Five Lakes Watershed Management Plan

Lagrange and Noble Counties, Indiana

July 25, 2006

Vision: Clean lakes, rivers and lands which provide a strong economic base and excellent quality of life for present and future generations.

Mission: To promote stewardship of the watershed and its resources to ensure sustainable watershed, functions, and uses for optimal conservation and economic benefits

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FIVE LAKES WATERSHED MANAGEMENT PLAN
LAGRANGE AND NOBLE COUNTIES, INDIANA

1.0 INTRODUCTION

This watershed management plan addresses non-point source pollution and other water quality concerns facing the Five Lakes watershed (Figure 1). The Five Lakes watershed encompasses three 14-digit watersheds (Figure 2) including the Little Elkhart Creek-Messick-Oliver Lakes (HUC 04050001170030) watershed, the Little Elkhart Creek-Dallas Lake (HUC 04050001170020) watershed, and the Little Elkhart Creek-Tamarack-Cree Lakes (HUC 0405001170010) watershed. In total, the Five Lakes watershed drains approximately 37,250 acres in southern Lagrange and northern Noble Counties (Figure 3). There are approximately 24 navigable lakes and over 14 miles of streams, ditches and other waterways located within this watershed which forms the headwaters of the Little Elkhart Creek. Little Elkhart Creek combines with water from the West Lakes and Sylvan Lake to form the North Branch Elkhart River. The North Branch Elkhart River eventually combines with the South Branch Elkhart River to form the Elkhart River, which flows into the St. Joseph River within the city of Elkhart. The Five Lakes watershed lies entirely within the larger St. Joseph River Basin (HUC 0405011; Figure 4). This watershed management plan documents the concerns watershed stakeholders have for the Five Lakes waterbodies and describes stakeholders' vision for these waterbodies. The plan outlines the goals, strategies, and action items watershed stakeholders have selected to achieve their vision. Finally, the plan includes methods for measuring stakeholders' progress towards achieving their vision and timeframes for periodic refinement of the plan.

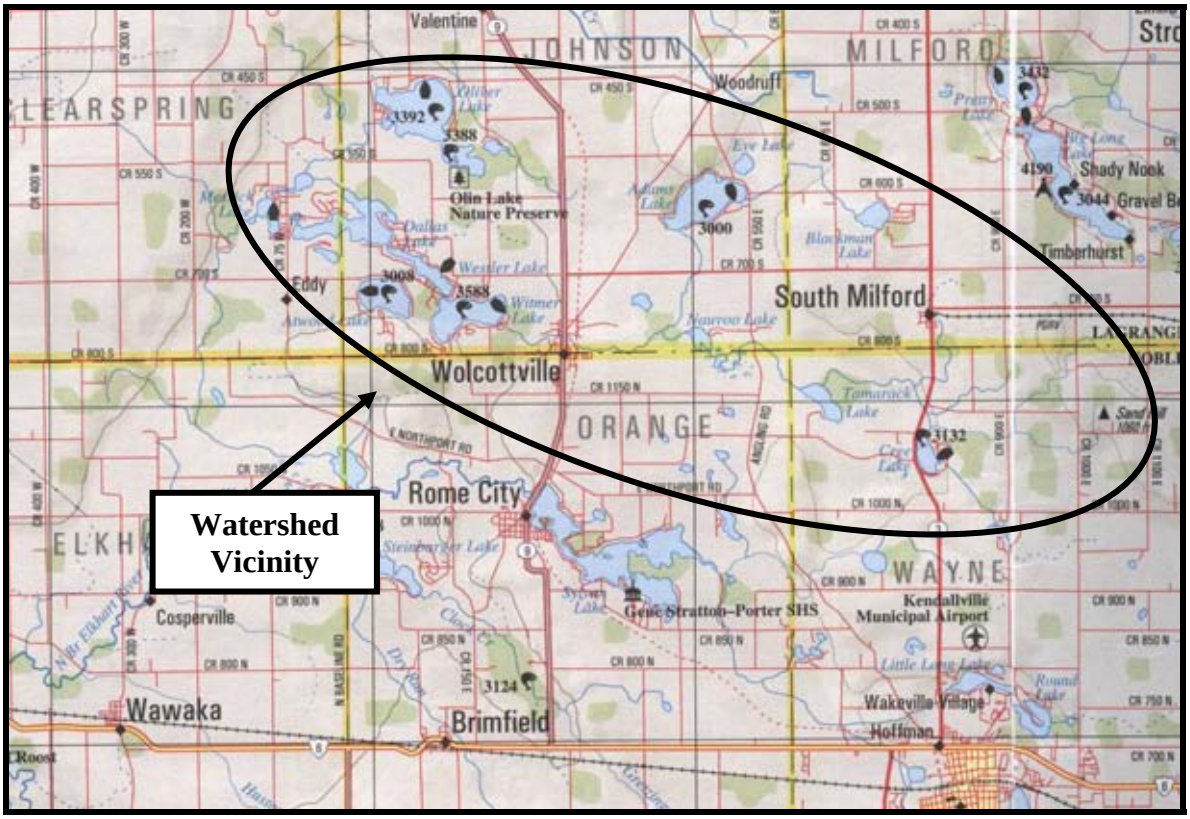

Figure 1. Five Lakes watershed location map. Source: DeLorme, 1998. Scale: 1"=approximately 2.5 miles.

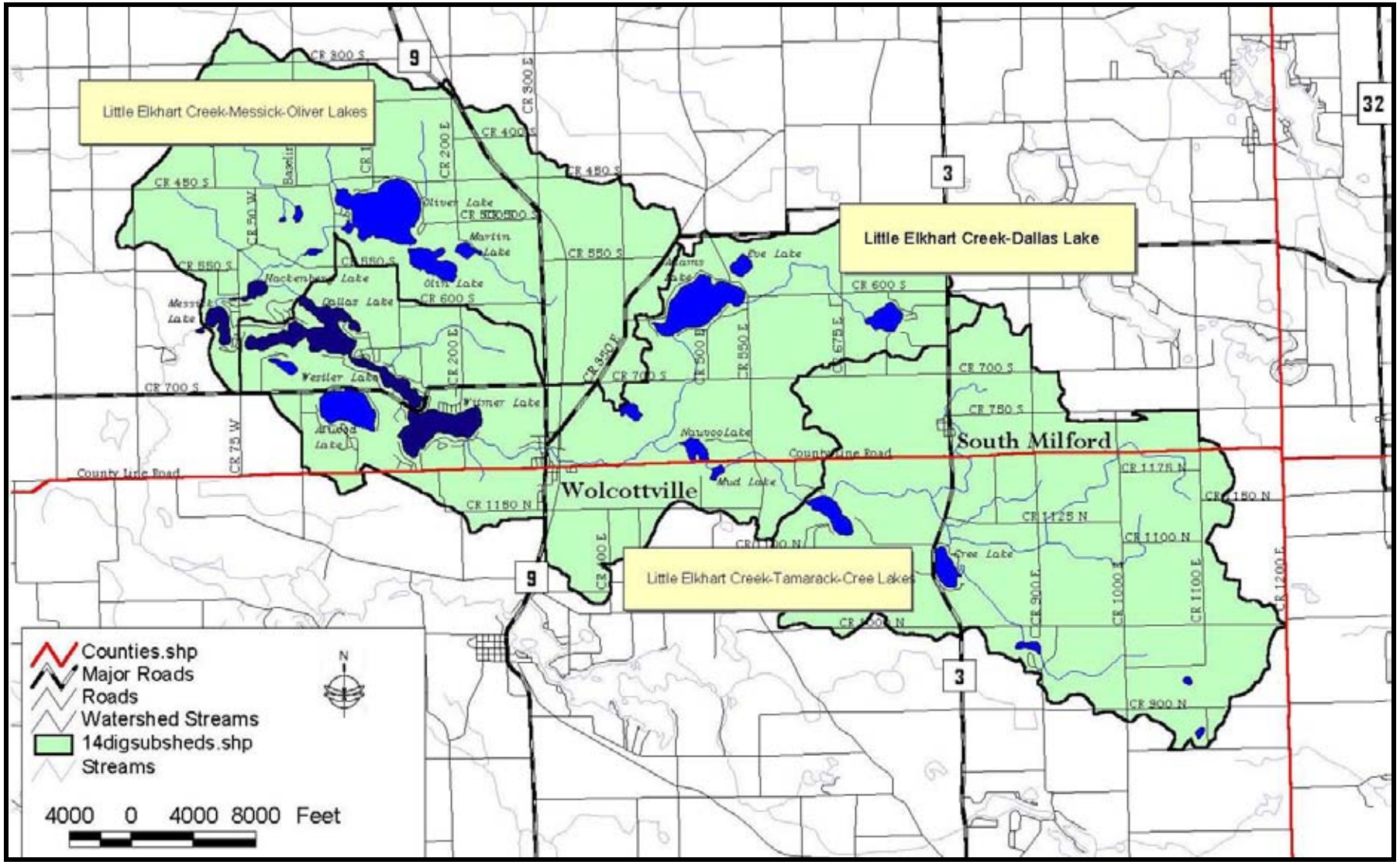

Figure 2. 14-digit watersheds which make up the Five Lakes watershed.

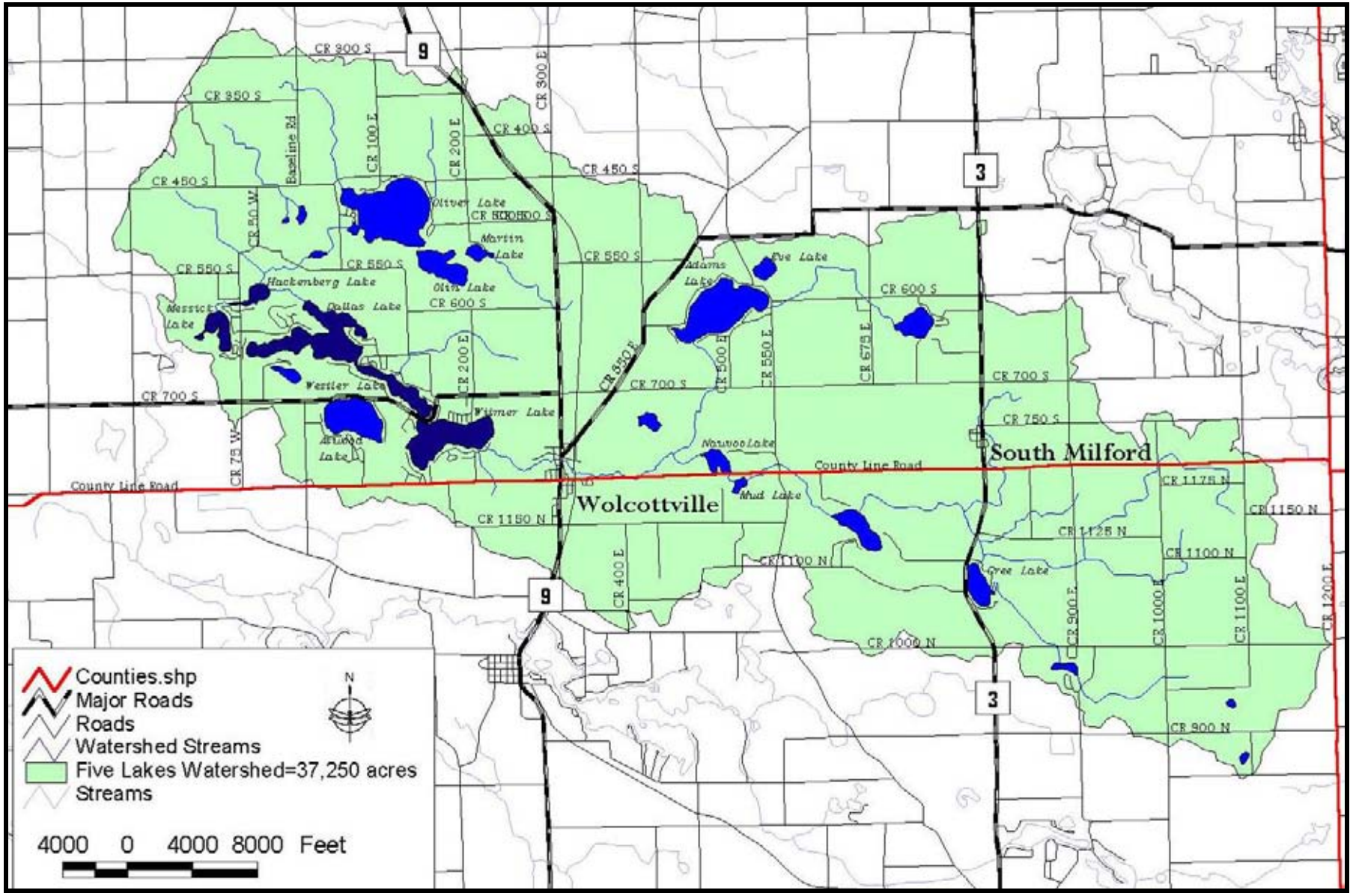

Figure 3. Five Lakes watershed.

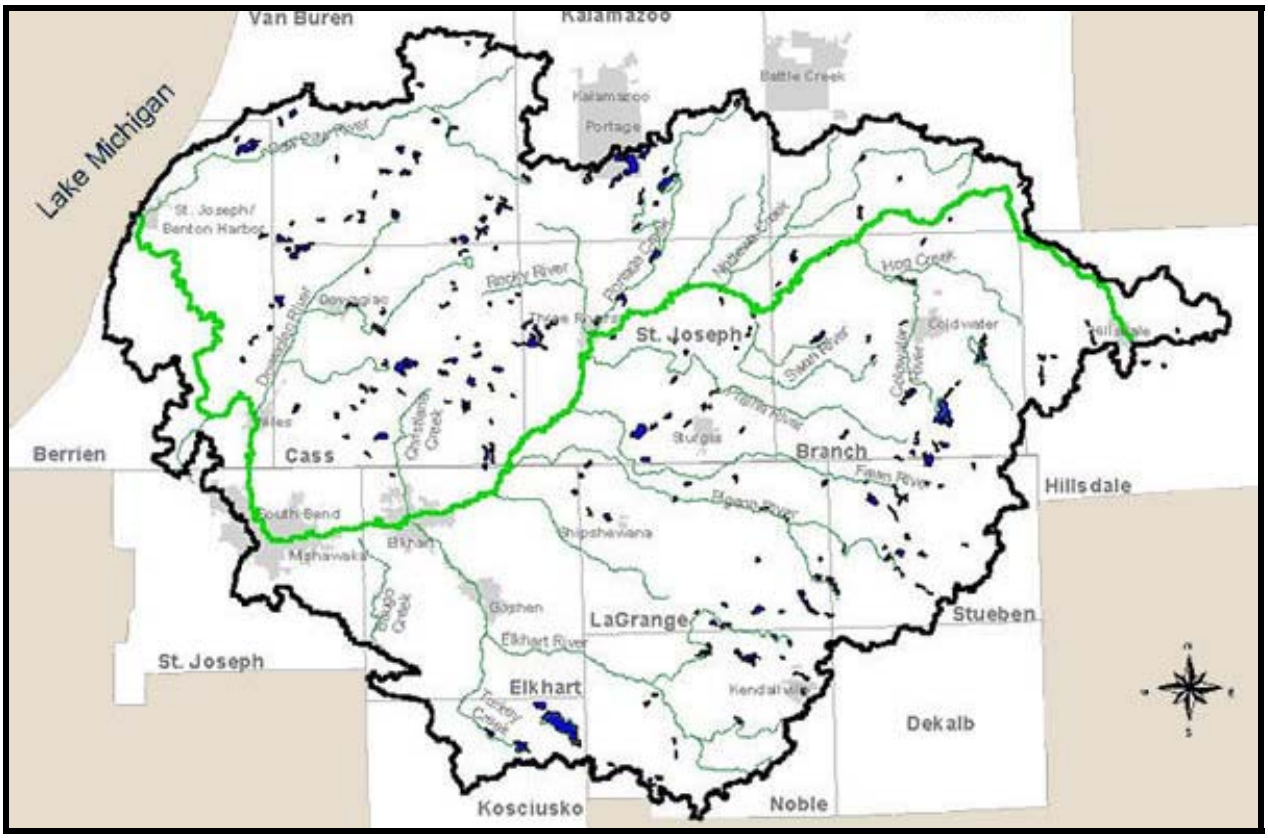

Figure 4. St. Joseph River basin. Source: FOTSJR, 2006.

Development of this watershed management plan grew out of efforts of the Five Lakes Conservation Association (FLCA). In 2002, the FLCA began working with a private consulting firm to determine what steps they could take to address non-point sources of pollution within the Five Lakes watershed which would eventually translate to improved water clarity and quality within the lakes. At the same time, the FLCA contacted regional watershed conservationists from the Indiana Department of Environmental Management (IDEM) and the Indiana Department of Natural Resources (IDNR) to determine methods to catalog water quality and watershed problems and identify potential projects which could be implemented to address these problems. Both the private consultant and the regional watershed conservationists encouraged the FLCA to develop a watershed management plan with input from all 24 lakes within the watershed and the entire community since the process of the developing a plan is designed to help watershed stakeholders understand each stakeholder's concerns and find common ground in resolving these concerns. With this in mind, the FLCA applied for and successfully secured a Section 319 grant from the United States Environmental Protection Agency (EPA) through IDEM's Section 319 grant program to develop a watershed management plan.

Although efforts prior to the development of this watershed management plan focused primarily on the immediate watershed draining to the Five Lakes, the watershed management plan's geographical scope includes all three 14-digit watersheds which drain into the Five Lakes (04050001170030, 04050001170020, and 04050001170010). This watershed includes more than 24 lakes and 14 miles of streams. A number of these waterbodies are listed on Indiana's list of impaired waterbodies. In 2004, Messick, Dallas, Hackenburg, and Witmer lakes were included on the final 303(d) list for

impaired biotic communities. These waterbodies remain on Indiana's list of impaired waterbodies for impaired biotic communities for the 2006 303(d) list. Two other lakes, Olin and Oliver lakes, were included on the 2004 303(d) list for mercury contamination; however, additional data collected by the IDEM indicates that these lakes should be removed from the 303(d) list in 2006 (IDEM, 2006). Finally, the North Branch Elkhart River and its tributaries are listed for elevated *E. coli* concentrations, while the Elkhart River itself is listed for excess *E. coli*, mercury, and PCBs (IDEM, 2006). It was assumed during the grant application process that many of the same non-point source concerns facing stakeholders immediately adjacent to the Five Lakes were shared by stakeholders across the entire Five Lakes watershed. Comments at the first several public meetings during the plan's development confirmed this assumption as many attendees expressed a concern for the water quality in the Elkhart River, which receives water from the Five Lakes watershed.

1.1 Watershed Partnerships

Five Lakes Conservation Association was the principal organization involved in developing the 319 funding proposal, securing the matching contribution and contracting with the IDEM. D.J. Case and Associates (DJCase) was subcontracted for the coordination, facilitation and implementation of the planning process. J. F. New & Associates (JFNew) was subcontracted for the implementation of the water quality, habitat, and biological assessment.

During the first administrative meeting with the IDEM staff, Five Lakes' leadership and the subcontractors, a list of stakeholders in the watersheds was developed. Organizations and individuals with a demonstrated interest in the planning activity (those who wrote letters supporting the 319 application) were added to the list as were state, local, and private agencies or organizations that are stakeholders or represented stakeholders in the watersheds.

The final list included individuals from the Adams Lake Cottage Owners Association, Dallas Lake Association, IDNR Agriculture Conservation Specialist, IDNR Resource Specialist, LaGrange County, Farm Services Agency, Fawn River State Fish Hatchery, Five Lakes Conservation Club, Hackenburg Lake, Hackenburg Mobile Home Association, IDNR Division of Fish and Wildlife Regional Fisheries Biologist, LaGrange County Commissioners, LaGrange County Dairy Herd Improvement Association, LaGrange County Extension Service, LaGrange County Farm Bureau Inc., LaGrange County Health Department, LaGrange County Soil & Water Conservation District, Messick Lake, Natural Resource Conservation Service, Noble County Soil & Water Conservation District, Westler Lake Property Owners Association, Witmer Lake Property Owners Association, and the Wolcottville Town Council.

These individuals were contacted with an invitation package to participate in the planning process. During the initial planning team meeting participants were asked to identify additional stakeholders who were not present and should be included in the process. These organizations were then contacted and invited to join in the process. A complete list of the individuals invited to participate the watershed planning team is located in Appendix A. This watershed planning team was formed to identify issues and concerns, develop mission, goals, and objectives, and to solicit/coordinate public involvement in Watershed Management Planning process.

1.2 Public Participation

Community outreach during the development of the WMP included the development and distribution of outreach materials for the community that described the project. The public

meetings were announced in local newspapers, radio stations, and with posters located in community gathering places that had community bulletin boards. Additionally, a flyer was distributed to over 900 watershed residents describing the process and inviting them to attend public meetings. All stakeholders and the general public were invited and encouraged to attend public meetings. A total of 8 public meetings were held over 24 months to insure that all stakeholders' needs and perspectives were considered in the development of the WMP.

1.3 Watershed Stakeholder's Concerns

During the beginning phases of the plan's development, the public was able to voice their concerns and receive information on the progress and preliminary results of the planning process. Public meetings were the primary method for collecting concerns from the stakeholders, although the project sponsor and other meeting attendees encouraged stakeholders to contact them with any concerns that the stakeholders thought of outside of the meetings. These comments were documented and included as consideration throughout the planning process. The initial concerns voiced during the planning process fit into various categories and are listed below. The order of the concerns listed below does not reflect any prioritization by the stakeholders.

Process

Concerns were expressed about the watershed management planning process. These included bringing together all existing information and making sure that all stakeholders are invited to participate.

- Stakeholders indicated that information was scattered through a number of sources and that a concerted effort needed to be made to gather that information and build on it.
- Stakeholders expressed concern that the Amish community is not involved to participate as a team member and should be.
- Stakeholders indicated that there were a number of studies completed in the late 1980's and mid 1990's, but they were done without public input. Their concern was that without stakeholders' buy-in the book sits on a shelf.
- Stakeholders indicted a need to continue addressing the problems and not blame the problems on other people.
- Stakeholder concluded that we need to investigate the whole picture including people, livestock, farmers, and the watershed.
- Stakeholders thought that the farmers were working with the lake property owners to ensure an even contribution throughout the process.
- Stakeholders expressed a desire for the plan to relate to the whole picture and include information on where are sources of nonpoint and point pollution are located.
- Stakeholders indicated that all stakeholders need to work together to address an all-encompassing perspective.

Information/education

Stakeholders voiced concerns about the amount of education and information available to the general public.

- Stakeholders expressed concern that watershed residents don't understand the problems and felt that it was difficult for residents to visualize how their activities cause problems.
- Stakeholders indicated that incentive-based conservation efforts help, but thought that residents will not implement conservation practices if they do not understand the problem.
- Stakeholders indicated that we should not assume that there is one solution for everyone. They further felt that many people are not involved with the conservation programs because they do not want money with government strings attached.

- Stakeholders felt that more educational efforts were necessary especially related to the over-application of lawn fertilizer.
- Stakeholders expressed a need to look for that teachable moment.

Nutrients

Stakeholders expressed concerns about the amounts and types of nutrients being discharged into the hydrologic system. These concerns included nutrients applied to agricultural and residential lands.

- Stakeholders felt that individuals typically over apply lawn fertilizer and are unaware of its impact.
- Stakeholders indicated that phosphorus loading to watershed waterbodies was excessive.
- Stakeholders thought that the lakes were becoming more eutrophic.
- Stakeholders expressed concern that elevated nutrient levels were reducing oxygen availability.
- Stakeholders indicated concern over the loss of cisco populations and wondered how this related to nutrient levels.
- Stakeholders felt that oxygen levels were dropping due to bacterial activity on nutrients and other oxygen-consuming wastes.
- Stakeholders indicated concern over livestock access to waterbodies and the resultant phosphorus and erosion that occurs along shorelines/streambanks as the animals enters the waterbody.
- Stakeholders felt that runoff promotes algae blooms and leads to excess weed growth.
- Stakeholders indicated concern over the contribution of nitrates from gypsy moths due to their flax.
- Stakeholders indicated concern over phosphorus contributions from geese. These concerns were based on a study completed by Purdue that indicted that phosphorus of four geese is similar to one cow.
- Stakeholders indicated that algae blooms were occurring where they previously did not occur.

Filter strips

Members of the watershed planning team and the public expressed concerns about the removal of natural filter strips along lake fronts and questioned the status of agricultural filter strips along streams and drainage ditches.

- Stakeholders felt that many of these lakefront homeowners have removed the natural shrubbery and want to have grass growing right down to the edge of the water.
- Stakeholders indicated the need to educate landowners about the negative impact of the removal of natural filters next to the lakes
- Stakeholders felt that natural filters were being removed adjacent to streams and should be preserved.

Point source

Concerns were expressed about the contribution of urban runoff for nutrients and sediments. Stakeholders wanted to insure that point sources were identified when possible.

- Stakeholders indicated the urban segment of the watershed and the impacts from storm water runoff from Wolcottville have not been adequately addressed.
- Stakeholders expressed a desire to address point source pollution in addition to non-point source pollution.
- Stakeholders expressed concern over the contribution of the Adams Lake sewer system on water quality.

Sedimentation/erosion

Stakeholders expressed concerns about the erosion of shoreline and streambanks, aggressive ditching, deer crossing stream banks causing erosion.

- Stakeholders expressed concern over the removal of native and resultant erosion of the shoreline.
- Stakeholders felt that ditching is occurring within the watershed and that this practice should be limited.
- Stakeholders felt there was a considerable amount of water draining through the watershed and that much of this water carries excess silt by the time it gets to the lake.
- Stakeholders indicated that islands have started to develop at the mouth of many of the lakes' inlets.
- Stakeholder felt that natural problems, like deer crossings of stream, can create substantial bank erosion.
- Stakeholders felt that Dallas Lake's transparency is poorer than it was previously.

Water level

Concerns were expressed about the changes in the water levels and impacts on water quality and the aquatic environment.

- Stakeholders expressed concern over how changes in the lakes' water levels impact water quality and the aquatic environment.

Values

Stakeholders expressed concerns about maintaining and improving property, aesthetic and recreational values.

- Stakeholders indicated concern over the impact of aesthetics, property values, and health values.
- Stakeholders felt that aesthetic problems result from algae blooms which could translate to lower property values.
- Stakeholders indicated that increased turbidity is a problem for fishing and aesthetics.

Recreation

Members of the watershed planning team and the public expressed concerns about the decreasing surface are of the lakes reducing the amount of the lake available for recreation, declining fish populations, and health concerns for swimming and skiing in contaminated water.

- Stakeholder indicated concern over decreased water surface area and its impact on recreation.
- Stakeholders felt that fish populations could decline due to dropping water levels.
- Stakeholders indicated that game fish populations had declined due to poor water quality.
- Stakeholders indicated concern over lake access issues due to sedimentation on small lakes.
- Stakeholders felt that weed and algae growth were becoming excessive and limiting boating, fishing, and swimming.
- Stakeholders expressed a desire for good water quality for recreation and fishing in the lakes.
- Stakeholders indicated a desire for safe water for recreation purposes.

Health

Concerns were expressed about skin problems due to algae in the water, e. coli, and general concerns about safe and clean water.

- Stakeholders felt that skin problems resulted from algae in water.
- Stakeholders expressed concern over potentially elevated E. coli levels and the impact on health and recreation.

Wildlife

Concerns were expressed about the geese population and their contribution to water degradation.

- Stakeholders indicated a need to control goose populations and limit their negative contribution to water quality.

Land use

Stakeholders were concerned about development involving intensifying land use changes and the potential for future land use to further degrade the watershed.

- Stakeholders felt that development involving intensifying land use changes could negatively impact water quality within the lakes.

Implementation

Stakeholders identified concerns about actually implementing the plan once it is completed. This included financial, social, technical, and political constraints for implementation.

- Stakeholders expressed concern over landowners being willing to implement practices since money has been available in the past and has gone unused.
- Stakeholders felt that an educational effort needed to be implemented to make landowners aware that money is available for implementation.
- Stakeholders indicated the need to develop a plan that can be and will be implemented; specifically they wanted to target a reduction in the destruction of wetlands.
- Stakeholders felt that it was important to identify the relationship of lake and watershed.
- Stakeholders expressed concern over the availability of funding for the implementation of projects.
- Stakeholders indicated that maintenance is typically lacking on the existing sediment traps and requested that a plan be implemented to clean these traps.

Political

Concerns were expressed about increasing governmental regulation in the watershed.

- Stakeholders expressed concern about increasing governmental regulation and its impact on the watershed.

Results

Members of the watershed planning team and the public expressed concerns about the conservation actions identified and implemented in this plan actually causing favorable results.

- Stakeholders indicated that conservation efforts have had near 100% compliance, including no till and buffer strips, yet they feel there is still a need to dredge the silt from the waterways.

1.4 Vision for the Future

As the Five Lakes watershed stakeholders listed concerns over the current state of water quality in their watershed, they concurrently described their vision for the lakes and streams in the future. Several common themes began to surface during the public meetings. Nearly all stakeholders envisioned clean lakes and streams that supported multiple uses. Stakeholders unanimously voiced support for a future in which the lakes maintained their economic and ecological value. Stakeholders also envisioned a future where more individuals have a better understanding of actions they could take to protect water quality. The Five Lakes watershed stakeholders summarized these themes in one overarching vision for the watershed:

Clean lakes, rivers and lands which provide a strong economic base and excellent quality of life for present and future generations.

This vision serves as the foundation for the Five Lakes Watershed Management Plan. Watershed stakeholders selected their mission

To promote stewardship of the watershed and its resources to ensure sustainable watershed, functions, and uses for optimal conservation and economic benefits

with this vision in mind. Additionally the goals and strategies documented in this plan are designed to ensure that they reach the identified vision while serving their mission as stated above.

2.0 THE FIVE LAKES WATERSHED

2.1 Watershed Location

The Five Lakes watershed encompasses approximately 37,250 acres in southern Lagrange County and northern Noble County in northeastern Indiana (Figure 1). The watershed contains three 14-digit watersheds (Figure 2) including the Little Elkhart Creek-Messick-Oliver Lakes watershed (HUC 04050001170030), the Little Elkhart Creek-Dallas Lake watershed (HUC 04050001170020), and the Little Elkhart Creek-Tamarack-Cree Lakes watershed (HUC 0405001170010) within the larger St. Joseph River basin. Specifically, the watershed is located in Clay, Clearspring, Johnson, and Milford Townships in Section 21, 27-28, and 33-36 of Township 36 North, Range 11 East; Sections 4-10 and 14-36 of Township 36 North, Range 10 East; Sections 1-2, 11-15, 23-26, and 36 of Township 36 North, Range 9 East; and Section 36 of Township 37 North, Range 9 East in Lagrange County. In Noble County, the watershed is located in Orange and Wayne Townships in Sections 1-18 of Township 35 North, Range 11 East and Sections 1-6 and 9-12 of Township 35 North, Range 10 East. Drainage from the watershed flows into the Five Lakes (Witmer, Westler, Dallas, Hackenburg, and Messick Lakes) located near the town of Wolcottville, Indiana. Water drains from Witmer Lake into Westler Lake, then through Dallas Lake to Hackenburg Lake, and exits the chain through Messick Lake. Water flows from Messick Lake though the North Branch of the Elkhart River into the West Lakes, eventually forming the North Branch Elkhart River. The North Branch Elkhart River is a tributary to the St. Joseph River.

To facilitate water quality problem identification, the Five Lakes watershed was divided into eight subwatersheds (Figure 5). These watersheds include six tributaries to the Little Elkhart Creek: Uhl Ditch, Hutchins Ditch, the Cree Lake outlet or Little Elkhart Creek headwaters, the South Milford tributary, the Adams Lake outlet, and the Oliver Lake outlet. The Hutchins Ditch subwatershed is the smallest of the tributary watersheds draining approximately 1,510 acres. The Uhl Ditch and South Milford tributary subwatersheds are also relatively small draining 2,870 and 2,525 acres, respectively. The Adams Lake subwatershed and the Creek Lake or Little Elkhart Creek headwaters subwatershed drain an additional 3,850 acres and 6,590 acres, respectively, while the Oliver Lake subwatershed is the largest of the tributary subwatersheds draining 8,660 acres. The two remaining subwatersheds divide the mainstem of the Little Elkhart Creek into two segments, Middle and Lower, which drain 13,076 and 20,070 acres, respectively.

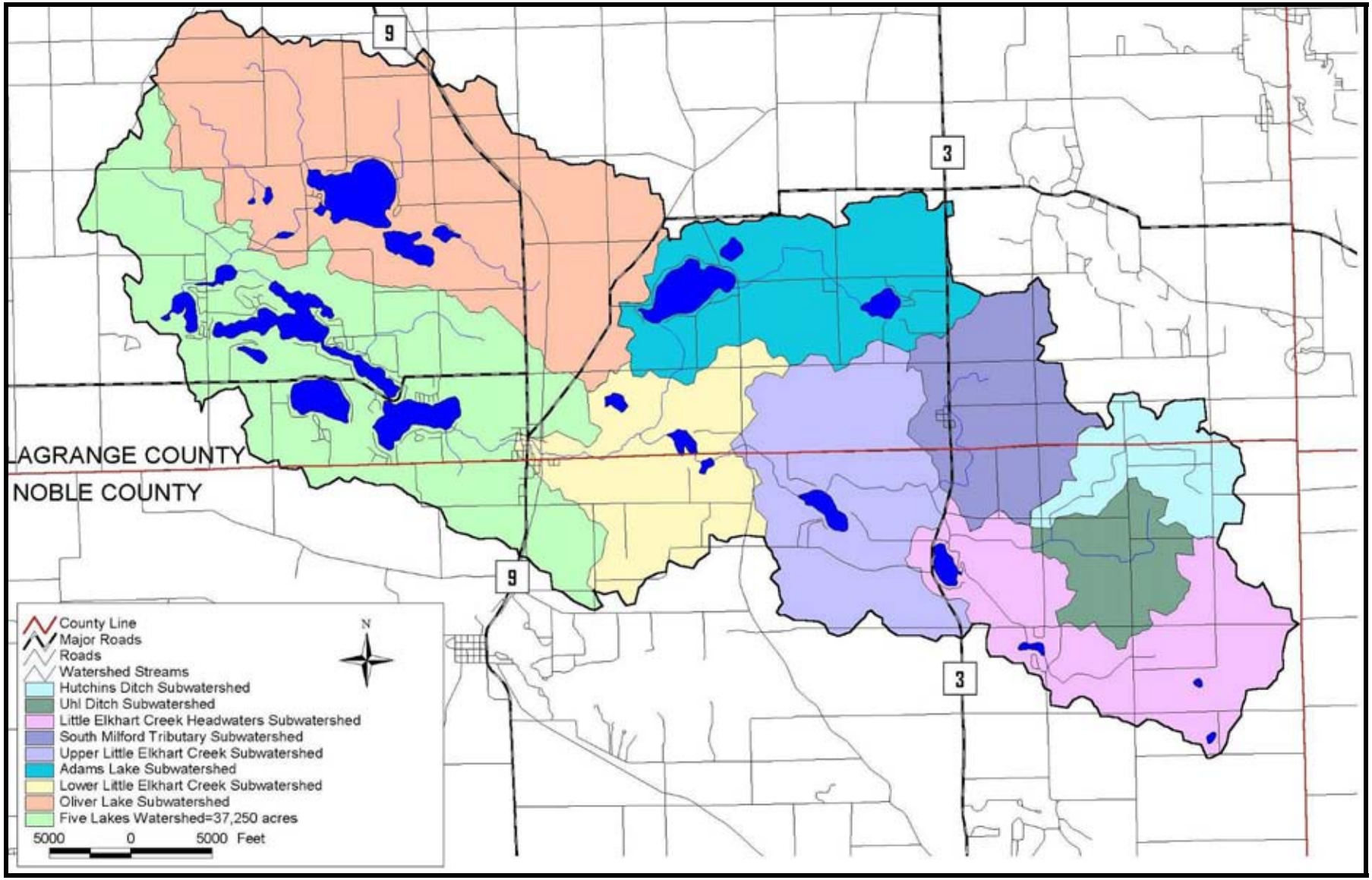

Figure 5. Subwatersheds of the Five Lakes watershed.

2.2 Climate

As a whole, Lagrange County experiences cold winter months and warm, occasionally hot, summer months. In winter, the average temperature in Lagrange County is approximately 27° F. In summer, the average temperature is approximately 71° F. The record low is -20° F recorded on February, 26, 1963, and the record high is 101° F recorded on June 28, 1971. Winter precipitation in Lagrange County is usually sufficient to minimize drought conditions for most soils during the summer months with annual snowfalls averaging nearly 32.5 inches. Approximately 60% of the total annual precipitation occurs between April and September, which corresponds to the growing season of most crops (Hillis, 1980). The average annual precipitation for Lagrange County is 32.99 inches.

The climate in Noble County is described as continental and has been somewhat modified by the Great Lakes. The climate is excellent for farming and rainfall is generally adequate during the growing season. However, there are some periods during mid-summer when evaporation exceeds rainfall. In winter, the average temperature is approximately 26° F. In summer, the average temperature is approximately 70° F (McCarter, 1977). Precipitation is evenly distributed throughout the year. However, spring and early summer rain generally exceeds precipitation in winter. The average annual precipitation for Noble County is 36.7 inches (Table 1). In 2004, approximately 30.2 inches of precipitation was recorded in Kendallville, Indiana. Rainfall during 2004 was approximately 6.5 inches below the annual average. This was primarily the result of dryer than normal periods during February, April, and September.

Table 1. Monthly rainfall data (in inches) for 2004 compared to average monthly rainfall data (in inches) from 1971-2000 as recorded in Kendallville, Indiana.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	2.02	0.33	4.14	0.47	4.42	3.44	3.89	4.00	0.85	1.77	2.88	1.98	30.19
Average	1.79	1.76	2.67	3.34	3.63	4.17	3.59	4.00	3.46	2.79	2.89	2.61	36.70

Source: Purdue Applied Meteorology Group, 2004.

2.3 Geology and Topography

The advance and retreat of the glaciers in the last ice age (the Wisconsin Age) shaped much of the landscape found in Indiana today. As the glaciers moved, they laid thick till material over the northern two thirds of the state. 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.

Several glacial lobes rather than a single sheet of ice covered northern Indiana during the last glacial age. The Saginaw and Erie Lobes covered most of northeastern Indiana. The movement, stagnation, and melting of the Saginaw Lobe of the Wisconsin glacial age is largely responsible for

the landscape covering the Five Lakes watershed. The Saginaw glacial lobe moved out of Canada toward the southwest carrying a mixture of Canadian bedrock with it. The Packerton Moraine and the Maxinkuckee Moraine mark the extent of the Saginaw Lobe's coverage in northern Indiana. In addition to these major moraines, the Saginaw Lobe also deposited many unnamed end moraines during its retreat. The ridge that separates the Five Lakes watershed from the headwaters of the Turkey Creek watershed to the east is part of an end moraine left by the Saginaw Lobe. A similar ridge along the southern edge of the watershed represents another end moraine left by the Saginaw Lobe. This ridge separates the Five Lakes watershed from the West Lakes and Sylvan Lake watersheds to the south. The lower, less distinct ridge separating the Five Lakes watershed from the Fly Creek and Little Elkhart River watersheds may also be part of an end moraine left by the glacial lobe. (Figure 6 shows the areas of greater relief (in orange) associated with the end moraines south of the watershed's southern boundary and along the watersheds eastern boundary.)

A complex mix of glacial till, outwash, and drift materials covers the Five Lakes watershed. A majority of the watershed is covered by undifferentiated outwash and loam till, both of which originated from Wisconsin Age glaciers. Three muck deposits which encompass present day Witmer and Atwood lakes, cover that entirety of and extends north of Dallas, Hackenburg, and Messick lakes, and surrounds Tamarack Lake extending south and east of the lake were present within the watershed. These three muck deposits indicate the locations of historic lake beds within the watershed (Figure 7). Additionally, Adams and Eve lakes appear within the surficial geology as one larger Wisconsin Age lake.

