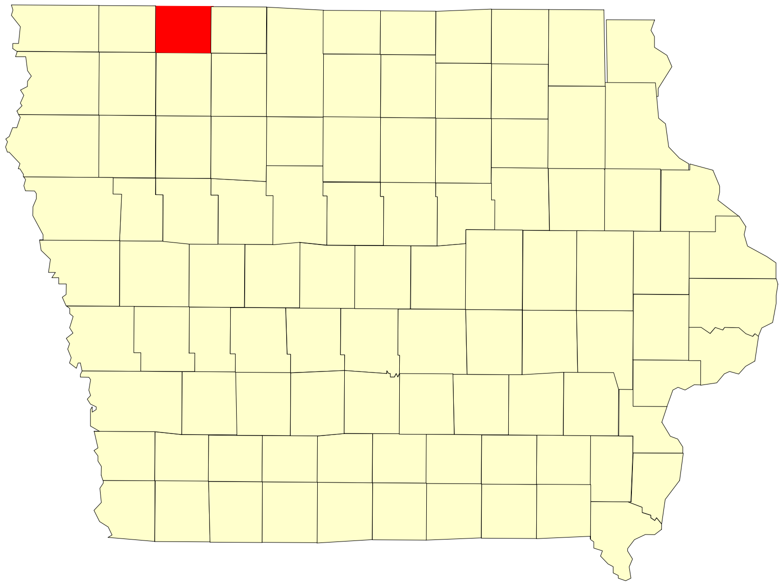
SECTION 1

INTRODUCTION



Map 1.1: Silver Lake in Dickinson County highlighted in red.

The watershed resources of Dickinson County, Iowa and Osceola County, Iowa provide an important source of recreation, drinking water and aesthetic enjoyment for residents and visitors. Good water quality is vital to the region's economy and enhances the quality of life for those who live within and visit the area.

The water quality of Silver Lake is threatened by agricultural nutrients, soil erosion, human and livestock waste, stormwater contaminants, urban development and the loss of natural wetlands. Preventing the potential spread of aquatic invasive species (AIS) into Silver Lake is a major concern. Other threats include potential spills of hazardous materials.

SILVER LAKE WATERSHED

Silver Lake watershed is an area of about 18,000 acres (27.3 square miles) located in northwest Iowa and southwest Minnesota. Approximately 94 percent of the watershed lies within Dickinson and Osceola County, Iowa and the remainder within Jackson County, Minnesota. Silver Lake is a recreational lake for Iowa residents and visitors from adjacent states with approximately 75,000 (estimated) visitors per year. 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 hub of the watershed lies at the intersection of the principal north-south route through the watershed (Iowa Highway 219) and the principal east-west route through Dickinson County (Iowa Highway 9). The two routes meet in the city of Lake Park.

Interstate 90 passes through Jackson County approximately ten miles north of the Iowa border. The major cities within Jackson County and the watershed include Alpha, Heron Lakes, Jackson, Lakefield, Okabena and Wilders. In addition, there are several townships with significant populations.

WATERSHED CHARACTERISTICS

Landuse

The total Silver Lake watershed area encompasses 18,050 acres. Within the watershed, land is used for a number of purposes.

2007 Land use	Acres	%
Row Crop	14,084	78
Water (Lakes)	1,033	6.0
Grassland, Grassed Waterways	704	3.9
Roadways	559	3.1
Hay/Pasture	541	3
Wetlands	325	1.8
Other	252	1.8
Farmsteads	270	1.5
Urban	163	.9

Table 1.1: Landuse data for 2007.

Dickinson County land use is characterized by concentrated urban development in the Iowa Great Lakes region (and somewhat in the Silver Lake region) and rural areas in the remainder of the county. There is increasing density of development and redevelopment on lakefront property. The county is also experiencing substantial growth along major transportation routes, and in unincorporated portions of Dickinson County and cities near the lakes.

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.

The county encompasses 243,904 acres, of which 203,000 acres (83 percent) are farmland. According to the 2002 Census of Agriculture, there are 492 farms in Dickinson County. The average farm size is 413 acres, compared to the state average of 350. Agricultural trends indicate the county is moving toward larger farm corporations and fewer family farms. As urbanization continues, more agricultural lands are taken out of production. (U.S. Census Bureau, 2000)

According to the Dickinson County Land Use Development Plan Summary, the County's land use objectives are to "establish a pattern of land uses that will maximize the safety and welfare of the residents, while considering the protection, preservation, and mitigation of sensitive environmental areas and critical natural habitats."

Land use in Osceola County is expected to remain predominantly agriculture. The county encompasses 263,340 acres, of which 257,044 acres (97.6 percent) is cropland and pasture. The remainder is urban and recreational development, or wildlife habitat. There is a trend towards larger and more intensive farming in both livestock and grains. Much of the livestock expansion is total confinement operations with storage of manure in concrete pits. There is no zoning in Osceola County for location from water bodies and recharge areas, slope, and sites to be used for manure disposal, in order to avoid contamination of surface and ground water. (U.S. Census Bureau, 2000)

Demographics

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
The heavier textured glacial soils occur within the Silver Lake watershed. The 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.
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. The steeper the slopes the higher the importance is of being converted to permanent pasture. (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.

Wildlife/Plants

Watershed Threatened and Endangered Species

TYPE OF	SCIENTIFIC NAME	COMMON NAME
plant	Berula erecta	Water Parsnip
plant	Lobelia kalmii	Brook Lobelia
plant	Gentianopsis procera	Small Fringed Gentian
plant	Aster puniceus	Swamp Aster
plant	Liparis loeselii	Green Twayblade
plant	Liparis loeselii	Green Twayblade
plant	Potentilla anserina	Silverweed
plant	Triglochin palustris	Slender Arrow Grass
plant	Triglochin palustris	Slender Arrow Grass
plant	Gentianopsis crinita	Fringed Gentian
animal	Bartramia longicauda	Upland Sandpiper
plant	Gentianopsis procera	Small Fringed Gentian
plant	Gentianopsis procera	Small Fringed Gentian
plant	Rhynchospora capillacea	Beakrush
plant	Juncus alpinus	Alpine Rush
plant	Juncus alpinus	Alpine Rush
plant	Juncus alpinus	Alpine Rush
plant	Eleocharis pauciflora	Fewflower Spikerush
plant	Eleocharis pauciflora	Fewflower Spikerush
plant	Triglochin maritimum	Arrow Grass
plant	Berula erecta	Water Parsnip

plant	Triglochin maritimum	Arrow Grass
plant	Triglochin maritimum	Arrow Grass
plant	Rhynchospora capillacea	Beakrush
plant	Cypripedium candidum	Small White Lady's Slipper
plant	Cypripedium candidum	Small White Lady's Slipper
plant	Juncus alpinus	Alpine Rush
plant	Platanthera hyperborea	Leafy Northern Green Orchid
plant	Pilea fontana	Springs Clearweed
plant	Spiranthes romanzoffiana	Hooded Ladies'-tresses
plant	Spiranthes romanzoffiana	Hooded Ladies'-tresses
plant	Lobelia kalmii	Brook Lobelia
plant	Lobelia kalmii	Brook Lobelia
plant	Utricularia minor	Lesser Bladderwort
plant	Utricularia minor	Lesser Bladderwort
plant	Triglochin palustris	Slender Arrow Grass
plant	Parnassia glauca	Grass Of Parnassus
plant	Platanthera hyperborea	Leafy Northern Green Orchid
plant	Muhlenbergia asperifolia	Alkali Muhly
animal	Oarisma powesheik	Powesheik Skipperling

Table 1.2 (IA DNR)

"Roughly, 23-million acres of pre-settlement Iowa was tallgrass prairie. Around 4 million acres of prairie pothole marshes dotted recently glaciated and poorly drained north central and northwest Iowa. The Silver Lake Watershed was part of the Prairie Pothole region of this tallgrass prairie area. Drought, fire and grazing acted on these plant communities to create a great patchwork of habitats in both time and space. On some sites, 250 species of plants could be found.

This great diversity of plant communities supported a diversity and abundance of wildlife that was foreign to settlers from the East. Prairie animals like bison, elk, pronghorn, prairie chickens and sharp-tailed grouse penetrated the tallgrass prairies from the West. The prairie pothole and riverine wetlands provided excellent nesting habitat and attractive resting and feeding stops for millions of migrating ducks and geese and other water birds and shorebirds. Beaver, muskrat and river otters were associated entirely with marshes, streams and rivers. A variety of predators fed on this abundance of game animals - gray wolf, coyote red and gray fox, bobcat, mountain lion and black bear. All together, 440 species of birds and mammals called Iowa home". (Securing a Future , 2005)

Currently in the Silver Lake Watershed a mixture of woodland species, prairie species, and prairie pothole species of wildlife and plants are found. The resident wildlife species include:
Woodland –
Deer, turkey, furbearing animals
Prairie Pothole –
Ducks, geese, swans (re-introduced and nesting), furbearing animals
Prairie –
Pheasants (not native), partridge (not native), songbirds, furbearing animals.

These prairie, woodland, and wetland wildlife residents are found in abundance in and around the Silver Lake Watershed.

Problem Species

Canada Geese, once thought to be a problem on Silver Lake, have declined in population recently as new housing developments have removed a large portion of once undisturbed lakeshore and replaced it with new homes. In the last few years the goose production on and around Silver Lake has continued to decreased. Weather, loss of nesting habitat, and other factors have contributed to this decline. Goose numbers on Silver Lake peaked in 2003 and since then the population has declined on an average of 18 percent. Numbers can certainly go up and down depending on the production year. Geese have not been an issue on Silver Lake other than for new lakeshore homeowners because these new lawns make excellent lounging and grazing areas for geese and their young. (IA DNR)

Water Use-Dickinson County

Water in Dickinson County is primarily used for public and private water supplies. Public water supplies provide 900 million gallons per year to Dickinson County residents and visitors. Other water usage consists of private use, and farms that accounts for 62 million gallons per year. Irrigation and mining combined account for 83 million gallons per year.

Visitors to the region increase the summer population within the county from approximately 20,000 to more than 100,000 people. The tourist population presents challenges to dealing with public wastewater systems, and raised concerns as early as the 1930s about a need to maintain a pollution-free environment. Currently, the City of Lake Park has connected all remaining lakeshore homes to its sanitary district.

Partnerships

There are several partnerships, lake associations, local governments, commissions and conservation organizations at work in the county to preserve and enhance the natural resources. There are two specific groups that coordinate the efforts of all of these groups. They are:

Water Quality Commission (WQC) 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 Clean Water Alliance (CWA) 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 Alliance has identified four main watershed goals for the Great Lakes area:

- 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.

SECTION 2

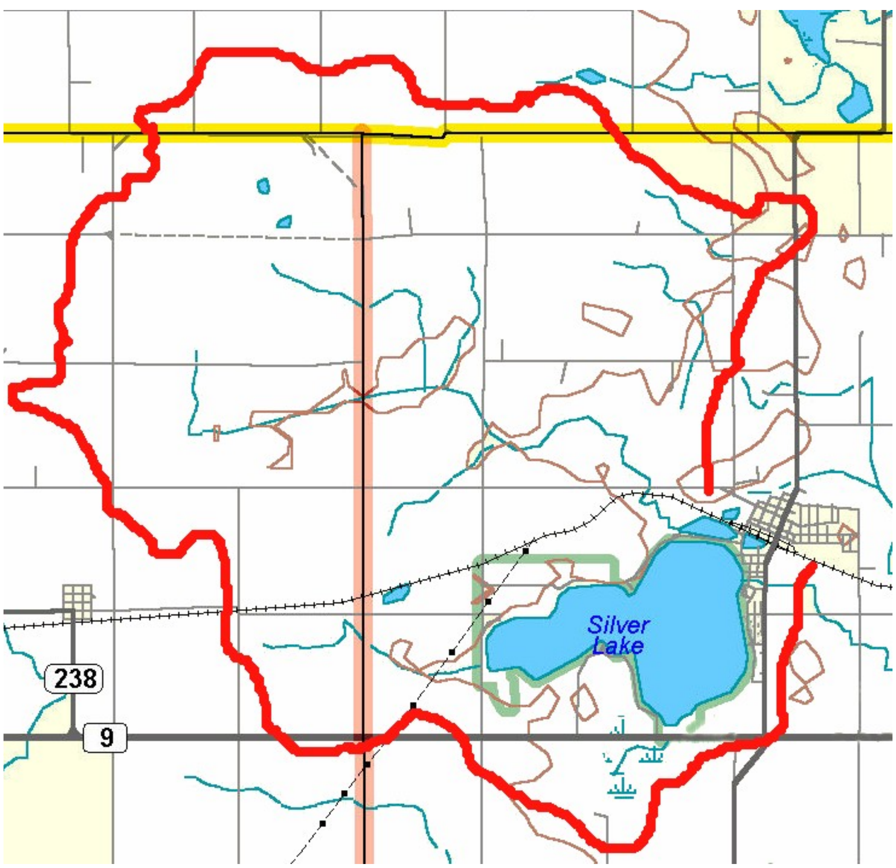
TOURISM

For more than 100 years, the Silver Lake area has been the ideal destination for family vacations. Truly, a recreational haven, Silver Lake is rich in heritage and abundant in leisure activities.

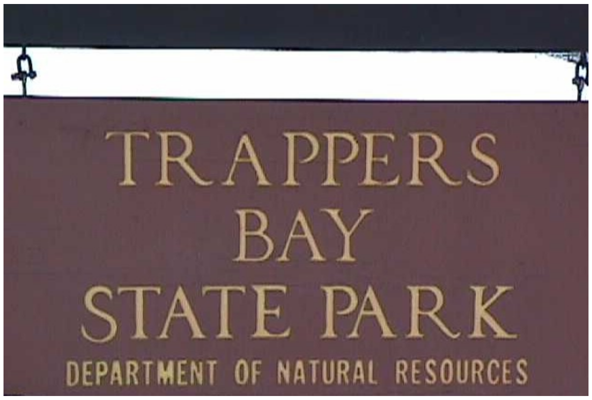
Dickinson County, with a population of 16,424 is known as a growing, progressive area in Iowa. It offers a wonderful place to live and work, but for many a vacation destination. There are more people here in the summer months than other times of the year, but many locals will tell you how much they love the quiet beauty of the off season. In addition, some perceptive visitors are just beginning to appreciate the area's natural beauty year around.

