifying needs and goals, selection of management alternatives based on good science, and a genuine stakeholder partnership. The Alliance promotes a voluntary conservation program driven by landowners, lake and park users, and public and private organizations that will reduce or prevent negative impacts to water, land, and economic resources within Dickinson County.

Support for the Silver Lake Watershed Project is tremendous. The members of the Clean Water Alliance fully support this project. Groups and individuals in Lake Park and around Silver Lake are excited about the opportunities this project will bring them. Landowners in the watershed are already investigating the opportunities available to them as a result of this project.

Silver Lake Park Improvement Association has a mission to protect and enhance water quality in Silver Lake. Other protective associations in Dickinson County have agreed to assist the Silver Lake Park Improvement Association in its efforts. The oldest of these is the Okoboji Protective Association, which celebrated its 100th anniversary in the summer of 2005. Many of the lake associations' projects are held around their individual lakes (e.g. clean-ups, education classes for Girl Scouts & Boy Scouts.)

Iowa Lakeside Laboratory (ILL) is a year-round environmental education facility with over 40 buildings on a 143-acre campus on West Lake Okoboji. Classes held at the lab serve numerous students from various universities throughout the state. Iowa Lakeside Laboratory is responsible for conducting the CLAMP water monitoring in Silver Lake.

Iowa DNR Northwest Regional Headquarters houses the Spirit Lake Fish Hatchery, and is the only cool water hatchery in the state. This hatchery is noted for its walleye, northern pike and muskellunge production which help to sustain healthy game fish populations in the lakes, streams and reservoirs of Iowa. The DNR regional headquarters also has offices dedicated to management of fisheries and wildlife resources in NW Iowa and the research of Iowa's natural lakes. Personnel from this office are analyzing the new Light Detection and Ranging (LiDAR) data as well as performing the GIS assessment for the watershed. This data will be used to determine future environmental planning.

Figure 1.1: Silver Lake sunset

2. Watershed Characteristics

Location

The Silver Lake watershed is an area of about 18,050 acres located in northwest Iowa and southwest Minnesota. Approximately 50 percent of the watershed lies within Dickinson County, Iowa, 45 percent of the watershed in Osceola County, Iowa, and the remainder within Jackson County, Minnesota. Silver Lake is a major recreational lake for Iowa residents and visitors from adjacent states. Agricultural runoff containing sediment, fertilizers, pesticides, herbicides, and feedlot waste negatively influence the water quality. Urbanization contributes pollution from stormwater run-off, and there is some suspicion that there are a number of private sewage disposal systems within the watershed area that are improperly installed or not properly maintained.

The drainage area to Silver Lake is a 17,025-acre watershed, not including the surface area of the lake. The moderately large lake to watershed ratio of 16.5 to 1 indicates that watershed characteristics have a significant potential impact on water quality of the lake.

Silver Lake

Silver Lake is a natural glacial lake. The watershed of Silver Lake is rather large compared to the lake area. The total lake watershed is 18,055 acres with a total lake area of 1,033. Silver Lake is typical of the shallow glacial till lakes from the last glacial period.

Silver Lake is listed on the State of Iowa's FY2002 and FY2004 Section 303(d) List of Impaired Waters for the impairments of sediment and nutrients entering the lake from rural and urban areas. Silver Lake is listed as a "Priority Lake" in the September 2002 State Non-point Management Program for Iowa. According to a 5-year study of Iowa's public Lakes, Silver Lake ranks in the bottom 25th percentile for average chlorophyll A concentrations, Secchi depth, average Carlson TSI, and average total phosphorous. By examining Silver Lake's position in the bottom 25th percentile of this list, it is evident that some of the poorest water quality in Iowa's public lakes can be found here.

IDNR Waterbody ID	IA 06-LSR-03105-L_0
10 Digit Hydrologic Unit Code (HUC)	1023000302
10 Digit HUC Name	West Fork Little Sioux River
Location	Dickinson County, S28, T100N, R38W
Latitude	43.5
Longitude	-95.3

Designated Uses	A1 – Primary contact recreation B(LW) – Aquatic life (lakes and wetlands) C – Drinking water supply HH – Human health (fish consumption)
Tributaries	West Branch Little Sioux River and one unnamed tributary
Receiving Waterbody	West Branch Little Sioux River
Lake Surface Area	1,032 acres (excludes Trappers Bay)
Maximum Depth	9.8 feet
Mean Depth	6.7 feet (excludes Trappers Bay)
Lake Volume	6,894 acre-feet
Length of Shoreline	9.61 miles (50,730 feet)
Watershed Area (excludes lake)	17,025 acres
Watershed:Lake Ratio	16.5:1
Lake Residence Time	121 days (estimated)

Table 2.1: Location/characteristics of Silver Lake and associated watershed

Land Use

The predominant land use in the Silver Lake Watershed is row crop agriculture, most of which is in a corn-soybean rotation. There is some cropland in a corn-soybean-oats-meadow rotation, but this accounts for only five percent of the total cropland in the watershed. Conservation Reserve Program (CRP) ground makes up a very small portion (less than one percent) of the area typically in crop production. Other land uses include farmsteads, timber, grasslands, wildlife area, urban, and roads. Table 1.2 reports the generalized land uses by acre and by percentage of watershed. Figure 1.1 shows a more detailed distribution of land use throughout the watershed.

The total land use breakdown for the Silver Lake Watershed is as follows:

General Land Use	Description	Area (Acres)	% of Watershed
Row Crops	corn, beans, oats, alfalfa, CRP	14,521.1	85.3
Conservation Areas	timber, grassland, wildlife areas	1,471.3	8.6
Farmsteads	homes, yards	269.3	1.6
Water	wetlands, ponds (excludes lake)	320.5	1.9
Urban/Roads	residential, commercial, roads	442.8	2.6
Total		**17,025**	**100.0**

Table 2.2: Land Use data for 2007

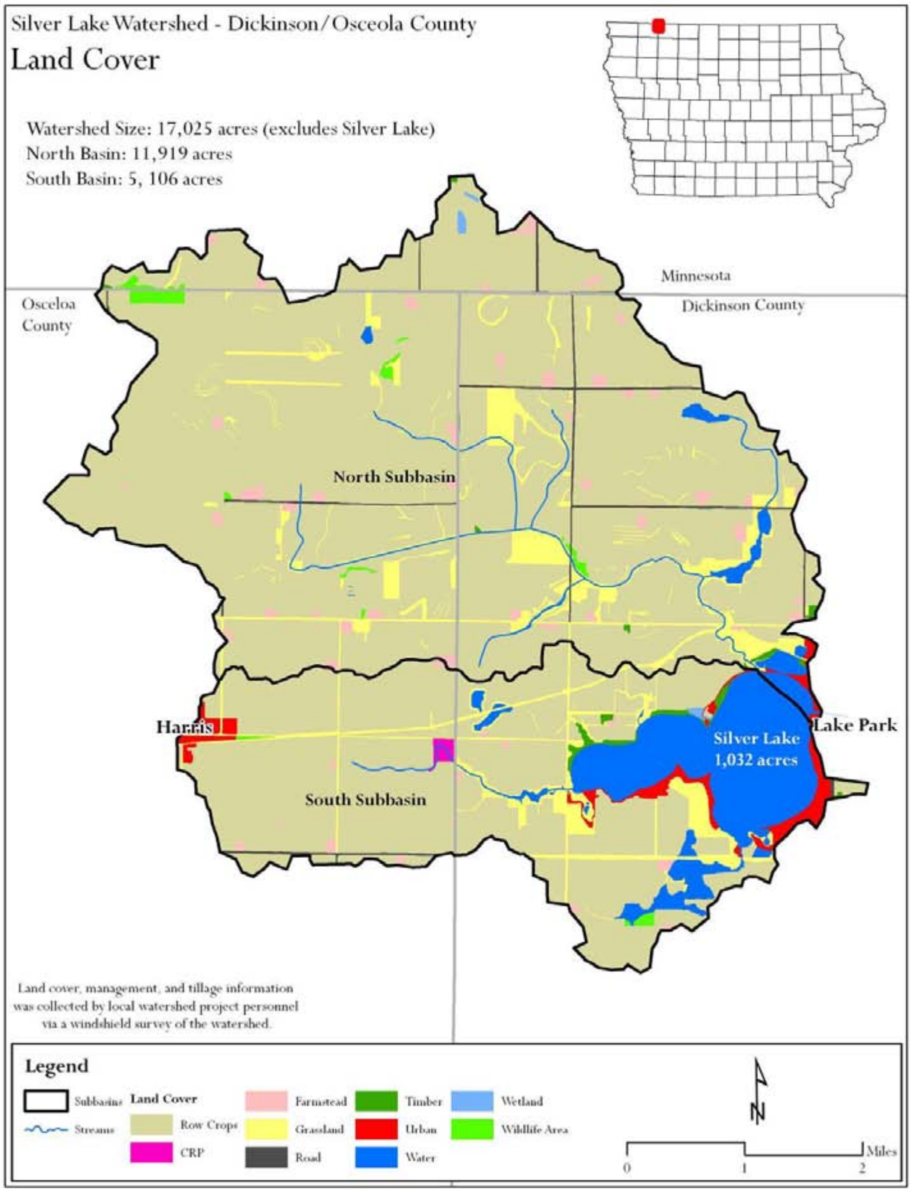


Figure 2.1: Land use distribution map (IDNR)

In addition to the parks and recreational facilities within the county, one of the state's most interesting natural area, the Silver Lake Fen, is located on the West edge of Silver Lake. The fen is one of the rarest forms of habitat in the State and perhaps one of the least well-known systems in Iowa. The Iowa Department of Natural Resources owns and operates 38 public areas, including the Silver Lake Fen, encompassing 19,911 acres within Dickinson County.

Population Dynamics

As of the census of 2000, in Dickinson County, Iowa there were 16,424 people, 7,103 households and 4,759 families residing in the county. The median income for a household in the county was $39,020 and the median income for a family was $47,739. The per capita income for the county was $21,929; 6 percent of the population and 4 percent of families were below the poverty line including, 6 percent of those under the age of 18 and 7 percent of those age 65 and older. (U.S. Census Bureau, 2000)

As of the census of 2000, in Osceola County, Iowa there were 7,003 people, 3,012 households and 1,943 families residing in the county. The median income for a household in the county was $34,274, and the median income for a family was $41,977. The per capita income for the county was $16,463. About 6 percent of families and 7 percent of the population were below the poverty line, including 7.9 percent of those under age 18 and 9.8 percent of age 65 or over. (U.S. Census Bureau, 2000)

Climate

The climate of the Silver Lake region is classified as humid-continental. Seasonal temperatures range from highs of 110 degrees Fahrenheit to lows of -40 F, while daily variations may be as much as 50 F. Annual precipitation is 27.62 inches, two-thirds of which falls between May and September. Summer precipitation ranges from severe storms to occasional drought. High summer temperatures produce evaporation levels typical of the prairies, discouraging forest growth.

The average frost free season is approximately 150 days, with a maximum growing season of 225 days from March 29 to November 9. The climate is dry enough to have aided the development of the prairie soils and humid enough to support a highly productive agricultural economy.

Geology

Geological events have been a primary driver in the natural features of the region, which in turn have influenced the development pattern. The simple geological resource (lakes) of the area is a reason the lakes have developed as a tourist and recreational area. The geologic history of the area has affected the surface contours of the land, the formation of soil types, location of minerals, groundwater, lake basins and stream channels. During the ice ages, massive glaciers moved across the region, carrying with them boulders, gravel, sand and clay and organic remains. As the glaciers melted, millions of tons of debris were deposited (glacial drift). The glacial drift forms a 200-to 300-foot cover over the region’s bedrock.

The glacial drift in the Silver Lake area was deposited in the Wisconsin Age of the Pleistocene Epoch. The Wisconsin glacier was the last of at least three major ice sheets to cover the area. The Des Moines lobe of the Wisconsin glacier, which originated in the Keewatin District west of Hudson Bay in Canada, pushed down into north-central Iowa across an area 70 to 80 miles wide. As the glaciers receded, the glaciers occasionally left large blocks of ice, which melted and formed basins for future lakes. The rugged bottom of West Okoboji Lake in Dickinson County suggests it may have been formed in this manner.

Water from the melting glaciers also cut new drainage patterns in the deposits below the ice. Outwashes of sand and gravel were carried by streams that drained glacial melt and deposited it in the valleys, which the glaciers had formed. Underlying the glacial drift are shales and sandstone created in the Cretaceous Age. The shales vary in thickness and are found exceeding several hundred feet just north of the northern boundary of the watershed. The sandstones vary in thickness but generally do not exceed the thickness of the shales.

Below the Cretaceous units, data regarding the age of the soil is limited. However, it appears that Ordovician and Cambrian Age sediment underlie the Cretaceous units in the southeastern half of the watershed. A few miles north of the northern boundary there also exists a buried northwest-southeast trending quartzite ridge of Pre-Cambrian Age.

Soils

Soils in the Silver Lake watershed are derived from Wisconsin (glacial) till on the Cary Lobe, within the Des Moines Lobe landform region. Depressional and calcareous soils are common in the region. The topography of the region is relatively flat, with some gently rolling hills and depressed areas that form isolated basins within the watershed. In its natural state, the watershed contained many wetlands in these low-lying depressed areas. However, due to its topography and poorly drained soils, approximately 85 percent of the watershed is tile drained, which enables the land to be agriculturally productive.

The heavier textured glacial soils occur within the Silver Lake watershed. These soils are not as erosive as the predominantly lighter textured loess soils found 50 miles to the southwest, but the soils do erode–especially during periods of abnormal rainfall or excessively high winds. Water erosion takes a toll on the steeper lands that are being row-cropped. The flatter land is more subject to wind erosion when it is left over winter without a cover of crop residue. The predominant soil types are listed below:

Soil Name	Description	Typical Slopes (%)
Nicollet	loam, somewhat poorly drained	1-3
Okoboji	silty clay loam, very poorly drained	0-1
Clarion	loam, moderately eroded, well drained	2-9
Webster	silty clay loam, poorly drained	0-2
Canisteo	silty clay loam, poorly drained	0-2

Table 2.3: Silver Lake Watershed predominant soil types. Courtesy of NRCS.

There are four major soil associations within the watershed. The major and minor soils are listed in order of importance below. Two associations may contain the same soils, but in a different pattern.

Wadena - Estherville

The Wadena – Estherville association consists of soils that are medium to moderately coarse textured, gently sloping (2 to 5 percent). The association developed from glacial outwash and is shallow to deep to calcareous and gravel. The soils are prone to drought when sand and gravel are within 15 to 30 inches of the surface. Minimum tillage is an excellent conservation practice to use here, since it retains moisture in the surface soil and slows wind erosion.

Webster - Clarion – Nicollet

These soils occur in a small portion of the watershed; one area is at the northern tip and one at the southern edge. The area is typified by level to gently undulating (0-5 percent slopes) medium and moderately fine textured soils that are developed from glacial till. There may be pond spots and high lime areas.

This has low potential as a sediment producing area because of its gentle slopes. Simple conservation practices such as contouring, strip cropping and minimum tillage are all that may be needed to keep erosion in check. Occasionally, terraces may be recommended on steeper slopes.

Clarion – Nicollet - Webster

This association is characterized by gently undulating to gently rolling (2 to 9 percent) slopes. The soils are developed from glacial till and are medium and moderately fine textured. This area is used extensively as farmland. Some steeper slopes and wet areas are in permanent pasture. Conservation measures would include contouring, contour stripping, stubble mulching and minimum tillage with terraces on steeper slopes.

Clarion - Storden – Okoboji

The Clarion soils occupy the greater portion of this association. They are dark brown, loamy, well-drained soils occupying an upland position on gently undulating to steep slopes. The Storden soils occur on the steeper slopes and knobs, usually above the Clarion soils on the landscape. Most of the larger permanent pastures are in the areas of predominately Storden soils, since they are not as well suited to faming operations as is Clarion. The Okoboji soils are dark, deep and poorly drained. They occupy potholes or small depressions within the association and ordinarily require artificial drainage to be productive farmland.

Conservation measures on this association, principally Clarion and Storden, consist of contouring, strip cropping, mulch tillage and terraces. Terracing is usually difficult because of short, irregular slopes (Dankert, 1980).

Topography

The topography of the watershed can be characterized as gently rolling. Lakes and wetlands lie within the hollows of the terrain. Runoff from precipitation drains into the lakes, evaporates, or percolates into the soil where it recharges the groundwater. Water draining into the lakes and streams carry contaminants from the land, which affect the water quality of the lakes.

Surface Water

Surface waters consist of tributaries, streams, drainage ditches, and lakes that make up the Little Sioux River drainage basin. The Little Sioux River and several tributary streams flow year-round. Most creeks are intermittent and carry water only in periods of heavy rainfall or spring thaw. Runoff corresponds to the annual precipitation rate. The large lake and wetlands make up a unique lake watershed.

Groundwater Resources

The Dakota sandstone and the Ordovician and Cambrian Age sandstones are the most important of the deep flow systems. The well source in the watershed is mainly from the Dakota sandstone aquifer. The wells in the region average 130-500 feet in depth. The gradient of the groundwater is generally south but local high water levels are found throughout the area following land surface contours. Ground water highs are found below the hills east and west of West Okoboji Lake and east of East Okoboji Lake. Topographic high areas are recharge areas and low lying marshes and wetlands are discharge areas.

Shallow flow systems found in glacial drift have the most impact on area lakes and streams. Depth to the water table near the lakes varies from flowing springs to depths 50 feet below the ground surface. In areas adjacent to the Little Sioux River, the contour configuration indicates the river receives groundwater discharge. The lakes also receive base flow from groundwater.

Pollutant Sources

The primary threats to the water quality of Silver Lake are sedimentation, excess nutrients, human and livestock waste, stormwater contaminants and loss of natural wetlands. Agricultural runoff contributes contaminants such as sediment, commercial fertilizers, pesticide, herbicides and animal wastes. Potential spills of hazardous waste and invasion of Aquatic Invasive Species are also a concern.

The prairie potholes and marshes adjacent to Silver Lake are ground water recharge areas, and serve as a natural filtration system by filtering and capturing contaminants carried in stormwater runoff, and infiltrating runoff from surrounding developed land. In the past, wetlands have been drained in favor of agriculture and urban developments, but it has more recently been recognized that wetlands are an integral part of a complex ecological system.

Increased urban development has presented stormwater quality and quantity problems. Urban stormwater runoff carries contaminants such as sediment, excess nutrients, pesticides and herbicides, heavy metals, and road salt. There is increasing pressure on drinking water supplies by the growing permanent population base and an expanding summer seasonal population. Good water quality is vital to the region's economy and quality of life for those who visit or live within the area.

3. Water Quality Monitoring

A number of different factors affect water quality in the Silver Lake region. Activities in the watershed dictate the quality of water reaching the lake. The size and depth of the lake also influence the water quality. Large lakes with large volumes of water can dilute nutrients from the watershed. Shallow lakes, such as Silver Lake, are susceptible to mixing and disturbance of the bottom sediments which allow nutrients to be released to the water column, while deep lakes don't experience as much mixing and stirring of the bottom sediments.

Local Watershed Monitoring

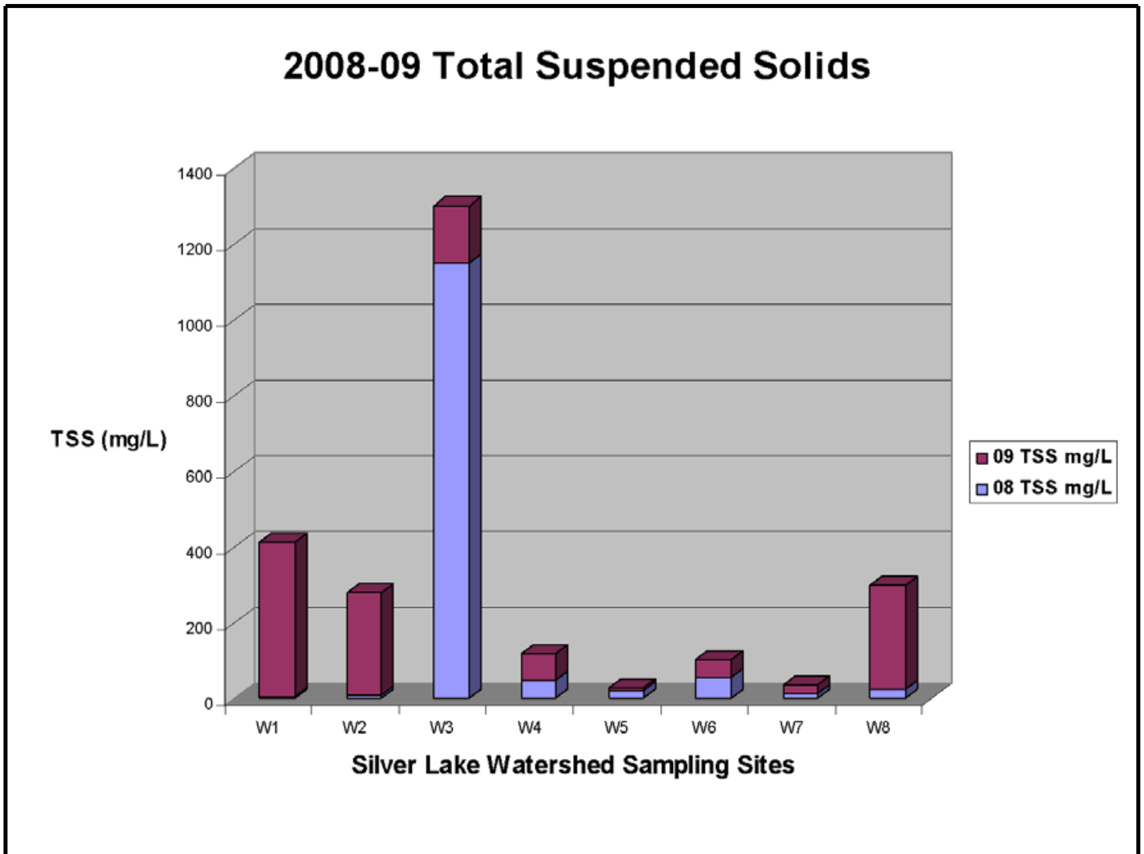
Beginning in 2007, the Dickinson Soil & Water Conservation District formed a partnership with the Silver Lake Park Improvement Association (SLPIA) and the Dickinson County Water Quality Commission to conduct an on-going monitoring program at key locations within the Silver Lake Watershed. Although several years of in-lake monitoring data were available, little effort had been given to monitoring the quality of water entering the lake from its watershed.