The geology and resulting physiography of the Five Lakes watershed typify the physiographic region in which the watershed lies. The Five Lakes watershed lies within Malott's Steuben Morainal Lake Area. Schneider (1966) notes that the landforms common in this diverse physiographic region include till knobs and ice-contact sand and gravel kames, kettle holes and lakes, meltwater channels lined with outwash deposits or organic sediment, valley trains, outwash plains, and small lacustrine plains. Many of these landforms are visible on the Five Lakes watershed landscape. Gray (2000) refines the physiographic region determination by noting that the Five Lakes watershed lies near the boundary of the Warsaw Moraines and Drainageways and the Auburn Morainal Complex. The Warsaw Moraines and Drainageways region is dominated by a complex fan of alluvium and extensive areas of outwash along which the Tippecanoe and St. Joseph rivers now flow. Complex topography delineates the St. Joseph River drainageways within this region. Like the Warsaw Moraines and Drainageways region, the Auburn Morainal Complex contains many ice block depression lakes in broad, deep troughs. The Five Lakes and Olin, Oliver, and Martin lakes are good examples of these kettle lake formations.

Approximately 300 to 400 feet of unconsolidated glacial materials cover most of the Five Lakes watershed (Clendenon and Beaty, 1987). The watershed's surficial geology covers a less complex bedrock foundation (Figure 8). Coldwater shale from the Mississippian Period underlies the unconsolidated glacial material covering a majority of the Five Lakes watershed. The southern edge of the watershed is covered by Elsworth Shale from the Devonian Period (Gutschick, 1966).

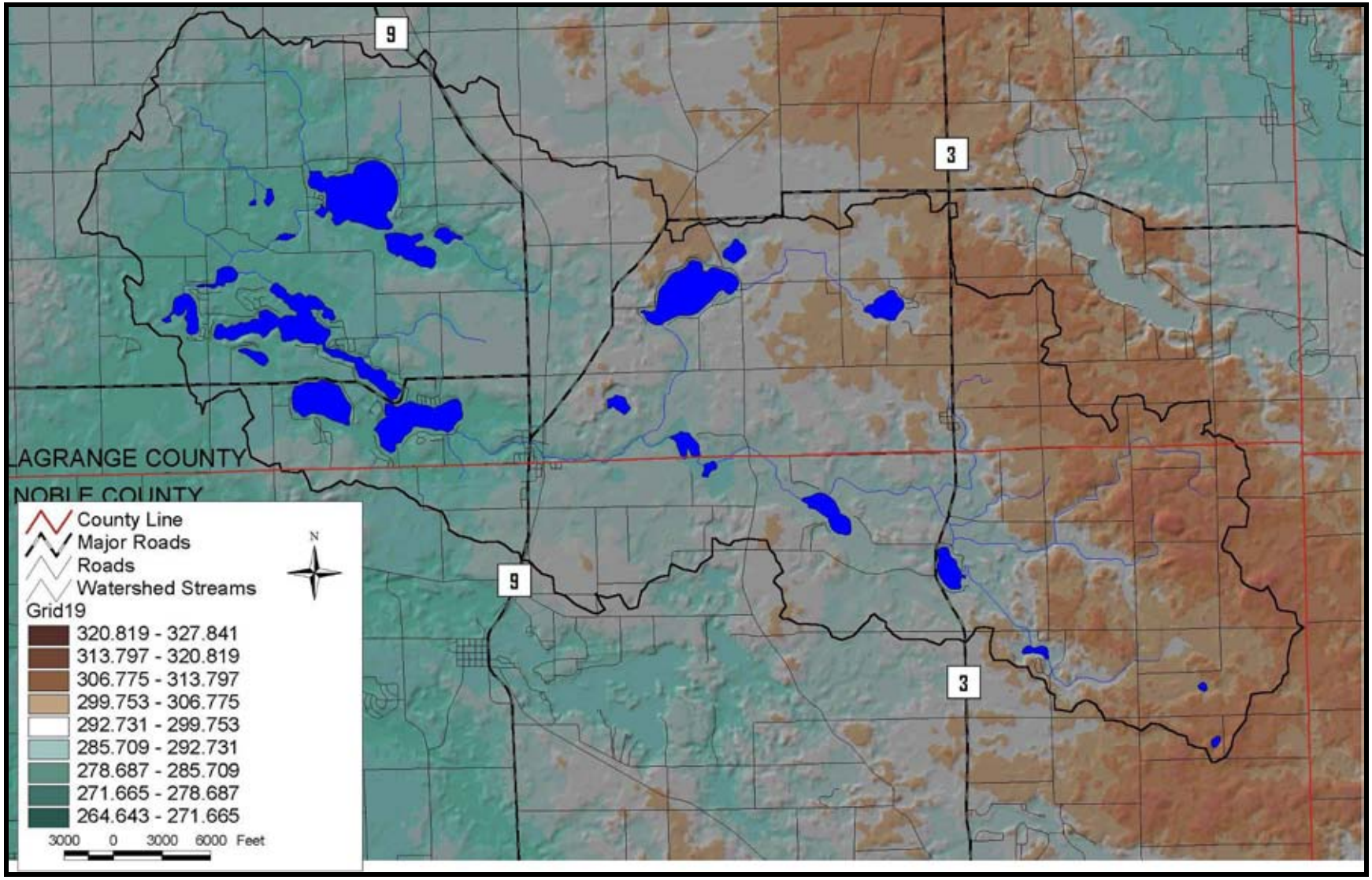

Figure 6. Topography of the Five Lakes watershed.

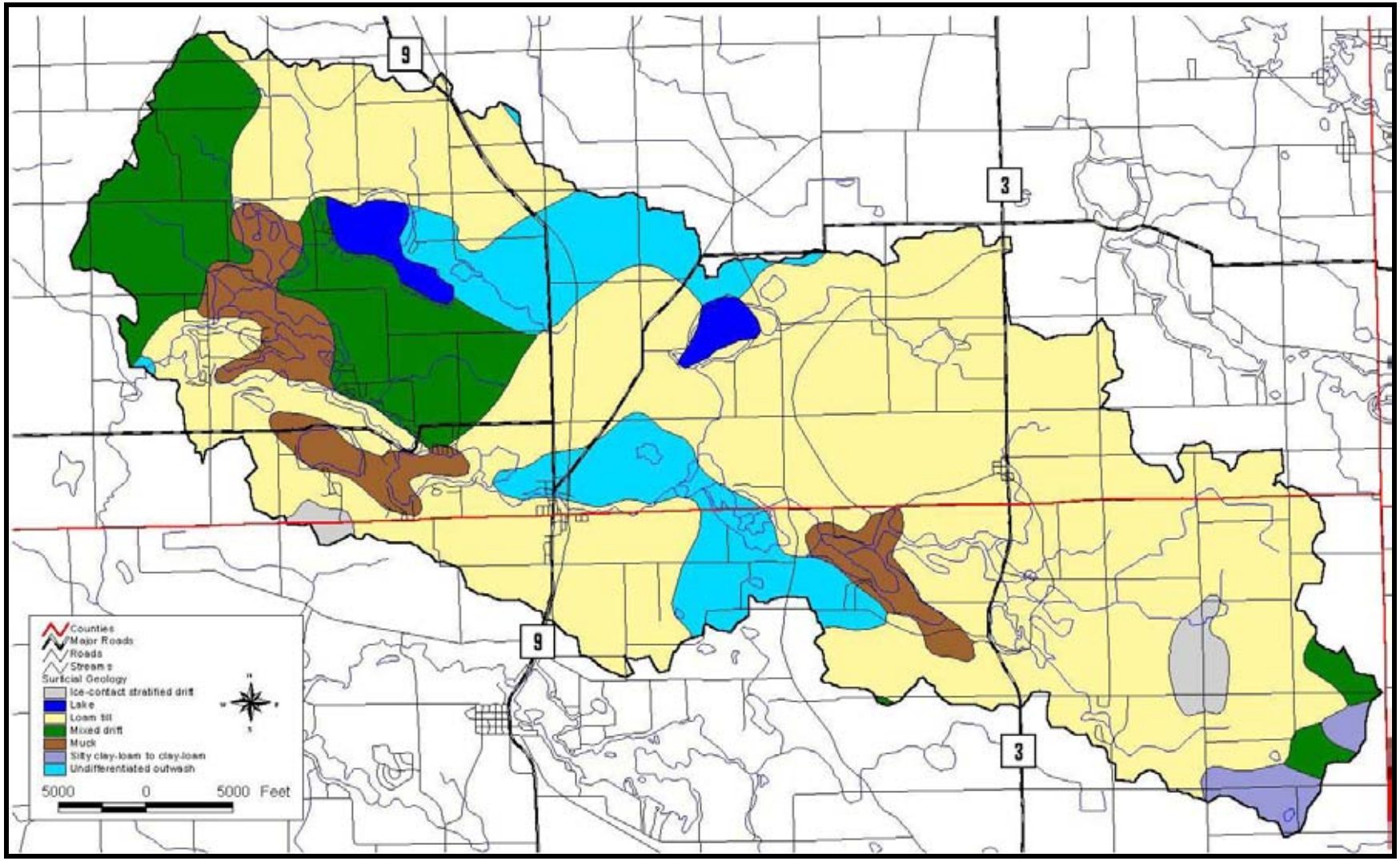

Figure 7. Surficial geology of the Five Lakes watershed.

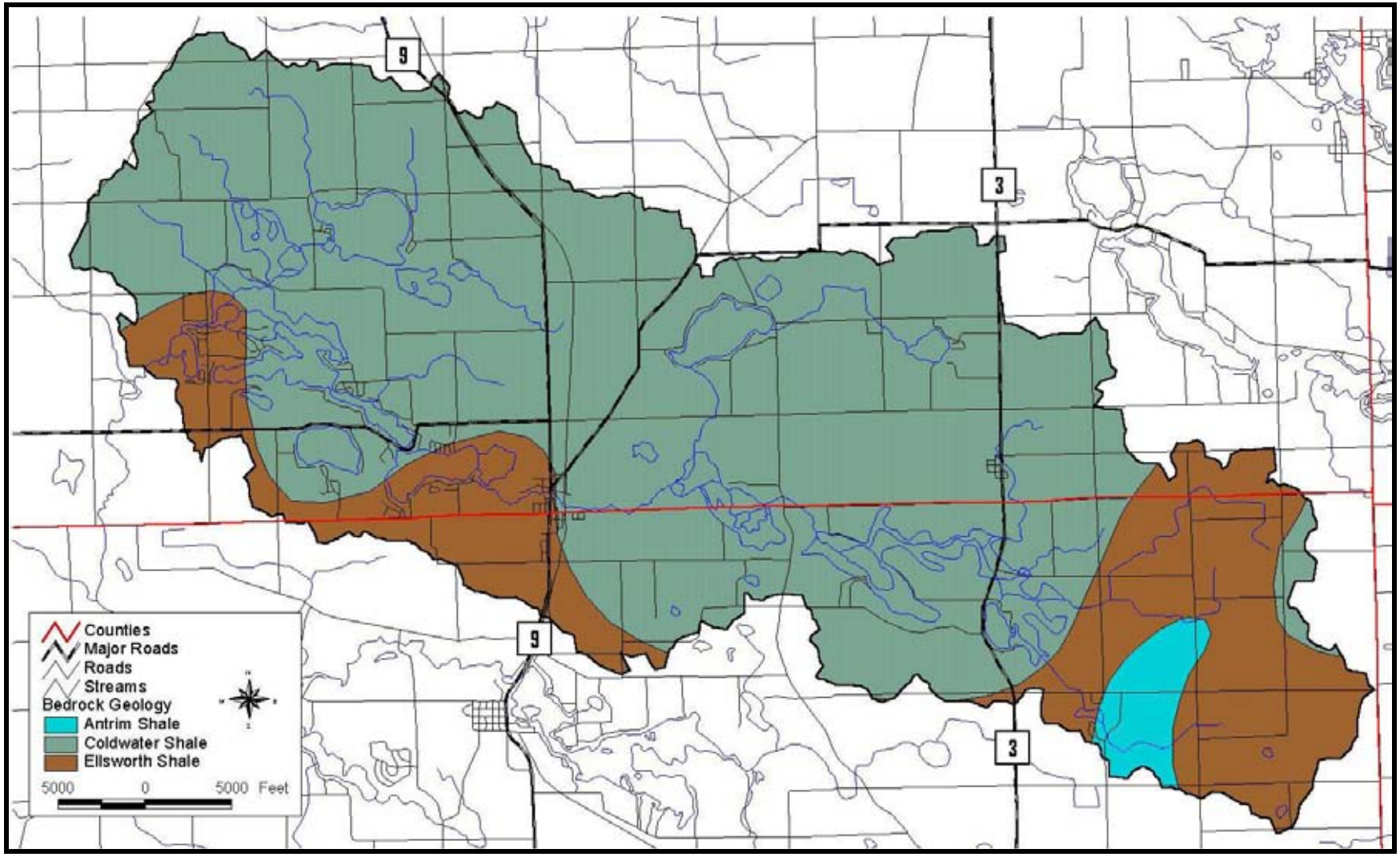

Figure 8. Bedrock geology of the Five Lakes watershed.

The watershed's geologic history is responsible for the watershed's topography (Figure 8). As noted previously, many of the Five Lakes watershed lakes are kettle lakes, part of the characteristic knob and kettle topography of end moraines. The lakes occupy the low spot in the watershed at 897 feet above mean sea level (MSL). The highest elevations in the watershed reach over 1000 feet above MSL and lie in the eastern portion of the watershed just south of Shockopee Lake (Figure 8). As with most watersheds, the steepest slopes exist in the upper watershed. Steep slopes occur in the headwaters east and south of Shockopee Lake and gradually fall as the watershed moves west. Historical maps and the hydric soil map suggest that areas around the shoreline of the Five Lakes as well as Cree, Shockopee, and Tamarack lakes were historically wetland habitat.

2.4 Soils

The Five Lakes watershed's geologic history described in the previous sections determined the soil types found in the watershed and is reflected in the major soil associations that cover the Five Lakes watershed (Figure 9). The soil types found in the Five Lakes watershed in Lagrange and Noble Counties are a product of the original parent material deposited by the glaciers in this area 10,000 to 12,000 years ago. The main parent materials found in the watershed are glacial till, outwash deposits, lacustrine deposits, and organic material that were left as the glaciers receded. The interaction of these parent materials with the physical, chemical, and biological variables found in the area (climate, plant and animal life, time, landscape relief, and the physical and mineralogical composition of the parent material) formed the soils found in Lagrange and Noble Counties today.

Before detailing the major soil associations covering the Five Lakes 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 8 to 15 distinct patterns of soil units. These patterns are the major soil associations of the county. Each soil association typically consists of two or three soil units that dominate the area covered by the soil association and several soil units (minor soils) that occupy only a small portion of the soil association's landscape. Soil associations are named for their dominant components. For example, the Miami-Riddles-Brookston soil association consists primarily of Miami loam, Riddles sandy loam, and Brookston silt loam. The following paragraphs provide more detailed information on each of the major soil association covering the Five Lakes watershed. The discussion relies heavily on Hillis (1980) for Lagrange County and McCarter (1977) for Noble County. Readers should refer to those texts for more information.

Hillis (1980) and McCarter (1977) map six soil associations in the Five Lakes watershed: the Miami-Riddles-Brookston soil association, the Houghton-Edwards-Adrian soil association, the Fox-Oshtemo soil association, the Wawasee-Hillsdale-Conover soil association, the Houghton-Adrian soil association, and the Boyer-Oshtemo soil association (Figure 9). Three of these, the Boyer-Oshtemo, Wawasee-Hillsdale-Conover, and the Houghton-Adrian associations cover Lagrange County, while the Houghton-Edwards-Adrian, Fox-Oshtemo, and Miami-Riddles-Brookston associations cover Noble County.

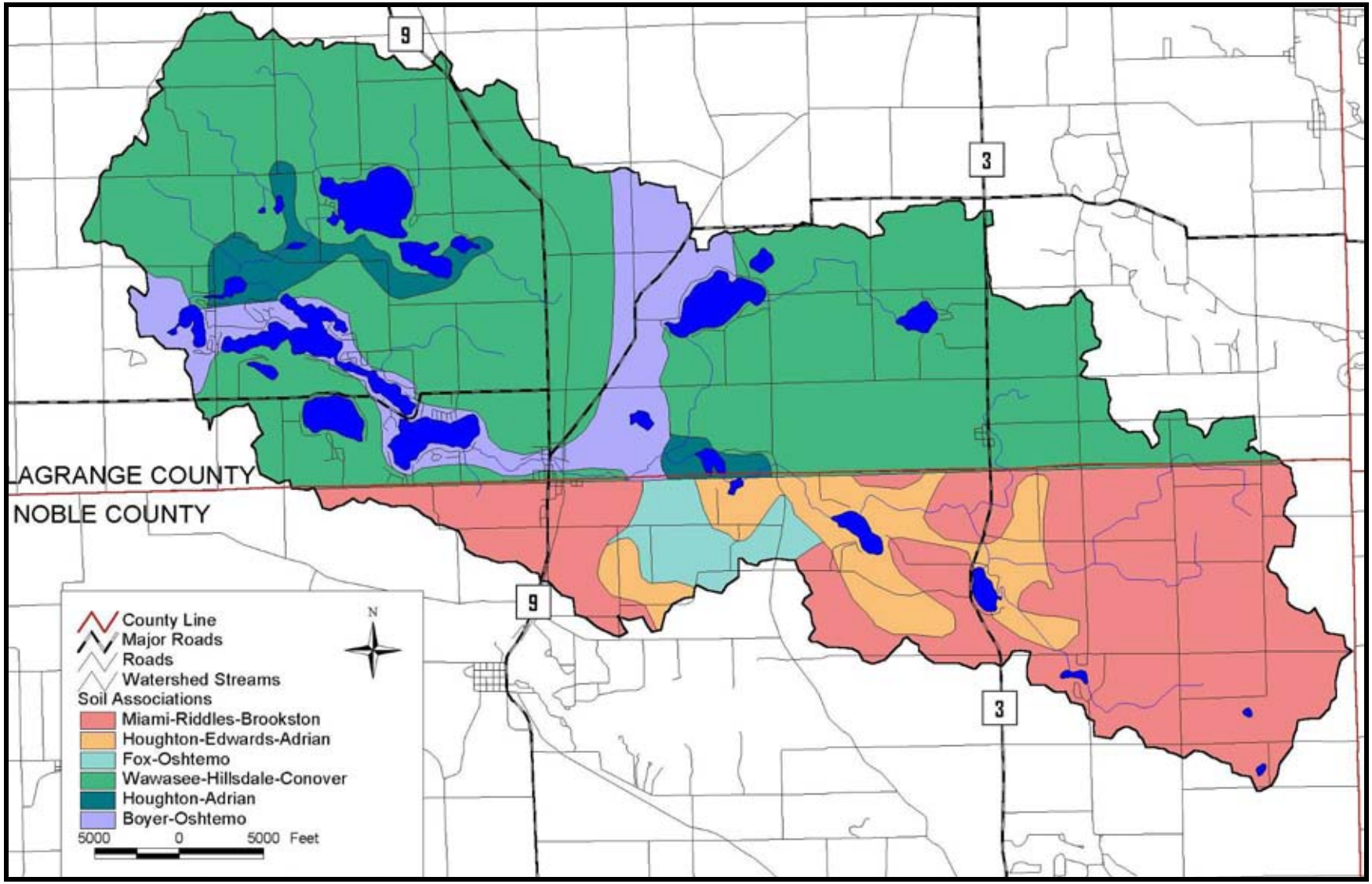

Figure 9. The major soil associations covering the Five Lakes watershed.

The Wawasee-Hillsdale-Conover soil association covers a majority of the Five Lakes watershed within Lagrange County. This association covers the Oliver Lake subwatershed, the Adams Lake subwatershed, the northern half of the Lower Little Elkhart Creek subwatershed, the northern half of the Upper Little Elkhart Creek subwatershed, the northern half of the South Milford Tributary subwatershed, and the northern part of the Hutchins Ditch Subwatershed. Soils in this association developed from glacial till parent materials. This unit occupies about 34 percent of the county. About 30 percent of this unit is Wawasee soils, 17 percent is Hillsdale soils, and 14 percent is Conover soils. The remaining 39 percent are soils of minor extent. The well-drained Wawasee soils are on knobs and breaks between drainageways, while the well-drained Hillsdale soils are on ridges between drainageways and on level till plains. The somewhat poorly drained Conover soils are typically found on broad flats or along drainageways. Areas of this map unit are used mainly for cultivated crops and for pasture. They are also well suited to residential uses and other urban uses. Erosion is a major hazard and low available water capacity and wetness are limitations.

The Houghton-Adrian soil association covers a small area within the Five Lakes watershed. This association lies adjacent to Hackenburg Lake, covers the watershed west of Oliver Lake, and abuts the south end of Olin and Martin lakes. A small area of Houghton-Adrian soil association also lies adjacent to Nauvoo Lake in the Lower Little Elkhart Creek Subwatershed. Soils in this association developed from deep deposits of decomposed plant remains. This map unit occupies about 6 percent of the county. 51 percent of this unit is Houghton soils and 18 percent is Adrian soils. These soils are found in bogs and other depressional areas. The soils in this unit are suited to cultivated crops and poorly suited to residential and other uses.

The Boyer-Oshtemo soil association borders four of the Five Lakes (Messick, Dallas, Witmer, and Westler lakes) and forms the drainageway for Little Elkhart Creek east toward Nauvoo Lake. This association also extends north from Nauvoo Lake forming the western boundary of Adams Lake. Soils in this association developed in loamy outwash. This map unit occupies about 30 percent of the county. 39 percent of this unit is Boyer soils and 33 percent is Oshtemo soils. The remaining percentage is mapped in minor soil components. These soils are found in the deeper depressions and low-lying pockets. Areas of this map unit are used mainly for cultivated crops or pasture. The main limitation is low available water capacity and erosion is a hazard in the more sloping areas. These soils are well suited to residential uses and other urban uses.

The Miami-Riddles-Brookston soil association covers a majority of the Five Lakes waterhsed in Noble County. This includes the southern half of the Upper Little Elkhart Creek subwatershed, the southern half of the South Milford Tributary subwatershed, and the Hutchins Ditch subwatershed. The soil association also covers all of the Little Elkhart Creek Headwaters subwatershed and the Uhl Ditch subwatershed. Soils in this association developed in medium textured glacial till. This soil association makes up about 28 percent of the county. It is about 40 percent Miami soils, 25 percent Riddles soils, and 10 percent Brookston soils. These soils are found on knolls, along drainageways and in some depressions. Erosion is a hazard along sloping areas and wetness is a limitation on Brookston soils.

The Fox-Oshtemo soil association covers a small portion of the watershed immediately south of Nauvoo Lake within Noble County. Soils in this association developed in medium-moderately textured glacial outwash. This soil association makes up about 15 percent of the county. It is 60 percent Fox soils and 15 percent Oshtemo soils. Fox soils are typically level to moderately steep and are well suited to corn, soybeans, and small grain. Drought is a limitation of this soil. Oshtemo soil

is typically found in the broad flats or breaks around potholes and long drainage ways or depressions on outwash plains. Drought and erosion are limitations of this soil.

The Houghton-Edwards-Adrian soil association covers almost areas adjacent to Cree Lake and Tamarack Lakes extending north from each of these lakes to the county line. Soils in this association developed in deep deposits of organic material. This soil association makes up about 10 percent of the county. It is about 60 percent Houghton soils, 12 percent Edwards soils, and 7 percent Adrian soils. All these soils are found in depressional areas of the upland and outwash plains. Wetness is the most serious limitation for them all. Drained areas are used mostly for crops, such as corn and soybeans.

2.4.1 Highly Erodible Soils

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

Highly erodible and potentially highly erodible are classifications used by the 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 Five Lakes watershed that the NRCS considers to be highly erodible. As Figure 10 indicates, potentially highly erodible soils cover a substantial portion (9,012 acres or 24%) of the Five Lakes watershed. Of the potentially highly erodible soils present within the watershed, Hillsdale sandy loam (HdC), Riddles sandy loam (RsB, RsC2), and Wawasee fine sandy loam (WeC2) soils are particularly dominant. The Little Elkhart Creek Headwaters and Uhl Ditch subwatersheds contain the highest percentages of potentially highly erodible soils (45% and 43%, respectively). The Hutchins Ditch, Upper Little Elkhart Creek, and Lower Elkhart Creek subwatersheds also possess relatively large portions of their watershed mapped as potentially highly erodible soils (38%, 37%, and 33%, respectively). Conversely, only 12% of the Oliver Lake subwatershed is mapped as potentially highly erodible soils. Highly erodible soils are less prevalent than potentially highly erodible soils within the Five Lakes watershed. In total, highly erodible soils cover 8.3 acres (2%). Like PHES, the Headwaters, Uhl Ditch, Hutchins Ditch, and Upper Little Elkhart Creek subwatersheds contain the largest percentages of area mapped as highly erodible soils. HES cover 5 to 7% of these subwatersheds. The Oliver Lake and Adams Lake subwatersheds contain the smallest areas mapped as HES; each subwatershed contains less than 1% of the total surface area as highly erodible soils.

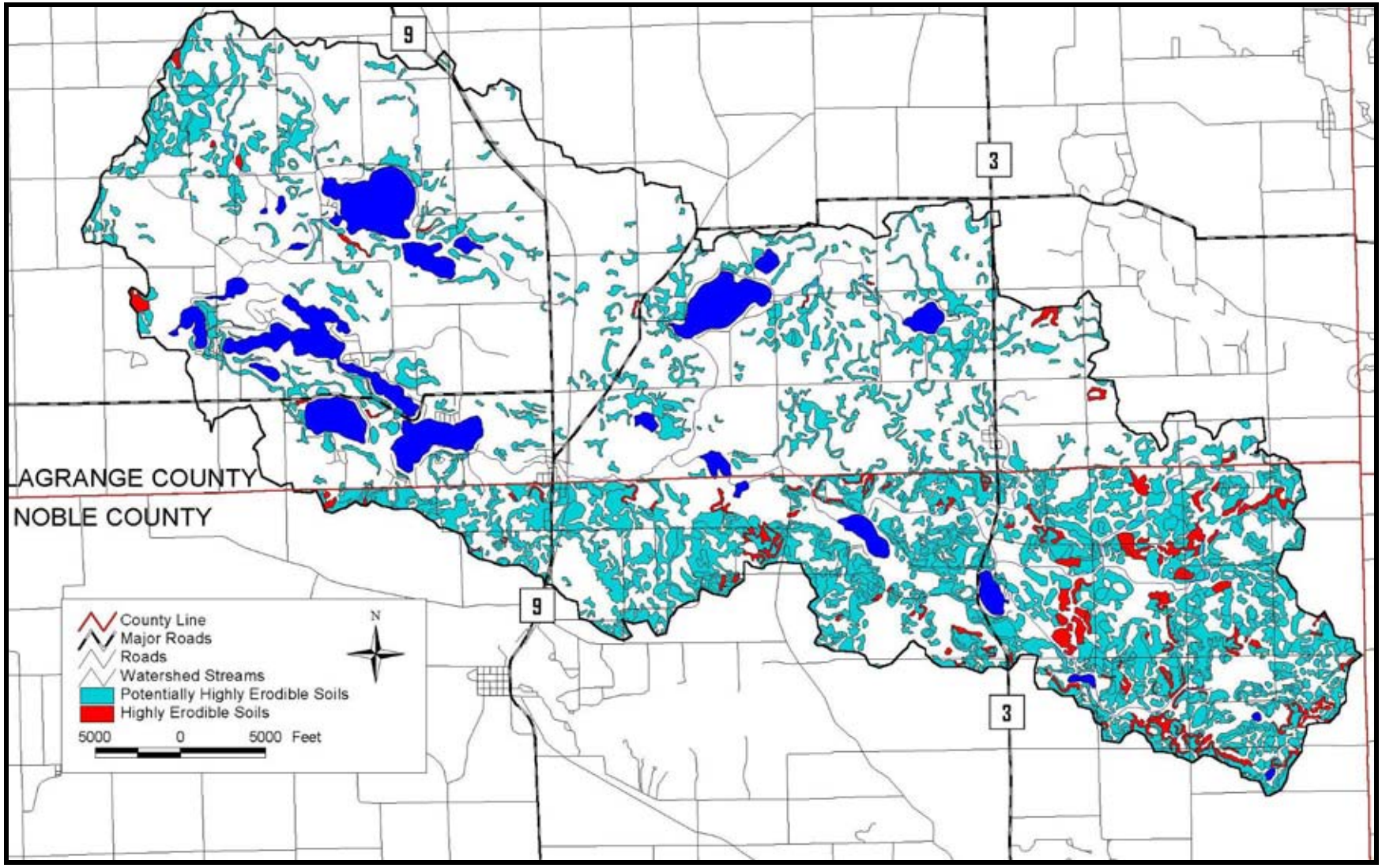

Figure 10. Highly erodible (red) and potentially highly erodible (teal) soils in the Five Lakes watershed.

Table 2. Highly erodible and potentially highly erodible soils units in the Five Lakes watershed.

Soil Unit	Soil Name	County Name	Detail*	Soil Description
BoB	Boyer loamy sand	Lagrange/Noble	PHES	2 to 6 percent slopes
BoC	Boyer loamy sand	Lagrange/Noble	PHES	6 to 12 percent slopes
BoD	Boyer loamy sand	Lagrange	PHES	12 to 18 percent slopes
BoD2	Boyer loamy sand	Noble	HES	12 to 18 percent slopes, eroded
CcC3	Casco sandy clay loam	Noble	HES	8 to 15 percent slopes, severely eroded
ChC	Chelsea fine sand	Lagrange	PHES	6 to 12 percent slopes
FoB	Fox sandy loam	Noble	PHES	2 to 6 percent slopes
FoC2	Fox sandy loam	Noble	PHES	6 to 12 percent slopes, eroded
FsD2	Fox-Casco sandy loams	Noble	HES	12 to 18 percent slopes, eroded
HdC	Hillsdale sandy loam	Lagrange	PHES	6 to 12 percent slopes
MeC	Metea loamy sand	Lagrange	PHES	6 to 12 percent slopes
MfB2	Miami loam	Noble	PHES	2 to 6 percent slopes, eroded
MfC2	Miami loam	Noble	PHES	6 to 12 percent slopes, eroded
MfD2	Miami loam	Noble	HES	12 to 18 percent slopes, eroded
MgC3	Miami clay loam	Noble	HES	6 to 12 percent slopes, severely eroded
MgD3	Miami clay loam	Noble	HES	12 to 18 percent slopes, severely eroded
MhB2	Miami loam, gravelly substratum	Noble	PHES	2 to 6 percent slopes, eroded
MrC2	Morley silt loam	Noble	PHES	6 to 12 percent slopes, eroded
MsC3	Morley silt clay loam	Noble	HES	6 to 12 percent slopes, severely eroded
MsD3	Morley silt clay loam	Noble	HES	12 to 18 percent slopes, severely eroded
MuC2	Morley, Miami, Rawson loams	Noble	PHES	6 to 12 percent slopes, eroded
OsB	Oshtemo loamy sand	Lagrange/Noble	PHES	2 to 6 percent slopes
OsC	Oshtemo loamy sand	Lagrange/Noble	PHES	6 to 12 percent slopes
OsD	Oshtemo loamy sand	Lagrange	HES	12 to 18 percent slopes
OsE	Oshtemo loamy sand	Lagrange	HES	18 to 25 percent slopes
OuC	Oshtemo-Hillsdale-Chelsea complex	Lagrange	PHES	6 to 12 percent slopes
PxC	Plainfield sand	Lagrange	PHES	6 to 12 percent slopes
RaB	Rawson sandy loam	Lagrange/Noble	PHES	2 to 6 percent slopes
RbB	Rawson loam	Noble	PHES	0 to 2 percent slopes
RdB2	Rawson, Morley, Miami loams	Noble	PHES	2 to 6 percent slopes, eroded
RsB	Riddles sandy loam	Noble	PHES	2 to 6 percent slopes
RsC2	Riddles sandy loam	Noble	PHES	6 to 12 percent slopes, eroded
RsD2	Riddles sandy loam	Noble	HES	12 to 18 percent slopes, eroded
WeC2	Wawasee fine sandy loam	Lagrange	PHES	6 to 12 percent slopes
WeD2	Wawasee fine sandy loam	Lagrange	HES	12 to 18 percent slopes
WhC3	Wawasee loam	Lagrange	PHES	6 to 12 percent slopes
WhD3	Wawasee loam	Lagrange	HES	12 to 18 percent slopes

*PHES=Potentially Highly Erodible Soil; HES=Highly Erodible Soil
Source: Hillis, 1980 Lagrange County Soil Survey & McCarter, 1977 Noble County Soil Survey.

2.4.2 Soils Used for Septic Tank Absorption Fields

As is common in many areas of Indiana, septic tanks and septic tank absorption fields are utilized for wastewater treatment within the Five Lakes watershed. 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 (waste discharge) will ultimately determine how well surface and groundwater is being protected.

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 depends on four factors: the amount of accessible soil particle surface area; the chemical properties of the surfaces; soil conditions like temperature, moisture, and oxygen content; and the type of pollutants present in the effluent (Cogger, 1989).

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 absorb them, but retention is not necessarily permanent. During storm flows, they 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 (without oxygen) and at lower soil temperatures because natural soil microbial activity is reduced.

The NRCS 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 mapped in the Five Lakes watershed in terms of their suitability for use as septic tank absorption fields. Figure 11 displays the location and extent of soils slightly, moderately, and severely limited for use as a septic tank absorption field.

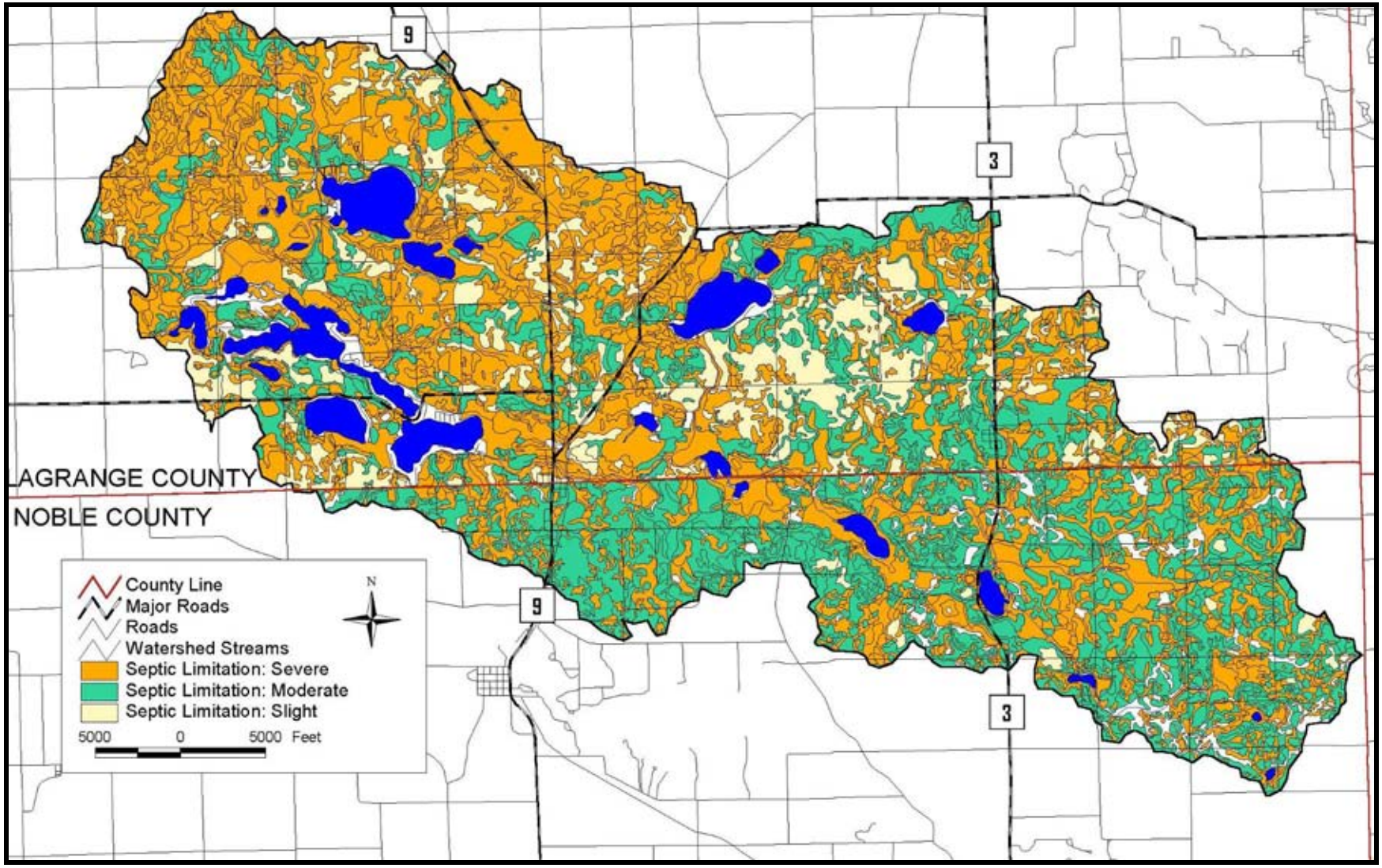

Figure 11. Soil septic field absorption suitability in the Five Lakes watershed.

Table 3. Soil types present in the Five Lakes watershed and suitability for use as a septic tank absorption field.