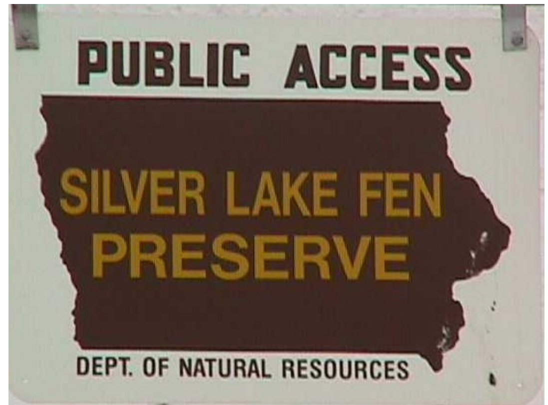
Regardless, tourism has proven itself as a major component of Iowa's economy, in the last decade. In 2006, it generated an impressive $5.4 billion in direct spending, while improving the quality of life for our citizens. Silver Lake is a major piece of the tourism puzzle especially for Northwest Iowa. (Iowa Great Lakes Chamber of Commerce)

Silver Lake serves as a recreational lake for Iowa Residents and visitors from adjacent states. The main attractions of the Silver Lake area are the glacier-carved lake.



Map 1.1





Photos 2.1 & 2.2: Public property on Silver Lake.


Photo 2.3: Skiing on Silver Lake.

Dickinson County tourism activities include:
- Iowa Rock N Roll Hall of Fame
- Iowa Great Lakes Maritime Museum
- Higgins Museum of Banking
- Okoboji Yacht Club Sailing School
- Grand National Walleye Cup (GNWC) Fishing Tournament
- Iowa State Fish Hatchery
- Iowa Lakeside Laboratories
- The Queen II Excursion Boat
- The Abbie-Gardner-Sharp Cabin and Spirit Lake Massacre Monument
- Dickinson County Museum
- The Annual Okoboji Winter Games
- Arnolds Park Amusement Park
- The Ranch Amusement Park
- Okoboji Summer Theater (50 years old)

- Treasure Theater (children's theater)
- Lakes Art Center
- Bridges Bay (indoor water park)
- Emerald Hills Golf Club
- Brooks Golf Club
- Inn Golf Course
- Okoboji View Golf Course
- Woodlyn Hills Golf Course
- Indian Hills Golf Course

Furthermore, located within Dickinson County are the following tourism related businesses, according to information obtained from the Okoboji Tourism Committee:

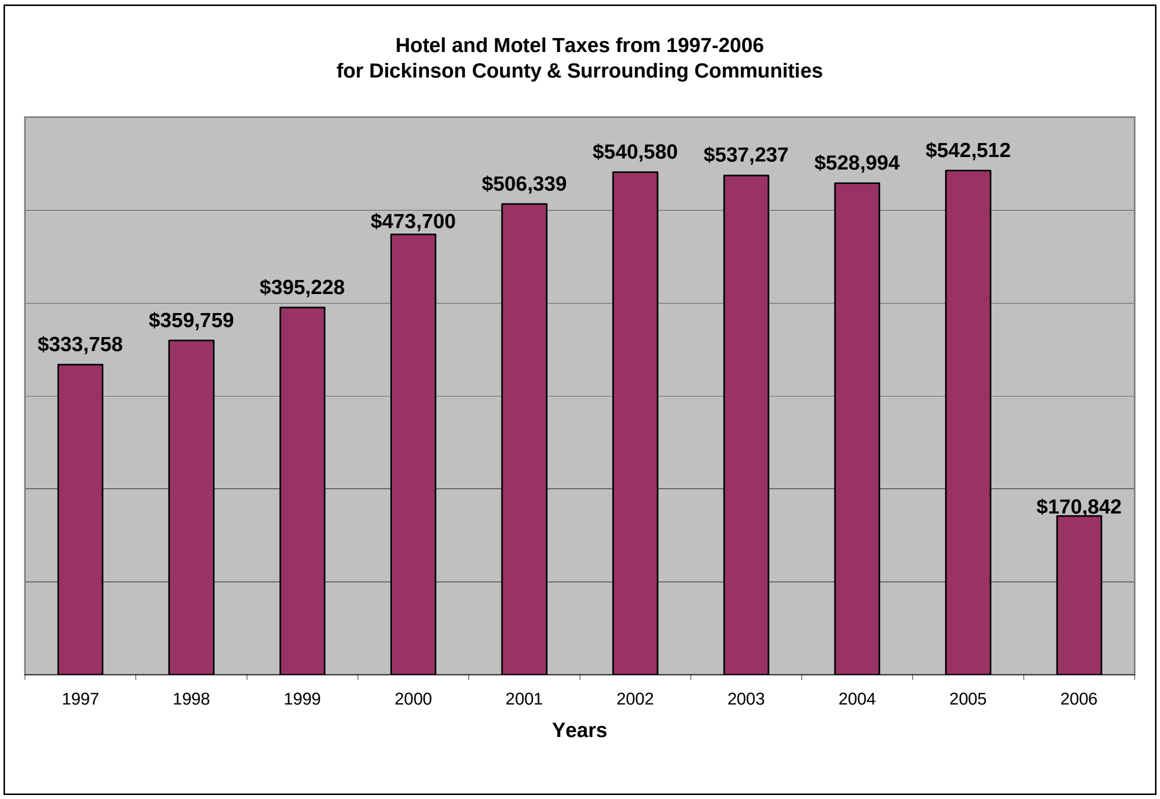
- 37 resorts or lodging facilities
- 15 campgrounds or camping facilities
- 11 recreation/tourism based businesses
- 72 restaurants or eateries

(Iowa Great Lakes Chamber of Commerce)

Photo 2.4: The Queen. Photo courtesy of www.vacationokoboji.com

Aside from the natural lakes themselves, probably the most widely recognized and visited destination in Dickinson County is the Arnolds Park Amusement Park complex, including the Maritime Museum, Queen II excursion boat, and the Iowa Rock N Roll Hall of Fame. The amusement park itself is a collection of 17 unique rides, including the legendary wooden roller coaster. There is a miniature golf course, a go-kart track, many games, souvenir stands, food vendors, the Tipsy House, mirror maze, caricature artist, and many other fun and eclectic activities to entertain the young and young at heart.

Research compiled by the Travel Industry Association of America indicates tourism was a $173.18 million dollar industry in Dickinson County in 2005. The tourism industry creates $25.38 million dollars in payroll affecting 1,770 employees throughout the county. It also creates $10.41 million dollars in state tax receipts and $3.6 million dollars in local taxes. Since 1997, according to the hotel/motel taxes collected, the Lakes have experienced steady growth in the last nine years (See G.2.1).



Graph 2.1: Shows the change in hotel & motel taxes in the past ten years. Note 2006 reflects the first and second quarters only. (Iowa Great Lakes Chamber of Commerce)

While it is interesting to know what tourist spend in a year or even in a decade, it should also be know what they spend in an average day and what they spend money on. With this information we can better cater the tourism industry to what tourist need, want, and require for a fulfilling vacation.

Visitors to the region increase the summer population within the county from approximately 20,000 to more than 100,000 persons. The tourist population presents challenges in dealing with public wastewater systems. These concerns were raised as early as the 1930's with a need to maintain a pollution free environment. The increase in tourism has created a demand on water resources for recreational purposes and housing development.

2005 Average Daily Spending by Travelers in Iowa		
Lodging	$	59.97
Food	$	47.36
Transportation	$	48.90
Entertainment	$	27.32
Retail	$	25.00
TOTAL	**$**	**208.55**
The average travel party in Iowa spends a total of $208.55 daily		
Source: 2005 Welcome Center Survey, IDED, Tourism Office		
Average Travel Party is 2.6 people		

Table 2.1: 2005 Average Daily Spending in Iowa

While tourism is a prosperous industry for Dickinson County, the increase of boat traffic also carries an immediate affect and the potential for degraded water quality increases due to several factors.

One factor is that fact that there are multiple places to buy fuel on the lakes. The resort owners all are very careful when they fill up the boats, however many people bring fuel from other sources to avoid the marine tax. There is a need to educate boat owners on how fuel spills could be harmful to water quality. The insurance companies who insure the resorts have very tough standards on shut offs from the tanks to the hoses in case of emergency. The resort owners who sell fuel on lake say they are inspected yearly on the conditions of the tanks, hoses, and all shut offs.

Another factor is human waste. As the size of boats increase in size, this leads to more people per boat for an increased amount of time enjoying the water. While these increases may seem insignificant, the result is intensification in waste. The new big boats all have sealed toilets systems where waste for the day is collected. Several marine owners offer services where the stored waste is pumped directly into the sanitary line on shore.

However, there are boats that don't have this type of sanitary system. For these boats, education is a must. They need to be informed on the sanitary systems available to them. Their waste needs to be dumped into the sanitary system when they get on shore, not in the lake water.

The third factor that has come to the forefront with increased tourism and boat traffic is how close boats are traveling to the shore line. What may seem like fun when you are the boater actually has the potential to degrade water quality. When the boaters travel fast in the shallow areas of the lakes the prop tends to stir up the bottom of the lakes thus

resulting in sediment being suspend in the water. This action also contributes to the spread of Aquatic Invasive Species (AIS). Further education and stricter boat laws will assist in a safer boat trip and vacation for today's and tomorrow's tourists.
While there are positive aspects of tourist industry it is important to understand and realize what the real impacts are upon the environment and the lakes. The increase in new and bigger houses has resulted in an increase in density of development and redevelopment on lakefront property. Other possible negative aspects of tourism include,

1. increase in liter and waste
2. overall use of the lakes
3. overall use of parks
4. increase in noise and pollution

It seems definite that our present form of tourism is bound to change, but as we have observed, our tourism base has already changed several times in the past. Change should not be feared but we should become more prepared and accept what comes. An analogy of our tourism season could be a comparison to a summer porch that is remodeled into a three season porch and finally into a year-round family room. Tourism will be spread out over an extended period and we will not see quite the congestion that we have now. That will be good for our economy and for the ecology of our lakes.

The ecology issue must be addressed head on; otherwise another catastrophe will be on the horizon, which will affect the everyday abuse our lakes already endure. These issues include the current threat of Eurasian watermilfoil, zebra mussel, and other Aquatic Invasive Species (AIS). These ecological disasters could cause widespread disruption to the lakes and the tourist industry.

If we have learned anything from our past, it should be known that changes and setbacks are inevitable. As long as our beautiful lakes draw people here the area will be a vacation destination in the future. Tourism is the key to the economic sustainability of Silver Lake area, which includes the lakes. Silver Lake must be protected in order to enjoy now and in the future.

SECTION 3

WATER QUALITY

INTRODUCTION

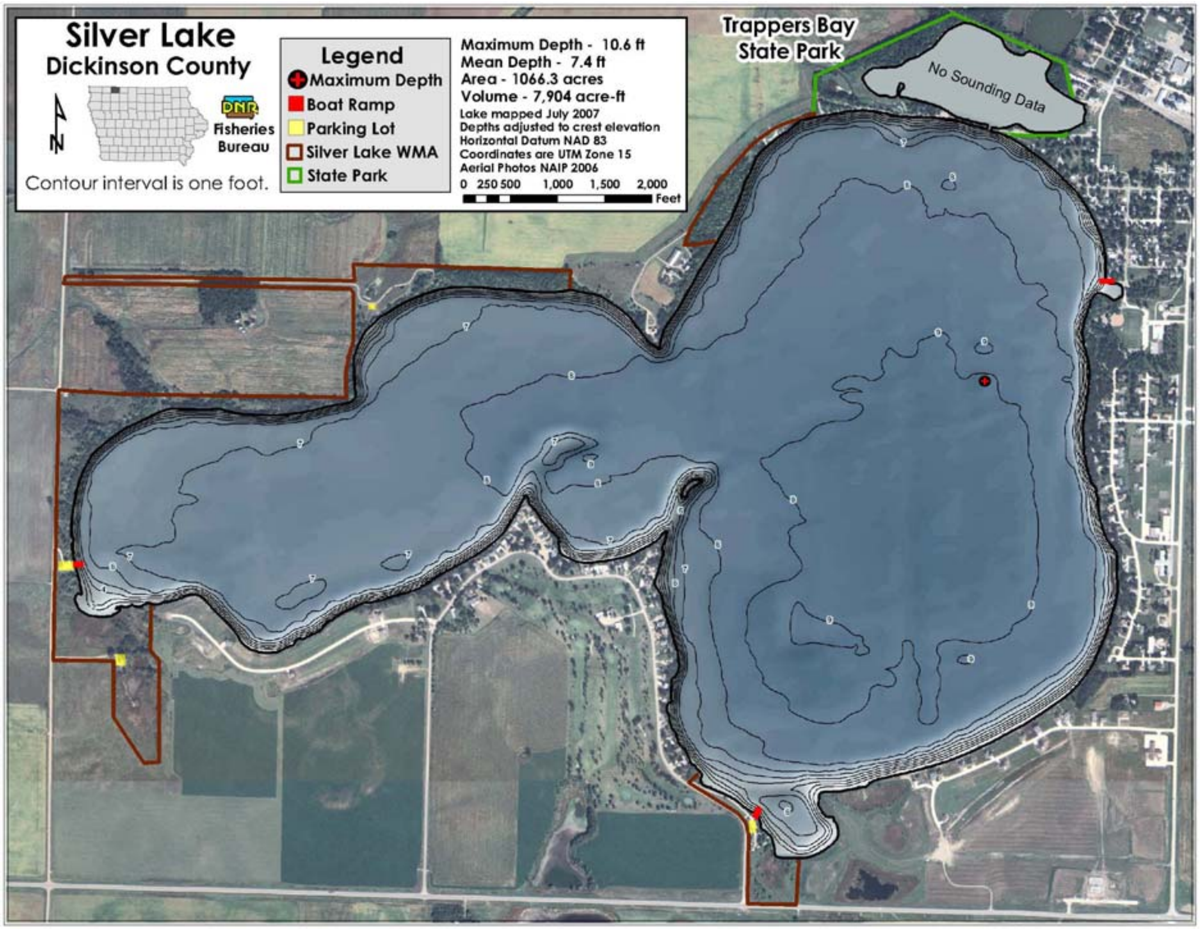
Surface water in Dickinson County is the single most important reason for the county's current economic prosperity and tourism industry. Dickinson County water resources are an important source of drinking water, recreation, wildlife habitat, and aesthetic enjoyment for residents and visitors. Because of the important of surface water to the county and its residents, there are many individuals, groups and organizations currently working to educate residents and businesses in the area about protecting water quality.

Photo 3.1: Silver Lake sunset

The prairie potholes and marshes adjacent to the lakes are ground water recharge areas, and serve as a natural filtration system for Silver Lake 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. In addition to the parks and recreation activities within Dickinson County, the wildlife and natural areas provide wildlife habitat and opportunities for walking, hiking, and bird watching.

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.

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.