The partnership realized that if they were to expect financial assistance for the installation of conservation best management practices (BMP's) and other water quality improvements, they would need data from the watershed itself. To date, this data has been used to provide a baseline in evaluating the overall health of the watershed, as well as helping pinpoint critical areas which should be targeted with incentives for the implementation of BMP's.

Figure 3.1: Silver Lake Watershed monitoring locations

Parameter	2007
Total Suspended Solids	17.9
Total Phosphorus as P (µg/L)	201.6
Total Nitrogen as N (mg/L)	6.04
E. Coli Upper	368.5

Table 3.1: 2007 Silver Lake Watershed monitoring summary results



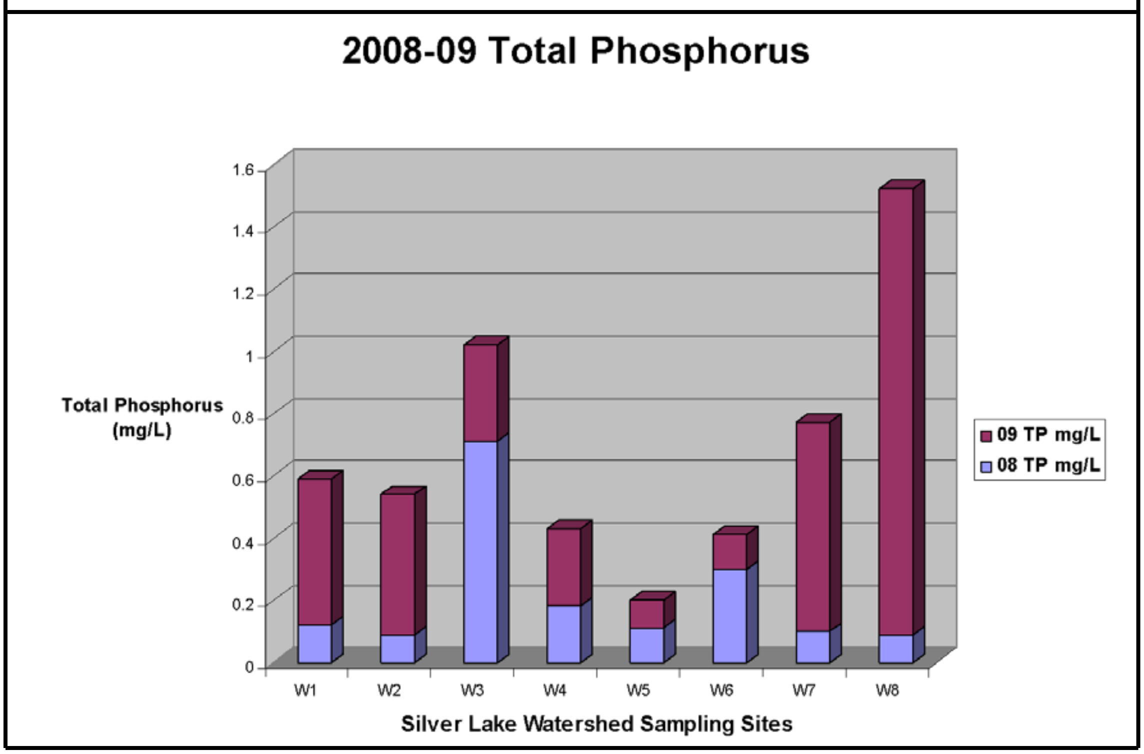


Figure 3.2: 2008-09 Avg. TSS and TP per Silver Lake Watershed sampling sites

Cooperative Lakes Area Monitoring Project (CLAMP)
CLAMP began in 1999 as an inspiration of the Friends of Lakeside Lab, local lake organizations and the Dickinson County Clean Water Alliance. The goal was to address the need for a long-term, unified approach to monitoring Dickinson County lakes. CLAMP is coordinated by Iowa Lakeside Laboratory, and supported by many local partners.

Over 100 volunteers have trained and participated in CLAMP since its inception in 1999. CLAMP volunteers sample nine lakes in Dickinson County: Big Spirit Lake, Center Lake, East Okoboji Lake, Little Spirit Lake, Lower Gar Lake, Minnewashta Lake, Silver Lake, Upper Gar Lake, and West Okoboji Lake. Volunteers collect field data including secchi depth, dissolved oxygen and temperature, and collect water samples for laboratory analysis including total nitrogen, ammonia nitrogen, total phosphorus, chlorophyll “a”, phytoplankton and microcystin analysis.

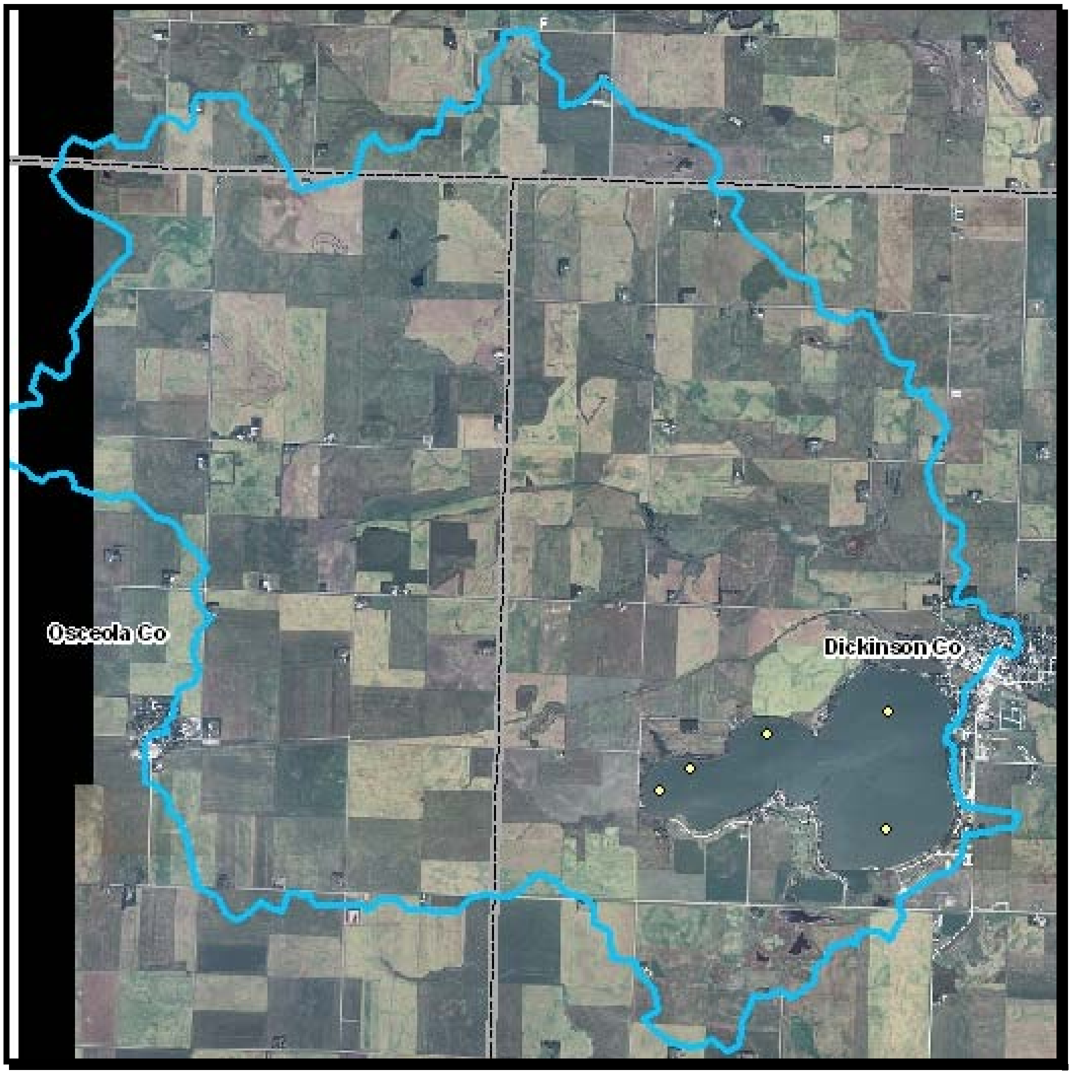


Figure 3.3: CLAMP monitoring locations on Silver Lake

Parameter	2007	2006	2005
Secchi Disk Depth (m)	0.7	0.6	0.7
Temperature(^{o}C)	22.3	22.6	22.7
Dissolved Oxygen (mg/L)	8.5	8.7	8.1
Dissolved Oxygen Saturation (%)	96.9	100.0	94.1
Chlorophyll a (µg/L)	58.0	60.3	143.9
Total Phosphorus as P (µg/L)	83	95	118
Total Nitrogen as N (mg/L)	2.31	3.34	2.99
Microcystin (ng/L)	8.4	3.0	1.9
Carlson Trophic State Index (Secchi)*	66	67	65
Carlson Trophic State Index (Chl a)*	70	71	79

Table 3.2: 2005-2007 water monitoring results in Silver Lake (CLAMP)

Year/ Principal Investigator	Sampling Period	Number sampling sites	Total samples collected	Avg Total P (mg/L)	SE
1979 Bachmann	June -- October	1	10	**0.097**	**0.012**
1990 Bachmann	5/26 -- 7/28	1	9	**0.105**	**0.004**
1999 CLAMP	7/30 -- 8/26	4	12	**0.123**	**0.008**
2000 CLAMP	6/6 -- 8/22	4	23	**0.164**	**0.015**
2001 CLAMP	6/5 -- 8/28	4	28	**0.209**	**0.017**
2002 CLAMP	6/11 -- 8/20	4	24	**0.185**	**0.029**
2003 CLAMP	6/10 -- 8/19	4	24	**0.170**	**0.017**

Table 3.3: CLAMP data median values 1979-2003

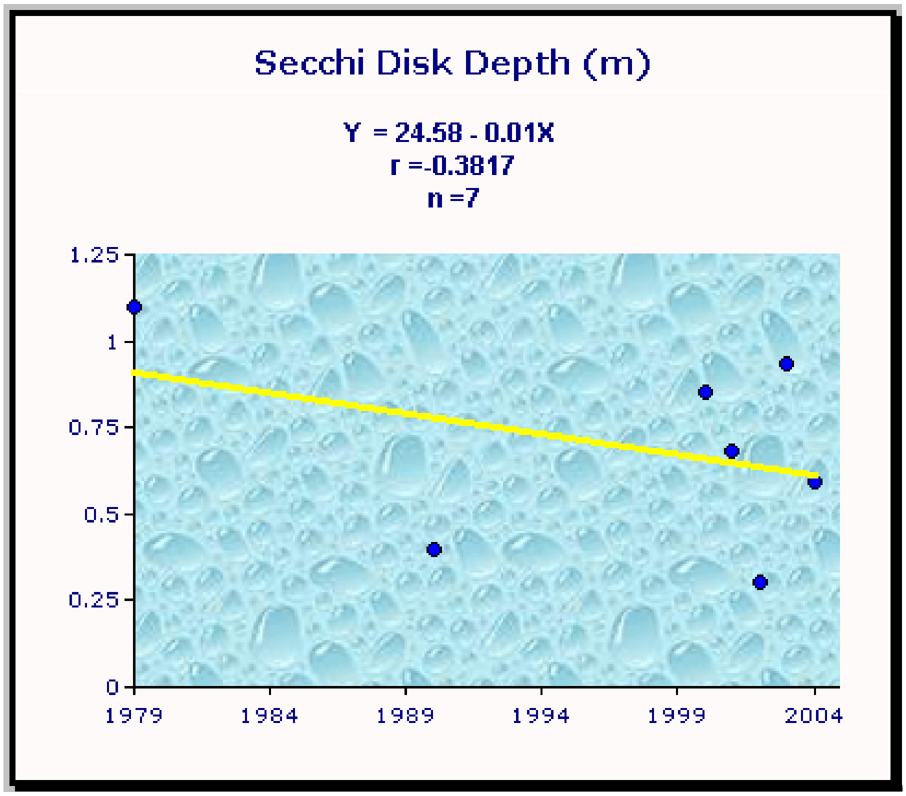


Figure 3.4: 1979-2004 trend in Secchi Depth

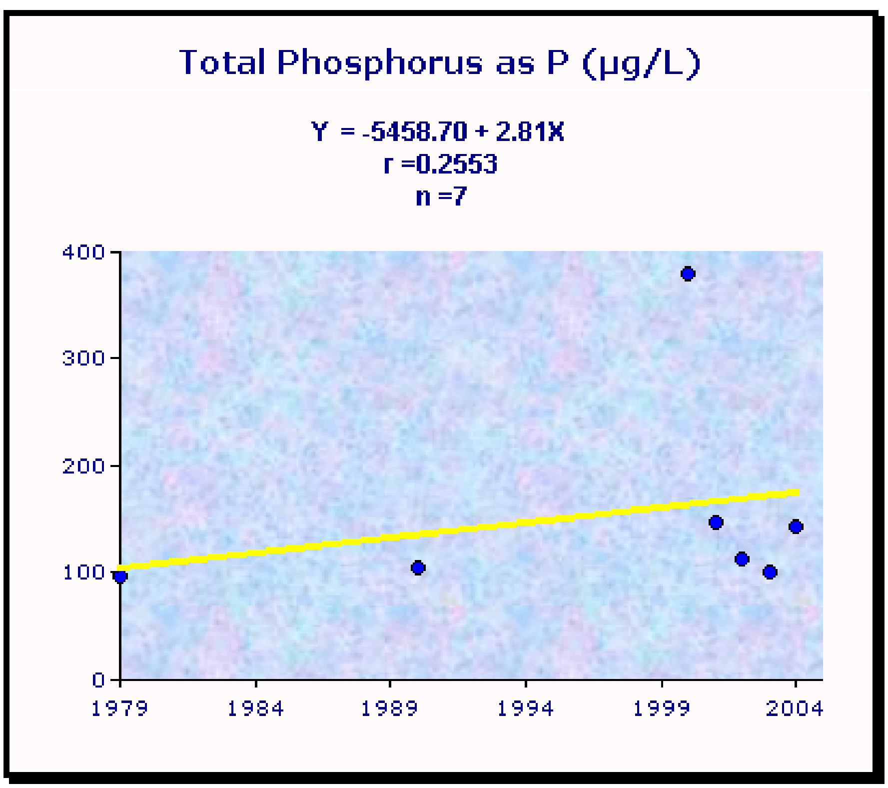


Figure 3.5: 1979-2004 trend in Total Phosphorus

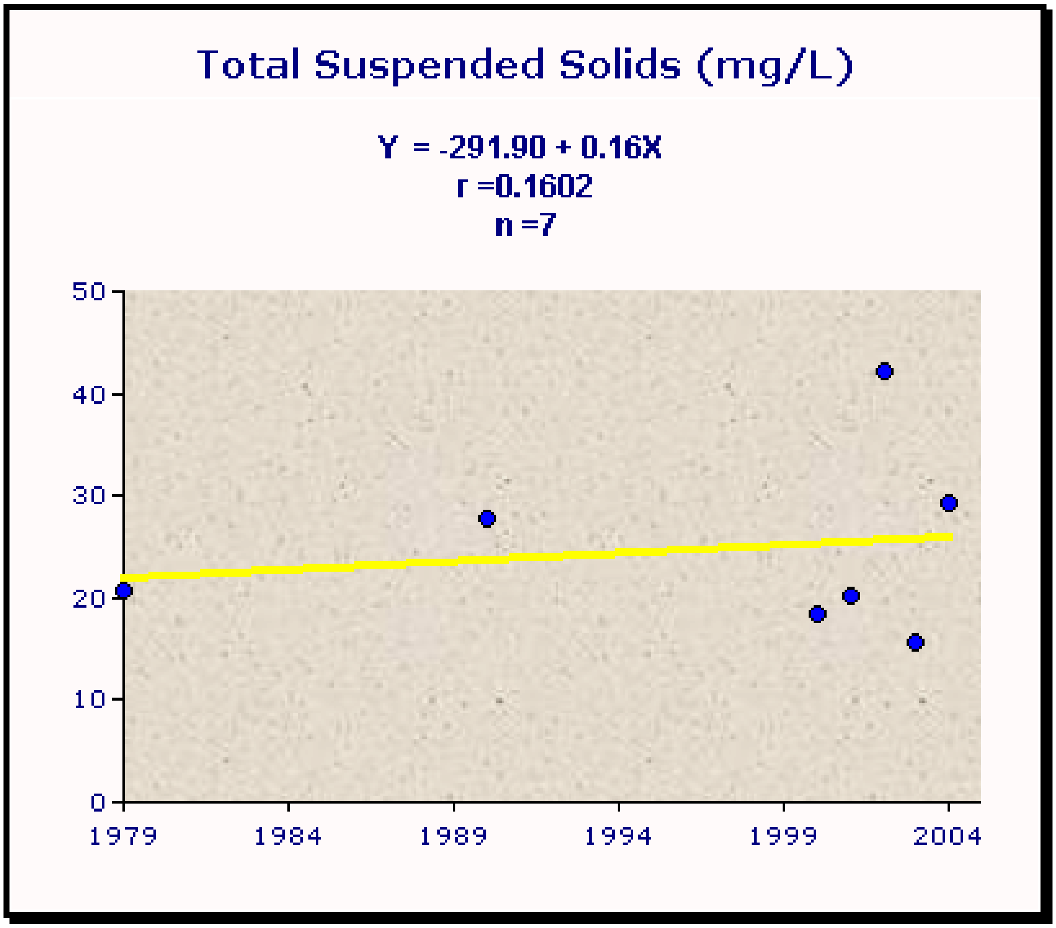


Figure 3.6: 1979-2004 trend in Total Suspended Solids

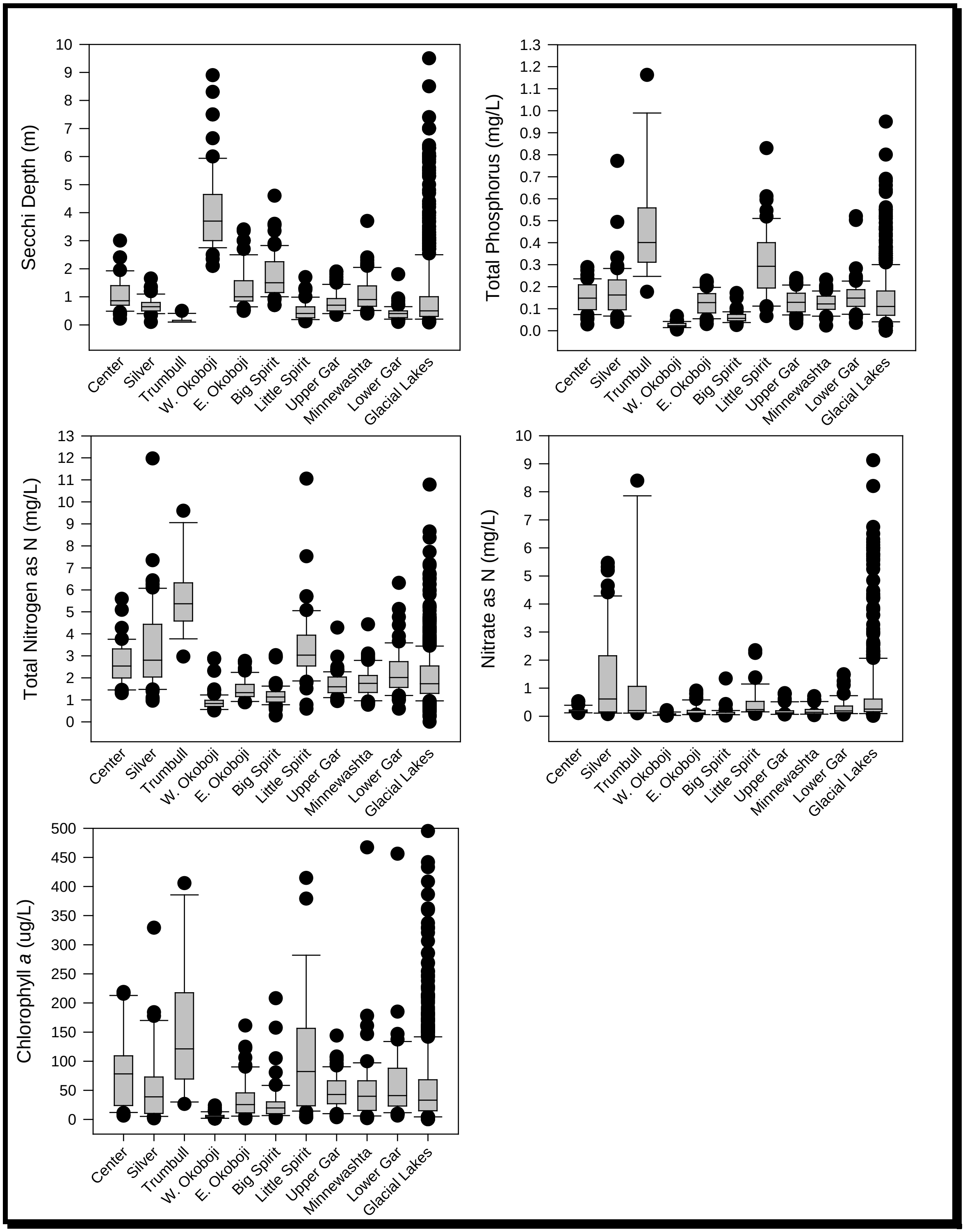


Figure 3.7: 1999-2006 Dickinson County CLAMP data

Silver Lake CLAMP Data Summary

Secchi depth ranged from 0.1 m to 1.7 m, with the deepest Secchi depths occurring in the spring, and the shallowest in late summer. Overall, Secchi depths in Silver Lake were shallower than most other CLAMP lakes and similar to the median for all monitored, glacial lakes in Iowa (Figure 3).

Total phosphorus concentrations ranged form 0.03 mg/L to 0.3 mg/L. The median total phosphorus concentration for Silver Lake was higher than all other CLAMP lakes with the exception of Trumbull and Little Spirit and higher than the median for all monitored, glacial lakes. Total nitrogen concentrations in Silver Lake were also higher than most other CLAMP lakes and the median for all monitored, glacial lakes (Figure 3).

Chlorophyll *a* concentrations ranged from 3 μg/L to 753 μg/L. The median chlorophyll *a* concentration for Silver Lake was similar to Upper Gar, Minnewashta, and Lower Gar as well as the median for all monitored, glacial lakes (Figure 3).

Trophic State

The large amount of water quality data collected by CLAMP can be difficult to evaluate. In order to analyze all of the data collected it is helpful to use a trophic state index (TSI). A TSI condenses large amounts of water quality data into a single, numerical index. Different values of the index are assigned to different concentrations or values of water quality parameters.