Symbol	Soil Name	County Name	High Water Table	Suitability for Septic Tank Absorption Field
Ad, Am	Adrian muck	Lagrange/Noble	0-1 ft	Severe: ponding
Au	Aubbeenaubbee fine sandy loam	Noble	1-3 ft	Severe: moderate permeability
BlA	Blount silt loam	Noble	1-3 ft	Severe: slow permeability
BoA- BoC	Boyer loamy sand	Lagrange	>6 ft	Severe: poor filter
BoD	Boyer loamy sand	Lagrange	>6 ft	Severe: poor filter, slope
BoD2	Boyer loamy sand	Noble	>6 ft	Severe: rapid permeability, slope
Bp	Brady sandy loam	Lagrange	1-3 ft	Severe: wetness, poor filter
Br	Brady sandy loam	Noble	1-3 ft	Severe: rapid permeability
Bx	Brookston silt loam	Noble	0-1 ft	Severe: ponding
CcC3	Casco sandy clay loam	Noble	>6 ft	Moderate: slope, moderate permeability
ChB-ChC	Chelsea fine sand	Lagrange/Noble	>6 ft	Severe: poor filter
CrA	Crosier loam	Lagrange/Noble	1-3 ft	Severe: wetness, percs slowly
Ed, Em	Edwards muck	Lagrange/Noble	0-1 ft	Severe: ponding, percs slowly
FoA-FoB	Fox sandy loam	Noble	>6 ft	Slight
FoC2	Fox sandy loam	Noble	>6 ft	Moderate: slope
FsD2	Fox-Casco sandy loams	Noble	>6 ft	Severe: slope
Fu	Fulton silt loam	Noble	1-3 ft	Severe: slow permeability
Gf	Gilford sandy loam	Lagrange/Noble	0-1 ft	Severe: ponding, poor filter
Gr	Granby loamy fine sand	Lagrange	+0.5-1 ft	Severe: ponding, poor filter
HaA	Haskins loam	Lagrange/Noble	1-3 ft	Severe: percs slowly, wetness
HdA- HdB	Hillsdale sandy loam	Lagrange	>6 ft	Moderate: percs slowly
HdC	Hillsdale sandy loam	Lagrange	>6 ft	Moderate: percs slowly, slope
Hh	Homer loam	Noble	1-3 ft	Severe: moderate permeability
Hm	Houghton muck	Noble	0-1 ft	Severe: ponding
Ho	Houghton muck, drained	Lagrange/Noble	0-1 ft	Severe: wetness, poor filter
Ht, Hw	Houghton muck	Lagrange	+0.5-1 ft	Severe: ponding, percs slowly
Hx	Houghton muck, ponded	Lagrange	+2-0.5 ft	Severe: ponding, percs slowly
Ma	Marl beds	Noble	0-1 ft	Severe: ponding
Mb	Marsh	Noble	N/A	N/A
MbB	Martinsville sandy loam	Lagrange	>6 ft	Slight
Mc	Martisco muck	Lagrange	+0.5-0.5	Severe: ponding, percs slowly
MdB	Martinsville fine sandy loam	Noble	>6 ft	Slight
MeB	Metea loamy sand	Lagrange/Noble	>6 ft	Moderate: percs slowly
MeC	Metea loamy sand	Lagrange	>6 ft	Moderate: slope, percs slowly
MfB2	Miami loam	Noble	>6 ft	Moderate: moderate permeability
MfC2	Miami loam	Noble	>6 ft	Moderate: slope
MfD2, MfE2	Miami loam	Noble	>6 ft	Severe: slope
MgC3	Miami clay loam	Noble	>6 ft	Moderate: slope

Symbol	Soil Name	County Name	High Water Table	Suitability for Septic Tank Absorption Field
MgD3	Miami clay loam	Noble	>6 ft	Severe: slope
MhA	Miami loam	Noble	>6 ft	Moderate: moderate permeability
MhB2	Miami loam, gravelly substratum	Noble	>6 ft	Moderate: moderate permeability
Mn	Milford silty clay loam	Noble	0-1 ft	Severe: ponding, percs slowly
MrB2	Morley silt loam	Noble	3-6 ft or >6 ft	Severe: percs slowly
MrC2	Morley silt loam	Noble	3-6 ft or >6 ft	Severe: slope, percs slowly
MsC3-MsD3	Morley silt clay loam	Noble	3-6 ft or >6 ft	Severe: slope, percs slowly
MuC2	Morley, Miami, Rawson loams	Noble	3-6 ft or >6 ft	Severe: slope, percs slowly
OsA- OsC	Oshtemo loamy sand	Lagrange	>6 ft	Severe: poor filter
OsD, OsE	Oshtemo loamy sand	Lagrange	>6 ft	Severe: poor filter, slope
OtA	Oshtemo sandy loam	Noble	>6 ft	Slight
OuB	Oshtemo-Hillsdale-Chelsea complex	Lagrange	>6 ft	Severe: poor filter Moderate: percs slowly Severe: poor filter
OuC	Oshtemo-Hillsdale-Chelsea complex	Lagrange	>6 ft	Severe: poor filter Moderate: percs slowly, slope Severe: poor filter
Pb	Palms muck, drained	Noble	0-1 ft	Severe: ponding
PdA	Parr loam	Noble	>6 ft	Moderate: percs slowly
Pe	Pewamo silty clay loam	Noble	0-1 ft	Severe: ponding, percs slowly
Pm	Palms muck, drained	Lagrange	+0.5-1 ft	Severe: ponding
PxB-PxC	Plainfield sand	Lagrange	>6 ft	Severe: poor filter
RaB	Rawson sandy loam	Lagrange/Noble	2.5-4.0 ft	Severe: percs slowly, wetness
Rb	Rensselaer loam	Lagrange	+0.5-1 ft	Severe: ponding, percs slowly
RbA-RbB	Rawson loam	Noble	3-6 ft or >6 ft	Severe: percs slowly
RdB2	Rawson, Morley, Miami loams	Noble	3-6 ft or >6 ft	Severe: percs slowly
Re	Rensselaer loam	Noble	0-1 ft	Severe: ponding, percs slowly
RsA-RsB	Riddles sandy loam	Noble	>6 ft	Moderate: percs slowly
RsC2	Riddles sandy loam	Noble	>6 ft	Moderate: slope
RsD2	Riddles sandy loam	Noble	>6 ft	Severe: slope
Se	Sebewa loam	Lagrange/Noble	0-1 ft	Severe: ponding
To	Toledo silty clay loam	Noble	0-1 ft	Severe: ponding, percs slowly
Wa	Wallkill silt loam	Lagrange/Noble	+0.5-0.5	Severe: ponding
WeA-WeB	Wawasee fine sandy loam	Lagrange	>6 ft	Slight
WeC2	Wawasee fine sandy loam	Lagrange	>6 ft	Moderate: percs slowly, slope
WeD2	Wawasee fine sandy loam	Lagrange	>6 ft	Severe: slope
WhC3	Wawasee loam	Lagrange	>6 ft	Moderate: percs slowly, slope
WhD3	Wawasee loam	Lagrange	>6 ft	Severe: slope
Ws	Washtenaw silt loam	Noble	0-1 ft	Severe: ponding, percs slowly
Wt	Whitaker loam	Lagrange/Noble	1-3 ft	Severe: wetness

Source: Hillis, 1980; McCarter, 1977.

2.5 Natural History

Geographic location, climate, geology, topography, soils, hydrology, 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 et al., 1985; Omernik and Gallant, 1988) have divided Indiana into several natural regions or ecoregions, each with similar geologic 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 Five Lakes watershed lies within Homoya's Northern Lakes Natural Region.

Prior to European settlement, oak-hickory forest likely covered most of the Five Lakes watershed, particularly in the middle portion of the watershed. Beech-maple forest covered the northwest and southeast portions of the watershed. For the oak-hickory forest, white oak was the dominant component, with red oak, black oak, shagbark hickory, and bitternut hickory as subdominants (Petty and Jackson, 1966; Homoya et al., 1985). 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 under story in the watershed's region. The dominant component of the beech-maple forest was sugar maple with beech, tulip poplar, white ash, and cork elm as subdominants (Petty and Jackson, 1966; Homoya et al., 1985).

2.6 Endangered Species

The Indiana Natural Heritage Data Center database provides information on the presence of endangered, threatened, or rare (ETR) species, high quality natural communities, and natural areas in Indiana. The database was developed 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 Indiana Department of Natural Resources. 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 B presents the results from the database search for endangered, threatened, or rare species and high quality natural communities in the Five Lakes watershed. (Appendix B also includes a listing of endangered, threatened, and rare species and high quality natural communities documented in Lagrange and Noble Counties for additional reference.

Lagrange and Noble Counties support a variety of endangered, threatened, and rare animals and plants. The listed animals in Lagrange County include six aquatic species: four freshwater mussels, including the state endangered snuffbox and two fish. Three amphibians (the blue-spotted salamander, the four-toed salamander, and the northern leopard frog) and four reptiles (the spotted turtle, the Blanding's turtle, the Copperbelly water snake, and the Eastern massasauga) are also listed. Twenty-five birds, including thirteen state endangered species, have been listed in Lagrange County. Six mammals, the star-nosed mole, the northern river otter, bobcat, least weasel, Indiana bat (state endangered), and American badger, have also been identified in the county. Eighty-five plant species

are also included in the database for Lagrange County. The county also supports fifteen high quality natural communities (Appendix B).

The listed animals in Noble County include one aquatic species: one fish (cisco). Two amphibians (the blue-spotted salamander and the common mudpuppy) and four reptiles (the spotted turtle, the Blanding's turtle, the Eastern massasauga, and butler's garter snake) are also listed. Fifteen ETR birds, including seven state endangered species, have been listed in Noble County. Five mammals, the star-nosed mole, the northern river otter, bobcat, least weasel, and American badger have also been identified in the county. Forty-eight plant species are also included in the database for Noble County. The county supports fifteen high quality natural communities (See Appendix B).

2.7 Hydrology

As is characteristic of much of the glaciated portion of the state, hydrologic features including lakes, streams, wetlands, and ponds are important components of the Five Lakes watershed's landscape. Twenty-four lakes lie within the Five Lakes watershed. Table 4 summarizes the morphological characteristics of the 16 lakes larger than 20 acres within the watershed. Of these lakes, Shockopee Lake is the smallest measuring 21 acres. Conversely, Oliver Lake is the largest of the lakes within the Five Lakes watershed covering 394 acres. Cree Lake is the shallowest of these lakes within the watershed with a maximum depth of only 26 feet; while Adams Lake is the deepest lake possessing a maximum depth of 93 feet. As headwaters lakes, Eve Lake possesses the smallest drainage area (329 acres) of any of the Five Lakes watershed lakes. As the most downstream lake, Messick Lake possesses the largest watershed (37,250 acres).

Table 4. Morphological information for lakes in the Fives Lakes watershed.

Lake	Area (acres)	Maximum Depth (feet)	Drainage Area (acres)	Watershed Area: Lake Area
Adams	308	93	3,626	11.8:1
Atwood	170	33	1,635	9.6:1
Blackman	52	57	1,635	31.4:1
Cree	58	26	6,592	113.7:1
Dallas	283	96	26,476	93.6:1
Eve	31	46	329	10.6:1
Hackenburg	42	38	36,207	862.1:1
Martin	26	56	3,086	118.7:1
Messick	68	54	37,250	547.8:1
Nauvoo	38	40	18,326	482.3:1
Olin	103	82	3,430	33.3:1
Oliver	394	91	6,817	17.3:1
Shockopee	21	26	2,607	124.1:1
Tamarack	50	37	12,395	247.9:1
Westler	88	33	25,085	285.1:1
Witmer	204	54	23,978	117.5:1

Many of the lakes within the Five Lakes watershed possess extremely large watershed area to lake area ratios. Only Adams, Atwood, Eve, Oliver, Blackman, and Olin lakes possess watershed area to lake area ratios that are typical for glacial lakes. Many glacial lakes have watershed area to lake area ratios of less than 50:1 and watershed area to lake area ratios on the order of 10:1 are fairly common

(Vant, 1987). Most of the other lakes have watershed area to lake area ratios that are more typical for reservoirs. Lake area to watershed area ratios for the other lakes in the watershed range from 93.6:1 for Dallas Lake to 862:1 for Hackenburg Lake. This means that for every surface are of water within Dallas Lake there are 93 acres of watershed drainage. Likewise, for every surface area of Hackenburg Lake there are 862 acres of drainage. The watershed area to lake area ratio for these lakes is elevated for glacial lakes; sometimes, the ratio exceeds levels typical of reservoirs (100:1 to 300:1; Vant, 1987).

As previously mentioned, watershed size and watershed to lake ratios can affect the chemical and biological characteristics of a lake. For example, lakes with large watersheds have the potential to receive greater quantities of pollutants (sediments, nutrients, pesticides, etc.) from runoff than lakes with smaller watersheds. For lakes with large watershed to lake ratios, watershed activities can potentially exert a greater influence on the health of the lake than lakes possessing small watershed to lake ratios. Conversely, for lakes with small watershed to lake ratios, shoreline activities and internal lake processes may have a greater influence on the lake's health than lakes with large watershed to lake ratios.

A number of streams are also present within the Five Lakes watershed. The main stream, Little Elkhart Creek, carries water from the eastern edge of the watershed through Tamarack and Nauvoo lakes before emptying into Witmer Lake. In total, Little Elkhart Creek flows approximately 34,320 feet from its headwaters in the east to Witmer Lake in the west. Little Elkhart Creek receives water from five main tributaries: Hutchins Ditch, Uhl Ditch, the South Milford Tributary, the Adams Lake outlet, and the Oliver Lake outlet. Hutchins Ditch is the longest of these streams covering approximately 22,975 feet before entering Little Elkhart Creek northeast of Cree Lake. The Adams Lake outlet (19,250 feet), the South Milford Tributary (12,745 feet), and Uhl Ditch (9,850 feet) cover nearly twice as much distance as the Oliver Lake outlet (5,185 feet). An additional 53,850 feet of stream are present in the watershed as well. This includes minor drainages to Adams, Martin, Shockopee, Hackenburg, Westler, and Witmer lakes.

Functioning wetlands filter sediments and nutrients in runoff, store water for future release, provide an opportunity for groundwater recharge or discharge, and serve as nesting habitat for waterfowl and spawning sites for fish. By performing these roles, healthy, functioning wetlands often improve the water quality and biological health of streams and lakes located downstream of the wetlands. In general, wetlands, including lake systems, cover roughly 15 to 20% of the Five Lakes watershed. The USGS Land Cover Data Set suggests that wetlands cover approximately 7% of the Five Lakes watershed and open water covers an additional 6% of the watershed. (See the Land Use Section for more detailed information.) The United States Fish and Wildlife Service's National Wetland Inventory Map (Figure 12) shows that wetlands cover approximately 20% of the Five Lakes watershed. (Table 5 presents the acreage of wetlands by type according to the National Wetland Inventory.) The differences in reported wetland acreage in the Five Lakes watershed reflect the differences in project goals and methodology used by the different agencies to collect land use data.

Table 5. Watershed hydrology by area in acres, hectares and percent of watershed by wetland classification.

Wetland Classification	Area (acres)	Area (hectares)	Percent of Watershed
Lacustrine	2,109.0	854.2	5.7%
Palustrine emergent	2,125.6	860.9	5.7%
Palustrine forested	2,620.8	1,061.4	7.0%
Palustrine scrub/shrub	735.2	297.7	2.0%
Palustrine submergent	1.3	0.5	0.0%
Ponds	163.3	66.1	0.4%
Riverine	1.7	0.7	0.0%
Total Wetlands	**7,756.9**	**3,141.5**	**20.8%**

The last glacial retreat in these northern counties left level landscapes dotted with wetland and lake complexes. Development of the land in these counties for agricultural purposes altered much of the natural hydrology, eliminating many of the wetlands. Figure 13 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. When combined, the total acreage of wetland (hydric) soils in the watershed (9,910 acres) and the area of the watershed mapped as water (lakes, ponds, etc.; 2,200 acres) indicates that historically, 12,100 acres of wetland and/or open water existed within the Five Lakes watershed. When this acreage is compared to the acreage of existing wetlands (7,757 acres), this calculation suggests that nearly 65% of the original wetland or open water acreage still exists today.

Wetland loss in the Five Lakes watershed is much lower than the loss present throughout much of the region and state. The Indiana Wetland Conservation Plan estimates that approximately 85% of the state's wetlands have been filled (IDNR, 1996). Furthermore, the 1978 Census of Agriculture found that drainage is artificially enhanced on 35% of the land in Noble County (cited in Hudak, 1995). The IDNR and watershed residents have undertaken efforts to protect and restore wetland acreage and functionality in the Five Lakes watershed. Because of these protection efforts, the wetland along the shorelines of many of the lakes and along the length of Little Elkhart Creek remains largely intact. Most of the wetland loss that has occurred within the Wawasee Area Watershed is located away from the lakes scattered throughout the watershed.

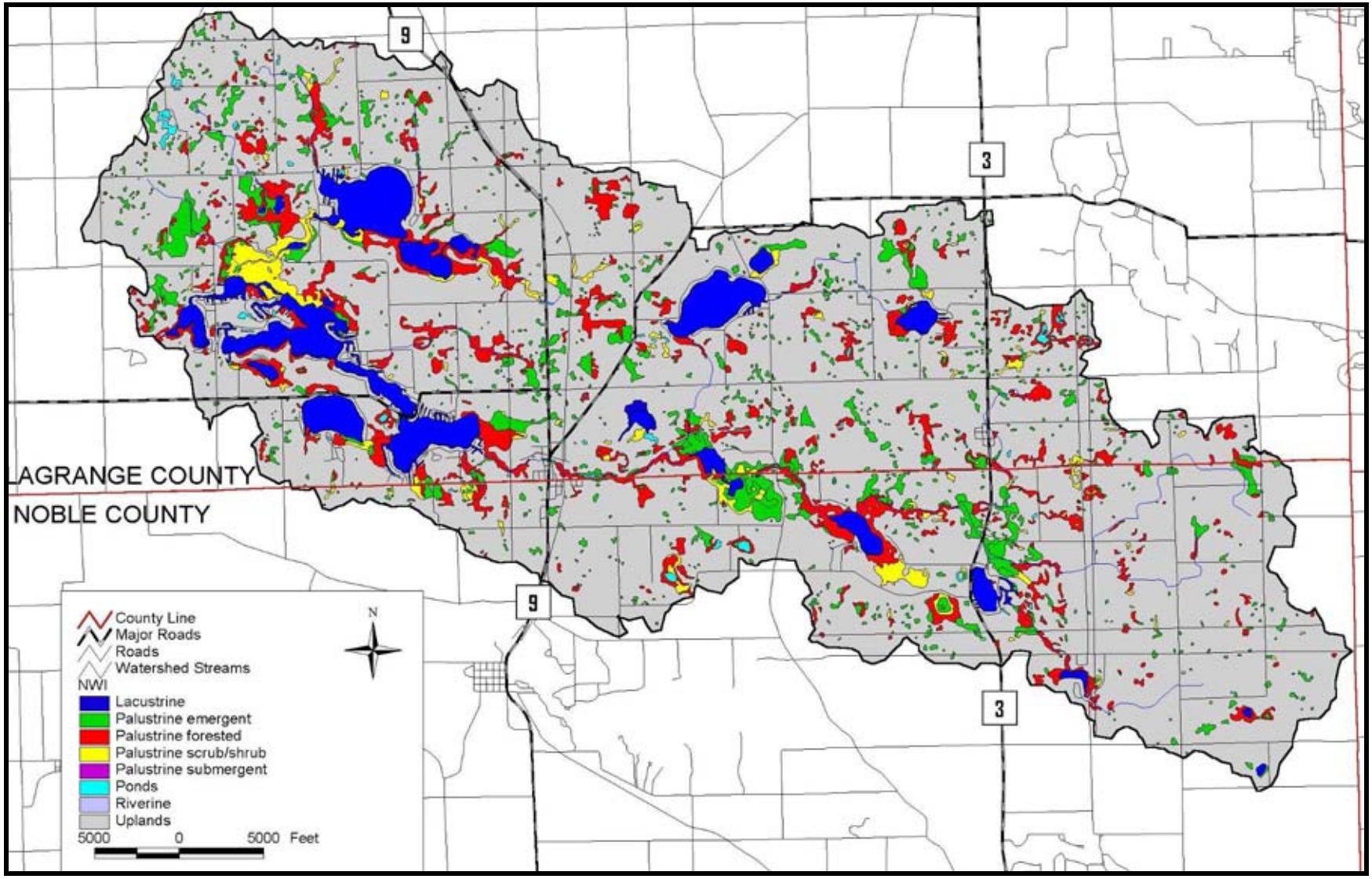

Figure 12. National Wetland Inventory (NWI) map.

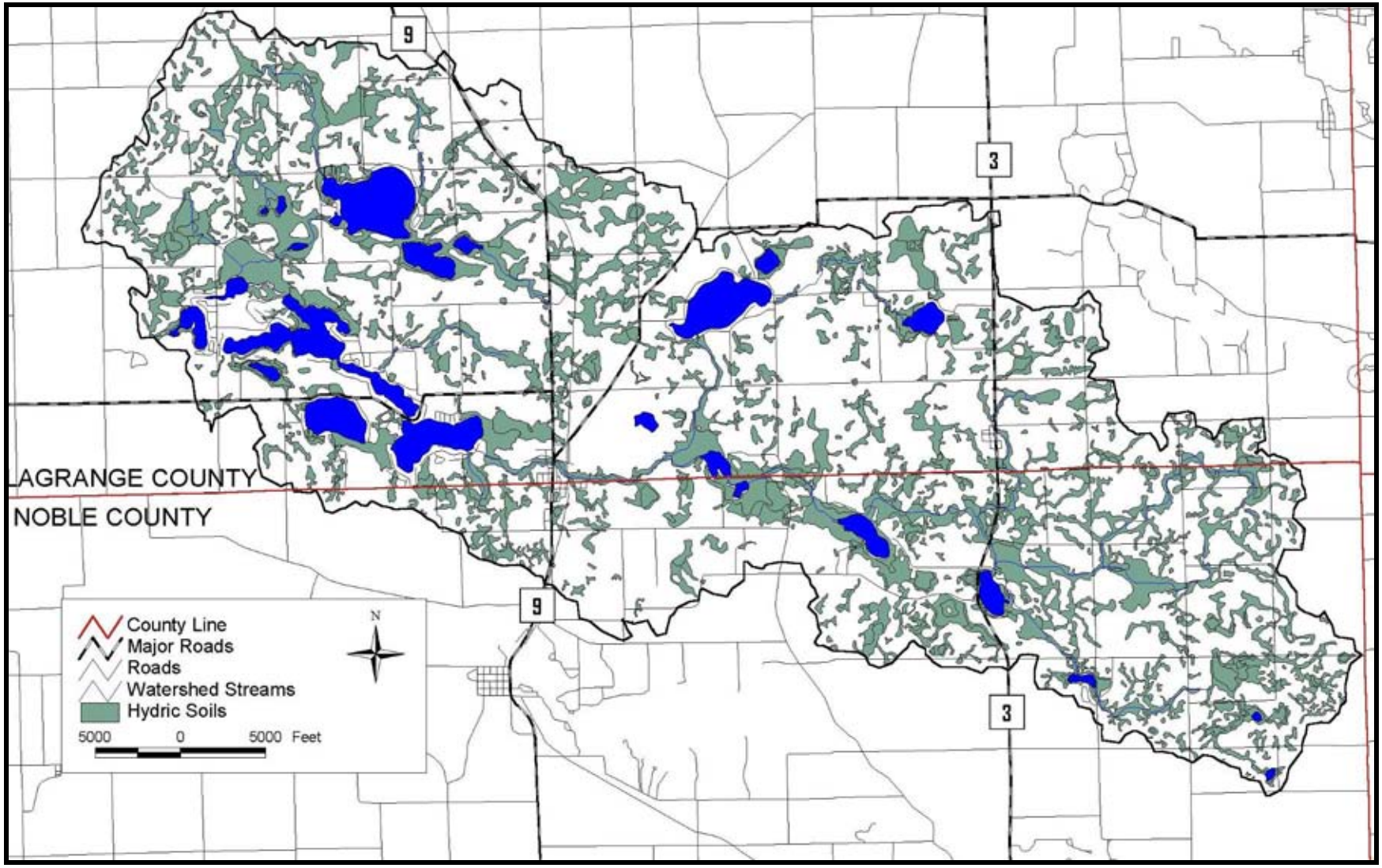

Figure 13. Hydric soils within the Five Lakes watershed.

2.8 Cultural Resources

There are no properties located in the watershed listed on the station or federal historic registers.

2.9 Land Use

Table 6 and Figure 14 present the land use information for the Five Lakes watershed. Land use data from the U.S. Geological Survey (USGS) forms the basis of Figure 14. The USGS data for the watershed was updated by examining 2003 orthophotography in ArcView GIS. Portions of the watershed were also field checked. Like much of Noble and Lagrange Counties (McCarter, 1977 and Hillis, 1980), agricultural land uses dominate the landscape of the Five Lakes watershed. Row crop agricultural areas cover nearly 60% of the watershed (22,272 acres). According to 2004 tillage transect data for Lagrange County, 62% of corn and 8% of soybean field (by acres) are in conventional tillage. In Noble County, 21% of corn and 7% of soybean field (by acres) are in conventional tillage. Lagrange County ranks 56th for the use of no-till farming on corn fields (by acre) and 46th for soybean fields. Noble County ranks 28th for the use of no-till farming on corn fields (by acre) and 28th for soybean fields (IDNR, 2004).

According to data from the office of the Indiana State Chemist (2004) there were 43,550 tons of fertilizer and plant nutrients applied in Lagrange County in 2004, while nearly 14,130 tons of fertilizer was applied to Noble County fields during the same period. The vast majority of this fertilizer was applied during the first half of the year in both counties. For comparison, in Kosciusko County, nearly 39,000 tons of fertilizer was applied to row crop agricultural areas, while in Steuben County only 13,100 tons of fertilizer was applied. The amount of fertilizer used is directly related to crop acreage and yields in these counties. The acreage of cropland is appreciably greater in Lagrange County (189,900 harvested acres in 2004) than the other counties (Kosciusko County (185,200 harvested acres; Noble County (118,900 harvested acres), and Steuben County (70,600 harvested acres; Indiana Census of Agriculture, 2005). Average yields in Lagrange County are also higher than Noble; this would further account for more fertilizer application.

Although row crop agriculture dominates the land use within the Five Lakes watershed, alternate land uses are also present on large portions of the watershed. Pasture occupies an additional 14.5% of the watershed. Forested land exists on approximately 11% of the watershed. Open water and wetlands cover 13.5% of the watershed. (This number differs slightly from the **Hydrological Features** section since different data sources were utilized.) Most of the forested and wetland areas lie around the outer edges of the lakes in the watershed and along the stream banks of Dove Creek and Little Elkhart Creek (Figure 14). Residential and commercial development account for less than 2% of the watershed land use.

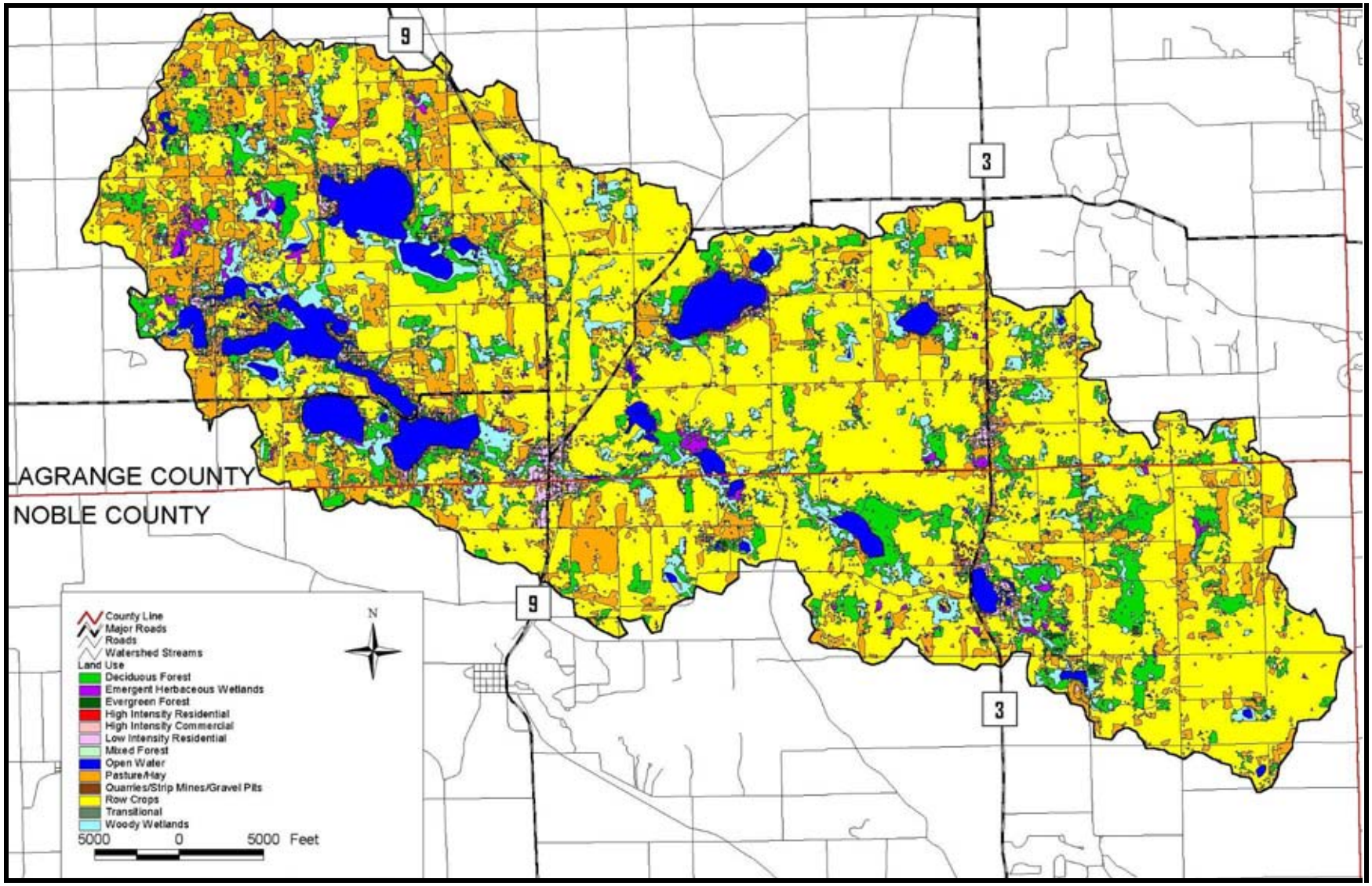

Figure 14. Land use in the Five Lakes watershed.

Table 6. Detailed land use in the Five Lakes watershed.

Land Use	Area (acres)	Percent of the Watershed
Deciduous Forest	4,011.6	10.8%
Emergent Herbaceous Wetlands	543.0	1.5%
Evergreen Forest	43.3	0.1%
High Intensity Residential	21.0	0.1%
High Intensity Commercial	65.2	0.2%
Low Intensity Residential	405.6	1.1%
Mixed Forest	4.6	0.0%
Open Water	2,191.8	5.9%
Pasture/Hay	5,404.7	14.5%
Quarries/Strip Mines/Gravel Pits	10.6	0.0%
Row Crops	22,272.2	59.8%
Transitional	9.7	0.0%
Woody Wetlands	2,265.0	6.1%
Total	**37,248.3**	**100.0%**

2.10 Land Ownership

The Indiana Department of Natural Resources owns small tracts of land adjacent to many of the lakes within the Five Lakes watershed. These areas are maintained as public access sites. The IDNR also owns the Olin Lake Natural Preserve which encompasses approximately 270 acres including the entire shoreline of Olin Lake. F.X. Browne and Associates (1992) noted the presence of nine natural areas covering more than 1,400 acres owned and maintained by the IDNR. Many of these areas have been passed to local groups or county agencies to maintain. Areas mentioned by F.X. Browne include: Olin Lake Nature Preserve, Svoboda Bog Natural Area, Nauvoo and Mud Lakes Natural Area, Tamarack Cemetery Natural Area, Holsinger Hole Natural Area, Quog Lake Natural Area, Hackenburg Lake Natural Area, Pond Lil Natural Area, and Atwood Lake Natural Area. Both the IDNR Division of Nature Preserves representative and individuals from the Lagrange and Noble County Parks Departments were invited to participate in the planning process.

3.0 BASELINE WATER QUALITY CONDITIONS

Data contained in this section document historic and some current water quality conditions in the Five Lakes watershed which includes at least seventeen lakes and several drainages, legal drains, and streams (Figure 15). Adams, Atwood, Blackman, Cree, Dallas, Eve, Hackenburg, Martin, Messick, Mud, Nauvoo, Olin, Oliver, Shockopee, Tamarack, Westler, and Witmer lakes comprise the open-water bodies that supported much of the historical sampling. Little Elkhart Creek flows through several of these lakes and was the site for a number of sampling efforts. The headwaters of Little Elkhart Creek commence in Shockopee Lake and from there the creek connects Cree, Tamarack, Mud, and Nauvoo lakes. The creek then flows through the town of Wolcottville into Witmer, Westler, Dallas, Hackenburg, and lastly Messick Lake.

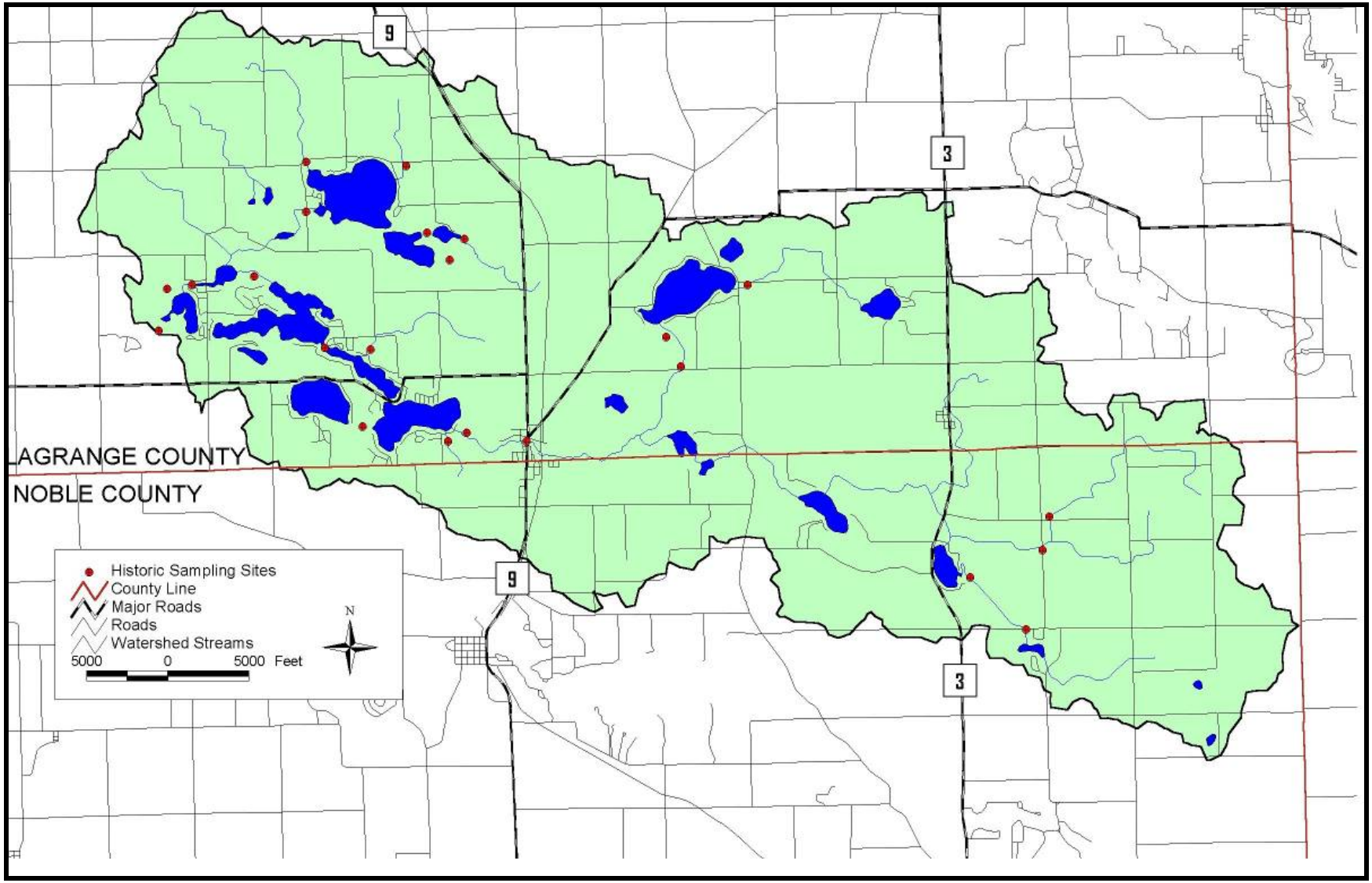

Figure 15. Historic water quality sampling site in the watershed. Red dots indicate the approximate sampling site as best identified by description in the referred documents.

A variety of resources were reviewed to establish the existing or baseline water quality conditions within the seventeen lakes, Little Elkhart Creek, and other drainages. Over 141 studies or assessments characterize water quality, fisheries, macroinvertebrate populations, aquatic plants, or watershed issues. (See Appendix C for the list of completed studies. Raw data from these assessments are contained in Appendix D.) Over 65 of the studies in some manner or another discuss the lakes' fisheries. The remainder of the studies relates results from water quality sampling efforts, nutrient loading rate estimations, and watershed plan development.

A number of unnamed drainages were historically sampled with a majority of sampling sites on drainages in the lower subwatersheds referred to as the Five Lakes area (Figure 15). Recently, sampling undertaken by JFNew in 2004 and 2005 characterized the water quality in streams in all of the subwatersheds (Figure 16).

This section of the report reviews historical water quality data for both the lakes and the drainages. Understanding the waterbodies' past and 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.

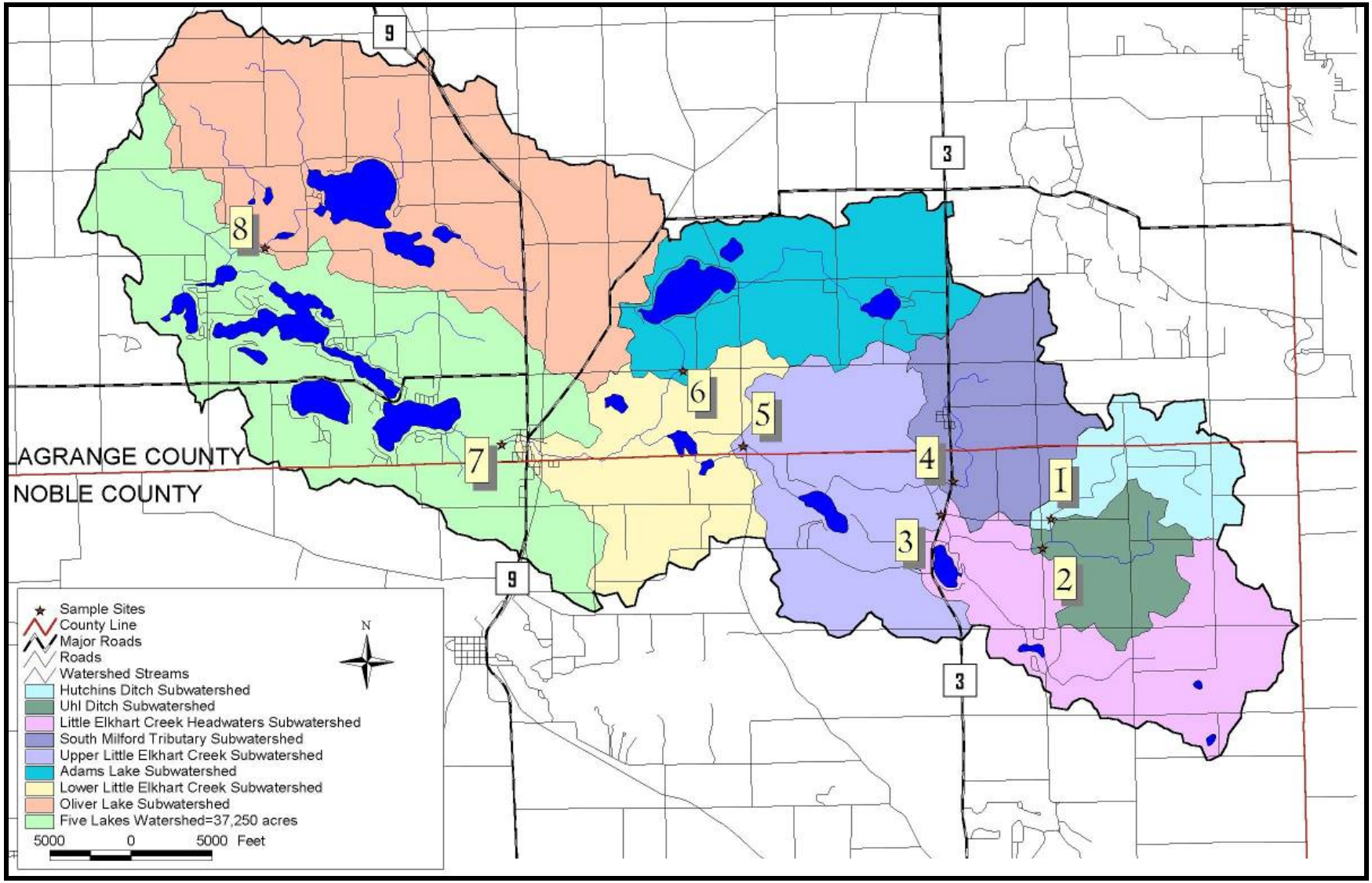

Figure 16. Locations of 2004 and 2005 water quality sample sites in the watershed conducted by JFNew and Associates.

3.1 The Lakes

The Indiana Trophic Status Index (ITSI) was developed by the Indiana Stream Pollution Control Board (ISPCB) and published in 1986. Sampling conducted in concert with the development of this index was the first formal sampling effort for the state. Many of the lakes in this watershed were sampled in the 1970s as part of this effort. Subsequently, the Indiana Department Environmental Management Clean Lakes Program's (CLP) sampled many of the lakes in the Five Lakes watershed in 1989, 1993, 2000 and 2003. Water quality data from CLP include all of the parameters required to compute the Indiana ITSI. (See IDEM, 1986 for more details on the ITSI.) A subset of these parameters, including Secchi depth, percent water column oxygen, epilimnetic and hypolimnetic total phosphorus, mean total phosphorus, and chlorophyll *a* concentrations are included in this discussion. (Additional data from these assessments are contained in Appendix D.) From 1993 to the present, IDEM through the Indiana Volunteer Monitoring Program (CLVMP), monitored Secchi depth, and in limited cases chlorophyll *a* and total phosphorus.

