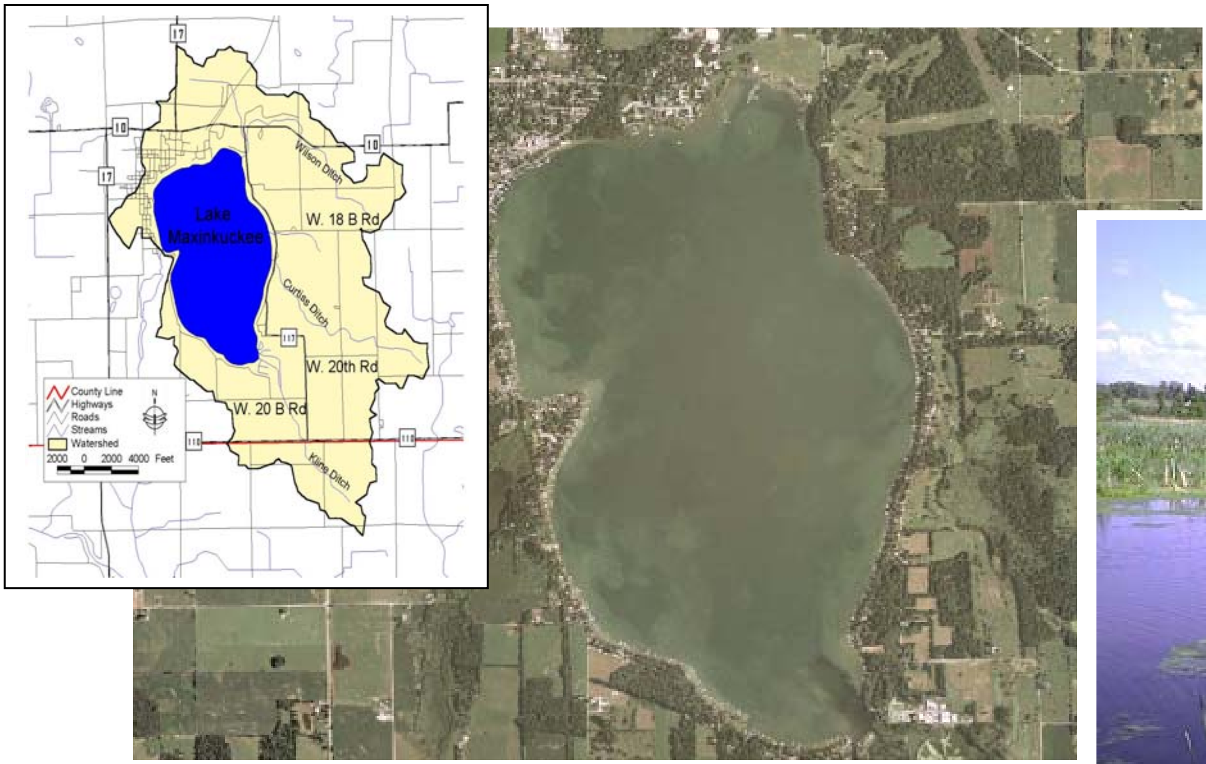
Lake Maxinkuckee
Lake and Watershed Management Plan



Lake Maxinkuckee Environmental Council

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Acronyms

IDEM	Indiana Department of Environmental Management
BMP	Best Management Practice
CLP	Clean Lakes Program
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
EQIP	Environmental Quality Improvement Program
GIS	Geographic Information System
IDNR	Indiana Department of Natural Resources
LARE	Lake and River Enhancement Program
LMEC	Lake Maxinkuckee Environmental Council
LMEF	Lake Maxinkuckee Environmental Fund
LWMP	Lake and Watershed Management Plan
mIBI	Macroinvertebrate Index of Integrity
NRCS	Natural Resources Conservation Service
PCB	Polychlorinated Biphenyls
QAPP	Quality Assurance Project Plan
QHEI	Qualitative Habitat Evaluation Index
SWCD	Soil and Water Conservation District
TP	Total Phosphorus
TSS	Total Suspended Solids
USEPA	United State Environmental Protection Agency

Executive Summary

This Lake and Watershed Management Plan was developed for Lake Maxinkuckee and its 8,850 acre watershed which is located in and around Culver, Indiana and is designated by the 14-digit Hydrologic Unit Code (HUC) 05120106060010. Three main tributaries, Curtiss Ditch, Wilson Ditch and Kline Ditch, drain into the lake and contribute approximately 70% of the phosphorus loading. The watershed is mainly rural with agricultural land comprising 41% of the watershed (27% row crop, 14% pasture). Developed areas cover almost 13%.

With funding through the Indiana Department of Environmental Management's Section 319 grant program and the Indiana Department of Natural Resources Lake and River Enhancement Program, the Lake Maxinkuckee Environmental Council and their consultant held several public meetings to hear residents input, reviewed historical data, and conducted water quality sampling to identify current water quality concerns.

The 10 members of the Lake Maxinkuckee Environmental Council (LMEC) acted as the steering committee. As per their bylaws, members of the LMEC represent lake residents, Culver Academies, Town of Culver, and the agriculture areas – the major stakeholders in the watershed. A second committee of volunteers helped categorized the hundreds of public comments and reviewed problems statements. The first two public meetings focused on recording stakeholder input, the third public meeting presented the water quality sampling results, the fourth discussed goals and strategies and at the fifth the draft plan was presented for public comment.

After reviewing the public input it was clear the stakeholders are primarily concerned with keeping the lake healthy for the benefit of all watershed residents and adopted the following statement to guide their goals:

Working toward an ecologically sound Lake Maxinkuckee and its surrounding watershed

This statement guides all the aspects of lake and watershed management. All decisions were then based on how the proposed objectives will promote a healthy lake ecosystem. While developing the goals and objectives the steering committee considered the public comments and was sensitive to all residents to include strategies and objectives which will achieve the goals and are acceptable to most of the stakeholders. Some original strategies were modified to achieve this.

Key issues were identified and strategies proposed for the following topics:

1. Nutrient and sediment loading
2. Land use issues (planning and zoning) and cooperation of local boards
3. Education of watershed residents on how to protect water quality of the lake
4. User-conflicts for boaters and potential over use by boaters
5. Shoreline and shoreland stewardship
6. Turbidity
7. Fisheries resource
8. Centralized watershed management

The associated management strategies focus on improving water quality and quality of life to optimize ecological benefits to the lake while taking into account the stakeholder's uses in the lake and watershed, including agricultural production, residential, municipal, and recreation.

Distribution List

All members of the steering committee have copy of the lake and watershed management plan. Copies were sent to individuals attending any of the watershed planning meetings and the Marshall and Fulton County Soil and Water Conservation District in the care of Jim Schwanke and Chris Gardner, respectively. The Culver Town Manager and members of the planning and zoning boards were provided a copy. Ten copies of the plan are also available at the Culver-Union Township public library. Electronic copies were provided to the sponsoring organizations (IDEM and LARE) and copies are available free upon request from the LMEC office. In all, 100 paper copies were printed for distribution.

Table of Contents

List of Figures **Page**

List Of Tables **Page**

1.0 Introduction

The purpose of a watershed management plan is to identify ways to improve water quality in a lake and conserve and enhance healthy natural resources in the watershed. Through the process of developing the plan, a community identifies issues, proposes solutions and prioritizes actions for future implementation. By working at the watershed level the project area is clearly defined and the connection is made between water quality problems and their sources. In addition, communities with approved plans are eligible to apply for funding from state and federal agencies for soil and water conservation practices.

This Lake and Watershed Management Plan (LWMP) was developed for Lake Maxinkuckee and its watershed. In the Lake Maxinkuckee watershed nonpoint source pollution is the primary water quality issue. The nonpoint source pollution, specifically nutrients, sediments and bacteria, in Lake Maxinkuckee originate from several sources including: the areas that drain into the streams and ditches leading to the lake, the shoreline, the areas draining directly to the lake, and the lake itself. In addition to nonpoint source concerns, this plan also incorporates the social, recreational, and land use concerns stakeholders expressed at the public meetings.

Culver/Lake Maxinkuckee Community

The Culver/Lake Maxinkuckee watershed area is several sub-communities existing in one small rural Indiana town. One of the more interesting aspects of the area is the diverse backgrounds of the residents. Some people come to the area because of their association with the Culver Academies, some to buy lake property, some are long-time seasonal residents, some are town residents and local business owners, and some are farmers or landowners in the watershed. Despite their various backgrounds or length of time in the area, all need to work together to protect Lake Maxinkuckee. Lake Maxinkuckee is the primary resource of the community and residents have supported the efforts of the local lake and watershed protection group, Lake Maxinkuckee Environmental Council (LMEC) since 1981.

Lake front property owners are directly affected by the quality of the lake. Their property values are related to the water quality, as well as their recreation and aesthetic use of the lake. For example, if the shoreline has an overabundance of aquatic vegetation, is covered with duckweed, foam or algae, or the water is turbid their immediate use and view of the lake is impaired. Lakefront property owners pay a higher real estate price to enjoy the benefits of lakeside living and poor water quality diminishes their experience.

While town and watershed residents may not be directly involved in lake activities, their land use practices contribute to the quality of Lake Maxinkuckee. Crisman, 1986 showed that nearly 60 % of the phosphorus loading is contributed by the three main ditches (Curtiss, Kline and Wilson) that drain water from the watershed. Town residents are also concerned about the loss of public access to the lake and want to keep the lake available for any person to enjoy, not just shoreline property owners.

At this time, Lake Maxinkuckee and the Culver Academies are the main economic engines for local businesses. With the loss of three manufacturing facilities from the community in recent years, most local businesses are dependent upon the trade brought to the community because of the lake and Academies. The tax base to operate the Town of Culver was also reduced with the loss of the Walker Plant, D.W. Wallcovering, and Rickman Tool. There has been a shift in economic activity from manufacturing to service industries, such as restaurants, marine services, and lawn and property care services.

While further development of Culver as a resort and service community fills a gap left by the loss of the industrial base, continual development focused on the lake fosters concerns among residents. This type of focused development could have a detrimental effect on the lake’s water quality and the livability of the community through increased runoff and overuse of the lake.

Culver is a rather isolated community. The closest major highway is 10 miles east of the town which makes traveling here on the smaller rural highways difficult for industrial traffic. However, many residents like the quiet, small town atmosphere. There are ongoing differences of opinions among community residents regarding the future growth of the community. Many agree, with the loss of the industrial base, the Town needs to replace the lost tax dollars with new development, but not all agree on the type of development the community should encourage.

Implementing sound land use practices by <u>all</u> landowners (lakefront, watershed, including agricultural, Town of Culver, and Culver Academies) in the watershed will be necessary. Developing initiatives that foster cooperation among the different stakeholders will the key for achieving the plan’s goals.

One aspect of a new watershed management plan which had not been addressed in previous studies is stakeholder input. The previous studies did not seek this input as it is prescribed today for management plans. They simply were reports on the state of the environment. Over the past 18 years the LMEC has been actively pursuing lake and watershed management strategies, believing an essential factor for success is education.   As the Lake Maxinkuckee watershed experiences increased pressure for development the community works hard to balance the need for an increased tax base with the need to preserve the quality of the lake. Now is a critical time to bring all stakeholders to the table for education, open discussion and input. This is one of the most critical times for the future of Lake Maxinkuckee.

Lake Maxinkuckee is the second largest natural lake in Indiana. It is important to Indiana residents for recreational use (fishing, boating, swimming, education (Culver Academies)) and is the major economic engine for the Culver community. Continuing to work to improve the lake's water quality with an up-to-date management plan will allow this significant natural state resource to continue to provide these opportunities and healthy benefits.

History

"Maxinkuckee," is an Indian word which has been loosely translated to "diamond lake," "clear water," or "gravelly bottom." An exact translation is not known. Lake Maxinkuckee is a 1,854 acre kettle lake located in the southwest corner of Marshall County in Union Township and was formed approximately 15,000 years ago by the receding glaciers. Kettle lakes are depressions in the earth's crust left behind after partially buried ice blocks melt and the depression is filled with water. The lake is 2.6 miles long and 1.6 miles wide with a maximum depth of 88 feet and an average depth of 24 ft.

The area around Lake Maxinkuckee was first home to the Potawatomi Indians, but in 1838 the last of the Indians in northern Indiana were forced by the U.S. Army to march to reservations in Kansas. This event was eventually called the "Trail of Death" because of the many deaths that occurred on the journey. White settlers first began occupying the area around the lake in 1836 and for the next forty years most of the area was used for agriculture. After the Civil War, Lake Maxinkuckee started to develop as a summer resort area. Several clubhouses, rooming houses and small cottages began to appear around the lake. A variety of steamers serviced the transportation needs of the resort goers as well as supplying food and supplies. In 1884 the Vandalia Railroad was completed through Union Township and the depot was located on the north shore of the lake. The railroad provided easy access to the lake and helped popularize Lake Maxinkuckee. Historic accounts estimate that 10,000 people would come to Lake Maxinkuckee on the weekend via the railroad. The late 19th and early 20th centuries saw a dramatic increase in the construction of cottages and large vacation homes on the lake.

The Town of Culver is located on the northwest shore of Lake Maxinkuckee and was laid out in 1844 as Union Town. In 1851 the town was renamed Marmont. The town grew slowly until 1884 when the Vandalia Railroad passed through. During the next four decades the town developed as a major resort area. In 1894, Henry Harrison Culver founded Culver Military Academy on the northern shore of Lake Maxinkuckee. The Academy began with three buildings and approximately 300 acres of land and has since grown to incorporate 37 buildings on approximately 2,000 acres. The Culver Academies is the largest property owner on Lake Maxinkuckee. And in 1895, due to the efforts of Henry H. Culver who founded the Culver Academies, the town's name was changed to Culver.

In 1900 the year-round population of Culver was 500; however, during the summer season that number swelled to over 2,000 when daily excursion trains brought thousands of visitors to the lake. (One can then understand why the Indiana State Board of Health conducted a sanitary survey of the northern end of the lake in 1921.) This massive influx resulted in a building boom in the town. Between the years 1910 and 1920, Culver was Marshall County's fastest growing town. By 1930 Culver's population reached 1,500. The population has remained steady since then with the current population still about 1,500 residents.

Unlike many small towns in Marshall County, Culver retained it economic vitality even with the decline of the railroad. The Culver Academies, the construction of new homes along the lakeshore and an increase in year-round residents resulted in commercial development in the downtown which kept the community economically stable.

Lake Studies and the Lake Maxinkuckee Environmental Council

Between 1899 and 1985 seventeen investigations were conducted on Lake Maxinkuckee. The most extensive survey of the lake was that of the United States Bureau of Fisheries, which maintained a field station on the lake between 1899 and 1914. Barton Warren Evermann and Howard Walton Clark published the results of the work along with the Indiana Department of Conservation in a two volume set in 1920. With the exception of the1921 sampling by the Indiana State Board of Health; no other data on the lake has been found before 1965. Appendix L lists investigations within Lake Maxinkuckee and its watershed.

Appendix A: List of Investigations on Lake Maxinkuckee and the watershed.

In the late 1800's, the Bureau of Fisheries (formerly known as the U.S. Fish Commission) began to study streams and lakes in the United States to learn about the distribution of fishes in response to resolutions from Congress. The studies started trying to cover a wide area, but the investigations were hurried and incomplete. It became evident to the Bureau for the need of more complete knowledge, not only of the fish, but also of the animals and plants associated with them, and of the physical and biological conditions in which they thrive.

In 1899, the Bureau narrowed its focus to glacial lakes in the Upper Mississippi Valley to conduct a study that would serve as a model for the investigation of all similar lakes. The criteria for the chosen lake was that is must not be too large to enable all parts to be reached readily from a central station; should possess no inlets or connecting waters which would complicate the problems; and the lake should be one where there are fishing and angling interests. Lake Maxinkuckee was chosen and on July 5, 1899 a station was established at the Duenweg cottage (Shady Point) on the west side of the lake at the base of the Long Point and continued through 1914. Evermann writes in the introduction, "… they feel that more is known of Lake Maxinkuckee, particularly of its biology, than of any other lake in the world."

During the early 1980's there was a growing concern among shoreline residents the lake's water quality was declining. In 1982, wanting to prevent the lake from becoming eutrophic, the residents of Lake Maxinkuckee supported the formation of the Lake Maxinkuckee Environmental Fund, Inc. (LMEF) – a tax exempt organization charged with raising funds for projects designed to address the lake's water quality problems. Shortly thereafter the LMEF established under its direction and authority the Lake Maxinkuckee Environmental Council (LMEC) to serve as the implementing body for projects funded by the LMEF. Their first project commissioned Dr. Thomas L. Crisman of the University of Florida to conduct a comprehensive study of Lake Maxinkuckee - the "Historical Analysis of the Cultural Eutrophication of Lake Maxinkuckee, Indiana" (Crisman Report, 1986). The Crisman Report,1986 compiled the seventeen known investigations of Lake Maxinkuckee and essentially updating the seminal work begun by Evermann and Clark in 1899. As a point of interest, only one natural glacial lake in the United Stated (located in Montana) has as much comprehensive scientific historical data going back as far as has Lake Maxinkuckee.

The Crisman Report was completed in 1986. It:

1. Delineated the trophic history of Lake Maxinkuckee for the past 100 years;
2. Determined factors that may be contributing to the cultural eutrophication of the lake;
3. Predicted future changes in the water quality of the lake, and;
4. Provided management alternatives to prevent further deterioration of water quality from current levels.

The Crisman Report revealed the water quality had significantly declined in recent years. The lake had remained basically unchanged from the early settlements to the mid- 1960's. From the mid-1960's to the early 1980's the lake's status had changed to bordering on the eutrophic boundary. If nothing was done to protect the lake, the Crisman Report predicted the lake would slip into the eutrophic category within the next 5-10 years and at that point (eutrophic status) restoration efforts would be more difficult and considerably more expensive. A list of 14 recommendations to prevent this from happening was included in the study.

The LMEF continued raising funds and began forming partnerships with area landowners to build three constructed wetlands on the lake's three major inlet ditches. These wetlands would serve to trap the sediment and nutrients flowing into the lake from the watershed. The first project was completed in 1987 on the Wilson Ditch which flows into the lake from the north. It became the first constructed wetland in Indiana. The second constructed wetland was completed in 1990 on the Curtiss Ditch which flows into the lake from the east and the third wetland was constructed on a previously drained wetland area on the south end of the lake – the Maxinkuckee Wetland Conservation Area. Before the wetlands were built, these three ditches contributed 59% of the phosphorus entering the lake. Since their construction these three wetlands have removed up to 85% of the phosphorus which would have otherwise flowed into the lake. Continued stewardship of these wetland areas to keep them functioning has been a priority of the LMEC. Other major projects include:

- Instituting an on-going water quality monitoring program, including chemical and water clarity testing.
- Installation of 4 stormwater treatment units to clean stormwater runoff from the Town of Culver before it empties into the lake. (4 more still needed)
- Creation and adoption of an Erosion Control Ordinance for the Town of Culver and its zoning jurisdiction.
- Working with local governing boards to implement sound land management practices, such as a maximum lot coverage (lakefront lots: the total square footage for all building footprints shall not exceed 60% of the lot)

- Providing educational information to watershed residents through quarterly newsletters and various speaking engagements.

1.1 Watershed partnerships

The bylaws of the LMEC, adopted in 1987, state the members of the Council shall be composed of two members of the farming community, two members from the Culver Academies, three members from Lake Maxinkuckee area, two representatives from the Town of Culver, and one at-large member. This group, representing the various stakeholder groups in the watershed, was the local sponsor and acted as the steering committee during the development of the LWMP. The steering committee met monthly throughout the planning period. The watershed coordinator and the steering committee developed the problems statements; reviewed data; created goals, strategies and objectives to meet the goals; and created the action plan.

Lake Maxinkuckee
Lake and Watershed Management Plan
Steering Committee

Tina Hissong, Watershed Coordinator
Allen Chesser, Chair
Gregg Anderson
Dave Blalok
Dusty Henricks
Anne Johnston
Jim Lemon
Dan Osborn
Bill Rhodes

Pam Buxton
Kevin Berger
Jack Cunningham
Katy Lewallen
Tom Sams

Public Workgroup Members

Patrick Bannon
Joel Fisher
Alex and Deanna Kolosowski
Fred Lane
Herb Rentschler
Ted and Chuckie Strang
Eleanor Swanke
Pete Trone

After a competitive bid process the LMEC selected JF New to conduct the water quality, habitat and biological assessments and assist in writing the plan. D.J. Case & Associates facilitated the first two public meetings. An NRCS specialist also worked with subcommittees during the public input and problem statement development stage.

Prior to the first public meeting a list of key stakeholders was created, which included Culver Chamber of Commerce, Second Century Committee, Lake Maxinkuckee Association (POA), Retail Merchants Association, Culver Plan Commission, Culver Board of Zoning Appeals, Culver Town Council, Culver Town Manager, Young Farmers, Soil and Water Conservation District Supervisor, Bob Robertson (Department of Natural Resources (DNR) Division of Fish and Wildlife), Marshall County Plan Commissioner, Marshall County Drainage Board, Marshall County Surveyor, County Commissioner, Steve Heim – State Representative, Culver Academies, Lion's Club, Kiwanis Club, Homemaker's Club, Tri Kappa, Antiquarian & Historical Society, Culver Community Schools, real estate businesses, local marinas, construction companies, Union Township Assessor. Individual letters were sent requesting their participation in the planning process. A copy of the letter is in Appendix F.

1.2 Public participation

Public participation (outside of the steering committee) began during the first quarter of the grant period with the first public meeting held December 3, 2003 to receive input from stakeholders. Participation in the public meeting was encouraged by the individual letters sent to the key stakeholders mentioned above, articles in the local community paper, The Culver Citizen, and the regional newspaper, The South Bend Tribune, the LMEC newsletter, flyers were posted throughout the community and a postcard was bulk mailed to all residents in the watershed. Forty-two (42) stakeholders attended the meeting

Because of the seasonal nature of lake communities many residents were not in town during the December 3 meeting; therefore, a second public input meeting was held June 25, 2004 to accommodate anyone who wanted to participate, but would have been out of town in December. Forty-three (43) stakeholders attended the meeting. Over 200 comments were recorded at the two meetings. The sign up sheets included an area where attendees could check if they were interested in participating with planning process. Twenty-eight participants signed up and formed a subcommittee to categorize the public input, review problem statements, goals and strategies.

A third public meeting was held on October 13, 2004 to present and discuss the results of the sampling (24 attendees) A fourth public meeting was held June 15, 2005 to review and discuss the goals and strategies developed by the steering committee (21 attendees) . The fifth and final public meeting to present the draft plan was December 15, 2005 (10 attendees).

Throughout the planning process, individuals were encouraged to contact the watershed coordinator with questions or concerns and many individuals who did not participate in the public meetings were able to provide input through this method.

1.3 Concerns

During the beginning phases of the plan's development stakeholders identified a number water quality related concerns for the lake and watershed. Public meetings were the primary avenue for collecting concerns from stakeholders, but individuals did contact the watershed coordinator to express concerns outside of the public meetings. The stakeholders concerns fit broadly into the categories listed below.

Local Government/Land Use
- Stakeholder's expressed concerns about lakeside development and funneling
- The need for adequate planning and zoning to protect the lake from over development
- Political boundaries may not meet current needs: form a governing body to cover the watershed

Watershed
- Stormwater runoff, both urban and agricultural
- Golf courses
- Development and impervious cover – want to keep development pressure under control, both residential and commercial
- Impact of sewers on lake and development

Fish and Wildlife
- Desire for healthy and diverse fish population
- Carp – seem to be a lot of carp in the lake
- Mercury
- Nutrients from birds
- Zebra mussels

Shoreline
- Lakeside septic tanks
- Need more environmentally friendly seawalls and emergent vegetation
- Responsible use of lake side property

In-lake water quality
- Effects of turbidity – from boats and wave action near vertical seawalls
- Impact of lake level

- Buoy placement 200 ft vs. 10 ft water depth
- Amount of foam
- Boating impacts – wakeboarding effects on turbidity, docked boats, workers on the lake
- Need new map of lake depths

Education

- More education on what is good for the lake
- Communicate impact of wetlands
- Need to get information to visitors, not just residents

Recreation

- Keep recreational boating pressure at a non-detrimental level
- Optimal number of watercraft/noise and water pollution
- Wakeboarding effects on turbidity, docked boats, workers on the lake

From 1987 to 1992 the LMEC constructed three wetlands on the three major ditches flowing into the lake to capture some of the sediment and nutrient loading described in the Crisman report. Follow up monitoring after construction showed the wetlands were retaining nutrients and sediments (JFNew, 1993). A follow up study by Crisman showed an increase in water clarity in the lake at the mouth of two of the three ditches (Crisman, 1999). With this background information it was surprising to learn from the 2004 sampling the phosphorus loading to the lake has increased since the USEPA sampling in 1973.

The confidence among the steering committee and stakeholders the wetlands were doing "enough" to control phosphorus runoff from the watershed is evident in their stated concerns. While there were a few comments relating to watershed runoff and it was ranked a priority item, the bulk of the concerns were related to other lake issues. Through the planning process and the water quality sampling it became clear additional work in the watershed needs to be done to reduce phosphorus input, *in addition to* stewarding the constructed wetlands. With this knowledge, implementation will begin with a focus on reducing the phosphorus loading through the Kline, Curtiss and Wilson ditches by working with landowners to increase the use of best management practices on the land in the watershed.

2.0 The Watershed

2.1 Watershed Location

The Lake Maxinkuckee watershed encompasses approximately 8,850 acres in and around Culver, Indiana (Figure 1). Specifically, the watershed is located in Sections 9-11, 13-16, 20-28 and 33-36 in Township 32 North, Range 1 East and Sections 1-3 in Township 31 North, Range 1 East. The Lake Maxinkuckee watershed includes one major public lake, Lake Maxinkuckee. The watershed stretches out to the east and south of the lake covering portions of Aubbeenaubbee Township in

Fulton County and Union Township Marshall County. The lake has three main tributaries, Curtiss Ditch, Kline Ditch, and Wilson Ditch (Figure 2). Curtiss Ditch drains water from 1,563 acres in the eastern portion the watershed, while Wilson Ditch carries water from 1,703 acres north and east of Lake Maxinkuckee. Kline Ditch drains 1,849 acres southeast of the lake, including the entire portion of the watershed located within Fulton County (Figure 3). The remaining 3,718 acres of the watershed drain through small tributaries or directly into Lake Maxinkuckee. The Lake Maxinkuckee watershed, shown in yellow, is part of the larger Lake Maxinkuckee-Lost Lake 14-digit watershed (HUC 05120106060010), shown in yellow and green, which lies within the Tippecanoe River basin (HUC 05120106; Figure 4). Water discharges through the lake's outlet on the western lakeshore and flows through Lost Lake to Wilson Ditch. Wilson Ditch transports water to the Tippecanoe River, ultimately reaching the Wabash River northeast of Lafayette, Indiana.

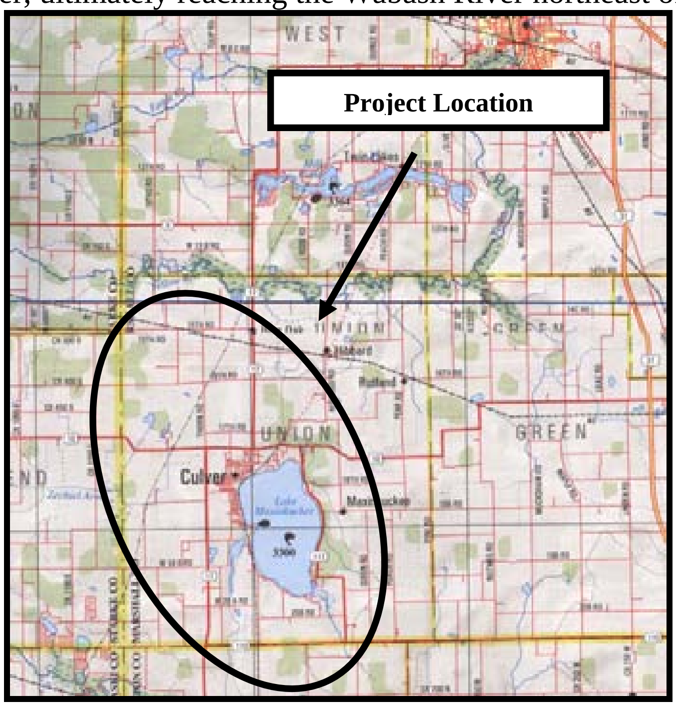

Figure 1. Location map. Source: DeLorme, 1998. Scale: 1"=approximately 2.5 miles.

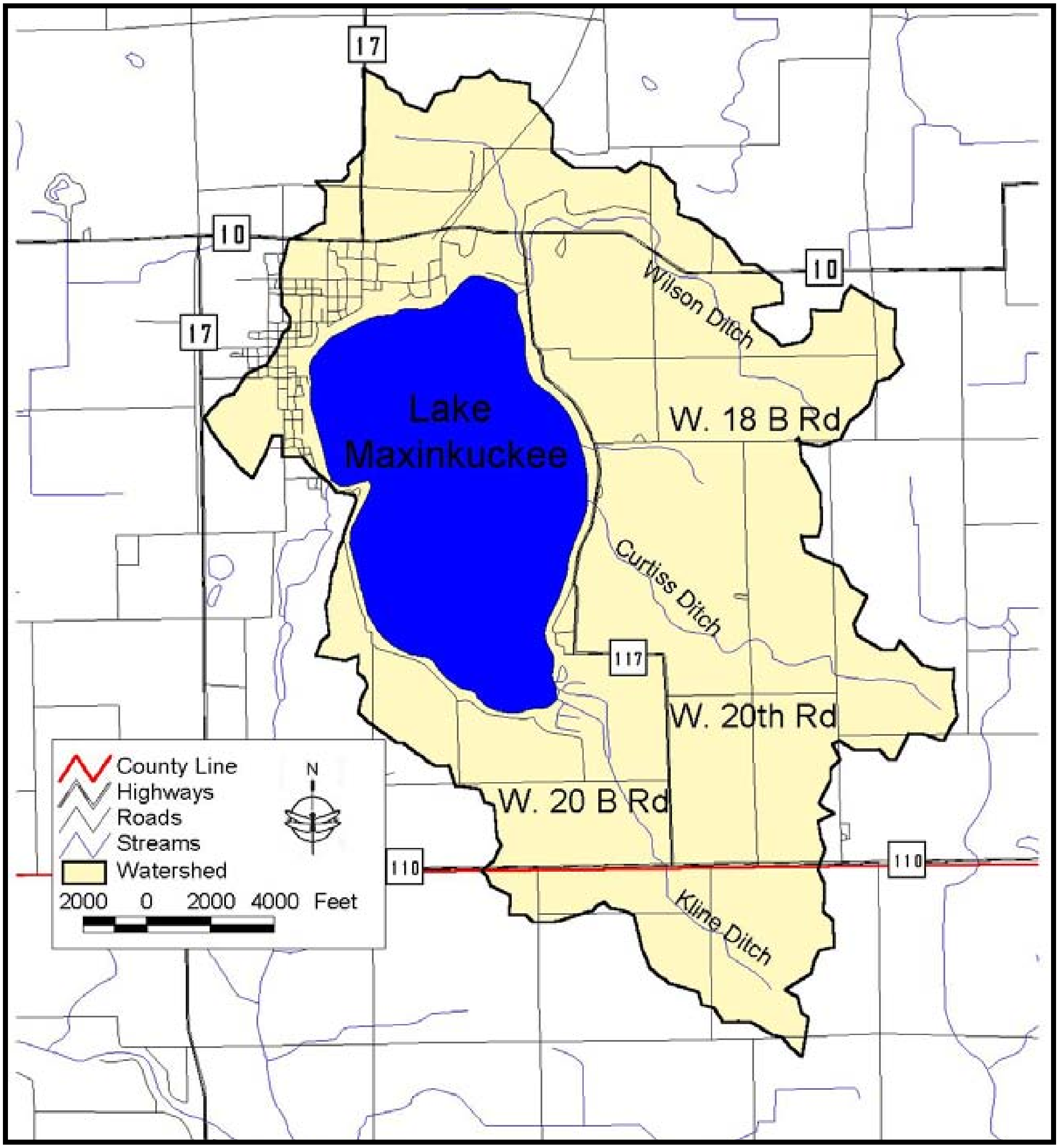

Figure 2. Lake Maxinkuckee watershed. Source: See GIS Appendix G.