The most widely used and accepted TSI, called the Carlson TSI, was developed by Bob Carlson (1977). Carlson's TSI is a set of mathematical equations created from relationships between summertime total phosphorus, chlorophyll *a*, and Secchi disk transparency for numerous lakes. Using this method a TSI score can be generated by just one of the three measurements. Carlson TSI values range from 0 to 100. Each increase of 10 TSI points (10, 20, 30, etc.) represents a doubling in algal biomass. Data for one parameter can also be used to predict the value of another.

The Carlson TSI is divided into four main lake productivity categories: *oligotrophic* (least productive), *mesotrophic* (moderately productive), *eutrophic* (very productive), and *hypereutrophic* (extremely productive). The productivity of a lake can therefore be assessed with ease using the TSI score for one or more parameters. Mesotrophic lakes, for example, generally have a good balance between water quality and algae/fish production. Eutrophic lakes have less desirable water quality and an overabundance of algae or fish. Hypereutrophic lakes have poor water quality and experience frequent algal blooms and hypolimnetic anoxia.

Carlson's TSI can be used to classify the CLAMP lakes. West Okoboji and Big Spirit have the lowest TSI scores in Dickinson County, indicating they are the least productive. Little Spirit Lake and Silver Lake have the highest TSI scores indicating they are the most productive. Most lakes are in the *eutrophic* category based on Carlson's TSI.

"Ambient Lake Monitoring Program"

The Iowa Department of Natural Resource's ambient lake monitoring program began in 2000. One hundred thirty-one lakes located throughout the state are monitored between 3 and 5 times during the summer by Iowa State University (2000-2007) and University of Iowa Hygienic Laboratory (2005-2007). Big Spirit, Little Spirit, East Okoboji, West Okoboji, Lower Gar, Upper Gar, Minnewashta, Center, and Silver Lake are all monitored as part of this program. Through the ambient lake monitoring program the lakes are monitored for a number of physical, chemical, and biological parameters. Physical parameters include: temperature, dissolved oxygen, specific conductivity, pH, Secchi depth, turbidity, total suspended solids, total fixed suspended solids, and total volatile suspended solids. Chemical parameters include: total nitrogen, nitrate + nitrite, ammonia, total phosphorus, soluble reactive phosphorus, silica, alkalinity, total organic carbon, and total dissolved solids. Biological parameters include: chlorophyll *a*, phytoplankton biomass and composition, and zooplankton biomass and composition. The ambient monitoring program characterizes current water quality in the monitored lakes and will provide an opportunity to track trends in lake water quality.

The ambient lake monitoring program differs from the CLAMP program in that the samples are collected and analyzed by professionals. The ambient program, however, only samples the lakes three to five times throughout the summer, while the CLAMP program is able to sample the lakes more frequently. The ambient program also only samples one location on the lake (deep spot) so that the data from each lake can be compared to other lakes in the state. The CLAMP program samples multiple locations on each lake, which allows for a more complete spatial characterization of the lakes.

The ambient program tests for more parameters than are feasible through the CLAMP program. This allows for a greater understanding of the characteristics of each of the lakes. The CLAMP program includes Secchi depth, total phosphorus, total nitrogen, nitrate plus nitrite nitrogen, and chlorophyll *a*, which are all explained above. The additional parameters monitored by the ambient lake monitoring program are explained below.

Physical Parameters

Temperature and Dissolved Oxygen (DO) profiles are measured at the sampling location. A probe is lowered in the water column and a reading is taken at regular intervals to determine if the lake is thermally stratified. Thermal stratification occurs when surface waters warm and the density difference between the cooler, deeper water and the warm surface water prevents mixing. One potential consequence of thermal stratification is anoxia (or low oxygen conditions) in the hypolimnion (the deep cold water area) due to respiration. Hypolimnetic anoxia can lead to release of phosphorus from the sediment which can lead to algae blooms. The extent of thermal stratification depends on several factors including depth, wind fetch, wind exposure, and spring temperatures. West Okoboji is the only lake in the Iowa Great Lakes that stratifies regularly. The other lakes are too shallow and are susceptible to mixing by the windy conditions in that area of the state.

Turbidity is a reduction in clarity that results from the presence of suspended particles. Turbidity usually consists of inorganic particles, such as sediment, and organic particles, such as algae. In general, the lakes in the Iowa Great Lakes region have lower turbidities than other natural lakes in the state with the exception of Little Spirit, Lower Gar, Upper Gar and Silver Lake.

Total Suspended Solids (TSS) includes all suspended particles in water that will not pass through a filter. Big Spirit (6 mg/L) and West Okoboji (2.3 mg/L) have low concentrations of TSS when compared to other natural lakes. Lower Gar (21.1 mg/L) and Silver Lake (17.1 mg/L) have the highest TSS concentrations of the Iowa Great Lakes.

Total Organic Carbon (TOC) is the sum of all organic carbon from decaying organic material, bacterial growth, metabolic activities of living organisms, and chemicals. (Humic acid, fulvic acid, amines, and urea are types of natural organic matter. Detergents, pesticides, fertilizers, herbicides, industrial chemicals, and chlorinated organics are examples of synthetic sources of organic carbon.) TOC can be used as a measure of organic contamination. Little Spirit (18.5 mg/L) and Center (14.6 mg/L) have relatively high levels of TOC (above the 75th percentile for all monitored, natural lakes).

All other lakes in the Iowa Great Lakes with the exception of Silver Lake fall below the 25th percentile for all monitored natural lakes.

Specific Conductivity is a measure of the ability of a solution to electrical flow. Specific conductivity is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron, and can be used as an indicator of water pollution. The higher the specific conductivity, the higher the amount of dissolved ions in the water. Silver Lake (629 µS/cm) and Center (571 µS/cm) have the highest median specific conductance among the Iowa Great Lakes, which was above the 75th percentile for all monitored, natural lakes. Big Spirit (480 µS/cm) and West Okoboji (466 µS/cm) had the lowest median specific conductance among the Iowa Great Lakes.

Chemical Parameters

Soluble Reactive Phosphorus (SRP) is the form of phosphorus that is directly taken up by algae and therefore constitutes the fraction of total phosphorus that is available for immediate uptake by algae. In phosphorus limited situations this form should be low to undetectable, as is the case in Big Spirit (0.003 mg/L) and West Okoboji (0.003 mg/L). As SRP increases, it implies that phosphorus is either not needed by algae or it is being supplied at a rate that is faster than the rate of biologic uptake. Little Spirit (0.09 mg/L), Silver Lake (0.04 mg/L) and East Okoboji (0.04 mg/L) have relatively high SRP levels when compared to other monitored, natural lakes in Iowa (greater than the 75th percentile).

Biological Parameters

Phytoplankton wet mass and composition are measured to get a better understanding of the biological dynamics of each lake. Phytoplankton or algae are the photosynthetic organisms that form the base of the food chain in lakes. The median phytoplankton wet mass ranged from 9.1 mg/L in West Okoboji to 36.0 mg/L in Upper Gar. Silver Lake had a lower median concentration than the median for all monitored, natural lakes in Iowa (39.7 mg/L). Most phytoplankton samples were dominated by cyanobacteria, which often dominate summer plankton in productive lakes.

Lake Name	Secchi Depth (m)	Total Phosph-orus (mg/L)	Soluble Reactive Phosphorus (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Ammonia (mg/L)	Nitrate +Nitrite (mg/L)	Chloroph-yll *a* (ug/L)	Dissolved Oxygen (mg/L)
Silver Lake	**0.6**	**0.114**	**0.043**	**1.4**	**0.111**	**2.183**	**14**	**8.7**

Lake Name	Turbidity (NTU)	Total Suspended Solids (mg/L)	Total Organic Carbon (mg/L)	Total Fixed Suspended Solids (mg/L)	Total Volatile Suspended Solids (mg/L)	pH	Alkalinity (mg/L)	Specific Conductivity (uS/cm)
Silver Lake	**33.9**	**17.1**	**9.4**	**11.4**	**6.1**	**8.4**	**151**	**629**

Lake Name	Phytoplankton Wet Mass (mg/L)	Zooplankton Wet Mass (mg/L)	Carlson Trophic State Index (Secchi)	Carlson Trophic State Index (Total Phosphorus)	Carlson Trophic State Index (Chlorophyll)
Silver Lake	**21.1**	**169.5**	**68**	**72**	**56**

Table 3.4: 200-2006 median values in CLAMP monitoring data

Nutrient Budget Summary

Lake nutrient budgets indicated that rainfall and dry deposition are major sources of total phosphorous (TP) and total nitrogen (TN) to the Iowa Great Lake. Surface water runoff contributes a substantial proportion of nutrients to the lake, but there is considerable annual variability in contribution from runoff depending on the amount of precipitation between dry and wet years.

Generally, Silver Lake's sediment appears to be a source of nutrients to the water column. The sediment in Silver Lake does not settle to the bottom never to be seen again as it does in West Okoboji. Rather, the sediment in Silver Lake, and other shallow lakes of its kind, is re-circulated by wind and wave action, prop disturbance, and the "rooting" of rough fish such as carp and buffalo.

The significance of this circulation of sediment is that it carries with it the essential nutrient, phosphorous, that is a major producer of algae. Because the sediment continues to bring the phosphorous to the surface it is a constant source of nutrient for algae, which then grows, dies and settles to the bottom only to be circulated again the next time there is a significant wind. In addition, there is additional phosphorus being brought into the lake via the three major drainage ditches and through the Lake Park storm sewer system.

Stratification

Data collected through the ambient lake monitoring program indicated that Silver Lake does not stratify regularly. Silver Lake is too shallow and susceptible to mixing by the windy conditions in the NW part of the state along the Buffalo Ridge, the windiest part of the Midwest.

Turbidity

In general, Silver Lake has a higher turbidity and concentration of total suspended solids (TSS) than other natural lakes in the state. Silver Lake ranks in the bottom 25th percentile for average chlorophyll A concentrations, Secchi, average Carlson TSI, and average total phosphorous.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO.

Sources of turbidity include soil erosion, waste discharge, urban runoff, eroding stream banks, large numbers of bottom feeders (such as carp), which stir up bottom sediments, and excessive algal growth.

Cyanobacteria
Sometimes called blue-green algae, cyanobacteria are organisms that naturally occur in fresh, brackish, and marine water. Cyanobacteria have many characteristics of bacteria, but they also contain chlorophyll, and can photosynthesize like algae and plants. Cyanobacteria often have a blue-green color, which is why they are also called blue-green algae. Cyanobacteria come in many sizes and shapes including microscopic single cells as well as filaments and colonies that are easily visible to the naked eye.

Photo 3.1: Cyanobacteria in Silver Lake, Dickinson County.
Photo courtesy of J. Graham, U.S. Geological Survey.

Cyanobacteria occur naturally in most lakes, but under the right conditions cyanobacteria may grow excessively causing massive accumulations (called blooms) of the algae. Many different factors may lead to cyanobacteria blooms including excessive nutrients, low light levels, elevated temperatures, and low water levels. Cyanobacteria blooms are unsightly and caused low dissolved oxygen levels and reduced water quality. In addition, cyanobacteria have the potential to produce toxins (called cyanotoxins), that are potent enough to poison aquatic and terrestrial organisms, including animals and humans. Alteration, degradation, and eutrophication of aquatic ecosystems has lead to an increasing occurrence of cyanobacteria blooms worldwide. Blooms have occurred everywhere from Brazil to China, Australia to the United States. During 2006, cyanobacteria made the news in at least twenty-one states; seven of those in the Midwest including Minnesota, Wisconsin, Illinois, Iowa, Missouri, Kansas, and Nebraska. Even more startling is the statistic that at least 33 States have anecdotal reports of human or animal poisonings associated with cyanotoxins.

Photos 3.2 & 3.3: Cyanobacteria blooms in Silver Lake. Photos courtesy of Steve Anderson.

There are many different ways that the algae can be transferred between ecosystems including flow from one lake to the next or from one reservoir to the next, transport of live cells or spores by animals, and people, and transport of spores by wind. There are several factors complicating our understanding of how and how often cyanobacteria are transferred among water bodies including: cyanobacteria spores may be dormant in lake sediments for many years or the cyanobacteria may typically be present in the water column at levels that are too low to detect until conditions become ideal for cyanobacteria growth. Transfer probably isn't as much of a concern in Silver Lake as water quality – from what biologists can see most of the lakes have the same cyanobacteria species present, although the dominant species may vary from lake to lake.

Concerns
There are four main concerns with cyanobacteria:

1. Cyanobacteria may potentially produce taste-and-odor compounds and toxins that are poisonous to both aquatic and terrestrial organisms.
2. Cyanobacteria blooms may form in warm, slow-moving waters that are rich in nutrients such as fertilizer runoff or septic tank overflows.
3. Cyanobacteria blooms in Silver Lake may occur at any time, but most often occur in late summer or early fall.
4. Unsightly, potentially toxic, cyanobacteria blooms may lead to a loss of recreational revenue. In addition, treating drinking water supplies with taste-and-odor problems associated with cyanobacteria are costly.

Solutions
A long-range strategic plan developed by the Dickinson Clean Water Alliance has identified four main watershed goals for Silver Lake and other lakes in Dickinson County:

1. Native biological diversity is respected and encouraged
2. Infiltration practices are promoted throughout the watershed
3. Impaired waters are protected and improved
4. High quality waters are maintained and improved

These goals will assist in reduction of the number of occurrences of cyanobacteria blooms. They can be achieved by protecting and improving water quality, which could reduce sediment and nutrient loads, which may decrease the low light/high nutrient conditions favored by the cyanobacteria; and native diversity of aquatic plants may discourage the growth of cyanobacteria.

4. Information & Education

It will no doubt be a significant challenge to involve and work with all stakeholders, not to mention keeping everybody on the same page and moving in the same direction. The Silver Lake Watershed Management Plan will be best implemented in phases, but only if those phases are implemented concurrently. In other words, the best option for Silver Lake is to implement the watershed management plan in phases, but to do those phases concurrently and in a reasonable timeframe.

The communications goal of the Silver Lake Watershed Project is to ensure all stakeholders of the Silver Lake Watershed know what they can do to protect and preserve the water quality of the lake through their actions. To accomplish the goal, the following action items will be used:

Action Item 1: Publish a notice of each planning meeting at least 7 days prior to the meeting so that we can achieve maximum participation from all stakeholders.

Action Item 2: Write press releases after the meetings that explain what happen during the meeting. Ensure these press releases go to media no later than 3 days after the meeting.

Action Item 3: Ensure key leaders of stakeholder groups receive special invitations so that those stakeholder groups feel they are represented.

Action Item 4: Hold Quarterly meetings after a plan has been developed to ensure public is aware of the progress of the project and how those projects affect Silver Lake.

Action Item 5: Establish a website that will show up to date information about project completion and developments in the Silver Lake Watershed.

Action Item 6: Generate fact sheets and brochures that describe what the project can do and how the practices can help the water quality of Silver Lake.

Action Item 7: Ensure that educational presentations are done at every opportunity to explain what is happening and why.

Action Item 8: Maintain a core Technical Advisory Group that has professionals as well as key local stakeholders in it who meet regularly and guide the implementation of the project.

Interested Parties/Stakeholders:
Stakeholders in this plan are varied and come from all lifestyles. The bottom line for each stakeholder is that they have a stake in what happens with Silver Lake. There are five groups of Stakeholders that have been identified. Those five groups are federal, State, local government, Non-governmental Organizations, and private citizens.

Federal Stakeholders:
- U.S. EPA, Region, 7 Non-point Source Region Headquarters (Section 319 Non-point Source Pollution Program)
- U.S. Fish and Wildlife Service, Desoto Bend Wildlife Area (Private Lands Biologist)
- USDA, Natural Resources Conservation Service, Dickinson and Osceola Counties (Wetlands Restoration Program, Wildlife Habitat Incentive Program, Environmental Quality Incentives Program)
- USDA, Farm Service Agency, Dickinson and Osceola Counties (Conservation Reserve Program)

- *State & Local Stakeholders:*
- Iowa Department of Natural Resources, bureaus of Fisheries, Wildlife, and Water Resources (Private Lands Wildlife Biologist)
- Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation, Field Services Bureau. (Resource Enhancement and Protection Funds, Watershed Protection Funds, Iowa Financial Incentives Program, Watershed Improvement Review Board)
- Iowa Department of Economic Development
- Local Government Stakeholders:
- City of Lake Park
- Dickinson Soil and Water Conservation District, Commissioners (Local Grants)
- Osceola Soil and Water Conservation District, Commissioners (Local Grants)
- Dickinson County, Supervisors
- Schools, Harris Lake Park School District (Future Farmers of America)
- Sanitary Sewer District, City of Lake Park
- Public Utilities, Alliant Energy and City of Lake Park

- Non-governmental Organizations:
- Silver Lake Park Improvement Association, Scott Mitchell, Chairman (Private Funding)
- Iowa Natural Heritage Foundation, Mark Ackelson, Chairman (Easement funds)
- The Nature Conservancy, Susanne Hickey, Private Lands Biologist (Habitat Restoration Program)
- Pheasants Forever, John Linquist, Regional Representative (Build A Wildlife Area)
- Ducks Unlimited, Dr. John Synhorst (Wetland Restoration Assistance)
- Lake Park Outdoors Club (private funding)
- Osceola County Sportsman Club (private funding)
- Dickinson County Clean Water Alliance, John H. Wills, Coordinator (Coordination and local funding)
- Dickinson County Water Quality Commission, Brad Jones, Chairman (Water Quality Grants)
- Private Citizens:
- Property owners
- Fishermen
- Hunters
- Investors
- Farmers
- Developers
- Boaters
- Swimmers

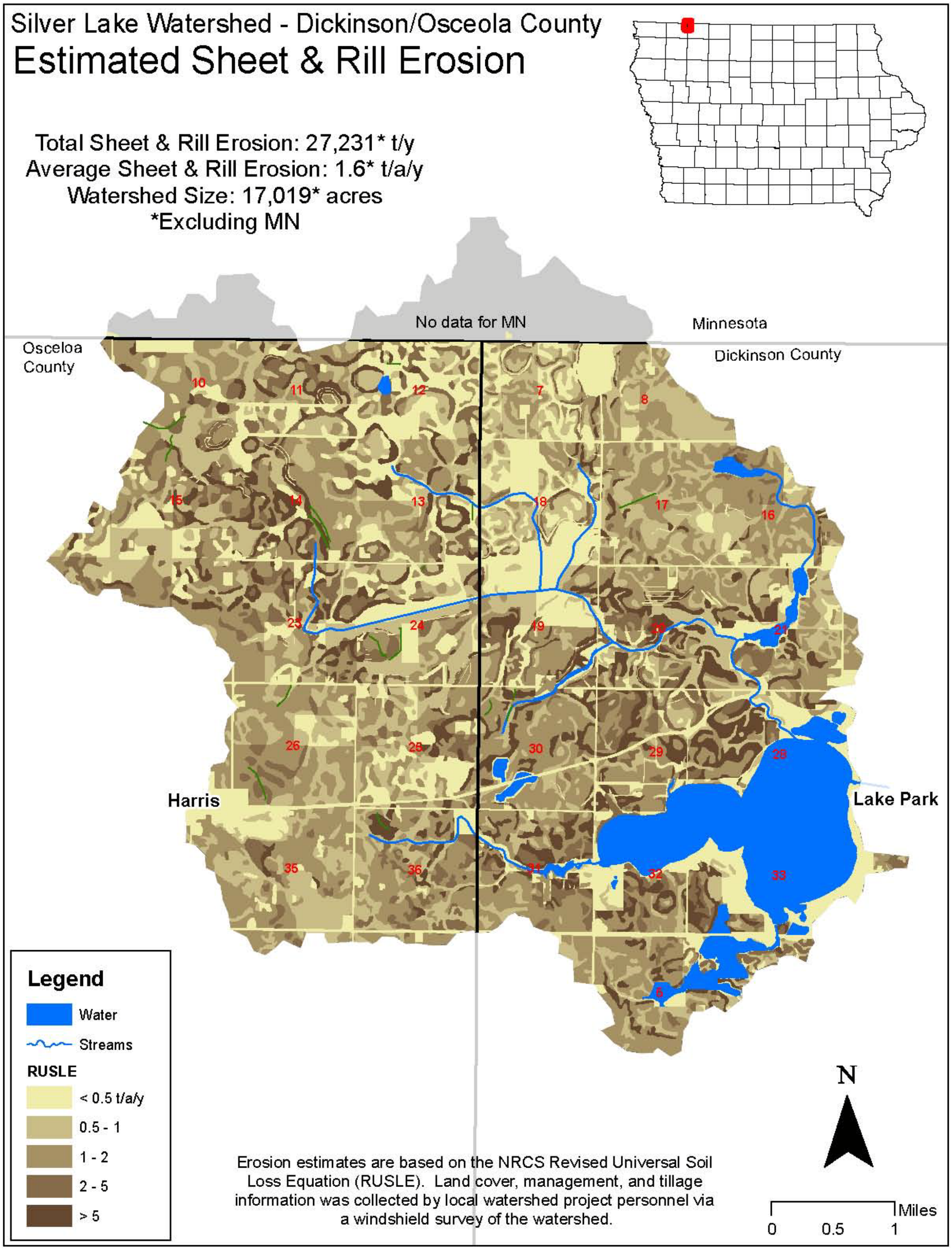
5. Sediment/Nutrient Loading

Using the NRCS Revised Universal Soil Loss Equation (RUSLE), it has been estimated that a total of 0.06 tons per acre per year of soil is delivered to Silver Lake. These figures only allow for sheet and rill erosion and do not include figures for gully or other erosion. This model, therefore, shows a total sediment delivery (with sheet and rill erosion) of 1,089 tons per year to Silver Lake.