Additional data from a variety of sampling methods supplement standard data for these lakes. The US Environmental Protection Agency (USEPA) (1976a-e) sampled a limited number of lakes in the watershed through their National Eutrophication Survey. Indiana Department of Natural Resources (INDR) fisheries biologists sampled temperature, dissolved oxygen, alkalinity, and pH for the lakes concurrent with fisheries assessments. (See Appendix E for a list of literature cited for fisheries assessments.) International Science & Technology, Inc. (1990) assessed Cree and Shockopee lakes to establish current conditions in 1989 and to make recommendations for lake and watershed management. International Science & Technology's (IS&T) sampling included basic parameters, Secchi depth, nutrients, chlorophyll *a*, total suspended solids, fecal coliform, phytoplankton, and aquatic macrophytes. They also sampled the lakes' sediment for nutrients, toxicity, and total volatile solids. F.X. Browne & Associates (1992) conducted a comprehensive survey of Adams, Atwood, Dallas, Hackenburg, Martin, Messick, Olin, Oliver, Westler, and Witmer lakes for basic parameters, Secchi depth, alkalinity, nutrients, total suspended solids, chlorophyll *a*, and phytoplankton. Both IS&T and F.X. Browne calculated a trophic state index using the ITSI. F.X. Browne also calculated Carlson's TSI and the USEPA's matrix for each lake.

As a preface to discussing the individual lakes, there are some guidelines and indices that may be helpful in understanding the water quality. Table 7 presents data from 456 Indiana lakes collected during July and August from 1994 to 2004 under the Indiana Clean Lakes Program. These data are median values obtained by averaging the epilimnetic and hypolimnetic pollutant concentrations in samples from each of the 456 lakes. It should be noted that a wide variety of conditions, including geography, morphometry, time of year, and watershed characteristics, can influence the water quality of lakes. Thus, it is difficult to predict and even explain the reasons for the water quality of a given lake. The total phosphorus values from each lake can be compared to these data and will allow the reader to determine whether a specific lake fares better or worse than the median of 456 Indiana Lakes.

Table 7. Water quality characteristics of 456 Indiana lakes sampled from 1994 through 2004 by the Indiana Clean Lakes Program. Means of epilimnion and hypolimnion samples were used.

	Secchi Disk (m)	Total Phosphorus (mg/L)	Chlorophyll *a* (µg/L)
Median	1.98	0.17	12.9
Maximum	9.99	2.81	380.4
Minimum	0.09	0.01	0.013

Another means of assessing water quality is based on results of studies conducted by Vollenweider (1975). These results are often used as guidelines for evaluating concentrations of water quality parameters. Vollenweider's results are given in Table 8. The study relates trophic state to total nitrogen, total phosphorus, and chlorophyll *a* concentrations. In general, oligotrophic lakes are considered to support low production. These lakes contain low nutrient levels, quality dissolved oxygen levels throughout the water column, and limited plant growth. Mesotrophic lakes are considered moderately productive and possess moderate nutrient levels and sufficient dissolved oxygen. Eutrophic lakes are considered productive and contain excess nutrients and low dissolved oxygen levels. Hypereutrophic lakes are considered highly productive. These lakes contain excessive nutrient levels; poor dissolved oxygen, and extremely heavy plant growth. These values and trophic states serve only as guidelines; similar concentrations in a particular lake may not cause problems if something else is limiting the growth of algae or rooted plants.

Table 8. Mean values of some water quality parameters and their relationship to lake production (after Vollenweider, 1975).

Parameter	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Total Phosphorus	0.008	0.027	0.084	>0.750
Total Nitrogen	0.661	0.753	1.875	-
Chlorophyll *a*	1.7	4.7	14.3	-

The Indiana Trophic State Index (ITSI) is also helpful in classifying the trophic state of the lakes. The ITSI uses ten parameters to calculate a score. Jones (1996) suggests that changes in an ITSI score of 10 or more points are indicative of a trophic status change, while smaller changes may be attributed to natural fluctuations in water quality. Appendix F contains a breakdown of the point values for each parameter. Table 9 shows the lake trophic category for ITSI score ranges.

Table 9. Lake trophic category by Indiana Trophic State Index score.

TSI Score	Water Quality Classification
0-15	Oligotrophic
16-31	Mesotrophic
32-46	Eutrophic
47-75	Hypereutrophic

The following discussion assesses each lake based on historical water quality data.

3.1.1 Adams Lake

Selected data from IDNR fisheries reports, Storet, the Clean Lakes Program, the Volunteer Monitoring Program, and F.X. Browne (1992) for Adams Lake are listed in Table 10. Raw data from all sampling events are included in Appendix D.

Table 10. Summary of historic data for Adams Lake.

Date	Secchi disk (m)	% oxic	Mean TP* (mg/L)	Pot. int. release	Chl *a* (µg/L)	Indiana TSI	Source**
8/22/72	3.0	54.5	0.33	--	--	28	ISPCB, 1986
8/28/72	3.0	41.6	--	--	--	--	Peterson, 1972a
7/15/74	2.7	27.7	--	--	--	--	Peterson,1975
6/22/81	--	100	--	--	--	--	Ledet, 1982a
6/25/84	2.9	66.7	--	--	--	--	Ledet, 1984a
8/20/86	1.8	42.8	--	--	--	--	Ledet, 1987
6/24/87	4.1	80.6	--	--	--	--	Ledet, 1988a
6/27/88	2.7	53.7	--	--	--	--	Ledet, 1988b
6/28/89	1.7	93.5	--	--	--	--	Ledet, 1989a
7/1/89	1.2	30.0	0.078	yes	--	34	CLP, 1989
4/24/90	--	100	--	--	--	--	Ledet, 1991
8/1/90	1.9	17.2	0.055	yes	2.90	36	F. X. Browne, 1992
6/1/92	5.4	100	--	--	--	--	Ledet, 1994
7/1/93	2.3	65.7	0.027	no		22	CLP, 1993
1998s	2.8	--	--	--	--	--	Volunteer Monitoring, 1998
1999s	2.4	--	--	--	--	--	Volunteer Monitoring, 1999
2000s	2.2	--	--	--	--	--	Volunteer Monitoring, 2000
7/10/00	2.2	21.0	0.080	yes	4.17	28	CLP, 2000
2001s	4.8	--	--	--	--	--	Volunteer Monitoring, 2001
2002s	2.8	--	--	--	--	--	Volunteer Monitoring, 2002
7/21/03	3.5	22.9	0.056	no	2.03	22	CLP, 2003

* Average of epilimnion and hypolimnion concentrations.
** Volunteer monitoring data collected through Indiana Clean Lakes Volunteer Monitoring Program. Data displayed in table represent median values for all data collected annually.

Transparency has changed little in the 30 years of sampling at Adams Lake. Secchi depth transparencies declined from 3.0 meters (m) in 1972, reaching a low of 1.2 m in 1989, and rebounded with a reading of 3.5 m in 2003. The best transparency measurements of 4.1 m in 1987, 4.8 m in 2001, and 5.4 m in 1992 occurred early in the season when water clarity is typically better.

Overall, total phosphorus concentrations appear to have changed little over time. Total phosphorus levels have ranged from a low of 0.027 mg/L in 1993 to 0.080 mg/L in 2000 with the exception of 0.33 mg/L in 1972. Phosphorus concentrations are well below concentrations measured in most Indiana lakes, while transparencies are much better than most Indiana lakes. The potential internal release data relates to the ability of phosphorus to be transferred from the sediment to the water column. If a majority of the total phosphorus in the hypolimnion is the form of soluble reactive phosphorus, the lake bottom may release phosphorus to the water column, thus enabling algal blooms. Adams Lake vacillated between a high and low internal release potential.

Chlorophyll *a* ranged from a low of 2.03 μg/L in 2003 to a high of 4.17 μg/L 2000. Chlorophyll *a* concentrations remain largely unchanged and are relatively low compared to most Indiana lakes. The extent of the water column which contains enough oxygen to support a healthy biotic community has varied over the years. The water column typically possesses sufficient dissolved oxygen, yet of concern is the recent low where only about 20% of the water column was oxygenated.

The ITSI scores indicate that overall productivity of Adams Lake has changed little over time. The ITSI score increased slightly from 1972 (28) to 1990 (36) before declining in the most recent assessment in 2003 (22). ITSI scores suggest that Adams Lake is moderately productive or mesotrophic. Comparison of the most recent data (2003) to Vollenweider categories also indicates that Adams Lake is mesotrophic.

As a fishery, Adams Lake was targeted for tiger muskie introductions in 1980 (Ledet, 1982). The 1992 fisheries report suggests that Adams Lake continued to be a good candidate for tiger muskie management and provides a good sport fishery (Ledet, 1994).

3.1.2 Atwood Lake

Selected data from the IDNR fisheries reports, the Clean Lakes Program, the Volunteer Monitoring Program, and F.X. Browne (1992) for Atwood Lake are listed in Table 11.

Table 11. Summary of historic data for Atwood Lake.

Date	Secchi disk (m)	% oxic	Mean TP (mg/L)*	Pot. int. release	Chl *a* (μg/L)	Indiana TSI	Source**
5/18/66	2.7	100	--	--	--	--	McGinty, 1967
7/29/70	1.9	45.5	--	--	--	--	Peterson, 1971
6/30/75	1.1	46.8	--	--	--	--	Peterson, 1976a
6/22/82	2.1	62.5	--	--	--	--	Ledet, 1982b
7/10/84	2.4	78.1	--	--	--	--	Ledet, 1984b
8/18/86	2.1	73.5	--	--	--	--	Ledet, 1987
6/22/87	2.6	100.0	--	--	--	--	Ledet, 1988c
6/20/88	2.0	57.1	--	--	--	--	Ledet, 1988d
7/1/90	1.9	60.0	0.063	no	--	16	CLP, 1990
8/1/90	2.1	48.5	0.039	no	3.00	16	F.X. Browne, 1992
7/1/93	1.8	55.6	0.041	no	--	25	CLP, 1993
7/17/00	1.3	55.0	0.070	no	3.05	19	CLP, 2000
7/8/03	1.1	40.0	0.019	no	18.33	26	CLP, 2003

* Average of epilimnion and hypolimnion concentrations;
** Volunteer monitoring data collected through Indiana Clean Lakes Volunteer Monitoring Program. Data displayed in table represent median values for all data collected annually.

Secchi disk transparency has changed little over time in Atwood Lake. Transparencies ranged from a low of 1.1 m in 1975 and 2003 to high of 2.7 meters 1966. Transparency in Atwood Lake fluctuates around the median value for Indiana lakes; however, most mid-summer samples indicate that Atwood Lake's transparency is poorer than most Indiana Lakes.

An oxygenated water column is typically present in Atwood Lake, but oxygen levels appear to have declined recently with only 40% (lowest recorded) of the water column being able to support a

healthy biotic community in 2003. Total phosphorus levels, ranging from a low of 0.019 mg/L in 2003 to a high of 0.070 mg/L in 2000, are less than levels observed in most Indiana lakes. The chlorophyll *a* levels ranged from 3.0 μg/L in 1990 to 18.3μg/L in 2003. The 1990 chlorophyll *a* measurement suggests that the lake had better water quality for this parameter than the median level for most Indiana lakes. However, more recent data suggests that an algal bloom may have occurred at the time of the 2003 assessment resulting in water poorer than most Indiana lakes.

The ITSI has fluctuated over time with the lowest score of 16 observed in 1990 and the highest score of 26 calculated in 2003. The ITSI score indicates that Atwood Lake may be mesotrophic. Comparison of Atwood Lake water quality to Vollenweider's guidelines suggests that the lake is mesotrophic to eutrophic.

The IDNR fisheries report (Ledet, 1988d) noted the poor quality sport fishery present in the lake. The IDNR recommended that the fish population in Atwood Lake be eradicated and that the lake be stocked with largemouth bass and bluegill (Ledet, 1988d).

3.1.3 Blackman Lake

Selected data from the IDNR fisheries reports, Storet, and the Clean Lakes Program for Blackman Lake are summarized Table 12.

Table 12. Summary of historic data for Blackman Lake.

Date	Secchi disk (m)	% oxic	Mean TP (mg/L)*	Pot. int. release	Chl *a* (μg/L)	Indiana TSI	Source
7/13/76	2.70	38.3	0.05	--	--	20	ISPCB, 1986
7/1/89	2.50	86.0	0.026	no	--	23	CLP, 1989
5/28/91	3.35	100	--	--	--	--	Koza, 1992
7/1/93	4.25	50.0	0.1545	yes	--	14	CLP, 1993
7/10/00	2.10	31.0	0.1065	yes	4.09	20	CLP, 2000
6/30/03	6.90	29.9	0.114	--	1.35	17	CLP, 2003

* average of epilimnion and hypolimnion concentrations

Secchi disk transparencies in Blackman Lake generally improved from 2.7 m in 1976 to 6.9 m in 2003. Historically, transparency in this lake was better than that observed in most Indiana lakes. Degree of oxygenation in the Blackman Lake water column has fluctuated over time, ranging from a low of 30% in 2003 to a high of 100% in 1991. The 1991 reading was collected earlier in the season when dissolved oxygen levels are typically better throughout the water column. Mean total phosphorus increased over time from 0.05 mg/L in 1976 to 0.114 mg/L in 2003. All total phosphorus concentrations measured in Blackman Lake are better than those present in most Indiana Lakes. However, there is some indication that the sediment releases phosphorus to the water column. Chlorophyll *a* levels were variable, ranging from a low of 1.35 μg/L in 2003 to 4.09 μg/L in 2000. Chlorophyll *a* levels are typically low in Blackman Lake and better than the median level for a majority of Indiana lakes.

The TSI scores have varied over time with a low of 14 in 1993 to a high of 23 in 1989. These scores indicate mesotrophic conditions over the lifetime of the monitoring efforts. Comparison of total phosphorus concentrations in Blackman Lake to Vollenweider's data indicates that the lake is eutrophic, while comparison of its chlorophyll *a* concentrations suggests that it is mesotrophic.

The IDNR Fisheries Report (Koza, 1992) indicates that the sport fishery was in good condition in 1991, with a good diversity of species.

3.1.4 Cree Lake

Selected data from the IDNR fisheries reports, International Science & Technology (1990), and the Clean Lakes Program for Cree Lake are summarized in Table 13.

Table 13. Summary of historic data for Cree Lake.

Date	Secchi disk (m)	% oxic	mean TP (mg/L)*	Pot. int. release	Chl *a* (μg/L)	Indiana TSI	Source
8/1/64	2.4	74	--	--	--	--	Pearson, 1995a
8/1/72	1.4	55.5	--	--	--	--	Pearson, 1972
7/1/74	1.6	--	0.070	--	--	39	ISPCB, 1986
8/1/75	--	18.5	--	--	--	--	Pearson, 1995a
7/13/89	2.8	51.8	0.232	--	4.70	27	IS&T, 1990
7/1/90	1.7	67.0	0.036	yes	--	41	CLP, 1990
7/1/91	1.5	55.5	--	--	--	--	Pearson, 1995a
7/1/93	3.7	63.3	0.157	yes	--	27	CLP, 1993
6/13/94	2.4	92.6	--	--	--	--	Pearson, 1995a
7/31/00	3.2	83.0	0.046	no	1.86	22	CLP, 2000
7/21/03	1.6	39.5	0.036	no	9.95	15	CLP, 2003

* Average of epilimnion and hypolimnion concentrations

Transparency in Cree Lake has fluctuated over time, and ranged from a 1.4 m 1972 to 3.7 in 1993. The most recent measurement completed in 2003 show a Secchi depth that is less than the median for Indiana lakes. The percent of the water column that is oxygenated has declined over the years with its lowest percentage at 39.5% in 2003. Total phosphorus levels range from 0.036 mg/L in 1990 to 0.232 mg/L in 1989. A majority of the measurements exceeded the median level for Indiana lakes. Chlorophyll *a* concentrations ranged from a low of 1.89 μg/L to a high of 9.95 μg/L in 2003. All of the chlorophyll *a* concentrations are below the median for Indiana lakes. Compared to the Vollenweider guidelines, chlorophyll *a* measurements place the lake in a mesotrophic to eutrophic category, while the total phosphorus concentrations place the lake in the eutrophic category. The ITSI scores indicate that water quality has improved and place the lake within a mesotrophic to eutrophic category.

International Science & Technology (1990) reported that Cree Lake was relatively healthy compared to its associated canal system. However, they stated that the lake was experiencing nutrient loading. The nutrient loading noted by IS&T (1990) likely manifested itself in the poor water quality measurements witnessed in 2003.

The fisheries reports indicate a diverse fishery with no further management indicated as of 1994 other than maintaining the natural character of the lake with its associated emergent vegetation (Pearson, 1995a).

3.1.5 Dallas Lake

Selected data from the IDNR fisheries reports, USEPA, Storet, the Clean Lakes Program, the Volunteer Monitoring Program, Grant (1988), and F.X. Browne (1992) for Dallas Lake are summarized in Table 14.

Table 14. Summary of historic data for Dallas Lake.

Date	Secchi disk (m)	% oxic	Mean TP * (mg/L)	Pot. int. release	Chl *a* (μg/L)	Indiana TSI	Source**
8/16/66	2.2	83.3	--	--	--	--	Hudson, 1967a
7/15/70	--	85.7	--	--	--	--	Gulish, 1972a
1973s	2.1	19.1	0.100	--	11.9	--	USEPA, 1976a
1975s	3.7	--	0.150	--	--	--	Grant, 1988
6/6/76	1.4	50.0	--	--	--	--	Peterson, 1977a
8/23/76	2.7	22.9	0.330	--	--	28	ISPCB, 1986
8/10/77	2.0	41.7	--	--	--	--	IDEM, 1977
6/8/82	2.2	100	--	--	--	--	Ledet, 1983a
8/1/90	2.1	54.2	0.052	--	2.6	34	F.X. Browne, 1992
7/1/93	2.1	78.6	0.133	yes	--	15	CLP, 1993
1997s	2.0	--	--	--	--	--	Volunteer Monitoring, 1997
6/1/98	3.7	78.9	--	--	--	--	Koza, 1999a
1998s	2.0	--	--	--	--	--	Volunteer Monitoring, 1998
1999s	1.8	--	--	--	--	--	Volunteer Monitoring, 1999
7/11/00	1.6	62.0	0.121	yes	2.9	31	CLP, 2000
2000s	1.5	--	--	--	--	--	Volunteer Monitoring, 2000
2001s	1.8	--	--	--	--	--	Volunteer Monitoring, 2001
2002s	1.8	--	--	--	--	--	Volunteer Monitoring, 2002
7/8/03	2.0	69.9	0.068	--	8.6	31	CLP, 2003
2003s	1.8	--	--	yes	--	--	Volunteer Monitoring, 2003

* Average of epilimnion and hypolimnion concentrations.
** Volunteer monitoring data collected through Indiana Clean Lakes Volunteer Monitoring Program. Data displayed in table represent median values for all data collected annually.

Secchi depth readings ranged from 0.8 m in 2000 to 4.7 m in 1975 (recorded by the Volunteer Monitoring Program). In general, transparency levels have changed little over time, and typically fluctuated from 1.4 m to 3.7 m. Most of the water column in Dallas Lake remained oxygenated with 20% to 100% of the water column possessing adequate dissolved oxygen for aquatic biota. In 2003, 69.9% of the water column could support a healthy biotic community. Total phosphorus levels fluctuated over the years, ranging from 0.052 mg/L in 1990 to 0.33 mg/L in 1976. Total phosphorus concentrations exceeded the median level of 0.17 mg/L for Indiana lakes on occasion, but for the most part, were lower than most Indiana lakes. There is some indication that phosphorus is released to the water column. Comparing the phosphorus levels to the Vollenweider guidelines, Dallas Lake is generally considered to be eutrophic. Chlorophyll *a* levels also suggest eutrophic conditions on occasion. Chlorophyll *a* concentrations ranged from a low of 2.6 μg/L in 1990 to a high of 11.9 μg/L in 1973. All of these levels are below those measured in most Indiana lakes. The ITSI scores have fluctuated from 15 (oligotrophic) in 1993 to 34 (eutrophic) in 1990. Typically, Dallas Lake falls within the mesotrophic category.

Dallas Lake was placed on the 303(d) in 2002 as a result of having an impaired biotic community and continues to be listed. Waterbodies can fully support, partially support, or not support a particular designated use such as aquatic life. In the case of Dallas Lake, the listing occurred because it only partially supports the aquatic life designated use. Dallas Lake apparently lost its native cisco population and shows no evidence of supporting a stocked trout fishery (IDEM, 2002, 2004; see IDNR Fisheries Reports – Hudson, 1967a; Gulish, 1972a; Peterson, 1977a; Ledet, 1983a; Koza, 1999a). However, Dallas Lake has supported cisco as recently as 1998. Commonwealth Biomonitoring (2001) reported the landing of a cisco, a fish that is associated with clean water, in Dallas Lake in 1998. The IDNR fishery report (Koza, 1999a) does not document cisco in its 1998 survey effort. However, Koza (1999a) states that Dallas Lake supports a good sport fishery dominated by bluegill and largemouth bass.

3.1.6 Eve Lake

Selected data from the Clean Lakes Program are summarized in Table 15 for Eve Lake.

Table 15. Summary of historic data for Eve Lake.

Date	Secchi disk (m)	% oxic	Mean TP * (mg/L)	Pot. int. release	Chl *a* (µg/L)	Indiana TSI	Source
7/13/1976	2.4	100	--	--	--	18	ISPCB, 1986
1994	2.5	100	0.046	no	1.26	8	CLP, 1994

* average of epilimnion and hypolimnion concentrations

Few data have been collected for Eve Lake, and those that have show the lake is oligotrophic to mesotrophic. One hundred percent of the water column was oxygenated during both assessments indicating the lake could support a healthy biotic community. Transparency was better than the median level of Indiana lakes during both assessments. The total phosphorus concentrations in 1994 were relatively low for Indiana lakes, and indicate that the lake was mesotrophic when compared to Vollenweider's guidelines. ITSI scores suggest that the lake was oligotrophic to mesotrophic during historical assessments.

No fisheries studies have been completed on Eve Lake.

3.1.7 Hackenburg Lake

Selected data from the IDNR fisheries reports, USEPA, the Clean Lakes Program, the Volunteer Monitoring Program, Grant (1988), and F.X. Browne (1992) for Hackenburg Lake are summarized in Table 16.

Transparency in Hackenburg Lake increased from 1.9 m in 1966 to 3.7 m in 1998. Since that time, transparency fluctuated from 2.1 m (2000) to 2.8 m (2003). Generally, transparency in Hackenburg Lake remains better than the median level for Indiana lakes. A greater percentage of the water column has become depleted of oxygen over time. In 2003, 36.4% of the water column was oxygenated to the extent it would support a healthy biotic community. From 1966 to 1984, 57% to 65% of the lake's water column was well oxygenated. Oxygen levels declined to 26% of the water column in 1986. Levels in increased in 1993 (64%) before dropping to levels observed in 2003. Total phosphorus concentrations varied over time, ranging from 0.07 mg/L in 1974 to 0.465 mg/L in 1999. On occasion, total phosphorus concentrations in Hackenburg Lake exceed the median value for most Indiana lakes, but are typically lower than concentrations in Indiana lakes. Internal

release of phosphorus typically occurs in Hackenburg Lake when it is stratified during mid-summer. Chlorophyll *a* concentrations fluctuated over time with concentrations ranging from 0.95 μg/L in 2000 to 10.6 μg/L in 2003. Chlorophyll *a* concentrations are lower in Hackenburg Lake than most Indiana lakes. For all the lakes in the Five Lakes chain, Hackenburg Lake rated the second highest ITSI score. The 1990s score of 56 suggests that conditions had worsened in the lake. Hackenburg Lake possessed its poorest Secchi disk transparency and highest plankton density in that year, suggesting that the lake may have been experiencing an algal bloom at the time of the assessment. Typically, Hackenburg Lake rated as mesotrophic to eutrophic based on its ITSI score. However, the lake rated as hypereutrophic based on the 1990 data from CLP and F.X. Browne (1992).

Table 16. Summary of historic data for Hackenburg Lake.

Date	Secchi disk (m)	% oxic	Mean TP * (mg/L)	Pot. int. release	Chl *a* (μg/L)	Indiana TSI	Source
8/16/66	1.9	57.1	--	--	--	--	Hudson, 1967b
7/1/74	2.0	--	0.070	--	--	29	ISPCB, 1986
8/19/75	--	--	0.270	--	--	--	Grant,1988
7/12/76	2.0	57.1	--	--	--	--	Peterson, 1977b
6/1/82	2.3	78.9	--	--	--	--	Ledet, 1983b
7/23/84	2.0	65.8	--	--	--	--	Ledet, 1984c
7/7/86	2.4	26.3	--	--	--	--	Koza, 1986
7/1/90	1.5	40.0	0.182	yes	--	56	CLP, 1990
7/1/93	2.4	64.0	0.281	yes	--	34	CLP, 1993
6/8/98	3.7	57.1	--	--	--	--	Koza, 1999b
8/1/99	2.3	42.1	0.465	--	3.80	56	F.X. Browne, 1992
7/17/00	2.1	43.1	0.065	yes	0.95	24	CLP, 2000
7/8/03	2.8	36.4	0.123	--	10.61	32	CLP, 2003

* average of epilimnion and hypolimnion concentrations

Hackenburg Lake was placed on the 303(d) list in 2002 as a result of having an impaired biotic community, and continues to be listed. In the case of Hackenburg Lake, the listing occurred because it only partially supports the aquatic life designated use. The lake is incapable of supporting a native cisco population, as no cisco have been documented in any of the fisheries reports (IDEM, 2002, 2004; Hudson, 1967b; Peterson, 1977b; Ledet, 1983b; Ledet, 1984c; Koza, 1986; Koza, 1999b). However, Koza (1999b) in the IDNR fisheries report suggests that Hackenburg Lake supports a diverse fishery comprised of bluegill, pumpkinseed, yellow perch, largemouth bass and redear.

3.1.8 Martin Lake

Selected data from the IDNR fisheries reports, Storet, the Clean Lakes Program, the Volunteer Monitoring Program, and F.X. Browne (1992) for Martin Lake are listed in Table 17.

Transparency levels for Martin Lake have improved over time. Levels ranged from 0.6 m as recorded by volunteer monitoring in 1997 to 5.2 m based on volunteer monitoring in 2001. Transparency is typically better in Martin Lake than it is in other Indiana lakes. The water column has remained oxygenated over time. Typically, 50% to 70% of the water column can support a healthy biotic community. There is little indication that internal releases of phosphorus occur. Chlorophyll *a* levels have ranged from 0.02 μg/L in 1995 and 1996 to 44.1 μg/L in a volunteer monitoring sample taken on September 10, 1996. Concentrations are typically lower than levels found in most Indiana lakes. Total phosphorus concentrations ranged from 0.013 mg/L recorded

by a volunteer in 1998 to 0.33 mg/L in 1974. Total phosphorus levels observed in Martin Lake are typically lower than most Indiana lake concentrations.

Table 17. Summary of historic data for Martin Lake.

Date	Secchi disk (m)	% oxic	Mean TP* (mg/L)	Pot. int. release	Chl *a* (µg/L)	Indiana TSI	Source**
1970s	--	56.3	--	--	--	--	Gulish, 1974
7/27/72	1.8	71.4	--	--	--	--	IDEM, 1972
8/17/72	2.1	70.6	--	--	--	--	Peterson, 1972b
7/1/74	3.2	--	0.330	--	--	35	ISPCB, 1986
7/24/75	--	94.6	0.065	--	--	--	IDEM, 1974
8/16/77	1.7	53.6	0.085	--	--	--	IDEM, 1977
7/5/83	3.5	62.5	--	--	--	--	Ledet, 1984d
7/1/90	3.6	81.0	0.018	no	--	31	CLP, 1990
8/1/90	4.2	57.1	0.049	--	3.50	32	F.X. Browne, 1992
6/22/93	2.5	--	--	--	--	--	Volunteer Monitoring, 1993
7/1/93	3.8	65.5	0.175	no	--	14	CLP, 1993
1993s	3.3	--	--	--	--	--	Volunteer Monitoring, 1993
1994s	4.1	--	0.034	--	3.40	--	Volunteer Monitoring, 1994
1995s	3.2	--	0.014	--	1.05	--	Volunteer Monitoring, 1995
1996s	2.6	--	0.036	--	1.94	--	Volunteer Monitoring, 1996
1997s	2.9	--	0.017	--	2.20	--	Volunteer Monitoring, 1997
1998s	3.2	--	0.013	--	1.84	--	Volunteer Monitoring, 1998
1999s	3.0	--	0.051	--	1.89	--	Volunteer Monitoring, 1999
7/11/00	3.7	56.0	0.042	no	1.02	16	CLP, 2000
2000s	2.6	--	0.036	--	2.34	--	Volunteer Monitoring, 2000
2001s	3.6	--	0.018	--	0.47	--	Volunteer Monitoring, 2001
2002s	3.2	--	0.022	--	0.77	--	Volunteer Monitoring, 2002
2003s	3.9	--	0.031	--	0.85	--	Volunteer Monitoring, 2003
7/7/03	3.7	65.6	0.014	no	0.10	21	CLP, 2003

* Average of epilimnion and hypolimnion concentrations.
** Volunteer monitoring data collected through Indiana Clean Lakes Volunteer Monitoring Program. Data displayed in table represent median values for all data collected annually.

ITSI scores for Martin Lake have also fluctuated over time ranging from 14 in 1993 to 35 in 1972. Overall, these data suggest that Martin Lake's water quality has improved over time. The lake was rated as eutrophic in the 1974 and 1990 assessments; however, more recent surveys classify the lake as mesotrophic. When compared to Vollenweider's data, the lake generally rates as mesotrophic. The ITSI score indicates that the lake has remained mesotrophic.

In 1973, the lake supported the highest cisco population density in any lake in the Elkhart River watershed (Gulish, 1974). Yet during the 1983 fish survey, Ledet (1984d) mentioned that only one cisco was collected. The IDNR fishery report (Ledet, 1984d) states that Martin Lake was a relatively unproductive lake with a small littoral zone and should be managed as a trout fishery.

3.1.9 Messick Lake

Selected data from the IDNR fisheries reports, Storet, the Clean Lakes Program, the Volunteer Monitoring Program, Grant (1988), and F.X. Browne (1992) for Messick Lake are summarized in Table 18.

Table 18. Summary of historic data for Messick Lake.

Date	Secchi disk (m)	% oxic	Mean TP* (mg/L)	Pot. int. release	Chl *a* (μg/L)	Indiana TSI	Source
8/16/66	2.0	50.0	--	--	--	--	Hudson, 1967c
9/4/74	2.6	37.0	0.130	--	--	34	ISPCB, 1974
5/24/75	4.1	--	--	--	--	--	Grant, 1988
8/19/75	--	--	0.260	--	--	--	Grant, 1988
7/12/76	1.8	30.0	--	--	--	--	Peterson, 1976b
8/10/77	2.0	31.7	0.100	--	--	35	ISPCB, 1986
6/1/82	3.0	100	--	--	--	--	Ledet, 1983c
7/1/89	1.5	24.0	0.234	yes	--	40	CLP, 1989
8/1/90	2.2	29.6	0.189	--	3.30	30	F.X. Browne, 1992
7/1/93	2.0	100	0.171	yes	--	22	CLP, 1993
1998s	2.1	27.7	--	--	--	--	Koza, 1999c
7/17/00	1.8	33.0	0.214	yes	10.02	33	CLP, 2000
7/8/03	3.2	29.9	0.063	--	0.56	34	CLP, 2003

* average of epilimnion and hypolimnion concentrations.

Transparency fluctuated over the years and has ranged from 1.5 m in 1989 to 4.1 m in 1975. The most recent Secchi depth reading (3.2 meters) ranks the lake's transparency better than the median for most Indiana lakes. Although 1993 and 1998 marked years of a 100% oxygenated water column, more recent years show that about one-third of the lake's water column is oxygenated, and therefore, capable of supporting a healthy biotic community. Mean total phosphorus levels exceeded the median concentration for Indiana lakes, and in many cases, place the lake in a eutrophic category according to Vollenweider's guidelines. Total phosphorus concentrations ranged from 0.063 mg/L in 2003 to 0.26 mg/L in 1975. Chlorophyll *a* concentrations have varied from 0.56 μg/L in 2003 to 10.02 μg/L in 2000. The measurement in 2000 was the highest, but the concentration was below the median level for most Indiana lakes.

The TSI scores indicate the lake has changed little over time. Scores range from 22 in 1993 to 40 in 1989. Based on this data the lake is in the mesotrophic to eutrophic categories. Based on a comparison with Vollenweider data, Messick Lake rates as an eutrophic lake.

Messick Lake is on the 303(d) list as a result of having impaired biotic communities (IDEM, 2004). In the case of Messick Lake, the listing occurred because it only partially supports the aquatic life designated use (IDEM, 2002, 2004). Messick Lake lost its native cisco population (cisco were documented only in the 1966 fisheries report) and is unable to support stocked trout (Hudson, 1967c; Peterson, 1976b; Ledet, 1983c; Koza, 1999c). However, the most recent fisheries report (Koza, 1999c) reveals that the sport fishery remains good. Channel catfish have been stocked in the lake and they continue to do well.

3.1.10 Mud Lake

There are no data available for Mud Lake.

3.1.11 Nauvoo Lake

Selected data from the Clean Lakes Program for Nauvoo Lake are summarized below (Table 19).

Table 19. Summary of historic data for Nauvoo Lake.

Date	Secchi disk (m)	% oxic	Mean TP * (mg/L)	Pot. int. release	Chl *a* (μg/L)	Indiana TSI	Source
7/13/1976	0.9	32.5	--	--	--	50	ISPCB, 1986
1993	0.9	36.6	0.162	yes	--	46	CLP, 1993
7/21/2003	1.5	40.0	0.064	--	13.41	58	CLP, 2003

* Average of epilimnion and hypolimnion concentrations.

Based on the few data collected over the past 30 years, Nauvoo Lake appears to be a hypereutrophic lake with low transparency. Transparency improved from 0.9 m in 1976 and 1993 to 1.5 m in 2003 in Nauvoo Lake, but remains poorer than most Indiana lakes. Total phosphorus concentrations declined from a level of 0.162 mg/L to a level of 0.064 mg/L in 2003, and are lower than levels observed in most Indiana lakes. However, the chlorophyll *a* concentration of 13.41 μg/L (2003) exceeded the median concentration for most Indiana lakes in the only sample analyzed for the lake.

ITSI scores indicate that overall water quality has not changed much in the past 27 years. Nauvoo Lake's ITSI scores (50, 46, and 58) rate it as hypereutrophic. The ITSI score of 58 is the highest score for all of the lakes in the Fives Lakes chain. Nauvoo Lake rates as eutrophic to hypereutrophic when compared with Vollenweider's guidelines.

3.1.12 Olin Lake

Selected data from the IDNR fisheries reports, Storet, the Clean Lakes Program, the Volunteer Monitoring Program, Grant (1988), and F.X. Browne (1992) for Olin Lake are summarized below (Table 20).

Transparency in Olin Lake ranged from 0.6 m as recorded by a volunteer in 2003 to 6.9 m as measured by a volunteer in 1994. Typical Secchi disk depth is 1.5 m to 3.5 m. Generally, Olin Lake possesses better transparency than the median level for lakes in Indiana. Transparency may have improved slightly in the mid-1990s, but overall transparency has changed little from 1972 to 2003. The water column in Olin Lake is typically well oxygenated and able to support a biotic community. Total phosphorus levels ranged from 0.009 mg/L in 2003 to 0.250 mg/L in 1972. Total phosphorus concentrations were typically below the median for Indiana lakes. Chlorophyll *a* concentrations were low and ranged from 0.02 μg/L measured by a volunteer in 1995 to 6.9 μg/L measured by the USEPA in 1973. These levels are well below the median of 12.9 μg/L for Indiana lakes. The ITSI scores doubled from the first assessment completed in the 1970s to the score observed in 1990 (10 and 22, respectively). Since that assessment, ITSI scores have fluctuated. ITSI scores indicate that Olin Lake is mesotrophic. Compared to Vollenweider's guidelines for total phosphorus and chlorophyll *a*, Olin Lake is typically mesotrophic.

Olin Lake has been targeted for trout introductions. Cisco were present in this lake until 1986 (Ledet, 1986a). Good water quality with oxygen levels sufficient to support trout and other fish species is present. However, Olin Lake is on the 303(d) list as a result of a fish consumption advisory relative to mercury (IDEM, 2004).

Table 20. Summary of historic data for Olin Lake.

Date	Secchi disk (m)	% oxic	Mean TP * (mg/L)	Pot. int. release	Chl *a* (µg/L)	Indiana TSI	Source**
1970s	--	50.0	--	--	--	--	Gulish, 1971; 1972b
7/27/72	2.7	46.3	0.250	--	--	10	ISPCB, 1986
8/21/72	2.1	56.0	--	--	--	--	Peterson, 1972c
1973s	2.6	56.0	0.013	--	4.2	--	USEPA, 1976b
8/15/77	2.1	12.1	--	--	--	--	IDEM, 1977
7/5/83	2.1	73.1	--	--	--	--	Ledet, 1984e
8/5/86	--	42.7	--	--	--	--	Ledet, 1986
8/1/90	3.5	100	0.012	--	1.2	22	F.X. Browne, 1992
9/4/90	2.7	67.1	--	--	--	--	Koza, 1991
7/1/93	2.5	82.0	0.028	yes	--	19	CLP, 1993
1993s	3.0	--	--	--	--	--	Volunteer Monitoring, 1993
1994s	3.0	--	0.042	--	2.0	--	Volunteer Monitoring, 1994
1995s	2.3	--	0.010	--	0.4	--	Volunteer Monitoring, 1995
1996s	3.5	--	0.020	--	1.6	--	Volunteer Monitoring, 1996
1997s	2.9	--	0.017	--	1.8	--	Volunteer Monitoring, 1997
1998s	2.5	--	0.010	--	1.3	--	Volunteer Monitoring, 1998
1999s	2.5	--	0.025	--	1.6	--	Volunteer Monitoring, 1999
7/11/00	1.2	75.0	0.100	no	1.2	26	CLP, 2000
2000s	2.6	--	0.043	--	0.9	--	Volunteer Monitoring, 2000
2001s	2.7	--	0.015	--	0.5	--	Volunteer Monitoring, 2001
2002s	2.8	--	0.019	--	0.8	--	Volunteer Monitoring, 2002
7/7/03	1.7	100	0.009	no	3.4	18	CLP, 2003
2003s	2.4	--	--	--	1.4	--	Volunteer Monitoring, 2003

* Average of epilimnion and hypolimnion concentrations.
** Volunteer monitoring data collected through Indiana Clean Lakes Volunteer Monitoring Program. Data displayed in table represent median values for all data collected annually.

3.1.13 Oliver Lake

Selected data from the IDNR fisheries reports, USEPA, Storet, the Clean Lakes Program, the Volunteer Monitoring Program, and F.X. Browne (1992) for Oliver Lake are summarized are in Table 21.

Transparency in Oliver Lake remained greater than 2 m from the 1970s to 2003, with the exception of the 1993 assessment. Typically, Oliver Lake supports clearer water than most Indiana lakes. The water column remains well oxygenated. Approximately 80% to 100% of the water column contains sufficient dissolved oxygen to support a healthy biotic community. Total phosphorus concentrations fluctuated, but remain less than the median level for Indiana lakes. Total phosphorus concentrations place the lake in the mesotrophic category according to Vollenweider's guidelines. Chlorophyll *a* levels generally declined from 3.42 µg/L in 1973 to concentrations less than 2 µg/L; chlorophyll *a* are very low compared to the median level for Indiana lakes. When compared to Vollenweider's guidelines, chlorophyll *a* concentrations place Oliver Lake in the oligotrophic category. The ITSI scores for the lake fluctuate, but place it in the oligotrophic to mesotrophic categories.

Table 21. Summary of historic data for Oliver Lake.

Date	Secchi disk (m)	% oxic	Mean TP* (mg/L)	Pot. int. release	Chl *a* (µg/L)	Indiana TSI	Source**
1970s	--	86.0	--	--	--	--	Gulish, 1971
7/26/72	3.7	100	0.300	--	--	--	IDEM, 1972
8/14/72	2.3	81.5		--	--	--	Peterson, 1972
1973s	3.0	100	0.014	--	3.4	--	USEPA, 1976c
8/17/77	3.0	53.7	0.330	--	--	--	ISPCB, 1977
7/22/83	2.6	82.4	--	--	--	--	Ledet, 1984f
8/1/90	2.7	94.6	0.020	--	2.7	20	F. X. Browne, 1992
7/1/93	1.7	100	0.010	no	--	21	CLP, 1993
1993s	2.4	--	--	--	--	--	Volunteer Monitoring, 1993
1994s	3.0	--	0.010	--	2.5	--	Volunteer Monitoring, 1994
1995s	3.0	--	0.011	--	1.1	--	Volunteer Monitoring, 1995
1996s	2.9	--	0.022	--	1.9	--	Volunteer Monitoring, 1996
1997s	2.5	--	0.012	--	0.8	--	Volunteer Monitoring, 1997
1998s	2.6	--	0.010	--	1.5	--	Volunteer Monitoring, 1998
1999s	2.7	--	0.028	--	1.2	--	Volunteer Monitoring, 1999
7/11/00	2.1	77.0	0.024	no	1.14	3	CLP, 2000
2000s	2.4	--	0.043	--	1.8	--	Volunteer Monitoring, 2000
2001s	2.5	--	0.016	--	0.3	--	Volunteer Monitoring, 2001
2002s	2.7	--	0.010	--	1.8	--	Volunteer Monitoring, 2002
7/7/03	2.0	80.3	0.010	--	1.44	15	CLP, 2003
2003s	2.9	--	0.021	--	1.4	--	Volunteer Monitoring, 2003

* Average of epilimnion and hypolimnion concentrations.
** Volunteer monitoring data collected through Indiana Clean Lakes Volunteer Monitoring Program. Data displayed in table represent median values for all data collected annually.