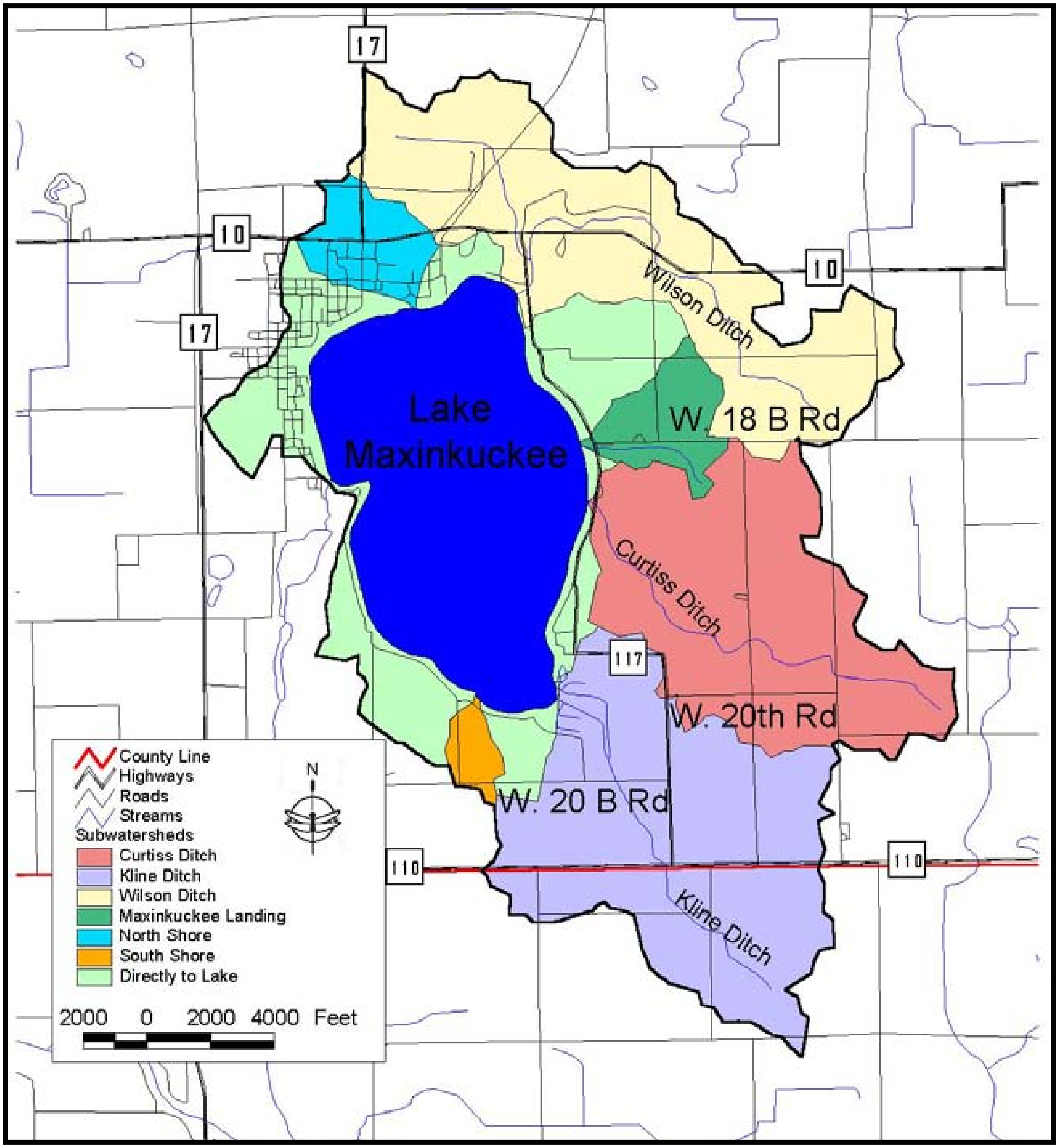

Figure 3. Lake Maxinkuckee subwatersheds. Source: See GIS Appendix G.

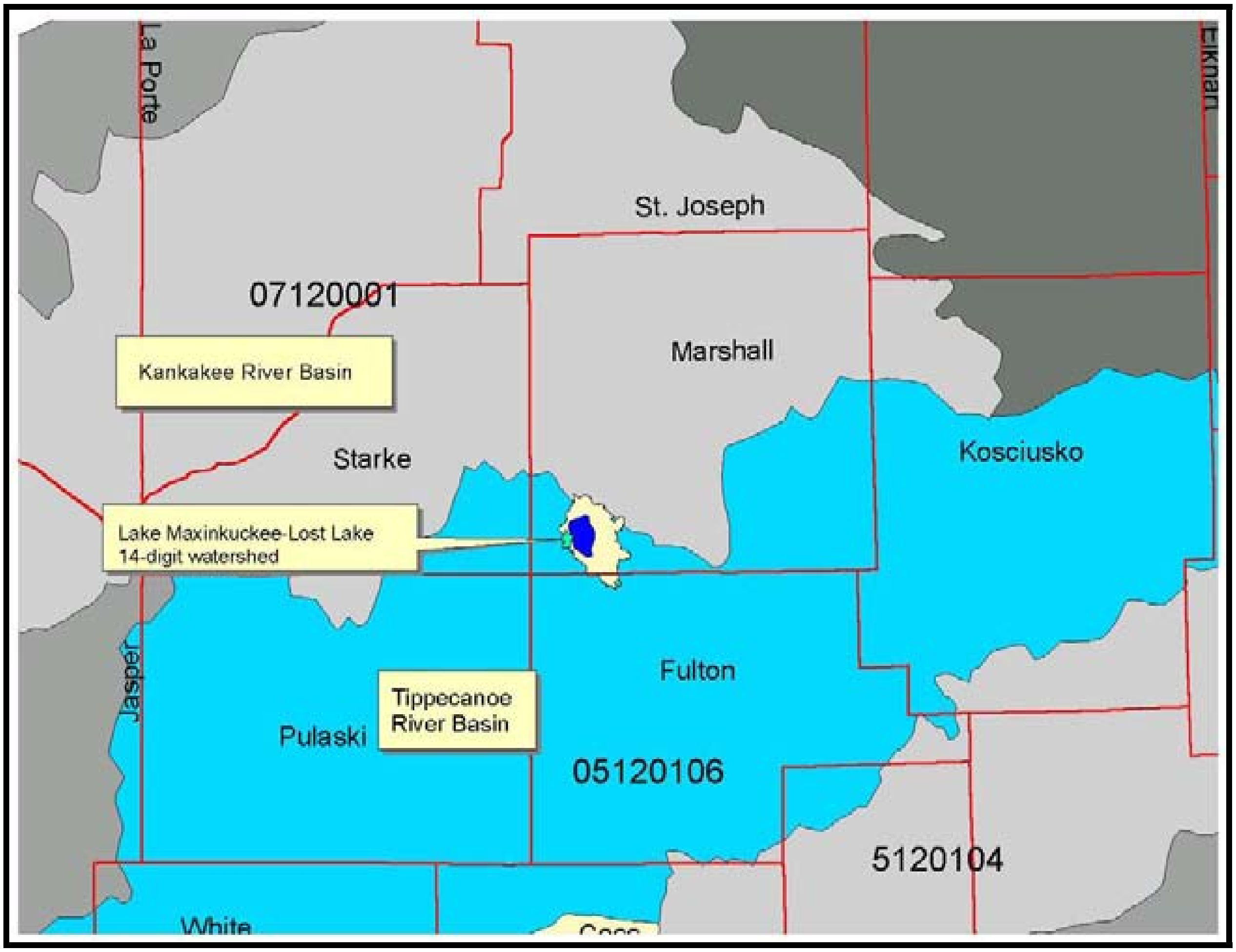

Figure 4. Tippecanoe River watershed. Source: See GIS Appendix G.

2.2 <u>Climate</u>

The climate of Fulton and Marshall Counties have warm summers and cold and snowy winters that are characteristic of northern Indiana. Winters in Fulton and Marshall Counties typically provide enough precipitation, in the form of snow, to supply the soil with sufficient moisture to minimize drought conditions when the hot summers begin. Winters are cold in both counties, averaging 26 to 27º F, while summers are warm, averaging 68 to 71º F. The highest temperature ever recorded in Fulton County was 101º F on September 2, 1953, while Marshall County's highest recorded temperature was 109º F on June 20, 1953. Mild drought conditions occur occasionally during the summer when evaporation is highest. Historic data from 1951-1974 suggest that the growing season (defined as days with an air temperature higher than 40º F) in both Fulton and Marshall Counties is typically 139 days long, although it can last as long as 164 days (Smallwood, 1980; Furr, 1987). The last day of freezing temperatures in spring usually occurs around May 6, while the first freezing temperature in the fall occurs around October 5. During summer, average relative humidity differs greatly over the course of a day averaging 80 percent at dawn and dropping to an average of 60 percent in mid-afternoon. The average annual precipitation is 38.52 inches. Table 1 displays average annual precipitation data for Fulton and Marshall Counties as well as precipitation data for 2004.

Table 1. Monthly rainfall data for year 2004 as compared to average monthly rainfall. Current data (2004) is based on rainfall as measured in Plymouth, Indiana; averages are based on available weather observations taken during the years of 1971-2000.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2004	1.24	0.70	2.64	0.64	7.31	3.99	4.08	8.00	1.76	1.66	4.54	2.71	39.27
Fulton	2.03	1.74	2.70	3.81	4.16	4.12	3.81	3.73	3.36	2.89	3.42	2.74	38.51
Marshall	1.92	1.84	2.87	3.87	3.79	4.20	4.10	3.33	3.62	3.02	3.03	2.93	38.52

Source: Purdue Applied Meteorology Group, 2004.

2.3 Topography and Geology

The advance and retreat of the glaciers in the last ice age shaped much of the landscape observed in Indiana today. As the glaciers moved, they laid thick till material, or ground moraine, over much of the northern two thirds of the state. This ground moraine left by the glaciers covers much of the central portion of the state. In the northern portion of the state, ground moraines, end moraines, lake plains, and outwash plains create a more geologically diverse landscape compared to the central portion of the state. End moraines, formed by the layering of till material when the rate of glacial retreat equaled the rate of glacial advance, add topographical relief to the landscape. Distinct glacial lobes, such as the Michigan Lobe, Saginaw Lobe, and the Erie Lobe, left several large, distinct end moraines, including the Valparaiso Moraine, the Maxinkuckee Moraine, and the Packerton Moraine, scattered throughout the northern portion of the state. Glacial drift and ground moraines cover flatter, lower elevation terrain in northern Indiana. Major rivers in northern Indiana cut through sand and gravel outwash plains. These outwash plains formed as the glacial meltwaters flowed from retreating glaciers, depositing sand and gravel along the meltwater edges. Lake plains, characterized by silt and clay deposition, are present where lakes existed during the glacial age.

The Lake Maxinkuckee watershed lies within the southwestern portion of the Maxinkuckee Moraine. The Maxinkuckee Moraine is a crescent shaped moraine covering approximately 30 to 40 miles of western Marshall County and portions of western St. Joseph and Fulton Counties. The Maxinkuckee Moraine formed when the Huron-Saginaw Lobe of the last Wisconsin Age glacier stalled during its last northeasterly retreat (Wayne, 1966). Movement of the Lake Michigan Lobe from the northwest may have influenced the moraine's formation as well (IDNR, 1990).

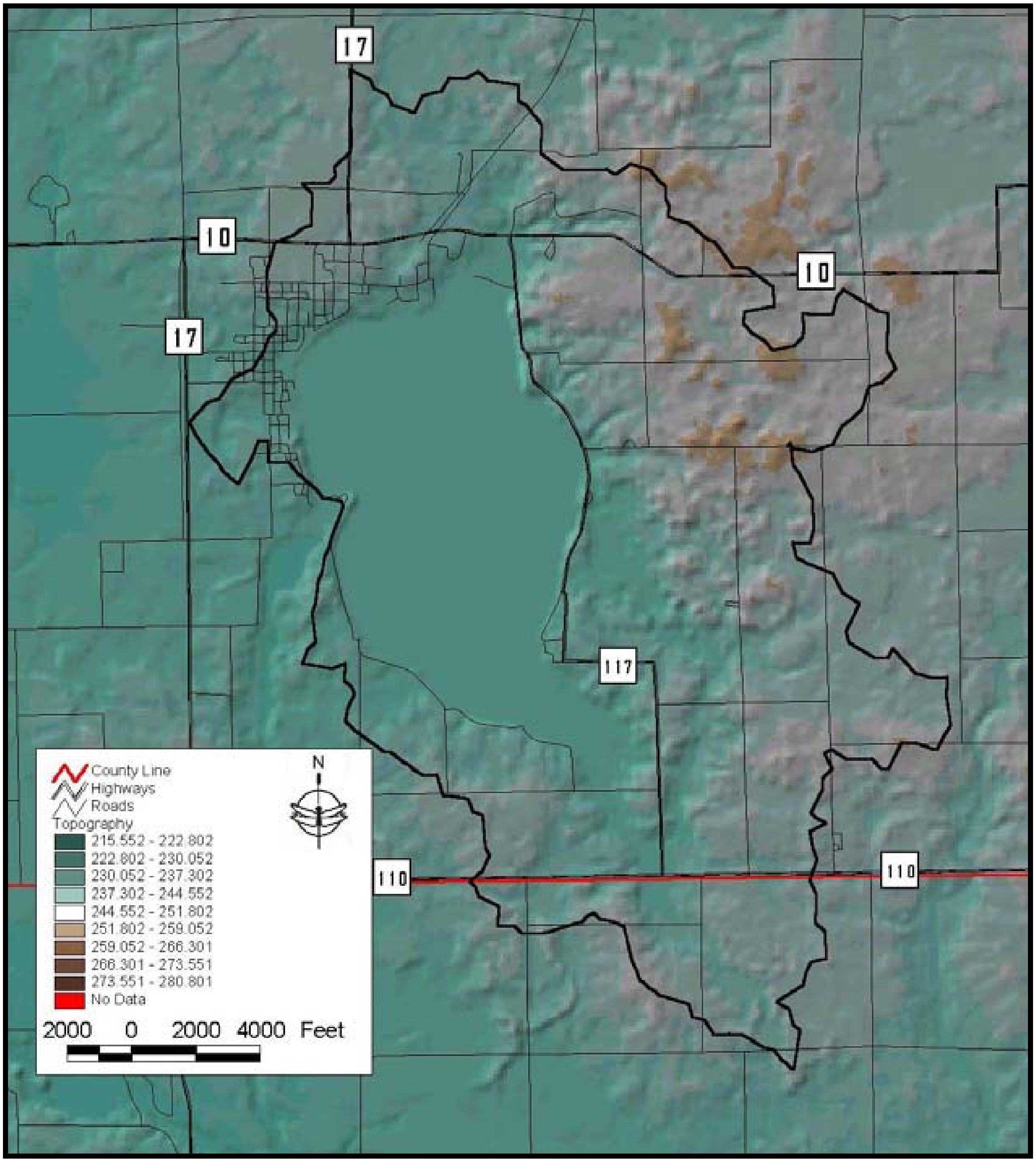

Figure 5. Topographic relief of the Lake Maxinkuckee watershed. Source: See Appendix G.

The watershed's geologic history is responsible for the watershed's topography (Figure 5). As noted previously, Lake Maxinkuckee is a kettle lake, part of the characteristic knob and kettle topography of end moraines. The lake occupies the low spot in the watershed at 733 feet above mean sea level (MSL). The highest elevations in the watershed reach over 850 feet above MSL and lie in the northeastern portion of the watershed just east of the town of Culver (Figure 5). As with most watersheds, the steepest slopes exist in the upper watershed. Steep slopes occur in the headwaters of the Wilson Ditch. Both Curtiss Ditch and Kline Ditch drain flatter land than that drained by Wilson Ditch. Curtiss Ditch and Kline Ditch possess relatively wide valleys, particularly at their confluences with Lake Maxinkuckee. Slopes bordering the eastern shoreline of Lake Maxinkuckee tend to be steeper than western shoreline of the lake. Historical maps and the hydric soil map suggest that Curtiss Ditch and Kline Ditch were historically wetland habitat rather than defined drainage channels.

The watershed's surficial geology covers a less complex bedrock foundation. Antrim shale lies under most of the Lake Maxinkuckee watershed. This bedrock shale is from the Devonian-Mississippian Period. Older Muscatatuck bedrock from the Devonian Period underlies a small portion of the northeastern and southwestern edges of the watershed (Gutschick, 1966).

2.4 Soils

Before detailing the major soil associations covering the Lake Maxinkuckee watershed, it may be useful to examine the concept of soil associations. Major soil associations are determined at the county level. Soil scientists review the soils, relief, and drainage patterns on the county landscape to identify distinct, proportional groupings of soil units. The review process typically results in the identification of eight to fifteen distinct patterns of soil units. These patterns are the major soil associations in the county. Each soil association usually consists of two or three soil units that dominate the area covered by the soil association and several soil units that occupy only a small portion of the soil association's landscape. Soil associations are named for their dominant components. For example, the Riddles-Metea-Wawasee soil association consists primarily of Riddles sandy loam, Metea loamy fine sand, and Wawasee sandy loam.

Because soil scientists developed county soil association maps at different times, soil associations in one county are not always consistent with soil associations in an adjacent county. Smallwood (1980) points to three reasons for the differences observed in soil association maps published at different times: 1. changes in the concepts of soil series occur; 2. variations in the extent of the soils occur; and 3. variations in the slope range allowed in the association occur. Differences between county soil association maps can be the result of one or more of these reasons.

The Fulton County and Marshall County soil association maps were published at different times. The *Soil Survey of Marshall County* (Smallwood, 1980) was issued in 1980, while the *Soil Survey of Fulton County* (Furr, 1987) was published seven years later. Consequently, soil associations in these counties do not agree with one another. Because the Lake Maxinkuckee watershed encompasses part of both counties, the soil associations covering the watershed end abruptly at the county line (Figure 6).

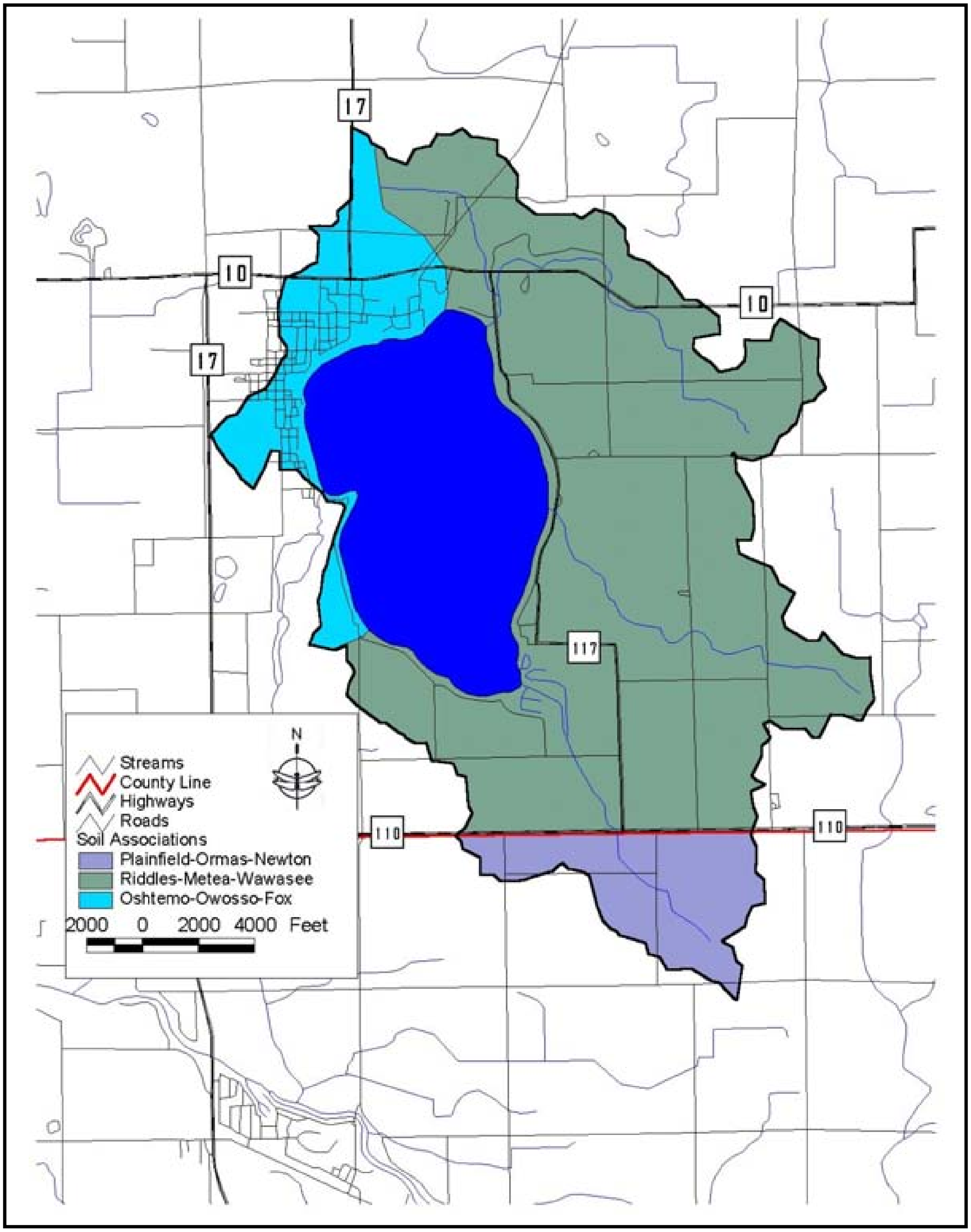

Figure 6. Soil associations present in the Lake Maxinkuckee watershed. Source: See Appendix G.

Three major soil associations cover the Lake Maxinkuckee watershed (Figure 6). Two of these soil associations, Riddles-Metea-Wawasee and Oshtemo-Owosso-Fox, lie within the Marshall County portion of the Lake Maxinkuckee watershed. The Riddles-Metea-Wawasee soil association covers the largest portion of the Lake Maxinkuckee watershed, including the northeastern, eastern, and southern shorelines of Lake Maxinkuckee and extending south to the Marshall County line. This association is the most common soil association found in the county, covering approximately 36% of the landscape. The Oshtemo-Owosso-Fox soil association covers the northern and western shorelines of Lake Maxinkuckee and is the second most common soil association in Marshall County (Smallwood, 1980). The third and final soil association, Plainfield-Ormas-Newton, covers the portion of the watershed located within Fulton County. The following discussion on soil associations in the Lake Maxinkuckee watershed relies heavily on the *Soil Survey of Marshall County* (Smallwood, 1980) and the *Soil Survey of Fulton County* (Furr, 1987). Readers should refer to these sources for a more detailed discussion of soil associations covering the Lake Maxinkuckee watershed.

The Riddles-Metea-Wawasee soil association covers most of the watershed. This soil association is characteristic of morainal areas in Marshall County, such as the Maxinkuckee Moraine. Soils in this association developed from glacial till parent materials. In general, Riddles soils account for approximately 54% of the total soils in the association; Metea soils account for 22%, while Wawasee soils comprise 13% of the soil association. Much of the remaining portion of the soil association consists of hydric soil components lining drainageways. Riddles soils occupy moraine ridges. Metea soils occur on low knolls and sides of moraines. Like Riddles soils, Wawasee soils exist on moraine ridges. Woodlands and forested areas thrive on the Riddles-Metea-Wawasee association; however, the soils' strong slopes may limit agricultural productivity. The strong slopes and sandy texture of the major components of this soil association increase the erosion potential of this soil association. As will be discussed later, most of the watershed's highly erodible soil units are mapped in this section of the watershed. The erodible nature of soils in this area suggests land use management efforts should target this area.

The Oshtemo-Owosso-Fox soil association covers the western and northwestern portions of the watershed immediately west and north of the Lake Maxinkuckee. Soils in the Oshtemo-Owosso-Fox soil association are well drained soils that are found on nearly level to gently sloping landscapes. Oshtemo soils comprise nearly 60% of this association, while Owosso and Fox soils account for 16% and 14%, respectively. Oshtemo soils lie on low knolls and ridges of moraines, Owosso soils are typically located on plains between the moraines, and Fox soils cover the side slopes of knolls and ridges. Minor soil units in the association include Linkville sandy loam, Brady sandy loam, Fluvaquents, and Gilford sandy loam. Farming, sand mining, and residential and urban development are typical uses of this soil type. Slope and poor water filtering limit the use of these soils for septic system effluent.

Soils in the Plainfield-Ormas-Newton soil association cover the entire portion of the Lake Maxinkuckee watershed located in Fulton County in the headwaters of Kline Ditch. This soil association exists in glacial outwash and windblown ridges covered by sand. This association consists of 25% Plainfield soils, 20% Ormas soils, and 15% Newton soils. Brems sand, Chelsea fine sand, Morocco loamy sand, and Metea loamy fine sand are minor soils included in the remaining 40% in the association. Plainfield soils are excessively drained soils located on gently to moderately sloped areas along moraine ridges. Ormas soils are gently to moderately sloping soils and are located along outwash plains. Very poorly drained Newton soils cover low lying areas. Droughtiness, erosion, and water ponding limit the use of this soil association for crops and sanitary effluent treatment.

2.4.1 Highly Erodible Soils and Land

Soils that erode from the landscape are transported to waterways where they degrade water quality, interfere with recreational uses, and impair aquatic habitat and health. In addition, such soils carry attached nutrients, which further impair water quality by increasing plant and algae growth. Soil-associated chemicals, like some herbicides and pesticides, can kill aquatic life and damage water quality.

Highly erodible and potentially highly erodible are classifications used by the Natural Resources Conservation Service (NRCS) to describe the potential of certain soil units to erode from the landscape. The NRCS examines common soil characteristics such as slope and soil texture when classifying soils. The NRCS maintains a list of highly erodible soil units for each county. Table 2 lists the soil units in the Lake Maxinkuckee watershed that the NRCS considers to be highly or potentially highly erodible. As Figure 7 indicates, potentially highly erodible soils cover a substantial portion (3,116 acres or nearly 35%) of the Lake Maxinkuckee watershed. This acreage is spread throughout the watershed. Highly erodible soils exist on approximately 413 acres (approximately 5%) of the watershed. Most of these are located in the eastern portion of the watershed and along the northeastern lakeshore.

Table 2. Highly erodible and potentially highly erodible soils units in the Lake Maxinkuckee watershed.

Soil Unit	Soil Name	County	Detail*	Soil Description
ChC	Chelsea fine sand	Marshall	PHES	2-6% slopes
FsB	Fox sandy loam	Marshall	PHES	2-6% slopes
FsC2	Fox sandy loam	Marshall	PHES	6-12% slopes, eroded
HdB	Hillsdale sandy loam	Marshall	PHES	2-6% slopes
KoC	Kosciusko-Ormas complex	Fulton	PHES	6-12% slopes
MeB	Martinsville loam	Marshall	PHES	2-6% slopes
MeC	Metea loamy sand	Fulton	PHES	6-12% slopes
MeC2	Martinsville loam	Marshall	PHES	6-12% slopes, eroded
MgC	Metea loamy fine sand	Marshall	PHES	6-12% slopes
OsB	Oshtemo loamy sand	Marshall	PHES	2-6% slopes
OsC	Oshtemo loamy sand	Marshall	PHES	6-12% slopes
OsD	Oshtemo loamy sand	Marshall	HES	12-18% slopes
PlC	Plainfield sand	Fulton	PHES	6-12% slopes
PsC	Plainfield sand	Marshall	PHES	3-10% slopes
PsD	Plainfield sand	Marshall	PHES	12-18% slopes
RlB2	Riddles fine sandy loam	Fulton	PHES	2-6% slopes, eroded
RlC2	Riddles fine sandy loam	Fulton	PHES	6-12% slopes, eroded

RsB	Riddles sandy loam	Marshall	PHES	2-6% slopes
RsC2	Riddles sandy loam	Marshall	PHES	6-12% slopes, eroded
RsD	Riddles sandy loam	Marshall	HES	12-18% slopes
TyC	Tyner loamy sand	Marshall	PHES	6-12% slopes
WkB	Wawasee fine sandy loam	Marshall	PHES	2-6% slopes
WkB	Wawasee sandy loam	Fulton	PHES	2-6% slopes
WkC2	Wawasee fine sandy loam	Fulton	PHES	6-12% slopes, eroded
WkC2	Wawasee sandy loam	Marshall	PHES	6-12% slopes, eroded
WkD	Wawasee fine sandy loam	Fulton	HES	12-18% slopes
WmD3	Wawasee sandy clay loam	Marshall	HES	12-18% slopes, severely eroded

*HES=Highly Erodible Soils; PHES=Potentially Highly Erodible Soils
Source: Smallwood, 1980; Furr, 1987; USDA/SCS Indiana Technical Guide II-C for Fulton County, 1993; USDA/SCS Indiana Technical Guide II-C for Marshall County, 1993

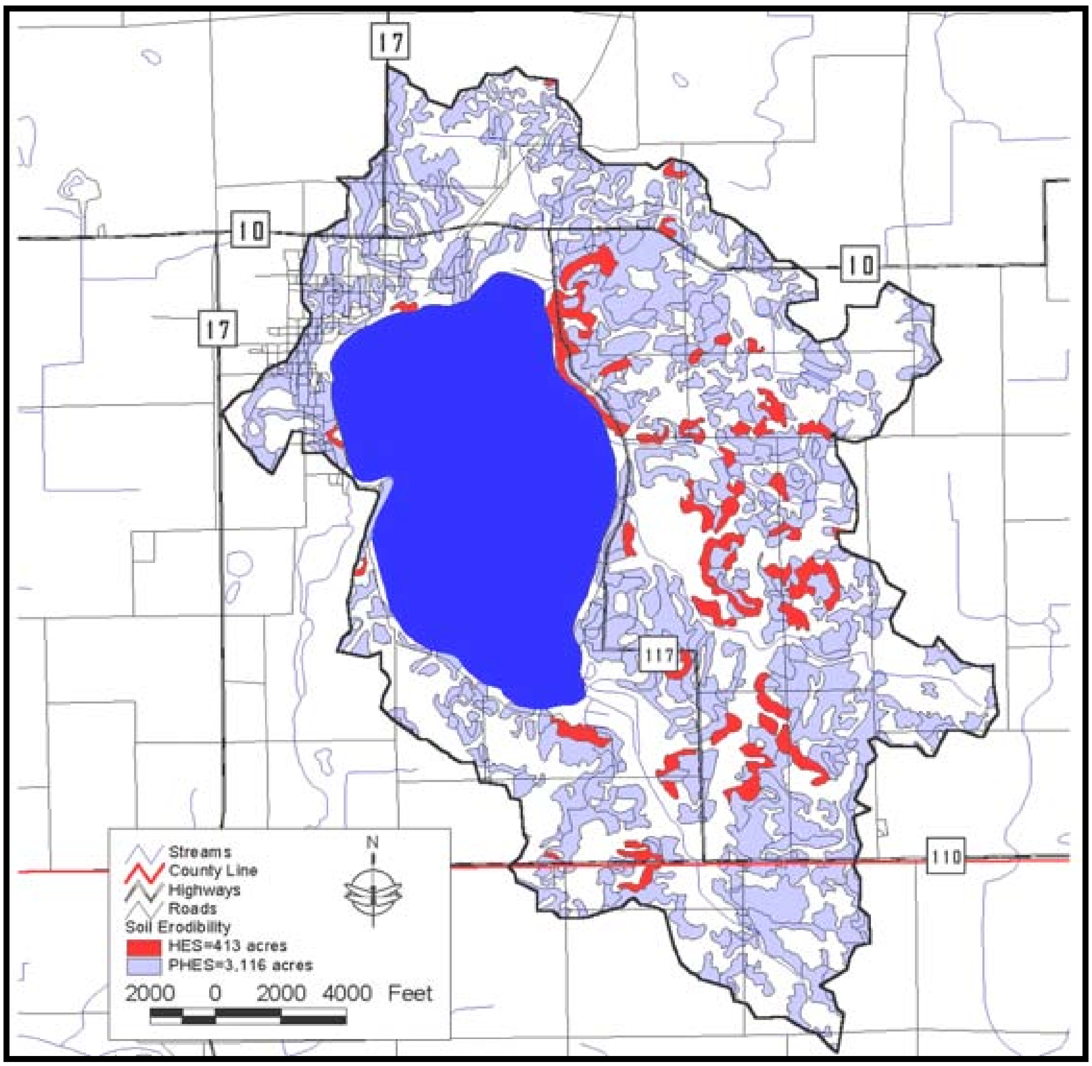

Figure 7. Highly erodible and potentially highly erodible soils in the Lake Maxinkuckee watershed. Source: See Appendix G.