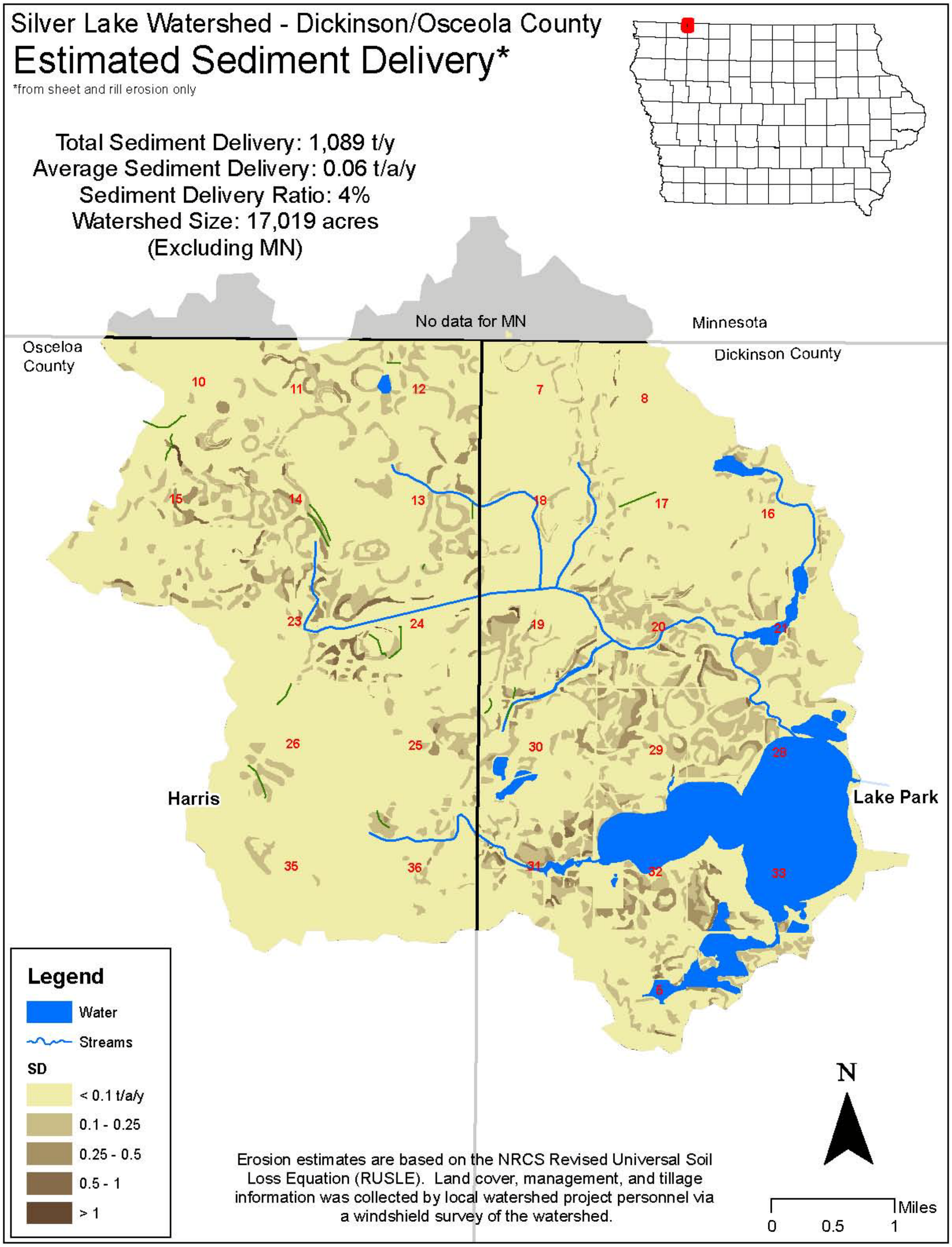
Using RUSLE we are able to see a part of the sediment delivery problem but not a complete picture. When considering sediment and erosion one must account for gully erosion as well. In some instances, a gully can produce more tons of erosion per acre than an entire field. Traditionally grassed waterways, one of the best ways to prevent or stop gully erosion, have not been widely accepted in the Silver Lake Watershed. A general shift toward larger equipment and more linear rows has resulted in fewer producers willing to consider waterways.

Approximately fifty areas have been identified within the watershed where gullies have begun to form. These gullies are providing direct sedimentation and in large amounts in comparison to the rest of the field. In these 50 sites, if grassed waterways and sediment basins were built the reduction of sedimentation would be a vast improvement. An important note is these gullies are not included in any of the following sediment delivery models as those only use RUSLE2 which does not figure gully erosion, only sheet and rill erosion.

Using the model and GIS technology, we see the total sediment delivery to the Lake from only sheet and rill erosion is 1,089 tons per year (see map 1). The average sediment delivery (without the gully erosion factored in) is .06 tons per acre per year. This means there is more sediment delivery than we can currently account for moving toward Silver Lake.

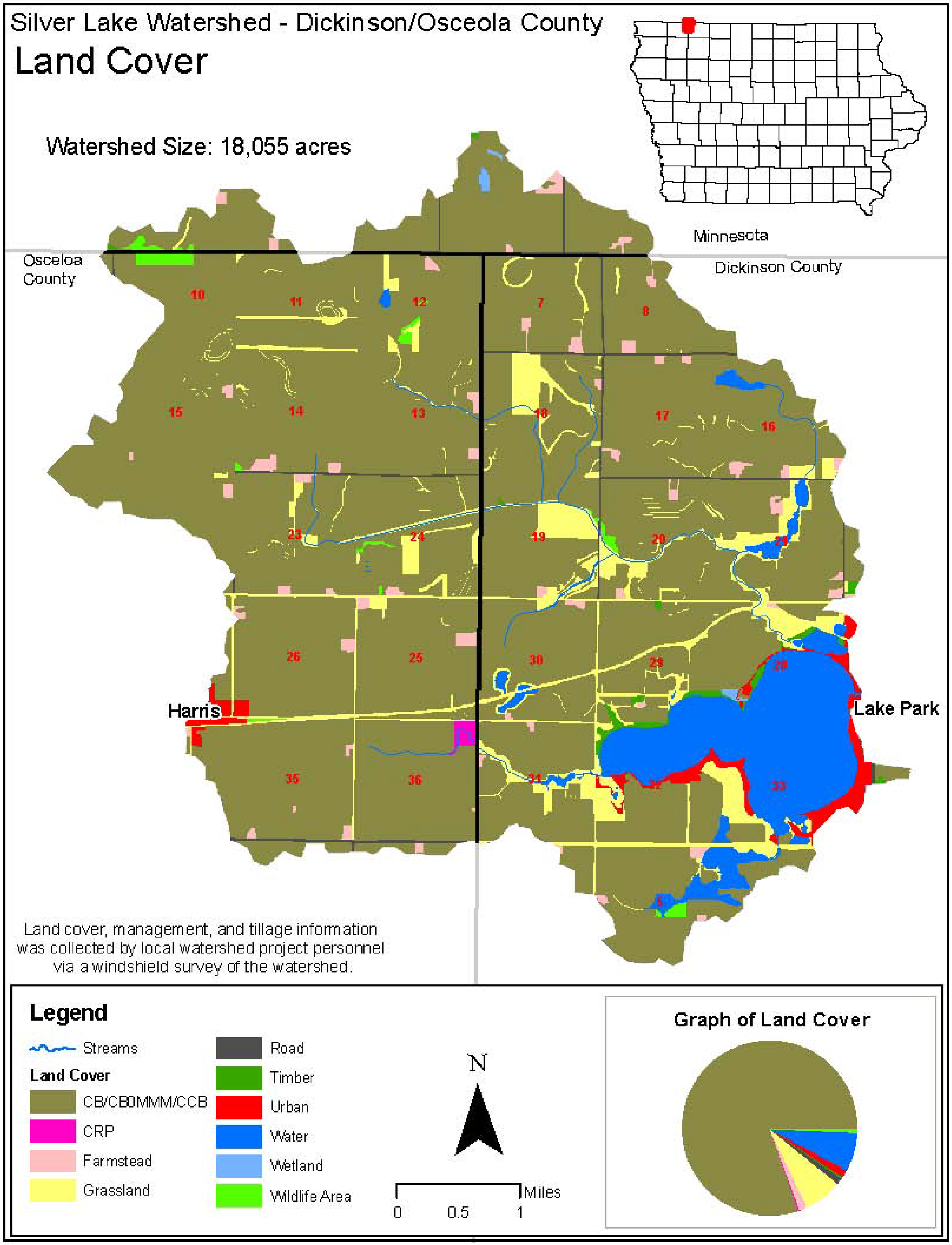


Map 5.1: Estimated Sheet & Rill Erosion in Silver Lake Watershed (Iowa DNR)



Map 5.2: Estimated Sediment Delivery to Silver Lake, Dickinson County (Iowa DNR)

Land Use Inventory



Map 5.3: 2007 Land Use Modeling in Silver Lake Watershed (Iowa DNR)

6. Pollutant Loading Reductions

Silver Lake is listed on the State of Iowa's Impaired Waters List for sediment and water clarity. A Total Maximum Daily Load (TMDL) for Turbidity has recently been completed by the Iowa DNR. According to this document, inorganic suspended solids and high phosphorous levels are the cause of the poor water quality conditions documented within the lake, which frequently result in excessive algal blooms. These conditions are affecting the Class A1 (Primary Contact Recreation) and the Class B(LW) (Aquatic Life) designated uses. Data from the Iowa Lakes Information System shows that out of 132 lakes surveyed, Silver Lake ranked 104th for turbidity, 102nd for total phosphorus, and 100th for secchi disk reading.

Nonpoint sources of phosphorous and sediment loading from the watershed are the primary pollutants causing the impairment. With the bulk of the watershed in some form of agricultural production, the majority of these loads most likely stem from those acres in row crop production. Soil erosion as a result of crop production aids in the transport of phosphorous to the lake. This phosphorous-laden sediment is often enriched by the land application of nutrients and manure during production. These contaminants are also likely transported through an extensive tile drainage system that has been installed to drain the landscape for increased crop production. The TMDL for Silver Lake suggests that the two largest sources of phosphorus loading to Silver Lake are runoff from row crop agriculture (46.1 percent) and phosphorus that is recycled within the lake (39.0 percent), which is often called internal loading.

In shallow lakes that have accumulated large amounts of sediment at the lake bottom over time, phosphorus can mix into the water column from these sediments. Silver Lake is shallow, susceptible to wind-induced mixing, provides power-boating and personal watercraft recreation, and has a large carp and bullhead population. All of these facts support the assumption that internal TP loading is problematic. The water quality model for Silver Lake indicated that internal loading comprises approximately 39 percent of the existing TP load. This relative contribution is consistent with internal loading rates reported for other shallow lakes in Iowa.

According to the Iowa DNR watershed management plan (TMDL), the existing annual average TP load to Silver Lake from April 2005 through March 2008 was estimated to be 19,980 lbs/yr, or 54.7 lbs/day. This period was selected for two primary reasons: (1) annual GWLF simulations must begin on April 1 and end on March 31, and (2) water quality monitoring data from UHL during the 2005-07 growing seasons were utilized in the calibration of the BATHTUB water quality. The existing daily maximum load is estimated at 107.8 lbs/day.

The existing average annual TP load to Silver Lake is an estimated 19,980 lbs/year. The TP target load, also referred to as the loading capacity, is 8,499 lbs/yr (average annual) and 45.9 lbs/day (maximum daily). To meet the target loads, a reduction of 11,481 lbs/yr, or 57.5 percent, is required.

The following table shows the estimated contribution of each pollutant source to the total phosphorus load entering Silver Lake on an annual basis. Also shown are load reductions for each pollutant source that would provide a practical solution to reducing the total phosphorus load entering Silver Lake down to an acceptable level.

Source of Total Phosphorus	**Existing Load (lb/yr)**	**LA (lb/yr)**	**Load Reduction (%)**
Row Crops	9,217	3,226	65
Conservation Areas	180	162	10
Farmsteads	76	76	0
Urban/Roads	164	123	25
Groundwater	2,158	2,158	0
Geese	45	45	0
Septic Systems	66	2	97
Atmospheric Deposition	276	276	0
Internal Load	7,798	1,560	80
Total	**19,980**	**7,627**	**61.8**

Table 6.1: Estimated TP loading to Silver Lake, and desired loading reductions.

7. Agricultural Best Management Practices

In order to decrease the incoming pollutant load and fix the listed impairment of Silver Lake, a wide variety of practices will be required to address the poor water quality that has caused impaired primary contact recreation. The majority of the phosphorus and sediment that enter Silver Lake is from agricultural land uses and internal recycling; however, some urban area drains to the lake as well. Therefore, potential practices for water quality improvement in Silver Lake are grouped into three groups: agricultural, urban, and in-lake. One of the primary sources of existing total phosphorus loads to Silver Lake is runoff from row crop agriculture.

Many conservation practices used in agriculture are designed to reduce erosion and/or capture sediment before it reaches a stream or lake. Because a large portion of phosphorus is adsorbed to sediment, practices that reduce erosion and sediment transport will also reduce TP loads. Water quality improvement alternatives implemented in row crop areas should include structural practices such as sediment control structures, wetlands, grass waterways, and terraces.

Nonstructural conservation practices such as contour farming, no-till and strip-till farming, diversified crop rotation methods, and use of a winter cover crop will also be considered. To obtain reductions in the phosphorus and sediment loads necessary to meet water quality targets, these practices should be focused where they are needed most (in areas with the highest potential to contribute sediment and phosphorus loads to the lake.) Highest priority will be given to areas that exhibit high erosion rates, high sediment delivery, and do not currently have a sediment reduction practice in place. We will also encourage landowners and producers to adopt a variety of techniques that implement multiple practices which will enhance reductions in sediment and phosphorus loading to the lake.

Management of livestock manure and synthetic fertilizer is another agricultural BMP that will significantly reduce pollutant loads to Silver Lake. It is well-documented that incorporation of applied manure and fertilizer into the soil by knife or injection equipment reduces phosphorus levels, as well as nitrogen and bacteria levels, in runoff from application areas. Knifing and injection will be presented to producers as a more efficient, cost-effective application technique than broadcast application. Although application rate is much slower with these techniques, we will stress that more of the nutrients are available for crop growth, and less for runoff with these practices.

Strategic timing of manure and fertilizer application, and avoiding over-application of manure, will also be stressed to livestock producers, especially those who are determined to continue broadcast techniques. Avoiding application on frozen ground, or soon after periods of heavy rainfall, will also be highlighted as an inefficient way to utilize livestock-derived nutrient inputs. It will also be communicated that manure application in either of these scenarios can directly result in extremely high levels of bacteria and phosphorus in adjacent streams if any runoff should occur.

Following is a list of agricultural-based BMP's scheduled as part of the project:

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	125 ac	2 lb/yr	250 lb/yr
Grassed Waterways	3,000 ft	0.1 lb/yr	300 lb/yr
Sediment Basins	25	10 lb/yr	250 lb/yr
No /Ridge/ Strip Till Incentive	1,750 ac	0.9 lb/yr	1,575 lb/yr
Wetland Restoration	250 ac	12 lb/yr	4,000 lb/yr
Rock Tile Intakes	115	3 lb/yr	345 lb/yr
		Total TP Reduction:	**6,720 lb/yr**

Table 7.1: Ag-based BMP's to be installed

8. Urban Best Management Practices

Urban areas in Dickinson County have been expanding at a significant rate when compared to other rural counties in Iowa. Most of that urban expansion and construction has been occurring in the Iowa Great Lakes Region. However, recent lakeshore and urban developments in the City Lake Park have begun to change that. With the recent addition of two new developments, Lake Park has put itself on the map as having a significant beginning to urban development. Future plans in these new areas calls for even more progression adjacent to or near the lakeshore of Silver Lake.

A majority of the existing City of Lake Park drains away from Silver Lake and is outside the actual watershed boundary. The biggest portion of Lake Park does not negatively affect Silver Lake. Existing houses on the lakeshore and those within the boundary of the watershed have the potential for negative impact on the lake. As with any urban areas, the primary problems are sediment from construction, lawn fertilizers and pesticides, lawn clippings, and chemicals associated with household residences.

Storm sewer inlets within the incorporated area of Lake Park, for the most part, drain away from the lake and out of the watershed. The following map shows the location of each storm sewer within the incorporated city which drains to the lake, and functions as a direct conduit for pollutants entering the lake.

Map 8.1: Lake Park storm sewer inlets entering Silver Lake

With the construction of new development areas around Silver Lake, there will no doubt be a rise in storm sewer installation around Silver Lake. Considering there are few places, excluding the lake itself, for storm water to flow, it is likely that with new development will come even greater storm sewer concerns for Silver Lake.

Sanitary Sewer
The sanitary sewer in Lake Park was recently expanded to include all the lakeshore that once held properties with septic systems, including the new developments on the South side of the lake.

The city of Lake Park, Iowa DNR and Dickinson County SWCD worked diligently over seven years to ensure the entire city of Lake Park was able to connect to the sanitary sewer. In 2003, the city started construction of an extension of the sanitary sewer system to ensure the entire lake had access to the system. As of 2008, only one or two houses out of approximately 35 are not connected to the sanitary sewer system and the city of Lake Park is in the process of taking action to get those connected. This work has been done to connect the new sub-divisions as well as existing built areas within the jurisdiction of the city.
Adjacent to the lake there is only one residence on the north shoreline, which has an individual septic system. Within the watershed there is one septic system, which is suspected of not functioning correctly or meeting current standards requirements for septic tanks and drainage fields.

Urban Residential Development
The drainage from urban areas can be broken down into four areas. The first area is north of the Silver Lake outlet; second south of the Silver Lake outlet, third the area from Silver Shores to West Bay sub-divisions and fourth areas that have development potential. Each of these areas has different features and will have different impacts on the water quality of the lake. The four urban drainage areas should have different priorities.

The north drainage encompasses the most highly developed portion of Lake Park. This drainage area has the largest impervious surface, and should be considered the highest priority. The drainage consists of residential properties, a school with a large parking area, as well as commercial and industrial buildings. Storm water drainage entering Silver Lake will need to be addressed as upgrades are made to streets and properties in this area. Work with private landowners and businesses will be required to ensure the installation of urban BMP’s.

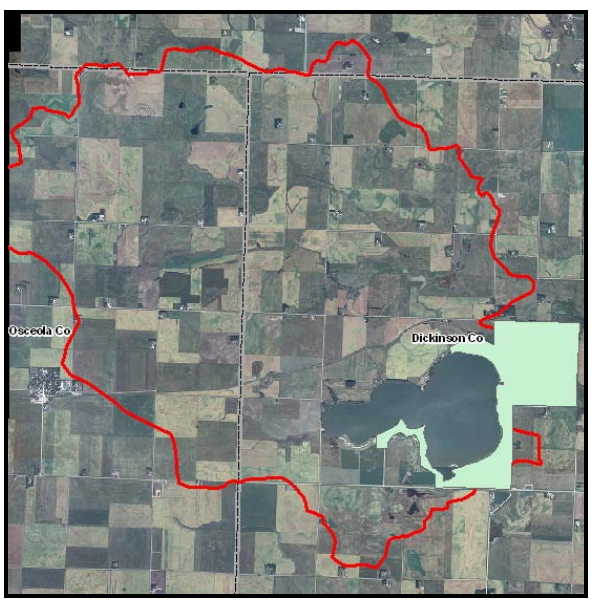
South of the outlet, the storm sewer systems are minimal and usually have pipes that drain a short distance to the lake. This is currently a lower priority because the areas have the least amount of impervious surface and drainage. If more construction takes place or a new sub-division is proposed in the watershed of these drainages then it may take a higher priority. The city of Lake Park should looking at addressing the drainage going to Silver Lake through infiltration based storm water management practices as they upgrade streets and drainage in this area.

Silver Shores, a recent development in the West End RMA, is also a high priority. A portion of the drainage in the two new sub-divisions all go to wetland areas before going to Silver Lake. At this time, these wetlands are helping to protect the lake, but as these sub-divisions are built, the wetlands used in this manor usually get over stressed and lose their filtering ability. Placing infiltration practices on the storm sewer systems will help buffer the wetlands and extend the life of their filtering capabilities. The area between these two sub-divisions like the south drainage have little impervious surface and in some areas may have issues with water table to property install infiltration practices. The only area of the Silver Shores section of Urban Development that might cause problems or might be beneficial to lake protection is the Silver Lake Golf Course.

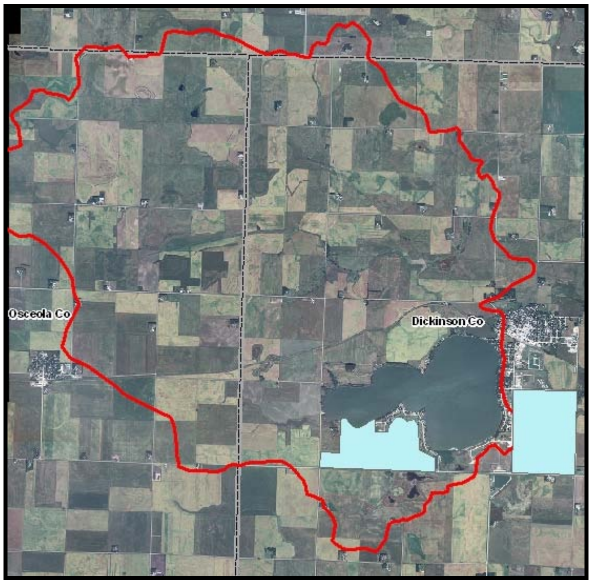
The last urban drainage area is future sub-divisions. The areas that are not defined can have protection through ordinance changes that would require storm water management based on water quality and flood control. Currently, the storm sewer systems are designed for flood control but no water quality requirements. The City of Lake Park should look at adopting ordinances similar to the Cities of Spirit Lake, Okoboji and Wahpeton, or Dickinson County. The Dickinson County Low Impact Development Ordinance, passed in June of 2008 will cover any unincorporated sub-divisions around Silver Lake.

Incorporated Area

The current incorporated areas in the City of Lake Park are shown below in Map 8.2. As you can see, most of the city does not fall within the watershed boundary of Silver Lake. These areas have remained constant until just a few years ago when the entire south shore of Silver Lake was annexed into the city along with 2 large developments. There are future annexation plans and future developments already in the works. Map 8.3 shows current future annexation plans, however, there are even more annexation plans in the works than what is shown.