Oliver Lake has been targeted for trout introductions according an IDNR fisheries report (Ledet, 1984f). Cisco were present in this lake until 1986. The lake is noted as unproductive due to its marl substrate. Oliver Lake contains good water quality with oxygen levels sufficient to support trout and other fish species. However, Oliver Lake is on the 303(d) list as a result of presence of mercury in fish tissue (IDEM, 2004).

3.1.14 Shockopee Lake

Selected data from the IDNR fisheries reports, International Science & Technology (1990), and the Clean Lakes Program for Shockopee Lake are summarized below (Table 22).

Table 22. Summary of historic data for Shockopee Lake.

Date	Secchi disk (m)	% oxic	Mean TP * (mg/L)	Pot. int. release	Chl *a* (µg/L)	Indiana TSI	Source
7/13/88	0.9	24.0	0.373	--	40.9	44	IS&T, 1990
1993	1.7	26.3	0.422	yes	--	33	CLP, 1993
7/11/94	3.2	76.9	--	--	--	--	Pearson, 1994b
2000	2.6	50.0	0.135	yes	3.1	41	CLP, 2000

* average of epilimnion and hypolimnion concentrations

Water quality improved in Shockopee Lake as evidenced by the increased transparency and decreased total phosphorus concentrations. Secchi disk transparency improved from 0.9 m in 1988 to 3.2 m in 1994. Since then, transparency remains better than that observed in most Indiana lakes. Likewise, total phosphorus concentrations declined from 0.422 mg/L in 1993 to 0.134 mg/L in 2000. Total phosphorus concentrations are still elevated, but remain better than most Indiana lakes. Chlorophyll *a* concentrations reflect the lower total phosphorus concentrations dropping from 40.9 μg/L in 1988 to 3.12 μg/L in 2000. The latter concentration is well below the median concentration for most Indiana lakes.

The ISTI scores indicate that Shockopee Lake remains relatively productive rating the lake as eutrophic. Comparison with Vollenweider's data suggests that the lake contains sufficient total phosphorus to be hypereutrophic; however, the plankton community manifests itself at mesotrophic levels. International Science & Technology (1990) indicated that the lake was influenced by agricultural runoff and that it received nutrients most likely from septic systems.

The 1994 IDNR fisheries report (Pearson, 1994b) notes that the lake supports a mediocre bluegill population, and that reduction of nutrient and sediment inputs are important.

3.1.14 Tamarack Lake

Selected data from the IDNR fisheries reports, International Science & Technology (1990), and the Clean Lakes Program for Tamarack Lake are summarized in Table 23.

Table 23. Summary of historic data for Tamarack Lake.

Date	Secchi disk (m)	% oxic	Mean TP (mg/L)	Pot. int. release	Chl *a* (μg/L)	Indiana TSI	Source
1993	0.6	41.1	0.265	yes	--	39	CLP, 1993
7/19/1994	1.2	37	--	--	--	--	Pearson, 1995b

* average of epilimnion and hypolimnion concentrations

Tamarack Lake transparency data show that the lake was turbid and that Secchi depths are less than the median for Indiana lakes. Less than half of the water column contained sufficient oxygen to support a healthy biotic community. Tamarack Lake's ITSI score indicates that it is eutrophic. The 1994 DNR fisheries report states that the lake offers good fishing for bluegills, largemouth bass, yellow perch, and crappies. The scarcity of aquatic plants and elevated turbidity, according to the report, indicate presence of carp (Pearson, 1995).

3.1.15 Westler Lake

Selected data from the IDNR fisheries reports, USEPA, Storet, the Clean Lakes Program, the Volunteer Monitoring Program, Grant (1988), and F.X. Browne (1992) for Westler Lake are summarized in Table 24.

Transparency has fluctuated in Westler Lake, and ranged from 0.9 m measured by Peterson in 1976 and a volunteer in 2000 to 4.6 m in 1998. The 1998 reading was taken early in the season when transparency is typically better. Secchi depths in Westler Lake approach, and in some cases exceed, the median (1.98 m) transparency measured in of Indiana lakes. However, transparency is typically worse in Westler Lake than most lakes in Indiana. Approximately half of the water column can support a healthy biotic community based on the historical data. Total phosphorus concentrations

fluctuated over time, ranging from 0.03 mg/L in 1975 to 0.75 mg/L in 1972. All the chlorophyll *a* concentrations, except for the 2003 concentration, are below the median for Indiana lakes. Chlorophyll *a* decreased from 12.7 μg/L in 1973 to 4.87 μg/L in 2000, before increasing to 17.22 μg/L in 2003.

Table 24. Summary of historic data for Westler Lake.

Date	Secchi disk (m)	% oxic	Mean TP* (mg/L)	Pot. int. release	Chl *a* (μg/L)	Indiana TSI	Source**
8/8/66	1.8	45.5	--	--	--	--	Hudson, 1967d
8/23/72	2.1	60.5	0.750	--	--	25	ISPCB, 1986
1973s	1.9	71.4	0.170	--	12.7	--	USEPA, 1976c
1975s	2.7	--	0.030	--	--	--	Grant, 1988
6/21/76	0.9	30.3	--	--	--	--	Peterson, 1976d
8/10/77	1.2	46.5	0.26	--	--	--	IDEM, 1977
6/14/82	1.2	60.6	--	--	--	--	Ledet, 1983d
7/23/84	1.1	60.6	--	--	--	--	Ledet, 1984g
7/7/86	3.2	44.1	--	--	--	--	Koza, 1986
7/1/89	1.2	42.3	0.245	yes	--	44	CLP, 1989
8/1/90	1.1	48.5	0.202	--	6.0	52	F.X. Browne, 1992
7/1/93	1.6	100	0.107	yes	--	24	CLP, 1993
1997s	1.9	--	--	--	--	--	Volunteer Monitoring, 1997
5/26/98	4.6	75.7	--	--	--	--	Koza, 1999d
1998s	1.5	--	--	--	--	--	Volunteer Monitoring, 1998
7/11/00	1.2	44.0	0.034	slight	4.9	34	CLP, 2000
2000s	1.2	--	--	--	--	--	Volunteer Monitoring, 2000
2001s	1.1	--	--	--	--	--	Volunteer Monitoring, 2001
2002s	3.0	--	--	--	--	--	Volunteer Monitoring, 2002
7/8/03	1.6	52.6	0.071	--	17.2	--	CLP, 2003
2003s	1.9	--	--	--	--	41	Volunteer Monitoring, 2003

* Average of epilimnion and hypolimnion concentrations.
** Volunteer monitoring data collected through Indiana Clean Lakes Volunteer Monitoring Program. Data displayed in table represent median values for all data collected annually.

The ITSI scores have fluctuated for Westler Lake overtime from a low of 24 in 1993 to a high of 52 in 1990. Westler Lake's ITSI scores place it in the eutrophic category. When compared to Vollenweider's data, chlorophyll *a* concentrations in Westler Lake place it in the eutrophic category, and the total phosphorus concentrations place it in the hypereutrophic category.

The IDNR fisheries report (Koza, 1999d) states that the lake supports a diverse sport fishery dominated by bluegill and largemouth bass.

3.1.16 Witmer Lake

Selected data from the IDNR fisheries reports, USEPA, Storet, the Clean Lakes Program, the Volunteer Monitoring Program, Grant (1988) and F.X. Browne (1992) for Witmer Lake are summarized below (Table 25).

Table 25. Summary of historic data for Witmer Lake.

Date	Secchi disk (m)	% oxic	Mean TP* (mg/L)	Pot. int. release	Chl *a* (µg/L)	Indiana TSI	Source**
8/8/66	1.8	37.0	--	--	--	--	Hudson, 1967e
6/19/70	--	100	--	--	--	--	Gulish, 1972a
1973s	1.5	31.2	0.176	--	11.7	--	USEPA, 1976f
9/19/73	2.0	100	0.040	--	--	--	ISPCB, 1986
1975s	1.5	--	0.285	--	--	--	Grant, 1988
9/28/76	1.2	27.7	--	--	--	--	Peterson, 1976e
8/10/77	--	--	0.260	--	--	--	ISPCB, 1986
6/14/82	1.1	74.1	--	--	--	--	Ledet, 1983e
7/6/86	2.3	18.5	--	--	--	--	Koza, 1986
7/1/89	1.1	31.3	0.239	yes		32	CLP, 1989
8/1/90	1.1	29.7	0.161	--	6.7	33	F.X. Browne, 1992
7/1/93	1.2	100	0.185	yes	--	27	CLP, 1993
1997s	1.5	--	--	--	--	--	Volunteer Monitoring, 1997
6/22/98	3.1	64.8	--	--	--	--	Koza, 1999e
1998s	1.2	--	--	--	--	--	Volunteer Monitoring, 1998
1999s	1.7	--	--	--	--	--	Volunteer Monitoring, 1999
7/11/00	1.4	29.0	0.181	yes	5.85	38	CLP, 2000
2000s	1.6	--	--	--	--	--	Volunteer Monitoring, 2000
2001s	1.8	--	--	--	--	--	Volunteer Monitoring, 2001
2002s	2.9	--	--	--	--	--	Volunteer Monitoring, 2002
7/8/03	0.9	24.6	0.076	yes	31.4	49	CLP, 2003
2003s	1.8	--	--	--	--	--	Volunteer Monitoring, 2003

* Average of epilimnion and hypolimnion concentrations.
** Volunteer monitoring data collected through Indiana Clean Lakes Volunteer Monitoring Program. Data displayed in table represent median values for all data collected annually.

Transparency levels for Witmer Lake are low and ranged from 0.8 m as measured by a volunteer in 1997 to 3.4 m as measured by a volunteer in 1998. Transparency in Witmer Lake is typically worse than the median for Indiana lakes. The percentage of the water column that is able to support a healthy biotic community has fluctuated over time, and has ranged from 18.5% in 1986 to 100% in 1973 and 1993. The total phosphorus concentrations are typically greater than the median for Indiana lakes. Total phosphorus concentrations ranged from 0.04 mg/L as measured by the IDEM (1986) in 1973 to 0.26 mg/L as recorded by IDEM (1986) in 1977. When compared to the Vollenweider guidelines, the total phosphorus concentrations place Witmer Lake in the eutrophic category. Chlorophyll *a* concentrations ranged from 6.7 µg/L in 1990 to 31.4 µg/L in 2003. Typically, Witmer Lake's chlorophyll *a* concentrations are below the median level for most Indiana Lakes; however, the 2003 assessment is nearly three times the concentration observed in most Indiana lakes. Typical, chlorophyll *a* concentrations place the lake in the mesotrophic category according to Vollenweider's guidelines. The 2003 concentration greatly exceeds Vollenweider's observation for eutrophic conditions. Witmer Lake's ITSI scores ranged from a low of 27 in 1993 to a high of 49 in 2003. Typically, Witmer Lake's ITSI scores places the lake in the eutrophic category with the exception of the 2003 score. The 2003 assessment places the lake in the hypereutrophic category.

The IDNR fisheries report (Koza, 1999e) states that the lake supported a diverse sport fishery, and that aquatic vegetation had reached nuisance levels in the past.

Witmer Lake is on the 303(d) list as a result of having impaired biotic communities. In the case of Witmer Lake, the listing occurred because it only partially supports the aquatic life designated use. The lake does not support a native cisco population, and has not in the past according to the IDNR fisheries reports (IDEM, 2002, 2004; Hudson, 1967e; Gulish, 1972a; Peterson, 1976e; Ledet, 1983e; Koza, 1986; Koza, 1999e).

3.2 Watershed Streams

Numerous stream sites have been monitored for basic parameters, nutrients, metals, and *E. coli* in the Five Lakes Watershed. (Raw data is included in Appendix D.) The purpose of the work ranged from establishing stream segment water quality standards to determining sources of pollutants and loads to the lakes. These monitoring sites are identified in Figure 15. The USEPA (1976a-e) monitored Dallas, Olin, Oliver, Westler, and Witmer Lakes, and in doing so, monitored inlet and outlet waters to determine nutrient loading rates. Grant (1988) monitored Little Elkhart Creek for nutrients. Uhl Ditch and Little Elkhart Creek were monitored for basic parameters, nutrients, and *E. coli* by IDEM (2000). Other studies focused on water quality in the watershed streams and drainages with the recognition that activities in the catchment of the lakes affect water quality in the lakes themselves. F.X. Browne (1992) monitored base and storm flows in connectors between lakes, the JJ Charles Drain, Dove Creek, and several unnamed inlets and outlets. The Hoosier Riverwatch program volunteers monitored Bert Hart Ditch, an unnamed ditch to the North Branch of the Elkhart River, and Dove Creek, which flows into Oliver Lake, for basic parameters, nutrients and *E. coli* in 2000. Bob Christen with the Five Lakes Conservation Club sampled for fecal coliform during 2001. Lastly, JFNew sampled for basic parameters, nutrients, sediment, and *E. coli* at eight sites in 2004. Also, as part of the JFNew study, macroinvertebrates were sampled and IDEM's macroinvertebrate Index of Biotic Integrity (mIBI) and Qualitative Habitat Evaluation Index (QHEI) scores were computed.

3.2.1 Assessment of Streams for Chemical and Biological Constituents

Under the Clean Water Act, all waterbodies, with a few exceptions, must be capable of supporting aquatic life and recreational beneficial uses. In other words, waterbodies must be "*fishable and swimmable*". Indiana state law has similar requirements. In order to measure their ability to do so, various indices are used. Tables 26 and 27 show the macroinvertebrate index of biotic integrity, the associated classification, and IDEM's criteria for aquatic life use support.

Table 26. Macroinvertebrate Index of Biotic Integrity scores and associated classification

Total mIBI Score	Integrity Class
6-8	Non-impaired
4-6	Slightly impaired
2-4	Moderately impaired
0-2	Severely impaired

Table 27. IDEM's criteria for aquatic life use support.

Parameter	Fully Supporting	Partially Supporting	Not Supporting
Benthic aquatic macroinvertebrate Index of Biotic Integrity (mIBI)	mIBI $\geq$ 4	mIBI < 4 and $\geq$ 2	mIBI < 2
Qualitative habitat use evaluation (QHEI)	QHEI $\geq$ 64	QHEI < 64 and $\geq$ 51	QHEI < 51
Fish community (IBI) (Upper Wabash basin)	IBI > 34	IBI $\leq$ 34 and $\geq$ 32	IBI < 32

Source: IDEM, 2004.

For purposes of determining whether a stream's chemical water quality meets state or federal standards or recommendations for nutrients, Table 28 provides a summary of state standards, USEPA guidelines, and recommended concentrations for nutrients.

Table 28. State or federal standards or recommendations for nutrient concentrations in streams.

Nutrient Species	Standard or Recommendation
Nitrate-nitrogen	• State drinking water standard < 10 mg/L (IAC, 2000) • Recommended nutrient criteria <0.63 mg/L in region (USEPA, 2000) • Ohio EPA biotic criteria for warm water habitat streams <1mg/L (Ohio EPA, 1999) • Streams under mesotrophic conditions >0.7mg/L; under eutrophic conditions >1.5 mg/L (Dodd et al., 1998)
Ammonia-nitrogen	• Based on temperature and pH (IAC, 2000)
Total Kjeldahl Nitrogen	• Recommended nutrient criteria <0.591 mg/L (USEPA, 2000); unlikely to be met in Indiana lakes; >2 mg/L general criteria
Total Phosphorus	• Recommended criteria 0.075 mg/L (USEPA, 2000); unlikely to be met in Indiana lakes • Ohio EPA biotic criteria for warm water habitat streams <0.1mg/L (Ohio EPA, 1999) • Streams under eutrophic conditions 0.075 mg/L (Dodd et al., 1998)

Table 29 provides a comparison of some of the historical water quality sampling efforts for nutrients at similar sites. This review concentrates on nutrients because many of the previous studies were concerned with nutrient loading to lakes. The data are presented as medians of multiple sampling events in 1973 and 1974 (USEPA, 1976a-e). Single sampling events are attributed to F.X. Browne (1992).

Table 29. Historical nutrient water quality data on selected stream sites from USEPA studies (1976a-e) and F.X. Browne (1992).

Stream	TP* (mg/L)	SRP (mg/L)	TKN (mg/L)	NH_3-N (mg/L)	NO_3-N (mg/L)	# of Samples	Source of Data
Atwood Lake Outlet	0.02 0.026 0.049	0.01 0.01 0.029	1.00 0.564 0.73	0.04 0.1 0.1	0.06 0.86 0.05	14 1 1	USEPA, 1976 F.X.Browne,1990, base flow F.X. Browne, 1991, storm flow
Dallas – Hackenburg Connection	0.03 0.19 0.023	0.01 0.01 0.005	1.00 0.35 0.49	0.05 0.1 0.1	0.22 0.10 0.23	14 1 1	USEPA, 1976 F.X.Browne,1990, base flow F.X. Browne, 1991, storm flow
Oliver Lake Outlet	0.01 0.073 0.039	0.01 0.01 0.027	0.68 0.26 0.54	0.03 0.1 0.1	0.78 1.00 1.12	14 1 1	USEPA, 1976 F.X.Browne,1990, base flow F.X. Browne, 1991, storm flow
Olin-Martin Connection	0.02 0.14 0.071	0.01 0.01 0.008	1.28 0.051 0.72	0.04 0.1 0.14	1.55 0.30 1.77	14 1 1	USEPA, 1976 F.X.Browne,1990, base flow F.X. Browne, 1991, storm flow
Oliver-Olin Connection	0.02 0.20 0.017	0.01 0.029 0.033	0.78 0.64 0.50	0.03 0.12 0.13	1.01 1.16 1.96	14 1 1	USEPA, 1976 F.X.Browne,1990, base flow F.X. Browne, 1991, storm flow
Dove Creek	0.01 0.20 0.22	0.01 0.029 0.058	0.68 0.64 2.23	0.03 0.12 0.26	0.78 1.16 7.76	14 1 1	USEPA, 1976 F.X.Browne,1990, base flow F.X. Browne, 1991, storm flow
Dallas-Westler Connection	0.05 0.06 0.031	0.02 0.01 0.005	1.66 0.6 0.94	0.15 0.1 0.12	0.61 1.25 1.40	14 1 1	USEPA, 1976 F.X.Browne,1990, base flow F.X. Browne, 1991, storm flow
Little Elkhart Creek	0.09 0.08 0.163	0.03 0.01 0.021	1.35 0.69 1.27	0.08 0.1 0.21	0.75 0.28 5.75	14 1 1	USEPA, 1976 F.X.Browne,1990, base flow F.X. Browne, 1991, storm flow
Witmer-Westler Connection	0.05 0.014 0.025	0.01 0.01 0.002	1.20 0.17 0.62	0.09 0.1 0.32	0.48 0.047 0.53	14 1 1	USEPA, 1976 F.X.Browne,1990, base flow F.X. Browne, 1991, storm flow

* USEPA data are medians from 14 samples taken from 1973 to 1974.

Shaded data show results that exceed recommended levels for nutrients. Although a comparison such as this is limited since sample size, laboratory analysis, flow events, and field methodologies are not equivalent; the information reveals that stream water quality has degenerated to some degree from 1973 to 1991.

In general, total phosphorus concentrations increased over time in the Atwood Lake Outlet, Dove Creek, Dallas-Westler Connection, Little Elkhart Creek, and the Witmer-Westler Connection sites. Soluble reactive phosphorus increased over time in the Atwood Lake Outlet, the Oliver Lake Outlet, the Oliver-Olin Connection, Dove Creek, and Little Elkhart Creek. However, without knowing analytical limits and loading rates, it is difficult to determine if certain statistically significant trends have occurred. Ammonia-nitrogen levels appear to have increased from 1976 to 1991 for all sites, with the exception of the Dallas-Westler Connection. Nitrate-nitrogen concentrations appeared to have increased over time at the Oliver Lake Outlet, Oliver-Olin Connection, Dove Creek, and in Little Elkhart Creek. Conditions in the Oliver-Olin Connection show higher than recommended nitrate-nitrogen levels even in the 1973 and 1974 samplings that were a part of the USEPA studies.

There appear to be no streams where water quality conditions have improved across the spectrum of parameters listed in Table 28.

Table 30 lists data associated with the Hoosier Riverwatch Program. Riverwatch Program carried out by volunteers, particularly students, throughout the state collects water quality at selected sites and rates the water quality based on the following scale: Excellent = 90-100; Good = 70-90; Medium = 50-70; Bad = 25-50; Very Bad = 0-25.

Table 30. Water quality data and index based on data collected by Hoosier Riverwatch.

Site	Bert Hart Ditch #93	Unnamed Ditch N. Branch Elkhart River	Dove Creek
Date	9/29/2000	9/29/2000	9/29/2000
D.O. (mg/L)	10	8	11
% Saturation	105	85	105
E. coli (cfu/100ml)	800	300	0
pH	8.3	8.4	8.01
BOD-5	--	--	7
Temp. Change (°F)	0	--	-4
Total Phosphate (mg/L)	0.36	0.06	0.3
Nitrate-Nitrogen (mg/L)	3.8	7.92	0.088
Turbidity (NTU)	15	40	60
Flow (cfs)	1.2	0.47	5.04
Water Quality Index	72	64	82
Pollution Tolerance Index	14	7	7

On September 29, 2000, Dove Creek rated the highest water quality based on the scale provided by Hoosier Riverwatch. Dissolved oxygen levels were good in all samples, though the water was slightly supersaturated with oxygen in Bert Hart Ditch and Dove Creek. No coliform bacteria were accounted for at this site, which is extremely unusual for the Five Lakes Watershed streams. (See discussion of JFNew sampling.) Total phosphate at Dove Creek and Bert Hart Ditch exceeded the Ohio EPA level of 0.10 mg/L for total phosphorus at which biotic impairment may occur. (Note that the species of phosphorus are not the same – total phosphorus includes all forms of phosphorus, both inorganic and organic, whereas phosphates as measured by Riverwatch measure only the inorganic forms of phosphorus. Total phosphates would be one component of a total phosphorus measurement, and thus likely to be less.) Nitrate-nitrogen in Bert Hart Ditch and the unnamed ditch exceeded the recommended Ohio EPA level of 1 mg/L. Both of these sites also exceeded the state standard for *E. coli* (235 cfu/100ml). The Hoosier Riverwatch effort also collected macroinvertebrates to assess stream water quality based on the biota. The unnamed ditch and Dove Creek revealed pollution tolerant macroinvertebrate populations (a rating of 10 or less indicates a poor macroinvertebrate population), while Bert Hart Ditch rated fair for its ability to support pollution intolerant species.

The IDEM (2000) and Grant (1988) data are presented in Table 31. Data presented are medians (with the exception of the *E. coli* data which is a geometric mean) for measurements taken in 1974 and 2000 in Little Elkhart Creek (SR9), Uhl Ditch, and Little Elkhart Creek (Cree boat ramp).

Table 31. Water quality data from IDEM (2000) and Grant 1988 in the Five Lakes Watershed.

Site	Little Elkhart Creek (SR9)	Uhl Ditch	Little Elkhart Creek (Cree boat ramp)
Dissolved Oxygen (mg/L)	--	9.62	8.88
% Saturation	--	94.5	109
Temperature (ºC)	--	18.60	25.1
pH	--	8.23	8.26
Turbidity (NTU)	--	70	2
Total Phosphorus (mg/L)	--	0.24	--
SRP (mg/L)	0.35	0.35	--
Total Suspended Solids (mg/L)	0.12	13	--
TKN (mg/L)	--	1.7	
Ammonia-Nitrogen (mg/L)	--	0.19	--
Nitrate-Nitrogen (mg/L)	--	2.30	--
E.coli cfu/100ml	1.70	--	95

Source: Grant, 1988 (Little Elkhart Creek at SR 9; n=3); IDEM, 2000 (Uhl Ditch; n=4); IDEM, 2000 (Little Elkhart Creek at Cree Lake Boat Ramp; n =5).

In general, dissolved oxygen levels were good during the 2000 sampling effort at Little Elkhart Creek and Uhl Ditch. The water was slightly supersaturated only at Little Elkhart Creek (Cree boat ramp). Total phosphorus level (0.24 mg/L) at Uhl Ditch exceeded the recommended Ohio EPA level of 0.1 mg/L for maintaining a healthy biotic community. Likewise, the nitrate-nitrogen level (2.30 mg/L) at the Uhl Ditch exceeded the recommended Ohio EPA level of 1.0 mg/L. *E. coli* levels did not exceed the state standard of 235 cfu/100ml at either Little Elkhart Creek sites.

The Five Lakes Conservation Association sampled for fecal coliform and various organic compounds in August, September, and November of 2001. The Association sampled Little Elkhart Creek above and below Wolcottville and above Witmer Lake with the intent of determining points of fecal coliform inputs along the creek. Table 32 summarizes the sampling effort.

Table 32. Results of sampling Little Elkhart Creek at various sites for fecal coliform in 2001.

Location	Date	Sample 1	Sample 2
East of CR 765 South (above Witmer Lake)	8/16/2001	--	15000
First stream east of CR 765 South (above Witmer Lake)	9/6/2001	580	2000
Cemetery Street (below Wolcottville)	9/13/2001	--	920
East of SR 9 (above Wolcottville)	9/25/2001	--	600
Immediately downstream of SR 9	11/1/2001	110	140
100 feet downstream of SR 9	11/13/2001	50	10

Since samples were taken on different days, trying to compare specific upstream and downstream affects related to inputs of fecal coliform is not possible. Fecal coliform counts are not equivalent to measurement of *E. coli* in water, and thus the usual limit of 235 cfu/100ml for *E. coli* does not apply to the counts in Table 32. Standards are no longer employed for fecal coliform in Indiana. However, concentrations measured above Witmer Lake and below Wolcottville exceed Illinois fecal coliform

standards (400 cfu/100ml). When they were used they were based on the designated use of the waterbody. Full body contact standards were less than for partial body contact as is the case with the present day *E. coli*. Regardless, the only trends revealed by the data suggest that fecal coliform levels diminish overtime. On 8/16/2001, the sample collected at E. 765 S. was analyzed for 59 organic compounds, such as benzene and toluene. (See Appendix D for list.) No organic compounds were detected in the sample based.

3.2.2 JFNew Watershed Streams

To supplement the base of existing data, JFNew collected water chemistry, biological community, and physical habitat data from eight streams. Stream sampling was completed at: Hutchins Ditch, Uhl Ditch, Cree Lake Outlet, South Milford Tributary, Upper Little Elkhart Creek, Adams Lake Outlet, Lower Little Elkhart Creek, and Oliver Lake Outlet (Figure 16). In 2004, water chemistry samples were collected from each site, twice following a storm event to capture a runoff event and twice following a period of little precipitation to serve as the "normal" stream condition. Each stream's biological community and physical habitat were assessed once in mid-late summer. The stream sampling and the appropriate quality assurance/quality control procedures are referenced in the project's Quality Assurance Project Plan (QAPP). Appendix G contains the project QAPP. Appendix H presents the raw data collected during the stream assessments in tabular and graphical form. Sampling location coordinates are also contained in Appendix H.

Three particular areas of concern arise upon review of the data. These include: *E. coli* concentration in excess of the Indiana state standard (235 colonies/100 mL) throughout the watershed; total phosphorus and nitrate-nitrogen concentrations greater than levels recommended to support a healthy biotic community (0.1 mg/L and 1.0 mg/L, respectively); and impaired biotic communities. The sampling effort in 2004 also determined that the Lower Little Elkhart Creek and Oliver Lake Outlet (Sites 7 and 8) contributed the largest volume of pollutants to the Five Lake Chain. Additionally, the Cree Lake Outlet and Upper Little Elkhart Creek (Sites 3 and 5) also contain high levels of pollutants depending on the volume, duration, and location of rainfall.

3.2.3 Site 1 Hutchins Ditch

Temperature, pH, conductivity, and turbidity measurements were all within normal ranges for Indiana streams at Hutchins Ditch. Dissolved oxygen concentrations were sufficient to support a healthy biotic community; however, the only recorded supersaturated condition occurred in Hutchins Ditch during the May sampling event. Supersaturated conditions typically arise from two sources: turbulent water traps more oxygen in the water than would typically occur when the stream is in equilibrium with the air, or algae or plants within the stream are photosynthesizing and producing higher than normal levels of dissolved oxygen. In the case of Hutchins Ditch, it is likely that algal material present during the May sampling event contributed to the supersaturated condition.

Some parameter concentrations were elevated within Hutchins Ditch. Neither ammonia-nitrogen nor nitrate-nitrogen concentrations measured at Hutchins Ditch exceeded the state standard. However, nitrate-nitrogen concentrations exceeded the median concentration observed in Ohio streams (1.0 mg/L) known to support healthy warmwater fauna (Ohio EPA, 1999). Hutchins Ditch's nitrate-nitrogen concentrations were greater than this threshold level during both the May (1.819 mg/L; storm) and July (2.423 mg/L; storm) sampling events. In fact, nitrate-nitrogen concentrations measured in Hutchins Ditch were among the highest recorded at sites in the Five Lakes Watershed during JFNew's sampling effort. Hutchins Ditch also contained the highest soluble

reactive phosphorus (SRP) concentration measured in the Five Lakes Watershed. This measurement (0.097 mg/L) was recorded during the September 7, 2004 base flow event. During three of the four sampling events, total phosphorus concentrations were also elevated within Hutchins Ditch exceeding the level (0.1 mg/L) at which the Ohio EPA (1999) observed impairment in the aquatic biota. Concentrations in excess of this threshold ranged from 0.172 mg/L during the May sampling event (storm) to 0.292 during the September 7 sampling event (base). *E. coli* concentrations measured in Hutchins Ditch exceeded the state standard (235 colonies/100 mL) during three of the four sampling events. Hutchins Ditch possessed the highest *E. coli* concentration observed during JFNew's assessment measuring nearly 100 times the state standard (33,000 colonies/100 mL).

Although most of the pollutant loads were generally low within Hutchins Ditch when compared with the other watershed streams, Hutchins Ditch exhibited the highest ammonia-nitrogen, nitrate-nitrogen, total Kjeldahl nitrogen, and total suspended solids areal loading rate during storm flow. 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 pollutant loading rates in smaller drainages. Hutchins Ditch also possessed the second highest soluble reactive and total phosphorus areal loading rates during base and storm flow and the third highest total Kjeldahl nitrogen and total suspended solids areal loading rates during base flow. The high (relative to other streams) sediment and nutrient loading rates suggest that the stream may carry a significant sediment load and/or stream erosion may be a source of sediment in the ditch.

The evaluation of Hutchins Ditch's biological community indicates that the ditch contains a quality biotic community despite its poor water quality and limited habitat. Hutchins Ditch received the highest mIBI score (5.2 of 8 total points). This score suggests that the stream is fully supporting for its aquatic life use designation as determined by the IDEM. Hutchins Ditch contains a good variety and number of moderately tolerant families (taxa) which represent this slightly impaired community. However, the habitat within Hutchins Ditch was relatively poor scoring only 37 of 100 total points (Figure 17). The stream possessed poor substrate, limited channel development, and lacked pool and riffle complexes. Based on this habitat score, it is likely that IDEM would rate Hutchins Ditch as non-supporting for its aquatic life use designation.

Figure 17. Hutchins Ditch sampling site during base flow.

3.2.4 Site 2 Uhl Ditch

In general, water quality within Uhl Ditch was relatively good when compared to other streams in the watershed; however, there were some parameters of concern. Temperature, pH, conductivity, and dissolved oxygen measurements were all within normal ranges for Indiana streams at Uhl Ditch. Turbidity concentrations were elevated during the July storm event exceeding the USEPA (2000) recommended concentration (9.88 NTU). The turbidity level observed in Uhl Ditch was the highest of any of the Five Lakes watershed streams. Ammonia-nitrogen and total Kjeldahl nitrogen concentrations were within typical ranges observed in Indiana streams. Nitrate-nitrogen concentrations exceeded the median concentration observed by the Ohio EPA to support healthy biota during both the May (2.005 mg/L) and July (2.145 mg/L) storm events. Soluble reactive and total phosphorus concentrations were also elevated during the assessments. Total phosphorus concentrations exceeded median concentrations observed by the Ohio EPA required to protect aquatic biota during the July (0.166 mg/L) storm event and the September 7 (0.111 mg/L) base flow sampling event. Total suspended solids concentrations were elevated during the storm events but did not exceed levels that are deleterious to aquatic biota (80 mg/L; Waters, 1995). However, *E. coli* concentrations were elevated during three of the four sampling events. Concentrations ranged from 156 colonies/100 mL during the May storm event to 7,000 colonies/100 mL during the July storm event. Concentrations exceeding the state standard were 1.2 to 21.5 times the standard concentration. Uhl Ditch also contained the highest soluble reactive areal loading rate during base flow. Uhl Ditch contained a severely impaired biotic community (mIBI score of 1.6); however, the ditch contained the highest quality habitat (QHEI score of 51) of any of the watershed streams (Figure 18). Macroinvertebrate community and habitat scores suggest that IDEM would consider Uhl Ditch to be non-supporting (biota) to partially supporting (habitat) for its aquatic life use designation.

Figure 18. Uhl Ditch sampling site during base flow.

3.2.5 Site 3 Cree Lake Outlet

Compared with other streams in the watershed, the Cree Lake Outlet possessed relatively poor water quality. Dissolved oxygen concentrations were low during all four assessments ranging from 1.4 mg/L during the September 21 base flow event to 6.6 mg/L during the September 7 base flow event. Only the dissolved oxygen concentration measured on September 21 fell below the Indiana state standard. Dissolved oxygen saturation was also generally low during the sampling events. Water saturation ranged from 14% to 78% during the four events. Ammonia-nitrogen and total Kjeldahl nitrogen concentrations were also elevated in the Cree Lake Outlet. Ammonia-nitrogen concentrations ranged from 0.050 mg/L during the July storm event to 0.966 mg/L during the September 21 base flow event. TKN concentrations ranged from 1.089 mg/L during the September 7 base flow event to 2.372 mg/L during the September 7 base flow event. These concentrations suggest that organic and particulate material may be limiting use of this tributary. The Cree Lake Outlet also possessed elevated soluble reactive and total phosphorus concentrations. SRP concentrations ranged from 0.043 mg/L during the September 7 sampling event to 0.088 mg/L during the September 21 event. During all four sampling events, total phosphorus concentrations exceeded levels that Dodd et al. (1998) determined to occur in eutrophic streams and levels that the Ohio EPA (1999) determined were necessary for the high quality aquatic biota communities. Total phosphorus concentrations ranged from 0.092 mg/L during the May storm event to 0.323 mg/L during the September 7 base flow event. Total suspended solids concentrations were also elevated in the Cree Lake Outlet ranging from 7.25 mg/L during the May event to 20 mg/L during the July event. *E. coli* concentrations exceeded the Indiana state standard during all four sampling events; concentrations ranged from 430 colonies/100 mL on September 7 to 7,000 colonies/100 mL the July storm event.

The Cree Lake Outlet also possessed elevated nutrient and sediment loading rates. Nitrate-nitrogen, total Kjeldahl nitrogen, soluble and total phosphorus, and total suspended solids loading rates were higher in the Cree Lake Outlet than at any other site during the July storm event. The Cree Lake Outlet contained the highest ammonia-nitrogen load during the September 21 base flow event and the second highest ammonia-nitrogen areal load for base flow. Overall, soluble reactive phosphorus

and total suspended solids loading rates at the Cree Lake outlet were higher than all but one site during the storm events. Likewise, total suspended solids areal loading rates exceeded those measured at all but one site during storm events.

The macroinvertebrate community present in the Cree Lake outlet reflects the poor water quality present within this stream. The Cree Lake Outlet macroinvertebrate community scored the lowest mIBI score (0.8) of any of the watershed streams. This stream possessed a prevalence of tolerant families, none of which represent the more intolerant mayfly, stonefly, or caddisfly families. Additionally, the lowest number of different families was observed at the Cree Lake Outlet. It is likely that IDEM would classify this severely impaired biotic community as non-supporting for its aquatic life use designation. The poor habitat present at this site likely contributes to the limited biotic community observed in the Cree Lake Outlet (Figure 19).

Figure 19. Cree Lake Outlet at the sampling site during base flow.

3.2.6 Site 4 South Milford Tributary

The South Milford Tributary is an intermittent stream that drains the entirety of South Milford Watershed. As an intermittent stream, this tributary does not contain water throughout the growing season as evidenced by Figure 20. Base flow water chemistry samples were not collected from the South Milford Tributary due to its lack of flowing water and later in the summer, its lack of water in general. Because base flow water chemistry samples were not collected from this site, only its conditions during storm flow events (May and July) could be assessed.

Figure 20. The South Milford Tributary sampling site during base flow.

During storm flow, temperature, dissolved oxygen, pH, conductivity, and turbidity levels within the South Milford Tributary were typical for Indiana streams. The turbidity concentration measured during the May event (10 NTU) exceeded the USEPA (9.98 NTU; USEPA, 2000) recommended criteria. Ammonia-nitrogen and total Kjeldahl nitrogen concentrations were also within ranges typical of Indiana streams. Nitrate-nitrogen concentrations were elevated within the South Milford Tributary. Concentrations exceeded the median level determined by the Ohio EPA (1999) for the protection of aquatic biota. In fact, the concentration measured in May (3.112 mg/L) was the highest of any of the measurements recorded in the Five Lakes watershed streams. Soluble reactive and total phosphorus concentrations were also elevated during both storm events. Total phosphorus concentrations ranged from 0.125 mg/L during the May event to 0.220 mg/L during the July event. Both concentrations exceeded the level determined by Ohio EPA as necessary for the protection of aquatic biota. *E. coli* concentrations exceeded the Indiana state standard during both sampling events. Concentrations ranged from 530 colonies/100 mL in May to 5,000 colonies/100 mL in July. The South Milford Tributary possessed the highest soluble reactive and total phosphorus areal loading rates and the second highest nitrate-nitrogen and total Kjeldahl nitrogen areal loading rates for the storm event sampling.

The South Milford Tributary possessed the poorest habitat of any of the Five Lakes watershed streams scoring a 24 of a possible 100 points. Poor substrate, limited channel development, lack of instream cover, and non-existent pool-riffle complexes limited habitat availability in this stream. Based on this QHEI score, the South Milford Tributary would likely be rated as non-supporting for its aquatic life use designation by the IDEM. The lack of water during base flow, poor water quality during storm flow, and limited habitat likely impair the stream's biotic community. The mIBI score at this site was 1.2. The macroinvertebrate community present in the South Milford Tributary was dominated by midges of the family Chironomidae; a majority of these individuals were actually blood midges, a taxon common in streams with poor water quality and low dissolved oxygen levels.

3.2.7 Site 5 Upper Little Elkhart Creek

Temperature, pH, conductivity, and turbidity concentrations were within normal ranges for Indiana streams. However, dissolved oxygen concentrations at the Upper Little Elkhart Creek sampling site were below the Indiana state standard during three of the four sampling events. Concentrations below the standard ranged from 2.4 mg/L during the September 7 sampling event to 4.9 mg/L during the September 21 sampling event. The stream contained sufficient oxygen to support aquatic biota during only the May sampling event. Like most of the streams in the Five Lakes watershed, nitrate-nitrogen concentrations at the Upper Little Elkhart Creek sampling site exceeded the level at which the Ohio EPA determined that biotic communities may become impaired during the May storm event (1.669 mg/L). Concentrations measured during the other three events ranged from 0.305 mg/L during the July event to 0.661 during the September 21 sampling event. Ammonia-nitrogen and total Kjeldahl nitrogen concentrations were relatively normal comparable to those measured in Indiana streams. However, soluble reactive and total phosphorus concentrations were elevated at this sampling site during all four events. Total phosphorus concentrations (0.125 mg/L) exceeded the median concentration for the protection of aquatic biota (Ohio EPA, 1999) during the July storm event. *E. coli* concentrations ranged from 120 colonies/100 mL during the May storm event to 1,050 colonies/100 mL during the July storm event. *E. coli* concentrations exceeded the Indiana state standard during only two events which measured 1.2 to 3.5 times the state standard.