Map 3.1: Bathymetric Map: Contour interval is 1 foot (IA DNR)

The 2006 Dickinson County Comprehensive Land Use Plan identifies several goals and objectives regarding protecting water quality and other valuable natural resources. The following Natural Resource/Conservation Land Use Policies are to be used when considerations are given toward environmentally sensitive areas in Dickinson County:

1) Recognize that Dickinson County contains many natural areas that must be protected from urban development, and provide measures within the zoning ordinance to accomplish this task.

2) Recognize that urban development is acceptable when adjacent to some environmental areas, but at the same time establish construction provisions to preserve environmental features.

3) Preserve flood plains and wetlands that are typically not suited for urban development. This would also include protection and preservation of those sensitive natural areas that include hydric soils.

4) The best preservation of environmentally sensitive areas lies with public ownership, but in the best interest of the county tax structure, preservation through limited

agricultural zoning districts that leave these lands in private ownership may be advisable.

5) Encourage the conversion of all abandoned waste disposal sites and excavation areas to recreational areas or other available alternatives.

6) Guide urban development to areas where soil characteristics are compatible with such development and consider construction techniques to overcome soil limitations.

7) Develop a storm water management control agency, a storm water district, which would be responsible for the control and management of storm water runoff through the county and implement a countywide management plan.

8) Update silt control ordinances in zoning and subdivision ordinances.

9) The County should weigh the benefits versus the effects of establishing a dredging program for specifically Minnewashta and Lower Gar Lakes for enhancement of all lake resources. Direct consultation and oversight from the IDNR is mandated in this endeavor.

10) Establish policies or ordinances to promote the capture or recycling of storm water.

11) Explore the potential and feasibility of designating "environmental zones" to outline and subsequently protect naturally sensitive environmental areas.

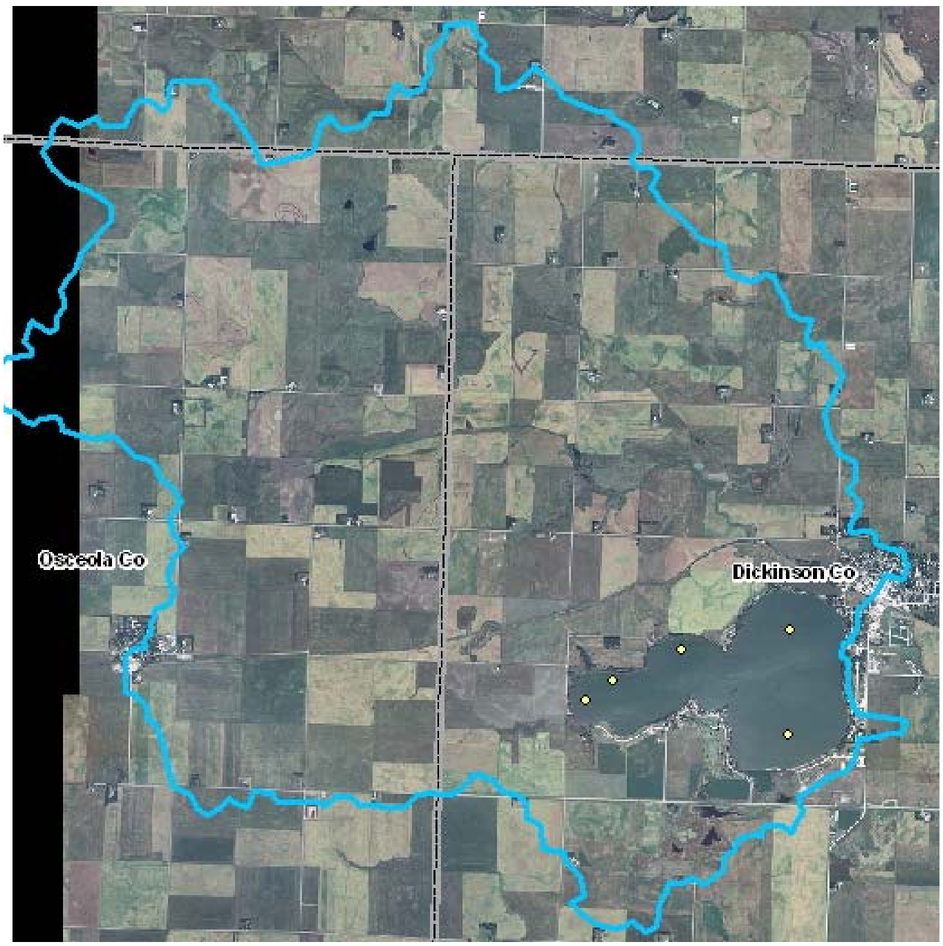
12) A plan and program should be incorporated to map and identify all sensitive natural resource areas within Silver Lake watershed and throughout Dickinson County.

WATER QUALITY STUDIES

The Cooperative Lakes Area Monitoring Project (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 is supported by the Friends of Lakeside Lab, the Dickinson County Water Quality Commission, the Okoboji Protective Association, the Spirit Lake Protective Association, and the East Okoboji Lakes Improvement Incorporation. Also, starting in 2005, CLAMP began a working relationship with the Iowa State Limnology Laboratory, which will result in volunteer data being accessible via the internet as part of the Iowa Lakes Information System.

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. By volunteering their time, CLAMP participants cut program costs in half, and at the same time have the opportunity to learn more about lake ecology and water quality issues. 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.

CLAMP is one component of several water quality research projects conducted out of Lakeside Lab in the Iowa Great Lakes region. CLAMP monitors in-lake conditions, while the goals of other projects include developing a nutrient budget for the lakes, identifying major nutrient inputs, evaluating the effect of different types of land use on water quality, and determining the effectiveness of conservation agriculture practices on reducing nutrient loading.



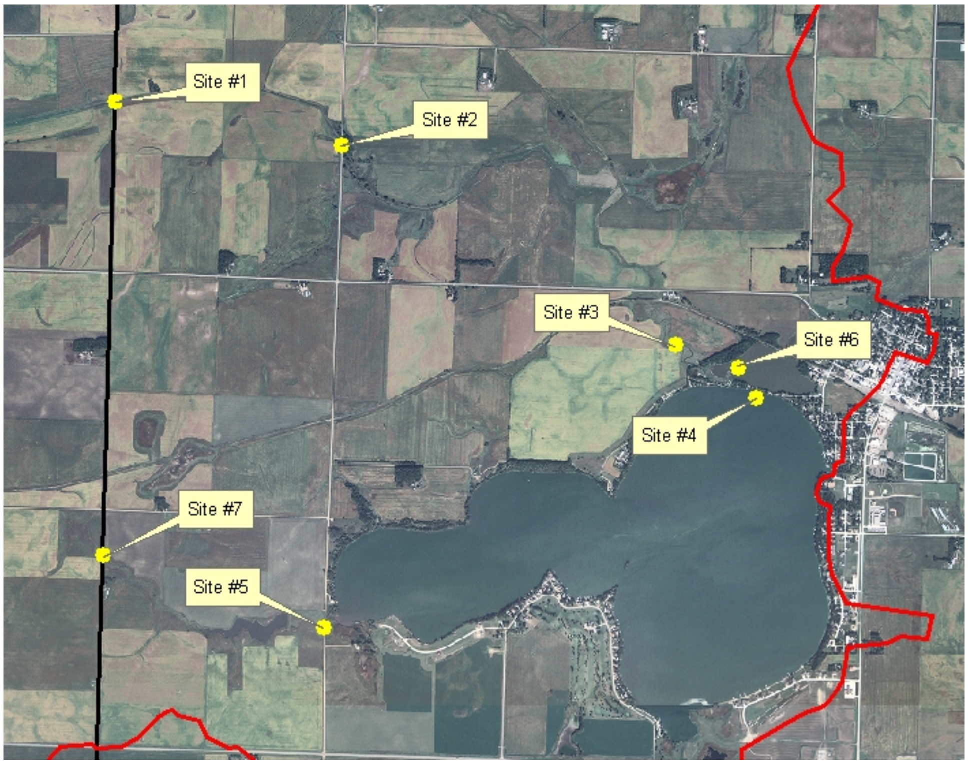
Map 3.2: CLAMP Sampling Locations.

Table 3.1 Clamp Testing Summary Table Results

Parameter	2007	2006	2005
Secchi Disk Depth (m)	0.7	0.6	0.7
Temperature(°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

**Samples taken from the lake only.



Map 3.3: Locally led Silver Lake Watershed Water Sampling Locations

Table 3.2 Silver Lake Testing Summary Table Results

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

Six Sample sites within the watershed monitored 7 times and averaged together.

Characteristics of Silver Lake

Silver Lake is a natural glacial lake in the northwest portion of the state. The watershed of Silver Lake is rather large compared to the lake area. The total lake watershed is 18,057 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, average Carlson TSI, and average total phosphorous. The bottom 25th percentile shows Silver Lake to be one of the poorest water quality in the state.

Water Quality in Silver Lake

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.

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

Table 3.3: Median Values water sampling data 1979 to 2003

Trends in water quality for Silver Lake from 1979 to 2004:

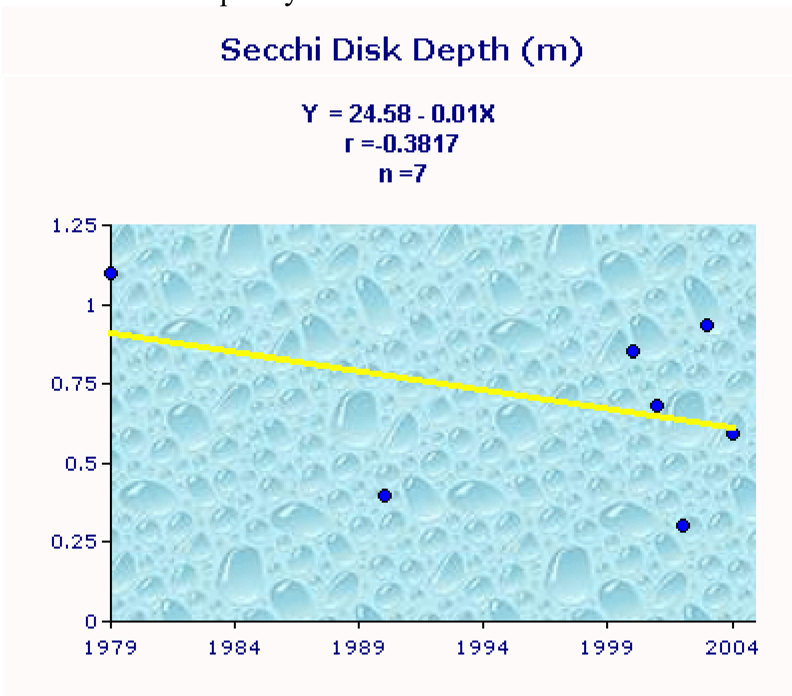


Figure 3.4 Secchi Disk Depth Trend from 1979 to 2004

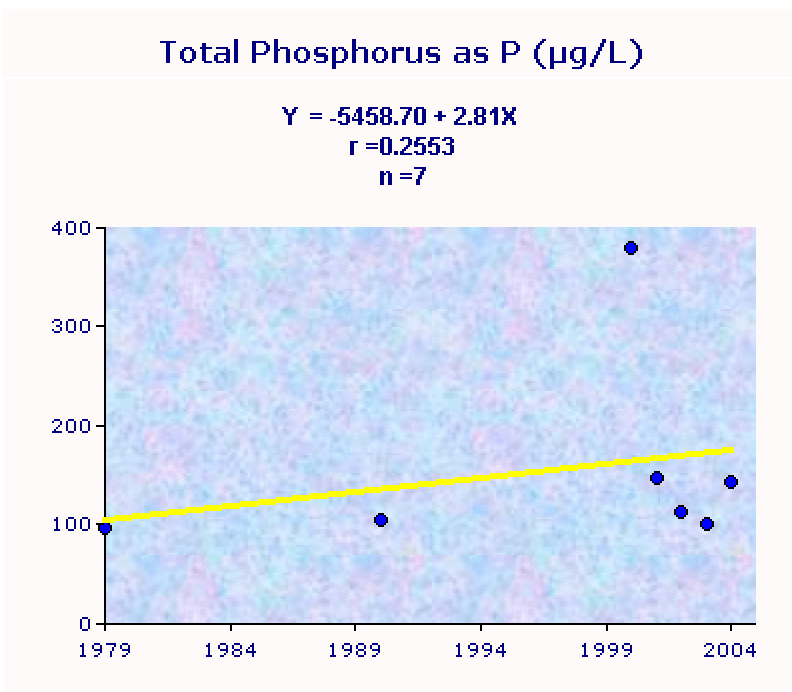


Figure 3.5 Total Phosphorus trend from 1979 to 2004

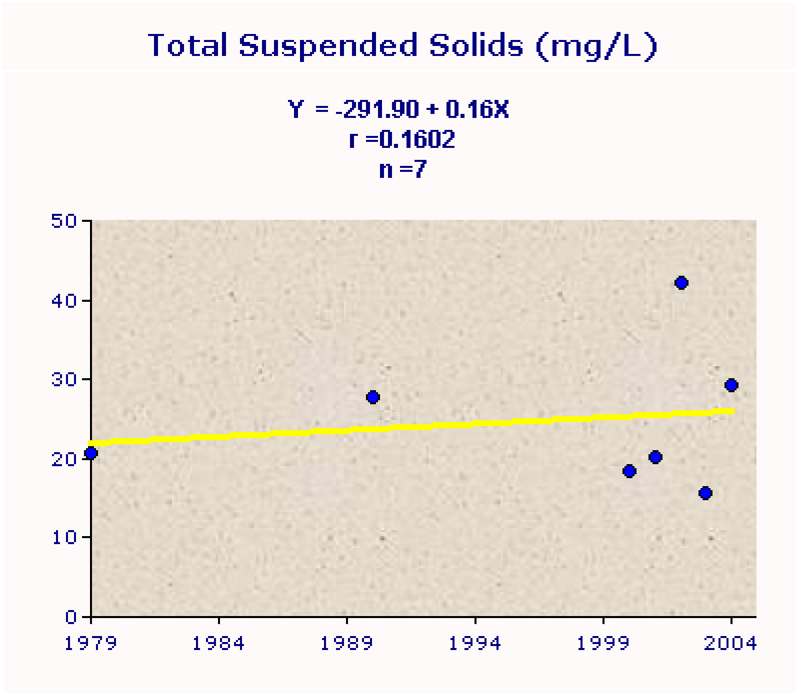


Figure 3.6: Trend in total suspended solids from 1979 to 2004
(Lakes Information System, IDNR)

All natural lakes monitored by the ambient lake monitoring program.