2.4.2 Soils Used for Wastewater Treatment

As is common in many areas of Indiana, septic tanks and septic tank absorption fields are utilized for wastewater treatment throughout much of the Lake Maxinkuckee watershed (shown in yellow in Figure 8). This type of wastewater treatment system relies on the septic tank for primary treatment to remove solids and the soil for secondary treatment to reduce the remaining pollutants in the effluent to levels that protect surface and groundwater from contamination. The soil's ability to sequester and degrade pollutants in septic tank effluent will ultimately determine how well surface and groundwater is protected.

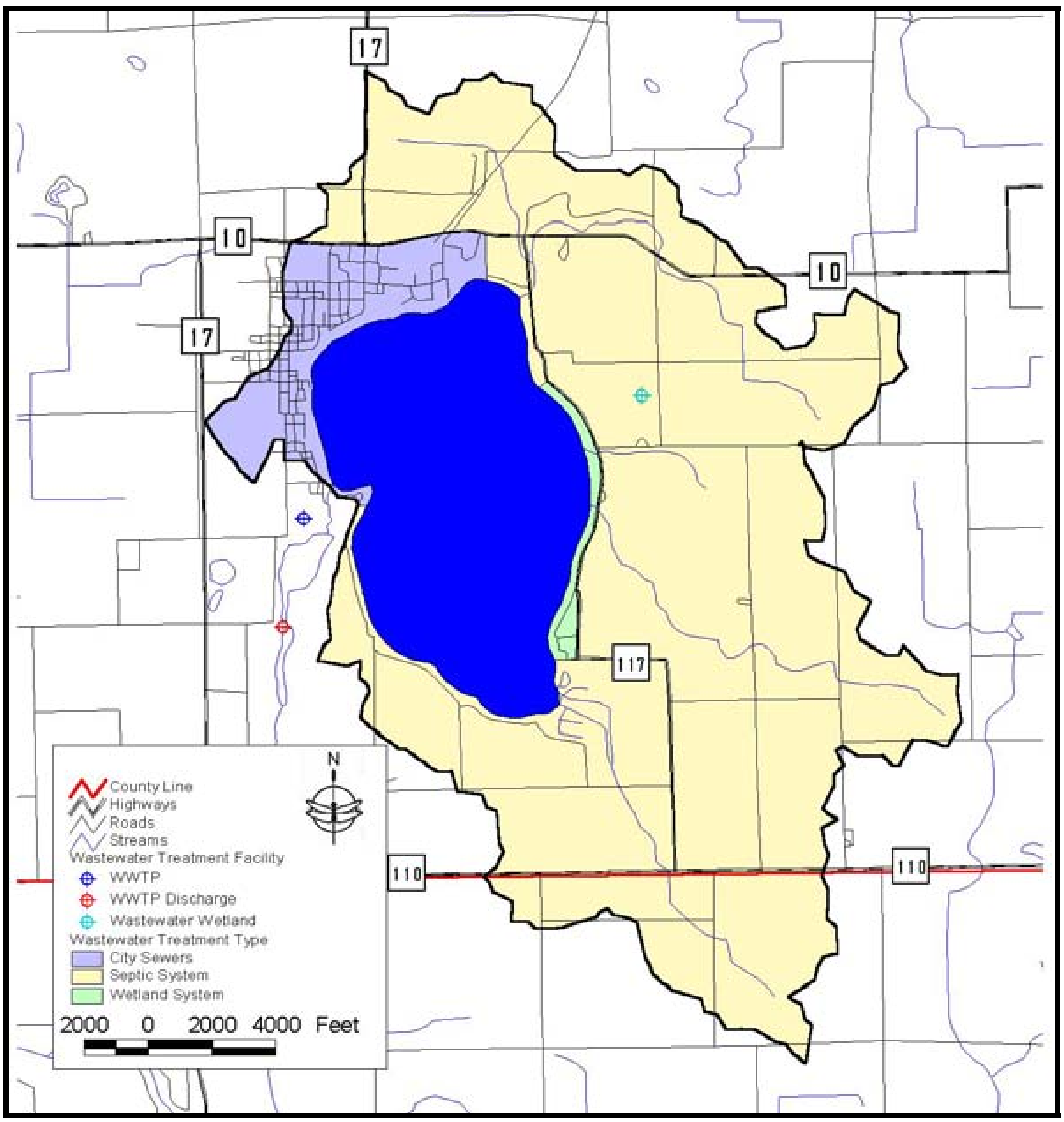

Figure 8. Sewer and septic tank system usage in the Lake Maxinkuckee watershed. Source: See Appendix B.

A variety of factors can affect a soil's ability to function as a septic absorption field. Seven soil characteristics are currently used to determine soil suitability for on-site sewage disposal systems: position in the landscape, slope, soil texture, soil structure, soil consistency, depth to limiting layers, and depth to seasonal high water table (Thomas, 1996). The ability of soil to treat effluent (waste discharge) depends on four factors: the amount of accessible soil particle surface area; the chemical properties of the soil surface; soil conditions like temperature, moisture, and oxygen content; and the types of pollutants present in the effluent (Cogger, 1989).

The amount of accessible soil particle surface area depends both on particle size and porosity. Because they are smaller, clay particles have a greater surface area per unit volume than silt or sand, and therefore, a greater potential for chemical activity. However, soil surface only plays a role if wastewater can contact it. Soils of high clay content or soils that have been compacted often have few pores that can be penetrated by water and are not suitable for septic systems because they are too impermeable. Additionally, some clays swell and expand on contact with water closing the larger pores in the profile. On the other hand, very coarse soils may not offer satisfactory effluent treatment because the water can travel rapidly through the soil profile. Soils located on sloped land also may have difficulty in treating wastewater due to reduced contact time.

Chemical properties of the soil surfaces are also important for wastewater treatment. For example, clay materials all have imperfections in their crystal structure which gives them a negative charge along their surface. Due to their negative charge, clays can bond cations of positive charge to their surfaces. However, many pollutants in wastewater are also negatively charged and are not attracted to the clays. Clays can help remove and inactivate bacteria, viruses, and some organic compounds.

Environmental soil conditions influence the microorganism community which ultimately carries out the treatment of wastewater. Factors like temperature, moisture, and oxygen availability influence microbial action. Excess water or ponding saturates soil pores and slows oxygen transfer. The soil may become anaerobic if oxygen is depleted. The decomposition process (and therefore, effluent treatment) becomes less efficient, slower, and less complete if oxygen is not available.

Many of the nutrients and pollutants of concern are removed safely if a septic system is sited correctly. Most soils have a large capacity to hold phosphate. On the other hand, nitrate (the end product of nitrogen metabolism in a properly functioning septic system) is very soluble in soil solution and is often leached to the groundwater. Care must be taken in siting the system to avoid well contamination. Nearly all organic matter in wastewater is biodegradable as long as oxygen is present. Pathogens can be both retained and inactivated within the soil as long as conditions are right. Bacteria and viruses are much smaller than other pathogenic organisms associated with wastewater, and therefore, have a much greater potential for movement through the soil. Clay minerals and other soil components may adsorb them, but retention is not necessarily permanent. During storm flows, these bacteria and viruses may become resuspended in the soil solution and transported in the soil profile. Inactivation and destruction of pathogens occurs more rapidly in soils containing oxygen because sewage organisms compete poorly with the natural soil microorganisms, which are obligate aerobes requiring oxygen for life. Sewage organisms live longer under anaerobic conditions and at lower soil temperatures because natural soil microbial activity is reduced.

The Natural Resources Conservation Service has ranked each soil series in terms of its limitations for use as a septic tank absorption field. Each soil series is placed in one of three categories: slightly limited, moderately limited, or severely limited. Use of septic absorption fields in moderately or severely limited soils generally requires special design, planning, and/or maintenance to overcome the limitations and ensure proper function. Table 3 summarizes the soil series in the Lake Maxinkuckee watershed in terms of their suitability for use as septic tank absorption fields. Figure 9 displays the septic tank absorption field suitability of soils mapped in the Lake Maxinkuckee watershed.

Figure 9 also shows the portions of the watershed where wastewater drains to a sewer system and treated off-site. All residences within the incorporated portion of Culver, including the Culver Academies, are hooked into the city sewer system. Wastewater is collected at the treatment plant located south of town, cleaned, and discharged into Wilson Ditch downstream of Lost Lake (Figure 8). Residences along the eastern shoreline from just south of 18th Road south to State Road 117 utilize a wastewater treatment wetland. Approximately 85 of the 115 homes located within the demarcated area (shown in green) are hooked into the wastewater wetland system. Water is pumped from these homes to the wastewater wetland east of the lake (Figure 8). The remainder of the homes along the Lake Maxinkuckee shoreline utilizes individual septic systems to treat their wastewater.

Table 3. Soil types present in the Lake Maxinkuckee watershed.

Symbol*	**Name**	**County**	**High Water Table**	**Suitability for Septic Tank Absorption Field**
Ad	Adrian muck	Fulton	+1.0-1.0 ft	Severe: ponding, poor filter
Ad	Adrian muck	Marshall	+0.5-1.0 ft	Severe: ponding
AuA	Aubbeenaubbee sandy loam	Marshall	1-3 ft	Severe: wetness
Bb	Barry loam	Fulton	+1.0.-1.0 ft	Severe: ponding
Bd	Brady sandy loam	Marshall	+1-3 ft	Severe: wetness, poor filter
BeA	Brems sand	Marshall	2-3 ft	Severe: wetness, poor filter
BoA	Bronson loamy sand	Marshall	2-3.5 ft	Severe: wetness, poor filter
Br	Brady sandy loam	Fulton	1-3 ft	Severe: ponding, wetness
Br	Brookston loam	Marshall	+0.5-1.0 ft	Severe: ponding
ChB-ChC	Chelsea fine sand	Fulton; Marshall	>6 ft	Severe: poor filter
CrA	Crosier loam	Fulton	1-3 ft	Severe: poor filter, wetness
CtA	Crosier loam	Marshall	1-3 ft	Severe: percs slowly, wetness
Ed	Edwards muck	Fulton; Marshall	+0.5-0.5 ft	Severe: ponding, percs slowly
FsA-FsB; FsC2	Fox sandy loam	Marshall	>6 ft	Severe: poor filter
Gf	Gilford fine sandy loam	Fulton	+0.5-1.0 ft	Severe: ponding, poor filter

Symbol*	Name	County	High Water Table	Suitability for Septic Tank Absorption Field
Gf	Gilford sandy loam	Marshall	+0.5-1.0 ft	Severe: ponding, poor filter
HdB	Hillsdale sandy loam	Marshall	>6 ft	Moderate: percs slowly
Hh	Histosols-Aquolls complex	Fulton	--	--
Hm; Ho; Hp	Houghton muck	Fulton; Marshall	+1.0-1.0 ft	Severe: ponding, percs slowly
KoC	Kosciusko-Ormas complex	Fulton	>6 ft	Severe: poor filter
MaA	Markton loamy sand	Fulton	1-3 ft	Severe: wetness
MeA-MeC	Metea loamy sand	Fulton	>6 ft	Severe: poor filter
MeA-MeB	Martinsville loam	Marshall	>6 ft	Slight
MeC2	Martinsville loam	Marshall	>6 ft	Moderate: slope
MgB	Metea loamy fine sand	Marshall	>6 ft	Moderate: percs slowly
MgC	Metea loamy fine sand	Marshall	>6 ft	Moderate: percs slowly, slope
Mu	Morocco loamy sand	Fulton	1-2 ft	Severe: wetness, percs slowly
Ne	Newton fine sandy loam	Fulton	+0.5-1.0 ft	Severe: ponding, poor filter
OsA-OsB	Oshtemo loamy sand	Marshall	>6 ft	Slight
OsC-OsD	Oshtemo loamy sand	Marshall	>6 ft	Moderate-Severe: slope
OwA	Owosso sandy loam	Marshall	>6 ft	Moderate: percs slowly
Pa	Palms muck	Marshall	+0.5-1.0 ft	Severe: ponding
PlA-PlC; PsA; PsC	Plainfield sand	Fulton; Marshall	>6 ft	Severe: poor filter
PsD	Plainfield sand	Marshall	>6 ft	Severe: poor filter, slope
Re	Rensselaer loam	Marshall	+1.5-1.0 ft	Severe: ponding, percs slowly
RlA; RlB2	Riddles fine sandy loam	Fulton	>6 ft	Moderate: percs slowly
RlC2	Riddles fine sandy loam	Fulton	>6 ft	Moderate: percs slowly, slope
RsA-RsB	Riddles sandy loam	Marshall	>6 ft	Moderate: percs slowly
RsC2	Riddles sandy loam	Marshall	>6 ft	Moderate: percs slowly, slope
RsD	Riddles sandy loam	Marshall	>6 ft	Severe: slope
Tx	Troxel silt loam	Marshall	+0.5-0 ft	Severe: ponding
TyA-TyC	Tyner loamy sand	Marshall	>6 ft	Severe: poor filter
Ua	Udorthents	Marshall	--	--
Wa	Wallkill silt loam	Fulton	+0.5-1.0 ft	Severe: ponding, poor filter
Wa	Wallkill loam	Marshall	+0.5-0.5 ft	Severe: ponding
Wh	Washtenaw silt loam	Fulton; Marshall	+0.5-1.0 ft	Severe: ponding, percs slowly
WkB	Wawasee fine sandy loam	Fulton	>6 ft	Moderate: percs slowly
WkB	Wawasee sandy loam	Marshall	>6 ft	Slight
WkC2	Wawasee fine sandy loam	Fulton	>6 ft	Moderate: slope, percs slowly
WkC2	Wawasee sandy loam	Marshall	>6 ft	Moderate: slope
WkD	Wawasee fine sandy loam	Fulton	>6 ft	Severe: slope
WmD3	Wawasee sandy clay loam	Marshall	>6 ft	Severe: slope
Wt	Whitaker loam	Marshall	1-3 ft	Severe: wetness

*Different counties may use the same symbol for different soil units. Similarly, different counties may use different symbols for the same soil units. Source: Smallwood, 1980; Furr, 1987.

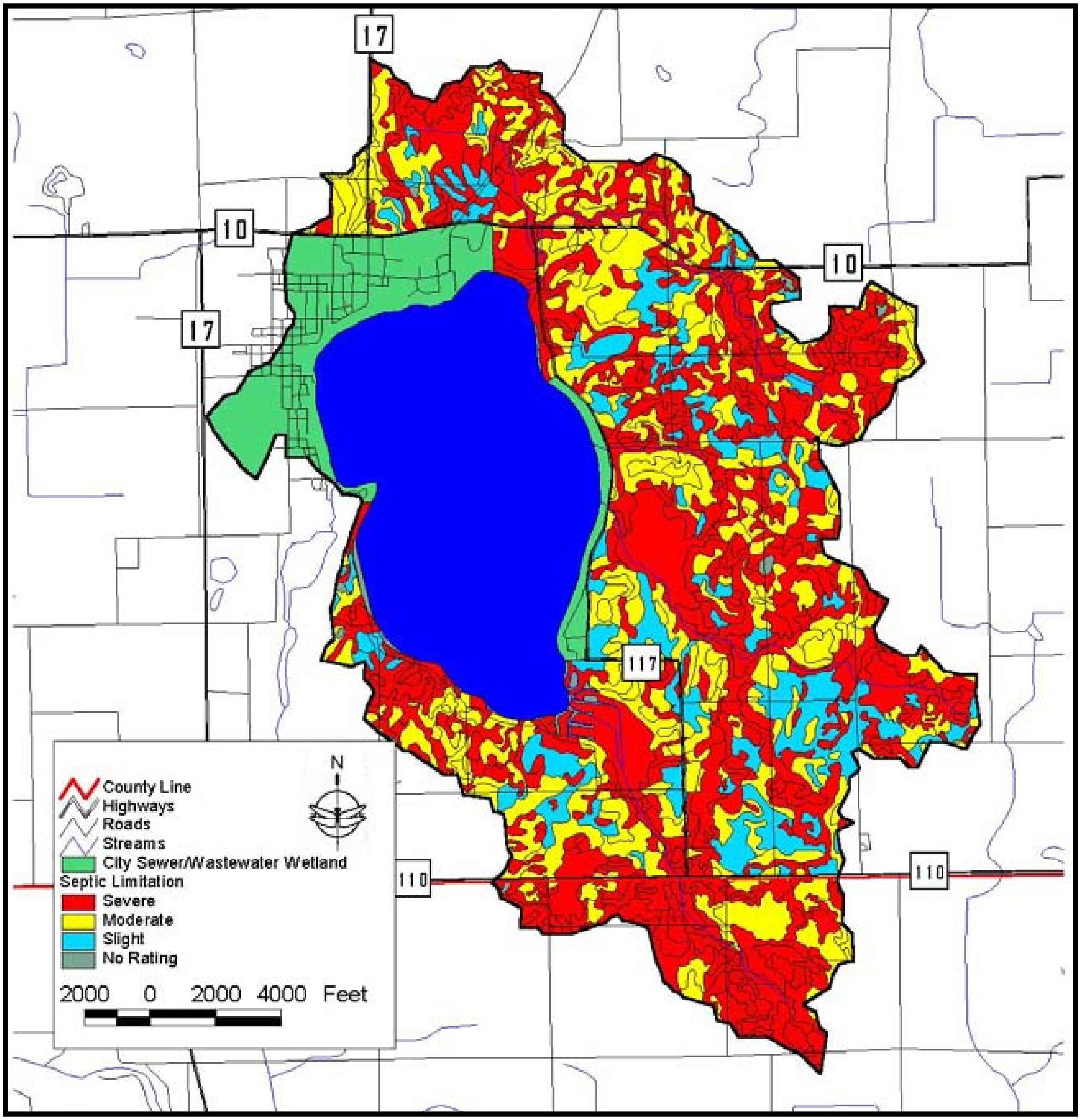

Figure 9. Soil series septic tank absorption field suitability. Source: See Appendix G.

2.5 <u>Natural History</u>

Geographic location, climate, geology, topography, soils, and other factors play a role in shaping the native floral and faunal communities in a particular area. Various ecologists (Deam, 1921; Petty and Jackson, 1966; Homoya, 1985; Omernik and Gallant, 1988) have divided Indiana into several natural regions or ecoregions, each with similar geographic history, climate, topography, and soils. Because the groupings are based on factors that ultimately influence the type of vegetation present in an area, these natural areas or ecoregions tend to support characteristic native floral and faunal communities. Under many of these classification systems, the Lake Maxinkuckee watershed lies at or near the transition between two or more regions. For example, the watershed lies at the western boundary separating Homoya's Northern Lakes Natural Area to the east from the Grand Prairie Natural Area to the west. Similarly, the Lake Maxinkuckee watershed lies in Omernik and Gallant's Eastern Corn Belt Plains (ECBP) ecoregion south of the point where the ECBP ecoregion meets the Central Corn Belt Plains and Southern Michigan/Northern Indiana Till Plains ecoregions. As a result, the native floral community of the Lake Maxinkuckee watershed likely consisted of components of neighboring natural areas and ecoregions in addition to components characteristic of the natural area and ecoregion in which it is mapped.

Prior to European settlement of Union Township, dense oak-hickory forests covered the Lake Maxinkuckee watershed (Historic Landmarks Foundation, 1990). Chamberlain (1849) describes the area as being heavily timbered with oak openings or barrens covered by wet or dry prairies and lakes. White oak was the dominant component of the heavily timbered areas with shagbark hickory, maple, beech, elm, walnut, butternut, and red and black oak as subdominants (McDonald, 1908; Petty and Jackson, 1966; Omernik and Gallant, 1988). White, red, and black oak, bur oak, and hickory as well as sugar maple and beech also grew in the watershed but likely not to the extent observed throughout northern Indiana (McDonald, 1908). Petty and Jackson (1966) list pussy toes, common cinquefoil, wild licorice, tick clover, blue phlox, waterleaf, bloodroot, Joe-pye-weed, woodland asters and goldenrods, wild geranium, and bellwort as common components of the forest understory in the watershed's region.

Historical accounts document the presence of unbroken forests and heavily timbered areas along the shores of Lake Maxinkuckee (Thompson, 1856; McDonald, 1908). Farrar's woods was the most notable forest in the early 1900s; oak, hickory, elm, willow, poplar, sassafras, and a variety of bushes vegetated this tract (Evermann and Clark, 1920). Thompson (1856) documented the presence of hundreds of springs along the shoreline and across the lake bottom and noted the lack of plants within the lake and the presence of a clean sand and gravel substrate. McDonald (1908) supports these observations noting the lack of inlet streams, grass, plants, or other "unsightly" items around the lake, and little brush, trees, logs, or other debris along the shoreline. Evermann and Clark (1920) describe the presence of a number of wetlands along the lakeshore. These areas were located near the mouth of present day Wilson Ditch, along the shoreline and extending to the head of present day Curtiss Ditch, near the outlet stream, and along the southern tip of the lake. Blue-joint grass, sedges, low willows, mountain holly, chokeberry, cotton grass, and pitcher plants vegetated wetlands adjacent to Lake Maxinkuckee (Evermann and Clark, 1920).

Wet habitat (ponds, marshes, and swamps) intermingled with the upland habitat throughout the Lake Maxinkuckee watershed. The hydric soil map and an 1876 map of Marshall County indicate that wetland habitat existed along the northeastern, eastern, and southern shorelines of Lake Maxinkuckee and in small openings throughout the watershed. These wet habitats supported very different vegetative communities than the drier portions of the landscape. Swamp loosestrife, cattails, soft stem bulrush, marsh fern, marsh cinquefoil, pickerel weed, arrow arum, and sedges dominated the marsh habitat throughout the watershed. Within the lake itself, common species included pondweeds, spatterdock, white water lilies, watershield, eel grass, and coontail (Evermann and Clark, 1920). Swamp habitat likely covered the scattered shallow depressions at higher topographical elevations in the watershed. Typical dominant swamp species in the area included red and silver maple, green and black ash, and American elm (Homoya, 1985). Smallwood (1980) adds swamp white oak to the list of dominants in swamp habitat throughout the county.

2.6 Endangered Species

The Indiana Natural Heritage Data Center Database provides information on the presence of endangered, threatened, or rare species, high quality natural communities, and natural areas in Indiana. The Indiana Department of Natural Resources (IDNR) developed the database to assist in documenting the presence of special species and significant natural areas and to serve as a tool for setting management priorities in areas where special species or habitats exist. The database relies on observations from individuals rather than systematic field surveys by the IDNR. Because of this, it does not document every occurrence of special species or habitat. At the same time, the listing of a species or natural area does not guarantee that the listed species is currently present or that the listed area is in pristine condition. The database includes the date that the species or special habitat was last observed in a specific location.

Appendix H presents the results from the database search for the Lake Maxinkuckee watershed. (For additional reference, Appendix H also provides a listing of endangered, threatened, and rare species documented in Fulton and Marshall Counties.) The database records the presence or historical presence of ten state endangered animal species including four birds and six reptiles: the least bittern (*Ixobrychus exilis*), king rail (*Rallus elegans*), Virginia rail (*Rallus limicola*), marsh wren (*Cistothorus palustris*), spotted turtle (*Clemmys guttata*), Kirtland's snake (*Clonophis kirtlandii*), Blanding's turtle (*Emydoidea blandingii*), eastern massasauga (*Catenatus sistrurus*), ornate box turtle (*Emydoidea blandingii*), and Butler's garter snake (*Thamnophis butleri*). The Virginia rail and marsh wren sightings are fairly recent (1994 and 1995, respectively), while the king rail (1927), spotted turtle (1906), Kirtland's snake (1906), Blanding's turtle (1954), eastern massasauga (1899 and 1900), ornate box turtle (1935), and Butler's garter snake (1900) are older. The least bittern has been spotted both recently (1995) and historically (1926). The database contains four additional animal records, including two state species of special concern, the hooded warbler (*Wilsonia citrina*) and cerulean warbler (*Dendoica cerulea*). Two species that are not listed as endangered, threatened, or rare, but their rarity warrants concern are the Ohio lamprey (*Ichtymyzon bdellium*) and the great blue heron (*Ardea herodias*).

The database also documents the occurrence of six state endangered plant species in the watershed. Horse-tail spikerush (*Eleocharis equisetoides*), Fries' pondweed (*Potamogeton friesii*), straight-leaf pondweed (*Potamogeton strictifolius*), and hairy valerian (*Valeriana edulis*) are all state endangered species. The horse-tail spikerush (1926), straight-leaf pondweed (1900), and hairy valerian (1920) observations occurred early in the twentieth century. The pondweed listings are fairly recent (1999), and the database places their occurrence throughout Lake Maxinkuckee. The database also includes two state rare species, small white lady's slipper (*Cypripedium candidum*) and slender pondweed

(*Potamogeton pusillus*). The database places the lady's slipper near the southern portion of the lake, while the pondweed was documented throughout Lake Maxinkuckee. The pondweed's sighting is fairly recent (1999); however, the observation of the lady's slipper occurred in 1920.

2.7 Hydrology

As is characteristic of much of the glaciated portion of the state, hydrological features, including streams, wetlands, and lakes, are important components of the Lake Maxinkuckee watershed landscape. Three major inlets flow into Lake Maxinkuckee. These are Wilson Ditch, Curtiss Ditch, and Kline Ditch. Wilson Ditch is the longest of the three channels measuring approximately 4.3 miles in length, while Curtiss Ditch (2.5 miles) and Kline Ditch (3.5 miles) are slightly shorter. Vegetated wetlands cover approximately 5.2% of the watershed (Figure 10). Several ponds are scattered throughout the watershed. One lake, Lake Maxinkuckee, exists within the watershed. Lake Maxinkuckee is 1,854 acres in size with a mean depth of 24 feet and a maximum depth of 88 feet. The lake is approximately 1.5 miles wide and 2.5 miles long. Combined, wetlands, ponds, and lakes cover approximately 26.5% of the watershed (Table 4).

Table 4. Acreage and classification of wetland habitat in the Lake Maxinkuckee watershed.

Wetland Type	**Area (acres)**	**Percent of Watershed**
Lake	1886.7	21.3%
Herbaceous	207.7	2.3%
Forested	202.7	2.3%
Shrubland	15.9	0.2%
Submergent	3.1	0.0%
Ponds	27.9	0.3%
Total	**2343.9**	**26.5%**

Humans have altered many of the watershed's natural hydrological features. Some portions of the stream channels still maintain elements of their historical structure. Evermann and Clark (1920) document three main stream channels flowing to Lake Maxinkuckee totaling approximately 6.5 miles or 34,320 linear feet in length. Current maps indicate that stream channels total approximately 56,460 linear feet or nearly 10.7 miles. An additional 4.2 miles of stream channel have been created over the past 85 years. Evermann and Clark (1920) describe Wilson Ditch (Culver Creek) as a marsh over two miles in length which flows generally southwest before entering Lake Maxinkuckee. An additional two miles of stream channel, which forms the western branch of Wilson Ditch, was dug at least partly through historical wetland areas. McDonald (1908) documents the installation of over 300 miles of drainage tile within the acreage owned by the H.H. Culver in order to drain and farm the land. Curtiss Ditch (Aubbeenaubbee Creek) also originated as a wetland approximately two miles from the lake. A mixture of sand and muck substrate covered the upper portion of the channel bed, while muck substrate and marshy vegetation covered the lower portion of the channel. The stream has been channelized to drain historical wetland areas. Kline Ditch (Norris Inlet) originated as a small spring approximately two and one-half miles southeast of Lake Maxinkuckee and flowed through a marsh immediately south of the lake. Like Wilson and Curtiss Ditches, Kline Ditch has been channelized to drain wetlands.

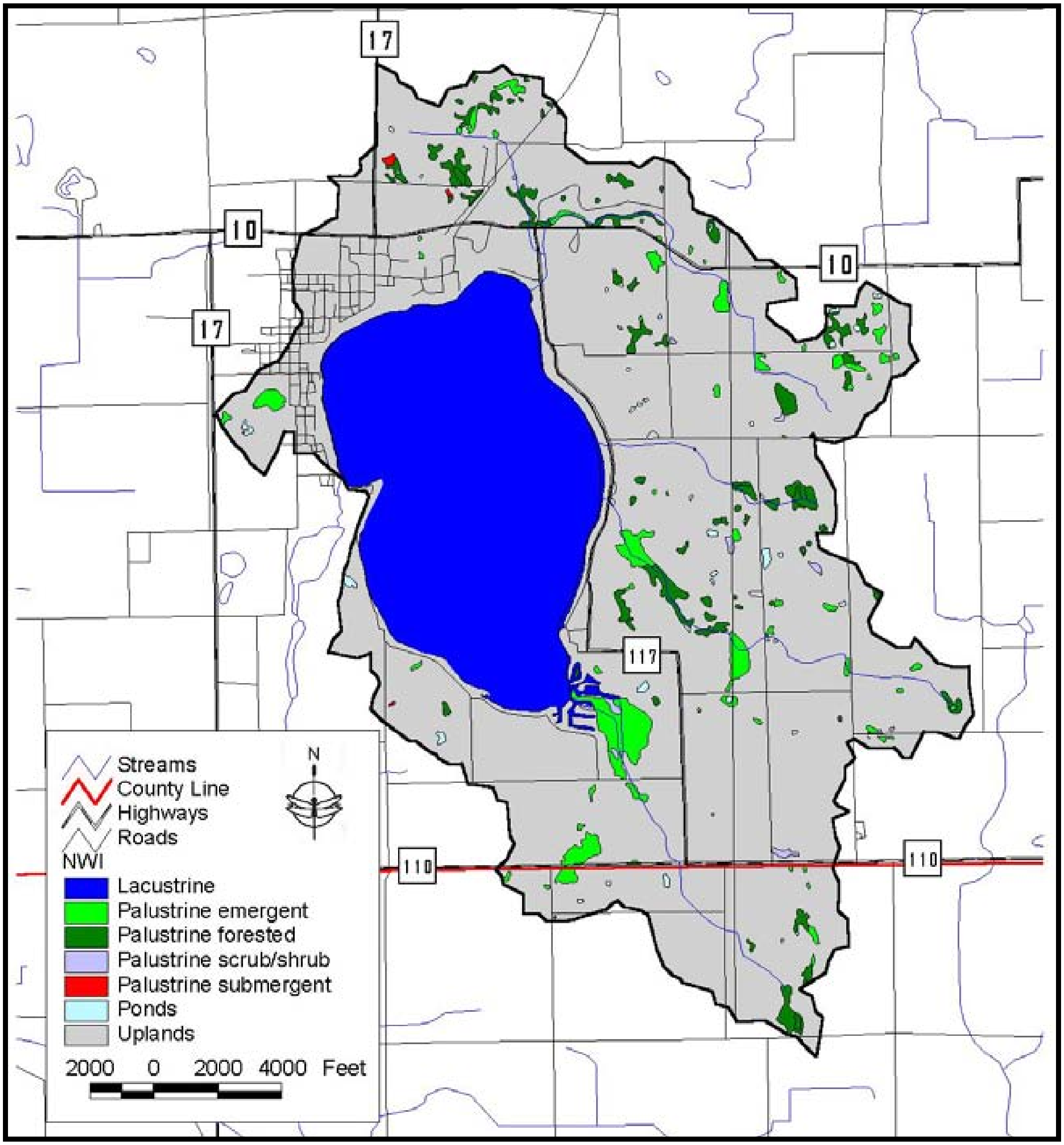

Figure 10. Wetland locations within the Lake Maxinkuckee watershed. Source: See Appendix G.