Loading rates within the Upper Little Elkhart Creek sampling site were also elevated. This site possessed the highest ammonia-nitrogen load during the July storm event and the highest total suspended solids load during the September 21 base flow event. The second highest soluble reactive phosphorus (July), total phosphorus (May and July), and nitrate-nitrogen (May) loading rates were also measured at this site.

The macroinvertebrate community reflects the poor water quality present at the Upper Little Elkhart Creek site. The mIBI score was 1.2, which suggests that the stream's macroinvertebrate community was severely impaired at the time of sampling. This stream site supported the most diverse macroinvertebrate community of any of the watershed streams. However, like most streams in the Five Lakes watershed, the families present in the stream were extremely tolerant to poor water quality conditions. The relatively good habitat (46 of 100 points) present at this site (Figure 21) suggests that poor water chemistry may play a larger role in the macroinvertebrate community then the limited habitat. Nonetheless, it is likely that IDEM would rate both the habitat and the macroinvertebrate community as non-supporting of their aquatic life use designation.

Figure 21. Upper Little Elkhart Creek sampling site during base flow.

3.2.8 Site 6 Adams Lake Outlet

The Adams Lake Outlet stream possessed relatively good water quality when compared with other watershed streams. Temperature, dissolved oxygen, turbidity, conductivity, pH, nitrate-nitrogen, ammonia-nitrogen, and total Kjeldahl nitrogen concentration were all within ranges typical for Indiana streams. However, soluble reactive and total phosphorus concentrations were elevated in the Adams Lake Outlet. Total phosphorus concentrations ranged from 0.049 mg/L during the September 7 sampling event to 0.113 mg/L during the September 21 sampling event. Only the September 21 total phosphorus concentration exceeded the level determined by the Ohio EPA for the protection of aquatic life. The Adams Lake Outlet possessed the highest total suspended solids concentration measured in the watershed streams (33.23 mg/L on September 21). *E. coli* concentrations within the Adams Lake Outlet were relatively low compared to other streams in the watershed. *E. coli* concentrations ranged from 186 colonies/100 mL during the September 21 sampling event to 450 during the July storm event. Poor substrate, riparian quality, and pool-riffle complex development limited habitat in the Adams Lake Outlet (Figure 22). (This site scored 37 of 100 possible points.) Although this site possessed the second highest mIBI score (2.4) of the watershed streams, the macroinvertebrate community reflects the poor habitat and limited water quality present within this stream. The QHEI and mIBI scores suggest that the IDEM would consider the Adams Lake Outlet non-supporting for its aquatic life use designation.

Figure 22. Adams Lake Outlet sampling site during base flow.

3.2.9 Site 7 Lower Little Elkhart Creek

Temperature, pH, conductivity, and turbidity levels present at the Lower Little Elkhart Creek sites were comparable to those measured in Indiana streams. Dissolved oxygen concentrations were adequate to support aquatic biota. Ammonia-nitrogen and total Kjeldahl nitrogen concentrations were relatively low compared to other watershed streams. Nitrate-nitrogen concentrations in the Lower Little Elkhart River were also relatively low; however, the concentration measured during the July storm event (1.153 mg/L) exceeded the level determined by the Ohio EPA (1999) for the protection of aquatic biota. Soluble reactive and total phosphorus concentrations were also relatively low compared to other watershed streams. Soluble reactive phosphorus concentrations ranged from 0.018 mg/L during the September 21 sampling event to 0.034 mg/L during the September 7 sampling event, while total phosphorus concentrations ranged from 0.065 mg/L during the September 21 sampling event to 0.103 mg/L during the July storm event. *E. coli* concentrations were elevated within the Lower Little Elkhart Creek ranging from 335 colonies/100 mL during the May event to 17,000 colonies/100 mL during the July storm event. This was the second highest *E. coli* concentration measured in the Five Lakes watershed. The Lower Little Elkhart Creek reach possessed relatively good habitat scoring 50 of 100 points (Figure 23) and a relatively good macroinvertebrate community (2 of 8 points) when compared with other watershed streams. However, the IDEM would likely consider the stream non-supporting for its aquatic life use designation as determined by its mIBI and QHEI scores.

As is expected of the stream with the largest drainage area, Lower Little Elkhart Creek possessed relatively high pollutant loads compared with other watershed streams. This stream contained the highest nitrate-nitrogen (May; September 7; September 21), ammonia-nitrogen (May), soluble reactive phosphorus (May; September 7; September 21), and total phosphorus (May; September 7; September 21) loading rates. This stream also possessed the second highest total Kjeldahl nitrogen (May; July; September 7; September 21), total suspended solids (May; July; September 7), and ammonia-nitrogen (September 7) loading rates and the second highest nitrate-nitrogen and total Kjeldahl nitrogen areal loading rates during base flow.

Figure 23. Lower Little Elkhart Creek sampling site during base flow.

3.2.10 Site 8 Oliver Lake Outlet

Temperature, turbidity, conductivity, and pH levels measured in the Oliver Lake Outlet were all comparable to levels measured in other Indiana streams. Typically, dissolved oxygen concentrations provided sufficient oxygen for aquatic biota; however, the dissolved oxygen concentration, measuring 4.9 mg/L, was below the state standard during the September 7 sampling event. Ammonia-nitrogen concentrations were relatively high compared with other watershed streams, but concentrations did not exceed state standards. Nitrate-nitrogen, total Kjeldahl nitrogen, soluble reactive phosphorus, and total phosphorus concentrations were relatively low compared to other streams in the watershed. *E. coli* concentrations exceeded the state standard during three of the four sampling events. Concentrations ranged from 43 colonies/100 mL during the September 21 sampling event to 880 colonies/100 mL during the July storm event.

The stream's macroinvertebrate community was relatively good compared to other watershed streams; however, the stream's habitat was relatively poor. The mIBI score (2 of 8 points) ranked the Oliver Lake Outlet as third among watershed streams; while the QHEI score (38 of 100 points) placed the stream fourth. Poor substrate and lack of pool-riffle development limited habitat at the Oliver Lake Outlet (Figure 24).

Figure 24. Oliver Lake Outlet sampling site during base flow.

Like the Lower Little Elkhart Creek, the Oliver Lake Outlet possessed relatively high pollutant loading rates. The Oliver Lake Outlet possessed the highest total Kjeldahl nitrogen (May; September 7; September 21), ammonia-nitrogen (September 7; September 21), and total suspended solids (September 7) loading rates. The Oliver Lake Outlet also contained the second highest ammonia-nitrogen (May; July), nitrate-nitrogen (September 7), soluble reactive phosphorus (September 7), and total phosphorus (September 7) loading rates. Furthermore, the Oliver Lake Outlet possessed the highest nitrate-nitrogen, total Kjeldahl nitrogen, total phosphorus, and total suspended solids areal loading rates of any of the watershed streams during storm flow and the highest ammonia-nitrogen areal loading rate during both base and storm flow.

3.3 303(d) List of Impaired Waterbodies

The Indiana Department of Environmental Management has placed the following lakes in the watershed on the 2004 303(d) list of impaired waters: Dallas Lake, Witmer Lake, Messick Lake, Hackenburg Lake, Olin Lake and Oliver Lake (Table 33). Olin and Oliver Lakes are proposed to be removed from Indiana's list of impaired waterbodies due to additional information being collected regarding mercury concentrations present in the lakes.

Table 33. The Indiana Department of Environmental Management 2004 303(d) list of impaired waters in the watershed.

14-digit HUC	County	Segment Code	Waterbody Name	Listing Reason
04050001170020	Lagrange	INJ01P1263_00	Dallas Lake	Impaired Biotic Communities
04050001170020	Lagrange	INJ01P1267_00	Witmer Lake	Impaired Biotic Communities
04050001170030	Lagrange	INJ01P1261_00	Messick Lake	Impaired Biotic Communities
04050001170030	Lagrange	INJ01P1262_00	Hackenburg Lake	Impaired Biotic Communities
04050001170030	Lagrange	INJ01P1026_00	Olin Lake	FCA for Hg
04050001170030	Lagrange	INJ01P1025_00	Oliver Lake	FCA for Hg

3.3 Fish Consumption Advisories

According to the Indiana Department of Natural Resources website the following lakes have fish consumption advisories in 2004: Adams Lake was listed for Group 3 (one meal/month) due to Mercury for walleye over 20 inches in length.

4.0 BASELINE WATERSHED CONDITIONS

Identifying areas of concern and selecting sites for future water quality improvement projects were the goals for this visual and watershed inspection. The Five Lakes watershed was toured twice throughout the completion of the watershed management plan. Inspections and tours included a stream crossing survey completed in September 2002 and several watershed walking and windshield tours completed in June of 2004 and July of 2005.

4.1 Stream Crossing Survey

In general, the stream crossing survey provided a basis for selecting water quality sampling sites. This assessment was designed to identify the best possible water quality sampling sites on the basis of stream accessibility. More than 24 stream crossings were examined throughout the watershed. Eight sampling sites were selected based on this tour. These sites were chosen because they represented a specific subwatershed draining to Little Elkhart Creek. Additional subwatersheds to each of these main subwatersheds could also be sampled; however, the number of sampling sites was limited to eight in order to assist with main subwatershed prioritization. Stakeholders are recommended to identify additional sample sites within each main subwatershed for additional water quality sampling. Additional sampling efforts should be aimed at the highest priority watersheds followed by those of lower priority. Photographs of the eight selected stream sampling sites as observed September 21, 2002 are included in Appendix I.

In addition to fulfilling its primary duty, this process allowed for the identification of a number of areas where water quality improvement projects could be implemented. (These areas are mapped with those identified during the walking and windshield tours in Figure 25.) Table 34 further details information regarding each of these sites and also lists the sites in the Five Lakes watershed where various concerns were observed during the stream crossing survey. Additionally, the table lists possible options for land management actions that could improve water quality within the Five Lakes watershed.)

Table 34. Concerns and sources of pollutants associated with the 8 water quality sampled sites, the existing data available for that site and suggested management practices for respective sites. All nutrient information is based on nitrate-nitrogen and phosphorus is based on total phosphorus.

Site	Concern/Source	Existing Data	Suggested Management Practice
S1	-Eroding waterways and use of improper tillage methods -Sediment and nutrient and phosphorous input from gravel roads, fields and impaired wetlands	**Nutrients** (based on N03-N) Violates Accepted Threshold: 05/18/04 (storm flow), 07/22/04 (storm flow) **Phosphorus** (Based on TP mg/l) Violates Accepted Threshold: 07/22/04 (storm flow), 09/07/04 (base flow) **E. Coli Bacteria** Violates State Standard: 07/22/04 (storm flow), 09/07/04 (base flow), 09/21/04 (base flow)	-Grass waterways and use correct tillage methodology -Wetland restoration below corn field -Install a berm to reduce sediment input into creek/stream from road -WASCOB to check flow off field; use grass waterways as well -Install buffer strip and restore wetland -Install buffer strip -Restore 8 wetland areas to reduce flow velocities at upper end and restore two wetlands at scattered sites
S2	Erosion	**Phosphorus** (Based on TP mg/l) Violates Accepted Threshold: 07/22/04 (storm flow), 09/07/04 (base flow) **E. Coli Bacteria** Violates State Standard: 05/15/04 (storm flow), 07/22/04 (storm flow), 09/07/04 (base flow), 09/21/04 (base flow) **Erosion and sedimentation** (based on TSS and Turbidity) Violates Accepted Threshold: 07/12/04 (storm flow for Turbidity)	-Install buffer strips -Limit impact of gravel roads to streams at crossings
S3	- Manure and erosion due to sheep and cattle access to stream - P-loading of Cree Lake and potential problems with septic systems on the lake (11) -Stream bank erosion	**Oxygen consuming wastes** (based on DO mg/l) Violates State Standard: 09/21/04 (base flow) **Nutrients** (based on N03-N) Violates Accepted Threshold: 05/18/04 (storm flow), 07/22/04 (storm flow) **Phosphorus** (Based on TP mg/l) Violates Accepted Threshold: 05/18/04 (storm flow), 07/22/04 (storm flow), 09/07/04 (base flow) **E. Coli Bacteria** Violates State Standard: 05/15/04 (storm flow), 07/22/04 (storm flow), 09/07/04 (base flow), 09/21/04 (base flow) **Erosion and sedimentation** (based on TSS and Turbidity) Violates Accepted Threshold: 07/12/04 (storm flow for Turbidity)	- Review grazing management for cattle and sheep - Potential installation of mounded septic systems - Stream bank stabilization - Installation of grassed water ways and grade control structures - Maintain no-till or mulch-till and haying practices in this area -Install a WASCOB on drainage to Shockopee

Site	Concern/Source	Existing Data	Suggested Management Practice
S4	-Stormwater issues	**Nutrients** (based on N03-N) Violates Accepted Threshold: 05/18/04 (storm flow), 07/22/04 (storm flow) **Phosphorus** (Based on TP mg/l) Violates Accepted Threshold: 07/22/04 (storm flow) **E. Coli Bacteria** Violates State Standard: 07/22/04 (storm flow) **Erosion and sedimentation** (based on TSS and Turbidity) Violates Accepted Threshold: 07/12/04 (storm flow for Turbidity)	-Determine stormwater/wastewater impacts from South Milford -Implement stormwater BMPs as necessary
S5	No specific concerns identified	**Oxygen consuming wastes** (based on DO mg/l) Violates State Standard: 09/07/04 (base flow), Violates Accepted Threshold: 07/22/04 (storm flow), 09/21/05 (base flow) **Nutrients** (based on N03-N) Violates Accepted Threshold: 05/18/04 (storm flow) **Phosphorus** (Based on TP mg/l) Violates Accepted Threshold: 07/22/04 (storm flow) **E. Coli Bacteria** Violates State Standard: 05/15/04 (storm flow), 07/22/04 (storm flow), 09/07/04 (base flow)	-All practices installed upstream in S1-S4 subwatersheds should positively impact water quality. -Identify additional projects (wetland restoration)
S6	-Ditch problems through barn yard	**E. Coli Bacteria** Violates State Standard: 05/15/04 (storm flow), 07/22/04 (storm flow), 09/07/04 (base flow)	-Install grassed waterways in fields to Blackman Lake - Review BMP for buffalo in this area
S7	-No specific problems identified	**Nutrients** (based on N03-N) Violates Accepted Threshold: 05/18/04 (storm flow) **Phosphorus** (Based on TP mg/l) Violates Accepted Threshold: 07/22/04 (storm flow) **E. Coli Bacteria** Violates State Standard: 05/15/04 (storm flow), 07/22/04 (storm flow), 09/07/04 (base flow), 09/21/04 (base flow)	
S8	-No specific projects identified	**Oxygen consuming wastes** (based on DO mg/l) Violates Accepted Threshold: 09/07/04 (base flow) **E. Coli Bacteria** Violates State Standard: 07/22/04 (storm flow), 09/07/04 (base flow)	-Determine potential impact of old landfill -Review impact of development of shoreline areas (Oliver, Olin, Martin lakes)

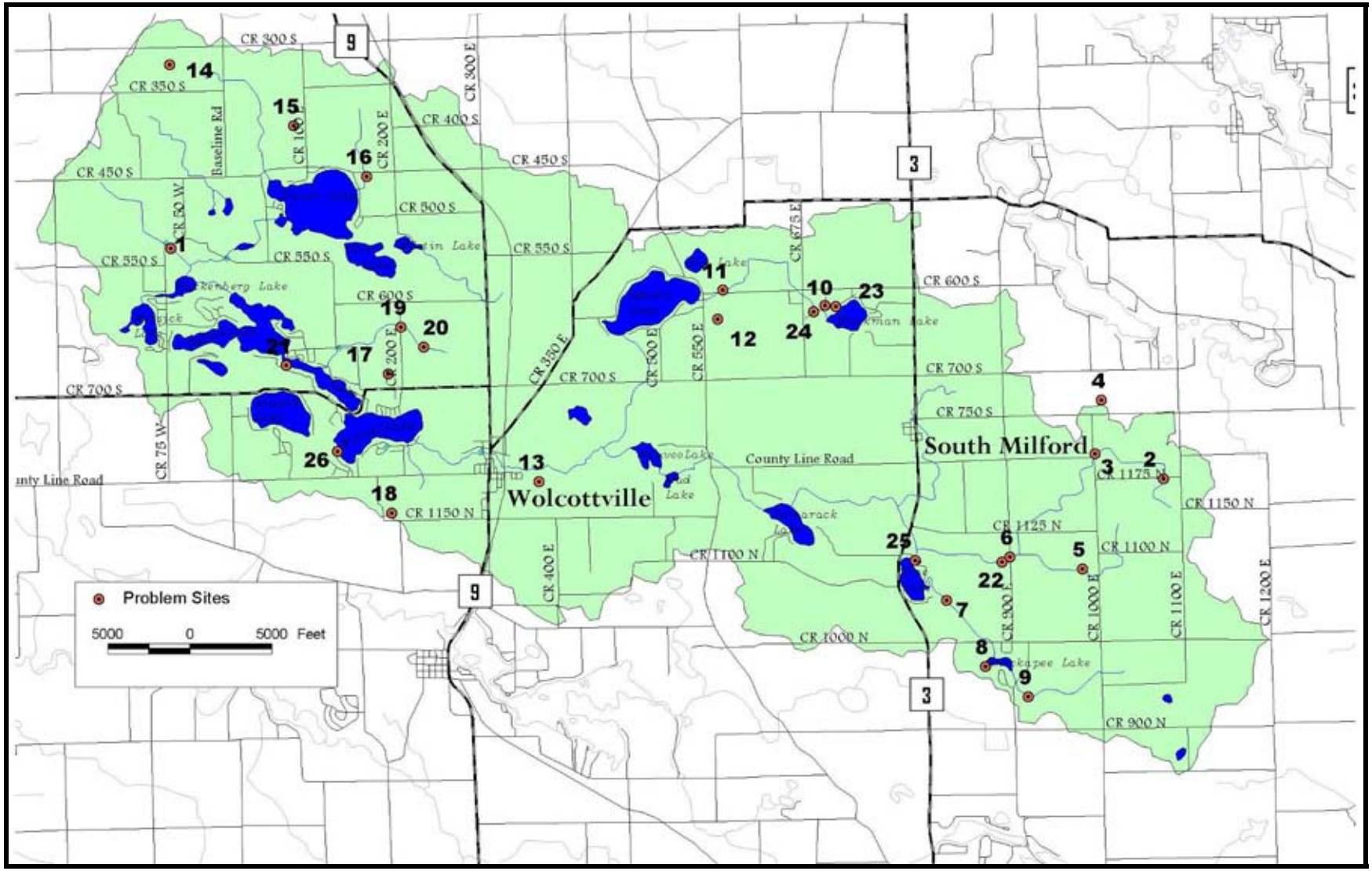

Figure 25. Watershed concerns identified during various watershed surveys in the Five Lakes watershed.

4.2 Walking and Road Stream Crossing Survey

Multiple stream crossing surveys occurred throughout the watershed. The first survey focused on the immediate Five Lakes; Olin, Oliver, and Martin lakes; and Atwood Lake area. Subsequent surveys targeted the Nauvoo and Adams lakes region and the upper watershed including Tamarack, Cree, and Shockopee lakes. The walking tour consisted of individuals from the Lagrange County SWCD, DJCase, JFNew, and the Five Lakes Conservation Association walking portions of Little Elkhart Creek and adjacent tributaries. These individuals recorded all potential watershed concern areas along the length of the stream. Additional areas within the watershed were also toured via a driving tour and are included herein. All areas of concern were noted during both the walking tour and the driving tours and are listed in Table 35. Locations of these observations are also included in Figure 25. Appendix I contains photographs of representative project areas.

Table 35. List of locations where the application of best management practices would improve water quality in the Five Lakes watershed as identified during the road stream crossing, water sampling and photo surveys.

Site	Concern	Suggested Management Practice
1	Livestock access to stream	Fence livestock from stream and correct drainage from pasture
2	Sediment loading from adjacent gravel road	Installation of a berm to reduce sediment input into creek/stream
3	Lack of buffer strip	Install buffer strips and restore wetland
4	Sediment loading from agricultural fields	Install grassed waterways and use correct tillage method
5	Lack of buffer strip on Uhl Ditch	Install buffer strip on Uhl Ditch
6	Grazing management issues; livestock access to creek	Fence livestock from stream
7	Sediment traps above Cree Lake require cleaning	Clean sediment traps
8	Bank erosion	Stabilize bank
9	Sheep in creek	Fence sheep out of creek
10	Possible livestock access to stream	Fence livestock out of stream and woods
11	Sediment and nutrient loading	Increase crop cover and manure management south of inlet to Adams Lake
12	ICM, nutrient and manure management issues	Less structural practices and more cover crop and management; grassed waterways
13	Stream bed and bank erosion	Install grade control at downstream end; seed and restore stream channel
14	Potential for wetland restoration	Restore wetland
15	Sediment and nutrient loading	Install filter strip on drainage to Dove Creek on the upstream end only
16	Lack of buffer strip	Install buffer strips on drainage to Oliver Lake
17	Potential site for wetland restoration	Restore wetland

Site	Concern	Suggested Management Practice
18	Potential site for wetland restoration	Restore wetland
19	Gravel road potentially drains into the stream	Investigate options for stormwater filtration
20	The buffer strip is too narrow	Narrow buffer strip
21	Erosion control at construction site	Implement erosion control
22	Grazing management issues; livestock access to creek	Fence livestock from stream
23	Erosion	Grass waterways
24	Ditch problems through barnyard	Fence livestock from stream
25	Elevated *E. coli* and nutrients	Determine if septic systems need improvement
26	Storm drain concerns	Improve storm drainage issue at Witmer Lake

5.0 CLARIFYING OUR PROBLEMS

5.1 Linking Concerns to the Existing Data

Previous sections presented existing data from lake and stream studies, which explain that several water quality parameters either violate state standards or exceed accepted levels for maintenance of a healthy aquatic biota. This section details the potential source of pollutants to water quality. These sources were identified through watershed tours, and could certainly contribute to the high levels of nutrients, sediments, bacteria, and low oxygen levels found during the diagnostic study, though they may not be the sole causative agent.

Aside from the actual water quality monitoring and the watershed tours, the public was invited to voice their concerns about their watershed throughout the watershed planning process. Their concerns were presented in the Concerns Section (Section 1.2) of the Introduction. The project sponsor and facilitating consultant developed a group of broad categories within which the stakeholder's concerns could fit. These same categories were used throughout the planning process to develop problem statements, identify priority areas, and set goals for watershed and water quality improvement. Stakeholder concerns are again discussed in this section through development of problem statements based on these broad categories. The problem statements reflect the information gathered throughout the entire planning process. Stressors, possible pollutant sources, and identified critical areas are listed for each problem statement. Table 36 reflects the stakeholders concerns, any existing data identified that supports or refutes those concerns, and identifies the problem statement developed for that particular concern.

Several concerns cannot be associated or supported by water quality data since they are process, social or political issues. For example, the stakeholders were concerned about the watershed planning process not being all inclusive. Over 900 flyers were sent out to people within the watershed notifying them that the project was in progress and noting that their participation was welcome. Stakeholders were concerned that values, including property, aesthetic and recreational values, be maintained or improved. Though the existing data cannot validate this concern, efforts to implement best management practices to reduce non-point source pollution can be measured

through future water quality monitoring efforts. These efforts can then be related to increases or decreases in real estate property. The stakeholders were also concerned about results. It is the responsibility of the stakeholders and the residents of the watershed to implement the actions addressed in this document. Only through resident and stakeholder efforts can an improvement in water quality occur. Again, the data do not necessarily support or correlate with this concern; however, this plan provides measures of success against which stakeholders can compare future water quality.

Table 36. Linking watershed stakeholders' concerns with existing data to develop problem statements.

Concern	Existing Data	Problem Statement
Process		
All information and studies previously completed have not been collected and reviewed.	More than 125 reports were reviewed as part of this study. It is impossible to say that all available data was reviewed; however, the large volume of material gathered provides an adequate baseline for comparing historic and current data.	
All entities who have a concern are not participating in the process.	Invitations were sent to more than 900 individuals to garner their input. Additional methods of information dissemination should be investigated during the implementation phase of this project.	4
Make sure that the project continues to aim at addressing problems not pointing fingers at people/groups.	No data is available to verify this concern. However, lake associations and conservation personnel indicate that additional education efforts focusing on the positives of the process should occur.	4
All people/groups should work together to make this plan work.	A core group of individuals attended the watershed planning meetings. Attendance fluctuated, but generally did not include all individuals with interest in the project. Future efforts should aim at including these individuals and entities.	4
Education/Information		
Watershed residents do not understand how their activities cause water quality problems.	No data to support or refute this concern. However, lake association personnel indicate that additional education efforts focused at the average homeowner could improve the understanding of individual's effects on water quality.	4
Incentive based conservation efforts helps, but no implementation if individuals don't understand the problem.	See above.	4
Impact of restrictions placed on private property if federal or state monies provided for conservation projects.	No data to support or refute this concern. SWCD and NRCS personnel indicate that individuals sign-on for a term (typically 10 years) after that time no restrictions exist on the property. Educational efforts should focus on passing out this information.	4
Need more education about phosphorus-free fertilizer.	No data to support or refute this concern. However, lake association personnel indicate that additional education efforts focused on the use of phosphorus free fertilizer would be beneficial.	4
Involvement of community in watershed planning.	900 flyers sent to watershed members; Invitees to watershed planning team may need to include other lake association members.	4

Concern	Existing Data	Problem Statement
Nutrients (Phosphorus and Nitrogen)		
Over-application of fertilizer.	No data from the watershed were available to verify this; however, fertilizer application data for Lagrange and Noble Counties indicates that application rates are on-par with crop acreage and yield when compared with surrounding counties.	1
Phosphorus load in water is creating a problem.	2004 stream sampling indicated elevated levels of total phosphorus, soluble reactive phosphorus, and nitrate-nitrogen in watershed streams. CLP data indicates elevated total phosphorus concentrations in some lakes; however, chlorophyll *a* levels do not indicate high algal densities.	1
The lakes are becoming more eutrophic/productive.	Historical lake water quality data reveal that Messick, Nauvoo, Shockopee, Tamarack, Westler, and Witmer lakes are either eutrophic or hypereutrophic based on the Indiana Trophic Status Index (ITSI). Total phosphorus levels in Blackman and Shockopee lakes exceeded concentrations found in eutrophic lakes based on guidelines developed by Vollenweider (1975). Data do not indicate that these lakes are becoming more productive.	1
Reduction in oxygen by nutrient introduction/algal production.	Historical water quality data show that some lakes exhibit less that acceptable oxygen levels (low percent oxic). Nutrient concentrations are also elevated in the hypolimnion of many of the watershed lakes. However, no cause-effect could be developed from these data.	1
Runoff/increased nutrient concentrations promote algal growth.	No data from the watershed were available to directly verify this concern. However, research on pollutant runoff suggests that runoff of nutrient or sediment-rich water can lead to additional algal growth.	1
Algal blooms are occurring where once they did not.	Chlorophyll *a* data collected by the CLP during 2003 suggests that chlorophyll *a* concentrations are higher in many lakes than during previous CLP assessments. However, these data are not significantly different. Additionally, for most lakes there are not enough data points to indicate a trend towards increasing density or duration. Additional data should be collected to refute or support this concern.	1
Loss of cisco population is due to increased nutrient levels.	Cisco were historically observed in Olin, Oliver, Martin, Messick, Hackenburg, Dallas, Atwood, and Witmer lakes (Frey, 1955). Frey suggested that the loss of the requisite temperature and oxygen regimes limits the distribution of cisco. No direct correlation between nutrient concentration changes in these lakes and the loss of cisco is apparent.	1
Livestock in streams cause increased inputs of nutrients.	No direct data for the Five Lakes watershed is available; however, multiple sites were livestock access the stream have been identified. Furthermore, literature suggests that livestock access to a waterbody increase turbidity, nutrients, and pathogen concentrations in the waterbody (Platts, 1991).	1
Contributions of phosphorus from geese are considerable and are increasing productivity of lakes.	No data from the watershed were available to verify this concern. However, studies show that geese increase nutrient loading up to 40% for total nitrogen and 75% for total phosphorus (Kitchell et al., 1999).	1

Concern	Existing Data	Problem Statement
Gypsy moths contribute high concentrations of nitrates from flax.	No data to support this state in regards to the Five Lakes watershed. Researchers state that gypsy moths can increase the nitrate concentration of forest streams and harm natural nitrogen cycling (Herms and Shetlar, 2002).	
Filter Strips/Riparian and Lakeshore Buffers		
Natural filters along lakeshore are being removed.	No data is available to corroborate statement. Mapping the existing shoreline of each lake would serve as a base point from which to compare future shoreline coverage; therefore, this is suggested as an action item. Research shows that buffers can reduce 50% of the phosphorus load (Conservation Technology Center, 2000).	1
Natural filters along streams are being removed.	No data is available to verify this concern. Completing a watershed tour and mapping riparian vegetation would serve as a baseline for future restoration work.	1
Lack of education in regards to shoreline vegetation leads to the removal vegetation around the lakes.	No data is available to verify this concern. Discussion with the watershed lake associations indicates that stakeholders could be better informed/educated with respect to water quality and how to manage their lakeshore to achieve better habitat and improve water quality.	1
Point Source		
Stormwater runoff and point sources below Wolcottville cause water quality problems.	No data from the watershed are available to verify this concern on its own. However, data from Site 7 reveals elevated phosphorus levels.	1 (nutrients) 2 (sediment)
Stormwater runoff and point sources from South Milford also contribute to water quality problems.	No data from the watershed are available to verify this concern on its own. However, data from Site 4 reveals elevated phosphorus and *E. coli* levels. Additionally, the nitrate-nitrogen concentrations recorded at this site were higher than those present at any other site in the watershed.	1 (nutrients) 2 (sediment)
Impact of the Adams Lake sewer on water quality entering the Five Lakes.	The Adams Lake Regional Sewer District (ALRSD) is permitted to discharge water only when their effluent occupies 10% of the stream flow. Permitted total phosphorus and total suspended solids levels (1.0 mg/L and 70 mg/L weekly average, respectively) exceed those levels indicated to be harmful to aquatic biota. However, as these loads incorporate themselves into the surround stream water, their contribution falls to only 0.1 mg/L and 7 mg/L, respectively. These concentrations are comparable to levels measured at Site 6 during the stream sampling portion of this project. This site was rated as possessing relatively good water quality; however, the habitat and macroinvertebrate community were rated as poor. It is thought that the habitat played a larger part in the biotic impairment than the water quality present. It is further suggested that the FLCA work with the ALRSD to collect additional water quality samples to determine the impact of the sewer on water quality.	1 (nutrients) 2 (sediment)
Erosion/Sedimentation		
Erosion of shore banks resulting from removal of lakeshore vegetation.	See Concern 1 under filter strips/riparian and lakeshore buffers for action items associate with this concern.	2

Concern	Existing Data	Problem Statement
Aggressive ditching causes increased erosion	An assessment of ditch cleaning or the construction of additional ditches within the watershed was not available. However, Uhl Ditch and Hutchins Ditch possessed poor habitat based on QHEI scores. These streams also routinely possessed the highest total phosphorus and *E. coli* concentrations.	2
Large volumes of silt and water drain to the lakes.	Accepted thresholds for turbidity were exceeded in Uhl Ditch (Site 2), Cree Lake Outlet (Site 3) and South Milford Tributary (Site 4) during the sampling portion of this project. Loading from streams that were sampled during 2004 could contribute over 785 tons of sediment to the Five Lakes watershed on an annual basis.	2
Islands/deltas have started to develop at the mouth of many of the lakes' inlets.	No exact data is available to verify the amount of accumulation. However, personal observation verifies the presence of accumulated sediment at the mouth's of some inlets. An action item aimed at the quantification and potential removal of this accumulated sediment is suggested.	
Water Level		
Decrease in water levels impact water quality and the aquatic biota.	No data to document change in lake legal level were available. If water levels were permanently lowered, nutrients and sediment could become concentrated; however, there is not evidence of this occurring within any watershed lakes.	6
Values		
Declining value of real estate when water quality declines	No data were available to verify this concern.	5
Safe and clean water is desirable.	See discussion under *E. coli*/Pathogens.	3
Turbidity limits fishing and aesthetics.	See discussion under sedimentation/erosion.	2
Chocolate colored water enters the lakes following rain events.	See discussion under sedimentation/erosion.	2
Recreation		
Decreased water surface reduces opportunities for fishing and general recreation and reduces the amount of lake available for use.	No data to document change in lake legal level were available. If water levels were permanently lowered, nutrients and sediment could become concentrated; however, there is not evidence of this occurring within any lakes in the watershed.	5
Reduced fish populations in general and game fish specifically. Poor quality fisheries present in lakes.	Hackenburg, Messick and Witmer lakes are on the 303 (d) list for impaired biotic communities as they do not support cisco currently. Olin and Oliver lakes were on the 2004 303(d) list for fish consumption advisories (mercury), but are suggested for removal from the 2006 list. Tamarack Lake supports a healthy carp population and high turbidity. Other lakes either support good or mediocre fisheries according to the IDNR reports.	5
Sedimentation on small lakes limiting boat access and usability.	No data from the watershed were available to confirm or refute this statement. Individual observations suggest that this is a valid concern; however, the determination of sediment accumulation in lakes throughout the watershed is suggested as an action item to determine the validity of this.	

Concern	Existing Data	Problem Statement
Increased aquatic plants and algae reduce recreational opportunities.	No data are available to support or refute these concerns. Water quality data indicates that chlorophyll *a* concentrations were higher in 2003 in many of the watershed lakes than levels historically recorded. These differences were not statistically significant and trends are limited by the number of observations recorded. An on-going aquatic plant management plan will assist with the determination of changes in the aquatic plant community.	5
Water quality is not good enough and the water is not safe for recreation and fishing.	No data are available to support or refute this concern. Nutrient and sediment levels do not impede recreational and fishing uses of the lakes. However, unsightliness can encourage users to recreate less. No pathogen data has been collected within the lakes.	1 (nutrients) 3 (*E. coli*)
Excess bacteria levels create unsafe and unclean water for swimming or skiing.	No data are available to support or refute this concern. No pathogen data has been collected within the lakes.	3
Health		
Safe and clean water is desirable. Concern with skin problems due to algae and *E. coli* within the lakes.	No data are available to verify this concern within the lakes. However, data suggest that *E. coli* levels in streams throughout the watershed exceed the state standards of 235 cfu/100 ml.	3
Wildlife		
Impact of geese on nutrients and pathogen levels; goose population needs to be controlled.	See goose discussion under nutrients concerns listed above.	1 (nutrients) 3 (*E. coli*)
Land Use		
Land use changes can affect water quality.	No specific data to refute or support. Research shows that best management practices can reduce inputs of nutrients and sediment to waterways.	1 (nutrients) 2 (sediment)
Erosion associated with wildlife and livestock.	No data to support the statement. Livestock and wildlife were observed in the streams during the watershed tour; however their exact contribution could not be quantified.	2
Dallas Lake's transparency is poorer than historic levels.	Historic Secchi disk transparency data indicate that Dallas Lake's transparency fluctuates from 1.4 m to 3.7 m (4.6 to 12.1 ft). The deepest measurements occurred in June 1975 and again in June 1998. All other measurements are within 0.2 m of the median value. Therefore, no evidence of declining transparency is apparent in Dallas Lake.	1
Implementation		
All implementation concerns regard items where data cannot be collected to refute or confirm the concern. They are simply expressions of a desire for implementation of practices and better conditions in the future.		
Political		
Impact of increasing regulation on the lakes and streams in the watershed	No data is available to determine the exact impact of increased regulation. However, lake association personnel indicated that increased awareness of regulations will assist individuals in making informed decisions to improve water quality.	4

Concern	Existing Data	Problem Statement
Results		
What is the impact of conservation efforts previously implemented?	No data is available to determine the exact impact of the conservation efforts. However, nutrient and sediment concentrations and loads recorded during the sampling portion of this project are on-par with or slightly below those measured in 1992 (F.X. Browne, 1992).	1

5.2 Developing Problem Statements

Problem statement development occurred throughout the planning process in an effort to tie watershed stakeholders' concerns with existing data to develop a clear pathway for future work in the Five Lakes watershed. The problem statements reflect information gathered throughout the watershed planning process. Details regarding stressors, pollutant sources, and identified hot spots are listed for each problem statement. It should be noted that many of the critical areas are located within the immediate vicinity of the Five Lakes. It is likely that other critical areas are located within the watershed as the watershed touring process was not exhaustive. Therefore, items identified at a later data should all be considered for implementation and should not be ignored due to not being identified during this planning process.

Problem Statement 1. Nutrient concentrations present in watershed streams and lakes are creating problems that compromise the health, aesthetics and recreational value of the lakes and streams in the Five Lakes watershed. During the water quality sampling portion of this project, both phosphorus and nitrate-nitrogen concentrations present in watershed streams exceeded levels at which the Ohio EPA (1999) observed impairment to the aquatic biota. A review of historic lake water quality data reveal that Messick, Nauvoo, Shockopee, Tamarack, Westler, and Witmer lakes are either eutrophic or hypereutrophic based on the Indiana Trophic Status Index (ITSI). Total phosphorus levels in Blackman and Shockopee lakes exceeded concentrations found in eutrophic lakes based on guidelines developed by Vollenweider (1975). Finally, most of the lakes and streams within the watershed contain phosphorus concentrations that exceed the level at which waterbodies are considered eutrophic (Carlson, 1977; Dodd et. al, 1998).

The stakeholders expressed their opinions about the likely sources of phosphorus. They surmised that over-application of fertilizer, lack of shoreline buffers along the lake and narrow or absent filter strips along the streams, erosion from animals entering the stream, and animals defecating in the streams and lakes were a few of the sources of phosphorus to the streams and lakes. The watershed tours corroborated these apparent sources and identified more. Where road crossings occurred, sediment with adsorbed nutrients flows into streams. Additional identified sources that lead to phosphorus contributions to the watershed's lakes and streams include erosion along streambanks, actively farmed land from which overland runoff flows to streams and lakes, ditches that flow through barnyards, and inadequate sewer and septic systems around some lakes. (Cree Lake was noted in particular.) Other potential areas not specifically identified by stakeholders include current and future development areas, improper disposal of yard wastes, and manure disposal areas.

Regarded as point sources, stormwater that enters Little Elkhart Creek through pipes near Wolcottville and South Milford, the release of effluent from the Adams Lake treatment system, and a failing sediment trap below Wolcottville downstream of State Route 9 are also potential

contributors to phosphorus and nitrogen loading to the Little Elkhart Creek and thus the Five Lakes.

General locations of sources identified within the Five Lakes watershed are listed below and displayed in Figures 25 and 26. Management efforts to reduce phosphorus input from the Five Lakes watershed should focus on the critical areas identified during the watershed tours.

Stressor: Phosphorus – total and soluble phosphorus
Nitrogen – nitrate, ammonia, organic, total Kjeldahl

Source:
- Streambank erosion (Figure 26)
- Overland flow from agricultural fields (Figure 15)
- Residential lawn and agricultural fertilizer
- Lack of buffers along lakes and filter strips along streams
- Lack of grassed waterways
- Inadequate/incorrect installation of tile risers in agricultural fields
- Animal waste
- Failing septic systems-particularly adjacent to watershed waterbodies (mapped as soils with severe septic limitation in Figure 12)
- Point sources from storm pipes and sewage treatment systems
- Livestock and wildlife access points (Figure 27)
- Improper disposal of yard wastes
- Residential/commercial development sites
- Improper manure disposal
- Loss of wetlands (Figures 13 and 14)

Hot Spots/Critical Areas:
Hutchins Ditch subwatershed – County Road 1175 North road crossing; agricultural fields in need of grassed waterways; wetland restoration in agricultural fields; buffer strips needed on ditch.

Uhl Ditch subwatershed - buffer strip needed on ditch mainstem; livestock management (Figure 26).