Map 8.2: Current Incorporated Area of Lake Park



Map 8.3: Potential Incorporated Area of Lake Park

Below is a list of urban and shoreline-based BMP's scheduled for implementation:

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
Shoreline Restoration	5,000 ft	0.1 lb/yr	500 lb/yr
Rain Gardens	20	2.5 lb/yr	50 lb/yr
		Total TP Reduction:	**550 lb/yr**

Table 8.1: Urban & shoreline BMP's to be installed

9. Project Goals

The Silver Lake Water Quality Project has as a goal to reduce sediment and phosphorous from reaching the water bodies of the Silver Lake. The primary reason for these two pollutants being the target is the TMDL's Silver Lake showing a need to reduce both in order to be removed from the 303d listing. Modeling shows the total phosphorous source and loading to be:

TP Source (land uses and other inputs)	Descriptions and Assumptions	Existing Load (lb/yr)	TP Load (%)
Row Crops	corn, beans, oats, alfalfa	9,217	46.1
Conservation Areas	forest, grassland, wildlife areas, CRP	180	0.9
Farmsteads	Farmsteads	76	0.4
Urban/Roads	residential lands use, roads	164	0.8
Septic Systems	49 septic systems, 30% contributing TP	66	0.3
Geese	150 geese (Oct-Apr); 100 geese (May-Sep)	45	0.2
Groundwater	TP inputs based on land use	2,158	10.8
Atmospheric	atmospheric deposition to lake	276	1.4
Internal Load	recycled from bottom of lake	7,798	39.0
Total		**19,980**	**100**

Table 9.1: Existing loads and sources of TP in Silver Lake Watershed

Load Reductions

Once again, the annual load reduction goal for phosphorus in the Silver Lake Watershed is shown below:

Source of Total Phosphorus	Existing Load (lb/yr)	LA (lb/yr)	Load Reduction (%)
Row Crops	9,217	3,226	65
Conservation Areas	180	162	10
Farmsteads	76	76	0
Urban/Roads	164	123	25
Groundwater	2,158	2,158	0
Geese	45	45	0
Septic Systems	66	2	97
Atmospheric Deposition	276	276	0
Internal Load	7,798	1,560	80
Total	**19,980**	**7,627**	**61.8**

Table 9.2: Annual load allocation and reduction of TP sources

The Watershed Management Plan for Silver Lake states: No single BMP will be able to reduce pollutant loads to Silver Lake. Rather, a comprehensive package of BMPs will be required to address poor water transparency that has caused “aesthetically objectionable conditions” and impaired primary contact recreation. The majority of the phosphorus and sediment entering Silver Lake is from agricultural land uses and internal recycling; however, some urban area drains to the lake as well. Therefore, potential BMPs for water quality improvement in Silver Lake are grouped into three components: agricultural, urban, and in-lake.

One of the primary sources of existing total phosphorus (TP) loads to Silver Lake is runoff from row crop agriculture. Many agricultural BMPs are designed to reduce erosion and/or capture sediment before it reaches a stream or lake. Because a large portion of TP is adsorbed to sediment, BMPs that reduce erosion and sediment transport will also reduce TP loads. Water quality improvement alternatives implemented in row crop areas should include structural BMPs such as sediment control structures, wetlands restoration, and grass waterways. Nonstructural conservation practices such as cross-slope farming, no-till and strip-till farming, diversified crop rotation methods, and use of a winter cover crop will also be encouraged. To obtain reductions in TP load necessary to meet water quality targets, these practices will be targeted to key locations throughout the watershed which will result in the greatest load reductions (i.e., in areas with the highest potential to contribute sediment and phosphorus loads to the lake).

Goal 1: Reduce Phosphorous Loading and Sediment Delivery to Silver Lake from Agricultural Lands by 43 %

Specific Project Objectives:

- Establish 1,750 (12% of cropland) acres of nutrient and pesticide management (reduction of 15% phosphorous on agricultural lands)
- Establish 1,750 (12% of cropland) acres of no-till, strip-till, ridge till, and conservation tillage (reduction of 20% sediment)
- Establishment of 3,000 feet of grassed waterway that drains water from 700 acres (elimination of ephemeral gully erosion and reduction of sediment delivery in areas covered by grassed waterway)
- Demonstrate Manure Management Best Management Practices
- Establishment of 25 water and sediment control basins that drains water from 700 acres (reduction of sediment delivery by 70%)
- Establishment of 115 rock tile intakes that drains water from 2,000 acres (reduction of phosphorous by 30%)
- Restore 250 acres of wetland with 3,250 acres of upland draining through the wetland acres (reduction of 30% of the phosphorous in the watershed loading)

Goal 2: Reduce Phosphorous Loading and Sediment Delivery to Silver Lake from Urban Areas and Rural Residences by 8 %

Specific Project Objectives:

- Construct 20 Low Impact Development Structures with 38 acres draining through these structures (removal of up to 87% of Phosphorous from millions of gallons of water and slow those runoff waters)
- Control 98% of construction site erosion runoff water so no runoff carries pollutants (98% effective)
- Conduct a Septic System Renovation Demonstration at a Rural Residence
- Promote Septic System Inspections on 10 Rural Residences
- Implement an Effective Information and Education Campaign to Promote Residential BMP's such as P-free fertilizer, filter strips, and LID practices.

Goal 3: Facilitate the Lake Renovation Process in Cooperation with Collaborating Agencies. Reduce internal phosphorous loading by 6%

Specific Project Objectives:

- Establishment of 5,000 feet of shoreline revegetation/stabilization (reduction of bottom sediment stirring and use of nutrient)

The goal of the restoration of Silver Lake will require shallow lake restoration techniques, which may take several years for the public to endorse. Over the past decade, IDNR has gained valuable insight into the mechanisms that drive water quality and the quality of fisheries in Iowa's shallow lakes. Restoration of these ecosystems requires an adaptive management approach utilizing a combination of complimentary techniques. Restoration techniques are geared towards emulating pre-settlement conditions. The goal is to shift the lake from a turbid system with little to no aquatic plants, to a clear water system dominated by macrophytes (aquatic plants). Shallow lake restoration techniques include:

- Wetland restoration to emulate natural lake hydrology.
- Water level management to establish rooted aquatic vegetation.
- Shoreline stabilization to reduce erosion and establish and sustain aquatic plants.
- Fisheries management to reduce bottom-feeding rough-fish species (common carp).
- Creation of sediment forebays at the mouth of tributary streams to filter sediment and nutrient loads.
- Limited dredging to remove known sediment deposits and create deep-water habitat to compliment fisheries management.

Following is an inclusive listing of practices along with the amount of reduction in phosphorous that could be expected is listed in the following table, which comes from the Silver Lake Management Plan (TMDL):

BMP or Activity	(1) Potential TP Reduction
Conservation Tillage:	
Moderate vs. Intensive Tillage	50%
No-Till vs. Intensive Tillage	70%
No-Till vs. Moderate Tillage	45%
Cover Crops	50%
Diversified Cropping Systems	50%
In-Field Vegetative Buffers	50%
Terraces	50%
Pasture/Grassland Management:	
Livestock Exclusion from Streams	75%
Rotational Grazing vs. Constant Intensive Grazing	25%
Seasonal Grazing vs. Constant Intensive Grazing	50%
Phosphorus Nutrient Application Techniques	
(2)Deep Tillage Incorporation vs. Surface Broadcast	-15%
(2)Shallow Tillage Incorporation vs. Surface Broadcast	-10%
Knife/Injection Incorporation vs. Surface Broadcast	35%
Phosphorus Nutrient Application Timing and Rates:	
Spring vs. Fall Application	30%
Soil-Test P Rate vs. Over-Application Rates	40%
Application: 1-month prior to runoff event vs. 1-day	30%
Riparian Buffers	45%
(3)Wetlands	20%

Table 9.3: Potential TP load reduction from agricultural BMP's

The practices listed above will be prioritized by the amount of sediment reduction that will be achieved by installation of these practices. Areas that are identified on the Sediment Delivery Map (Appendix 1) as producing higher sediment delivery rates will be the areas that will be approached first in the delivery of these programs. It is clear to see where the priority areas will be or where the water moves from those priority areas. The prevention of the delivery of sediment and the nutrients it carries will be a key to the success of this project.

Using the RUSLE modeling that is available to us, we will use a 3-phase plan. By using this 3-phase plan the residents and visitors to Silver Lake will realize a reduction of nearly 60% of the incoming phosphorous into the lake. The first phase of the plan is already in motion, and includes offering landowner incentives for wetland restoration via grant funding from the State of Iowa Watershed Improvement Review Board (WIRB). In this project, 250 acres of wetland and 750 acres of upland are to be restored in targeted locations throughout the watershed.

A GIS assessment of potential sites has been conducted in cooperation with DNR Fisheries personnel in Spirit Lake. These sites have been prioritized based upon the projected load reductions, feasibility of the site, and landowner participation. The wetlands will remove up to 70% of the sediment and phosphorous that enters into it and the uplands can remove or slow runoff prior to the runoff reaching the wetland. Phase two of this plan includes treating the upper reaches of the watershed in areas that wetlands and uplands will not be constructed or built. The practices that will be used in this phase include waterways, sediment basins, filter strips, shoreline restoration, conservation tillage, and nutrient and pesticide management. Finally, phase 3 of this plan will be a continuation of upland protection as well as shallow lake management processes.

The treatment to be applied to the Silver Lake Watershed, in the three-phase process outlined above, is logical and provides a clear plan that will reach the successful conclusion of removing Silver Lake from the 303d list of impaired waters.

Each of the practices listed has been identified as a priority method to eliminate specific pollutants. It is estimated, using the RUSLE Model that for an annual delivery of 6,425 pounds of phosphorous being delivered to a water body or catchment. If the above practices were constructed in key locations, as much as 30% of the phosphorous movement to the lakes would be reduced for a total reduction of 4,497 pounds of phosphorous each year.

An implementation schedule to accompany the watershed management plan will be a vital component to the success of this project. Below is the implementation schedule for the five years of this project:

Year 1

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	25 ac	2 lb/yr	50 lb/yr
Shoreline Restoration	1000 ft	0.1 lb/yr	100 lb/yr
Grassed Waterways	500 ft	0.1 lb/yr	50 lb/yr
Sediment Basins	4	10 lb/yr	40 lb/yr
No /Ridge/ Strip Till Incentive	200 ac	0.9 lb/yr	180 lb/yr
Wetland Restoration	200 ac	16 lb/yr	3,200 lb/yr
Rock Tile Intakes	20	3 lb/yr	60 lb/yr
Rain Gardens	10	2.5 lb/yr	25 lb/yr

Year 2

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	25 ac	2 lb/yr	50 lb/yr
Shoreline Restoration	1000 ft	0.1 lb/yr	100 lb/yr
Grassed Waterways	500 ft	0.1 lb/yr	50 lb/yr
Sediment Basins	5	10 lb/yr	50 lb/yr
No /Ridge/ Strip Till Incentive	150 ac	0.9 lb/yr	135 lb/yr
Wetland Restoration	50 ac	16 lb/yr	800 lb/yr
Rock Tile Intakes	15	3 lb/yr	45 lb/yr
Rain Garden	10	2.5 lb/yr	25 lb/yr

Year 3

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	25 ac	2 lb/yr	50 lb/yr
Shoreline Restoration	1000 ft	0.1 lb/yr	100 lb/yr
Grassed Waterways	500	0.1 lb/yr	50 lb/yr
Sediment Basins	5	10 lb/yr	50 lb/yr
No /Ridge/ Strip Till Incentive	600 ac	0.9 lb/yr	540 lb/yr
Rock Tile Intakes	50	3 lb/yr	150 lb/yr

Year 4

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	25 ac	2 lb/yr	50 lb/yr
Shoreline Restoration	1000 ft	0.1 lb/yr	100 lb/yr
Grassed Waterways	750	0.1 lb/yr	75 lb/yr
Sediment Basins	6	10 lb/yr	60 lb/yr
No /Ridge/ Strip Till Incentive	500 ac	0.9 lb/yr	450 lb/yr
Rock Tile Intakes	15	3 lb/yr	45 lb/yr

Year 5

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	25	2 lb/yr	50 lb/yr
Shoreline Restoration	1000 ft	0.1 lb/yr	100 lb/yr
Grassed Waterways	750	0.1 lb/yr	75 lb/yr
Sediment Basins	5	10 lb/yr	50 lb/yr
No /Ridge/ Strip Till Incentive	300 ac	0.9 lb/yr	270 lb/yr
Rock Tile Intakes	15	3 lb/yr	45 lb/yr

Project Composite

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	125 ac	2 lb/yr	250 lb/yr
Shoreline Restoration	5,000 ft	0.1 lb/yr	500 lb/yr
Grassed Waterways	3,000 ft	0.1 lb/yr	300 lb/yr
Sediment Basins	25	10 lb/yr	250 lb/yr
No /Ridge/ Strip Till Incentive	1,750 ac	0.9 lb/yr	1,575 lb/yr
Wetland Restoration	250 ac	12 lb/yr	4,000 lb/yr
Rock Tile Intakes	115	3 lb/yr	345 lb/yr
Rain Gardens	20	2.5 lb/yr	50 lb/yr
		Total TP Reduction:	**7,270 lb/yr**

Tables 9.4-9.9: Annual/composite scheduled BMP units & TP load reductions

10. Targeted Implementation

Following are comprehensive Resource Management Plans for each of the three subwatersheds which comprise the Silver Lake Watershed.

Although each subwatershed has its own unique set of characteristics and challenges, the general plan to treat each area will be similar in many ways. BMP’s such as residue and nutrient management, grassed waterways, filter strips, sediment basins, and rock tile intakes will be used to reduce soil erosion and impede sediment and nutrient delivery to the various drainages of the Silver Lake Watershed.

To accompany these erosion and sediment delivery control practices, we will also focus on wetland restoration in several key basins. This involves the first phase of the comprehensive plan to remove Silver Lake from the State of Iowa 303(d) Impaired Waters List, which is already in motion. Not only do the restored wetland basins capture and hold excess sediment and nutrients upstream of Silver Lake, but they also offer a significant decrease in flow velocity following rainfall events. These wetlands will act as a crucial filter for loading that we were not able to prevent via erosion control practices.

West Bay Resource Management Area (RMA)

***Objective* –** Restore and maintain Silver Lake to a clear water state.

<u>Restoration Planning Components</u>

Watershed Practices

Analysis has identified two priority wetland restorations in this subwatershed (Figure 2). These wetland restorations have the potential to effectively intercept 1,564 acres (84% of the priority subwatershed) of primarily agricultural runoff. In lieu of restoration of these priority wetland areas, analysis has identified several locations for sediment retention basins or constructed wetlands. Discussions with individual landowners will determine if wetland restorations or sediment retention basins are more feasible. In the event neither wetland restorations nor sediment basins can be achieved, other management practices will be discussed to reduce sediment loss from the property.

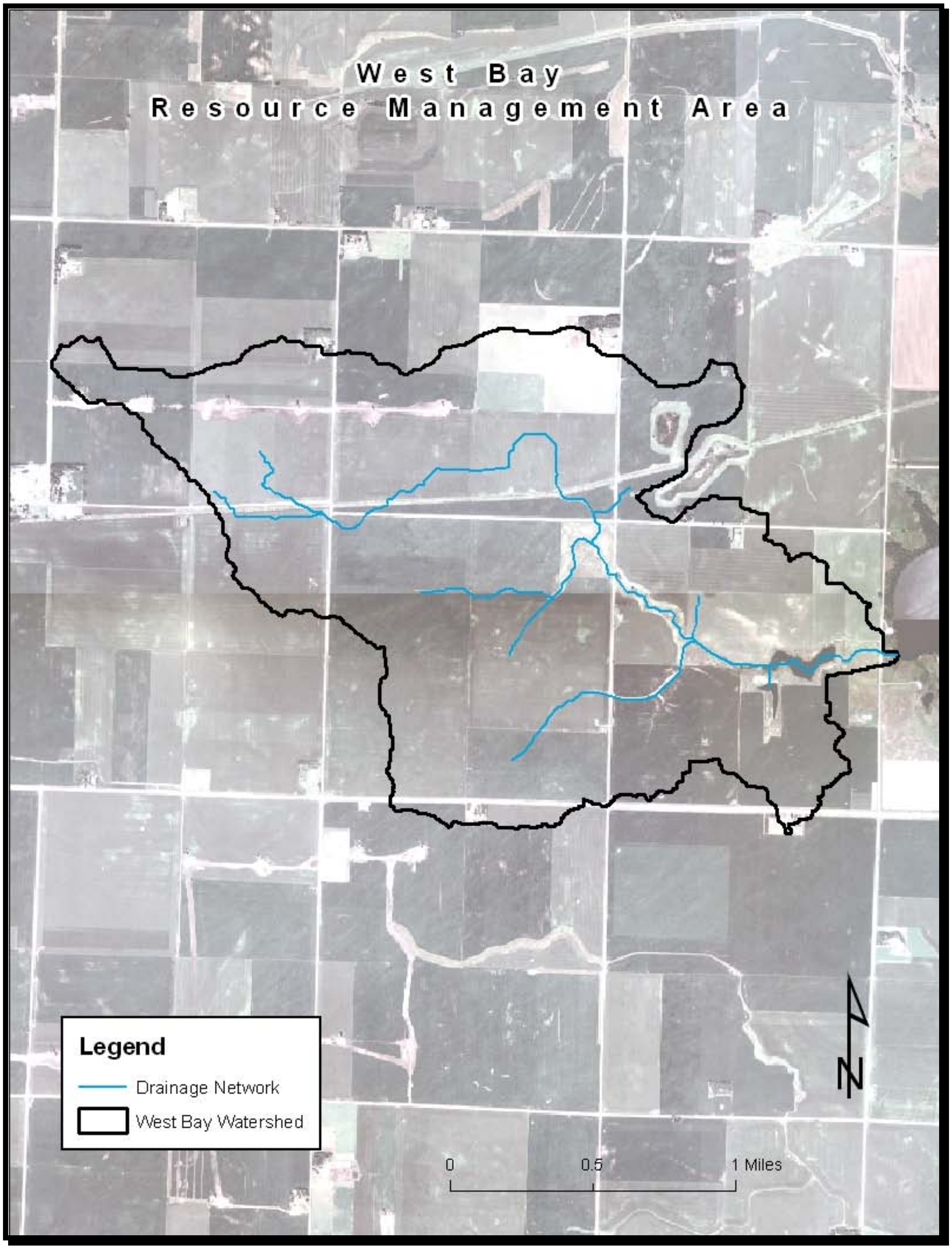
Modeling has identified 4.5 miles of concentrated flow areas within agricultural fields (Figure 3). By installing grassed waterways within each of these areas, 50 acres of upland habitat can be created and sediment loss from these areas significantly reduced.
Analysis has shown 16 agricultural fields devoted to row crop production that exceed sediment loss thresholds (Figure 4). These fields, totaling 907 acres, account for 50% of the sediment loss within the targeted watershed. By implementing conservation/minimum tillage programs on these fields, this sediment loss could be significantly reduced.
Sediment loss can be reduced on 140 acres of row cropped fields by implementing alternative practices (i.e. permanent vegetation, sediment basins, and reduced tillage) where field slope is greater than seven percent. Another 46 acres have been identified and should have alternate land practices implemented because their slope is greater than 15% (Figure 5).

A total of 1,658 acres are currently being utilized for the production of corn and soybeans within the West End RMA. A nutrient and pesticide management plan should be set up with each individual landowner to ensure that over application and runoff of nutrients and pesticides is minimized. A plan should also be put into place to protect field tile intakes from excessive nutrients and sediment. Rock tile intakes with an additional 50 foot vegetative buffer should be discussed and if possible, implemented at all tile intake locations within this subwatershed.

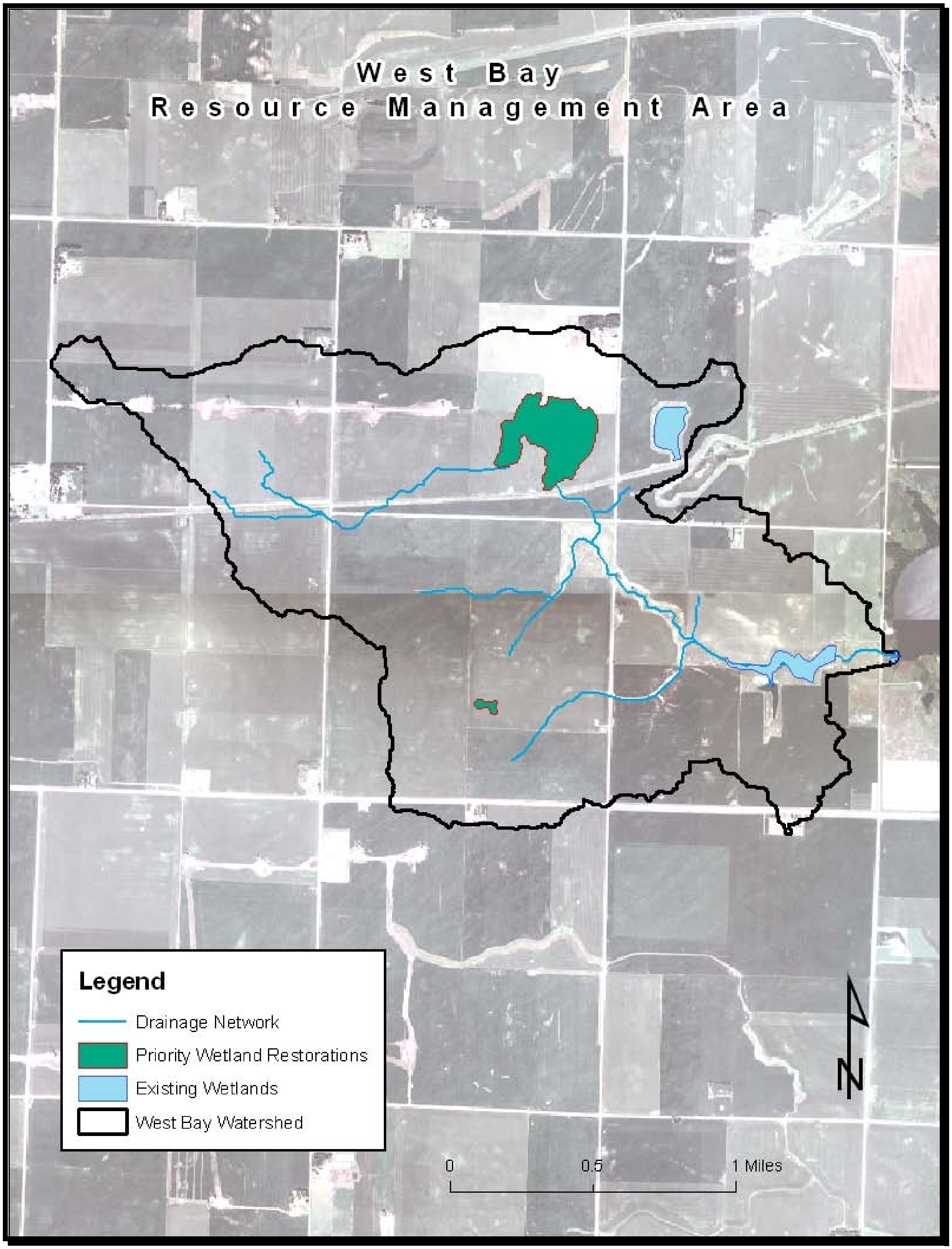
West Bay Project Implementation

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	25 ac	2 lb/yr	50 lb/yr
Grassed Waterways	500 ft	0.1 lb/yr	50 lb/yr
Sediment Basins	5	10 lb/yr	50 lb/yr
No /Ridge/ Strip Till Incentive	400 ac	0.9 lb/yr	360 lb/yr
Wetland Restoration	25 ac	12 lb/yr	300 lb/yr
Rock Tile Intakes	25	3 lb/yr	75 lb/yr
		Total TP Reduction:	**885 lb/yr**