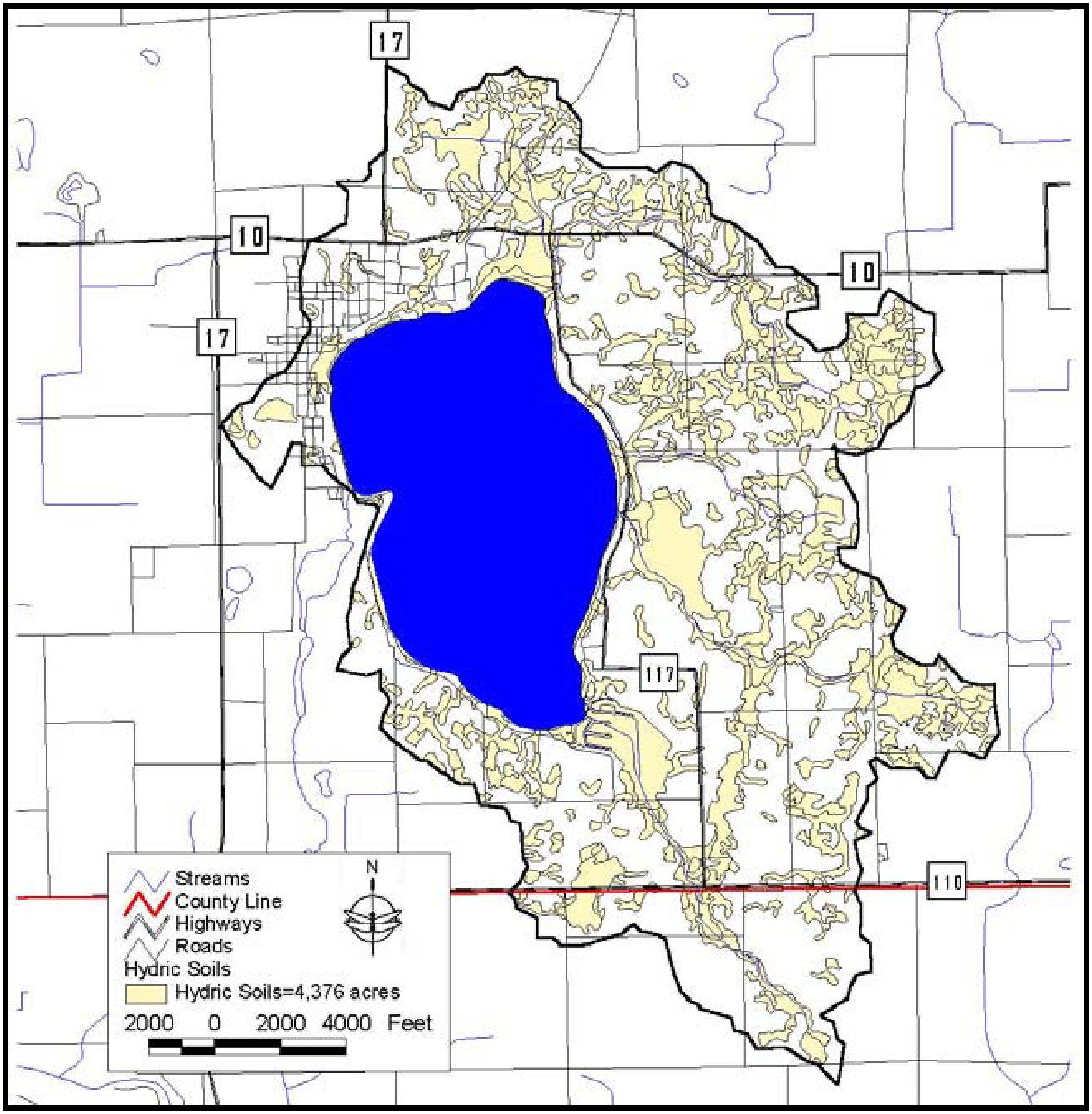

Figure 11. Hydric soils in the Lake Maxinkuckee watershed. Source: See Appendix G.

In additional to stream channelization, the landscape has lost many of its wetlands. Figure 11 illustrates the extent of hydric soils in the watershed. Because hydric soils developed under wet conditions, they are a good indicator of the historical presence of wetlands. Comparing the total acreage of wetland (hydric) soils in the watershed (4,376 acres) to the acreage of existing wetlands (490 acres) suggests that nearly 11% of the original wetland acreage exists today. Wetland loss in the Lake Maxinkuckee watershed is fairly typical for the area. (The Indiana Wetland Conservation Plan (IDNR, 1996) estimates that approximately 85% of the state's wetlands have been filled.) Much of the loss occurred along the current locations of Wilson, Curtiss, and Kline Ditches. The LMEC and watershed residents have undertaken efforts to protect and restore wetland acreage

2.8 <u>Cultural Resources</u>

Early settlers began arriving in the area over 200 years ago. Prior to European settlement, two bands of Pottawatomie Indians, the Aubbeenaubbee and Menominee, lived in the Lake Maxinkuckee watershed. Both bands were lived in this region year-around, frequently camping along the shores of Lake Maxinkuckee. Hunting, fishing, trapping, and gathering were a part of their culture; however, they also cultivated gardens for certain staple products. They sustainably harvested resources from the woods, wetlands, and prairies that covered the land around them. Ultimately, as the European pioneers entered the region, the majority of Pottawatomie tribes departed the region. By the mid-1830s, the tribes were relegated to their federally designated reservations in Kansas.

Fulton County was formed from a portion of Cass County in 1835 (Historic Landmarks Foundation, 1987), while settlers carved Marshall County from Saint Joseph County in 1836 (Chamberlain, 1849; Historic Landmarks Foundation, 1990). In 1838, Marshall County planners created Union Township, the township which includes the Lake Maxinkuckee watershed, from the western section of Green Township (MCCVB, 2004). Surveyors completed platting the Marshall County in 1878 (Smallwood, 1980). In 1839, Fulton County planners formed Aubbeenaubbee Township from the western portion of Richland Township. However, the remoteness of the area and swampy land use present throughout Aubbeenaubbee Township limited settlement of the area (Historic Landmarks Foundation, 1987). Nonetheless, settlers began to inhabit the immediate vicinity of Lake Maxinkuckee in 1836 (McDonald, 1908).

During the next forty years, pioneers in the Lake Maxinkuckee watershed began altering the natural landscape in order to use the area surrounding the lake for agriculture (Historic Landmarks Foundation, 1990). In an effort to cultivate the rich ground, forests were logged for their resources. Concurrently, wetland and prairies were filled or cleared then plowed for cultivation and pastureland. Many of the streams were channelized and wetlands drained. Over time, corn, soybeans, and small grain production increased. In the early 1900s, nearly 93% of Marshall County was farmed (Indiana Agricultural Statistics Service, 1999). Glimpses of the watershed's early history can be seen in the historic landmarks present throughout the area. Figure 12 maps some of these notable landmarks, which include homes, churches, cemeteries, and farmsteads dating back to the early to late 1800s and early 1900s. Three districts, the East Shore Historic District, the Culver Commercial Historic Distric and the Forest Place Historic District are listed in the National Register of Historic Places. The Woodbank Building (also known as Rasmussen Cottage) is also listed as a historic place.

Online Reference:
http://nationalregisterofhistoricplaces.com/IN/Marshall/state.html

(Landmarks shown in Figure 12 and discussed in this section are of local historical significance as indicated in works completed by the Historic Landmarks Foundation in 1987 and 1990.)

As individuals began to clear areas for farming, urbanization throughout the county increased including the areas around Lake Maxinkuckee. In 1836, the town of Maxinkuckee was established east of Lake Maxinkuckee. Eight years later, Bayless Dickson platted Union Town along the northern shoreline of Lake Maxinkuckee (Historic Landmarks Foundation, 1990). The plat established the town in a manner that all areas of the town could enjoy a beautiful view of the lake (MCCVB, 2004). The town has since been renamed three times: once called Marmont after a French general and, in 1895, renamed Culver City, then eventually Culver, for Henry Harrison Culver (State Legislature, 1938). The town grew steadily until 1884 when the Vandalia and the New York, Chicago, St. Louis Railroads passed through town. The railroad brought many new people to the area, and houses soon dotted the shoreline of Lake Maxinkuckee (McDonald, 1908). The railroad provided easy access to the lake and helped to develop the area as a resort. Clubhouses, small cottages, and rooming houses provided hospitality to visitors along the shore of the Lake Maxinkuckee. By the early 1900s, Culver's population had grown to 500. Historic accounts indicate that the population numbered more than 2,000 individuals when daily trains brought passengers to Lake Maxinkuckee (Historic Landmarks Foundation, 1990).

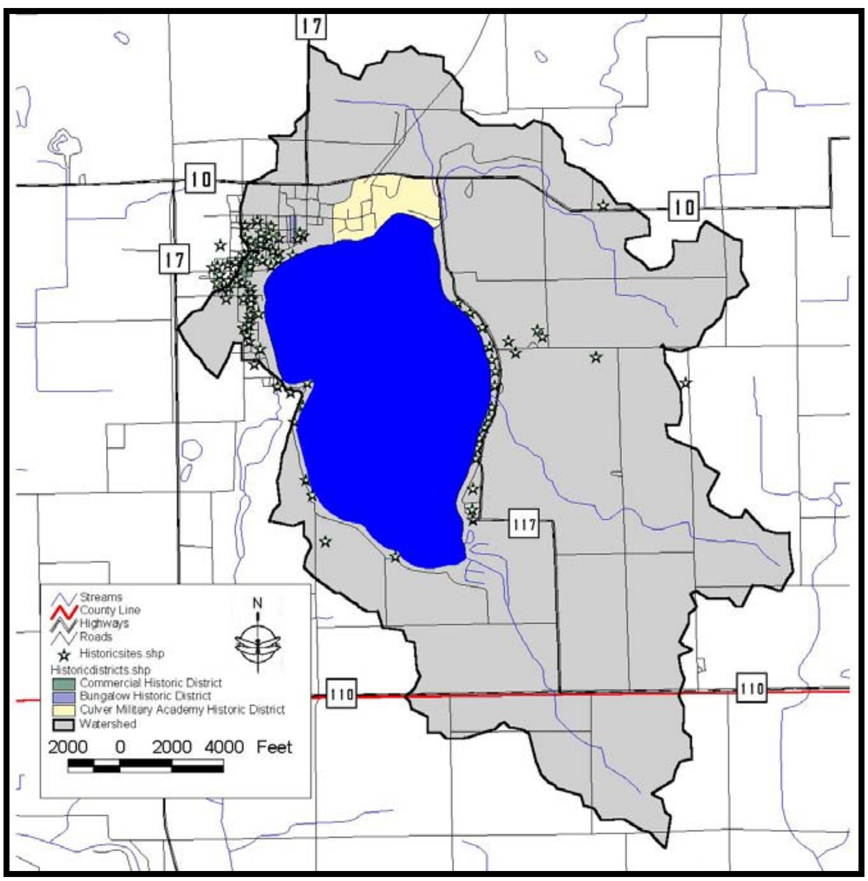

Figure 12. Historic sites and structures in the Lake Maxinkuckee watershed. Source: See Appendix G.

Over the next twenty years, Culver was the fastest growing town in Marshall County. A new train depot, a Carnegie library, several houses, a post office, and newly bricked streets accompanied the town's growth (Historic Landmarks Foundation, 1990). Homes and vacation cottages were built along the shores of Lake Maxinkuckee during this period of growth. Evidence of the area's commercial and residential growth spurt can be seen in the historic landmarks that survive today. Many historical structures are still present in the Culver Commercial Historical District and the Culver Bungalow Historical District and are also scattered throughout the town and along the shores of Lake Maxinkuckee. Figure 12 maps these two districts and some of these notable landmarks, which include the Carnegie library, homes, churches, and commercial buildings dating back to the early to mid 1900s.

Figure 12 also maps the Culver Military Academy Historic District. In 1894, Henry Harrison Culver established Culver Military Academy on the northeastern shore of Lake Maxinkuckee. Culver purchased 300 acres of land and, in 1899, built three buildings including a hotel and small cottage (Historic Landmarks Foundation, 1990). The first buildings were destroyed in a fire in 1895. Following this tragedy, permanent buildings using only steel, brick, stone, or iron were built on the grounds (Historic Landmarks Foundation, 1990). The main barracks and west barracks built in 1895, the calvary school established in 1897, the dining hall built in 1910, and the gothic revival Culver Memorial Chapel created as a tribute to graduates who served in World War II are just some of the historical sites present on the campus. More than 85 historic sites including many of the early buildings still exist on the property owned and maintained by Culver Academies (MCCVB, 2004).

2.9 Land Use

Figure 13 and Table 5 present current land use information for the Lake Maxinkuckee watershed. Agricultural land uses dominate the Lake Maxinkuckee watershed. Row crop agricultural areas cover approximately 27% of the watershed. Pasture occupies an additional 14% of the watershed. An additional 7% of the watershed includes former pasture or row crop agricultural fields currently enrolled in the Conservation Reserve Program (CRP). CRP is a program managed by the Natural Resources Conservation Service designed to convert land in production to non-productive uses such as trees, hay, or prairie. The natural landscape remains on a smaller portion in the watershed. Forested land exists on approximately 15% of the watershed. Wetlands and open water cover nearly 24% of the watershed. (This number differs slightly from the one in the Hydrology section since different data sources were utilized.) Most of the wetlands in the watershed lie along the southern portion of the lake within the Lake Maxinkuckee Wetland Conservation Area. Lake Maxinkuckee accounts for all of the open water acreage (22%). Developed areas, including Culver, Culver Academies, and residences around the shoreline of Lake Maxinkuckee cover almost 13% of the watershed. Most of the developed land use consists of low intensity residential land use and urban parkland. In the Indiana Land Cover Data Set, the USGS defines high intensity residential areas as areas with high entities of multi-family residences (apartment complexes, condominiums, etc.). Hardscape covers approximately 80-100% of the landscape in the high intensity residential land use category. Low intensity residential areas consist largely of single family homes and hardscape covers only 30-80% of the landscape.

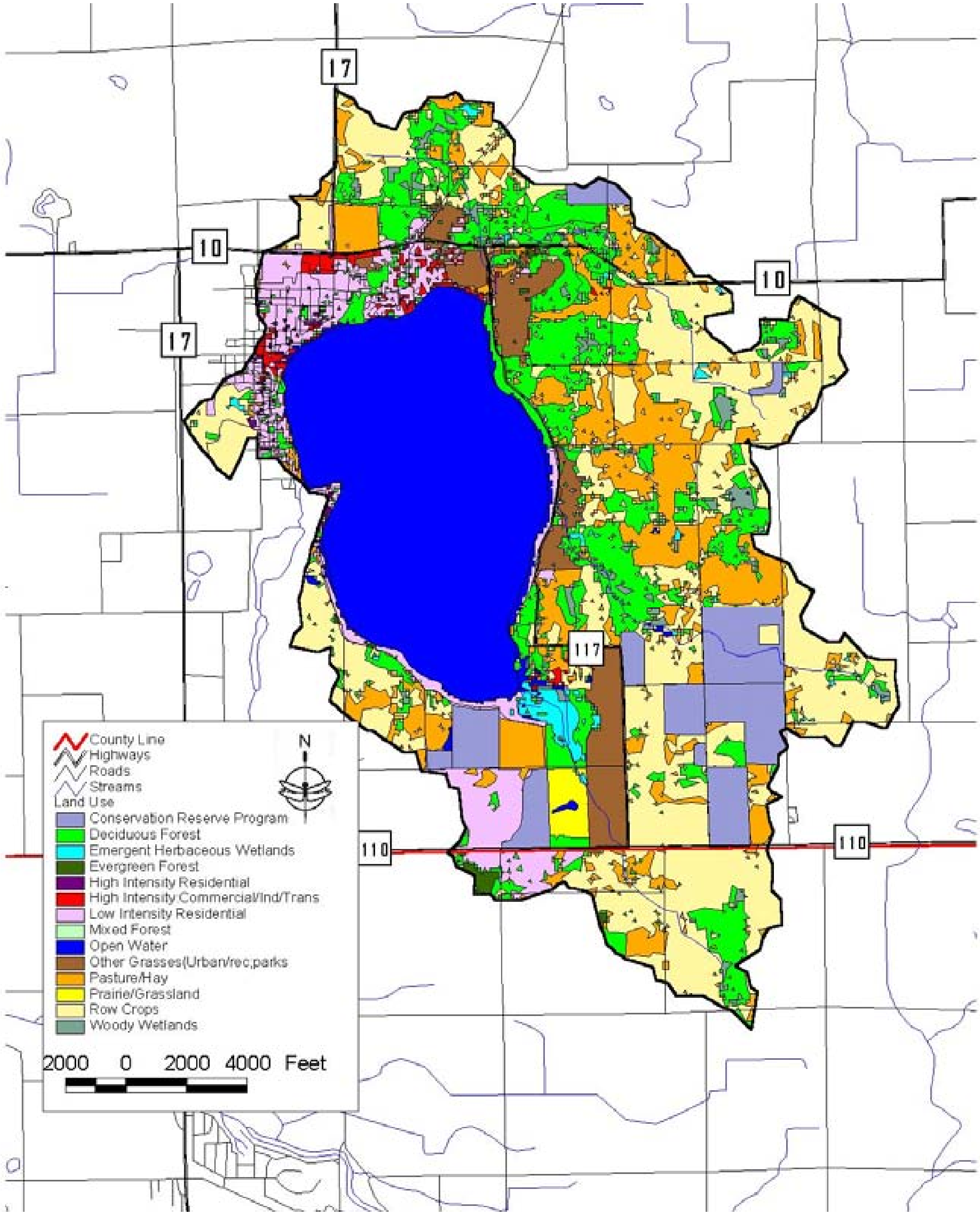

Figure 13. Land use in the Lake Maxinkuckee watershed. Source: See Appendix G.

Table 5. Detailed land use in the Lake Maxinkuckee watershed.

	Area (acres)	Percent of Watershed
Row Crops	2,386.9	27.%
Open Water	1,900.8	21.5%
Deciduous Forest	1,271.5	14.4%
Pasture/Hay	1,227.5	13.9%
Low Intensity Residential	633.9	7.2%
Conservation Reserve Program	615.4	7.0%
Urban Parks	414.0	4.7%
Woody Wetlands	124.4	1.4%
Emergent Herbaceous Wetlands	87.0	1.0%
High Intensity Commercial	74.6	0.8%
Prairie/Grassland	60.7	0.7%
Evergreen Forest	25.5	0.3%
High Intensity Residential	24.5	0.3%

2.10 Land Ownership

Figure 14 presents land ownership information for the Lake Maxinkuckee watershed. Land ownership data from the Culver Academies, the Indiana Department of Natural Resources, Mystic Hills Golf Course, and the Lake Maxinkuckee Country Club form the basis of Figure 14. Nearly 12% of the Lake Maxinkuckee watershed (1,065 acres) is owned by the Culver Academies (Figure 14). Henry Harrison Culver purchased 40 acres of land in 1890. By 1894, Culver owned approximately 300 acres. Currently, the Culver Academies own approximately 1,800 acres of land, 1,065 acres of which are located in and around the northern portion of the watershed (Figure 14). The Culver Academies own the northeastern corner of the Lake Maxinkuckee shoreline. The Culver Academies and its associated buildings, sport fields, and equestrian facilities; the Culver airport; and residential housing facilities are all associated with and located on property owned by the Culver Academies.

The Indiana Department of Natural Resources owns nearly 80 acres or approximately 1% of the Lake Maxinkuckee watershed (Figure 14). This acreage consists of two parcels, the Lake Maxinkuckee public access site located along the western shoreline and the Lake Maxinkuckee Wetland Conservation Area (WCA) at the south end of the lake. The IDNR purchased the Lake Maxinkuckee WCA in 1976 in order to provide a wetland filter for sediment and nutrients entering the lake through Kline Ditch and to establish a public area for hunting, fishing, and trapping (IDNR, unpublished). Habitat varies throughout the Lake Maxinkuckee WCA and includes upland areas covered by a variety of grasses, shrubs, and trees; wetland areas in which an uncatalogued number of flora and fauna reside; and a drainage ditch (Kline Ditch) which carries water into Lake Maxinkuckee from the southern portion of the watershed. Active management has been limited to surveying and posting property boundaries, periodic site inspections, water level manipulation, and trash removal. Hunting, wetland trapping, hiking, mushroom hunting, berry picking, bird watching, boating, canoeing, and hosting school field trips are all encouraged in the Lake Maxinkuckee WCA (IDNR, unpublished).

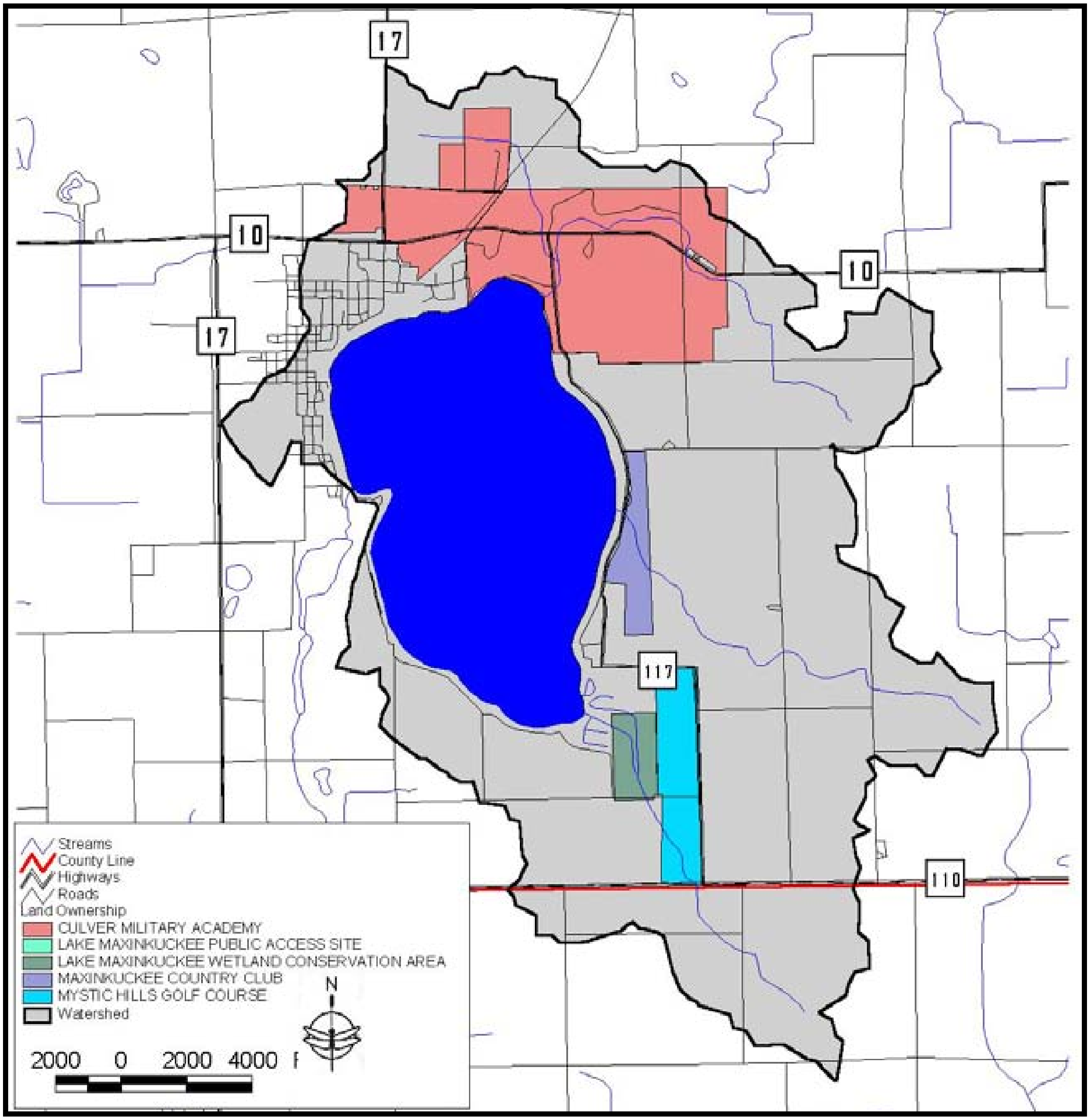

Figure 14. Tracts of land owned by the Indiana Department of Natural Resources, Culver Academies, Lake Maxinkuckee Country Club, and Mystic Hills Golf Course. Source: See Appendix G.

2.11 Organizational Resources

The Lake Maxinkuckee Environmental Fund, Inc. (LMEF) is the legal entity of the sponsoring organization and has a 501(c)(3) designation from the IRS, which means donation to the organization may be tax deductible. The LMEF has conducted fundraising activities annually since

1991 to fund water quality improvements in the Lake Maxinkuckee watershed. In addition to the local funding, the organization has and will look to outside sources to supplement project funding.

For projects in the lake and in the watershed, the Lake and River Enhancement Program of the Department of Natural Resources, and the Indiana Department of Environmental Management's 319 Non-Point Source programs offer competitive grant programs. The Marshall County Community Foundation is a potential funding source for smaller outreach projects and equipment needs. Agriculture programs such as the Conservation Reserve Enhancement Program which assist farmers in installing filter strips along ditches are available through the Marshall County Soil and Water Conservation District. Contact information for these and other agencies is located in Appendix N.

3.0 HISTORIC AND BASELINE WATER QUALITY CONDITIONS

Data contained in this section documents current water quality conditions in the waterbodies of the Lake Maxinkuckee watershed. These waterbodies are Lake Maxinkuckee itself and the tributaries to Lake Maxinkuckee including the major tributaries, Wilson Ditch, Curtiss Ditch, and Kline Ditch, and minor tributaries, the north shore tributary, Maxinkuckee Landing, and the south shore tributary. Understanding the waterbodies' current conditions will help watershed stakeholders set realistic goals for future water quality conditions. This data will also serve as the benchmark against which future water quality conditions can be compared to measure stakeholder success in achieving their vision for the future of these waterbodies.

A variety of resources were reviewed to establish the existing or baseline water quality conditions within the Lake Maxinkuckee watershed. In general, few studies have been completed on the waterbodies in the Lake Maxinkuckee watershed. The U.S. Environmental Protection Agency sampled Lake Maxinkuckee and its tributaries in the early 1970s. Lake Maxinkuckee Environmental Council (LMEC) volunteers monitored the major and minor inlets to Lake Maxinkuckee from 1993 to 1999. The LMEC monitored Lake Maxinkuckee's water clarity through the Indiana Clean Lakes Volunteer Monitoring Program from 1995 to 2004. Indiana Clean Lakes Program staff assessed the health of Lake Maxinkuckee on multiple occasions. The latest details for the 2004 assessment are included below. IDNR Fisheries Biologists documented the fish and macrophyte communities on several occasions including1965, 1975, 1983, 1984, 1995, and 2001. The LMEC initiated three aquatic vegetation surveys in 1993, 1999 and 2004. JFNew collected additional data from each of the three major streams and three minor streams listed above during the summer of 2004 as part of this plan's development to supplement the existing data. The following paragraphs outline the findings of these assessments.

3.1 <u>USEPA Assessment</u>

The U.S. Environmental Protection Agency sampled Lake Maxinkuckee and its tributaries as part of their National Eutrophication Survey in the 1970s. The USEPA sampled many common parameters such as dissolved oxygen, temperature, pH, total phosphorus, total Kjeldahl nitrogen, ammonia-nitrogen, nitrate-nitrogen, transparency, and chlorophyll *a* within various depths of Lake Maxinkuckee. Based on these parameters, the lake was rated as mesotrophic or moderately productive (USEPA, 1975). In general, total phosphorus concentrations were below the level (0.03 mg/L) at which eutrophication occurs in a lake system (Correll, 1998). The lake also possessed low nitrogen and chlorophyll *a* concentrations and maintained good transparency throughout the three sampling events.

Additional samples were collected from the three major inlets streams, Wilson Ditch, Curtiss Ditch, and Kline Ditch. Parameters sampled included: total suspended solids (TSS), nitrate-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN), orthophosphorus (OP), and total phosphorus (TP). None of the concentrations of the measured parameters exceeded the state standards for water quality. (It is important to note that Indiana does not have a state standard for each parameter measured by the USEPA during this sampling event.) The concentrations of two parameters, nitrate-nitrogen and total phosphorus, were higher than desirable during a number of the twelve monthly sampling events. Indiana does not have numeric criteria that target biotic health for either of these parameters, but some potential management targets for ensuring stream health are 1.0 mg/L for nitrate-nitrogen (Ohio EPA, 1999) and 0.075-0.1 mg/L for total phosphorus (Dodd et al., 1998; Ohio EPA, 1999; USEPA, 2000).

3.2 <u>LMEC Volunteer Sampling Program</u>

The LMEC Volunteers monitored the water quality of the three major and nine minor inlet streams from 1993 though 1999. Volunteers collected water quality data three times annually for a variety of parameters. Total phosphorus concentrations in all inlet streams were generally greater than levels at which biotic impairment occurs (Ohio EPA, 1999). The north shore and south shore tributaries generally possessed the highest total phosphorus concentrations of any of the streams sampled. Nitrate-nitrogen concentrations were also elevated, but did not exceed Indiana state standards. Likewise, *E. coli* concentrations were also elevated throughout the sampling period. The highest concentrations were measured in minor tributaries which correspond with the north shore and south shore tributaries sampled during the current study. *E. coli* concentrations ranged from 10 to 3,200 colonies/100 mL in the south shore tributary and from 0 to 3,600 colonies/100 mL in the north shore tributary (JFNew, 1993; JFNew, 1995; JFNew, 1996; JFNew, 1997; JFNew, 1999).