Little Elkhart Headwaters subwatershed- Cree Lake septic systems need improvement; land practices (erosion) downstream of Shockopee Lake; improved grazing practices upstream of Shockopee Lake implemented; sediment traps above Cree Lake require cleaning.

Adams Lake subwatershed - Buffalo grazing practice management requires improvement; increased cover crop and manure management south of inlet to Adams Lake; sewage treatment plant effluent (concern regarding potential elevated ammonium levels).

Lower Little Elkhart subwatershed - point sources below Wolcottville including storm flow and urban runoff; waste storage in ponds at dairy upstream from Wolcottville; installation of bed and bank stabilization upstream of Wolcottville.

Oliver Lake subwatershed - wetland restoration; filter strip installation on drainage to Dove Creek; buffer strip installation on drainage to Oliver Lake; widen grass waterways on northern drainage to Martin Lake.

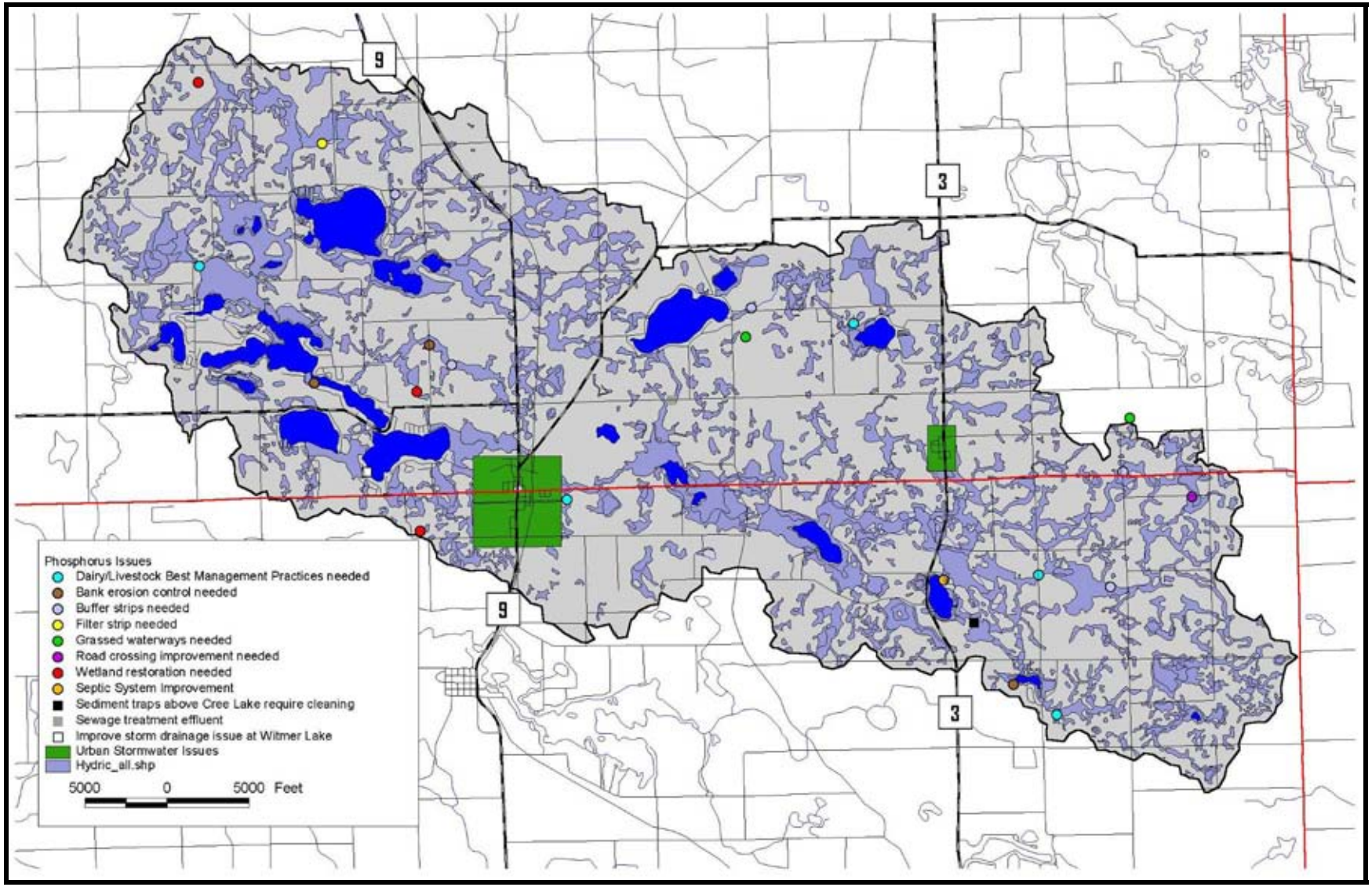

Figure 26. Critical areas targeted for nutrient (phosphorus) loading reduction in the Five Lakes watershed.

Five Lakes watershed - septic system improvement in entire watershed; wetland restoration and enhancement; stream road crossing improvement at County Road 200 East; widen buffer strip at drainage above County Road 200 East, install riparian buffer above State Road 9, and install riparian buffer adjacent to lakeshore (Figure 28); enhance erosion control at residential developments; improve storm drainage issue at Witmer Lake; improve grazing management by fencing and mowing drainage at County Road 50 West; widen buffer strips adjacent to all lakes; educate residents on the impact of yard waste and phosphorus-based fertilizers on the lakes; ditching and tiling throughout the watershed (Figure 29).

Figure 27. Representative location where livestock have access to waterbodies within the Five Lakes watershed.

Figure 28. Representative locations where riparian buffer/buffer strip installation should occur adjacent to a lake (left) and stream (right) within the Five Lakes watershed.

Figure 29. Representative location where ditching and tiling occurs within the Five Lakes watershed.

Problem Statement 2. Erosion and sedimentation in the streams of the Five Lakes watershed contribute to poor water quality in the streams and the lakes (Figure 30). Furthermore, silt and sediment are degrading and filling the watershed waterbodies and limiting their use for recreation, drainage, and aesthetic purposes. Poor water clarity was a documented and supported concern of watershed stakeholders. Accepted thresholds for turbidity (9.8 NTU recommended by USEPA, 2000) were exceeded in Uhl Ditch (Site 2), the Cree Lake Outlet (Site 3), and the South Milford Tributary (Site 4) during the sampling portion of this project. Concentrations of total suspended solids did not exceed recommended levels for maintenance of aquatic biota (80 mg/L, Waters, 1995) at any of the sites sampled during the 2004 sampling effort. However, the greatest loading of total suspended solids occurred at the Oliver Lake Outlet (Site 8), Lower Little Elkhart Creek (Site 7), and Upper Little Elkhart Creek (Site 5) during the same sampling period. It is estimated that loading from streams in the watershed contribute more than 785 tons of sediment to the Five Lakes watershed on an annual basis (based on sampling completed during 2004).

In general, erosion and sedimentation result from overland runoff from agricultural fields, stream bed scouring, road-stream crossings, urban areas, and surface runoff from residential areas. Additionally, a review of scientific literature indicates that streambank erosion and land use/land use changes (including active construction sites and areas converted from old field to agricultural or residential uses) are likely sources of silt and sediment in the Five Lakes watershed. Active construction sites, active farm fields, and unvegetated stream banks are also sources of sediment in streams in lakes. Although not intuitive, hardscape (impervious surfaces) such as streets and parking lots can also be contributors of sediment to waterways (Bannerman et al., 1993). Dirt on these surfaces often washes directly to storm drains. Gravel roads can also add sediment to nearby waterways. Specific sources of sediment identified by stakeholders include: aggressive ditching, streambank erosion, and wildlife and livestock crossing streams. Stakeholders also mentioned that strips of natural vegetation along the lake's edge in residential areas were being removed. Lastly, urban runoff from Wolcottville, an inadequately functioning sediment trap downstream of State Road 9, and a dam structure that is failing could contribute to the sediment load. Watershed tours

revealed specific locations where sediment or silt causes the greatest problems for water quality. These sites are located in Figure 25 and 30.

Stressor: Sediment/silt

Source:
Streambank erosion
Overland flow from agricultural fields (Figure 15)
Lack of filter strips along lakes
Lack of grassed waterways/swales
Wildlife and livestock crossing streams
Streambed scouring
Stream-road crossings
De-vegetated urban areas
Surface runoff from residential areas (Figure 15)
Highly erodible soils/steeply sloped soils (Figure 12)
Inadequately functioning sediment trap at State Road 9
Failing dam structure at Wolcottville
New house construction and grading/clearing all vegetation
Inadequate erosion control management at new construction areas
Point sources
Changes in land use (future development)

Hotspots/Critical Areas:
Hutchins Ditch subwatershed – County Road 1175 North road crossing; agricultural fields in need of grassed waterways; wetland restoration; buffer strips needed on ditch.

Uhl Ditch subwatershed – County Road 1000 East buffer strip installation; livestock management.

Little Elkhart Headwaters subwatershed- stream bank stabilization west of CR 1000E; grassed waterways on agricultural lands in upper end of Little Elkhart Creek; improve sediment traps on channel to Cree Lake; grazing management; place a WASCOB on drainages to Shockopee Lake.

Adams Lake subwatershed - Need grassed waterways in fields upstream of Blackman Lake; buffalo grazing practice management (Figure 31); streambank erosion at entrance to Adams Lake; erosion requiring filter strips along inlet to Adams Lake; increase cover crop management south of inlet to Adams Lake.

Lower Little Elkhart subwatershed - Urban runoff from Wolcottville; dam structure at Wolcottville requires repair; sediment trap at State Road 9 requires cleaning; stormwater from pipes introduces pollutants to water (investigate potential for diversion).

Oliver Lake subwatershed - wetland restoration; filter strip on drainage to Dove Creek; buffer strip on drainage to Oliver Lake; widen grass waterways on northern drainage to Martin Lake

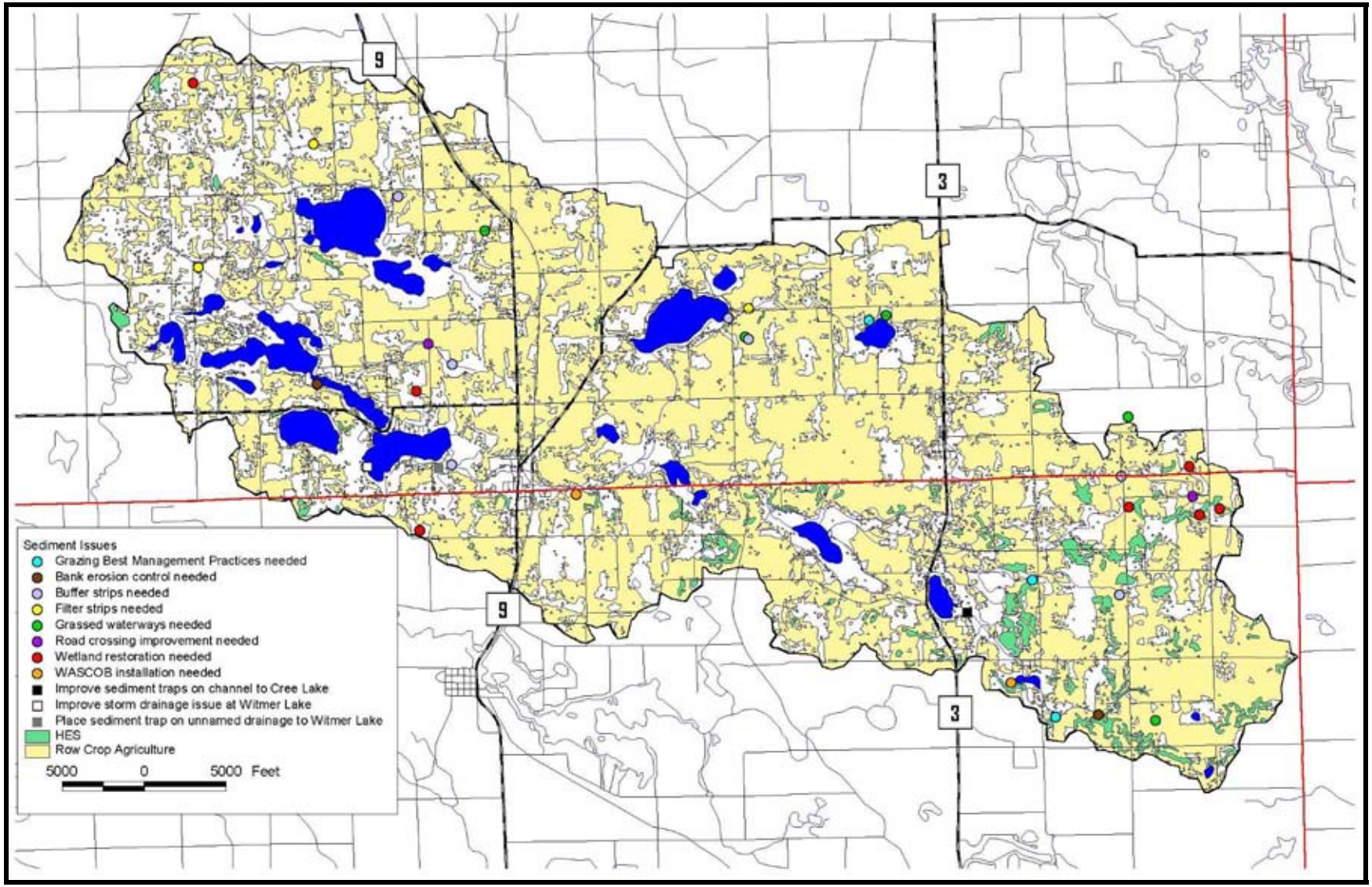

Figure 30. Critical areas targeted for sediment loading reduction in the Five Lakes watershed.

Five Lakes watershed - install WASCOB structure from wooded area east of Wolcottville and south of stream; wetland restoration and enhancement; stream road crossing improvement at County Road 200 East; widen buffer strip at drainage above County Road 200 East; enhance erosion control at construction sites; improve storm drainage issue at Witmer Lake; remove sediment source at inlet to Witmer Lake; place sediment trap on unnamed drainage to Witmer Lake; improve grazing management by fencing and mowing drainage at County Road 50 West; improve all stream road crossings; install erosion control at all new residential and commercial construction sites; widen/install buffers strips along lake shoreline.

Figure 31. Example of need for livestock grazing improvement.

Problem Statement 3. Elevated pathogen levels are a human health concern in the Five Lakes watershed (Figure 32). *E. coli* indicates the presence of pathogenic organisms. *E. coli* measured in the Five Lakes watershed exceeded state standards at all of the sites sampled during the completion sampling portion of this project. Pathogenic organisms can potentially harm the biota living in the stream. Such organisms can also make humans who come in contact with the water sick. Currently, none of the watershed streams meet the state standard for *E. coli*, an indicator for pathogens. Though still exceeding state standards, *E.coli* levels at the site below Adams Lake on the Little Elkhart River (Site 6) exhibited the lowest of the measured *E. coli* levels. Changes to treatment of sewage may have improved conditions for Adams Lake, yet there remains concern among stakeholders that the current discharge permit allows effluent releases too high in bacterial counts and nutrients. The effluent is stored in detention ponds and released twice annually to the Little Elkhart River.

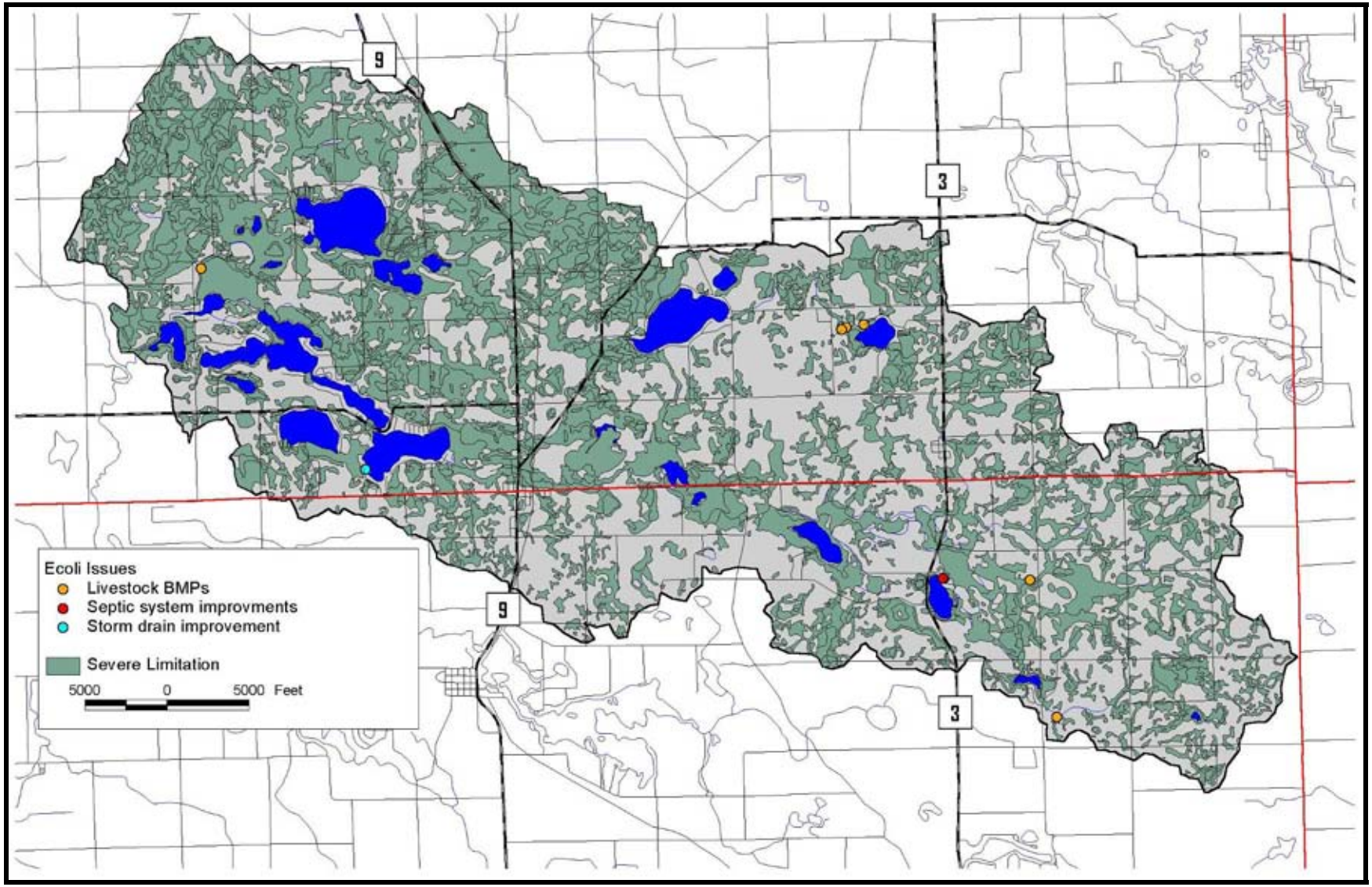

Figure 32. Critical areas targeted for pathogen (*E. coli*) concentration reduction in the Five Lakes watershed.

Common sources of *E. coli* include human and wildlife wastes, fertilizers containing manure, previously contaminated sediments, septic tank leachate, illicit septic connections, and geese. Specific concerns raised by stakeholders include failing septic systems around the many of the lakes and the introduction of pathogens from grazing livestock adjacent to the watershed's waterways. Wildlife's contribution to pathogens in the lakes and streams were also a noted concern. Goose populations around the lakes are detrimental to the water quality from a health standpoint. Likewise, deer access to streams causes immediate elevated bacterial levels. In urban areas, pet waste may enters the water stream and causes elevated bacterial levels.

The watershed tour focused on locating sources of *E. coli* in the upper watershed. Most attention was paid to grazing livestock adjacent to streams or drainages. Specific locations where livestock access causes the greatest problems for water quality are located in Figures 25 and 32. Another area of focus is downstream of the Adams Lake sewage treatment facility, and below the town of Wolcottville where stormwater emanating from storm pipes enters the Little Elkhart Creek.

Stressor: *E. coli*/Pathogens

Sources: Septic system failures; citing septic systems on severely limited soils (Figure 11)
Livestock grazing adjacent to streams (Figure 32)
Effluent from Adams Lake sewage treatment system entering Little Elkhart Creek
Stormwater from Wolcottville and South Milford entering stream from storm pipes
Pet waste entering stream and lakes
Wildlife adjacent or in streams and lakes

Hot Spots/Critical Areas:
Uhl Ditch subwatershed - review grazing management near County Road 900 West.

Little Elkhart Creek Headwaters subwatershed - upstream of Lake Shockopee - review grazing management; buffalo ranch - review grazing management; livestock access to ditches- County Road 675 East; Cree Lake - failing septic systems.

Adams Lake subwatershed - sewage treatment plant effluent.

Five Lakes Watershed - management practices on waste storage ponds on diary farm east of Wolcottville; improvement of storm drains at Witmer Lake; fence livestock from drainage at drainage near County Road 50 West; fence and vegetate stream channel at drainage near County Road 50 West; control goose population on all lakes in watershed.

Problem Statement 4. Stakeholders voiced concerns about the lack of education and information available to the general public. Specifically, the watershed residences do not understand how their activities can impair water quality in the Five Lakes watershed. The stakeholders noted that one solution would not fit all problems, and that some solutions if funded with federal, state, or local monies place restrictions on the property owner. Stakeholders also voiced concerned that the watershed management plan process was not all-inclusive, nor would it address all concerns including point source pollution. Lastly, stakeholders were concerned about implementing the watershed plan once it was completed. Political, financial, social, and institutional road blocks were viewed as not always surmountable when trying to implement some of the projects. The

stakeholders voiced that they wanted results. Conservation efforts such as no till farming methods and installation of buffer strips have been implemented, but sediment and nutrients still reach the waterways.

Source: Lack of knowledge

Source: Lack of education or information about watershed issues is not tied to a specific subwatershed; therefore, there is no specific source

Hot Spots/Critical Areas:
Residential property owners
Agricultural property owners
Sewage treatment plant operators
Agency personnel
Town officials

Problem Statement 5. Elevated algal density, large amounts of sediment, and elevated *E. coli* concentrations are limiting the recreational (swimming, boating, fishing, skiing) and aesthetic use of the lakes within the Five Lakes watershed. Indiana lakes are a major source of recreation. The inhabitants of the Five Lakes watershed with its 16 lakes differ little from other Indiana lake inhabitants in their desire to recreate on their lakes and enjoy the aesthetic setting while accruing value in their land. The stakeholders desire good water quality with enough surface water in the lakes for boating, fishing, swimming and waterskiing. The stakeholders are concerned that the lake levels are declining, that the fish populations are declining and that contamination of the lakes create health problems for swimmers and water skiers in the lakes.

The Indiana DNR has multiple of fish surveys on lakes in the Five Lakes watershed over the past 40 years. Though some lakes support good fisheries, other lakes are on the 303(d) for having impaired biotic communities or for fish consumption advisories. Hackenburg, Messick, Dallas, Witmer, Olin, and Oliver lakes historically contained sustainable cisco populations, but currently do not support this specie. Tamarack Lake exhibits high turbidity and supports a healthy carp population. Impairments or poor fisheries bode poorly for recreational activities. The IDNR is active in managing the fishery of the lakes and continues to monitor the fish and water quality on a periodic basis. However, poor fisheries most likely stem from stressors such as nutrients and sedimentation. To improve the recreational opportunities on the lakes, the sources of nutrients and sediment should be addressed and education of all watershed stakeholders increased so that everyone is aware of the impact that they have on the lakes' water quality.

Stressor: Nutrients, Sediment, Pathogens

Sources: Fertilizers
Human and animal waste
Organic materials
Soil erosion

Hot Spots/Critical Areas:
See Problem Statements 1-3

Problem Statement 6. Concerns were expressed about the changes in water levels for all of the lakes. Lowering of the lake level can lead to concentration of nutrients, increased algal densities, and higher turbidity, thus causing poor water quality. Poor water quality leads to a reduction in the health of the lake systems as well as a reduction in the recreational and aesthetic value of the lakes. Bathymetric maps were prepared by the Indiana DNR in cooperation with the USGS between 1955 and 1977. Lake legal levels are established for the lakes in the Five Lakes watershed. Outside of monitoring the lake levels, there is little the stakeholders can do to change the lake water elevations. However, the stakeholders can manage water quality by fostering best management practices which reduce nutrient and sediment inputs into the lakes. Sources of phosphorus and sediment inputs are identified in earlier problem statements.

Stressor: Drought

Source: Global Climate Change

Hot Spot/Critical Areas:
All of the lakes within the Five Lakes Watershed

6.0 GOALS AND DECISIONS

During the Watershed Planning Team meetings, considerable time was spent defining goals and determining conservation actions needed to improve and maintain water quality. Goals were identified based on major water quality parameters measured during this project. Several facilitation tools were utilized during the formation of goals and prioritization of decisions (Appendix J). The Planning Team decided that all areas of the watershed were of equal importance and that they were unwilling to identify one area as more important based on the data and their perspectives. As developed by the group, the initial goals for improving and maintaining water quality in the watershed were as follows:

Goal 1: Reduce phosphorous loads by 50% by 2015 [from 2004 levels]
Goal 2: Reduce nutrient loads by 25% by 2015 [from 2004 levels]
Goal 3: Reduce *E. coli* loads by 25% by 2015 [from 2004 levels]
Goal 4: Reduce erosion resulting in sediment loads by 50% by 2015 [from 2004 levels]

However, these goals were further refined to meet certain water quality standards in the case of *E. coli* or recommendations for clean water in the case of phosphorus and sediment. Also, the original stakeholders in the first meetings voiced their concern about a lack of information about their watershed; they indicated that educating the watershed residents would be useful. Without knowing what problems exist in their watershed, and without knowing the basics of watershed and water quality science, watershed residents possess little understanding of how to improve or why it is important to improve the water quality in their watershed. To that end, another goal aimed at education has been added. Finally, the stakeholders voiced concerns about recreation on their lakes and the relationship between water quality/water levels and the ability to recreate on the lakes. As a result, the plan includes a goal to address the recreational concerns of the stakeholders.

The final goals for the Five Lakes Watershed are:

Goal 1: Reduce phosphorus loads to streams from 2004 levels by 50% to reach recommended phosphorus concentrations of < 0.075 mg/L (Dodd et al., 1998) by 2015.

Goal 2. Reduce total suspended solid loads to streams from 2004 levels by 50% by 2015.

Goal 3. Reduce E. coli concentrations in waterbodies in the Five Lakes watershed so that water within the streams and lakes meets the Indiana state standards of 235 colonies/100 ml by 2015.

Goal 4. Within four years, 50% of landowners within the Five Lakes watershed will learn and/or implement at least one water quality improvement practice/technique on his/her own property.

Goal 5. Maintain and improve the recreational setting of the Five Lakes watershed by developing and implementing a recreational management plan within five years.

6.1 Prioritization of Water Quality Goals and Objectives

As mentioned above, the Watershed Planning Team was resistant to prioritizing water quality problems from a geographic perspective and similarly, they were unable to identify or select what they felt was the greatest specific water quality problem. Specifically, one of the members asked "Aren't all of the waters in Indiana important and aren't all of these problems significant? They may be doing different damages to the watershed but they all need fixing equally bad". Additionally it was felt that actual implementation would depend greatly on individual landowner willingness to participate and funding opportunities. The Planning Team was willing to prioritize specific objectives under each goal. Results from the meeting where the Planning Team prioritized objectives are found in Appendix J. Though the goals have been revised, the objectives to reach the goals are similar those suggested by the Planning Team. The goals, objectives, action items to achieve the goals and potential goals are provided below.

Goal 1: Reduce phosphorus loads to streams from 2004 levels by 50% to reach recommended phosphorus concentrations of < 0.075 mg/L (Dodd et al., 1998) by 2015.

Goal time frame: Except for annual or continuous tasks, the goal would be reached by 2015.

Associated costs: Evaluated by objective.

Estimated load reduction: The entire watershed is targeted for phosphorus load reductions. However, through the watershed tours and analysis of water quality data from collected during the completion of the water quality sampling portion of this project that certain subwatersheds contribute greater total phosphorus loads than other subwatersheds. Table 37 presents the total phosphorus load average over the four sampling events (two base flow and two storm flows) and the ideal average loads to meet a reduction to stream total phosphorus concentrations of 0.075 mg/L. Dodd et al. (1998) indicate that concentrations of total phosphorus greater than 0.075 mg/L contribute to eutrophication in streams and reduce the ability for some aquatic organisms to survive. To calculate the ideal loads, flows at each sampling site were averaged over all the sampling events. The average flow for each site was multiplied by 0.075 mg/L and a conversion factor (0.0864) to

adjust for seconds to days. Table 37 shows that reducing loads by a watershed average of 50% will achieve and/or exceed the goal of 0.075 mg/L total phosphorus concentration in the streams.Some sites require greater reductions than others. The greatest reductions are required in the upper watershed.

More importantly, this calculation was also completed for base flows and storm flows (Table 37). Total phosphorus loads during base flows did not require reduction; however total phosphorus loading during storm flows requires reductions of greater than 100% for most of the subwatersheds. This is to be expected since it is the storm events that will cause excessive runoff from the watershed, and result in sediment introduction into the streams. Hence, these sediments and the adsorbed phosphorus will enter the streams and be reflected in the sampling effort.

Table 37. Average total phosphorus load, ideal total phosphorus load, and percent reduction required to meet 0.075mg/L concentration in streams.

Site and Subwatershed	TP load (kg/d)	Ideal TP load (kg/d)	% Reduction to meet target (0.075 mg/L) TP concentration
1 (Hutchins)	0.696	0.366	89%
Storm Flow Averaged	1.360	--	271%
Base Flow Averaged	0.031	--	No reduction
2 (Uhl)	0.546	0.310	76%
Storm Flow Averaged	1.041	--	236%
Base Flow Averaged	0.051	--	No reduction
3 (Little Elkhart Creek Headwaters)	1.734	0.873	99%
Storm Flow Averaged	3.436	--	293%
Base Flow Averaged	0.031	--	No reduction
4 (South Milford Tributary)	2.558	1.052	143%
Storm Flow Averaged	2.557	--	143%
Base Flow Averaged	No data	--	--
5 (Upper Little Elkhart Creek)	1.919	1.325	45%
Storm flow Averaged	3.785	--	186%
Base Flow Averaged	0.053	--	No reduction
6 (Adams Lake)	0.286	0.286	No reduction
Storm Flow Averaged	0.563	--	97%
Base Flow Averaged	0.012	--	No reduction
7 (Lower Little Elkhart Creek)	2.295	2.0147	14%
Storm Flow Averaged	4.284	--	113%
Base Flow Averaged	0.305	--	No reduction
8 (Oliver Lake)	1.428	2.229	No reduction
Storm Flow Averaged	2.616	--	17%
Base Flow Averaged	0.240	--	No reduction
Entire watershed	1.433	1.057	36%
Storm Flow Averaged	2.455	--	132%
Base Flow Averaged	0.090	--	No reduction

Potential targets: All the subwatersheds will be targeted; however, emphasis will be placed on the Hutchins, Uhl, Little Elkhart Headwaters, and South Milford tributary subwatersheds. Streambank erosion; wetland restoration; filter strip, buffer, and grassed waterway implementation; and grazing management efforts will be the focus. Reduction of goose populations present adjacent to the lakes

and improvement of existing septic systems should also be targeted. Specific sites for action are identified in Figure 32.

Estimated load reduction: As many of the implementation tasks will result in a reduction in pollutant loads and the volume of pollutant loading reduction that will be observed will depend upon the type of water quality improvement project implemented, the following information sources provide a range of pollutant load reduction values. Current research suggests that the installation of structural management practices, such as wetland restoration or streambank stabilization, may remove more than 80% of the sediment and approximately 45% of the nutrients (Winer, 2000; Claytor and Schueler, 1996; Metropolitan Washington Council of Governments, 1992). Olem and Flock (1990) report 60 to 98% reduction in sediment loading and 40 to 95% reduction in phosphorus loading as a result of utilizing conservation tillage methods. Buffer strips can reduce up to 50% of the phosphorus in runoff according to the Conservation Technology Information Center (2000). Filters strips adjacent to active agricultural row crop fields can reduce total phosphorus concentrations in runoff from 28 to 78 % depending on the type of filter strip implemented (Lowrance et al., 1995). Removal efficiencies depend upon site conditions and factors related to the structure's design, operation, and maintenance. Nutrient removal efficiencies also differ depending upon the form of the nutrient measured. For example, total phosphorus removal efficiencies are often greater than soluble phosphorus removal efficiencies. Specific load reductions estimated for each objective (when possible) are included within each objective's discussion.

With no action: If no action occurs, phosphorus loading will continue to occur at its existing pace and may increase. Without the installation of water quality improvement projects, it is unlikely that water quality within the Five Lakes and their watershed waterbodies will improve.

Objective 1: Exclude livestock from stream bank and lakeside access.

Estimated load reduction: An exact estimate of sediment and phosphorus loading was not completed for the livestock currently pastured adjacent to streams and lakes within the Five Lakes watershed. As such, it is difficult to estimate a reduction in sediment and phosphorus loading that will result from restricting livestock access to waterbodies within the watershed. Michigan DEQ (1999) developed a load reduction calculation form that assists land managers in assessing the ability of various best management techniques to reduce phosphorus loads to water. For example, installation of a waste storage facility can reduce introduction of phosphorus from 1 cow and one offspring from 7 lb/yr to 3 lb/yr. Filter strips along streambanks appear to be more effective and reduce phosphorus loads from 7 lb/yr to 1 lb/yr. Depending on the area treated and the number of cattle or other livestock present, reduction of phosphorus can be substantial.

Using IDEM's load reduction worksheet (Steffen, 1982), it is estimated that livestock access to two areas identified within the Five Lakes watershed results in and annual loading of 109 pounds of phosphorus to the watershed from there areas. (These areas are considered representative for the entire watershed as they include one area with approximately 10 head of livestock adjacent to a stream reach of approximately 200 feet and an area with 2 head of livestock adjacent to a stream reach measuring approximately 100 feet. More areas were identified within the watershed and the results are extrapolated from these two areas.) However, when these calculations are extrapolated for the entire watershed (based on identified facilities only) more than 1,100 pounds of phosphorus are introduced to the watershed from livestock areas. By fencing livestock out of these areas, the load

reduction worksheet estimates that phosphorus loading would decrease to 330 lbs/yr. This would result in approximately 70% lower phosphorus loading to the Five Lakes watershed which would ultimately result in a greater reduction in total phosphorus loading than is prescribed by the current plan.

Estimated Costs: Costs include design of fencing, materials and labor. Costs for materials associated with fencing may be $2/ft. Costs for stabilizing streambanks are discussed in Objective 2.

Actions:
- Identify properties where livestock fencing should occur.
- Work with the NRCS and the associated landowners to identify a feasible solution to restrict livestock access to the associated waterbody.
- Identify an alternate watering source for the livestock.
- Estimate fencing needs for willing landowners.
- Pursue grant money for fencing.
- Hire a contractor to install fencing along specified drainages.

Objective 2: Implement stream bank stabilization.

Estimated load reductions: The current phosphorus contribution from eroding banks at sites identified in Figure 26 has not been calculated; therefore, actual load reductions cannot be determined. It should be noted that most of the areas requiring streambank stabilization are associated with livestock exclusion. This is one reason that load reductions were not calculated for this particular objective. However, Steffen (1982) calculated phosphorus and sediment loads to streams from streambank erosion, and subsequent reduction of loads from stabilizing streambanks. Under conditions of moderate erosion with soil containing about 0.0005 lb of phosphorus per lb soil, stabilizing 200 feet of streambank reduced phosphorus loading by approximately 3.3 lbs/yr and reduce sediment loading by 3.9 tons/yr. This results in approximately a 30% reduction in phosphorus and sediment loading. With this in mind, the watershed group should target a minimum of 400 feet of streambank to reach their phosphorus load reduction goal. The areas of highest priority are mapped in Figure 26.

Estimated Costs: Stabilization of the streambanks with an effective dense and tall herbaceous cover ranges from approximately $22/foot to $56/foot depending on how far the buffer will extend. This cost includes seed, plugs and installation. This does not include the cost for any reshaping of the shoreline, erosion control fabric or coir fiber logs. The following provides additional costs as estimated by JFNew: coir fiber logs (with plants)-$55/foot without volunteer labor, $20/foot with volunteers; willow staking, fascines, or mats-$35/foot without volunteer labor, $5/foot or less with volunteers; bank reshaping, erosion control blanket and seeding-$25/foot without volunteer labor, $10/foot with volunteers; and soil encapsulated lifts-$75/foot without volunteer labor, $35/foot with volunteers.

Actions:
- Identify landowners that are willing to fence livestock from streams and that have streambank erosion occurring as a result of livestock access or those landowners that have streambank erosion issues.
- Pursue grant money for buffer or filter strip installation, or streambank stabilization.
- Install filter strips, buffers or stabilize streambanks along identified sections.

Objective 3: Reduce geese populations on lakeshore properties.

Estimated load reduction: As measured in some wetland ponds, geese increase total phosphorus loading rates by up to 75% (Kitchell et al., 1999). Olson et al. (2005) determined that 85-93% of the phosphorus load to a Pennsylvania reservoir came from geese. Though the authors of these studies established this information on work completed in the western and eastern U.S., it indicates the level of impact that these birds have on aquatic systems. No actual load reductions are calculated for individual lakes in the Five Lakes watershed, but reductions in nutrient loadings could be significant if geese were removed. Eliminating contributions of phosphorus to the lakes from geese could result in reducing the total phosphorus concentration in the lakes. An actual per goose load of total phosphorus cannot be calculated at this time; however, all data indicate that reduction in the goose population by half would result in better water quality within the lakes.

Cost estimate: Per 100 linear feet of buffer, a 5-foot wide buffer would cost approximately $22/linear foot, $40/linear foot for a 10-foot wide buffer, and $56/linear foot for a 15-foot wide buffer. For greater shoreline distances, costs per linear foot would be less. Costs for goose removal and/or egg treatment can be obtained on a per treatment basis from a contractor. Estimates to implement goose removal and relocation at Oliver Lake in 2006 are $1800 to $3500 for all geese identified (Lynn Bowen, personal communication). Treatment is expected to occur this fall and reoccur next spring.

Actions:
- Identify properties in need of buffers.
- Identify funding sources for buffer design and installation.
- Coordinate with property owners for buffer installation.
- Select appropriate sites to serve as demonstration projects and determine the appropriate buffer improvement techniques and plants to be planted.
- Hold a volunteer field day to complete the recommended plantings in and around the Five Lakes.
- Install natural vegetation, which inhibits geese from entering the lake easily. (Install along 35% of lakeshore properties that do not have buffers.)
- Relocate geese and/or implement egg treatment.
- Coordination with Ducks Unlimited and the local IDNR biologist to remove geese.

Objective 4: Implement wetland restoration, if feasible, and maintain the existing sediment traps upstream of the Five Lakes.

Objective notes: In general, 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, thereby protecting

the streams from the energy associated with high flows. Multiple potential wetland restoration projects were identified during the planning process (Figure 26). Individual landowners have expressed a desire to restore wetlands on their properties. However, additional wetland restoration sites may be located throughout the watershed. As such, all of the hydric soils (soils which developed under wetland conditions) are mapped in Figure 13 and should be considered as target areas. It should be noted that the primary areas targeted by this objective are the wetland restoration sites mapped in Figure 26; however, additional wetland restoration opportunities mentioned above are not being ruled out for restoration opportunities.

Estimated load reduction: No model is available to predict a reduction in sediment and phosphorus loading by restoring wetlands in the watershed. The estimated load reduction notes (above) list general research on pollutant removal rates through wetland restoration. As specifics of wetland restoration opportunities are not yet determined for the Five Lakes watershed, load reductions using these values were not calculated as part of this plan.

Estimated costs: Costs to create wetlands vary based on the type of wetland and whether land must be purchased or placed in a conservation easement. If excavation is required to create the wetland costs can even be higher. The cost of wetland creation can range from $20,000 to $35,000 plus the cost of land.

Actions:
- Identify of potential wetland protection, restoration, and creation sites. Particular attention should be paid to the location of the wetland relative to adjacent waterways.
- Design the size, placement, and construction methods required for wetland creation or restoration.
- Develop conservation easements on created and existing wetlands to protect wetlands.
- Coordinate with individuals who have mitigation requirements, if possible.
- Determine if control of exotic/nuisance species is necessary and control these species with the appropriate method (burning, herbicide, hand pulling, etcetera).
- Identify and apply for funding for restoration or creation of wetlands.
- Obtain permits and landowner permission and hire contractors to restore or create wetlands.