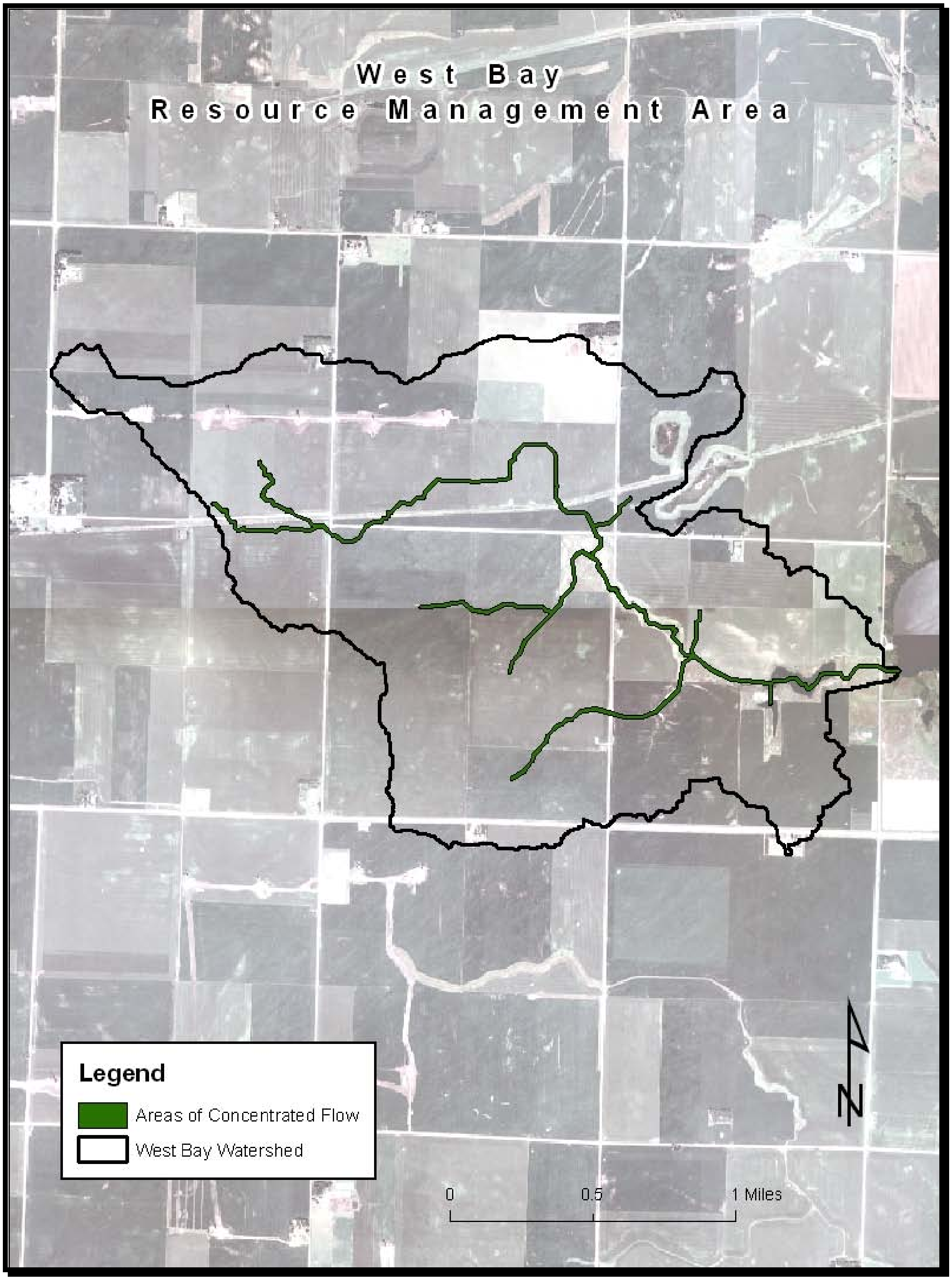
Table 10.1: BMP's & TP load reductions in West Bay Subwatershed



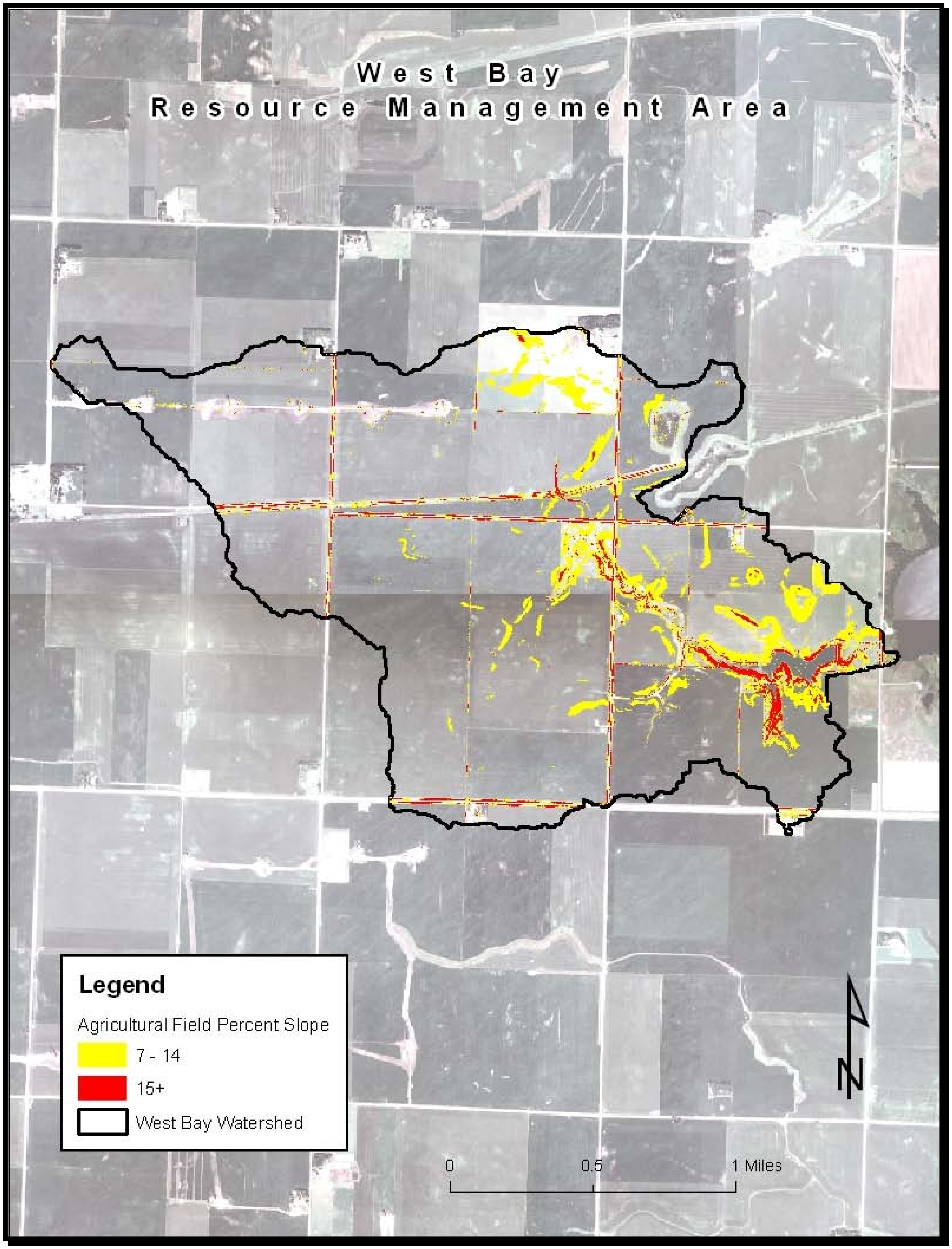
Map 10.1: West Bay drainage



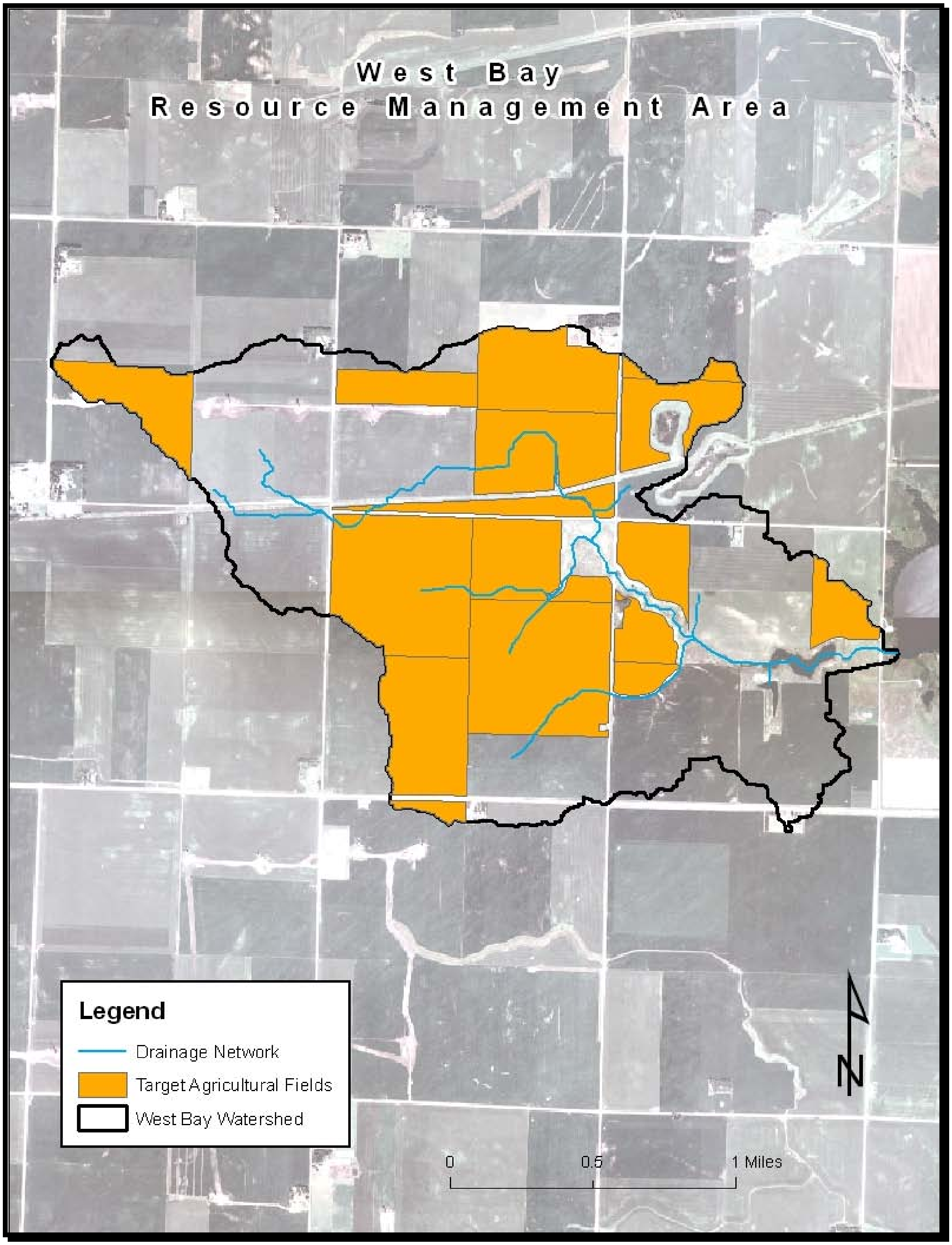
Map 10.2: West Bay wetland basins



Map 10.3: West bay concentrated surface flow



Map 10.4: West Bay highly erodible slopes



Map 10.5: West Bay agricultural fields of highest priority

Trapper's Bay Resource Management Area (RMA)

Objective – Restore and maintain Silver Lake to a clear water state.

Restoration Planning Components

Watershed Practices

Analysis has identified four priority wetland restorations in this subwatershed (Figure 2). These wetland restorations have the potential to effectively intercept 4,830 acres (46% of the priority subwatershed) of primarily agricultural runoff. In lieu of restoration of these priority wetland areas, analysis has identified several locations for sediment retention basins or constructed wetlands. Discussions with individual landowners will determine if wetland restorations or sediment retention basins are more feasible. In the event neither wetland restorations nor sediment basins can be achieved, other management practices will be discussed to reduce sediment loss from the property.

To complement the top four priority wetland restorations, there are many other restorable wetland basins in this subwatershed that are currently in row crop production or similar land uses. The restoration of these basins will also receive a large amount of attention. Restoration of these smaller basins will provide an initial filter for much of the water in this subwatershed and lessen the pressure on some larger basins, thus enhancing the water quality benefits provided by the highest priority wetlands.

Modeling has identified 36 miles of concentrated flow areas within agricultural fields (Figure 3). By installing grassed waterways within each of these areas, 301 acres of upland habitat can be created and sediment loss from these areas significantly reduced. Analysis has shown 99 agricultural fields devoted to row crop production that exceed sediment loss thresholds (Figure 4). These fields, totaling 5,405 acres, account for 50% of the sediment loss within the targeted watershed. By implementing conservation/minimum tillage programs on these fields, this sediment loss could be significantly reduced. Sediment loss can be reduced on 1,037 acres of row cropped fields by implementing alternative practices (i.e. permanent vegetation, sediment basins, and reduced tillage) where field slope is greater than seven percent. Another 290 acres have been identified and should have alternate land practices implemented because their slope is greater than 15% (Figure 5).

A total of 9,951 acres are currently being utilized for the production of corn and soybeans within the Trapper's Bay RMA. A nutrient and pesticide management plan should be set up with each individual landowner to ensure that over application and runoff of nutrients and pesticides is minimized. A plan should also be put into place to protect field tile intakes from excessive nutrients and sediment. Rock tile intakes with an additional 50 foot vegetative buffer should be discussed and implemented at all tile intake locations within the subwatershed.

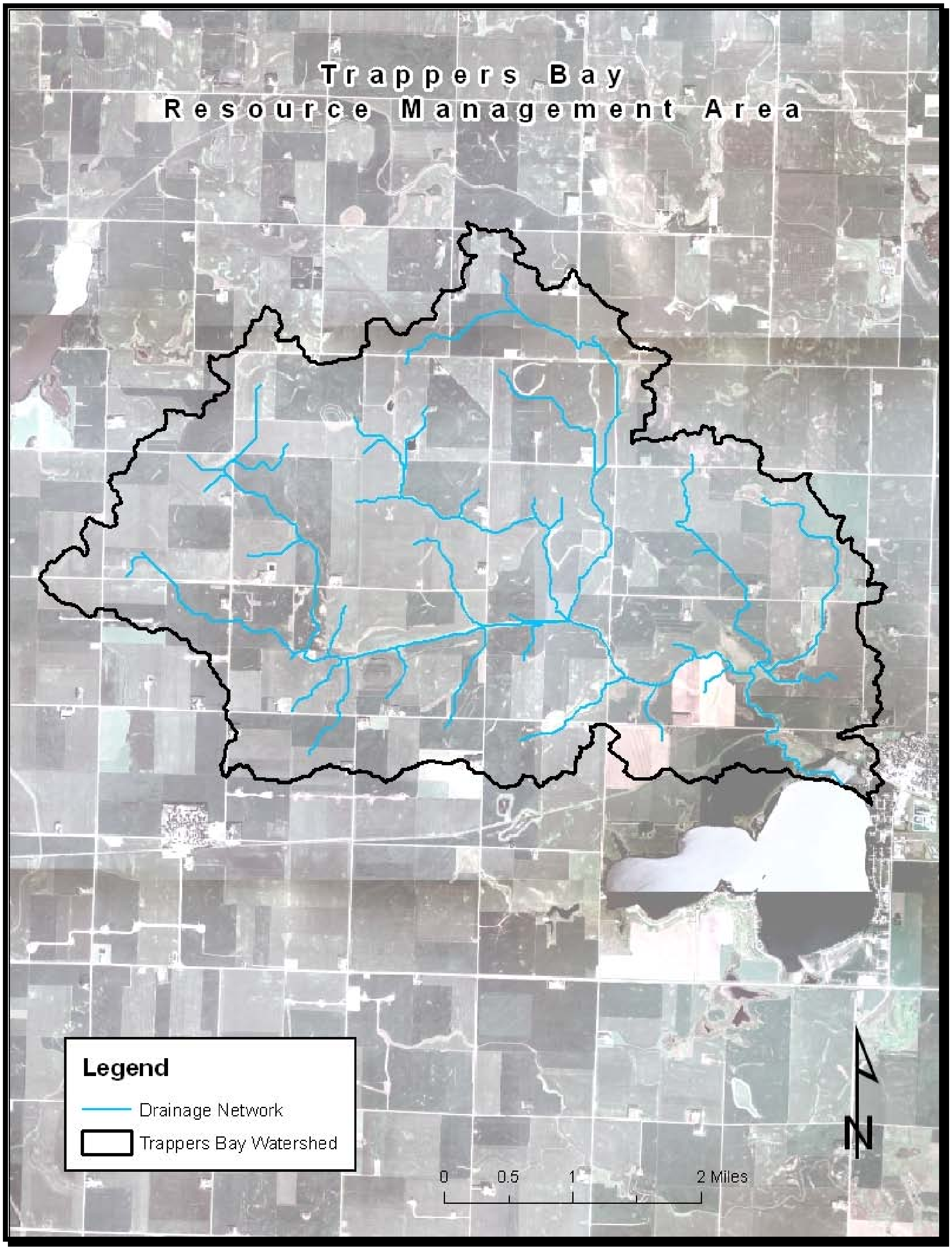
Lake Restoration
Another high priority involving the Trapper's Bay RMA will be the installation of a fish barrier beneath the bridge connecting Trapper's Bay to the lake itself. Presently, the large rough fish (predominantly common carp) population of Silver Lake uses Trapper's Bay as a staging and spawning grounds during the spring and summer months. Their intense spawning and feeding activity in the shallows of Trapper's Bay causes a tremendous amount of sediment and nutrients to be resuspended into the water column before flowing into the lake. In effect, what was historically a very efficient settling basin for sediment loads entering Silver Lake, Trapper's Bay has become a major contributor to the pollutant load of Silver Lake.

Local Iowa DNR fisheries staff is currently undergoing a comprehensive study of the rough fish population in Silver Lake. Although this should provide concrete data supporting a fisheries renovation on some level in Silver Lake, it has been widely accepted for some time that management of the rough fish population will need to be addressed before any marked water quality improvements might be observed in Silver Lake. Management of the rough fish population will provide a key supplement to the installation of BMP's in the waterhshed, and further allow the benefits of these practices to be observed in Silver Lake itself.

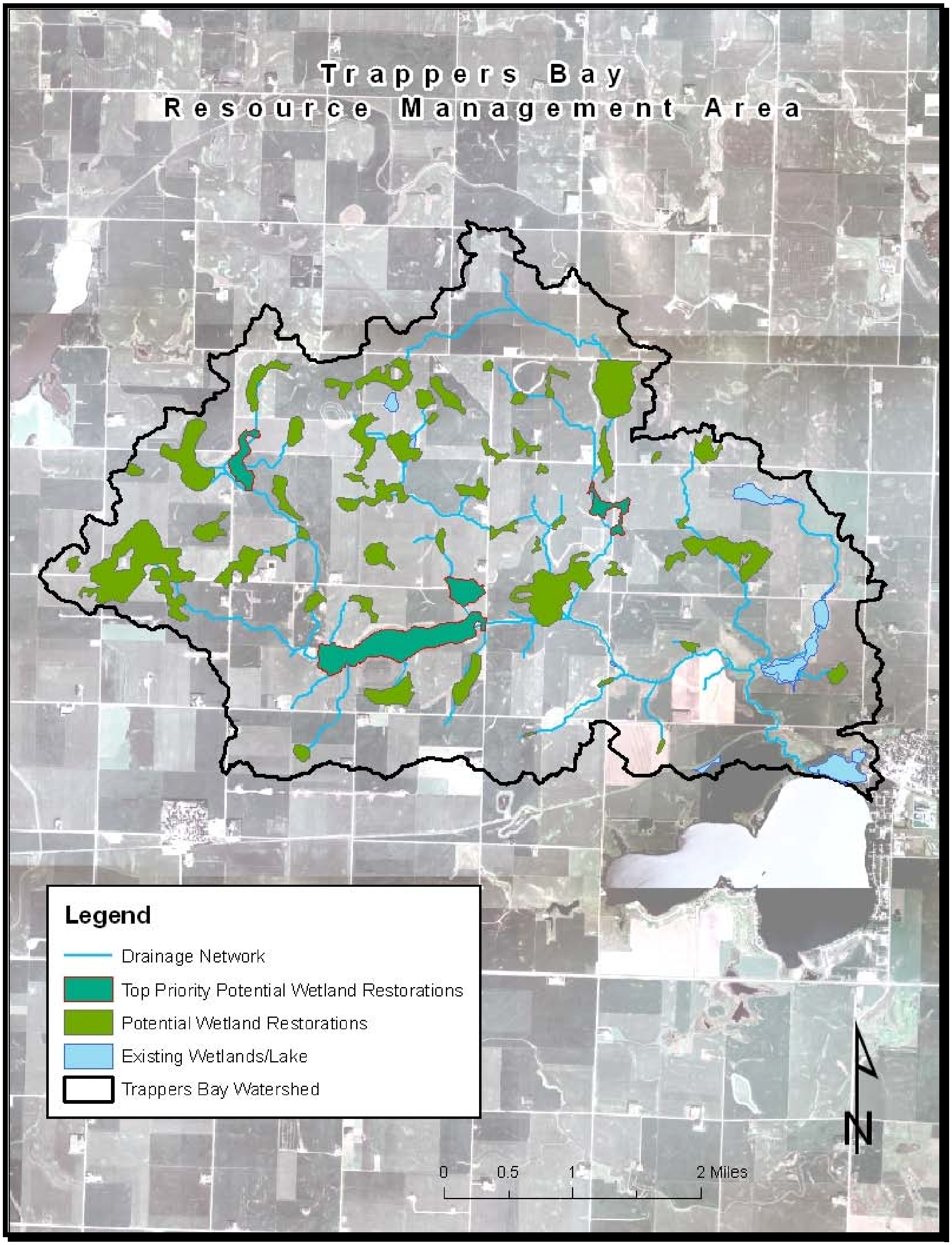
Trapper's Bay Implementation Schedule

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	90 ac	2 lb/yr	180 lb/yr
Grassed Waterways	2,200 ft	0.1 lb/yr	220 lb/yr
Sediment Basins	19	10 lb/yr	190 lb/yr
No /Ridge/ Strip Till Incentive	1,100 ac	0.9 lb/yr	990 lb/yr
Wetland Restoration	215 ac	12 lb/yr	2,580 lb/yr
Rock Tile Intakes	85	3 lb/yr	255 lb/yr
		Total TP Reduction:	**4,415 lb/yr**