3.3 <u>Indiana Clean Lakes Volunteer Monitoring Program</u>

The LMEC monitored Lake Maxinkuckee's water clarity through the Indiana Clean Lakes Volunteer Monitoring Program from 1995 to 2004. Citizen volunteers in the ICLVMP are trained by ICLVMP staff to collect water clarity data from individual lakes on a biweekly basis (if possible) throughout the summer months, typically from June through August. Water clarity data is measured by the volunteer with a Secchi disk using the standard methodology employed by most lake management professionals (Indiana Clean Lakes Volunteer Monitoring Program, 2001). Volunteers monitored one site over the deepest part the lake once a month in June, July and August each year for the CLP. See Appendix J for Secchi disk testing sites. The mean July/August Secchi transparency (in feet) has ranged from 5.3 in 2002 to 9.1 in 1999. The median value for Indiana lakes is 6.9 feet.

3.4 Lake Maxinkuckee Secchi Monitoring Program

In addition to sampling the one location for the Clean Lakes Program, an extensive secchi program was developed on Lake Maxinkuckee during the 1980's by Dr. Thomas Crisman, which has been continued. Twenty-six sites have been monitored in addition to the one location for the CLP. This program was designed to address whether, as suggested by Hamelink (1971), power boats significantly alter water clarity and the impact of inflowing streams on water clarity.

Secchi disk transparency in Lake Maxinkuckee in 1971 approximated that of 1907. Between 1971 and 1977, water clarity progressively declined, displaying a 25% reduction for the six year period. The results of the 1984 and 1985 secchi disk monitoring programs suggest that water clarity did not changed appreciably from1977 to 1985. The averages for 1984 and 1985 were 7.24 and 5.81 feet respectively. (Crisman, 1986)

In 1999, Dr. Crisman and a graduate student reviewed Secchi disk transparency and other relevant data gathered since the completion of his study in 1986 and the three constructed wetland treatment systems. This review was aimed at determining what, if any, changes to the lake had occurred. His study, presented in December of 2000, concluded water clarity increased at the mouths of the Kline and Wilson Ditches, showing a statistically significant improvement in Secchi disk transparency of at least 20 cm since wetland construction. In addition, the 1991 improvement to the sewage treatment system for the Town of Culver improved water clarity at three of the five stations located near Culver, in some cases water clarity increased over 30 cm. Water clarity of the lake as a whole has improved. While the improvement is relatively small (8 cm), it is statistically significant. (Crisman and Patterson, 2000)

3.5 Indiana Clean Lakes Program Monitoring

The Indiana Clean Lakes Program sampled Lake Maxinkuckee on August 16, 2004 using their standard protocol. Program staff collected and analyzed samples for total phosphorus, soluble reactive phosphorus, total Kjeldahl nitrogen, nitrate-nitrogen, ammonia-nitrogen, chlorophyll *a*, transparency, and plankton. The data were then used to calculate the Indiana Trophic State Index (ITSI) which assigns a numeric value to all lakes based on their relative water quality. The values are then used to determine the trophic status or productivity of the lake. Lakes are then compared across the state based on their ITSI score.

Lake Maxinkuckee is best classified as a mesotrophic lake. Mesotrophic lakes often exhibit moderate water clarity and low to moderate nutrient concentrations. Lake Maxinkuckee's nutrient concentrations were lower than nutrient concentrations found in other mesotrophic lakes (Vollenweider, 1975 and Carlson, 1977). Lake Maxinkuckee's chlorophyll *a* (an indicator of algae) concentration was also comparable to chlorophyll *a* concentrations found in other mesotrophic lakes (Carlson, 1977). Similarly, Lake Maxinkuckee's water clarity was on par with that found in many mesotrophic lakes. Altogether, this data suggests that the lake is mesotrophic in nature.

While the data above suggest the lake is in moderate shape, a comparison of data collected from Lake Maxinkuckee with selected water quality data from other Indiana lakes suggests Lake Maxinkuckee is better than most Indiana Lakes. Table 6 presents a comparison of Lake Maxinkuckee data to data collected from 1994 through 2004 by the Indiana Clean Lakes Program. The CLP data summarized in the table are minimum, maximum, and median values obtained by averaging the epilimnetic (surface water) and hypolimnetic (bottom water) pollutant concentrations from each of the 456 lakes. At the time of sampling, Lake Maxinkuckee possessed better water clarity and lower nitrate-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen, soluble reactive and total phosphorus, and chlorophyll *a* concentrations than most lakes in Indiana. All of the nutrient concentrations measured in Lake Maxinkuckee suggest that it is typically free from nuisance algae blooms. (Total phosphorus concentrations greater than 0.03 mg/L and inorganic nitrogen concentrations greater than 0.1 mg/L are known to support algal blooms.) The lake's low chlorophyll *a* concentration suggests that the lake was not experiencing an algal bloom at the time of the survey.

Table 6. Water quality characteristics of 456 Indiana lakes sampled from 1994 through 2004 by the Indiana Clean Lakes Program compared to data collected from Lake Maxinkuckee by the Indiana Clean Lakes Program on August 14, 2004.

	Secchi Disk (ft)	NO_3-N (mg/L)	NH_3-N (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	Chlorophyll *a* (μg/L)
Minimum	0.3	0.01	0.004	0.230	0.01	0.01	0.013
Maximum	32.8	9.4	22.5	27.05	2.84	2.81	380.4
Median	6.9	0.275	0.818	1.66	0.12	0.17	12.9
Lake Maxinkuckee	**7.8**	**0.013**	**0.343**	**0.816**	**0.010**	**0.023**	**2.71**

3.6 <u>Fisheries Reports</u>

With the U.S. Bureau of Fisheries Survey of Lake Maxinkuckee from 1899-1914 which was compiled by Evermann and Clark in 1920, Lake Maxinkuckee is fortunate to have a long history of fish surveys which can be used to evaluate the status of the current fishery in the lake.

Fish surveys were conducted from 1899-1914 by the U.S. Bureau of Fisheries and in 1965, 1975, 1983, 1984, 1995, and 2001 by the Department of Natural Resources. Creel surveys (fisherman catch) were conducted in 1985, 1988, 1990, 1991, 1996, 1999, and an ice fishing creel was completed in 2004. Beginning in 1980 and continuing through 1990, walleye fry were stocked yearly in the lake by the Indiana Department of Natural Resources Division of Fish and Wildlife (Cwalinski, 1997) to enhance the sport fishing in the lake. A small walleye population existed in the lake due to stocking in the late 1800's. The 1980's stocking has been successful. Lake Maxinkuckee is one of three natural lakes in northern Indiana where extensive walleye population research is conducted. Numerous walleye studies have been conducted with the most recent in 2003. A 14" size limit for walleye was implemented in the fall of 1996.

While the more recent walleye stockings have been successful, not all attempts to manage the sport fishery have been successful. Lake trout were stocked four times from 1890-1894; however, not a single fish was taken by an angler. The demise of the lake trout was attributed to the summertime hypolimnetic anoxia (deep water deoxygenation) that occurs in the lake each year. Trout require cold well-oxygenated water (Evermann & Clark, 1920). Between 1889 and 1913 a total of 34,138,830 fish were stocked in Lake Maxinkuckee. The species and numbers are shown in Table X. (Evermann & Clark, 1920)

Table 7. Fish stockings in Lake Maxinkuckee between 1889 and 1913

Species	Number stocked
Lake Trout	10,587
Pike Perch	34,100,000
Black Bass, both species	18,558
Warmouth Bass	400
Crappie	3,200
Yellow Perch	385
Catfish	5,700
TOTAL	**34,138,830**

At the turn of the century the fish community was dominated by yellow perch and blue gill with rock bass being the principal subdominate. In the 1965 and 1975 surveys yellow perch was the dominant species, as it had been at the turn of the century. In the 1983 and 1984 surveys yellow perch slipped from being the most dominant to the third most dominant. This declined was attributed to increased predation pressure associated with the introduction of walleyes starting in 1980. As Lake Maxinkuckee becomes more eutrophic, the decline of the perch population could be beneficial for the lake. Perch prey on large zooplankton (microscopic animals). With fewer perch there is more zooplankton. Zooplankton feed on algae (microscopic plants) and when there is more zooplankton there will be less algae. Less algae provide better recreational potential for the lake. Enhanced zooplankton populations have proven effective at eliminating algal blooms in spite of high nutrient levels (Crisman, 1986).

An abundance of carp and shad are characteristic of eutrophic lakes. Gizzard shad are of concern because an important part of their diet is algae. Shad feed by filtering water through their gills and ingesting the collected algae; however, the fish are unable to digest blue-green algae which are passed through the gut alive. Once shad are established in a lake, they promote dominance of blue-green species of algae. Carp are undesired because they mix bottom sediments during feeding activities, enhancing phosphorus release to the water column.

Gizzard shad and carp were not in the lake at the turn of the century. Carp established a population around 1905. Gizzard shad were reported in the lake in the 1965-1984 surveys. At this time, the shad and carp populations are not considered a problem as their populations remain a small percentage of the overall fish population, but further eutrophication of the lake could encourage population growth and should be watched.

Smallmouth bass, another popular sport fish, dominated the catch in the 2000 fish survey. Lake Maxinkuckee smallmouth bass growth rates continue to be above average compared to smallmouth bass in Indiana rivers.

Overall the composition of species of the fish community of Lake Maxinkuckee has not changed much since the turn of the century. Instead the relative dominance ordering has changed in response to increasing trophic state and an alteration in predation intensity associated with the walleye stocking program.

Appendix K lists the fish surveys.

3.7 Aquatic Vegetation

Regarding aquatic vegetation, again, Lake Maxinkuckee has numerous studies dating back to 1900. Aquatic vegetation surveys were conducted 1900, 1920, 1993, and 1999. The presence of aquatic plants has many advantages including stabilizing sediments and shoreline, decreasing erosion and turbidity, uptake of chemical toxins and excess nutrients, oxygen input into the lake, and they provide habitats for invertebrates, such as snails and crayfish, and breeding areas for fish. Invertebrates are the staple diet of many small gamefish which are in turn food to larger fish. Healthy invertebrate populations are necessary for a stable and expanding populations of important game fish.

The first two studies of the lake’s flora were conducted by governmental agencies. Both these vegetation studies occurred over a long period of time while the U. S. Fisheries Bureau maintained a station at Lake Maxinkuckee. Unfortunately, budget constraints today do not allow for such longitudinal studies. However, the extensive data from U.S. Geological Report (1900) and Evermann and Clark’s (1920) study serves as a comparison with more recent aquatic vegetation surveys. This comparison allows for identification of trends in the plant community.

In 1900, as part of the State Geologists Report, over 200 species of plants were identified in Lake Maxinkuckee growing below the high water mark, 61 of those species were aquatic vascular plants. The 1920 Evermann and Clark volumes compile data gathered from 1899 to 1914 including observations of the lake’s flora over many seasons. One interesting comment was the lake became markedly more weedy than it was at the beginning of the study. Dr. Scovell, who worked on the State Geologists Report is quoted as saying “Out to a depth of 25 feet the lake abounds in vegetation.” The increasing weediness was attributed to two possible factors: 1) the removal of protecting trees opened the lake more to the sweep of winds which disseminates the under-water plants and 2) the reduction in waterfowl fowl. Formerly immense flocks of coots and ducks made great raids on some of the water plants. The birds uprooted the plants before they ripened or set seed and therefore kept the growth of plants in check. Without the water fowl predation, the plants grew unimpeded. (Evermann and Clark, 1920) No reason is given for the reduction of waterfowl at the lake. A note of interest is a dam was placed at the outlet to the lake the summer of 1906.

The current distribution of aquatic plants appears much different than the description of the early 1900's. Since no official aquatic plant surveys occurred between 1914 and 1993, an exact timeframe for plant community change cannot be determined.

No formal aquatic vegetation survey was conducted for the 1986 Crisman Report, however, there is some discussion that included a reference to a 1965 Indiana Department of Natural Resources fish survey which noted most macrophytes displayed a scattered distribution and were generally limited to water less than 25 feet deep. A letter dated February 10, 1985 from Dr. Scott Holaday, botanist at Texas Tech University and a former lake resident, is also mentioned. Dr. Holaday noted the exotic species *Myriophyllum spicatum* (Eurasian Watermilfoil) was not in the lake in 1900, but has become established and currently dominates most of the weed beds in the lake, especially at the southeastern corner of the lake. Macrophyte beds often develop in lakes immediately offshore from major sources of nutrient input. The southeastern inlet (now known as the Kline Ditch) was a major nutrient source for the lake at the time (1985), contributing 20-27% of the total phosphorus input and where a rich macrophyte bed established immediately offshore.

The 1993, 1999 and 2004 aquatic vegetation surveys were initiated by the Lake Maxinkuckee Environmental Council with the understanding that information on the identity, distribution and abundance of aquatic plants can be useful in the context of evaluating ecosystem integrity and developing lake management strategies.

A summary of the 1993 report showed 29 species of aquatic plants and one dominant macrophytic species of algae. Relative to the size of the lake, species diversity and abundance was lower than expected. The small number of aquatic plants is likely a result of a combination of physical factors that have prevented the establishment of many plants into more extensive populations, such as shoreline development, boat traffic and ice scouring. (New, 1993)

In 1993 the most common submergent aquatic plant throughout the lake was *Chara globularis*, a macrophytic algal species known for its ability to form thick mats on the bottom of lakes at depths up to 25 feet. This species requires less light than other species in the lake, seldom grows to more than one and half feet and does an excellent job of stabilizing sediments. In water exceeding 10 feet the most common aquatic plant species was Eurasian watermilfoil. Eurasion watermilfoil is a non-native noxious weed which was has been spreading through Indiana lakes. Eurasian watermilfoil begins to grow earlier in the season than native plants and continues growing later in the year. It can form dense mats which shade out and replace native plants producing a monoculture. Decaying mats of Eurasion watermilfoil also reduce oxygen levels in the water. While in many Indiana lakes Eurasian watermilfoil creates considerable problems, it has not historically been a problem in Lake Maxinkuckee.

The Kline Ditch outlet showed the highest diversity and abundance of aquatic plants. This area has the most organic sediments of any site samples, likely from the extensive marsh area. From the Culver Marina area as far as the Culver Academies Woodcraft swimming pier there is little or no shallow water aquatic vegetation and virtually no noteworthy shallow water vegetation exists heading west of the Academies until the public access site. (New, 1993)

In the 1999 survey 31 aquatic vascular plants were recorded, compared to the 61 species identified in the Evermann and Clark survey (1920). Compared to the 1993 survey the most pronounced change was the decrease in abundance of Eurasian watermilfoil which was far more wide spread in 1993. This decrease could be attributed to a couple of factors. First, the 3 constructed wetlands were built on the major tributaries to reduce nutrient loading to the lake. Eurasian watermilfoil tends to prefer eutrophic lakes, out-competing native species as nutrient loading increases. Second, zebra mussels were discovered in the lake in 1995 and they rapidly spread throughout the lake. Zebra mussels filter large volumes of water and can reduce nutrients in a water body. The resulting increase in water clarity has been strongly correlated with reductions in Eurasian watermilfoil and increase in aquatic plant diversity. (Scribailo, 1999) The study also noted there is very little aquatic plant growth out to a distance of 50 feet or greater from the shoreline.

Appendix K lists the 1900,1920, 1993, and 1999 aquatic plant inventories.

3.8 Historic In-lake Water Quality Data

As described in the previous sections, a variety of water quality data was collected from Lake Maxinkuckee over the past 100 years. Much of this data was collected in various manners, which can make comparison across the years somewhat difficult. With this in mind, a sub-sampling of available water quality data is listed in Table 8.

Table 8. Summary of historic data for Lake Maxinkuckee.

Date	Secchi (ft)	Percent Oxic	Mean TP (mg/L)	Plankton Density (#/L)	TSI Score (based on means)	Chl *a* (mg/L)	Data Source
9/20/07	9.0	44%	0.011	--	--	--	Evermann and Clark, 1920
9/24/07	--	27%	--	--	--	--	Evermann and Clark, 1920
6/7/65	--	34%	--	--	--	--	Crisman, 1986
7/27/70	--	41%	--	--	--	--	Crisman, 1986
9/9/70	--	41%	--	--	--	--	Crisman, 1986
5/2/73	11.0	--	0.022	--	--	4.7	USEPA, 1976
8/13/73	7.5	--	0.014	--	--	5.7	USEPA, 1976
10/13/73	7.0	--	0.031	--	--	5.9	USEPA, 1976
6/2/75	--	85%	--	--	--	--	Crisman, 1986

7/22/75	--	34%	--	--	--	--	Crisman, 1986
8/3/75	--	34%	--	--	--	--	Crisman, 1986
7/1/77	--	33%	--	--	--	--	Crisman, 1986
7/20/77	--	15%	--	--	--	--	Crisman, 1986
7/22/77	--	55%	0.010	--	--	--	USEPA Storet
8/3/77	--	8%	--	--	--	--	Crisman, 1986
8/25/77	--	33%	--	--	--	--	Crisman, 1986
9/7/77	7.5	--	0.010	--	--	--	USEPA Storet
7/24/78	--	47%	--	--	--	--	Crisman, 1986
7/31/78	--	45%	--	--	--	--	Crisman, 1986
8/14/78	--	39%	--	--	--	--	Crisman, 1986
8/28/78	--	34%	--	--	--	--	Crisman, 1986
9/6/83	--	28%	--	--	--	--	Crisman, 1986
7/17/84	--	34%	--	--	--	--	Crisman, 1986
8/31/84	--	43%	--	--	--	--	Crisman, 1986
1984*	7.24	--	--	--	--	--	Crisman, 1986
1985*	5.81	--	--	--	--	--	Crisman, 1986
7/1/93	7.2	40%	0.010	1,083	18	--	CLP, 1993
8/8/95	9.5	36%	0.020	806	13	2.84	CLP, 1995
8/11/98	6.9	32%	0.022	1,731	17	3.34	CLP, 1998
8/16/04	7.8	44%	0.023	806	16	2.71	CLP, 2004

*Summer averages for 22 stations throughout the lake from Crisman, 1986.

Fluctuations in transparency are normal within Lake Maxinkuckee as demonstration by this long-term data and by Crisman (1986) for data collected at more than 20 sites throughout the lake. There is no apparent trend in lake transparency within Lake Maxinkuckee. Secchi disk transparency measurements declined from 9 feet in 1907 to a mid-summer average of 5.8 in 1984. Crisman (1986) noted a 25% decline in water clarity from 1971 to 1977 and indicated that water clarity had not improved from 1977 to his sampling in 1984. Crisman (1986) describes the 1984 and 1985 averages as average values for all 22 monitoring stations throughout the lake. The report further details improvements in water clarity at increasing distances from the shoreline. The mid-lake average for 1984 measured 11.2 feet, which is the best transparency documented in Lake Maxinkuckee. Transparency levels have fluctuated since 1984 reaching a mid-lake low of 6.9 feet in 1998. Transparency improved during the 2004 assessment measuring 7.8 feet. Furthermore, all recorded transparencies exceed the transparency measured in most Indiana lakes (6.9 feet).

The same holds true for dissolved oxygen levels within Lake Maxinkuckee. A variety of sources document low oxygen levels in Lake Maxinkuckee's hypolimnion. There is no apparent trend in this data. The poorest dissolved oxygen level was recorded in August 1977 with minimal oxygen present below 7 feet. The best dissolved oxygen level was observed in July 1977 where oxygen was present to a depth of 45 feet. Evermann and Clark (1920) noted long periods of anoxia within Lake Maxinkuckee annually during the fall. Crisman (1986) hypothesized that the morphometry of the lake basin limited the ability of the lake to undergo fall overturn. This effectively minimizes the ability for the whole lake to mix, rather mixing occurs in the deep pockets of the lake on an individual basis much earlier than whole lake mixing occurs. Nonetheless, no apparent change in dissolved oxygen levels can be observed in Lake Maxinkuckee.

Total phosphorus concentrations also exhibit the fluctuations observed in the transparency and dissolved oxygen data. Total phosphorus concentrations were low in 1907 measuring only 0.011 mg/L (Evermann and Clark, 1920). Concentrations increased reaching their highest observed levels in October 1973 measuring 0.031 mg/L. Concentrations measured 0.010 mg/L during the 1977 and 1993 assessments conducted by the Indiana Department of Environmental Management and the Indiana Clean Lakes Program, respectively. Total phosphorus concentrations doubled from 1993 to 1995 (0.020 mg/L) and have remained at this level during the past three Clean Lakes Program assessments (1995, 1998, and 2004). Crisman (1986) suggested that the 0.023 mg/L level observed in Lake Maxinkuckee during the summer of 1973 were the stable level at which Lake Maxinkuckee would reside.

It should be noted that elevated total phosphorus concentrations do not correspond with poor transparency measurements or larger percentages of the water column containing low levels of dissolved oxygen. There is, however, a general patter between water transparency and plankton density. Transparencies are typically poorer in Lake Maxinkuckee when plankton densities are higher. The highest density plankton (1,731 colonies/100 mL) corresponds with the poorest transparency recorded (6.9 feet). Likewise, the lowest density plankton (806 colonies/100 mL) occurred during the highest transparency measurement (9.5 feet). Chlorophyll *a* concentrations also follow this same pattern in that the highest plankton density, highest chlorophyll *a* concentration, and poorest Secchi disk transparency all occur during the same sampling event. This suggests that algal turbidity affects water transparency in Lake Maxinkuckee more than non-algal turbidity.

Historical data collected from within Lake Maxinkuckee does not provide a clear trend towards improving or declining water quality. However, in-lake phosphorus concentrations have increased over time suggesting that nutrient levels are higher in Lake Maxinkuckee than those historically observed. Based on calculations using the Vollenweider (1975) model (see Section 3.14), a majority of the phosphorus entering the lake comes from external sources. However, internal phosphorus loading increased over time accounting for a larger percentage of the total. Water quality data indicate that the effect of increasing total phosphorus concentrations has not yet become apparent. This may be due in part to the lake's extremely large volume (55,042,000 m^3; USEPA, 1976), long retention time (6.7 years; USEPA, 1976), and/or the relatively small watershed area to lake area ratio (4.6:1). The lake's retention time means that Lake Maxinkuckee's water is entirely replaced every 6.7 years. Based on this calculation, only 15% of Lake Maxinkuckee's volume is replaced on an annual basis. Due to the small watershed area to lake area ratio (4.6 acres of watershed drain to each acre of lake), nutrient and sediment controls implemented in the watershed should result in vast improvements in water quality within the lake.

3.9 <u>JFNew Watershed Stream Sampling</u>

To supplement the base of existing data, JFNew collected water chemistry, biological community, and physical habitat data from each of the three major watershed streams: Wilson Ditch, Curtiss Ditch, and Kline Ditch and Maxinkuckee Landing and collected water chemistry data for two remaining (Maxinkuckee Landing is considered a minor tributary) minor tributaries: the north shore tributary and the south shore tributary. With the exception of Wilson and Curtiss Ditches, one sampling station was located on each stream (Figure 15). JFNew biologists conducted macroinvertebrate and habitat assessments at separate locations from the chemical collection sites for Wilson and Curtiss Ditches. Macroinvertebrate and habitat assessments occurred upstream of the constructed wetland on Curtiss Ditch and upstream of State Road 10 on Wilson Ditch to reduce the negative impact of poor habitat on the streams' biotic communities. Water chemistry samples were collected three times from each stream, once following a storm event to capture a runoff event and twice following a period of little precipitation to serve as the "normal" stream condition. For each of streams where biological community and physical habitat assessments occurred, these were conducted once in mid-late summer. The stream sampling quality assurance/quality control procedures are referenced in the project's Quality Assurance Project Plan (QAPP). Appendix P contains the project QAPP. Tables 9 through 12 present the raw data collected during the stream assessments in tabular form. Appendix L presents the data in graphical form. Sampling location coordinates are also contained in Appendix L.

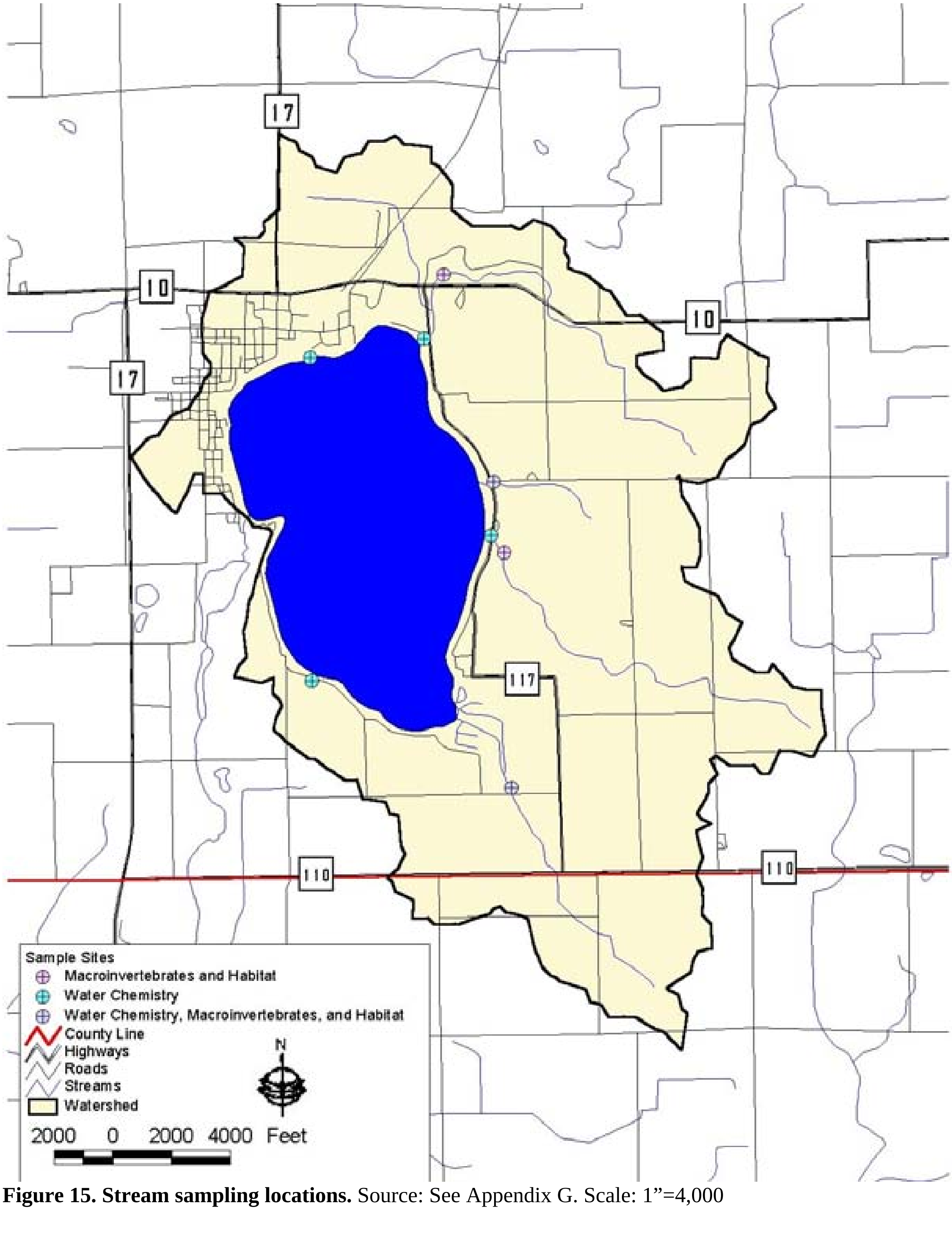

Figure 15. Stream sampling locations. Source: See Appendix G. Scale: 1"=4,000

Table 9. Physical parameter data collected during base and storm flow sampling events in the Lake Maxinkuckee watershed waterbodies on June 1, July 21, and September 8, 2004.

Site	Stream Name	Date	Event	Flow (cfs)	Temp (deg C)	DO (mg/L)	% Sat	pH	Cond (µs/cm)	Turb (NTU)
1	North Shore Tributary	6/1/2004	storm	0.25	14.7	7.9	77.7	7.2	--	1.7
		7/21/2004	base	--	--	--	--	--	--	--
		9/8/2004	base	0.01	16.3	7.6	77.7	8.3	1437	4.6
2	Wilson Ditch	6/1/2004	storm	5.63	16.0	8.9	90.1	7.4	--	14
		7/21/2004	base	0.37	19.3	8.5	87.6	7.6	--	4.1
		9/8/2004	base	0.83	15.9	7.8	79.7	7.9	712	3.6
3	Maxinkuckee Landing	6/1/2004	storm	1.45	15.9	8.9	90.3	7.5	--	10.5
		7/21/2004	base	0.29	18.1	9.4	100.6	7.6	--	16.0
		9/8/2004	base	0.37	16.1	6.7	68.3	8.3	779	3.9
4	Curtiss Ditch	6/1/2004	storm	7.49	18.0	5.5	57.4	7.3	--	3.6
		7/21/2004	base	0.24	24.8	7.8	104.2	7.7	--	2.9
		9/8/2004	base	0.02	19.2	6.4	69.9	7.7	653	3.8
5	Kline Ditch	6/1/2004	storm	5.55	17.9	6.7	70.4	7.1	--	26
		7/21/2004	base	0.39	21.1	7.3	81.6	7.0	--	2.8
		9/8/2004	base	1.59	16.7	5.6	56.9	7.6	659	1.6
6	South Shore Tributary	6/1/2004	storm	0.50	16.0	8.6	87.1	7.4	--	14
		7/21/2004	base	--	--	--	--	--	--	--
		9/8/2004	base	0.02	16.1	8.7	87.9	8.3	628	5.8

Table 10. Chemical and bacterial characteristics of the Lake Maxinkuckee watershed waterbodies on June 1, July 21, and September 8, 2004.

Site	Stream Name	Date	Event	NH_3-N (mg/L)	NO_3-N (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
1	North Shore Tributary	6/1/2004	storm	0.200	0.733	1.347	0.068	0.117	3.5	440
		7/21/2004	base	--	--	--	--	--	--	--
		9/8/2004	base	0.018	0.237	0.873	0.136	0.212	12.0	920
2	Wilson Ditch	6/1/2004	storm	0.176	5.150	1.959	0.038	0.117	27.7	1900
		7/21/2004	base	0.08	0.627	0.395	0.024	0.068	4.5	450
		9/8/2004	base	0.018	0.571	0.593	0.028	0.052	1.8	446
3	Maxinkuckee Landing	6/1/2004	storm	0.192	7.990	0.871	0.051	0.093	14.7	3200
		7/21/2004	base	0.054	0.307	0.385	0.024	0.088	121.6	540
		9/8/2004	base	0.022	0.994	0.415	0.027	0.054	23.3	1270
4	Curtiss Ditch	6/1/2004	storm	0.056	0.440	1.096	0.061	0.093	0.75	430
		7/21/2004	base	0.027	0.018	0.579	0.04	0.095	4.3	112
		9/8/2004	base	0.018	0.068	0.750	0.034	0.111	6.5	390
5	Kline Ditch	6/1/2004	storm	0.164	5.907	2.587	0.110	0.183	24.3	630
		7/21/2004	base	0.025	0.858	0.505	0.027	0.074	6.3	1800
		9/8/2004	base	0.018	1.688	0.727	0.037	0.069	7.1	320
6	South Shore Tributary	6/1/2004	storm	0.095	1.259	2.127	0.122	0.202	20.3	13000
		7/21/2004	base	--	--	--	--	--	--	--
		9/8/2004	base	0.018	0.698	0.519	0.099	0.135	29.5	62

Table 11. Chemical loading data for Lake Maxinkuckee watershed waterbodies on June 1, July 21, &September 8, 2004.