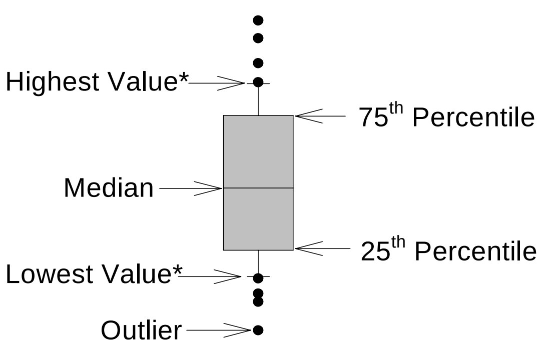
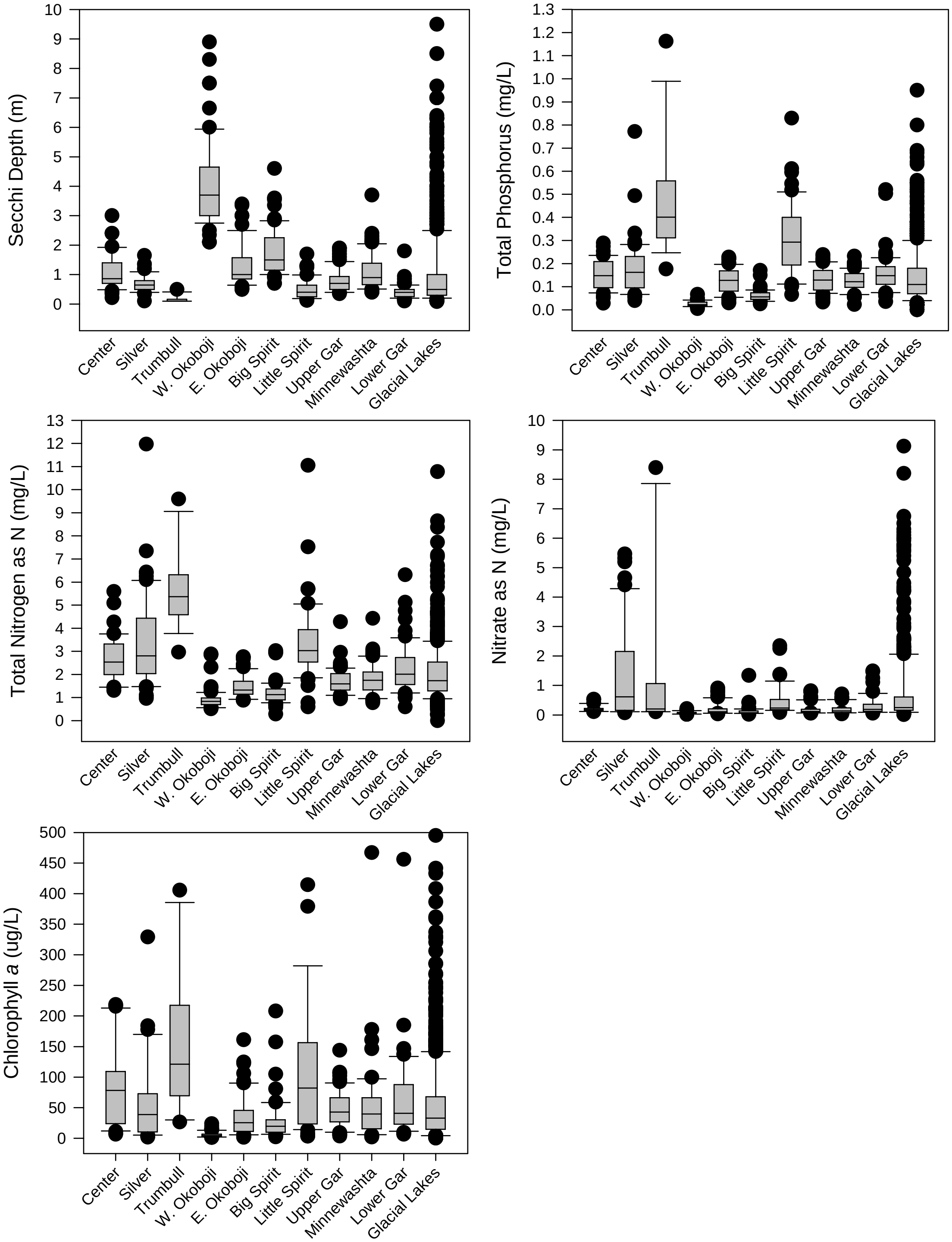


Figure 2. Reading a box plot. The median is the middle value in a group of numbers arranged in increasing order. If the median line is not in the center of the box, then the data are skewed. The length of the box represents the spread of the data (the larger the box, the greater the spread). An outlier is an unusual case

Highest Value* Lowest Value* Median Outlier 75th Percentile 25th Percentile

Figure 3.7 CLAMP data 1999-2006.



Silver Lake

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 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 Fixed Suspended Solids (TFSS) is a measure of the inorganic fraction (sediment) of suspended solids. Big Spirit, Center, East Okoboji, Minnewashta and West Okoboji all have relatively low median TFSS concentrations (below the 25th percentile for all monitored, natural lakes).

Total Volatile Suspended Solids (TVSS) is a measure of the organic fraction of suspended solids. Big Spirit, East Okoboji, Minnewashta, Upper Gar and West Okoboji all have relatively low median TVSS concentrations (below the 25th percentile for all monitored, natural 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).

Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen and ammonia in water. High concentrations of TKN in a water body are generally from organic pollution, such as sewage or manure discharges. Little Spirit (2.6 mg/L) and Center (2.0 mg/L) have TKN concentrations above the median for other monitored, natural lakes in Iowa (1.7 mg/L).

Ammonia is a soluble form of nitrogen that is found in water. Ammonia can be toxic to fish and invertebrate populations when at high levels. Ammonia is commonly used as an agricultural fertilizer. Little Spirit, Minnewashta, Center, and Lower Gar have the highest median ammonia concentrations, while Big Spirit and West Okoboji have the lowest (Table 2).

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. All lakes in 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.

Zooplankton wet mass and composition are measured to get a better understanding of the biological dynamics of each lake. Zooplankton are the microscopic and macroscopic animals that float, drift, or swim weakly in the water column. Zooplankton are the primary consumers of algae and many fish rely on them as a food source. The median zooplankton wet mass ranged from 94.1 mg/L in West Okoboji to 288.5 mg/L in Lower Gar. Zooplankton samples were composed mainly of cladocerans, copepods, protozoa and rotifers.

Table 3.8. Median values for ambient lake monitoring program data (2000-2006).

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	33.9	17.1	9.4	11.4	6.1	8.4	151	629

Lake								

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

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.

SUMMARY

Because no study has been collected specifically for Silver Lake in reference to the nutrient budget one must look at studies conducted for similar watersheds and lakes to determine the nutrient budget and how it affects Silver Lake. Based on data collected by Hickock and Associates from 1971-1972, in the Management Plan for Water Quality Iowa Great Lakes, total phosphorous was found to be the critical element in the IGL systems. There was a linear relationship between TP inputs and algal levels, so that a halving of the TP input to a given lake might be expected to reduce the algal population by one half. There is a lower limit to this relationship if all inputs were removed; there would still be phosphorous recycled from the sediments.

High amounts of surface runoff correlated to the highest phosphorous concentration in the streams, the greatest input of phosphorous to the lakes, and the highest levels of summer algal blooms in the lakes. The number of animal units in a watershed had a significant correlation with the amount of phosphorous delivered by that watershed, indicating that livestock were a significant source of phosphorous to the IGL in 1971-1972.

The results for nitrate-N concentrations were less clear cut. There was a significant negative correlation for the percent of watersheds in marshlands and a positive correlation for animal units. However, when the two factors were combined in a multiple regression analysis, no significant correlation was found for animal units. An earlier analysis of 1971 data produced a significant relationship between nitrate-N and percent of watersheds in row crops and a negative relationship with percentage of watersheds in marshland. No significant relationship was found between ammonia-N and any of the watershed land uses.

In Dickinson County, the CLAMP data collected from 1999 to present indicates that West Okoboji and Big Spirit Lakes are the least productive of the IGL. West Okoboji is in the *mesotrophic* category. Most of the other lakes are in the *eutrophic* category. Little Spirit Lake and Silver Lake have the highest TSI scores; which indicates they are the most productive and are considered *hypereutrophic*.

The data show that nitrate concentrations are highest in the spring and early summer months before declining in the summer. This time coincides with spring applications of fertilizers as well as high amounts of rain.

The data also show that water clarity is greatest in the spring before water temperatures increase and algal populations increase. Secchi depths are generally deepest in June and shallowest in August and September for the lakes.

The IADNR ambient lake-monitoring program differs from the CLAMP program in that the samples were collected and analyzed by professionals from 2000 to 2007. The ambient monitoring program characterizes current water quality in the monitored lakes and provides an opportunity to track trends in lake water quality. Some of the main factors are summarized below.

<u>Stratification</u>
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.

<u>Turbidity</u>
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 25^{th} 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.
Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macro invertebrates. 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.

Phytoplankton

Most phytoplankton samples were dominated by cyanobacteria, which often dominate summer plankton in eutrophic lakes. The median phytoplankton wet mass ranged from 24.94 mg/L in 2007 to 404.78 mg/L in 2002. Silver Lake had a higher median concentration (85.37 from 2000 to 2007) than the median for all monitored, natural lakes in Iowa (39.7 mg/L).

Phytoplankton or algae are the photosynthetic organisms that form the base of the food chain in lakes. Phytoplankton wet mass and composition are measured to get a better understanding of the biological dynamics of each lake. In a sample pulled from Silver Lake a person can typically find 6 to 12 species of phytoplankton.

Zooplankton

The median zooplankton wet mass ranged from 304.67 mg/L in 2007 to 46.45 mg/L in 2000. Zooplankton are the microscopic and macroscopic animals that float, drift, or swim weakly in the water column. Zooplankton is the primary consumers of algae and many fish rely on them as a food source. Typically, one can find 6 to 8 species of zooplankton in a sample taken from Silver Lake.

SECTION 4

AQUATIC INVASIVE SPECIES

Introducing non-native species into Iowa waters can upset the balance of the ecosystem, hurting the environment. Aquatic Invasive Species (AIS), which include plants, animals and other organisms, may dominate aquatic ecosystems where they are introduced because they are freed from natural competitors, predators and diseases.

Presidential Executive Order 13112 of February 3, 1999 - Invasive Species defines an *invasive species* as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." The Executive Summary of the National Invasive Species Management Plan, developed by the federal interagency National Invasive Species Council (NISC) further clarifies and defines an invasive species as "a species that is *non-native to the ecosystem under consideration* and whose introduction causes or is likely to cause economic or environmental harm or harm to human health."

Congress established the Aquatic Invasive Species (AIS) Task Force with the passage of the Non-indigenous Aquatic Invasive Species Prevention and Control Act in 1990 and reauthorized it with the passage of the National Invasive Species Act in 1996 (Act). The Act charges the AIS Task Force with developing and implementing a program for waters of the United States to prevent introduction and dispersal of Aquatic Invasive Species; to monitor, control and study such species; and to disseminate related information. Some states, including Iowa, are strengthening their own invasive species laws, regulations, or policies instead of awaiting stronger federal action.

Successful AIS reproduce early, often, in large numbers and in multiple ways, out-competing or consuming native species to the point of extinction. Their ability to grow rapidly, colonize disturbed sites, and tolerate a wide range of environmental conditions can be disastrous for the natural environment, economies, and/or public health.

Once established in a new location, AIS may:

- Negatively impact economies of nearby communities
- Decrease waterfront property values
- Reduce populations of native species
- Reduce fish spawning areas
- Interfere with boating, fishing, swimming and other water recreation
- Clog drinking water plants, power plants, and dams, substantially increasing operating and maintenance costs
- Affect human health
- Be impossible to eradicate

Aquatic Invasive Species cost billions of dollars annually in damage and control measures. Zebra mussels alone are estimated to have cost the United States $750 million to $1 billion from 1989 to 2000. Because of the negative impacts to water quality, economies, and public health, both aquatic and terrestrial invasive species have gained new prominence in federal and state policy. There is increased cooperation among environmental nonprofits, government agencies, and trade organizations to halt or slow the spread of invasive species.

The United States has the interagency NISC and a National Invasive Species Management Plan, Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW), and federal AIS Task Force in place to combat invasive species and promote state/interstate invasive species management plan.

IOWA AQUATIC INVASIVE SPECIES PROGRAM

The Iowa Department of Natural Resources Aquatic Invasive Species Program (DNR-AIS) is responsible for monitoring and managing AIS in Iowa. Bighead carp, silver carp, Eurasian watermilfoil, zebra mussels and other nonnative aquatic species threaten Iowa waters.

The Iowa AIS Program aims to:

- Reduce the risk of further introductions of AIS in Iowa
- Limit the spread of established populations of AIS into un-infested waters in Iowa
- Eradicate or minimize the impacts resulting from infestations of AIS in Iowa

In 2005, Iowa Great Lakes Water Safety Council raised $32,000 to fund three DNR Law Enforcement Bureau Water Patrol Officers. Funding for the positions was donated by the Messengers of Healing Winds, Okoboji Protective Association, Alliant Energy Foundation, East Okoboji Lakes Improvement Corporation, Spirit Lake Protective Association, Conservation Foundation of Dickinson County, Mau Marine, Oak Hill Marina, Bridgewater Boats, and an individual donor. The funding was supplemented by DNR to hire eight additional summer officers. While the officers have the authority to issue citations for violations, the program emphasis is soft enforcement through education and voluntary compliance. The DNR-AIS focuses on raising public awareness to prevent the spread of AIS, monitoring state water bodies for AIS introductions, and control of AIS infestations.

In 2006, the DNR-AIS program targeted twelve high and medium priority boat ramps in Dickinson County for inspections and public education because of greater boater activity and/or the greater likelihood boaters could be coming from lakes known to have invasive species. Currently there are no monitoring programs on Silver Lake. Intervention through early detection and rapid response is a critical strategy for preventing the establishment of new AIS populations. Early detection and rapid response efforts increase the likelihood that invasions will be addressed successfully while populations are still localized and population levels are not beyond that, which can be contained and eradicated.

Because of the critical need for early detection, the DNR-AIS and its local partners have identified the need for increased measures to prevent the spread of AIS in Iowa.