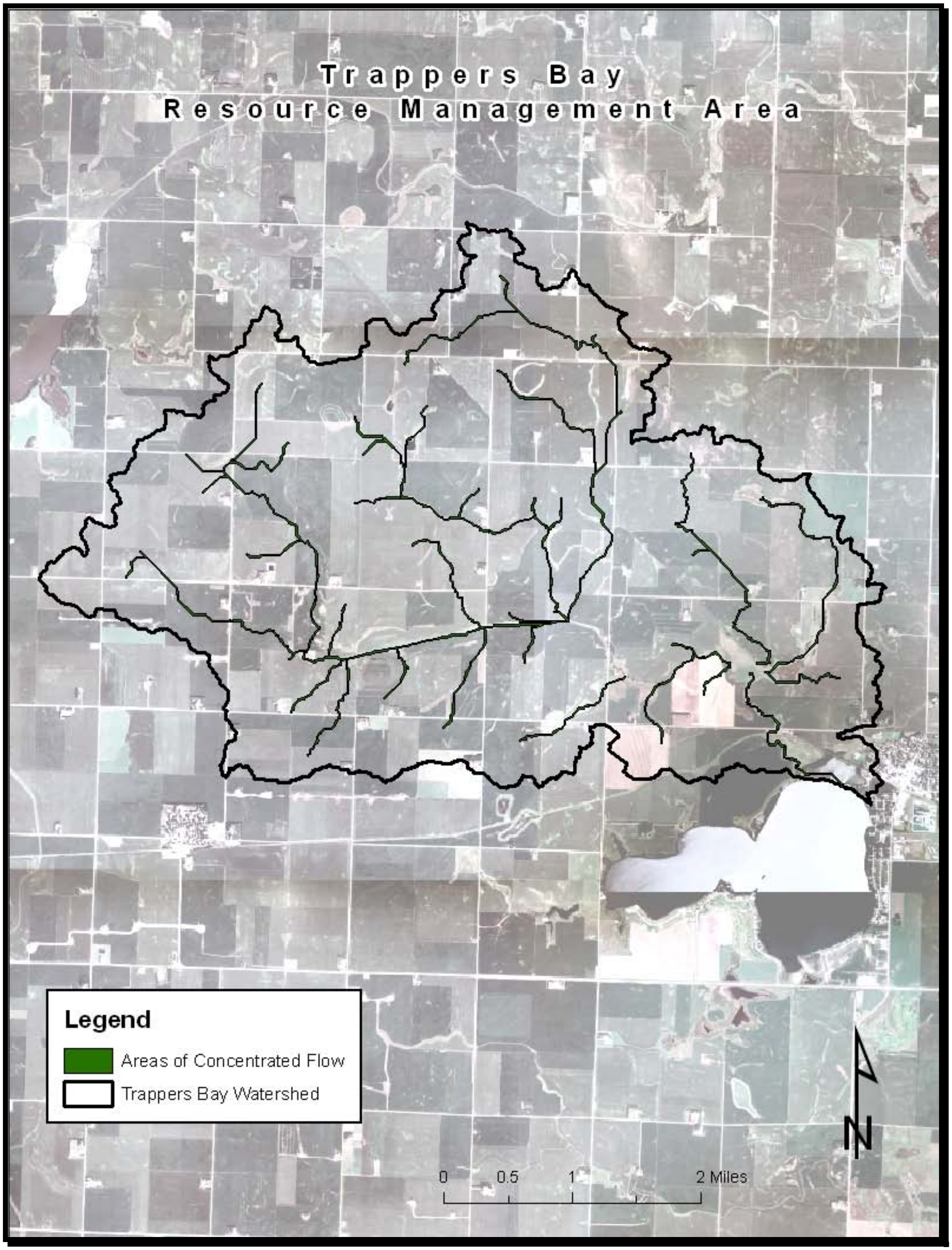
Table 10.2: BMP's & TP load reductions in Trapper's Bay subwatershed



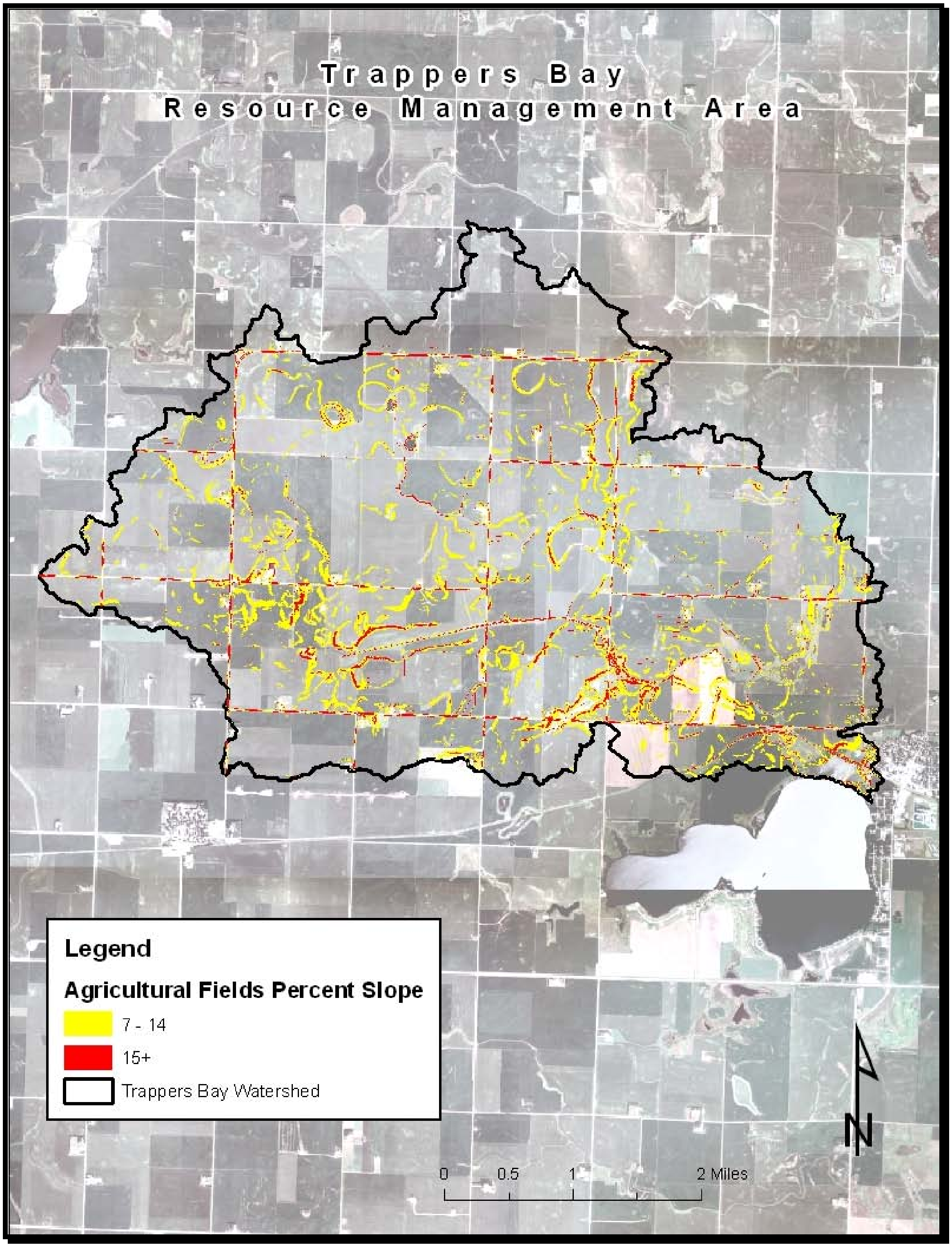
Map 10.6: Trapper's Bay drainage



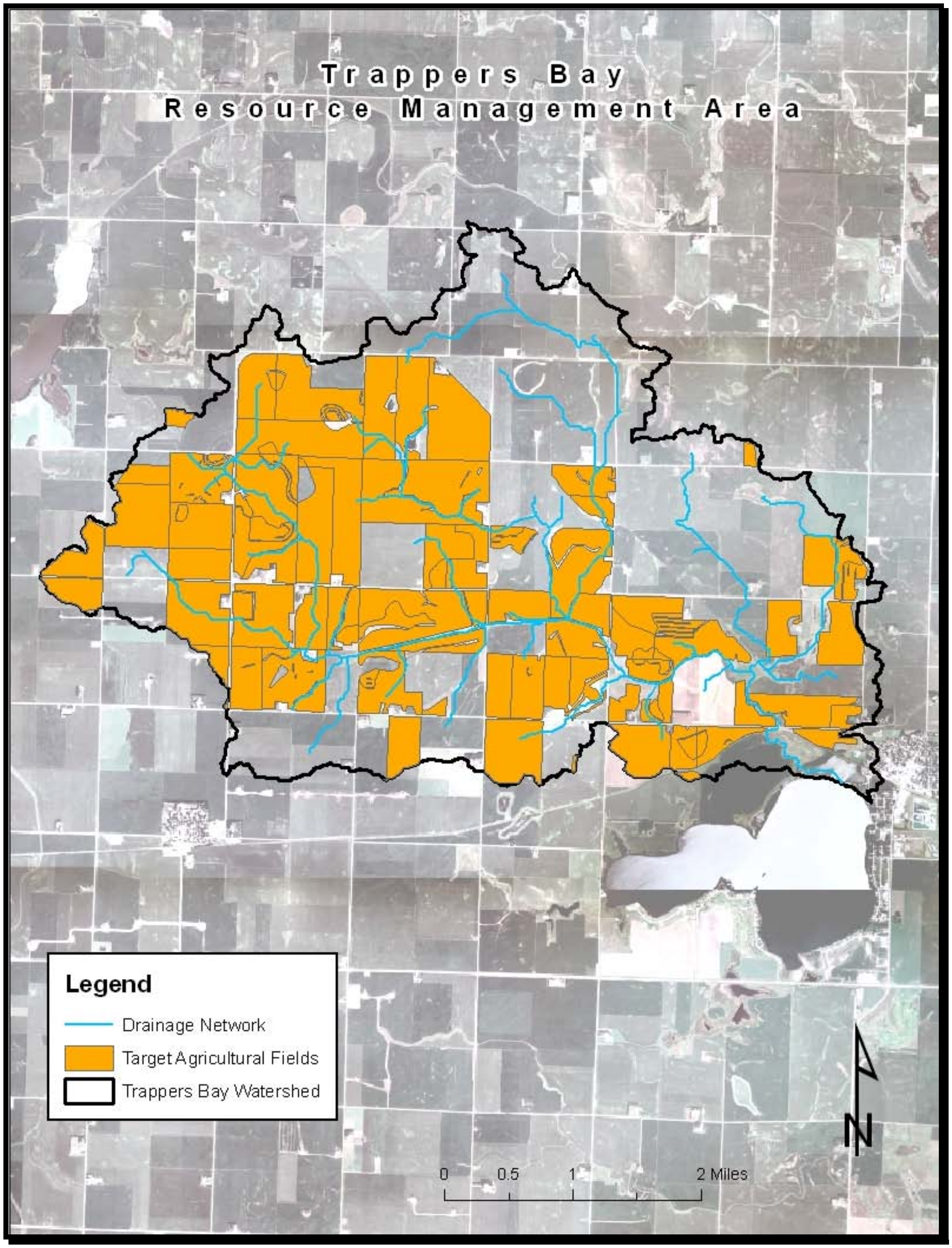
Map 10.7: Trapper's Bay wetland basins



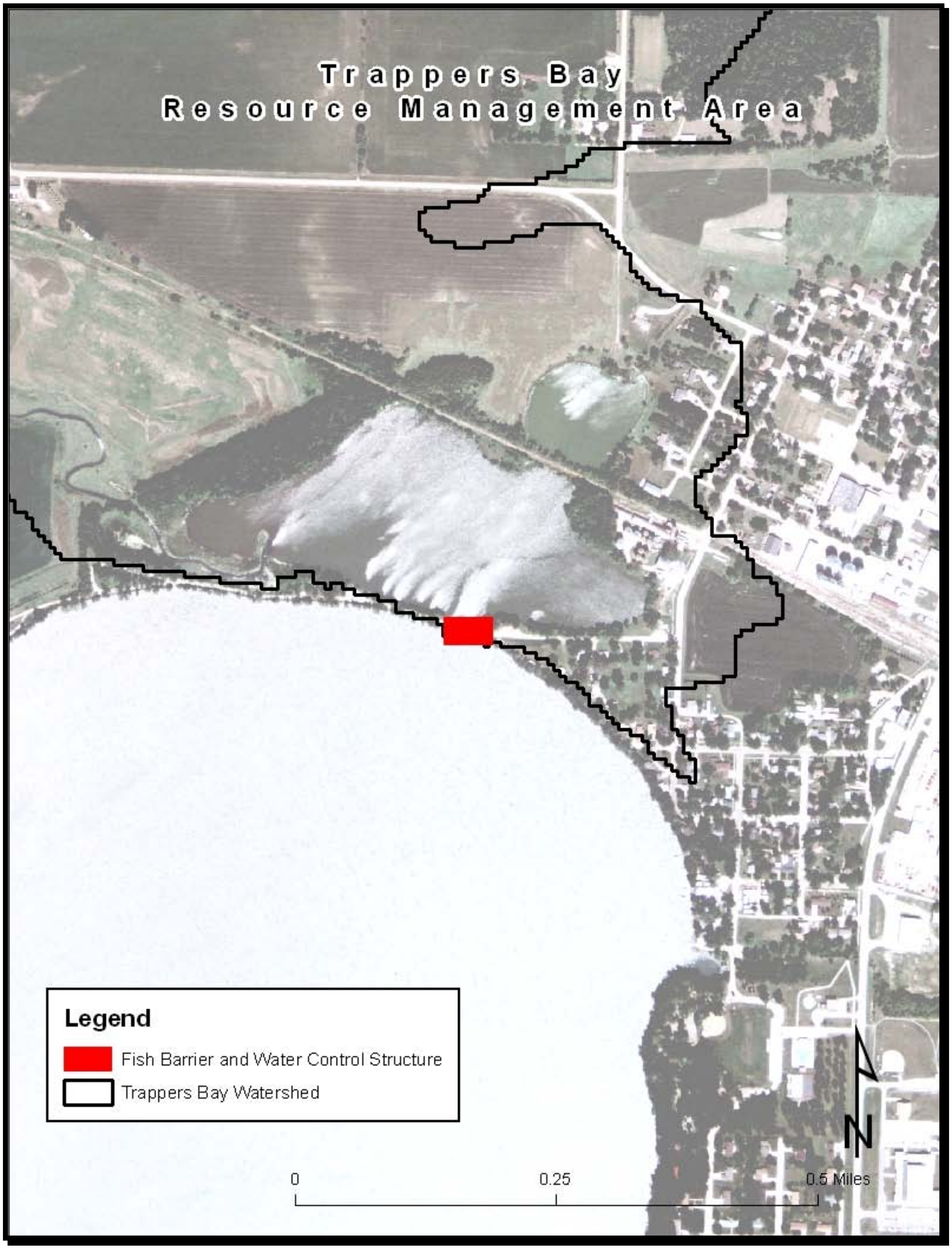
Map 10.8: Trapper's Bay concentrated surface flow



Map 10.9: Trapper's Bay highly erodible slopes



Map 10.10: Trapper's Bay agricultural fields of highest priority



Map 10.11: Trapper's Bay fish barrier

South Bay Resource Management Area (RMA)

Objective – Restore and maintain Silver Lake to a clear water state.

<u>Restoration Planning Components</u>

Watershed Practices
Analysis has identified two potential wetland restorations in this subwatershed (Figure 2). These wetlands would help to boost the ability of the existing wetland chain of intercepting runoff from nearby agricultural fields. These new wetland restorations have the potential to effectively intercept 78 acres (8% of the priority subwatershed) of primarily agricultural runoff. In the event wetland restorations cannot be achieved, other management practices will be discussed to reduce sediment loss from the property. Modeling has identified 1.5 miles of concentrated flow areas within agricultural fields (Figure 3). By installing grassed waterways within each of these areas, 13 acres of upland habitat can be created and sediment loss from these areas significantly reduced.

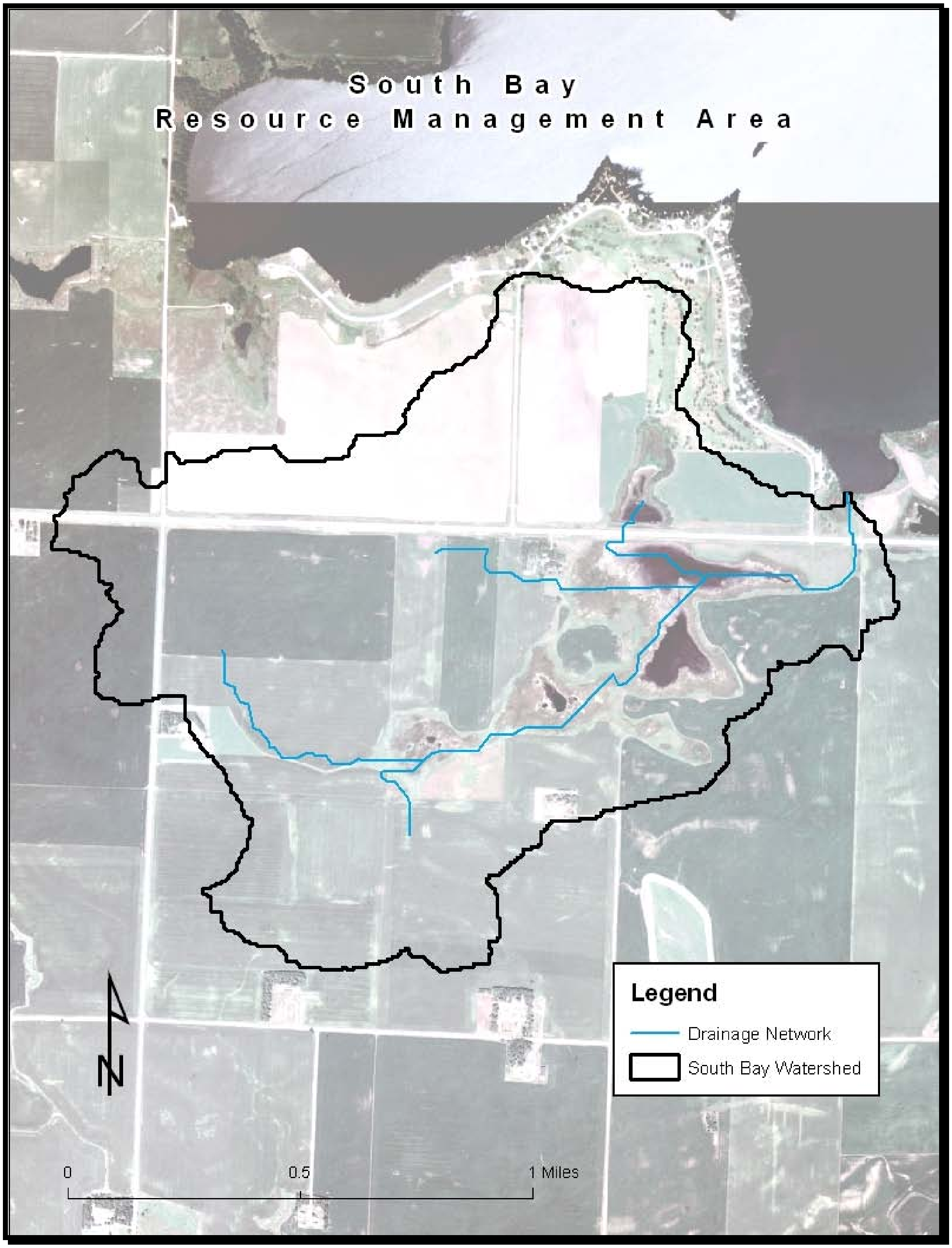
Analysis has shown 7 agricultural fields devoted to row crop production that exceed sediment loss thresholds (Figure 4). These fields, totaling 427 acres, account for 50% of the sediment loss within the targeted watershed. By implementing conservation/minimum tillage programs on these fields, this sediment loss could be significantly reduced. Sediment loss can be reduced on 136 acres of row cropped fields by implementing alternative practices (i.e. permanent vegetation, sediment basins, and reduced tillage) where field slope is greater than seven percent. Another 25 acres have been identified and should have alternate land practices implemented because their slope is greater than 15% (Figure 5).

A total of 710 acres are currently being utilized for the production of corn and soybeans within the South End RMA. A nutrient and pesticide management plan should be set up with each individual landowner to ensure that over application and runoff of nutrients and pesticides is minimized. A plan should also be put into place to protect field tile intakes from excessive nutrients and sediment. Rock tile intakes with an additional 50 foot vegetative buffer should be discussed and implemented at all tile intake locations within this subwatershed.