Site	Stream Name	Date	Event	NH_3-N Load (kg/d)	NO_3-N Load (kg/d)	TKN Load (kg/d)	SRP Load (kg/d)	TP Load (kg/d)	TSS Load (kg/d)
1	North Shore Tributary	6/1/2004	storm	0.122	0.448	0.823	0.042	0.072	2.139
		7/21/2004	base	--	--	--	--	--	--
		9/8/2004	base	0.000	0.006	0.023	0.004	0.006	0.320
2	Wilson Ditch	6/1/2004	storm	2.416	70.895	26.962	0.523	1.611	381.044
		7/21/2004	base	0.073	0.570	0.359	0.022	0.062	4.093
		9/8/2004	base	0.037	1.158	1.203	0.057	0.106	3.724
3	Maxinkuckee Landing	6/1/2004	storm	0.678	28.248	3.079	0.180	0.329	52.151
		7/21/2004	base	0.039	0.221	0.278	0.017	0.063	87.711
		9/8/2004	base	0.020	0.892	0.372	0.024	0.048	20.864
4	Curtiss Ditch	6/1/2004	storm	1.017	8.065	20.088	1.118	1.705	13.746
		7/21/2004	base	0.016	0.010	0.336	0.023	0.055	2.509
		9/8/2004	base	0.001	0.003	0.038	0.002	0.006	0.334
5	Kline Ditch	6/1/2004	storm	2.219	80.104	35.083	1.492	2.482	329.930
		7/21/2004	base	0.024	0.822	0.484	0.026	0.071	6.067
		9/8/2004	base	0.070	6.563	2.826	0.144	0.268	27.700
6	South Shore Tributary	6/1/2004	storm	0.117	1.552	2.621	0.150	0.249	25.053
		7/21/2004	base	--	--	--	--	--	--
		9/8/2004	base	0.001	0.039	0.029	0.006	0.008	1.659

Table 12. Areal loading of sediment and nutrients for base and storm flow sampling events in the Lake Maxinkuckee watershed waterbodies on June 1, July 21, and September 8, 2004.

Site	Stream Name	Date	Event	NH_3-N Load (kg/ha-yr)	NO_3-N Load (kg/ha-yr)	TKN Load (kg/ha-yr)	SRP Load (kg/ha-yr)	TP Load (kg/ha-yr)	TSS Load (kg/ha-yr)
1	North Shore Tributary	6/1/2004	storm	0.533	1.957	3.595	0.182	0.312	9.343
		7/21/2004	base	--	--	--	--	--	--
		9/8/2004	base	0.021	0.276	1.016	0.158	0.247	13.966
2	Wilson Ditch	6/1/2004	storm	1.419	41.629	15.832	0.307	0.946	223.748
		7/21/2004	base	0.427	3.349	2.110	0.128	0.363	24.035
		9/8/2004	base	0.215	6.799	7.065	0.334	0.620	21.868
3	Maxinkuckee Landing	6/1/2004	storm	6.397	266.492	29.045	1.701	3.102	491.988
		7/21/2004	base	3.675	20.891	26.199	1.633	5.988	8274.655
		9/8/2004	base	1.862	84.149	35.133	2.286	4.571	1968.264
4	Curtiss Ditch	6/1/2004	storm	0.651	5.160	12.852	0.715	1.091	8.795
		7/21/2004	base	0.100	0.067	2.147	0.148	0.352	16.054
		9/8/2004	base	0.006	0.022	0.246	0.011	0.036	2.135
5	Kline Ditch	6/1/2004	storm	1.200	43.323	18.1976	0.807	1.342	178.437
		7/21/2004	base	0.130	4.448	2.618	0.140	0.384	32.814
		9/8/2004	base	0.378	35.492	15.282	0.778	1.451	149.812
6	South Shore	6/1/2004	storm	1.362	18.041	30.480	1.748	2.895	291.320

	Tributary	7/21/2004	base	--	--	--	--	--	--
		9/8/2004	base	0.118	4.564	3.394	0.647	0.883	192.909

3.9.1 Wilson Ditch

In general, water quality was relatively good in Wilson Ditch, although some parameters were of concern. During both base flow and storm flow conditions, none of the samples violated the Indiana state standards for temperature, dissolved oxygen, pH, conductivity, nitrate-nitrogen, or ammonia-nitrogen concentrations. These results are consistent with historical data collected by the USEPA (1975) and LMEC Volunteers (JFNew, 1993; 1995-1999). The evaluation of Wilson Ditch's physical habitat indicated that the ditch exceeded the threshold at which IDEM typically considers a stream to be "fully supportive" of its aquatic life use designation. However, the biological community assessment indicated that the ditch fell short of the threshold level set by IDEM for the ditch's aquatic life use designation. Wilson Ditch received the highest habitat score of any of the streams in the Lake Maxinkuckee watershed (Figure 16). The stream rated a QHEI score of 66. The ditch received a mIBI score of 1.6 which is the lowest of any of the Lake Maxinkuckee streams. This score places the stream below the "non-supporting"-"partially supporting" threshold boundary. This score places the ditch in the severely impaired category.

Figure 16. Typical habitat present in Wilson Ditch.

The 2004 sampling of Wilson Ditch highlighted a few areas of concern. First, the ditch exhibited *E. coli* concentrations above the Indiana state standard of 235 cfu/100mL during both the storm flow and base flow sampling events. While exceeding the state standard is of concern, the concern should be tempered by the fact that the *E. coli* concentrations observed in Wilson Ditch were below the average *E. coli* concentration typically found in Indiana streams. In reviewing ten years worth of data from Indiana fixed monitoring stations, White (unpublished) found the average *E. coli* concentration in Indiana streams to be approximately 650 cfu/100mL. The *E. coli* concentrations measured during the 2004 water quality assessment were generally consistent with concentrations measured in Wilson Ditch by LMEC Volunteers (JFNew, 1993; 1995-1999). Also of concern are Wilson Ditch's nitrate-nitrogen and total phosphorus concentrations. While the nitrate-nitrogen concentrations did not exceed the state standard, both the nitrate-nitrogen and total phosphorus concentrations during storm flow conditions were above the concentration recommended by the Ohio EPA to protect aquatic life. (In a study correlating nutrient concentrations to biotic health, the Ohio EPA (1999) recommended keeping nitrate-nitrogen concentrations below 1.0 mg/L and total phosphorus concentrations below 0.1 mg/L in most streams to protect aquatic life.) Additionally, nitrate-nitrogen concentrations during storm flow were above the 3-4 mg/L concentration at which the Ohio EPA found a definite correlation with impaired biotic health (Ohio EPA, 1999). Nitrate-nitrogen and total phosphorus concentrations measured during the 2004 water quality assessment were also consistent with concentrations measured by the USEPA (1976) and LMEC Volunteers (JFNew, 1993; 1995-1999).

Wilson Ditch also exhibited elevated pollutant loads relative to other streams during both base and storm flow sampling. Wilson Ditch possessed the highest ammonia-nitrogen and total suspended solids loads during the storm flow event and the second highest nitrate-nitrogen, total Kjeldahl nitrogen, soluble reactive phosphorus, and total phosphorus loads during at least one of the base flow events. The elevated (relative to other watershed streams) total suspended solids loading rate suggests that the stream may carry a significant suspended solids load and/or stream erosion during storm flow may be a considerable source of sediment in the ditch. Wilson Ditch also exhibited the second highest ammonia-nitrogen areal loading rate during the storm flow event and the first base flow event. (Areal loading rate is the pollutant loading rate divided by drainage area. This allows for a comparison of loading rates in different sized drainages. Normally, pollutant loading rates in larger drainages are expected to be higher than the pollutant loading rates in smaller drainages.)

3.9.2. Maxinkuckee Landing

Although temperature, dissolved oxygen, pH, conductivity, nitrate-nitrogen, and ammonia-nitrogen concentrations measured in Maxinkuckee Landing did not violate any Indiana standards, Maxinkuckee Landing exhibited some of the poorest water quality observed in any of the six watershed streams. The stream possessed nitrate-nitrogen concentrations during storm event and total phosphorus concentrations during both base and storm flow that exceed the level at which the Ohio EPA indicate that biota are impaired. Total phosphorus concentrations measured by LMEC Volunteers were consistent with concentrations observed during 1997 and 1999 water quality assessments (JFNew, 1997; 1999). The total suspended solids concentration measured during the July base flow sampling effort was elevated (129 mg/L) exceeding the level at which suspended solids concentrations become deleterious to aquatic biota (Waters, 1995). All other TSS concentrations were within normal levels for Indiana streams. These TSS concentrations are consistent with historic TSS concentrations (USEPA, 1976; JFNew, 1993; 1995-1999). The *E. coli* concentrations in Maxinkuckee Landing were four to ten times higher than the state standard and two to five times higher than the average *E. coli* concentration in Indiana streams. These concentrations are similar to those measured by volunteers in the 1990s where *E. coli* concentrations ranged from 210 to 2000 colonies/100 mL (JFNew, 1993; 1995-1999).

Maxinkuckee Landing also possessed the highest total suspended solids loading rate during the July base flow sampling event, and the second highest ammonia-nitrogen and total suspended solids loading rates during the July base flow event, and the second highest ammonia-nitrogen and total phosphorus loading rates during the September base flow sampling event. When normalized for area, Maxinkuckee Landing possessed the highest loading rates for all parameters during both base flow events and the highest ammonia-nitrogen, nitrate-nitrogen, total phosphorus, and total suspended solids loading rates during the storm event. Finally, the biological and physical habitat (Figure 17) assessments indicated impairment of these components of the ecosystem. Maxinkuckee Landing received the second lowest mIBI score (2.2) placing the stream in the moderately impaired category. The stream's habitat was poor receiving a QHEI score of 35. Both of these scores suggest that the stream is non-supporting of its aquatic life use designation.

Figure 17. Typical habitat present in Maxinkuckee Landing.

3.9.3 Curtiss Ditch

Like Wilson Ditch, for many of the parameters measured, Curtiss Ditch exhibited relatively good water quality. None of the temperature, dissolved oxygen, pH, conductivity, nitrate-nitrogen, or ammonia-nitrogen measurements violated Indiana state standards. These results are consistent with concentrations measured by the USEPA (1976) and LMEC Volunteers (JFNew, 1993; 1995-1999). However, dissolved oxygen was low during the 2004 water quality assessment exhibiting undersaturated conditions (57%) during the September base flow sampling event. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced and/or flow in the stream is not turbulent enough to entrain sufficient oxygen. As flow through Curtiss Ditch is relatively slow, it is likely that low saturation results from a combination of both of these factors. Conversely, Curtiss Ditch exhibited supersaturated (104%) conditions during the July base flow sampling event. Based on the amount of algal growth observed in the stream during sampling, it is likely that supersaturated conditions present in Curtiss Ditch during the July event are likely due to photosynthetic activity at this site. Additionally, Curtiss Ditch possessed the lowest nitrate-nitrogen concentrations of any of the streams during both base and storm flow event sampling. The restored wetland located upstream of the sampling site likely plays a part in the low nitrate-nitrogen concentrations observed in Curtiss Ditch.

Curtiss Ditch also exhibited a few characteristics of concern. During both base and storm flow conditions, the ditch's total phosphorus concentration exceeded the concentration at which the Ohio EPA found a definite correlation with impaired biotic health (Ohio EPA, 1999). Total phosphorous concentrations also exceeded the levels at which streams are rated as eutrophic or highly productive (Dodd et al., 1998). These exceedences are consistent with historic measurements (USEPA, 1976; JFNew, 1993; 1995-1999). Additionally, total and soluble reactive phosphorus and total Kjeldahl nitrogen concentrations were the highest of any of the streams during the July base flow sampling. Curtiss Ditch also possessed *E. coli* concentrations during all three sampling efforts that exceeded the state standard of 235 cfu/100mL. *E. coli* concentrations measured during the current assessment concur with those observed historically in Curtiss Ditch (USEPA, 1976; JFNew, 1993; 1995-1999). Curtiss Ditch possessed the second highest soluble reactive and total phosphorus loading rates during the storm event and the second highest soluble reactive phosphorus loading rates during the July base flow event. When drainage size is normalized, Curtiss Ditch contained the second highest soluble reactive phosphorus loading rate during the September base flow event. This suggests that phosphorus reduction techniques should be the focus when targeting management actions in this subwatershed. Finally, Curtiss Ditch received the lowest QHEI score (31) and the second lowest mIBI score (2.2) of any of the streams in the Lake Maxinkuckee watershed (Figure 18). IDEM considers streams with QHEI scores under 51 non-supportive and mIBI scores between 2 and 4 to be partially supportive of their aquatic life beneficial use. This suggests that IDEM would consider Curtiss Ditch to be non-supporting to partially supporting for its aquatic life use designation. Curtiss Ditch's macroinvertebrate community was dominated by extremely tolerant taxa including the mayfly family *Caenidae*, which is typically characterized as a silt tolerant taxon. When looking at Curtiss Ditch's habitat, the dominance of this family is not surprising.

Figure 18. Typical habitat present in Curtiss Ditch.

3.9.4 Kline Ditch

The water chemistry conditions in Kline Ditch were fairly similar to those observed in Wilson Ditch, Curtiss Ditch, and Maxinkuckee Landing. None of the temperature, dissolved oxygen, pH, conductivity, nitrate-nitrogen, or ammonia-nitrogen measurements taken in Kline Ditch during either the storm event or under base flow conditions violated Indiana state standards. These conditions are generally consistent with those measured historically (USEPA, 1976; JFNew, 1993; 1995-1999). However, some of the nitrate-nitrogen concentrations measured by the USEPA exceeded the level at which biotic impairment occurs (Ohio EPA, 1999). The ditch received the highest mIBI score (3.0) observed in the Lake Maxinkuckee watershed placing the ditch's biological community in the moderately impaired category.

Characteristics of concern within Kline Ditch include its high nitrate-nitrogen concentration; high E. coli concentration; high nitrogen, phosphorus, and total suspended solids loading rates during base and storm flows; high total Kjeldahl nitrogen and soluble reactive phosphorus loading rates relative to the ditch's drainage size during the storm event; and high total suspended solids and total phosphorus loading rates relative to the ditch's drainage size during base flow, and a poor habitat score (Figure 19). Kline Ditch exhibited a nitrate-nitrogen concentration of 5.9 mg/L and 1.7 mg/L during storm flow and base flow (September) conditions, respectively. These concentrations are within the range found by the Ohio EPA to be correlated with biotic community impairment. Thus, high nitrate-nitrogen concentrations could be negatively impacting the fauna within Kline Ditch. Kline Ditch also possessed *E. coli* concentrations during all three sampling efforts that exceeded the state standard of 235 cfu/100mL. Furthermore, Kline Ditch possessed the highest nitrate-nitrogen, total Kjeldahl nitrogen, soluble reactive phosphorus, and total phosphorus loading rates during both the July base flow event and the storm event and the highest loading rates for all parameters measured during the September base flow event. When drainage size is normalized, Kline Ditch had the second highest nitrate-nitrogen loading rate following the storm event; the highest loading rate for nitrate-nitrogen, total Kjeldahl nitrogen, total phosphorus, and total suspended solids during the July base flow event; and the highest loading rate for all parameters measured during the September base flow event. This suggests runoff related issues should focus on when targeting management actions in this subwatershed. Finally, Kline Ditch received a low QHEI score (36). IDEM considers streams with QHEI scores under 51 to be non-supportive of its aquatic life beneficial use. Kline Ditch is primarily a highly modified feature so its low QHEI score is expected.

Figure 19. Typical habitat present in Kline Ditch.

3.9.5 North Shore Tributary

The north shore tributary possessed relatively good water quality throughout the assessment period. Temperature, dissolved oxygen, pH, nitrate-nitrogen, and ammonia-nitrogen concentrations measured in the north shore tributary did not violate any Indiana standards. However, the conductivity concentration measured during the September base flow event exceeds the Indiana standard. During both base and storm flow, the north shore tributary also possessed total phosphorus concentrations in excess of the level at which the Ohio EPA indicate that biotic impairment occurs (Ohio EPA, 1999). The *E. coli* concentrations in the north shore tributary exceeded the state standard during the September base flow and the storm flow events. Results observed in the north shore tributary are generally better than those measured by LMEC Volunteers in the 1990s (JFNew, 1993; 1995-1999). During historic assessments, the north shore tributary routinely possessed the highest TKN, TP, and *E. coli* concentrations measured in any of Lake Maxinkuckee's tributaries.

3.9.6 South Shore Tributary

Like the north shore tributary, the south shore tributary possessed relatively good water quality. Temperature, dissolved oxygen, pH, conductivity, nitrate-nitrogen, and ammonia-nitrogen concentrations measured in the south shore tributary did not violate any Indiana standards. However, there were some areas of concern related to the south shore tributary's water quality. The *E. coli* concentrations measured in the south shore tributary were 40 times the Indiana standard following the storm event. Similar results were observed in historic water quality samples (JFNew, 1993; 1995-1999). This stream also possessed the highest total phosphorus concentration during the September base flow event and the storm event. In both cases, the phosphorus concentration exceeded the level at which the Ohio EPA indicates impairment of the biotic community occurs (Ohio EPA, 1999). When normalized for drainage size, the south shore tributary possessed the highest total Kjeldahl nitrogen and soluble reactive phosphorus loading rates and the second highest total phosphorus and total suspended solids loading rates following the storm event. This indicates that the stream carries a relatively high sediment load for its small drainage area and that sediment-related measures should be targeted in this subwatershed.

3.10. Indiana Geological Survey

Data layers within the Indiana Geological Survey's GIS (Geographical Information Systems) Atlas for Indiana were reviewed to identify any additional water quality data or threats. A review of the data layers revealed the presence of one permitted confined feeding operation, three restricted waste sites (RCRA), and five documented leaking underground storage tank locations (LUST) within or immediately adjacent to the Lake Maxinkuckee watershed. Locations of each of these facilities are documented in Figure 20. Additional review revealed that no corrective action sites, construction demolitions waste sites, industrial waste sites, National Pollution Discharge Elimination System facilities or pipe locations, open dump sites, septage waste sites, solid waste landfills, Superfund sites, or voluntary remediation program sites exist within the Lake Maxinkuckee watershed (IDEM, 2002a-b; IDEM, 2004a-e; IDEM, 2004g-q).

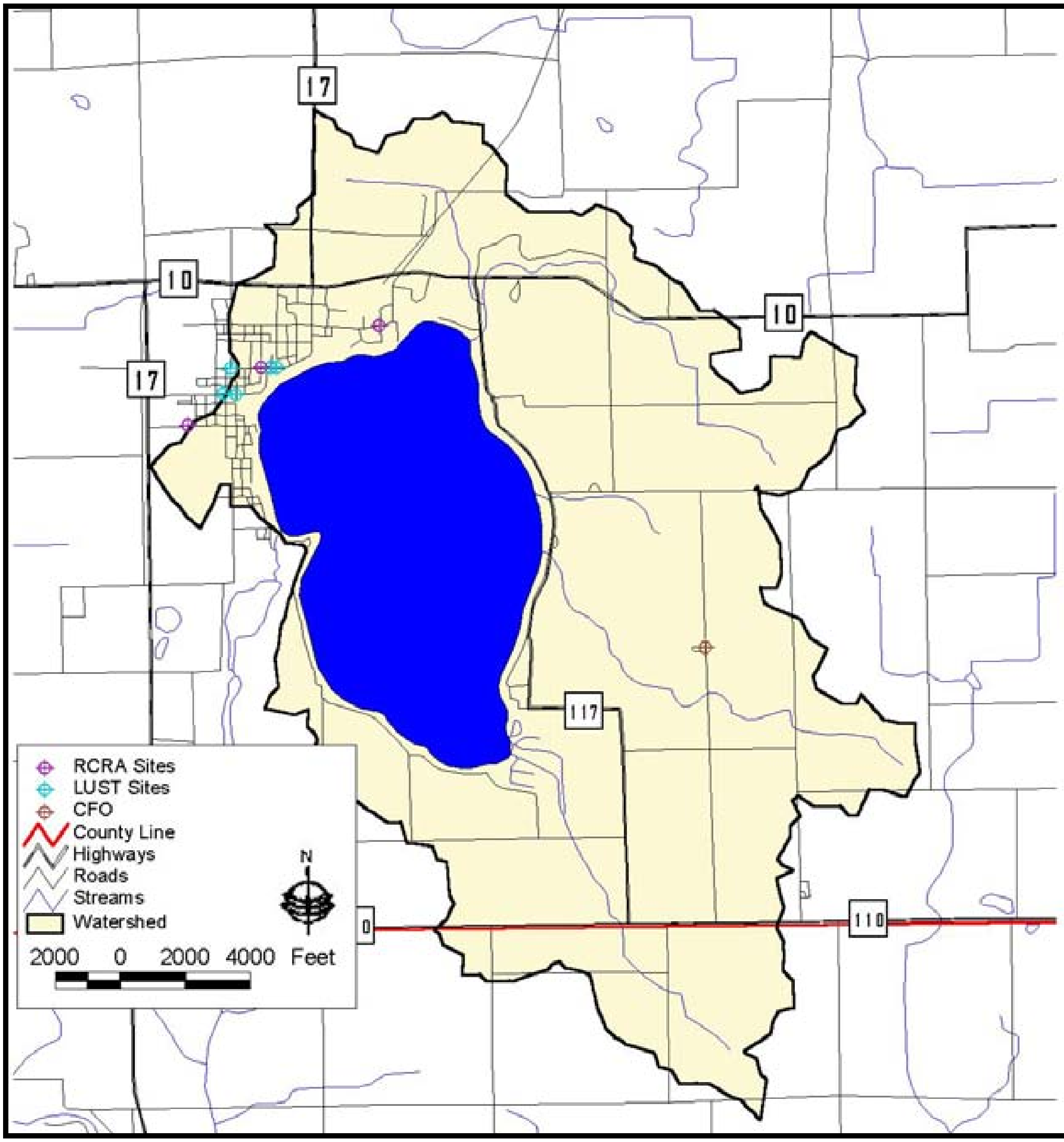

Figure 20. Confined feeding operation (CFO), restricted waste (RCRA), and underground storage tank (LUST) locations within the Lake Maxinkuckee watershed. Source: See Appendix G. Scale: 1"=4,000'.

3.11 Statewide Impaired Waters 303(d) list

The Section 303(d) list, named after the enabling legislation in the federal Clean Water Act, provides a listing of waters that do not or are not expected to meet applicable water quality standards.

Lake Maxinkuckee which is part of the Upper Wabash Basin and identified by the HUC 0512010606001, is listed in Category 5B of the 303(d) list as being impaired due to a fish consumption advisory for PCBs and/or mercury. Category 5B of the 303(d) list composes a portion of the impaired waters the State believes a conventional TMDL is not the appropriate approach, and therefore is not a targeted area for funding through the Section 319 Nonpoint Source Grant Program.

Online Resource:
http://www.in.gov/idem/water/planbr/wqs/303d.html

3.12 Unified Watershed Assessment (UWA)

Lake Maxinkuckee and its watershed is located within the priority areas in the 2001 Unified Watershed Assessment that described watersheds in need of financial or technical assistance for maintenance and improvement of water quality.

Online Resource:
http://www.in.gov/idem/water/img/prioritywatersheds.jpg

3.13 Fish consumption advisories

A number of Indiana lakes, including Lake Maxinkuckee, are listed on the 2004 fish consumption advisory for mercury and polychlorinated biphenyls (PCBs) in fish. The information below regarding these persistent chemicals is provided by the Indiana State Department of Health (ISDH) in the 2004 Indiana Fish Consumption Advisory

Mercury is a naturally occurring metal that does not break down, but cycles between land, water and air. Naturally it occurs as a result of normal breakdown of minerals in the earth's crust and some mercury reaches our waters naturally. Mercury is also released into the air from coal-burning power plants and from burning household and industrial waste. Once in the water, methyl mercury is very persistent in lakes and streams. Like mercury, PCBs remain in aquatic systems long after their introduction. PCBs were used as industrial coolants, insulating materials and lubricants in electrical equipment. The United States stopped making PCBs in 1977 because of a range of potential health effects demonstrated in laboratory animals.

PCBs and methyl mercury build up in the body over time. Long and short term exposure to mercury can damage the brain, kidney, and developing fetuses. Men face fewer health risks following exposure to mercury. Unborn children are especially sensitive to mercury poisoning and the strictest consumption advisories are focused on children under age 15, nursing mothers, and women of childbearing years to protect children from developmental problems.

In the 2004 Indiana Fish Consumption Advisory, for children and women of childbearing years;

Group 1 fish should be limited to one meal per week; Group 2 fish should be limited to 1 meal per month; Group 3 fish should not be eaten. Note that advisories for men and women beyond childbearing years are less restrictive.

The fish consumption advisory for Lake Maxinkuckee is for mercury contamination in walleye over 23 inches (Group 3) and for PCB contamination in channel catfish over 21 inches (Group 3).

Two other Marshall County lakes, Mill Pond and Lake of the Woods, have fish consumption advisories for PCBs. Lake Wawasee in Kosciusko County is the closest in size in the northern region to Lake Maxinkuckee. Lake Wawasee is listed for PCB contamination in bullhead larger than 15 inches.

Online resource:
Indiana State Department of Health Fish Consumption Advisories
http://www.ai.org/isdh/programs/environmental/fa_links.htm

3.14 Vollenweider Phosphorus Loading Model

Vollenweider's Model
Since phosphorus is the limiting nutrient in Lake Maxinkuckee, a phosphorus model can be used to estimate the dynamics of this important nutrient. With its role as the limiting nutrient, phosphorus should be the target of management activities to lower the biological productivity of Lake Maxinkuckee.

The relationships among the primary parameters that affect a lake's phosphorus concentration were examined employing the widely used Vollenweider (1975) model. Vollenweider's empirical model says that the concentration of phosphorus ([P]) in a lake is proportional to the areal phosphorus loading (L, in g/m^2 lake area - year) and inversely proportional to the product of mean depth ($\bar{z}$) and hydraulic flushing rate (ρ) plus a constant (10):

$$[P] = \frac{\mathbf{L}}{10 + \bar{z}\rho}$$

During the 2004 sampling of Lake Maxinkuckee completed by the Indiana Clean Lakes Program, the mean volume weighted phosphorus concentration in the lake was 0.023 mg/L. It is useful to determine how much phosphorus loading from all sources is required to yield a mean phosphorus concentration of 0.023 mg/L in Lake Maxinkuckee. Plugging this mean concentration along with the lake's mean depth and flushing rate into Vollenweider's phosphorus loading model and solving for L yields an areal phosphorus loading rate (mass of phosphorus per unit area of lake) of 0.255 g/m^2-yr. This means that in order to get a mean phosphorus concentration of 0.023 mg/L in Lake Maxinkuckee, a total of 0.255 grams of phosphorus must be delivered to each square meter of lake surface area per year.

Total phosphorus loading (L_T) is composed of external phosphorus loading (L_E) from outside the lake (watershed runoff and precipitation) and internal phosphorus loading (L_I). Since L_T = 0.255 g/m^2-yr and L_E = 0.252 g/m^2-yr (estimated from the watershed loading of 1,890 kg/yr), then internal phosphorus loading (L_I) equals 0.003 g/m^2-yr. Thus, internal loading accounts for about 1.2% of total phosphorus loading to the water column Lake Maxinkuckee.

When current results are compared with historic phosphorus concentration, phosphorus areal loading rates appear to have increased (Table 13). Land use information was gathered from aerial photographs from the early 1900s and 1971 to calculate external phosphorus loading rates. In 1907, external phosphorus accounted for nearly 100% of the phosphorus in Lake Maxinkuckee. Internal phosphorus likely accounted for a small portion of the total phosphorus present in the water column; however, based on Vollenweider's model, this concentration was negligible. By 1973, the areal loading rate was nearly double the level present in 1907. External loading still accounted for a major portion of the phosphorus present in the water column (99.6%) with internal loading accounting for less than 1% of the phosphorus in the lake's water column. During the latest assessment, this trend continues. Total areal loading was more than double the level observed in 1907. External loading accounted for 99% of the total load, while internal loading accounted for a little more than 1% of the total load. Overall, this suggests that while total phosphorus loading rates have increase, both the external and internal loading rates have also increased. Of greater importance, internal sources of phosphorus account for a greater portion of the total load.

Table 13. Areal phosphorus loading rates in Lake Maxinkuckee over the past 100 years.

Date	Total Loading Rate	External Loading Rate	Internal Loading Rate
1907	0.125 g/m^2-yr	0.125 g/m^2-yr	0 g/m^2-yr
1973	0.220 g/m^2-yr	0.219 g/m^2-yr	0.001 g/m^2-yr
2004	0.255 g/m^2-yr	0.252 g/m^2-yr	0.003 g/m^2-yr

Source: Evermann and Clark, 1920; USEPA, 1976; CLP, 2004.

The significance of Lake Maxinkuckee's phosphorus areal loading rate is best illustrated in Figure 21 in which areal phosphorus loading is plotted against the product of mean depth times flushing rate. Overlain on this graph are two curves, which are based on Vollenweider's model. These curves represent two different acceptable loading rates that yield a phosphorus concentration in lake water of 10 μg/L (0.01 mg/L) and 30 μg/L (0.03 mg/L), respectively. Lake Maxinkuckee's areal phosphorus loading rates from three separate sampling are included on the graph. These assessments occurred in the early 1900's (Evermann and Clark), in the mid-1970's (Howard/USEPA), and in August of 2004 (CLP). The oldest assessment of the lake was completed by Evermann and Clark in the early 1900's. This assessment possesses the lowest areal phosphorus load. The assessment completed in the 1970's indicates that areal phosphorus loading from the watershed is increasing over time. Likewise, the assessment completed in 2004 contains the highest areal phosphorus load. However, it should be noted that none of these assessments results in areal phosphorus loads above the acceptable line (0.03 mg/L).

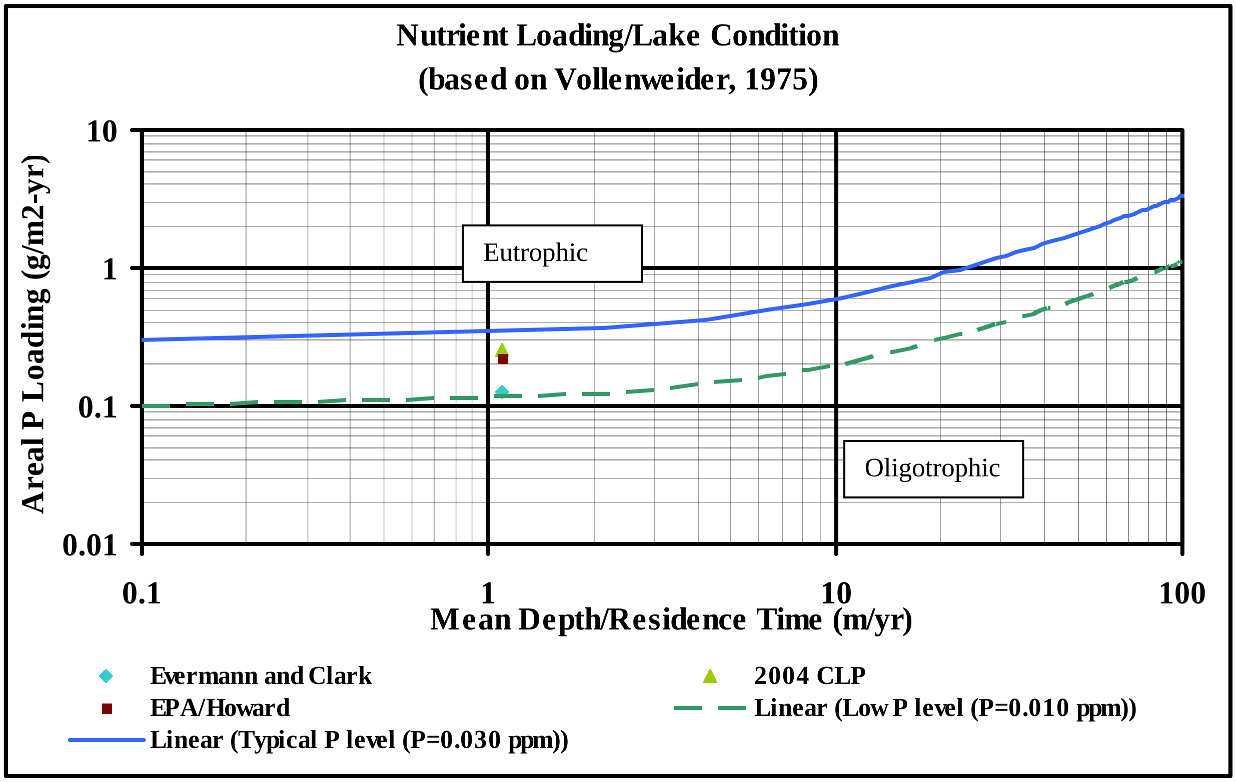

Figure 21. Phosphorus loadings to Lake Maxinkuckee from three separate assessments as compared to acceptable loadings determined from Vollenweider's model.