A successful AIS program must include:

- A comprehensive public outreach effort-including but not limited to, facilitated public meetings, distribution of fact sheets, public service announcements, newspaper advertisements, rest area displays, traveler information systems, and gas pump toppers
- Active local partnerships to assist with developing watershed AIS management plan
- Permanent DNR-AIS program staff to conduct public education and volunteer programs
- Seasonal officers to conduct watercraft inspections and on-site public education
- Support for research that identifies pathways to limit the spread of AIS and identifies new AIS control methods
- Education of recreational users (boaters and anglers)

What the public can do

Now that you know about AIS and the problems they can cause to a watershed, there are some things the public can do to decrease the probability of spreading AIS. Here are a few suggestions:

- Personal watercraft users should avoid running the engine through aquatic plants. When they are finished riding, they should run the engine for 5-10 seconds on the trailer to blow out excess water and vegetation from the internal drive, then turn off the engine.

- Sailors should remove aquatic plants and animals from the hull, centerboard or bilge board wells, rudder post area and trailer.

- Boaters should inspect their boats after taking them out of the lake and remove any vegetation caught on the trailer or anything attached to the boat. Drain all water from the boat. In addition, boaters should rinse the boat and trailer with a high-pressure washer or hot tap water above 104 degrees before the boat is used somewhere else, or allow the boat to dry for up to five days.

- Anglers should throw away unwanted bait by putting it in the trash, rather than throwing it into the water.

- Waterfowl hunters should remove all plant and animal material and mud from their boats, motors, trailers, waders or hip boots, decoy lines and anchors, and cut cattails or other plants above the waterline when they are used for camouflage or blinds.

4.1 and 4.2 Photos Courtesy of Iowa DNR.

Important Fish AIS in Iowa

4.3 Bighead and Silver Carp (Hypophthalmichthys nobilis, Hypophthalmichthys molitrix)
Photo Courtesy of Iowa DNR

- Native to central and southern China (bighead) and eastern Asia (silver)
- Introduced in 1970s by fish farmers
- Bighead have spread to at least 23 states; silver has spread to 16
- Both species found in the Mississippi and Missouri Rivers bordering Iowa
- Bighead carp also in the Des Moines, Iowa, Chariton, Cedar, Platte, Nodaway, Nishnabotna, and Big Sioux Rivers and smaller tributaries
- Silver carp also in the Des Moines and Chariton Rivers

Identification

- Deep, laterally-compressed body
- Large mouth without teeth
- Tiny scales
- Eyes far forward and project downward

Impacts

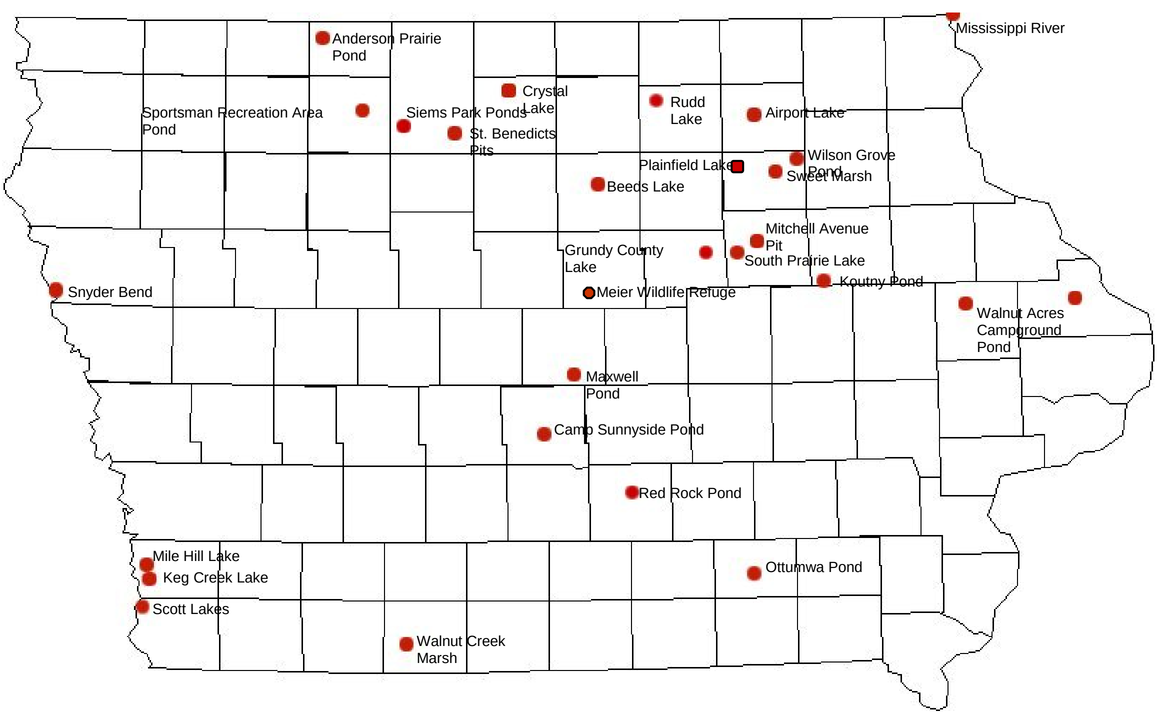
- Compete with native filter-feeders (paddlefish, buffalo, mussels, larval fish)
- Disrupt commercial fishing
- Leap out of water when boats approach

Other Fish AIS:
Black Carp
White Perch

Round Goby
Rudd
Ruffe

Important Plant AIS in Iowa
Eurasian Watermilfoil
It can form thick underwater stands of tangled stems and vast mats of vegetation at the water's surface. In shallow areas, the plant can interfere with water recreation such as boating, fishing, and swimming. The plant's floating canopy can also crowd out important native water plants.

<u>Eurasian Watermilfoil Infestations in Iowa through 2007</u>[1]



Map 4.1
Eurasian watermilfoil (Myriophyllum spicatum)

[1] Map and locations of Eurasian Watermilfoil provided by Kim Bogenshutz with the Iowa DNR, 2007.

4.4 Photo Courtesy of Minnesota DNR.

- Native to Europe and Asia
- Introduced into North America in the 1940s
- Invaded at least 45 states and three Canadian provinces

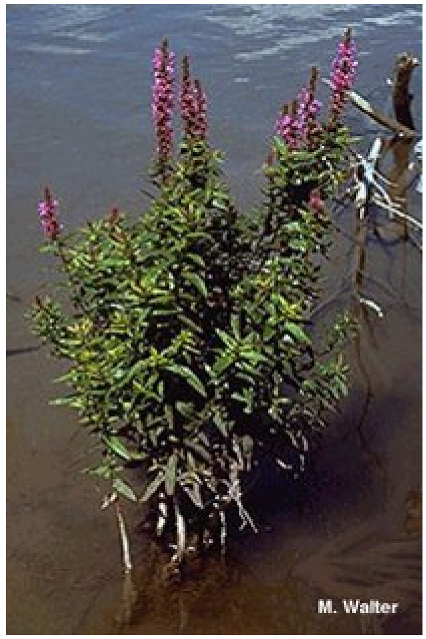
Identification
- 12-21 pairs of leaflets
    - Appearance - leaves collapse against stem when removed from water

4.5 Photo Courtesy of Iowa DNR.

- Branches profusely at water surface forming dense mats

Impacts
- Displaces native aquatic vegetation
- Forms dense surface mats which restrict boating, water-skiing, fishing, and other aquatic recreation
- Lowers value of lake front property

- Reproduces primarily by vegetative propagation and spreads from lake to lake by watercraft and/or trailers



4.6 Purple Loosestrife (Lythrum salicaria) Photo Courtesy of Iowa DNR

- Native to Europe and Asia
- Established along the east coast of the U.S. by 1800s
- Currently found in almost all states and all Canadian provinces

Identification
- Plant height 2-7 feet
- Linear leaves with smooth edges, usually opposite
- Long spikes of purple or magenta flowers with 5-6 petals
- Flowers in July and August

Impacts
- Dense stands displace native vegetation and wildlife
- Clogs drainage ditches
- Single plants produce up to two million seeds each year; roots and underground shoots also produce new plants
- Tolerant of a wide variety of growing conditions

4.7 Brittle Naiad (Najas minor) Photo Courtesy of Iowa DNR

Photo Courtesy of North Carolina State University.

- Native to Europe
- Introduced into North America in the 1930s
- Invaded at least 24 states in the eastern and southern United States
- First identified in Iowa in 2003

Identification
- Stems - up to four feet long, highly branched, crowded terminal nodes
- Leaves - opposite, about one inch long, prominent marginal teeth, often re-curved

Impacts
- Displaces native aquatic vegetation
- Forms dense mats which restrict boating, water-skiing, fishing, and other aquatic recreation
- Reproduces by fragmentation and seeds
- Plant is very brittle, breaks apart, and spreads from lake to lake by watercraft and water movement

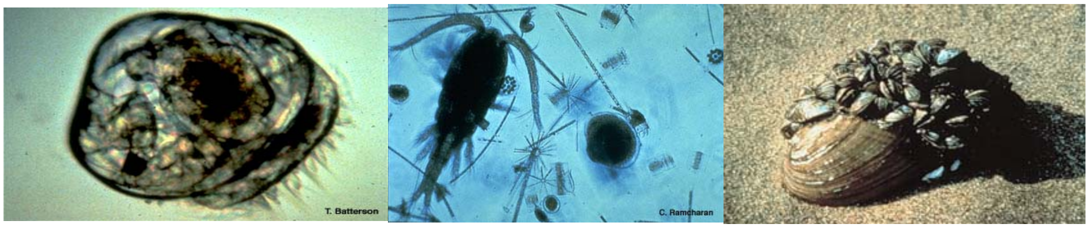
A key factor in the plant's success is its ability to reproduce through stem fragmentation and underground runners. A single segment of stem and leaves can take root and form a new colony. Fragments clinging to boats and trailers can spread the plant from lake to lake. The mechanical clearing of weed beds for beaches, docks, and landings creates thousands of new stem fragments that can drift with the wind and current. Removing native vegetation creates perfect habitat for invading Eurasian watermilfoil.

For example, water hyacinth is commonly used in aquatic gardens, but populations that have escaped to natural areas have completely covered lakes and rivers, devastating the water bodies and the life they support.

Other Plant AIS:
Curly-leaf Pondweed
Flowering Rush

Salt Cedar

Important Invertebrate AIS in Iowa



4.8, 4.9, 4.10 Zebra Mussel (Dreissena polymorpha) Photos Courtesy of Iowa DNR

- First found in Iowa in 1992 in the Mississippi River
- In one year, spread throughout the entire Mississippi River along Iowa
- Veligers (Juvenile Zebra Mussels) collected in 2003 from Missouri River in South Dakota
- Discovered in Clear Lake in 2005
- Discovered in Lake Delhi in 2006

Identification
- Yellow and/or brown D-shaped shells up to two inches long with alternating light and dark bands
- Usually grow in clusters containing numerous individuals
- Only freshwater mollusks that attaches to solid objects

Biology
- Sexually mature within one year
- Each female may produce up to one million eggs each year
- Veligers are free swimming and move with the currents
- Veligers fall out of the water column after 2-4 weeks

Impacts
- Clog pipes
- Hamper boating
- Clog beaches
- Kill native mussels, plants, crayfish
- Compete with small fish and native mussels for food

A series of aquatic invaders in Silver Lake, including the rusty crayfish, silver carp and zebra mussel, could introduce new parasites and diseases causing catastrophic declines in populations of native species.

Other Invertebrate AIS:
Quagga Mussel
Rusty Crayfish

Fishhook Waterflea
New Zealand Mudsnail
Spiny Water Flea

4.11 Zebra Mussels, Photo Courtesy of Iowa DNR

Zebra mussels can spread rapidly in the United States because they have no natural enemies here. Clear Lake – less than 100 miles from Silver Lake - provides a text book example of the threat. In 2005 two adult zebra mussels were found. Two years later there is a wide spread outbreak of zebra mussels in Clear Lake. When docks and hoists were removed from Clear Lake in the fall of 2007, the exponential increase of zebra mussels became readily apparent.

4.12 Dock with zebra mussels

The boat hoist at left shows what was found in the fall of 2007 as docks and hoists were removed from the lake. In comparison, only two adult Zebra Mussels were found in Clear Lake in 2005. In 2006, juvenile Zebra Mussels were found in the same area of Clear Lake.

To monitor the mussels, the DNR set out five plate samplers around Clear Lake and checked them monthly during summer 2007. All of the plate samplers had zebra mussels. The plate at left had the most, with more than 500 zebra mussels on it in July.

The Zebra Mussels in Clear Lake probably arrived on or in a boat that had picked up the mussels in an infested water body. Young Zebra Mussels are microscopic and can be unintentionally transported on boats or trailers.

Our environment, particularly our public lands and waters, is facing many different, complex threats like expanding pollution impacts, invasive species, urban sprawl and the consequences feeding off of our culture's insatiable demand for petroleum-based products (ethanol). All of these issues threaten our natural resources; however when they are combined with greater demands on our public resources and a scarcity of public funding to support traditional resource management, the sustainability of our natural resource base is being questioned by taxpayers who wonder why tax dollars are going towards acquisition of public land.[2]

Affected Areas

- Eurasian watermilfoil and curly-leafed pond weed can be found around Iowa. Although they most likely cannot be eradicated completely, natural resources officials have had areas around boat docks, beaches and fishing jetties treated for the weeds to keep the areas clear.

  Zebra mussels, which have inundated the Mississippi and Missouri rivers, have now been found in Clear Lake and Lake Delhi.

  Big-head carp have reached the Red Rock Dam on the Des Moines River. They also can be found in the Chariton, Cedar, Platte, Nodaway, Nishnabotna, Mississippi, Missouri and Big Sioux Rivers and smaller tributaries. In 2007, Iowa fisheries biologists found a fish kill in a wetland area off the Missouri River, called Louisville Bend. The 40-acre area had an estimated 6,000-8,000 dead fish, of which 50 to 60 percent were bighead, grass, and silver carp.

How to Battle Invasive Species

Iowa Department of Natural Resources officials are asking people who recreate in Iowa waters, as well as in other states, to take precautions to help prevent the spread of invasive species like big-head carp, silver carp, Eurasian watermilfoil, curly-leafed pond weed and zebra mussels.

To decrease the chances of spreading some of these invasive species:

- Remove any visible plants, fish, animals or mud from boat, trailer, and other equipment

- Drain water from all equipment- motor, live well, bilge, transom well

- Clean and dry anything that comes into contact with water - equipment, boots, clothing, pets.

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[2] Protect Your Waters, http://www.protectyourwaters.net/news/ and http://www.newwest.net/index.php/citjo/article/10009/C38/L38. accessed April 12, 2007.