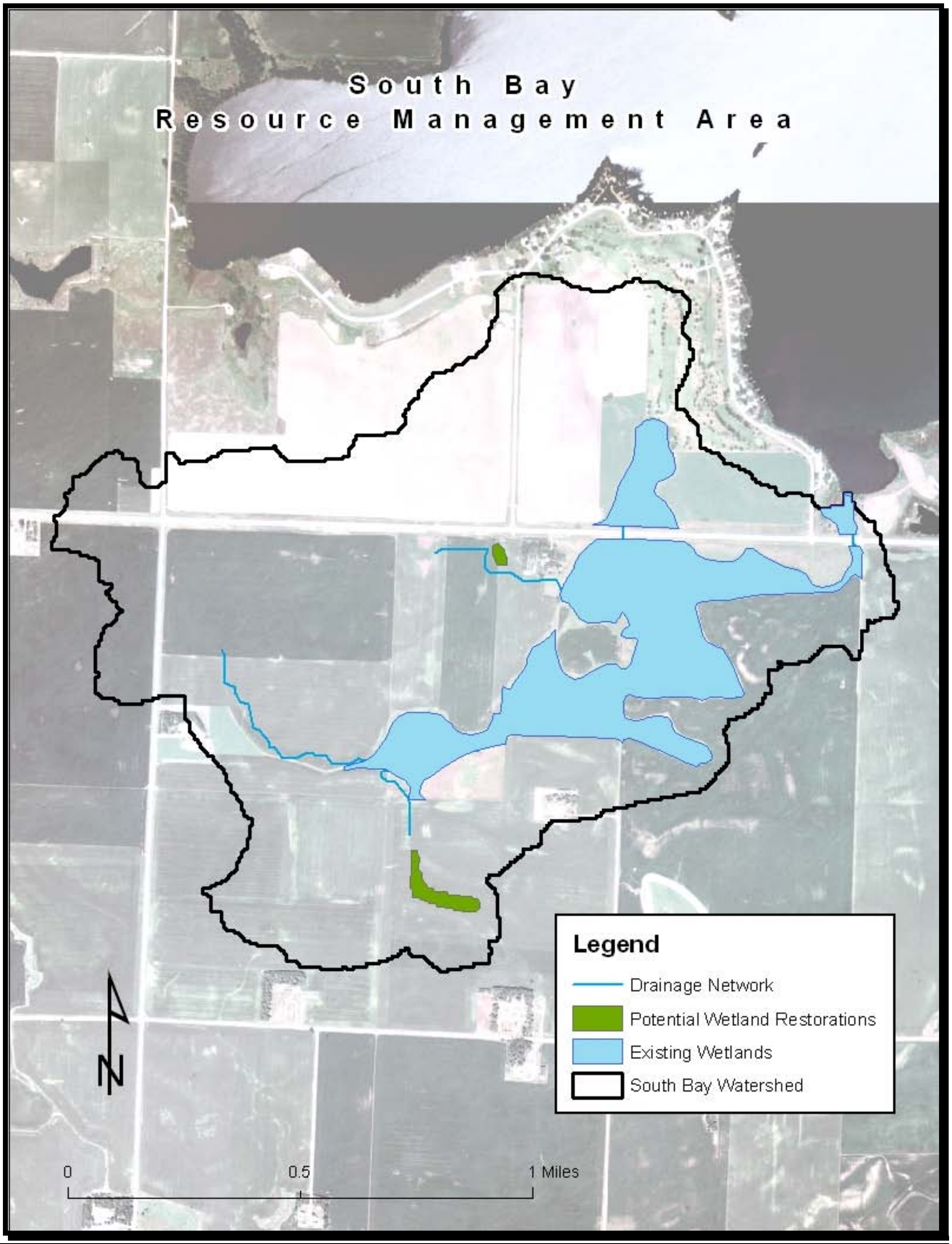
South Bay Implementation Schedule

BMP	Units	TP Load Reduction per Unit	Total TP Load Reduction
CRP Incentive	10 ac	2 lb/yr	20 lb/yr
Grassed Waterways	300 ft	0.1 lb/yr	30 lb/yr
Sediment Basins	1	10 lb/yr	10 lb/yr
No /Ridge/ Strip Till Incentive	250 ac	0.9 lb/yr	225 lb/yr
Wetland Restoration	10 ac	12 lb/yr	120 lb/yr
Rock Tile Intakes	5	3 lb/yr	15 lb/yr
		Total TP Reduction:	**420 lb/yr**

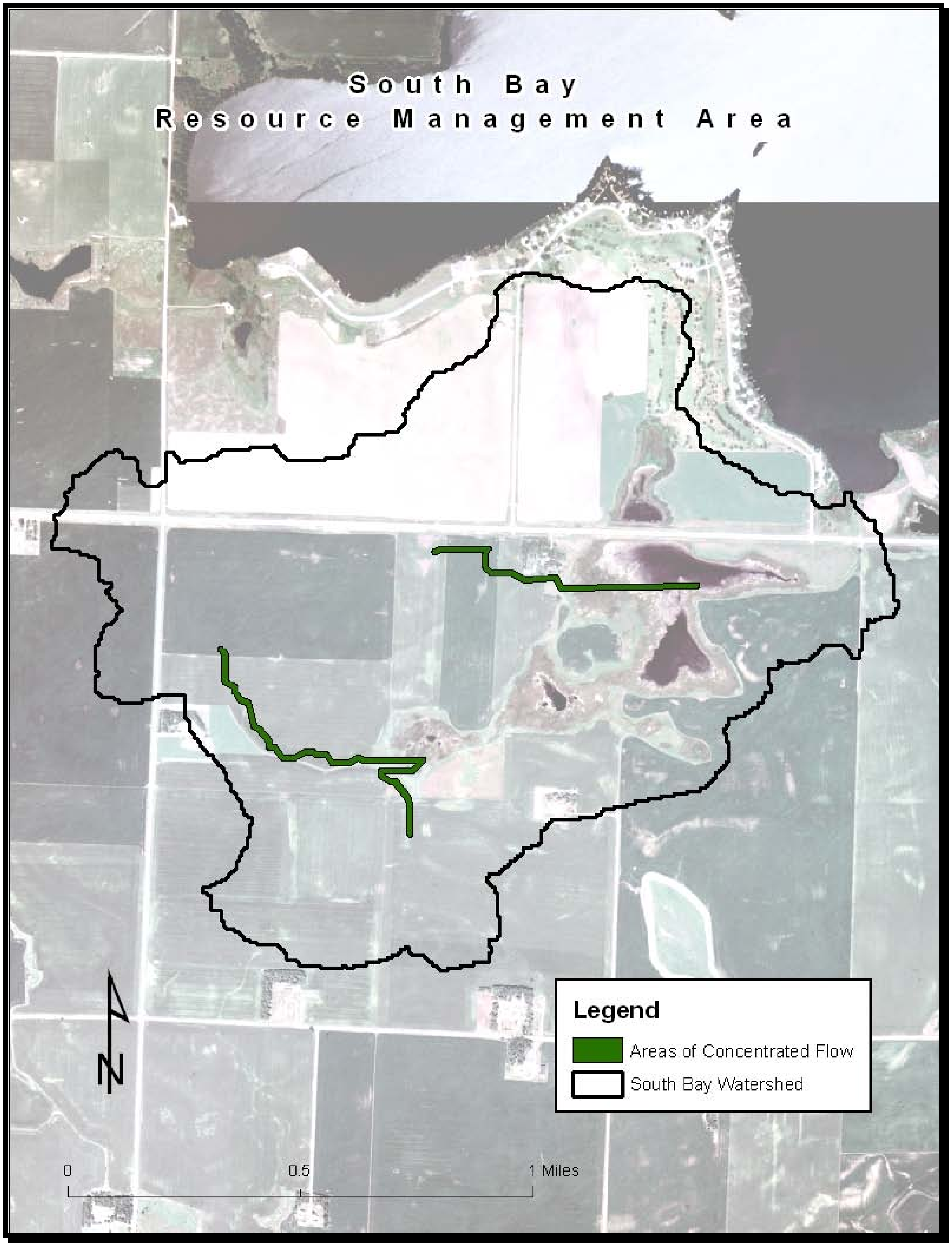
Table 10.3: BMP's & TP load reductions in South Bay subwatershed



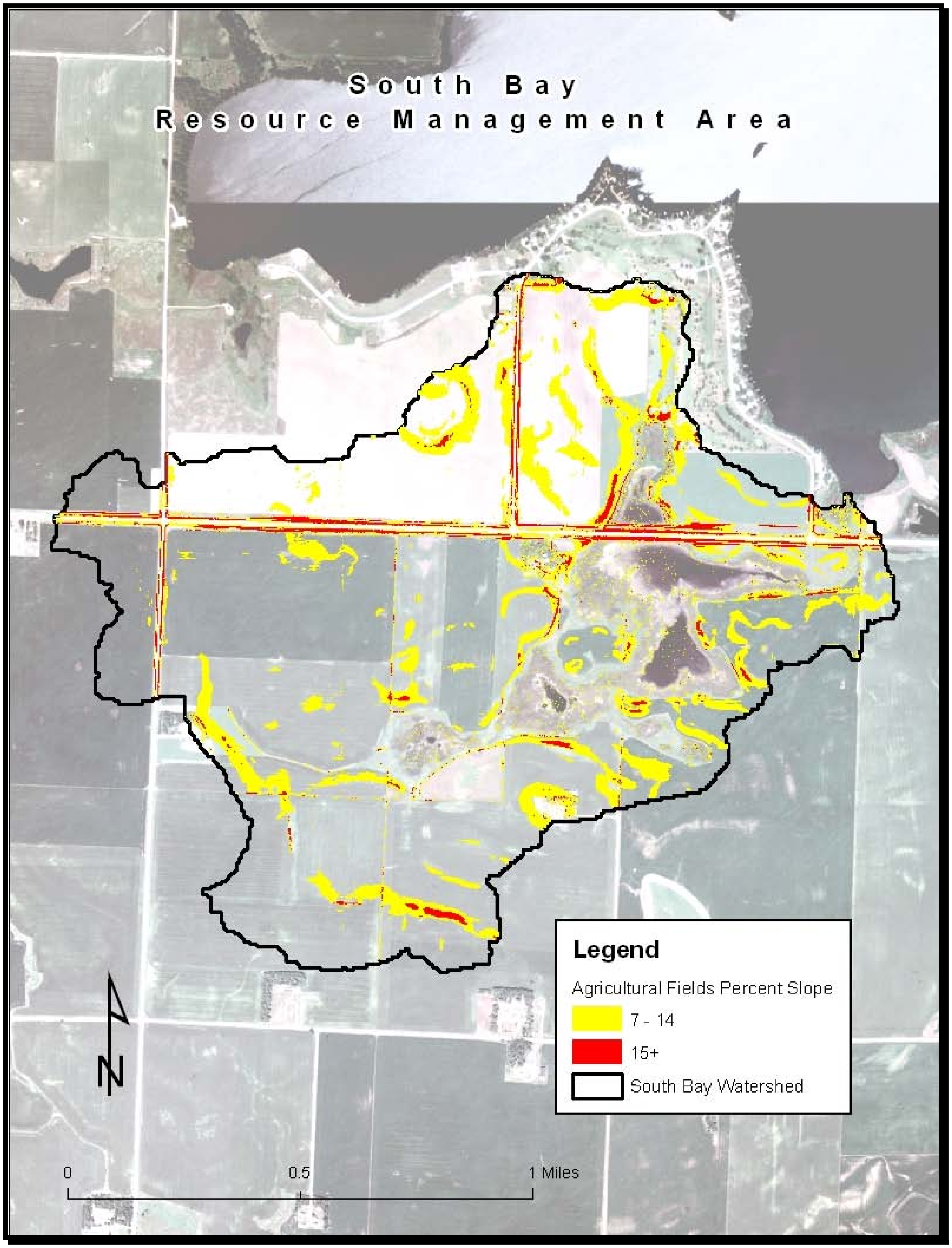
Map 10.12: South Bay drainage



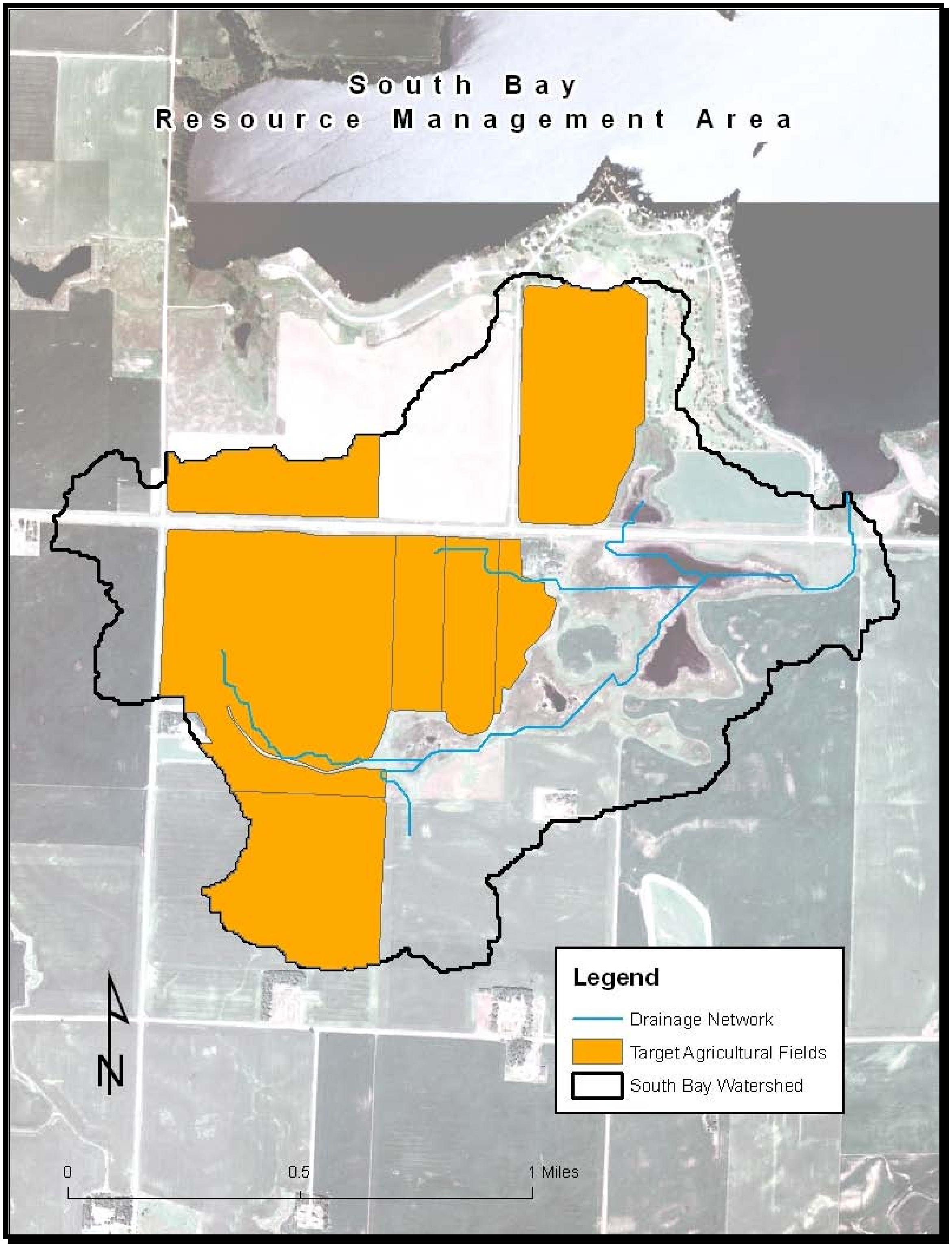
Map 10.13: South Bay wetland basins



Map 10.14: South Bay concentrated surface flow



Map 10.15: South Bay highly erodible slopes



Map 10.16: South Bay agricultural fields of highest priority

11. Wetland Prioritization

Below is a chart that was prepared utilizing GIS assessment of watershed drainage and wetland basins in the Silver Lake Watershed. This information has provided us an extremely beneficial management tool when determining which wetland basins will give our project the highest water quality benefits per dollar invested.

By examining this chart, we are able to determine how many acres would be impacted by restoration of a particular wetland basin, as well as estimate a quantitative reduction in sediment delivery and nutrient catchment. As each wetland basin is restored, we are able to run new calculations factoring in that particular restoration. Because restoration of a particularly large or high priority basin may impact the priority of several associated basins, our focus may shift to other areas of the watershed following restoration of key wetland basins.

Silver Lake Watershed Wetland Prioritization

Wetland ID Green = Dickinson Blue = Osceola	Flows into	Flows into	Flows into	Flows into	Flows into	Flows into	Flows into	Flows into	Water shed Area (acres)	Wetland Size (acres)	Watershed minus wetland (acres)	Watershed to Wetland Ratio	Watershed Ratio < 75:1	GIS/RUSLE Priority	Restored (X)
64									8,430.4	99.8	8,330.6	83.5			
35	64								5,219.0	149.8	5,069.2	33.9	*	1	
33	35	64							2,115.6	9.4	2,106.2	225.2			
25	33	35	64						1,991.8	4.3	1,987.5	462.3			
28	25	33	35	64					1,682.7	17.8	1,664.9	93.8			
53	64								1,519.4	25.1	1,494.2	59.4	*	2	
54	53	64							1,425.3	15.8	1,409.5	89.2			
18	25	28	33	35	64				1,391.6	31.1	1,360.4	43.7	*	4	
31	35	64							1,255.4	29.4	1,226.0	41.8	*	5	
44									1,070.3	1.7	1,068.6	637.2			
26	31	35	64						1,070.0	5.4	1,064.6	198.1			
45	54	53	64						955.1	75.2	879.8	11.7	*	6	
23	26	31	35	64					840.5	30.1	810.4	26.9	*	10	
63									845.4	66.0	779.3	11.8	*	9	
16	18	28	25	33	35	64			678.0	24.2	653.9	27.1	*	8	
59	64								566.5	2.5	564.0	224.9			
15	18	28	25	33	35	64			554.3	64.8	489.4	7.5	*	11	
56	63								468.1	2.7	465.4	170.5			
40									493.6	44.9	448.7	10.0	*	19	
1									465.0	31.4	433.5	13.8	*	7	
41	44								396.9	1.6	395.4	252.0			
36	64								348.2	24.4	323.8	13.3	*	13	
58	59	64							328.0	7.4	320.6	43.3	*	14	
68	56	63							302.8	18.0	284.9	15.9	*	26	

43	44	0							283.3	3.1	280.2	90.7			
27	25	33	35	64					270.3	6.1	264.2	43.5	*	12	
47	54	53	64						270.6	8.2	262.4	32.1	*	20	
13	23	26	31	35	64				263.4	2.7	260.7	96.9			
24	15	18	28	25	33	35	64		264.4	18.6	245.8	13.2	*	15	
12	13	23	26	31	35	64			226.7	10.1	216.6	21.4	*	27	
48	47	54	53	64					209.0	5.3	203.7	38.4	*	25	
37	35	64							226.4	32.4	194.1	6.0	*	17	
22	58	59	64						192.2	15.1	177.1	11.7	*	21	
66									183.0	9.8	173.2	17.6	*	28	
39	35	64							174.7	8.0	166.7	20.9	*	35	
29	27	25	33	35	64				192.1	30.2	161.9	5.4	*	18	
24	23	26	31	35	64				264.4	18.6	245.8	13.2	*	15	
42	43	44							156.5	2.0	154.5	75.8			
2	1								152.5	1.3	151.2	120.4			
65									135.7	4.8	130.9	27.3	*	23	
38	35	64							305.5	178.1	127.3	0.7			
61	63								123.4	7.5	115.9	15.5	*	30	
14	28	25	33	35	64				125.4	13.6	111.8	8.2	*	29	
7	48	47	54	53	64				96.3	3.4	92.9	27.5	*	31	
49	68	56	63						92.7	2.9	89.8	30.8	*	40	
10	12	13	23	26	31	35	64		114.4	31.4	83.0	2.6	*	32	
3									82.6	2.0	80.6	39.5	*	22	
34	35	64							74.7	10.9	63.8	5.9	*	24	
8	16	18	28	25	33	35	64		70.5	6.8	63.8	9.4	*	34	
11	21	23	26	31	35	64			73.7	10.2	63.5	6.2	*	36	
9	12	13	23	26	31	35	64		78.1	18.2	59.9	3.3	*	42	
52									62.1	2.7	59.3	21.6	*	43	
32	26	31	35	64					72.4	17.7	54.7	3.1	*	33	

5									56.7	3.3	53.4	16.3	*	37	
53									1,519.4	25.1	1,494.2	59.4	*	2	
55	59	64							52.3	3.4	48.9	14.4	*	38	
19	15	18	28	25	33	35	64		42.1	5.8	36.4	6.3	*	47	
51	68	56	63						38.5	2.2	36.2	16.3	*	48	
30	38	35	64						40.7	5.0	35.7	7.2	*	39	
38	24	15	18	28	25	33	35	64	305.5	178.1	127.3	0.7			
50									41.4	10.4	31.0	3.0	*	46	
62	64								36.8	6.0	30.8	5.1	*	44	
4									34.3	4.0	30.2	7.5	*	41	
67	22	58	59	64					36.8	7.9	28.9	3.7	*	45	
46	41	44							131.8	105.4	26.5	0.3			
20	23	26	31	35	64				16.9	4.8	12.1	2.5	*	49	

Table 11.1: Prioritization and expected benefits of wetland restorations in the Silver Lake Watershed

12. Extended Water Monitoring

To ensure consistent progress, it will be crucial to evaluate the project regularly to determine if the project objectives are being met. The watershed and lake monitoring practices described at length in pages 11-25 of this document will continue to provide a barometer with which to measure the impacts of implemented practices and further challenges facing the watershed. The resultant data from this watershed monitoring will also be used to evaluate the success of the Silver Lake Watershed Project by estimating annual load reductions of sediment and phosphorus.

In the future, this continued watershed monitoring data will be used to gauge the impact of certain BMP's on the quality of water entering Silver Lake. This program will play a vital role in measuring the success of water quality projects in the Silver Lake Watershed.

13. Future Funding Sources

Despite our initial efforts, many years of work may be needed to protect the Silver Lake Watershed, and allow Silver Lake to be removed from the 303(d) Impaired Waters List. We are confident that our initial efforts will evoke cooperation and assistance from a variety of local organizations, as well as state and federal agencies. Following is a list of funding sources, technical assistance providers, and partners that we hope to involve in the Silver Lake Watershed Project. Many of these sources have already contributed to the project in some way, and most have promised additional assistance moving forward.

Funding Sources (Grant and Program)

1. State of Iowa Watershed Improvement Review Board (WIRB)
2. Environmental Protection Agency (EPA) Section 319 Program
3. Iowa Department of Ag & Land Stewardship (IDALS) WSPF/WPF Program
4. State of Iowa Resource Enhancement and Protection (REAP) Program
5. United States Department of Agriculture (USDA)
    - Wetland Reserve Program (WRP)
    - Conservation Reserve Program (CRP)
    - Environmental Quality Incentives Program (EQIP)
    - Wildlife Habitat Incentives Program (WHIP)
6. Dickinson County Water Quality Commission (WQC)
7. Iowa DNR Lakes Restoration Program
8. Iowa Natural Heritage Foundation

Partner Agencies/Organizations

1. Dickinson Soil & Water Conservation District (SWCD)
2. Osceola Soil & Water Conservation District (SWCD)
3. Silver Lake Park Improvement Association (SLPIA)

4. Natural Resources Conservation Service (NRCS)
    - Office space, equipment, vehicle
    - Technical Assistance
5. Pheasants Forever
    - 4 Local Chapters
    - Farm Bill Biologists
6. Iowa DNR (Spirit Lake Field Offices)
    - Fisheries Staff
    - Wildlife Staff (Private Lands Biologist)
7. Iowa Soybean Association (ISA) Watershed Program
8. Osceola County Sportsman's Club
9. Silver Lake Sportsman's Club
10. Dickinson County Conservation Board
11. Osceola County Conservation Board
12. Ducks Unlimited
13. Non-profit organizations
14. Local Retailers
15. Local Landowners/Homeowners