4.0 Developing Problems Statements

4.1 From Concerns to Problem Statements

During the December 3, 2003 and June 25, 2004 public input meetings several hundred stakeholder comments were recorded. (Appendix F) Because of the large number of stakeholder concerns expressed, each concern could not be investigated individually. Concerns with common themes were grouped together and from these grouped themes twenty-five Problem Statements were developed. Steering Committee and subcommittee members prioritized the top 12 concerns.

Not all the problem statements can be linked to empirical data because they reflect recreational or governmental concerns, or areas which have not been sampled. While some problem statements do not have the data link to back up the concerns, they were ranked as a priority concern by stakeholders and therefore were retained in the list which was then converted into goal statements and action items.

Problem Statements
(❖❖❖indicates priority concern)

1. Interaction with Local Boards (Goal 7) ❖❖❖

Problem Statement: Part-time Culver residents are concerned that since their primary residence, where they vote, is elsewhere, they are not adequately represented on local boards and since they don't vote in the community their concerns may not be considered when decisions are made.

Local board members encouraged non-voting property owners' attendance at local meetings even if they do not have direct personal issues on the agenda. Public interest drives the decisions.

2. Planning and Zoning (Goal 4) ❖❖❖

Problem Statement: Concerns were expressed to minimize on-lake and near-lake development such as multifamily housing, commercial establishments and funneling. Local Planning and Zoning ordinances should be reviewed regarding lot coverage and height of homes.

3. Centralized Watershed Management ❖❖❖

Problem Statement: The Lake Maxinkuckee watershed is in three zoning and planning districts (Culver, Marshall Co. and Fulton Co.), two counties (Marshall and Fulton), and three taxing districts (Town of Culver, Union Township (Marshall County), Aubbeenaubbee Township (Fulton County)). Because the lake is impacted by the watershed and the watershed is not inside one political or governing boundary, a new governing body could be created to regulate activities in the watershed regardless of what township, county, or zoning district currently has regulatory authority.

This is a long-range goal as achieving it will be difficult.

4. Boat Restrictions (Goal 6) ❖❖❖

Problem Statement: Over the years, residents and lake users have noticed a change in the type of boats appearing on the lake. Boats are larger, faster and louder . Residents have safety concerns with the larger, faster boats on an inland lake. Recreational quality is also a concern with the noise level and the number of boats on the lake. As a public lake in Indiana, the Indiana Department of Natural Resources regulates on the lake activities. Addressing size, horsepower, speed limits, noise, and optimal number of watercraft will need the cooperation of the Indiana Department of Natural Resources.

5. Buoy Placement (Goal 6) ❖❖❖

Problem Statement: Boating activity in shallow water churns the lake bottom and resuspends sediments into the water column creating environmental damage and ascetic problems with the turbid water. High-speed boating activity is lawful outside the 200 ft buoy line; however, water depth is variable at 200 feet from shore. In some places, the water may only be 4 feet deep 200 feet from shore. Placing buoys according to lake depth and not a specified distance from shore would keep high speed boating in deeper water and reduce churning of the lake bottom. The Department of Natural Resources (DNR) regulates the buoy placement on public lakes and change from a distance from shore to lake depth will require DNR approval.

6. Stormwater runoff/Impervious and agricultural (Goal 1) ❖❖❖

Problem Statement: Stormwater runoff, whether from developed areas or the agricultural areas of the watershed, are avenues to bring pollutants to the lake. As the watershed becomes more developed and impervious surfaces increase, local stormwater regulations in town and around the lake need to be upgraded to prevent further degradation of the lake. Watershed areas that drain into local ditches need to comply with regulations, such as buffer strips.

7. Academy (Goal 1) ❖❖❖

Problem Statement: The Culver Academies is the largest landowner in the watershed. This private boarding school is its own community within the Culver/Lake Maxinkuckee community and has potential to impact the lake's water qualtiy. They operate their own physical plant, maintain their buildings, walkways, horse troupe, and grounds and there is a need to work with the Academies separately to reduce contaminants in their runoff.

8. Wetlands (Goal 2) ❖❖❖

Problem Statement: Three wetlands were constructed on the three major ditches to trap sediment and nutrients and prevent them from reaching the lake. Maintaining optimal performance of the wetlands is important to the lake. There is a need to continue monitoring of the wetlands to determine their impact in order to evaluate their performance and value to the lake.

9. Seawalls and emergent vegetation (Goal 7) ❖❖❖

Problem Statement: Previous studies identified the Lake Maxinkuckee shoreline is composed almost entirely of bulkhead seawalls and results of these shoreline alterations are the decline of emergent shoreline vegetation and increased turbidity near shore. Educational efforts of the LMEC and the DNR permitting requirements has begun a trend toward more environmentally friendly seawalls, such as glacial stone and bioengineering at Lake Maxinkuckee. A 2003 shoreline survey showed 73 properties have either a glacial stone seawall or natural shoreline or beach, and 5 properties have emergent shoreline vegetation. While these numbers show the beginning of a trend they are still a minority of all the seawalls and more are needed. More educational efforts are needed to promote the benefits of environmentally friendly seawalls and emergent shoreline vegetation.

10. Shoreland Stewardship (Goal 7) ❖❖❖

Problem Statement: The shoreland (area immediately landward of the waterline) around Lake Maxinkuckee is extensively developed. Larger homes are being built on existing lots reducing greenspace. Manicured lawns up to the water's edge remain prominent around the lake. The number of watercraft per home, in some cases, is increasing beyond usual and customary. Planning and zoning can regulate building, but fostering stewardship practices of landowners will assist with restoration efforts.

11. Turbidity (Goal 5) ❖❖❖

Problem Statement: A common observance on Lake Maxinkuckee is cloudy or turbid water during and several days after busy boating times. There are areas of the lake outside the 200ft buoy line that are shallow, less than 10 feet, and prop action from high speed boating churns the lake bottom creating turbid conditions. Water clarity typically returns to pre-boating level by the Tuesday or Wednesday following the weekend. Scouring of the shoreline from wave action along bulkhead seawalls also creates turbid water. Wakeboarding is a recent trend in water recreation. Boats are designed to create a significant wake for a wakeboarding and the deep draft of the boats needed to make a wake could be contributing to turbidity. The LMEC installed a new weir at the outlet to maintain the water level of the lake and help combat turbidity. Is that enough and what more needs to be learned about this subject?

12. Education (Goal 7) ❖❖❖

Problem Statement: Education of <u>all</u> watershed stakeholders will be the key to successfully implementing the goals developed in the watershed management plan. Educational efforts should include: information to visitors at the public access, information on how the constructed wetlands improve water quality, how a lake works and what it needs to be healthy, available map of lake depths highlighting the shallow areas for boaters to avoid. Simply disseminating information will not be enough, on-going learning to keep pace with new management techniques and lake management issues needs to be part of the education issue. There is a need to develop further educational campaigns and strategies.

13. Direction to assist local government from other agencies, entities

Problem Statement: Some of the concerns and problems expressed cannot be addressed through the local zoning, planning and municipal boards. Action at the State and County level may be needed to move these concerns into regulations that will address them.

14. Toilets at Public Access

Problem Statement: The Department of Natural Resources places and maintains a portable toilet at the public access site on the west side of Lake Maxinkuckee. During peak boating times the toilet is overloaded and creates a health hazard. As a portable unit, residents are concerned about vandalism.

15. Hawk/Lost Lake (USGS official name: Lost Lake/Hawk Lake is the common name)

Problem Statement: Lost Lake is an approximately 60 acre shallow, degraded lake downstream of Lake Maxinkuckee. It appears the primary cause for the degradation of Lost Lake was the Town of Culver's sewage treatment plant effluent that emptied into the lake until the early 1990's. While Lost Lake is out of the Lake Maxinkuckee watershed, outflow water from Lake Maxinkuckee flows into Lost Lake. Concerns were raised regarding the affect of the input of water from Lake Maxinkuckee versus Lost Lake's watershed.

16. Sewers/ Septic Systems around Lake Maxinkuckee (Goal 3)

Problem Statement: Until recently all lakeside homes outside of the Culver town limits (approximately 350 homes) used on-site sewage disposal systems. Homes within the town limits are served by Culver's sewage treatment system. In 2002, residents on the East Shore formed a corporation and installed a wastewater wetland treatment system that serves 85 of the 114 homes in the East Shore Corporation's defined territory. On-site sewage disposal systems, such as septic systems, used for lakefront property can leach untreated sewage effluent into Lake Maxinkuckee, which can impair water quality. Previous leachate testing has shown this is happening at Lake Maxinkuckee. Some type of collection and treatment system is necessary for the remaining homes along the lake, yet a centralized sewage treatment system, while good for the water quality, may allow more development than is desirable around the lake. Balancing the need for proper sewage treatment with the desire to prevent overdevelopment in the watershed (which can be a degradation factor) concerns residents.

17. Golf Courses in the Watershed (Goal 1)

Problem Statement: There are three golf courses in the Lake Maxinkuckee watershed. Two private nine hole courses are operated by the Culver Academies and the Maxinkuckee Country Club (whose future plans include expanding to eighteen holes) and the third is a public eighteen hole course called Mystic Hills. The Maxinkuckee Country Club course boarders and drains into the Curtiss Ditch, less than a quarter mile from Lake Maxinkuckee and the Mystic Hills course boarders the Kline Ditch. The Maxinkuckee Country Club and Mystic Hills are two of the 5 major property owners in the watershed. The 80-acre restored wetland on the Kline Ditch is between the lake and the Mystic Hills course. Typically, golf courses maintain their grounds, fairways and greens for an aestically pleasing appearance and playability with turf chemicals and fertilizers. These chemicals and fertilizer can make their way into the lake. Because of the large amount of land use in the watershed as golf courses, regulations to prevent runoff into the lake need to be enforced and probably enhanced. In addition, the Maxinkuckee Country Club periodically cleans a large sediment trap in the Curtiss

Ditch. Arrangements for cleaning and work on the pumps near the lake need to be timed and executed to prevent the release of sediment into the lake.

18. Inclusion for representation for all watershed stakeholders

Problem Statement: All watershed landowners, lakeside, agricultural, and Town residents need to be represented during the development of the Watershed Management Plan.

19. Healthy fish population (Goal 5)

Problem Statement: There seems to be an adequate population of walleyes and small mouth bass, which are popular game fish, however, fisherman have reported fewer large mouth bass and fewer bluegill and perch, which are forage fish. Carp and gar seem to be abundant. Does Lake Maxinkuckee have a healthy fish population? Residents report seeing fewer turtles now, than in the past few decades.

20. Nutrients from birds (Goal 3)

Problem Statement: Populations of Canada geese and seagulls have increased in recent years. With the increase in the number of birds, comes the increase in the amount of bird waste. The birds and their waste are creating hazardous conditions along the lakeshore and with lakefront property.

21. Mercury contamination in fish (Goal 6)

Problem Statement: Lake Maxinkuckee is listed on 2003 IDEM 303(d) list of impaired waters for mercury contamination in walleye over 23 inches and for PCB contamination channel catfish over 21 inches. It is suspected the mercury and PCB's enter the system through air deposition from coal burning power plants.

22. Zebra Mussels (Goal 5)

Problem Statement: Zebra mussels were discovered in Lake Maxinkuckee in 1995. Since their discovery, the population has grown considerably. Over the years, the zebra mussel infestation has been a hazard for swimmers and residents have become accustomed to wearing water shoes to prevent cuts. Any hard object left in the water will become covered with zebra mussels. While residents have become accustomed to the zebra mussels, all are concerned what the long-term consequences are for the lake.

23. Dredging/Silt (Goals 1 & 2)

Problem Statement: Residents have observed areas of the lake bottom that were sandy and now silty and dirty. Water quality sampling data indicate that each of the watershed streams carry elevated sediment loads during at least some portion of the year. Can the accumulated silt be removed and what are the regulations?

24. Foam/Organic matter

Problem Statement: After windy days or times of heavy boat traffic foam accumulates on shorelines around the lake. Residents have commented the amount of foam is greater now than in previous decades. The foam is not aesthetically pleasing to the residents where it collects. If the appearance of foam is determined by the amount of organic plant material in the lake, is there more plant material in the lake?

25. Miscellaneous

Problem Statement: Residents have commented the lake is "spring-fed" and have wondered how that helps the lake quality. Each year firework displays are performed over the lake and is that a pollution issue? The water level of the lake fluctuates throughout a year. How does that relate to water quality? The location of weed patches, deep holes and shallows were common knowledge among regular fisherman on the lake, but not so anymore. What do changes in the location of weed patches, etc. mean?

4.2 Linking Concerns to Existing Data

Table 14. Linking Stakeholder's Concerns to Existing Data

Problem Statement Bold lettering indicates priority rank concern	Existing Data
1. Interaction with Local Boards	No data link
2. Planning and Zoning	No data link
3. Centralized Watershed Management	No data link
4. Boat Restrictions	Recommendations #26 and #27 of the 1999 Final Report of the IN Lakes Mgmt Workgroup echos these same concerns. (ILMWG, 1999)
5. Buoy Placement	Boating impacts on water clarity are documented in the Crisman Report (Crisman, 1986) and in volunteer secchi disk data. Recommendation #3 of the 1999 Final Report of the IN Lakes Mgmt Workgroup echo these same concerns. (ILMWG, 1999)
6. Stormwater Runoff/Impervious Cover and Agriculture	The Vollenweider Phosphorus loading model which utilized the 2004 water quality sampling program indicates increasing phosphorus loading to the lake from the watershed.
7. Academy	No data link
8. Wetlands	2004 water quality sampling indicate the wetlands are positively affecting the lake's water quality.
9. Seawalls and emergent vegetation	Historic and current vegetation surveys indicate a reduction in near shore vegetation and visual, informal surveys indicate the majority of seawall types around the lake are bulkhead style.
10. Shoreland Stewardship	Phosphorus loading model suggests nearly ¼ of the

	phosphorus entering the lake is from direct drainage
11. Turbidity	While the overall water clarity of the lake is improving (Crisman, 1999), regional areas see reduced water clarity during the boating season
12. Education	The increasing number of glacial stone seawalls indicates educational efforts can be effective.
13. Direction to Assist Local Government	No data link
14. Toilets at Public Access	A 1995 leachate study indentified the most serious hotspots occurred immediately off the boat ramp at the public fishing site and near Long Point, indicating a need for toilet facilities at the public access site. (Commonwealth, 1995) Maintaining these facilities so they are regularly used may improve these hotspots.
15. Hawk/Lost Lake	Lost Lake is not in the Lake Maxinkuckee Watershed, but Lake Maxinkuckee is a large part of the Lost Lake watershed.
16. Sewers/Septics around lake	Nearly ¾ of the lake is not on septic systems. Only the South and West shores remain on septic systems and they are currently organizing for form a conservancy district to sewer.
17. Golf Courses	Three golf courses are in the Lake Maxinkuckee watershed. No data exists which shows specific impact from the golf courses, however, phosphorus loading model indicates nearly 4,000 pounds of phosphorus enters the lake each year. As part of the watershed it is assumed they may be contributing.
18. Inclusion of all Watershed Stakeholders	Every watershed resident was sent postcards announcing the first two public input meetings along with numerous newspaper articles to increase awareness of planning process.
19. Healthy Fish Population	Historic and current fishery studies indicate a healthy fish population.
20. Nutrients from birds	No data specifically identifies contamination from birds, however, residents confirmation of geese, seagull and other waterfowl populations on the lake, and from e. coli data collected, it is assumed they may be contributing.
21. Mercury Contamination in Fish	Lake Maxinkuckee does have a fish consumption advisory for mercury and PCBs

22. Zebra Mussels	Zebra mussels were discovered in the lake in 1995.
23. Dredging/Silt	Sediment coring conducted for the Crisman Report suggests sedimentation increased 39% from the early 1960's to 1984. (Crisman,1986) Results of the 2004 modeling suggest that wetlands and ponds throughout the watershed are removing and storing a portion of the TSS load reaching the ditches.
24. Foam/Organic Matter	No data exists to confirm or deny problems associated with lake foam.
25. Misc.	No data exists to confirm or deny concerns

5.0 Critical Areas Based on Nutrient/Sediment Loading to Lake

Due to delays at the Federal level, the grant contract for this project was not finalized until the fall of 2003. Typically, contracts are completed in July and sampling can be conducted in the beginning of the watershed planning process. Work on the project could not begin until the contract was signed, which, by September, was too late in the season to conduct water quality sampling. However, project work did began the fall of 2003 by collecting and reviewing historic data, identifying stakeholders, conducting the public input meetings and organizing input information. Water quality sampling was conducted the summer of 2004, being finalized in September. Both public input sessions were without the benefit of actual sampling data to guide public concerns. The public input, however, was comprehensive, covering all major areas of concern for watershed management: runoff from watershed, shoreline habitat, in-lake management, recreation, land use planning. The stakeholder's comprehensive overview of concerns demonstrates their high education level and concern for the health of the lake and should be recognized.

The Lake Maxinkuckee Environmental Council has been working on lake and watershed issues since 1981 and has provided information to stakeholders for many years. Public input was comprehensive and covered all major areas of concern for lake and watershed management, demonstrating the high education level of stakeholders in the community. Of the twelve priority concerns, only one regarded nutrient loading from the watershed. As the Lake Maxinkuckee watershed land use consists primarily of agricultural land uses, this land use type was a primary focus of critical area identification. These areas are also key targets for water quality improvement projects.

5.1 Agricultural Land Use

Agricultural land uses dominate the Lake Maxinkuckee watershed. Row crop agricultural areas cover approximately 27% of the watershed. Pasture occupies an additional 14% of the watershed. Production of crops can affect water quality, depending upon use of nutrient application, drainage, and erosion control practices. Nutrients applied to fields can reach waterways in stormwater runoff if sufficient management practices are not utilized. Most of the agricultural lands, (82%), lie in the Curtiss, Kline, and Wilson ditch watersheds.

Based on a review of aerial photography, approximately 10,000 feet of ditch in these three watersheds were estimated to be in need of filter strips or widening and/or enhancement of existing filter strips.

Tillage transects for Marshall and Fulton Counties suggest corn producers utilize mulch tillage 66% and 29% of the time, respectively; no-till 11% and 14% of the time, respectively; and conventional tillage methods 23% and 57% of the time, respectively. The tillage transect data indicate soybean producers in Marshall and Fulton Counties utilize mulch tillage 59% and 37% of the time, respectively; no-till 36% and 56% of the time, respectively; and conventional tillage methods 5% and 11% of the time, respectively. Use of conservation tillage specifically in the Lake Maxinkuckee watershed is not known, but the county-wide tillage data may serve as a good estimate.

Tillage practices have changed dramatically over the past few decades. Historically, all cropland was plowed in the spring and fall to prepare the soil and reduce weed growth. As a consequence, bare ground eroded easily, sending sediment into streams and lakes. Conservation tillage leaves residue on the ground in the form of roots, stems and leaves that are effective in reducing soil erosion and sedimentation. By reducing soil loss, transport of phosphorus bound to the soil is also reduced.

IDNR Soil Conservation defined tillage practices:

No-till - any direct seeding system, including strip preparation, with minimal soil disturbance.

Mulch Till – Any tillage system leaving greater than 30% crop residue cover after planting, excluding no-till.

Conventional – Any tillage system leaving less than 30% crop residue cover after planting.

5.2 Nutrient/Sediment Loading to Lake

In 1973 the US EPA determined Lake Maxinkuckee is phosphorus-limited (Crisman, 1986), meaning the photosynthesis of algae and aquatic plants are limited by the amount of available phosphorus. In other words, the more phosphorus added to the lake, the greater the growth and abundance of algae and aquatic plants. Conversely, less phosphorus in the system, results in less problem aquatic plant growth. Excessive plant growth is typically a characterization of increasing eutrophication. From a lake management standpoint reducing the amount of phosphorus entering the lake is a critical goal.

Lake water quality is categorized into three broad categories: oligotrophic, mesotrophic and eutrophic. Oligotrophic lakes are clear, unproductive lakes that support little algae and aquatic plants and have reduced fish abundance. Mesotrophic lakes have moderate algae, aquatic plant production, and water clarity with well developed gamefish populations. Eutrophic lakes are extremely productive and experience severe aquatic plant management problems which may include algae blooms.

At the turn of the century Lake Maxinkuckee's classification was on the oligotrophic-mesotrophic boundary (Crisman, 1986).

The 1982 Howard Consultants phosphorus loading model shows an annual phosphorus load to the lake of 1,566 kilogram per year. A Vollenweider model constructed in 1982 placed the lake near the mesotrophic-eutrophic boundary. (Crisman, 1986)

The 2004 phosphorus loading budget shows an increase in the annual loading to 1,703 kilograms per year and the Vollenweider model places Lake Maxinkuckee closer to the mesotrophic-eutrophic boundary than the 1982 model. While the phosphorus loading has increased over the years, the *rate* of increase has slowed, evidence practices put in place since the 1986 Crisman Report are working. Lake Maxinkuckee, based on the phosphorus loading, should be becoming more eutrophic. However, it is not experiencing excessive plant growth or algae blooms and Indiana Clean Lakes Program, based on their data collection, classify Lake Maxinkuckee as mesotrophic. It should be noted Clean Lakes data collection occurs over the deepest part of the lake and not near inlet ditches. Possible explanations for the increasing phosphorus loading without the eutrophication symptoms is the enhanced zooplankton populations brought on by the walleye stocking as mentioned in the fisheries section and the "sinking" of the phosphorus into the deeper waters. Despite the varying degrees of classifications of the lake, it is prudent to continue phosphorus reducing strategies in the lake management program and therefore are priority goals in this plan. The critical areas defined below are areas where improvement in land use practices can result in reduced phosphorus loading into the lake.

2004 Phosphorus Loading

Table 15. 2004 Phosphorus Loading

	Total Phosphorus (TP) based on Sampling (TP kg/yr)	**%**	**Total Phosphorus based on Model (TP kg/yr)**	**%**
Wilson Ditch	216.32	24.34	465.84	30.73

Curtiss Ditch	214.78	24.16	355.80	23.47
Kline Ditch	343.19	38.61	528.31	34.85
Maxinkuckee Landing	53.62	6.03	59.21	3.91
North Shore Tributary	14.08	1.58	90.56	5.97
South Shore Tributary	46.82	5.27	16.12	1.06
Total From Tributaries	**888.82**	**100%**	**1,15.85**	**100%**
Direct to Lake*	374.64		374.64	
Subtotal	**1,263.46**		**1,890.49**	
Septics*	40.00		40.00	
Precipitation**	400.00		400.00	
Total Annual Phosphorus load to Lake	**1,703.46**		**2,330.49**	

*Used estimate from TP model
** Used estimate from Howard Consultants, Inc.

The sampling data is used to estimate the current annual total phosphorus load to Lake Maxinkuckee of 1700 kg/yr. A simple model suggested that the current annual total phosphorus load to Lake Maxinkuckee is 2330 kg/yr rather than 1700 kg/yr. The 1700 kg/yr estimate should be viewed with caution since it is based on three sampling events. This is the only data available at this point. At the same time, the 2330 kg/yr estimate may be an overestimate since it does not account for the presence of the three wetlands on the three major inlets which likely are removing some phosphorus from the system. For ease, the figures based on sampling data will be used in discussion and comparisons.

(note: 1 kg = 2.2 lbs, therefore 1703.46 kg = 3,747.60 lbs)

Howard Consultants
Annual Phosphorus Loading
1982

Table 16. Howard Consultants

	Total Phosphorus (TP) (TP kg/yr)	**%**

Wilson Ditch	100	6.4
Curtiss Ditch	240	15.3
Kline Ditch	310	19.8
Minor Tributaries and direct drainage	476	30.4
Septics	40.00	2.6
Precipitation	400.00	25.5
Total Annual Phosphorus Load to Lake	**1,566**	**100**

Based on the 2004 Phosphorus Loading Budget, of the phosphorus reaching the lake from the watershed (tributaries and direct drainage), approximately 30% is being contributed by the direct drainage areas and 70% from the outlying watershed through the tributaries. (see Appendix I for Subwatershed Land Use)

5.3 Direct Drainage

Hot spots

- Residential and urban land due to lawn fertilizer use and high percentage of impervious surface: 70% of the residential/urban land drains immediately to the lake or to the lake via a storm sewer or minor drainage.
- Shoreline residential land due to lawn fertilizer use and lack of buffer between property and lake

Primary phosphorus exporting land uses where change in practices can reduce phosphorus export is shown in Table 17.

Table 17: Direct Drainage Primary Land Uses

Land Use	Acres	Phosphorus export Kg/yr
Low Intensity Residential	318	103
Row Crop	296	120
High Intensity Commercial	37	37
High Intensity Residential	23	23

Reducing phosphorus input from direct drainage areas can be addressed by increasing landowner education and incorporating Best Management Practices into property management.

5.4 Tributaries

Hot spots in the subwatersheds of three main tributaries

Three golf courses and recreational or park land: 83% of the golf course or recreational/park land in the Lake Maxinkuckee watershed lies within the subwatersheds of the lake's three main tributaries. Based on a review of aerial photography, approximately 5,000 feet of ditch were estimated to be in need of wider buffer.

- Agricultural land: 82% of the agricultural land in the watershed lies in one of these three subwatersheds. Based on a review of aerial photography, approximately 10,000 feet of ditch were estimated to be in need of filter strips or widening and/or enhancement of existing filter strips.
- Eroding banks along Wilson Ditch: approximately 3,100 feet of ditch were estimated to be in need of some type of erosion control or stabilization work.

5.4.1 Kline Ditch In both the 1982 and the 2004 budgets, the Kline Ditch carries the largest phosphorus load into the lake. Primary phosphorus exporting land uses where change in practices can reduce phosphorus export is shown in Table 15. Review of aerial photographs shows approximately 5,000 feet of ditch are estimated in need of a wider buffer or filter strip.

Table 18: Kline Ditch Primary Land Uses

Land Use	Acres	Phosphorus export Kg/yr
Low Intensity Residential	174	56
Row Crop	697	282
Golf Course	174	106
Pasture/Hay	214	146

5.4.2 Curtiss Ditch Primary phosphorus exporting land uses where change in practices can reduce phosphorus export is shown in Table 16. Review of aerial photographs show approximately 2,300 feet of ditch are estimated in need of a wider buffer or a filter strip.

Table 19: Curtiss Ditch Primary Land Uses

Land Use	Acres	Phosphorus export Kg/yr
Golf Course	48	29

Row Crop	551	223
Pasture/Hay	335	54

5.4.3 Wilson Ditch In addition to phosphorus loading Wilson Ditch exhibited elevated Total Suspended Solids, suggesting streambank erosion may be a considerable source of the sediment. Approximately 3,100 feet of ditch were estimated to be in need of some type of erosion control or stabilization work.

Primary phosphorus exporting land uses where change in practices can reduce phosphorus export is shown in Table 17. Review of aerial photographs show approximately 8,200 feet of ditch are estimated in need of a wider buffer or filter strip.

Table 20. Wilson Ditch Primary Land Uses

Land Use	Acres	Phosphorus export Kg/yr
Row Crop	714	289
Golf Course	120	73
Pasture/Hay	300	49

5.4.4 Maxinkuckee Landing, North Shore Tributary, South Shore Tributary These three tributaries each showed areas of concern, especially Maxinkuckee Landing which exhibited the poorest water quality observed in the six watershed streams; however, their overall contribution to the lake is much smaller than the Curtiss, Kline and Wilson Ditches.

6.0 Setting Goals, Objectives and Action Plans

To maintain the integrity of a watershed stakeholder driven plan, goals were developed from the problem statements. The seven goals address the recreational, governmental, in-lake, and watershed concerns shown by the water quality sampling and expressed by stakeholders. The goals developed and reviewed by steering committee members, were presented at a public meeting June 15, 2005. Additional comments were received and incorporated into the goals and strategies.

During the development of implementation strategies, care was taken to discuss strategies with representative stakeholders to ensure strategies in the plan were acceptable and practical to implement. Modifications were made as necessary. For example, vegetative buffer strips are an effective Best Management Practice used to reduce runoff of lawn care products, particularly fertilizer, from lakeside property. Lakeside property owners were more receptive to using phosphorus-free fertilizer and using more care in its application to prevent runoff than creating vegetative buffer strips. With the highly positive response to more carefully applied phosphorus-free fertilizer, the strategy of increasing vegetative buffer strips was replaced. With increased stakeholder participation it is expected this practice will substantially reduce phosphorus loading from this source than an unpopular strategy.

The Lake Maxinkuckee Environmental Council has made a policy of basing decisions and actions on science-based information. Development of the current status of the lake through the water quality sampling and phosphorus budget was based on sound scientific methods to provide usable data from which management decisions could be made. Adherence to the Quality Assurance Project Plan (QAPP) provides that assurance. All strategies relating to nutrient and sediment reduction were developed with the most current knowledge of practices proven to provide water quality improvement.

Action plans highlighted in this section are for priority goals. A full list of action plans for all goals and objectives are listed in Appendix M.

Highlighted areas indicate priority item

Goal 1: Slow the cultural eutrophication of Lake Maxinkuckee. In the next ten years, reduce the annual total phosphorus load to Lake Maxinkuckee from approximately 1700 kg/yr estimated from current sampling to the 1973 estimate of 1565 kg/yr. This is just over 8% reduction in total phosphorus load to the lake.