- Before transporting to another water body, rinse boat and equipment with water 104 degrees or hotter, spray boat and trailer with high-pressure water at a car wash, or dry boat and equipment for at least five days

- Never release fish, animals or plants into a water body unless they came from that water body

- Empty unwanted bait in trash

- Learn to identify aquatic invasive species and report any suspected infestations to the nearest DNR fisheries station

- People who shore and fly-fish should remove aquatic plants, animals and mud from waders and hip boots and drain water from bait containers.

Summary

Aquatic Invasive Species greatly affect the balance of the ecosystem. These AIS choke native species so that they cannot thrive in their natural environment. More times than not, people are at fault for mistakenly or knowingly transporting these species. Understanding what we can do to keep our ecosystem clean will ensure that the same outdoor activities can be experienced for generations to come.
(Iowa DNR)

SECTION 5

CYANOBACTERIA

Cyanobacteria, sometimes called blue-green algae, 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 5.1: Cyanobacteria can be large enough to be seen with the naked eye.
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 5.2 & 5.3: Cyanobacteria blooms in Silver Lake during June 2008. 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.

<u>ADDITIONAL RESEARCH COMPLETED ON CYANOBACTERIA</u>

The United States Geological Survey (USGS) has been involved with further research on cyanobacteria. The USGS Kansas Water Science Center has established an Algal Toxin Team and some of their research have included sampling the Iowa Great Lakes during bloom events.[3]

[3] The University of Missouri sampled Silver Lake for algal toxins from 1999-2004 (J. Graham).

Research Needs

- Consistent sampling protocols. Collection technique and sample location(s) when collecting samples for cyanotoxin analysis are important and should be as consistent as possible to enable more accurate readings.
- Robust and quantitative analytical methods. Analytical methods for a variety of cyanotoxins will depend on the capabilities of the USGS and other laboratories.
- Regional distribution and occurrence of cyanotoxins
- Long term studies to identify the key environmental factors leading to toxic cyanobacteria blooms.
- for early detection should include continuous real-time water-quality monitors
- models

Problems

During the last ten years, less than 10% of row crops within Silver Lake watershed were converted to Conservation Reserve Program (CRP) acres. The area continues to urbanize with construction of summer homes and condominiums and the associated recreational and service facilities, such as golf courses, strip malls, and restaurants. These changes may cause increased runoff and nutrient loading to Silver Lake, as well as other ecosystem disturbances, conditions that favor the growth of cyanobacteria.

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 the Great Lakes area:

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 the 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.

How to protect yourself, family, and pets from exposure to cyanobacteria toxins:

- Don’t swim, water ski, or boat in areas where the water is discolored or where you see foam, scum, or mats of algae on the water.
- If you do swim in water that might have a cyanobacteria bloom, rinse off with fresh water as soon as possible.
- Don’t let pets or livestock swim in or drink from areas where the water is discolored or where you see foam, scum, or mats of algae on the water.
- If pets (especially dogs) swim in scummy water, rinse them off immediately—do not let them lick the algae (and toxins) off their fur.
- Don’t irrigate lawns or golf courses with pond water that looks scummy or smells bad.
- Report any "musty" smell or taste in your drinking water to your local water utility.
- Respect any water-body closures announced by local public health authorities.

(Iowa DNR)

SECTION 6

SOURCE WATER PROTECTION

SOURCE WATER RESOURCES

Geology

Geological events that occurred during the ice ages were a primary determinant of the natural features of Silver Lake region. The geological history of the area affected the surface contours of the land and formation of soil types, and the location of minerals, ground water, lake basins and stream channels. During the ice ages massive glaciers moved across the region carrying with them boulders, gravel, sand and clay, as well as organic remains. As the glaciers melted and receded, millions of tons of debris were deposited. This mixture is known as glacial drift and forms a 200 to 300 foot cover over the original bedrock of the area.

The glacial drift in Silver Lake area was deposited in the Wisconsin Age of the Pleistocene Epoch. The Wisconsin glacier was the last of 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.

In addition to depositing glacial drift, the receding glaciers occasionally left behind large blocks of ice, which melted and formed the basins for future lakes. The rugged bottom of West Okoboji suggests it may have been formed in this manner. Water from melting glaciers cut new drainage patterns into the deposits below the glaciers. This water washed out sand and gravel from the till deposits and carried it downstream until the water lost velocity and deposited debris in the valleys that were carved. In this way, sand and gravel outwash deposits were formed from streams that drained the glacial melt.

Underlying the glacial drift are shale and sandstone of Cretaceous Age. The shale vary in thickness and are found exceeding several hundred feet just north of the northern boundary of the watershed. The sandstone varies in thickness but generally do not exceed the thickness of the shale.

Below the Cretaceous units, data regarding the stratigraphic sequence 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 exists a buried northwest-southeast trending quartzite ridge of Pre-Cambrian Age.

Ground Water Systems

A number of ground water flow systems exist in Silver Lake region. The deeper flow systems are contained in the deep bedrock units underlying the glacial drift. Of the deep flow systems, the Dakota Sandstone, and Ordovician and Cambrian Age sandstones are the most important. These systems are generally penetrated by wells extending to depths of 300 to 500 feet.

The flow system having direct bearing on the lakes and streams of the area is the shallow system found in the glacial drift. The gradient of the ground water in the drift generally is to the south, but local ground water highs are found throughout the area. The topographic high areas are recharge areas and the low lying swamps and lakes are discharge areas. In the areas adjacent to the Little Sioux River, the contour configuration indicates that the river is receiving ground water discharge. The lakes are also receiving base flow from ground water.

The quality of ground water varies throughout the area depending upon location and well depth penetration. The Dakota sandstone and Ordovician and Cambrian Age sandstones typically contain highly mineralized waters. Dissolved solids are found in concentrations exceeding 1000 parts per million (ppm). The water is also very hard with concentrations of more than 700 ppm of total hardness. High sulfates are characteristic of the Dakota sandstone.

Silver Lakes' & Dickinson County's Environmental Facts and Demographics

A geological drama of 14,000 years ago - when the Des Moines lobe of the Wisconsin glacier retreated across the upper Midwest - created a glacial phenomenon that sculpted the earth with unimaginable power and beauty, fashioning the landscape now known as Silver Lake Region. With more lakes, wetlands, public land and state parks than any county in Iowa, Dickinson County is arguably the most environmentally diverse in the state.

The following are environmental facts and demographics about Dickinson County and about the Silver Lake watershed. These facts and demographic details the value of the lake, why it is important to protect the water along with the numerous benefits offered by the lake:

- Dickinson County population is approximately 16,672.
- Estimated Transient (Tourists) population – nearly 1 million.
- The Silver Lake watershed is composed of land in Dickinson County, Iowa, Osceola County, Iowa, Nobles County, Minnesota, and Jackson County, Minnesota – over 18,000 acres in total.
- Being part of the Prairie Pothole Region, it contains a large concentration of wetlands.
- There two cities within the watershed: Lake Park and Harris.
- Tourism employs about 1,740 workers in the region, with a payroll of about $23 million.
- The area pulls tourists from Iowa, Minnesota, South Dakota, Nebraska, Missouri, and Illinois, as well as other parts of the country.
- In 2002, tourists brought an estimated $139 million into the local economy.
- There are about 5,000 lakeside homes in Dickinson County.
- In 2002, the per capita personal income in Dickinson County was $31,359. This was an increase of 18.6% from 1997.

Physical Characteristics
Dickinson County is home to ten natural lakes covering more than 16,000 acres, all of which are public use resources. Although most of the lakeshore acres on these lakes are held in private ownership, there are ten lakeside state parks and public accesses to each. The lakes are noted fisheries for game species such as walleyes, northern pike, largemouth and smallmouth bass, yellow perch, crappies and bluegills. Large numbers of anglers from throughout the Midwest travel to Dickinson County each year to sample the fishing. Walleye Weekend, for example, held annually on the walleye opener in early May, attracts thousands of anglers.

In addition to the natural lakes, Dickinson County has more than 15,000 acres of public land managed by the Department of Natural Resources or about 15 percent of the total land area in the county. These areas consist of shallow natural lakes, natural or restored prairie wetlands, prairie grass uplands, woodlands and meadows. Enjoyed by hunters, anglers, bird watchers, kayakers, canoeists and nature lovers, these public acres add to the environmental allure of the area. About half of the land in Dickinson County remains agricultural cropland, 12% grassland and about 2% woodland. Work continues throughout the lakes watersheds to restore wetlands and other buffers to reduce runoff pollution.

Agencies and Organizations Protecting the IGL Watershed

There are several lake associations, Local Governments, Commissions, and conservation organizations at work in the county to preserve and enhance the natural resources. Many of their members were present for the first public meeting in 2003 (over 70 community members attended) and it is the hoped that many of these members and others from the public will be active in implementing this Source Water Plan. Listed below are some examples of what local organizations and volunteers have accomplished:

1) The Dickinson County Clean Water Alliance (CWA) coordinates the efforts of governmental agencies, non-profit organizations and private organizations through the help of the Dickinson County Soil and Water Conservation District. Its slogan is "United to keep our lakes alive." The CWA is an uncommon federation of dozens of groups working in harmony to protect the water resources of the area. The CWA was formed in 1990 by the Dickinson County SWCD, the area lake protective associations, and the Iowa DNR and continues to coordinate activities for water quality. The goal of the CWA is to educate, communicate, coordinate, and fund the work of clean water for Dickinson Counties Lakes. The working members of the CWA are as follows.

Clean Water Alliance Partners

Nonprofit Associations

Center Lake Protective Association
Ducks Unlimited
Dickinson County Pheasants Forever
East Okoboji Improvement Corp.

Friends of Iowa Lakeside Lab
Iowa Environmental Council
Inter-Lake Association
Iowa Great Lakes Association
IGL Water Safety Council
Iowa Natural Heritage Foundation
Okoboji Protective Association
Osceola County Pheasants Forever
Silver Lake Park Improvement Association
Spirit Lake Protective Association
Three Lakes Protective Association
University of Okoboji Foundation

Local Governments and Commissions

Active Okoboji
Central Water
Character Counts in Dickinson County
City of Arnolds Park
City of Lake Park
City of Milford
City of Okoboji
City of Orleans
City of Spirit Lake
City of Superior
City of Terril
City of Wahpeton
City of West Okoboji
Dickinson County Board of Supervisors
Dickinson County Water Quality Commission
Iowa Great Lakes Chamber of Commerce
Iowa Great Lakes Sanitary District
Milford Utilities
Okoboji Tourism
Spirit Lake Utilities

County Boards and Districts

Dickinson Co. Conservation Board
Dickinson County Farm Bureau
Dickinson County Soil & Water Conservation District
Jackson (MN) Co. Soil & Water Conservation District
Jackson (MN) Co. Planning & Environmental Services
Osceola Soil and Water Conservation District

State Agencies

Iowa Dept. of Land Stewardship, Division of Soil Conservation
Iowa Department of Natural Resources
Iowa Lakeside Laboratory
Iowa Rural Water Association
Iowa State University Extension Service
Minnesota Department of Natural Resources

Federal Agencies

Environmental Protection Agency
Farm Service Agency
Natural Resources Conservation Service
Research Conservation & Development Service
U.S. Fish & Wildlife Service
U.S. Geological Service

Private Business

Beck Engineering Inc.

And Interested Citizens

The CWA works throughout Dickinson County and in the Watershed of Silver Lake in Osceola County, Iowa and Nobles and Jackson County, Minnesota. The CWA has been a leader in moving the Low Impact Development (LID) style of development forward in Dickinson County. Developers and citizens have moved to development of many LID projects - including rain gardens, bio-swales, pervious parking and other storm water management implementation. Lake Park has implemented a LID ordinance on new construction and the county has developed an LID Ordinance.

2) The Dickinson County Water Quality Commission (WQC) is a one-of-a-kind organization in the state created by a *28(e) agreement*. Through its creation it has provided a steady funding source for clean water projects. In its seven-year existence, the WQC has funded $900,000 towards dozens of diverse projects Some examples are, water quality monitoring construction of rock tile intakes, purchase of key watershed protection properties, and projects to increase wildlife habitat. The Water Quality Commission has a goal of matching at least 3 dollars for every one dollar it grants. To date the Water Quality Commission has brought 14 dollars of matching money for every one dollar it has granted for water quality projects in Dickinson County.

3) 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.)

4) Iowa Great Lakes Water Safety Council (WSC) is unique among the not-for-profit public service organizations because it concerns itself with both water safety and clean water issues. In its short history, the WSC played a large role, for instance, in the passage of a state law raising boat registration fees, providing funds for water safety, and the prevention of invasive species projects.

5) 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.

University of Iowa botany professor, Thomas MacBride, founded ILL in 1908. He wanted to establish an onsite scientific research facility in the lakes area, which he said supported the most diverse environmental habitats in Iowa.

6) The 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.

SECTION 7

Agricultural Land

Dickinson County and Silver Lake watershed is a host to one of the states unique environments. Agriculture is one of the primary economic engines in the county. Silver Lake watershed is in the prairie pothole region of Iowa and Minnesota. The Clarion-Nicollet, Nicollet-Clarion, and Canisteo-Nicollet-Okoboji associations comprise approximately 80% of the soil types in the watershed. These soils are level to strongly sloping, somewhat poorly drained to very poorly drained. Theses soils are loamy and silty soils formed in the glacial till uplands. The low impounded areas are commonly referred to as potholes. These potholes require drainage before they can be productive for row crops. Most of these soils have been drained and are in intensive row crops. The primary crops are corn and soybeans with a large portion of the watershed also having alfalfa as part of the crop rotation due to ARCO dehydration plant located in Lake Park. This crop rotation of corn, soybeans, oats, meadow, and meadow is a very soil conserving rotation and should be encouraged if it is profitable to the landowner/operator.

There are approximately 14,084 acres of cropland in the watershed. There are a limited number of small feedlots and pastures in the Silver Lake watershed. In the Osceola County, Iowa portion of the watershed, there are larger and more feedlots/CAFO's. In the Iowa portion there are 7 feedlots. Iowa feedlots are required to register if they have 999 animal units or more. Even though the number of feedlots and small pastures is small in the watershed, there is a large amount of animal waste being applied in the watershed. There are over 1 million chickens located, on several farms, within 20 miles of the Silver Lake watershed and the manure from these farms is being brought into the watershed and applied, in some instances on frozen ground. A loophole in the State of Iowa Manure Management Plan allows animal waste to be sold to elevators where it becomes fertilizer and then sold back to farmers or custom applicators that are then not regulated in how they apply the manure.

As in the rest of the state, the number of farms in the watershed continues to decline at a steady pace. Farming operations continue to grow larger which in turn lead to intense row crop production. The Natural Resources Conservation Service (NRCS) and the Dickinson and Osceola Soil and Water Conservation Districts have done a great amount of planning and applying conservation practices and land retirement programs in the watershed. Farm programs such as Conservation Reserve Program (CRP), Environment Quality incentive program (EQIP), Wetlands Reserve Program (WRP) and several state and local cost share programs have been very popular with landowners to assist them in controlling soil erosion. The farmers in the Silver Lake watershed have not widely accepted conservation tillage and no-till. The farmers in the Silver Lake Watershed tend to own larger equipment and prefer straight long rows.

Most farmers use some type of conservation tillage system in their rotation. This spring being a wet year seemed to have a higher than average level of tillage. The majority of the watershed is not highly erodible which allows farmers to use as much tillage as they deem suitable. Unfortunately, with the high commodity and Land prices land retirement programs are becoming less popular to landowners in the watershed. There are approximately 150 acres of CRP in the watershed. The contracts are due to retire and it is doubtful that many of these acres will be reenrolled in CRP if the trends in high commodity and Land prices continue.

Confinement and Feedlots

There are currently seven confinement feeding operations located within the watershed or near the boundary of the watershed. These CAFO's contain mostly hogs but also contain cattle. There are approximately 875 total animal units located in these CAFO's and the manure is generally spread near the confinement site. In the Watershed monitoring conducted by the Clean Water Alliance and its partners in 2007 a very high bacteria count and high phosphorous level was found in the North-central portion of the watershed. There are no confinements or feedlots located near that site. The only location these two indicators could be coming from is manure spread on crop fields.

A larger threat to the water quality of Silver Lake than resident animal feeding operations is the amount of manure brought into the watershed from outside the watershed. Several large animal-feeding operations located outside the watershed transport manure long distances to custom farmers and to farmers who pay someone to bring the manure into the watershed to use as fertilizer. As sometimes happens this manure has been left on the surface of frozen ground and not incorporated until the spring thaw. There is one open feedlot located within the boundaries of the watershed.

Sediment Delivery

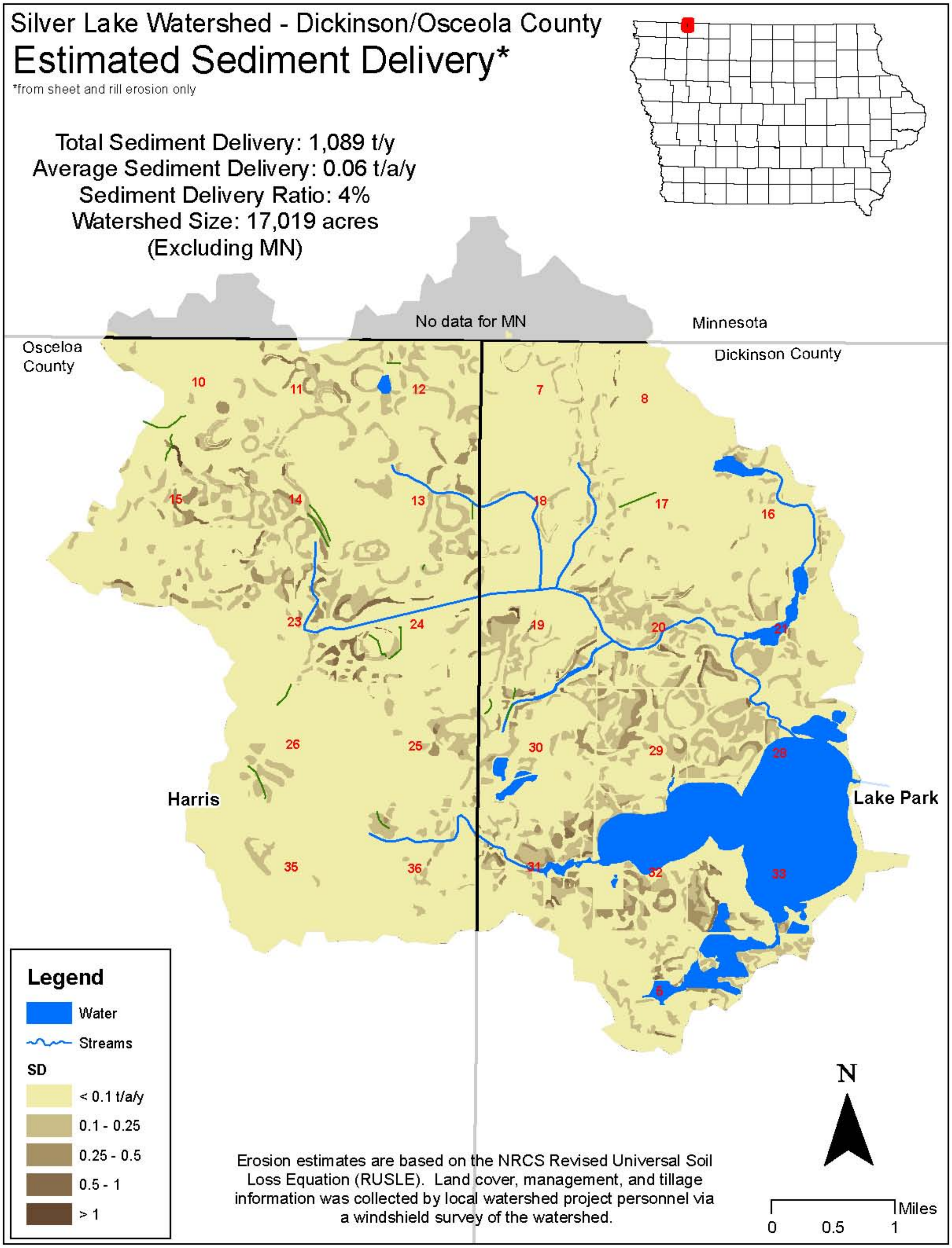
Using the NRCS Revised Universal Soil Loss Equation (RUSLE), it has been estimated that a total of 0.06 tons per acre per year of soil is delivered to Silver Lake. These figures only allow for sheet and rill erosion and do not include figures for gully or other erosion. This model, therefore, shows a total sediment delivery (with sheet and rill erosion) of 1,089 tons per year to Silver Lake. Using the figure of 1.3 pounds of phosphorous delivery per ton of sediment we can assume a total of 1415.7 pounds of phosphorous being delivered to the lake each year.

As little as 15 parts per billion of total phosphorous can encourage excessive production algae. Undesirable aquatic plant growth results from additions of phosphorus to the water. The net result of the eutrophic condition and excess plant growth in water is the depletion of oxygen in the water due to the heavy oxygen demand by microorganisms as they decompose the organic material. It severely impacts the lakes natural ability to support aquatic life. (Algae Management, 2007) Further it is significant to note that "one pound of phosphorus can grow up to 1000 pounds of algae and concentrations as low a 0.03 parts per million of total phosphorus will support an algae bloom". (Carlson, 2008) When looking at an additional 1415 pounds of phosphorous each year into the lake we can assume, using accepted multipliers, that an additional 1.4 million pounds of algae could be produced in Silver Lake each year due to the influx of additional phosphorous.

Using the 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. The move toward larger equipment and a desire for straight rows has caused many farm operators to move away from waterways.

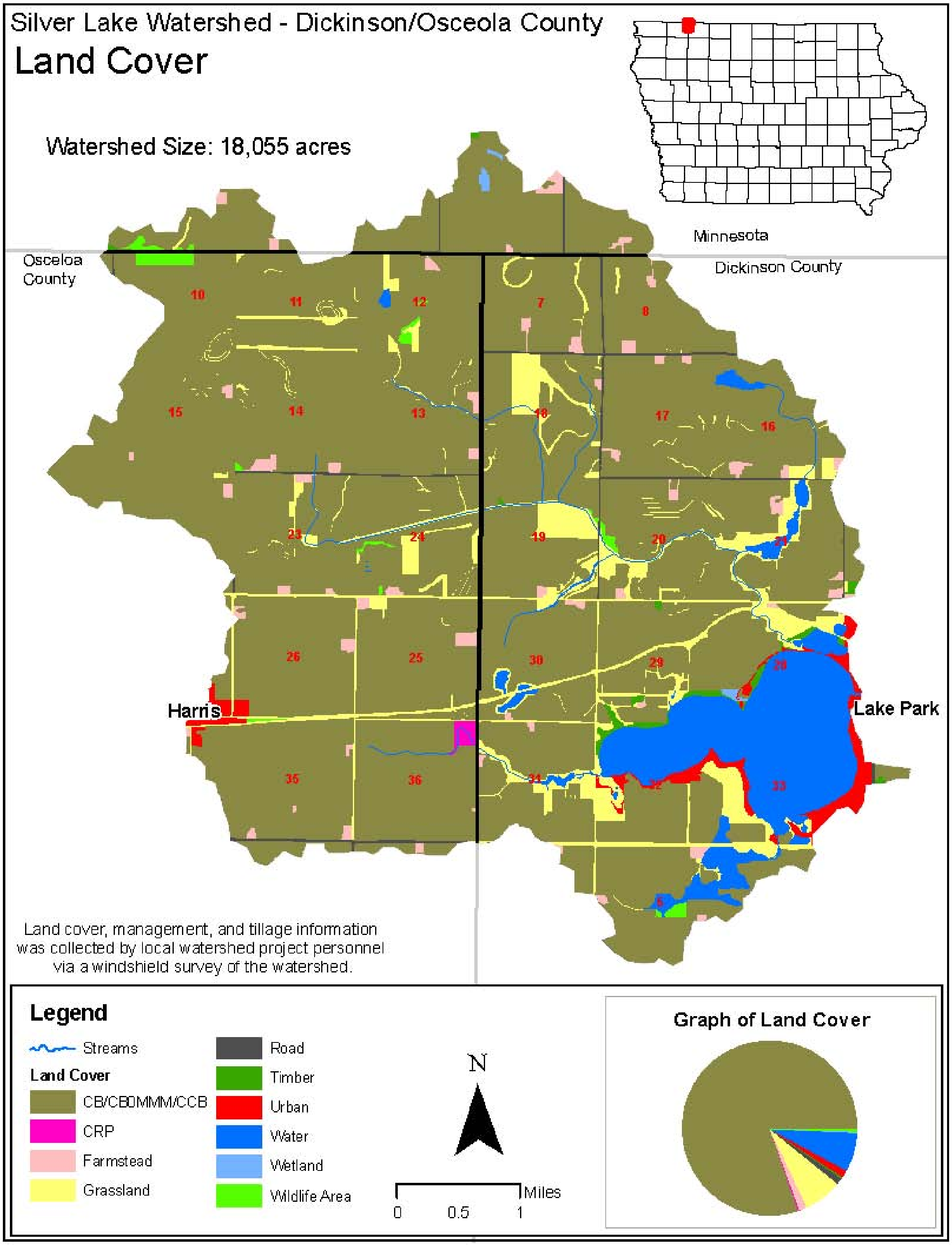
Approximately fifty areas have been identified within the watershed where gullies have begun to form. These gullies are providing direct sedimentation and in large amounts in comparison to the rest of the field. In these 50 sites, if grassed waterways and sediment basins were built the reduction of sedimentation 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 are is more sediment delivery than we can currently account for moving toward Silver Lake.



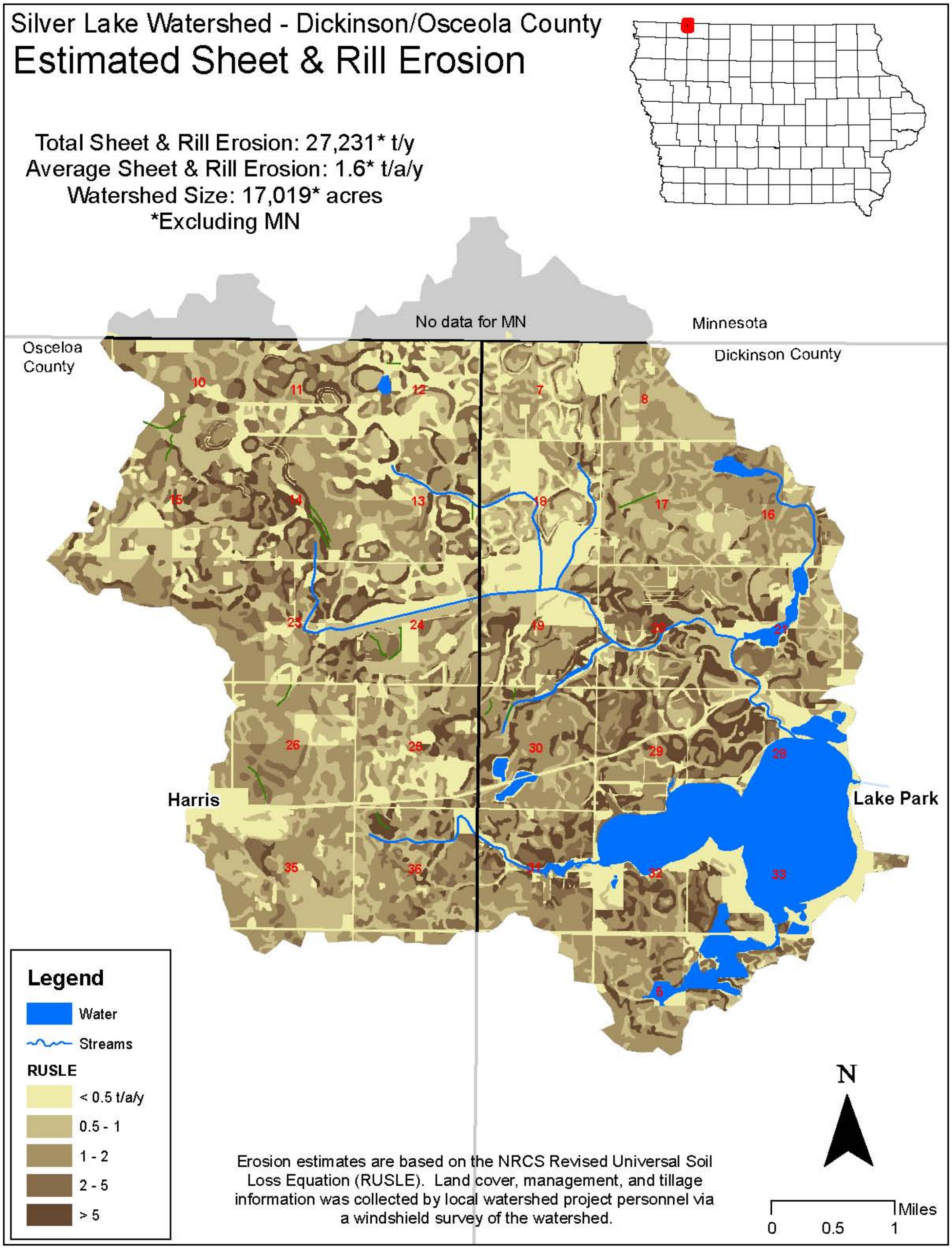
Map 7.1 (Iowa DNR)