Sources of phosphorus
Fertilizers
Atmospheric deposition
Wildlife waste
Human waste
Bank erosion

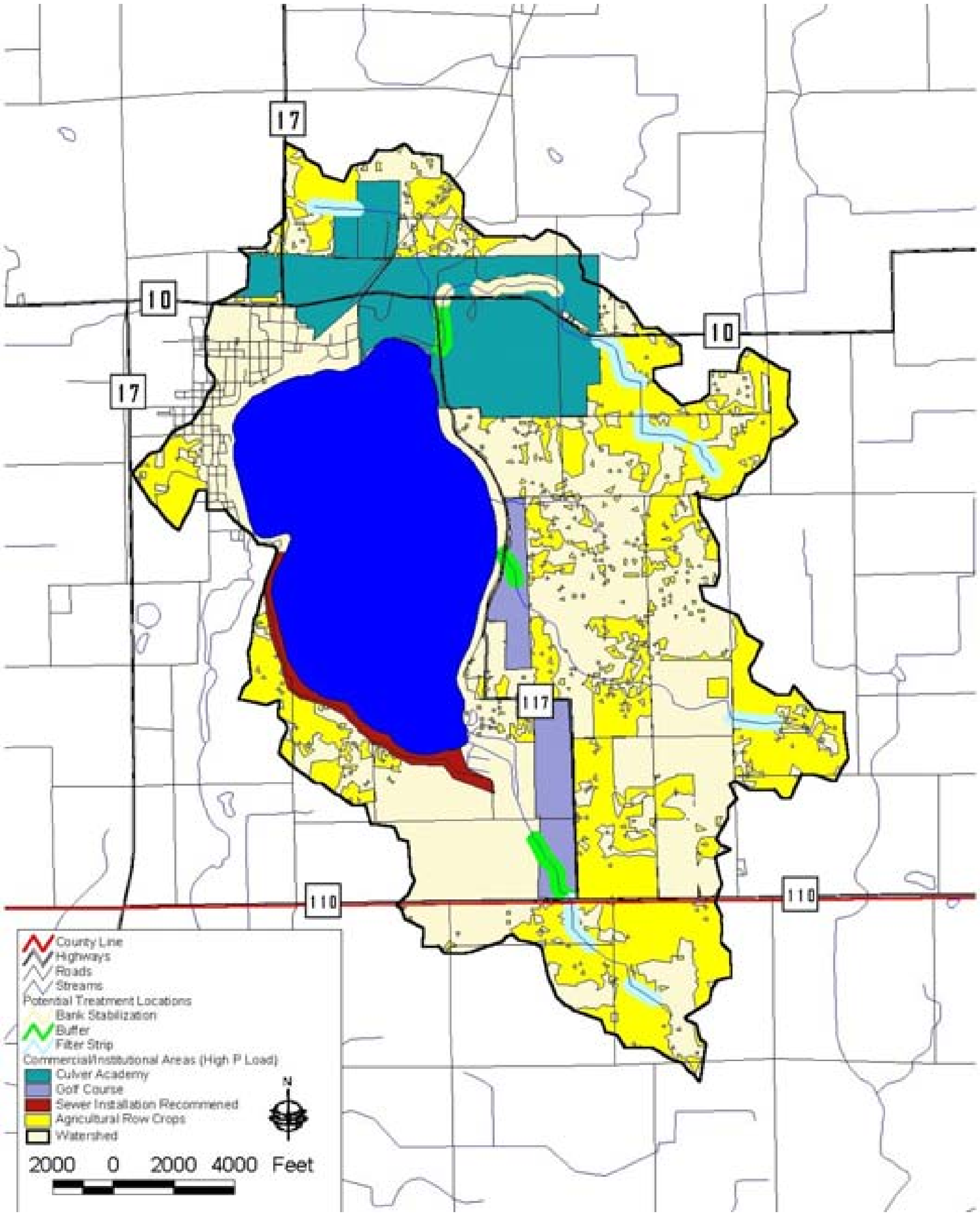

Figure 22. Critical areas targeted for nutrient loading reduction in the Lake Maxinkuckee watershed. Goal 1. Source: See Appendix G.

Subgoal A: Achieve a 33% reduction in total phosphorus load from each of the main tributaries to Lake Maxinkuckee (Wilson Ditch, Curtiss Ditch, and Kline Ditch).

Objective 1. Work with the Culver Academies and the three golf courses to greatly reduce or eliminate use of phosphorus containing fertilizers on these properties.

- No model available to predict reduction in TP but restricting fertilizer use to phosphorus-free fertilizers should significantly lower TP load to the lake.
- Potential Strategy 1. Golf courses to become certified through Audubon International golf course management program.
- Potential Strategy 2. Golf course to use ditch water to irrigate property.

Action Plan:
Contact major non-agricultural landowners, obtain fertilizer practices, evaluate and suggest appropriate changes to reduce runoff.
Responsibility: LMEC Time: Fall 05
Funding Source: LMEC Staff salary

Objective 2. Plant or increase existing buffers along ditches, particularly in the parks and golf course areas and agricultural land. Installing or improving 1,500 feet of buffer strip/grassed waterways each year for the next 10 years will achieve the needed 10,000 feet of buffer strips/grassed waterways along the main tributaries in the watershed.

- Based on model, expect to see an approximately 9% reduction in TP load if *filter strips* are added to all agricultural land where filter strips are limited in size or lacking.
- No model available to predict reduction in TP by using buffers along golf courses, but it is reasonable to expect a reduction.

Action Plan: Identify all agricultural landowners in watershed and develop a contact list. Identify major, influential farmers to approach first. Work with Marshall and Fulton County SWCD to enroll riparian areas in programs. Host Informational dinner for agricultural landowners with representatives of Conservation Reserve Enhancement Program and The Nature Conservancy.
Responsible: LMEC create contact list and influential farmer list. LMEC to plan and pay for informational dinner. SWCD and LMEC to contact landowner. LMEC track process of enrolled programs.
Time: Fall 05 – create contact list
Winter 06 – begin landowner contact, host informational dinner
Funding Source: LMEC staff salary, Conservation Reserve Enhancement Program or other Agricultural programs

Objective 3. Work with the Marshall and Fulton County SCWDs to increase the use of no-till tillage methods throughout the watershed.

Action Plan: Same as Objective 2's Action Plan. Include tillage education with buffer strip, grassed waterway education.

Objective 4. Stabilize eroding ditch banks along Wilson Ditch.

- Based on model, expect approximately 1.8% reduction in TP using this BMP.
- Practice will also reduce TSS to the lake.
- Method depends on amount of erosion, which varies in Wilson Ditch, and the available funding. Biolog installation, soil encapsulated lifts, erosion control blankets and seeding/plugging, and Palmiter methods are all options for stabilizing the ditch banks.

Action Plan: Obtain landowner contact information. Set appointment to make presentation on problem.
Responsible: LMEC
Time: Fall 05/Winter 06
Funding Source: Culver Academies, Lake and River Enhancement Program

Subgoal B: Achieve a 50% reduction in total phosphorus load from the area draining directly to the lake or indirectly to the lake via storm sewers or minor tributaries.

Objective 1. Work with City officials, local businesses, and residents to ensure streets, sidewalks, driveways, and any other hardscape is swept regularly to reduce impact of atmospheric deposition.

- Based on model, expect a 6% reduction in TP using this BMP.
- Practice will also reduce TSS to the lake by 16%.

Action Plan: Evaluate Town of Culver's current street sweeping program and work with Town toward changes that may improve program. Include hardscape sweeping benefits in educational program.
Responsible: LMEC/Town of Culver/Education Committee
Time: Fall05/Winter 06 (if time constraints then Spring 06)
Funding Source: LMEC staff salary and Volunteer effort

Objective 2. Conduct outreach to ensure lake residents are utilizing best management practices. These include proper yard, pet, and wildlife waste disposal; use of lake water rather than fertilizers to fertilize yards; stabilization of all drainages with rock or preferably vegetation; and use of rain gardens/barrels where appropriate.

- No model available to predict reduction in TP by using implementing individual property BMPs, but it is reasonable to expect a reduction.

Action Plan: Include these topics for agenda for Education Committee. Investigate communal composte for yard waste disposal
Responsible: LMEC/Education Committee
Time: Fall 05 – on going
Funding Source: LMEC staff salary, LMEC budget and/or Marshall Co. Comm. Fnd.

Objective 3. Work with the south side residents to enable the elimination septic systems for treating residential waste water.

- Elimination of septic systems would reduce TP loading to lake by 1.7-2.3%.

Goal 2: Decrease the sediment load to Lake Maxinkuckee by 25% over the next 10 years.

Sources
Active construction sites
Eroding stream banks
Agricultural land

Hot spots

- Near shore area likely to be location of development (i.e. active construction)
- Eroding banks along Wilson Ditch: approximately 3,100 feet of ditch were estimated to be in need of some type of erosion control or stabilization work.
- Agricultural land: 82% of the agricultural land in the watershed lies in one of these three subwatersheds
- Proposed bridge reconstruction/realignment: will be a future hot spot. (The IN. Dept. of Transportation will be replacing a culvert and realigning a portion of the Wilson Ditch upstream of the constructed wetland in 2007)

Objective 1. Stabilize eroding stream banks along Wilson Ditch

- The model predicts a greater decrease in TSS loading than the measured TSS load in Wilson Ditch. Some of the sediment that has eroded from these unstable banks is likely stored in the wetland/pond complex immediately upstream of the intersection of State Road 10 and State Road 117. Thus, the measured TSS *in the ditch* is lower than the TSS load *reaching the ditch*. It is important to remember that the measured TSS is an estimate of the annual load rather than a calculation of it. It was estimated from the three sampling events. Consequently there is likely error associated with it. Regardless, it is reasonable to expect a reduction in TSS if the banks along the eroding portions of Wilson Ditch are stabilized.
- Method depends on amount of erosion, which varies in Wilson Ditch, and the available funding. Biolog installation, soil encapsulated lifts, erosion control blankets and seeding/plugging, and Palmiter methods are all options for stabilizing the ditch banks.

Action Plan: Same as Goal 1, Objective 4

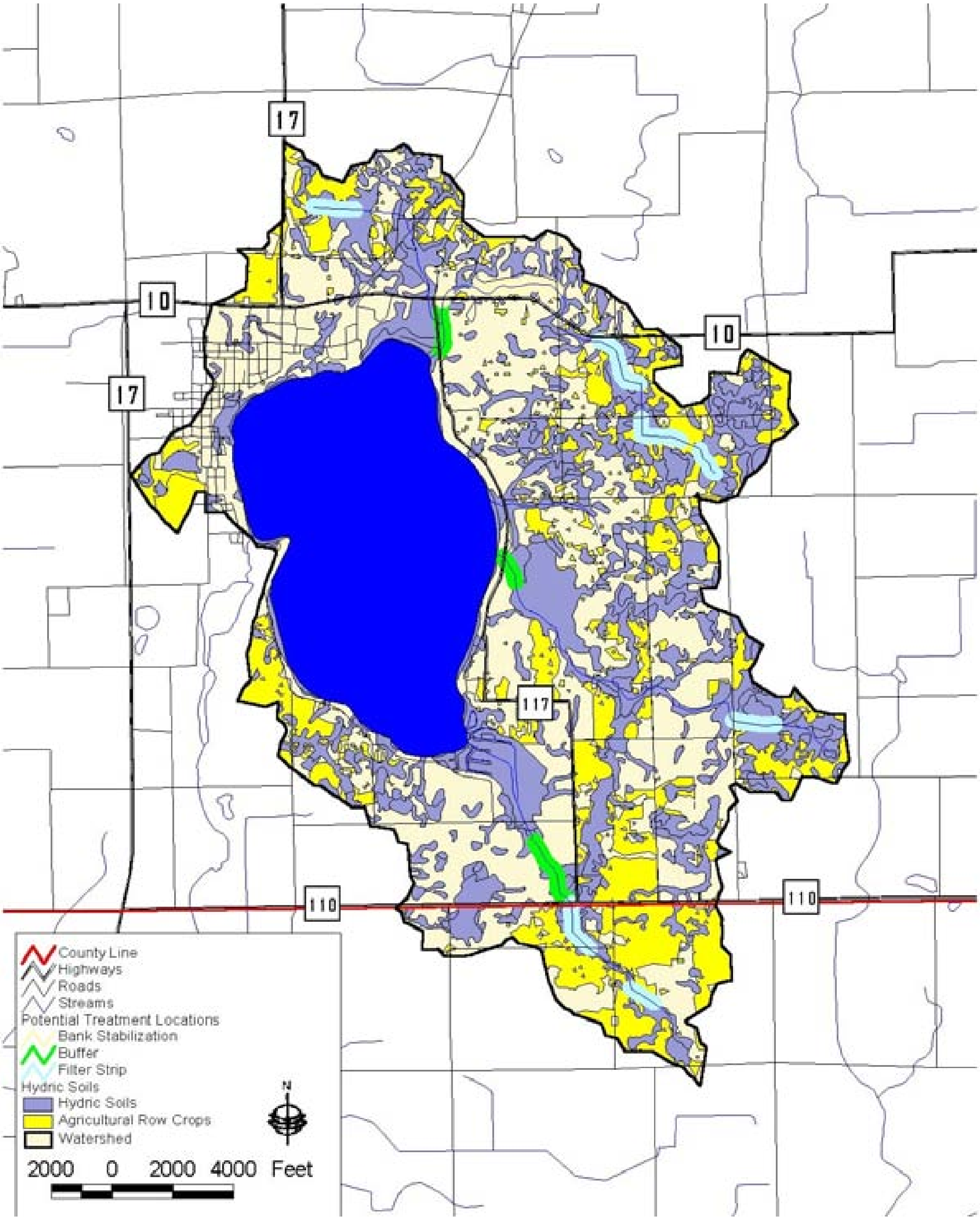

Figure 23. Critical areas targeted for sediment loading reduction in the Lake Maxinkuckee watershed. Goal 2.
Source: See Appendix G.

Objective 2. Construct filter strips and *grassed waterways* or increase width of existing filter strips along agricultural land.

- Again, the model predicts a greater decrease in TSS is possible with the implementation of filter strips than the measured TSS load in the ditches. The watershed's existing wetlands and ponds likely trap and store a significant portion of the TSS load reaching them, resulting in lower measured TSS loads at the mouths of the ditches than the TSS loads that may be reaching the ditches. It is reasonable to expect a reduction in TSS load to the lake if filter strips are installed throughout the watershed.

Action Plan: Same as Goal 1, Objective 2

Objective 3. Work with the Marshall and Fulton County SCWDs to increase the use of no-till tillage methods throughout the watershed.

Action Plan: Same as Goal 1, Objective 2

Objective 4. Restore the watershed's wetlands where feasible.

- The results of the modeling suggest that wetlands and ponds throughout the watershed are removing and storing a portion of the TSS load reaching the ditches. Restoring wetlands where feasible will increase the storage potential of the watershed. In addition to storing sediment, wetlands serve as groundwater recharge sites and allow the watershed to regain its natural hydrological regime. This helps prevent bed and bank erosion in adjacent streams since water is stored in wetlands during high flows, protecting the streams from the energy associated with high flows. Wetland restoration should be targeted to the Wilson Ditch subwatershed first where stream banks are already eroding.
- No model is available to predict reduction in TSS loading by restoring wetlands in the watershed.

Action Plan: Same as Goal 1, Objective 2. Will include wetland restoration information when contacting landowners. Funding Source: Wetland Reserve Program

Objective 5. Protect existing wetlands, ponds, and other water storage areas.

- Of the tributaries sampled, the TSS load was second lowest in Curtiss Ditch despite the fact that this ditch drains the third largest subwatershed. The TSS load in Curtiss Ditch was less than that in Maxinkuckee Landing and the South Shore Tributary. Curtiss Ditch flows through several wetland and ponds complexes before it outlets to Lake Maxinkuckee. These areas likely play a role in removing sediment from the water before it reaches the lake. These areas and other similar areas should be protected from development to ensure they continue providing this benefit to the lake.
- No model available to predict reduction in TSS by protecting wetlands and ponds in the watershed.

Objective 6. Install check dams in steep minor drainages such as the South Shore Tributary.

- Based on the model, expect to see a 50% reduction in TSS load from the South Shore Tributary if check dams are installed in that ravine.

Objective 7. Address erosion from active construction sites.

- No model is available to predict reduction in TSS loading by increasing the use of erosion control on watershed sites, but it is reasonable to expect a reduction.
- Potential strategy: Work with city officials to amend erosion control ordinance to include provisions requiring site clearing to be done in phases, eliminating the possibility of complete site clearing prior to building.
- Potential strategy: Work with local officials to ensure the existing erosion control ordinance is being adhered to at all sites under which it is applicable.

Goal 3: Reduce pathogenic inputs to the lake and its tributaries to the point where the waterbodies meet the state geometric mean standard for *E. coli* in the next 10 years.

Sources
Failing or ill-sited septic systems
Illicit connections
Wildlife – including geese
Fertilizers containing manure

Hot spots

- The residential areas along the south side of the lake utilize septic systems for the treatment of household wastewater. Figure 9 **(**Soil series septic tank absorption field suitability) shows areas where soils are severely and moderately limited for use as a septic tank absorption field. These are areas of concern and should be considered hot spots. Similarly, areas located within 100 feet of a tributary to the lake and where soils are severely and moderately limited for use as a septic tank absorption field should be considered hot spots.
- Culver Academies manure pile

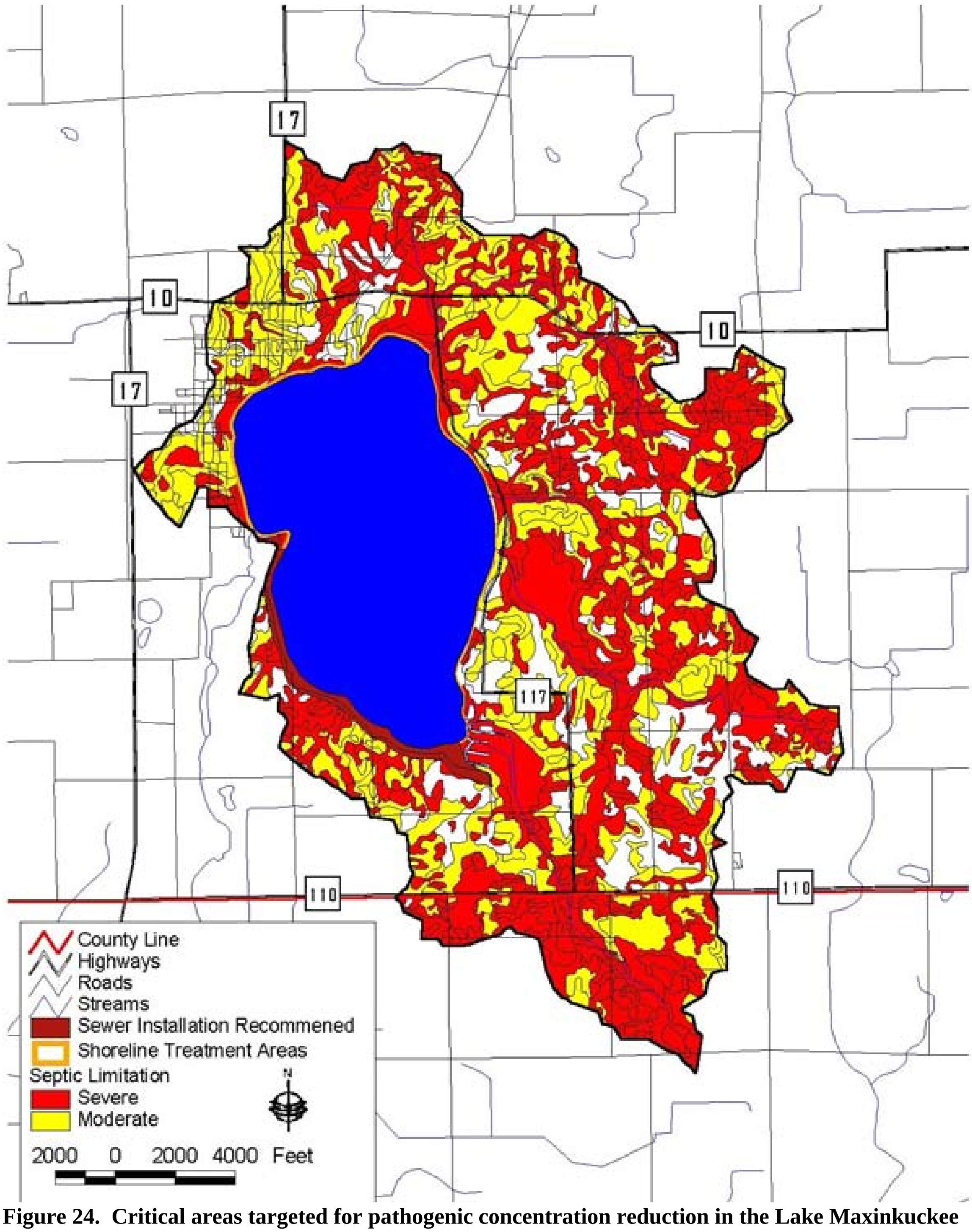

Figure 24. Critical areas targeted for pathogenic concentration reduction in the Lake Maxinkuckee watershed. Goal 3. Source: See Appendix G.

Objective 1. Assist the south side residents were possible in the formation of a Conservancy District to enable the elimination of septic systems for treating residential wastewater.

Objective 2. Develop a manure management program or implement a structural project to increase the effectiveness of the current BMP's used for the Culver Academies manure pile.

Objective 3. Work with golf course officials and other commercial properties that have open water areas to install vegetative buffers around the open water areas to discourage geese from taking up residence in these areas.

Objective 4. Educate watershed residents on BMPs to reduce pathogenic contamination of adjacent waterbodies.

Individual property owner BMPs to discourage geese include (McGowan et al., 2002):

1. Do not feed geese
2. Reduce or eliminate fertilizer use; geese prefer fertilized lawns
3. Reduce lawn size and/or utilize less palatable grasses (i.e. fescue vs. bluegrass) for lawns
4. Eliminate mowing where possible, particularly around the water's edge.
5. Plant a vegetative buffer that is ideally at least 30 inches tall.
6. Use rock barriers and fences. These may help some but these must be tall enough in the case of rock barriers and without openings in the case of fences.

Individual property owner BMPs to maintain septic systems include:

1. Clean (not just pump) septic tanks with a frequency dictated by tank size and number of members in the household according to Jones and Yahner (1994).
2. Decrease or eliminate use of a garbage disposal.
3. Avoid the use of cleaning products that damage or kill the bacteria in the absorption field.
4. Implement water conservation measures to decrease load to septic system.

Objective 6. Work with watershed landowners that have septic system absorption fields located within 100 feet of a tributary to the lake to ensure these fields are being maintained properly and/or help landowners obtain the assistance needed to install an alternative method of wastewater treatment.

Goal 4: Improve land use planning in the Lake Maxinkuckee watershed to include all appropriate measures that will safeguard the quality of Lake Maxinkuckee. Impervious cover in the Lake Maxinkuckee Watershed is estimated between 2.8% and 8%. Research shows water quality begins to decline when impervious surface exceeds 10% with severe degradation expected when it exceeds 25%.

(Impacts, March 2003)

Objective #1: Keep the impervious cover in the Lake Maxinkuckee watershed at or below 10% .

Work with Town of Culver and Planning Boards to adopt within 2 years of the completion of the Watershed Management Plan:

- Greenspace and Open Space Ordinance
- Stormwater Ordinance

Work with Marshall County Planning Boards to adopt within 3 years of completion of the Watershed Management Plan.

- Greenspace and Open Space Ordinance
- Stormwater Ordinance

Objective #2: Maintain low density nature of existing watershed development and control potential multifamily, commercial, or funneling developments:

- Review interpretation of existing anti-funneling ordinance with Plan Commission within one year of completion of the plan.
- Work with DNR to coordinate pier size with lakefrontage and coordinate pier permits with land use activities.

Objective #3: Form watershed-wide conservancy district to create one (1) governing body to regulate land use planning. (Long-range Goal, achieving this goal is not expected for 10years.)

Action Plan: Facilitate the formation of a Citizen's Committee to address the above objectives.
Responsibility: LMEC to facilitate formation of group
Time: Fall 05 formation, group will meet until agenda items are completed.
Funding Source: Volunteer and LMEC staff time

Goal 5: Develop an understanding of the internal dynamics of the lake including the biological, chemical and physical aspects. Improve the biological communities, reduce damaging physical effects (wave action, vertical seawall), reduce internal phosphorus release (chemical). Lakes are dynamic ecosystems and in-lake issues are important aspects of lake management in addition to reducing nutrient, sediment and

pathogenic inputs from the watershed.

Objective 1: Work with universities to develop a lake-wide study of the internal phosphorus release in the lake.

Potential study topics include:
- Monitor the anoxic boundary when the lake is stratified
- Monitor the internal response to turbidity (phosphorus release, algal response)

> Action Plan: Develop potential project, identify funding sources and deadlines
> Responsibility: LMEC
> Time: Fall 05 for project development, implementation summer 06, if funded
> Funding Source: LMEC Budget

Objective 2: Increase shoreland Best Management Practices around Lake Maxinkuckee to reduce the runoff of lawn care products into the lake and improve near shore habitat by:

1. Develop an environmental policy with the Property Owners Association
2. Produce educational brochures to be distributed at least once a year.
3. Develop program for shoreline residents to install natural or glacial stone seawalls and shoreline (littoral zone) vegetation. Develop pilot project.
4. Work with agencies to open funding for shoreline restoration

Also See Goal #7

> Action Plan Goal 5 Objective 2.3 : Identify landowners wiling to participate in shoreline restoration. Develop individual restoration plans. Identify funding sources. Apply for funding. Develop education/promotion campaign.
> Responsible: LMEC/Education Committee
> Time: Winter '06 with implementation summer 06, if funded.
>
> Action Plan Goal 5 Objective 2.1: Work with Property Owners Association to develop an environmental policy for homeowners.
> Responsible: LMEC
> Time: Winter 06
>
> Objectives 2.2 and 2.4 will be on agendas for Education and Citizens Committee, respectively.
>
> Funding Source: LMEC budget and Lake and River Enhancement Program

Objective 3: Increase near shore water clarity by 1 foot over the next 5 years by instituting a mult-faceted approach to managing activities in the near shore area.

1. In the first year develop additional Secchi disk monitoring program to test water clarity in near shore areas not offshore of an inlet ditch or stream.
2. Develop a program within two years to place buoys at a specified depth rather than distance from shore
3. Increase the number of glacial stone or natural shorelines at a rate of at least 5 per year.
4. Develop map of current lake depth
5. Investigate dredging options
6. Determine appropriate size, horsepower, speed limit and optimal number of boats to protect and preserve Lake Maxinkuckee's water quality

By improving shoreline habitat with more natural seawalls, an increased aquatic vegetation should occur. It is expected that the fish, amphibian, macroinvertebrate and other wildlife populations will increase in numbers and diversity, thereby improving the overall ecosystem integrity of Lake Maxinkuckee.

The current Secchi disk testing sites were selected in the early 1980's during Crisman's investigation primarily to determine the impact of sedimentation from the inlet ditches. The program has continued with no change to maintain a long-term record of water clarity readings. It is strongly suspected the turbidity lake shore residents are concerned with results from motorized watercraft. New sites will need to be tested to determine this impact.

Action Plan: Develop secchi disk testing sites based on internal turbidity, not inlet streams
Responsible: LMEC
Time: Develop program winter 06, implement summers thereafter.

Action Plan: Develop glacial stone seawalls project with local contractors. Identify potential fundir sources
Responsible: LMEC to facilitate program development with contractor and identify funding sources, then contractor continues program
Time: Winter 06

Action Plan: Develop buoy placement based on water depth.
Responsible: Citizens Committee
Time: 2006

Funding Source: LMEC staff time and LMEC budget

Objective 4: zebra mussels

- Maintain zebra mussels infestation warning signs at access sites to prevent spreading to other waterbodies.

Goal 6: Lake Maxinkuckee is primarily used for recreation. Investigate potential user-conflicts and potential over-use and develop management plans as appropriate.

Objective 1: Within one year form a Governance Committee to encourage development and enforcement of laws and regulations designed to protect Lake Maxinkuckee and its watershed. Potential topics to address are:

- Boat size and speed on an inland lake;
- Boating capacity;
- Investigate and facilitate the development of legislation to reduce mercury emissions.

Lake Maxinkuckee is listed on the 303 (d) list as impaired for Mercury and PCB's. The ISDH specifically lists Lake Maxinkuckee and provides a fish consumption advisory for certain fish in the lake. A reduction in air-borne mercury emissions from coal burning power plants will reduce mercury levels, but a regulatory change is necessary to insure compliance by emitting power plants.

Action Plan: Form Citizen's Committee to advocate and facilitate regulations to address boat size, speed, boating capacity and local building and development. Members of the committee to ask: large landowners, Property Owners Assoc., Township Trustee, Business Owners, local government officials, general public.
Responsible: LMEC facilitate formation of committee
Time: Winter 06
Funding Source: LMEC staff time

Goal 7: Develop and implement educational programs for all watershed residents.

Objective 1: Work with outside communications specialists to develop a marketing strategy to more effectively utilize communication tools, staff and other resources to positively affect landowner behavior.

Objective 2: Work with local board to ensure part-time Culver residents are allowed input and watershed-level decisions.

Action Plan: Develop marketing strategy with outside communications specialists to guide education committee. Apply for funding
Responsible: LMEC
Time: Fall 2005 or Winter 2006

Action Plan: Form education committee to guide the educational programs outlined in plan
Responsible: LMEC facilitate committee formation
Time: Winter 06 – on going

Action Plan: Host luncheon for area Realtors to provide them with lake education for new lakeshore property owners. Educating and engaging realtors will help enlighten new owners to lakeside living.
Responsible: LMEC
Time: Fall 2005 or Winter 2006

Funding Source: LMEC Staff time, LMEC budget and IDEM 319 program

An Action Register and Action Plan can be found in Appendix M. The Action Register lists the action items along with an estimated range of cost and potential funding source. The Action Plan list the action items based on their priority and who will be responsible for the action.

7.0 Measuring Progress

Measuring the progress of the implementation strategies is an important component of this plan. Periodic evaluation of the implementation process gives the organization valuable feedback on their progress and helps to keep the watershed management process on track with the stated goals. Tracking progress will also help evaluate which strategies are working, those that are not and what changes need to be made; information that will be valuable when evaluating the plan.

This plan calls for the instigation of numerous programs and tasks. Keeping track of the progress of each, based on its priority level, will be critical for the organization to stay organized and focused on its goals. These tasks are shown below for ease in evaluating progress.

First Quarter

- Contact major landowners regarding phosphorus use
- Create list of agricultural landowners
- Organize agricultural landowner dinner
- Organize realtor luncheon
- Meet with town officials regarding maintenance, erosion control, ordinance review
- Form Education Committee

- Form Citizen's Committee
- Develop lake study projects
- Develop environmental policy with Lake Association
- Develop seawall project
- Determine new secchi testing sites

First year

- Install 1,500 feet of new or improved buffer strips or grassed waterways
- Meet with Wilson Ditch landowner regarding streambank erosion
- Begin new Secchi disk testing in addition to regular testing
- Clean Lakes Volunteer Monitoring Program four time during the summer.
- Develop Open Space/Stormwater Ordinance
- Shoreline restoration projects
- Implement in-lake studies

Yearly

- Continue Clean Lakes Program Secchi disk and total phosphorus testing
- Continue Secchi testing programs, both old and new
- Inspect Culver Academies manure pile. Current investigation shows appropriate practices are in place: pile is in pit, most runoff water is detained, risers and detention basins control runoff for major events. Yearly check is recommended
- Continue agriculture conservation initiative (goal 1,500 feet of buffer strip/grassed waterway each year for 10 years)
- Educational programs
- Yearly evaluation of program progress and updates to the plan
- Tributary sampling through Hoosier Riverwatch trained volunteers

5-Year

- Clean Lakes Program (CLP) evaluated the lake in 2004, Based on their 5 year rotation, Lake Maxinkuckee will be tested again in 2009
- Water quality sampling to coincide with CLP sampling to produce new phosphorus loading budget and Vollenweider model and assess BMP's
- Vegetation survey

8.0 Plan Evaluation

This plan is not intended to be static document. The impacts of implementation must be periodically evaluated and updated to accommodate success or failure of strategies, changes in the watershed, changes in watershed management, and changing expectations for land and water use.

Responsibility for evaluation

The Lake Maxinkuckee Environmental Council (LMEC) sponsored the watershed management plan and acted as the steering committee during plan development and will be responsible for plan implementation and evaluation. As stated in their bylaws volunteers in the organization represent the major stakeholders in the watershed: lake, agriculture, Academy, & Town of Culver. As a long standing organization which adequately represents the lake and watershed interests, the LMEC is the most logical and most capable organization to assume this responsibility.

Timeline for evaluation and adaptation

The plan will be reviewed annually in the fall. Evaluating in the fall will allow for completion of summer projects, creation of annual work plans and budgets for the upcoming year. Evaluating in the fall will also allow the group to prepare project plans in time for grant due dates later in the year. Results of the annual evaluation may be reported in newsletters, direct mailing, local newspaper, and/or other local events.