Land Use Inventory
This land inventory was conducted Spring 2007



Map 7.2 (Iowa DNR)

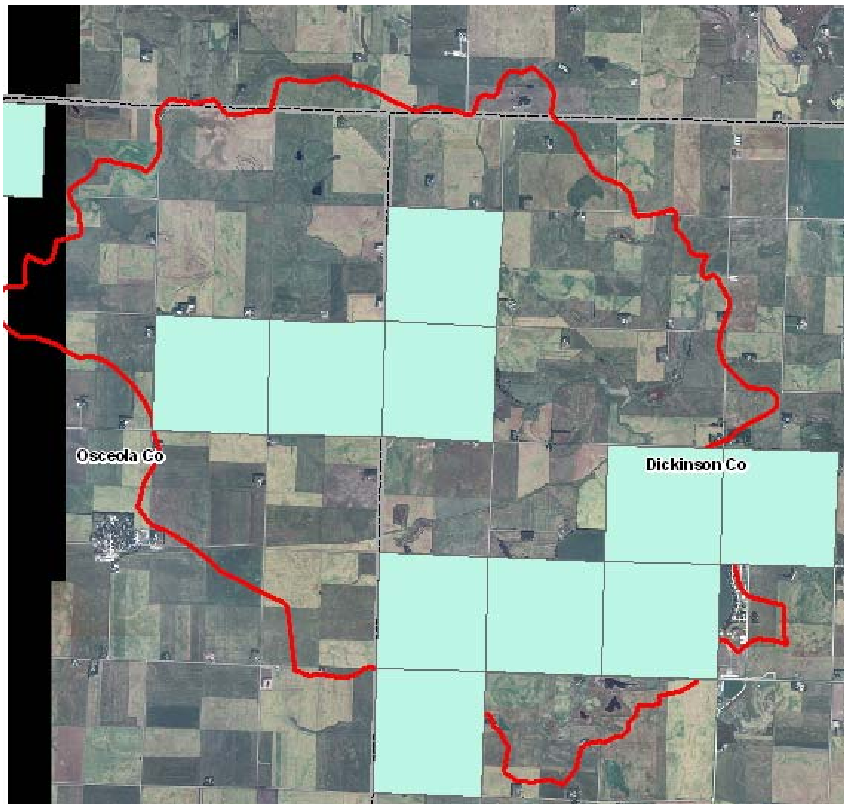
Agricultural Modeling



Map 7.3 (Iowa DNR)

Cultural Resources

There are Cultural Resources found in the watershed especially in the areas adjacent to Silver Lake and a drained lake called Ash Island. The drained lake was drained in the 1930's through a government drainage program to bring the land in this area under agricultural production. Map 7.4 shows the sections in which cultural resources have been discovered in the past. These sections would receive special consideration when conservation planning is going to be conducted.



Map 7.4

SECTION 8

Urban Areas

The urban areas of Dickinson County have been expanding at a significant rate when compared to other rural counties in the State of Iowa. Most of that urban expansion and construction has been occurring in the Iowa Great Lakes region of Dickinson County, however, recent developments in the City of Lake Park (around the lakeshore of Silver Lake) have begun to change that. The City of Spirit Lake has been the most progressive in recent past in developing its residential base. Lake Park with two new developments has put itself on the map as having a significant beginning to urban development. Future plans in these new development calls for even more development along or near the lakeshore of Silver Lake.

The most of the existing City of Lake Park is drained away from Silver Lake and is outside the actual watershed boundary. The biggest portion of Lake Park does not negatively affect Silver Lake. The houses on the lakeshore and those, which are 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 (map 5) shows the location of each of the storm sewers within the incorporated city which drains to the lake and are a direct conduit carrying pollutants directly to the lake.

With the construction of new development areas around Silver Lake, it is likely there will be more infrastructure with storm sewers built along the South shore of Silver Lake. Since there is no where to go with those storm sewers, except the lake it is likely with new development will come even greater storm sewer waters in the future unless a plan is conducted to reduce those waters.

Sanitary Sewer

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

Urban Residential Development

Sanitary Sewer

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.

In the unincorporated areas of the watershed are currently all on septic systems. These systems are under jurisdiction of the Dickinson County public health. Adjacent to the lake there is only one residence on the north shoreline, which has an individual septic system. Within the watershed there are on septic systems, which are suspected of not functioning correctly or meeting current standards requirements for septic tanks and drainage fields.

Urban Residential Development

The drainage from urban areas should be broken down in to 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 currently the built up area of Lake Park. These drainage areas has some of the largest impervious surfaces and should be considered the highest priority. The drainage consists of residential, school with a large parking area and some commercial and industrial areas. The city of Lake Park should address the drainage going to Silver Lake through infiltration based storm water management practices as they upgrade streets and drainage in this area. Work with private landowners and businesses will also help to get practices installed.

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.

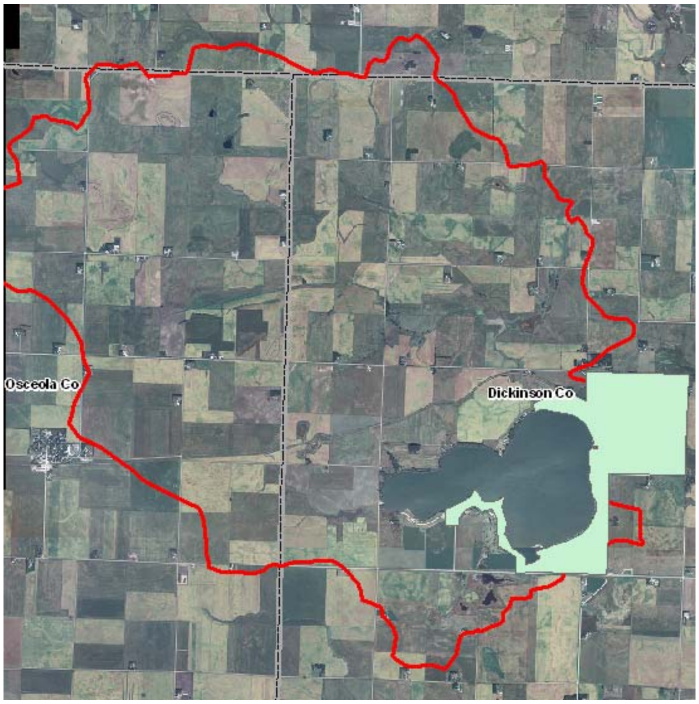
Silver Shores through to the West Bay drainage area is a lower priority also. The drainage in the two new sub-divisions all go to wetland areas before going to Silver Lake. This practice is protecting the lake but as these sub-divisions are built, the wetlands used in this manor usually get over stressed and loose 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.

Map 8.1

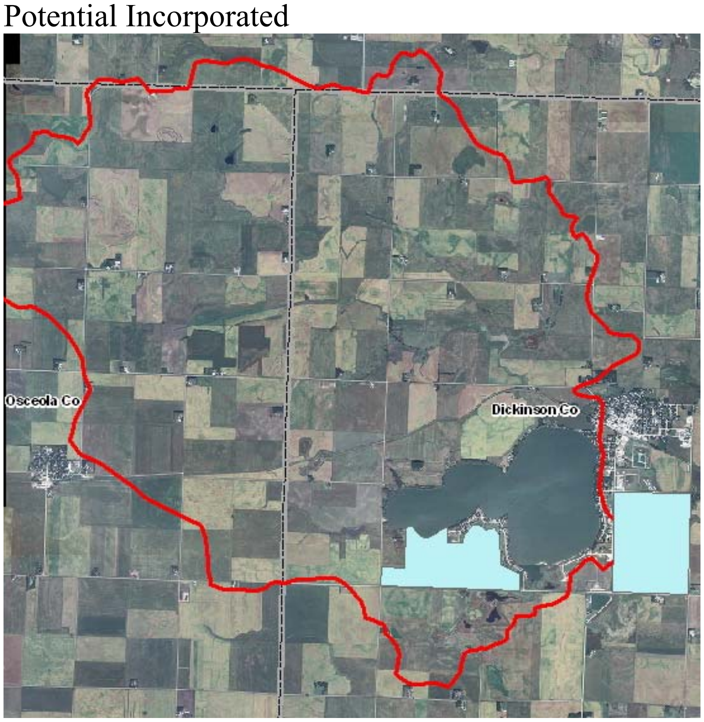
Incorporated Area

The current incorporated areas of the City of Lake Park are shown on Map 6. 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 7 shows current future annexation plans, however, there are even more annexation plans in the works than what Map 8.3 shows.



Map 8.2

Potential Incorporated



Map 8.3

ARCO Dehydration Plant

Within the Silver Lake watershed is a major industry for Lake Park, ARCO Dehydration Plant. Besides being one of the biggest land users within the watershed, ARCO Dehydration is situated along the east shore of Trappers Bay. ARCO harvests alfalfa 3 to

4 times per year and dehydrates that alfalfa into pellet form. The alfalfa, in pellet form is used as feed for animals.

ARCO does much good within the watershed as they have a longer than normal crop rotation of Corn, Soybeans, Oats, Meadow, Meadow, Meadow (sometimes more meadow) in their effort to raise alfalfa. This rotation helps to keep the sediment delivery to the lake down a great deal because the extended 100% cover crop, alfalfa, prevents most erosion from occurring. Some of ARCO's dehydration practice has the potential to cause problems with Silver Lake, however. The fact that ARCO is so close to the lake causes a contaminate problem to become a bigger concern.

Section 9

Water Quality Management Plan

The pollutants contained in the runoff toward Silver Lake from the agricultural areas are the largest source of pollutants in the watershed. The pollutants come along two major drainage areas into the Lake and consist, primarily, of sediment and animal waste indicators. The plan for management of the water quality of the Silver Lake Watershed consists of several different elements. The elements can be implemented at once or over a number of years. The plan will be most successful if implemented as a continuous program.

The plan includes wetland restoration, conservation practice installation, filter strips, animal waste management, conservation tillage, urban development plans and ordinances. The following are recommended elements to be adopted to preserve and protect the Silver Lake Watershed and Silver Lake itself.

1 Construction of erosion control structures such as sediment basins, grassed waterways, and grade stabilization structures. There are 14,084 acres of cropland that need protection within the Silver Lake Watershed. Of those acres, it has been determined a need on at least 50 locations of some sort of construction practice to reduce or to diminish a gully that has begun to form. The grassed waterways, if constructed have the potential to cost over $105,000 or more if all were constructed according to NRCS specifications.

   There are many areas within the watershed, where the land operators have heavy and large equipment and do not want to incorporate grassed waterways into their farming plan. Those areas would be best served by emplacing sediment basins or small terraces to protect the gullies that are forming. These sediment basins would entail building an earth fill basin at a distance, which allows the large multi-row equipment to pass without half rows. The cost of building these sediment basins would be a little bit more expensive than the grassed waterways but polling within the watershed shows the basins would be more culturally acceptable to the farmers within the watershed.

2 Wetland Restoration within the watershed should become a priority for all government agencies within the area. Nearly all of the wetlands that once were abundant within the watershed have been drained or reduced through tiling and through the construction of drainage ditches such as the Ash Island Lake drainage district. The system of drainage ditches and tiling are an efficient way to reduce wet spots and wetland areas within the watershed, however, the drainage has caused easy access of pollutants to the lake. Wetlands, once a very efficient system of filters, slowed water from moving toward the lake reducing volume and pollutant load.

   The restoration of these wetlands will improve drainage on already stressed drainage systems while cleaning the water that moves through them. By moving through a system of wetlands and upland grasses designed to “catch” as much flow as possible and thereby reducing volume and pollution loading. Programs such as the Wetland Reserve Program should be considered in order to provide long-term protection of these wetlands once they are identified and restored. The wetlands should be targeted to the areas that will provide the largest reduction of sediment delivery to the lake.

3 Management practices such as conservation tillage, no-till, and manure management should be considered invaluable to this watershed. The land around Silver Lake is mostly non-highly erodible meaning the conservation that is done on and around the lake is done voluntarily. Little change in the way tillage has been done around Silver Lake has happened over the last 20 years. Where no-till and other conservation tillage has increased in other areas, it has declined in the Silver Lake area. Conservation management practices or best management practices should be provided as alternatives within the watershed using incentives and education.

4 Conservation Cover has been in use for many years but with the rise of commodity prices in the region, the popularity of these practices has declined sharply. The Silver Lake Watershed currently has very little in the way of conservation cover and with the rise of commodity prices will probably see a decline in the existing cover. Incentives should be offered which will make areas, which are the largest producers of sediment delivery and pollutants less attractive to farm. The Conservation Reserve Program should be an important feature in protecting land with conservation cover. Practices that would qualify as conservation cover include grassed waterways, field and farmstead windbreaks, wildlife habitat, wetland restoration, and filter/buffer strips.

These practices can be targeted by providing larger incentives for practices, which will reduce sediment delivery at a greater amount. Farmstead and field windbreaks are an important practice in the Silver Lake watershed because the wind is an important contributor to the "stirring" of the lake bottom and the re-suspension of sediments and nutrients. Another practice, which would be important in Silver Lake, is lakeshore re-vegetation. Most vegetation within Silver Lake has been destroyed by poor management practices. The reduction of wave action can be achieved by re-vegetating the lakeshore.

5 Urban management which would include storm water management, education of fertilizer and their effects on the lake, sanitary sewer and septic tank maintenance, and proper development of the watershed. The best way to manage new developments is using good and well thought out ordinances, which manage storm-water runoff using low impact development. Existing urban areas should have a targeted education effort, Low Impact Development retrofit, and lawn care education. The city of Lake Park and the county must not allow any new sub-divisions without requiring connection to a sanitary sewer system.

6 Any program designed to reduce the water quality problems of Silver Lake will fail if it does not have a strong conservation education program, which will show the

need for developing these practices and structures. A conservation education program is something not always thought of when considering reducing pollution to a lake but without the education component long-term change in the watershed cannot be done.

7 Upon completion of the above watershed management plan, dredging of key areas within the lake to remove the nutrient sink that has developed over years of sediment and nutrient deposition. A primary area of consideration for dredging is the Trappers Bay area; there may be other areas that would benefit from dredging in order to improve the water quality of the lake. Those areas should be looked at seriously after successful watershed restoration and protection has been complete but not before. Dredging should be considered a final step in the restoration and protection of Silver Lake and only upon successful protection of the watershed. This step will be the final step so that the dredging isn't completed only to be filled in again by sediment from the watershed.

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