Objective 5: Promote the usage of alternative fertilizers and/or the reduction in use of fertilizer.

Objective note: Five Lakes stakeholders have already located a source of phosphorus-free fertilizer. It is available, but there has been little interest in the product. Education and promotion of phosphorus-free fertilizer is integral to achieving this objective.

Estimated load reduction: No actual measurements of soil phosphorus were completed during the planning process. As such, an exact estimate of phosphorus load reduction is not possible. However, Garn (2002) estimated that the use of phosphorus-free fertilizer could reduce phosphorus runoff from near shore lawns by as much as 57%.

Actions:

- Disseminate information explaining how fertilizers impact water quality and the importance of reducing fertilizer usage in the watershed via a newsletter, email list, or other medium. Residential watershed stakeholders should be provided information on how to test their soils to determine the need for phosphorus in residential fertilizer applications and how to obtain phosphorus-free fertilizer. (The local SWCD can provide soil testing information.)
- Explore methods for marketing phosphorus-free fertilizer through the Five Lakes Watershed.

Objective 6: Educate lakeshore residents about what they can do to reduce nutrient loading to the lake.

Actions:

- Identify potential techniques that individual lakeshore residents can do personally to improve water quality within the Five Lakes. Potential techniques include, but are not limited to, establishing shoreline buffers, utilizing phosphorus-free fertilizer, establishing a protocol for yard and pet waste disposal, and encouraging residents to wash cars away from existing drains which flow directly to the lake.
- Work with the SWCD and IDEM Project Manager to locate or develop educational materials addressing shoreline Best Management Practices.
- Host one annual demonstration day highlighting activities that lakeshore residents can complete on their own.

Objective 7: Work with county sanitarian to identify any failing septic systems and promote proper septic system maintenance in the watershed. Work with lake associations throughout the watershed to implement sewer systems, where possible.

Objective note: Figure 11 indicates that portions of the watershed are mapped in a soil unit that is considered moderately to severely limited for septic systems. The areas mapped in the severely limited soil unit and those closest to the watershed's waterbodies should be targeted for septic system maintenance and/or sewer installation first.

Estimated load reduction: Grant (1988) established that each person contributes 1 pound (453,592 mg or 0.454 kg) of phosphorus per year through a septic system. The study also established that leachate enters lakes from septic systems; however, an estimate of the amount of leachate entering the study lakes was not presented. Properly functioning enhanced septic systems can reduce phosphorus loading by 95% (Colorado Department of Public Health and Environment, 1999), but these are not the typical systems installed by many homeowners. A community with a connected sewer system would eliminate contribution of nutrients by 100% over a period time. However, nutrients held by soils could remain for some time and be released slowly.

Actions:

- Work with the Noble and Lagrange County Health Departments to identify any failing septic systems in the watershed, targeting the areas noted above first.
- Develop list/summary of "Best Management Practices" available to reduce the risk of pathogenic contamination of watershed waterbodies. The list should include management techniques that address contamination from all sources, including domestic and wild animals, in the watershed. Additionally, the list should be written in language that is understood by a non-technical audience.

- Disseminate the list/summary of "Best Management Practices" available to reduce the risk of pathogenic contamination of watershed waterbodies via an email distribution list, newsletter, or other medium.
- Work with lake associations throughout the watershed to complete sewer system feasibility studies.

Objective 8: Reduce contamination from urban sewage system infrastructure.

Objective note: This objective involves point source inputs at Wolcottville and South Milford and monitoring the Little Elkhart River below the Adams Lake Sewage Treatment system to determine if phosphorus concentrations exceed recommended levels of 0.075 mg/L.

Estimated load reduction: Load calculations cannot be provided for this objective because phosphorus and sediment concentration and loading from the stormwater pipes at Wolcottville and South Milford and below the Adams Lake Sewage Treatment Plant and Lagoon have not been measured adequately.

Actions:
- Map the location of storm water pipes at Wolcottville and South Milford.
- Monitor concentration of phosphorus and measure flows of at storm water pipe outlets.
- Determine if storm water can be directed to constructed wetland or other detention feature through discussion with municipality.
- Complete feasibility study to determine how rain gardens and filter swales can be used in Wolcottville to reduce storm water discharge into the Little Elkhart River.
- Continue to monitor water quality below Adams Lake Sewage System discharge in Little Elkhart River.
- Compare phosphorus loads from monitoring to estimated load from Adams Lake Sewage System NPDES discharge permit (1 mg/L allowed in effluent).

Objective 9: Enroll willing landowner in the CRP program, review farmland in CRP program, and promote other practices to reduce phosphorus loads to streams.

Estimated load reduction: Exact load reductions will depend upon the BMP utilized and acreage to which the BMP is applied. An example load reduction calculation for converting a portion of a row cropped field to pasture (CRP) was completed for the Five Lakes watershed. The example utilizes IDEM's pollutant load reduction workbook. Revised Universal Soil Loss Equation (RUSLE) parameters were taken from the U.S. Environmental Protection Agency's STEPL (Spreadsheet Tool for the Estimation of Pollutant Load) model. Using the IDEM pollutant load reduction model, converting 100 acres of row crop land to pasture will result in a reduction of 96 tons of sediment per year, 134 pounds of phosphorus per year, and 268 pounds of nitrogen per year.

It should be further noted that all items listed above including livestock restriction, wetland restoration, and buffer and filter strip installation are part of the Conservation Reserve Program. As such, load reductions were calculated for each of these items above and should be used for this objective as well. Additional reduction can occur when conservation tillage or other CRP items are implemented. The numbers used below for implementation are estimates based on input from what

stakeholders thought were appropriate. These numbers should be used as a guideline and are therefore not included in phosphorus load reduction estimates.

Cost estimates: Costs will be based on individual task basis and can likely be provided by the SWCD for the current year's payment based on location, area history, and soil type.

Actions:
- Attend local SWCD meetings.
- Identify agricultural producers who are using no-till and other conservation practices.
- Facilitate interaction between those producers using conservation practices and other landowners interested in adopting conservation practices by hosting one demonstration day annually.
- Apply for cost-share funding to install practices. Target enrollment of 25 new landowners with at least fifteen establishing forested riparian buffers totaling 500 lineal feet.
- Review existing CRP enrolled filter strips and other items paid for through the WLT program to evaluate maintenance and condition.
- Conduct one annual field day to demonstrate practices for agricultural producers and watershed residents.

Objective 10: Identify and map all surface and subsurface drains that discharge to the Five Lakes and their tributaries

Estimated load reduction: Load calculations cannot be provided for this objective because it targets identification and mapping only. No implementation actions are included for this objective at this time.

Actions:
- Work cooperatively with the county drainage boards to identify locations of known surface and subsurface drains based on county drainage board maps and personnel's field knowledge of the watershed.
- Identify all property owners along Little Elkhart Creek, its tributaries, and other drainages to the Five Lakes using plat maps and information from the county assessor's office. A portion of this action item has been completed during the development of this watershed management plan.
- Identify which portions of the Five Lakes tributaries are legal drains on which the county might hold easements to access the waterbody.
- Obtain permission to survey the entire length of the open streams and tributaries.
- Survey the entire length of streams and its tributaries. Surveys should be conducted from within the stream itself where possible.
- Enter data/map locations of all surface and subsurface drains in a GIS or similar system. Attributes such as size of pipe/ditch, whether it is a surface or subsurface drain, whether it carries water continuously or is simply a wet-weather conduit, and potential pollutants associated with it should be attached to the location information for each drain.

Objective 11: Quantify pollutant (sediment, nutrients, and bacteria) loads from all storm drains that discharge to the Five Lakes and other lakes within the watershed.

Estimated load reduction: Load calculations cannot be provided for this objective because this objective targets mapping and identification items only. No implementation items are included for this objective at this time.

Actions:
- Identify all storm drains entering the Five Lakes and other lakes within the watershed.
- Develop a spreadsheet/database containing the location of all storm drains.
- Enter data/map or update maps of the storm drains. Attributes such as size of pipe, area of drainage, whether it carries water continuously or only during wet weather, and potential pollutants associated with it should be attached to the location information for each drain.
- Identify funding sources to support sampling efforts.
- Develop a plan to measure pollutant loads. Sampling protocol will have to be developed once the nature and location of storm drains is known (i.e. some drains may not be accessible to sampling while others may only carry water during storm events). Sampling protocol will depend upon the funding available to sample identified storm drains.
- Develop spreadsheet/database to hold sampling results.
- Disseminate results of this sampling to watershed stakeholders in a watershed stakeholder meeting. Future versions of the watershed management plan should include methods for addressing storm drain pollutant loads, if necessary, and a prioritization of which drains should be addressed first.

Objective 12: Monitor the phosphorus load of each of the eight stream sampling sites used during the development of this plan and total phosphorus concentration in each of the Five Lakes.

Objective notes: Monitoring should be completed monthly during the growing season (May to October) and quarterly the remainder of the year.

Actions:
- Identify individuals to complete the Hoosier Riverwatch and Indiana Clean Lakes Program Volunteer Monitoring Program training.
- Complete Hoosier Riverwatch and ICLVMP monitoring on a monthly or quarterly basis.
- Maintain a water quality sampling database to track results to allow comparison.
- Compare results from the lifetime of sampling.
- Publish sampling results to the watershed group (Goal 4) and in the local newspaper.

Goal 2. Reduce total suspended solid loads to streams from 2004 levels by 50% by 2015.

Goal time frame: Except for annual and continuous tasks, the goal should be reached by 2015.

Associated cost: Evaluated by objective.

Estimated load reduction: The entire watershed is targeted for sediment load reductions, but particular emphasis will be placed on the upper watershed. A review of the watershed tours

information and analysis of water quality data collected during the water quality sampling portion of this project shows that contribution of sediments during storm flows is substantial, and is more prevalent in the upper watershed than the lower watershed. Table 38 presents the average sediment load measured as total suspended solids (TSS) over the four sampling events (two base flow and two storm flows) and the ideal average loads to meet a reduction of TSS loading by 50%.

Table 38. Average TSS load and ideal TSS load required to meet 50% load reduction in streams.

Site and Subwatershed	TSS load (kg/d)	Ideal TSS load (kg/d)	% Reduction to meet target TSS level
1(Hutchins)	103.14	51.57	50%
Storm Flow Averaged	204.65	102.33	50%
Base Flow Averaged	1.63	0.82	50%
2 (Uhl) -Flows Averaged	78.095	39.04	50%
Storm Flow Averaged	152.87	76.434	50%
Base Flow Averaged	3.32	1.66	50%
3 (Little Elkhart Creek Headwaters)	203.49	101.74	50%
Storm Flow Averaged	405.54	202.77	50%
Base Flow Averaged	1.44	0.72	50%
4 (South Milford Tributary)	332.90	166.45	50%
Storm Flow Averaged	332.90	166.45	50%
Base Flow Averaged	--	--	--
5 (Upper Little Elkhart Creek)	173.76	86.88	50%
Storm flow Averaged	341.36	170.68	50%
Base Flow Averaged	6.16	3.08	50%
6 (Adams Lake)	37.07	18.53	50%
Storm Flow Averaged	73.19	36.59	50%
Base Flow Averaged	0.95	0.47	50%
7 (Lower Little Elkhart Creek)	312.065	156.03	50%
Storm Flow Averaged	612.42	306.21	50%
Base Flow Averaged	11.71	5.85	50%
8 (Oliver Lake)	209.55	104.77	50%
Storm Flow Averaged	400.31	200.15	50%
Base Flow Averaged	18.79	9.39	50%
Entire Watershed	160.45	80.22	50%
Storm Flow Averaged	315.4	157.70	50%
Base Flow Averaged	5.5	2.75	50%

The stakeholders identified reduction of sediment in their watershed as one of their original goals. They recognized that the presence of turbid waters indicates that something is wrong with the watershed. (There is a relationship between turbidity and TSS within an order of magnitude (Dodd and Whiles, 2004.) Because phosphorus adheres to sediment, reducing sediment loads to a stream will result in phosphorus loads being reduced as well. Also, other states have as their standards for stream water quality TSS levels that are substantially less than 80 mg/L. Some of these standards are as low as 10 mg/L. Furthermore, drinking water regulations in the United States require that water not exceed 5 NTU (which is a measurement of turbidity). Based on work completed by Dodd and Whiles (2004), approximately 19 mg/L of TSS is equivalent 5 NTU. Though no one should be drinking water directly from the streams and lakes in the Five Lakes Watershed, having water with

low TSS, and therefore low turbidity, is a goal that can ensure human safety, aquatic life sustainability, and recreational satisfaction. Therefore, we started with a target of 20 mg/L within each of the streams. Most of the streams already possess concentrations less than this. Based on this issue and the fact that we are targeting a 50% reduction in total phosphorus, stakeholders chose to target a 50% reduction in sediment as well. Table 38 details the required reductions at each sampling site to meet an overall reduction of 50% of sediment loading.

Potential load targets: All the subwatersheds will be targeted; however, emphasis will be placed on Hutchins, Uhl, Little Elkhart Headwaters, and South Milford tributary subwatersheds. Streambank erosion, wetland restoration, filter strips and buffers, grazing management efforts, and ways to improve stormwater runoff below Wolcottville will be the focus. Specific sites for action are identified in Figure 32.

Estimated load reductions: Estimated load reductions are provided by objective.

With no action: If no action occurs, sediment loading will continue to occur at its existing pace and may increase.

Objective 1: Exclude livestock from stream bank and lakeside access.

See Goal 1 for information and action items relative to this objective.

Objective 2: Implement stream bank stabilization.

See Goal 1 for information and action items relative to this objective.

Objective 3: Implement wetland restoration.

See Goal 1 for information and action items relative to this objective.

Objective 4: Enroll willing landowner in the CRP program, review farmland in CRP program, and promote other practices to reduce sediment loads to streams.

See Goal 1 for information and action items relative to this objective.

Objective 5: Reduce contamination from storm water and sewer system infrastructure.

See Goal 1 for information and action items relative to this objective.

Objective 6: Reduce erosion from active construction sites.

Objective notes: This objective deals with the both the education of the watershed group and of developers in the area. As such, specific on-the-ground implementation tasks are not a part of this objective. Future iterations of the Five Lakes Watershed Management Plan should account for any potential implementation practices and associated costs and sediment load reduction as information becomes available.

Actions:

- Become familiar with typical erosion control practices used at both small (1 acre) and large (>5 acres) construction sites.
- Work with county officials to require erosion control on all construction sites regardless of whether it is required by the state under Rule 5.
- Work with county officials to implement strict erosion control ordinances that include provisions requiring site clearing to be done in phases, eliminating the possibility of complete site clearing.
- Work with state and county officials to ensure that Rule 5 is being adhered to at all sites under which it is applicable.
- Develop a system of recognition for county builders actively implementing erosion control practices on active construction sites.

Objective 7: Work with Lagrange and Noble County officials to increase awareness of any proposed development within the Five Lakes watershed.

Actions:

- Currently, the Five Lakes watershed is not experiencing significant development pressure. However, establishing a good working relationship with Lagrange and Noble County planning officials is recommended. Therefore, watershed residents should attend at least one Noble County planning meeting and one Lagrange County planning meeting annually.

Objective 8: Encourage county officials to maintain vegetated riparian buffer along legal drains and to reduce the use of chemical applications along Five Lakes' waterbodies.

Actions:

- Meet with the Lagrange and Noble County Surveyors to determine the maintenance schedule for legal drains within the Five Lakes watershed.
- Attend one Lagrange County Drainage Board meeting and one Noble County Drainage Board meeting annually.

Objective 9: Monitor the sediment load of each of the eight stream sampling sites used during the development of this plan and water clarity (Secchi disk transparency) in each of the Five Lakes.

Objective notes: Monitoring should be completed monthly during the growing season (May to October) and quarterly the remainder of the year.

Actions:

- Identify individuals to complete the Hoosier Riverwatch and Indiana Clean Lakes Program Volunteer Monitoring Program training.
- Complete Hoosier Riverwatch and ICLVMP monitoring on a monthly or quarterly basis.
- Maintain a water quality sampling database to track results to allow comparison.
- Compare results from the lifetime of sampling.
- Publish sampling results to the watershed group (Goal 4) and in the local newspaper.

Goal 3. Reduce *E. coli* concentrations in waterbodies in the Five Lakes watershed so that water within the streams and lakes meets the Indiana state standards of 235 colonies/100 ml by 2015. This will on average result in nearly a 95% reduction in *E. coli* loading throughout the watershed.

Goal time frame: This is a long-term goal. The goal should be reached by 2015. The tasks associated with Total Maximum Daily Load (TMDL) development are subject to the development schedule of IDEM. Lakes within this portion of the Elkhart River watershed are slated for TMDL development; however, an exact date for which development is planned has not yet been determined. The following items can be implemented to reduce *E. coli* concentrations whether a TMDL is ultimately developed or not.

Goal notes: Many of the objectives included for Goals 1 and 2 will also help to reduce the concentration of *E. coli* within the waterbodies of the Five Lakes watershed. Completing specific tasks including excluding livestock from waterbodies within the watershed; reducing lakeshore geese populations; identifying and correcting failed septic systems and/or implementing sewer systems throughout the watershed; reducing the contribution from point sources (town or lake sewers); and establishing buffers adjacent to lakes and streams within the watershed will increase the likelihood of meeting this goal as well. Other potential tasks should target education of watershed residents and participation in development of the *E. coli* Total Maximum Daily Load (TMDL) for the Elkhart River watershed.

Associated costs: All of the tasks associated with this goal will utilize personal time. Actual dollar costs associated with educational tasks are low, totaling less than $5,000 over the next ten years.

Estimated load reduction: As this is an educational goal and all implementation projects are included as part of Goals 1 and 2. However, the entire watershed is targeted for *E. coli* load reductions, but particular emphasis will be placed on the upper watershed. A review of the watershed tours information and analysis of water quality data collected during the water quality sampling portion of this project shows that contribution of *E. coli* during storm flows is substantial, and is more prevalent in the upper watershed than the lower watershed. Table 39 presents the average *E. coli* load measured over the four sampling events (two base flow and two storm flows) and the ideal average loads to meet a reduction of *E. coli* loading to reach the state standard of 235 colonies/100 mL.

Potential targets: Specific targets associated with this goal include the entire Five Lakes watershed and all of its stakeholders.

With no action: If water quality improvement projects, such as livestock fencing upstream of Shockopee Lake and along watershed streams are not implemented it is anticipated that *E. coli* concentrations will likely remain at their current levels or increase as erosion continues and population levels increase throughout the watershed.

Table 39. Average *E. coli* load and ideal *E. coli* load required to meet the 235 colonies/100 mL concentration (nearly 95% load reduction) in watershed streams.

Site and Subwatershed	*E. coli* load (mil col/d)	Ideal *E. coli* load (mil col/d)	% Reduction to meet target *E. coli* level
1(Hutchins)	770.5	11.1	98.6%
Storm Flow Averaged	1539.0	21.9	98.6%
Base Flow Averaged	1.9	0.3	84.2%
2 (Uhl) -Flows Averaged	142.7	9.7	93.2%
Storm Flow Averaged	280.0	18.4	93.4%
Base Flow Averaged	5.3	1.0	81.1%
3 (Little Elkhart Creek Headwaters)	436.9	27.4	93.7%
Storm Flow Averaged	873.0	54.4	93.8%
Base Flow Averaged	0.8	0.3	60.0%
4 (South Milford Tributary)	387.0	32.9	91.5%
Storm Flow Averaged	387.0	32.9	91.5%
Base Flow Averaged	--	--	--
5 (Upper Little Elkhart Creek)	101.7	41.5	59.2%
Storm flow Averaged	201.0	81.1	59.7%
Base Flow Averaged	2.3	1.9	17.4%
6 (Adams Lake)	16.0	9.0	44.1%
Storm Flow Averaged	31.5	17.4	44.8%
Base Flow Averaged	0.50	0.50	0.0%
7 (Lower Little Elkhart Creek)	2157.2	63.1	97.1%
Storm Flow Averaged	4294.0	116.4	97.3%
Base Flow Averaged	20.3	9.8	51.7%
8 (Oliver Lake)	203.2	69.8	65.6%
Storm Flow Averaged	385.0	125.1	67.5%
Base Flow Averaged	21.4	14.5	32.2%
Entire Watershed	599.9	36.5	93.9%
Storm Flow Averaged	1137.0	64.3	94.3%
Base Flow Averaged	8.7	4.6	46.5%

Objective 1: Learn more about identifying the sources of *E. coli* from the Total Maximum Daily Load development process for the Elkhart River. (The Elkhart River is on the 303(d) list for *E. coli* contamination.)

Actions:

- Attend and participate in the Total Maximum Daily Load development process for the Elkhart River.
- Create and distribute TMDL meeting minutes to watershed stakeholders.

Objective 2: Publicize Best Management Practices available to reduce pathogenic contamination of the Five Lakes watershed waterbodies.

Actions:

- Meet with the Lagrange and Noble County Health Departments to discuss Best Management Practices available to maintain properly functioning septic systems.

- Develop a list or summary of Best management Practices available to reduce the risk of pathogenic contamination of watershed waterbodies. The list should include management techniques that address contamination from all sources, including domestic and wild animals in the watershed.
- Publish a newspaper particle targeting the list or summary of Best Management Practices available to reduce the risk of pathogenic contamination of watershed waterbodies.

Objective 3: Monitor the *E. coli* load of each of the watershed stream sampling sites as used for development of this plan.

Objective notes: Monitoring should be completed monthly during the growing season (May to October) and quarterly the remainder of the year.

Actions:
- Identify individuals to complete the Hoosier Riverwatch *E. coli* training.
- Complete Hoosier Riverwatch monitoring on a monthly or quarterly basis.
- Maintain a water quality sampling database to track results.
- Compare results from the lifetime of sampling.
- Publish sampling results to the watershed group (Goal 1) and in the local newspaper.

Goal 4. Within four years, 50% of landowners within the Five Lakes watershed will learn and implement at least one water quality improvement practice/technique on his/her own property.

Goal time frame: Except for annual or continuous tasks, the goal should be reached by 2010.

Goal notes: This goal is ultimately targeted at educating individual stakeholders within the Five Lakes watershed. The actual implementation of the practice or technique will be handled by the landowner themselves. Specific grants or cost-share programs may be available for the implementation of these practices or techniques. However, as all of the objectives and action items target education, associated costs for this goal also target education not implementation.

In order for educational efforts to be developed and practices to be implemented, a watershed group representing the various lake associations, interested groups and individuals, and local and state governmental entities should form a stable watershed group. As a small group of individuals have attended all of the watershed planning meetings to date, these individuals will likely be charged with maintaining the current attendance standard and will need to work with other community members to boost interest and participation in project implementation phase of this project. The core group of individuals working on planning in the Five Lakes watershed should always contain a representative from the Five Lakes Conservation Association and the Noble and Lagrange County SWCDs. Meeting this goal requires that a core group of individuals begin implementation of this plan and that these individuals meet at least on a quarterly basis.

Associated cost: This goal is targeted at educating individuals within the Five Lakes watershed. As such, educational efforts will be targeted at items that will result in reduced nutrient, sediment, and pathogen loads as described in Goals 1 through 3. Specific implementation items will not be

described here. Rather, the actual implementation of the practice or technique will be handled by the landowner themselves. Those techniques are described in Goals 1 through 3. Specific grants or cost-share programs may be available for the implementation of these practices or techniques. However, as all of the objectives and action items target education, associated costs for this goal also target education not implementation. In regards to sampling equipment, the Lagrange County SWCD maintains a set of Hoosier Riverwatch sampling equipment, which the Five Lakes watershed group could borrow for use during stream monitoring. The Indiana Clean Lakes Program provides lake monitoring equipment to the Five Lakes Conservation Association free of charge. Multiple lakes within the Five Lakes watershed already possess this equipment and could share it with other interested lake associations/groups.

Estimated load reduction: A load reduction cannot be attributed to this goal or any of its objectives or action items. As this goal deals specifically with education, pollutant load reduction is not the ultimate goal. However, as many of the implementation tasks will result in a reduction in pollutant loads and the volume of pollutant loading reduction that will be observed will depend upon the type of water quality improvement project implemented. For specific load reductions based on the type of practice implemented, see Goals 1 through 3.

Potential targets: This goal targets the entirety of the Five Lakes watershed and all of the individuals which live within it. This goal is designed to bring together community members, county officials, and individuals living in the Five Lakes watershed. Their work towards forming a cohesive group directed at improving water quality and way of life within the Five Lakes watershed will provide longevity for the Five Lakes Watershed Management Plan.

With no action: With no additional education, watershed landowners will continue to be informed by the Five Lakes Conservation Association, individual lake associations and groups, and by the Lagrange and Noble County SWCD and NRCS offices. However, it is unlikely that each and every landowner within the watershed will learn and/or implement a water quality improvement project as they will not all be exposed to the educational materials. Without the installation of water quality improvement projects, it is unlikely that water quality within the Five Lakes watershed will improve.

If the Five Lakes watershed group does not continue to meet, then there will be no checks or balances on any of the activities identified as part of this plan. Likewise, individual's completing work items through this plan will not have a forum to discuss successes or failures. Additionally without an established watershed group, a mechanism to implement projects related to this plan or to review and update the plan will not be in place.

Objective 1: Establish a core group of individuals willing to work together to generate interest in the watershed management plan, coordinate implementation of the plan, and discuss watershed management issues and water quality concerns in the watershed.

Actions:

- Contact potential core group members including the local IDNR conservation officer, high school biology teacher, County SWCD, or other community and conservation groups active in the watershed.
- Advertise the formation of the group in local newspapers and mailing to stakeholders.
- Host regular water quality meetings in various locations throughout the watershed.

- Biannually, invite local, regional, and state natural resources professionals to attend watershed group meetings. Hold discussions dealing with local and state efforts/events highlighting water quality (including regulatory efforts) and resources available to assist watershed groups.
- Publish meeting minutes via an email list, newsletter, and/or website. These publications should include information detailing current and future efforts at improving water quality, the aesthetic value of a healthy watershed, and information on how stakeholders may get involved in these efforts.

Objective 2: Organize and hold one annual field day highlighting the value of the streams and lakes in the Five Lakes watershed and how to protect the water quality and aquatic life of the watershed.

Actions:
- Work with the NRCS and SWCD representatives to identify members of the agricultural community in the watershed who are participating in a conservation program or utilizing conservation tillage. Work with those individuals to hold demonstrations on their properties.
- Invite IDNR biologists or other experts to speak at field days, particularly concerning the value of the waterbodies of the Five Lakes watershed.
- Advertise the field days via press releases to the local media, an annual newsletter, and/or mailings to stakeholders using the existing stakeholder database and SWCD contacts.

Objective 3: Publicize the value of the Five Lakes watershed, its waterbodies, and of ways to protect its water quality and aquatic life through various forms of media.

Actions:
- Develop a list of "Best Management Practices" that protect water quality in nearby waterways for agricultural land.
- Develop a list of "Best Management Practices" that protect water quality in nearby waterways for residential land.
- Summarize the value of the Five Lakes watershed and the Five Lakes watershed group in language understood by a non-technical audience.
- Develop a system of mailing information to residents on the water quality of the Five Lakes watershed and information on how individuals can help to improve water quality.
- Publish an annual newsletter containing information outlined in the first three action items of this objective.
- Develop a web site containing information outlined in the first three action items of this objective.

Objective 4: Work with the NRCS, SWCD, and agricultural property owners in the watershed to promote water quality Best Management Practice in the watershed.

Actions:
- Work with the NRCS and SWCD to identify which property owners in the Five Lakes watershed are using conservation tillage methods and/or land conservation programs. Where possible or appropriate, assist the NRCS and SWCD in encouraging agricultural property owner's not using conservation tillage or not participating in conservation programs to utilize these programs.

- Work with NRCS and SWCD representatives to hold one demonstration day annually on properties where landowners are implementing conservation tillage methods and/or land conservation programs. This effort will help advertise available methods to reduce soil loss from land and pollutant loading to local streams.
- Attend local SWCD meetings.

Objective 5: Work with the NRCS, SWCD, and residential property owners in the watershed to promote residential water quality Best Management Practices in the watershed.

Actions:
- Work with the NRCS and SWCD to develop a list of potential activities that residential property owners can do to improve water quality within the Five Lakes watershed.
- Work with NRCS and SWCD representatives to hold one demonstration day annually on residential properties where landowners are implementing water quality improvement projects. This effort will help advertise available methods to reduce soil loss from land and pollutant loading to local streams.
- Locate and develop a list of potential grant monies for residential water quality improvement project implementation.

Objective 6: Establish and maintain a watershed and water quality education table at the Lagrange and Noble County Fairs.

Actions:
- Talk with fair representatives to determine the feasibility of establishing a table or booth at the Lagrange and Noble County Fairs to target watershed and water quality education.
- Work with the NRCS, SWCD, and IDEM Project Manager to develop program materials and handouts for the table or booth.
- Establish a core group of individuals to manage the table or booth during the fair and provide educational information to attendees on the watershed, water quality, and the watershed management planning process.

Objective 7: Develop a volunteer monitoring network through Hoosier Riverwatch.

Actions:
- Identify groups (local schools, Girl/Boy Scouts, 4-H groups, other community groups) that may be interested in participating in volunteer monitoring.
- Identify landowners in the Five Lakes Watershed who may be willing to allow a group of volunteers to perform water quality monitoring of streams on their property.
- Attend Riverwatch training sessions.
- Advertise results of sampling to the community through various media outlets mentioned in Objective 1.
- Enter results of the sampling efforts into the Hoosier Riverwatch online database.

Objective 8: Develop a volunteer monitoring network through the Indiana Clean Lakes Program.

Actions:

- Identify groups (local schools, Girl/Boy Scouts, 4-H groups, other community groups) that may be interested in participating in volunteer monitoring.
- Attend Clean Lakes Program training sessions.
- Advertise results of sampling to the community through various media outlets mentioned in Objective 1.
- Enter results of the sampling efforts into the Clean Lakes Program online database.

Goal 5. Maintain and improve the recreational setting of the Five Lakes watershed by developing and implementing a recreational management plan within five years.

Goal time frame: Except for annual or continuous tasks, the goal should be reached by 2011.

Goal notes: This goal is targeted at addressing all recreational issues identified by watershed stakeholders. The goal will be met when a recreational plan for the Five Lakes has been developed or when the Five Lakes Conservation Association has addressed each of the items listed below. Each objective targets a specific type of recreational issue. Specific objectives and action items which target water quality improvements to generate improved recreation are found under Goals 1 through 3.

Associated costs: All of the tasks associated with this goal will utilize personal time. Actual dollar costs associated with water quality improvement project implementation are found under Goals 1 through 3, while educational effort costs are found under Goal 4. Some tasks may require funding for the actual implementation of the item. The associated cost cannot be determined at this time as some background work must first be completed to identify the specific item for implementation.

Estimated load reduction: There is no exact load reduction that can be calculated for this goal. As this goal deals specifically with recreation and in-lake issues, pollutant load reduction is not the ultimate goal. However, as many of the implementation tasks will result in a reduction in internal pollutant loads, the volume of pollutant loading reduction that will be observed will depend upon the type of water quality improvement project implemented. Again, as specific items to be implemented are in included with this goal an estimate of load reduction cannot be generated at this time.

Potential targets: The entire watershed and all of the watershed waterbodies are targeted by this goal. Specifically the Five Lakes are listed in this text; however, any of the lakes within the watershed can implement these items.

With no action: With no additional recreational planning, recreational issues within the Five Lakes and other lakes within the watershed will continue to be plagued by the same recreational issues. Ultimately, it is unlikely that water quality within the Five Lakes will improve without the implementation of some of these recreational planning items.

Objective 1: Develop an aquatic plan management plan and implement the recommendations defined in that plan.

Objective notes: Any treatment of exotic or invasive species that occurs on the Five Lakes will serve to reduce the spread of the exotic or invasive species within the immediate chain. However, if lakes upstream of the Fives Lakes possess resident populations of these plants, the plants will eventually re-occur within the Five Lakes. Steps should be taken to implement aquatic plant management efforts throughout the watershed to increase the impact of plant control efforts.

Actions:

- Complete aquatic plant surveys as required by the LARE program. These surveys should be completed between May 15 and June 15 and again between July 15 and August 30 each year.
- Host a meeting which includes representatives from each of the Five Lakes and their lake associations to discuss recommendations for aquatic plant treatment within the Five Lakes.
- Work with the IDNR Regional Fisheries Biologist and LARE program staff to develop a work plan for aquatic plant treatment or in-lake and shoreline planting, as necessary.
- Review, update, and implement actions, as appropriate, as stated in the Five Lakes Aquatic Plant Management Plan, once developed.
- Educate property owners and the general public on aquatic plant issues, such as value of aquatic plants as habitat, prevention of the spread and transfer of invasive species, and aquatic plant control methods.
- Apply for funding to implement the recommended treatment regime. (Note: The LARE program provides funding for surveys and treatment. Contact the LARE program staff for specific funding information for that fiscal cycle.)

Objective 2: Develop a boating use/recreation plan. A number of items should be included in this plan. The following sub-objectives outline just some of the information necessary to address boating issues on the Five Lakes.

Objective notes: The Lakes Management Work Group and others have discussed whether it may be possible to identify a boat number per acre that defines thresholds for negative impacts. No studies have been conducted in the state of Indiana to determine the watercraft capacity of natural lakes for ecological, aesthetic or recreational purposes. However, the Steuben County Lakes Council and the Lagrange County Lakes Council are in the process of completing a study to determine this information. It may be reasonable to predict that more boats on the water will detract from user satisfaction, diminish aesthetic values, add to ecological impacts, and increase safety issues.

Even if boating capacity were defined, it may be difficult to enforce numerical limits. The watercraft capacity issue might be better served by addressing any development that will exponentially increase boat numbers per riparian lake front acreage such as condominiums, campgrounds, and other new housing developments in and around the lake with deeded lake easements and boat piers. Future consideration of regulating lakeshore owners for the number of watercraft docked at a pier or in use at one time may also be necessary.

Sub-Objective 2-A: Determine the number of users that are appropriate for the Five Lakes.

Actions:
- Conduct a literature search to review research available from other states on watercraft capacity in lakes so that this information can be extrapolated to the Five Lakes.
- Design and conduct a survey to determine the impacts of watercraft crowding on ecological, aesthetic, safety, and recreational user satisfaction.
- Should survey results indicate overcrowding, restrict parking, fishing tournaments and non-resident use of the lake.
- Monitor transient use of lake for 3 – 5 years.

Sub-Objective 2-B: Educate lakeshore residents and lake users in regards to Indiana's boating laws and develop a plan to ensure compliance with these laws.

Actions:
- Encourage boaters to take boater education courses and follow all regulations.
- Sponsor boater education courses in conjunction with an event to gain larger attendance.
- Provide boater educational handouts at all local events.
- Develop plan with Sheriff to enforce laws and increase lake patrols.
- Utilize new LARE funds available to the County Sheriff to train deputy law enforcement officers specifically for patrolling the lakes.
- Obtain funding to employ a law enforcement person.

Sub-Objective 2-C: Educate lake users on the negative impacts (agitation and resuspension of sediment and nutrients from the lakebed) of boating in shallow waters.

Actions:
- Encourage boaters to reduce speeds over shallow water through education and use of local law enforcement.
- Explore establishment of ecological protection zones to protect bulrush and other habitat in shallow waters around selected areas of the lake.
- Dredge areas of accumulated sediment that are not identified as ecological protection zones

Sub-Objective 2-D: Address fuel contamination issues, which result from boats with poorly maintained or older engines and also occur during refueling.

Actions:
- Place warning and informational signs at marina(s) encouraging boaters to take care when refueling.
- Encourage watercraft owners to maintain or replace older engines.
- Work with the public or commercial facilities to minimize fuel spills during in-lake refueling.
- Support restrictions on group piers to limit fuel spills
- Work with marina(s) to post warning signs concerning fuel spills
- Submit proposal that fuel contamination be added to county ordinances regarding group pier issues.

Sub-Objective 2-E: Track the impact of group piers, funneling, and boating speed limits on lakes throughout northern Indiana. Participate in efforts of the Lagrange County Lakes Council and the Indiana Lakes Management Society to reduce the negative impact of these items on lakes throughout the county and state.

Actions:
- Attend ILMS meetings and workshops to track progress of these items.
- Review the progress of the Indiana Lakes Management Work Group and convey information to lakeshore residents and users.

Objective 3: Monitor and improve the fish community within the Five Lakes and other lakes within the Five Lakes watershed.

Actions:
- Work with the IDNR Regional Fisheries Biologist to monitor the fish community present within the watershed lakes.
- Determine what actions, if any, the residents can implement to improve the game fish community within the Five Lakes.
- Implement water quality improvement projects as discussed in Goals 1 through 3 to assist with improving water quality within the lakes.

Objective 4: Determine the amount of accumulated sediment at the mouth's of inlets throughout the watershed and develop a plan to remove this accumulated sediment.

Actions:
- Map sediment accumulated at inlet mouths.
- Determine appropriate methodology for removing sediment.
- Develop sediment removal plan including disposal location, funding sources, and amounts and characteristics of sediment to be removed.
- Apply for and obtain funding for sediment removal.
- Complete sediment removal.

7.0 MEASURING SUCCESS

Measuring stakeholders' success at achieving their goals and assessing progress toward realizing their vision for the Five Lakes watershed is a vital component of the plan. The following describes concrete milestones for stakeholders to reach and tangible deliverables produced while they work toward each goal. Interim measures or indicators of success, which will help stakeholders evaluate their progress toward their chosen goals, are included in the Action Register contained in Appendix K. Monitoring plans, where appropriate, to evaluate whether or not stakeholders have attained their goals are also included below. Because several of the goals are long-term goals (i.e. it will take more than 5 years to attain), regular monitoring is essential to ensure the actions stakeholders take are helping achieve those goals. Monitoring will allow stakeholders to make timely adjustments to their strategy if the monitoring results indicate such adjustments are needed. Finally, potential funding sources for implementing these projects are included in Appendix L.

Goal 1: Reduce phosphorus loads to streams from 2004 levels by 50% to reach recommended phosphorus concentrations of < 0.075 mg/L (Dodd et al., 1998) by 2015.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2015.)

- Landowners contacted regarding potential livestock exclusion.
- Plans developed for livestock exclusion.
- Funding obtained for livestock exclusion.
- Contractor for livestock exclusion installation hired.
- Landowners contacted regarding streambank stabilization/buffer installation.
- Grant monies applied for and obtained for streambank stabilization.
- Filter strips, buffer strips, and streambank stabilization implemented.
- Properties in need of buffer installation adjacent to the lakeshore identified.
- Landowners contacted regarding shoreline buffer installation.
- Planting plan for the Five Lakes' shoreline developed.
- Contractor for goose removal identified and contacted.
- Goose removal completed.
- Potential wetland restoration sites identified.
- Landowners contacted regarding potential wetland restoration.
- Wetland restoration designed.
- Funding for wetland restoration applied for and obtained.
- Information regarding phosphorus-free fertilizer disseminated.
- Marketing methods for phosphorus-free fertilizer determined/developed.
- Meeting regarding failing septic systems held with the two county health departments.
- Failing septic systems identified.
- Sewer system feasibility studies completed for all appropriate lakes.
- Stormwater pipes from Wolcottville and South Milford identified and mapped.
- Stormwater feasibility study completed for Wolcottville and South Milford.
- Water quality monitoring below the Adams Lake sewer outfall completed.
- SWCD meetings attended.
- Residences for CRP implementation identified.
- Appropriate CRP technique selected and implemented.
- Surface and subsurface drains identified, cataloged, and mapped.
- Pollutant loading calculations for surface and subsurface drains completed.

Goal Attainment: The goal is attained when the phosphorus load to the Five Lakes is reduced by half of its current load.
Indicator to be monitored: Phosphorus load of less than half the current load for each waterbody (eight stream sites used for this project).
Parameter assessed: Total phosphorus.
Frequency of monitoring: Monthly during the growing season; Quarterly the remainder of the year.
Location of monitoring: Each stream's sampling point as indicated in Figure 16.
Length of monitoring: The monitoring will occur for ten years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project (Appendix G) or utilizing the Hoosier Riverwatch protocol for measuring total phosphorus (Crighton and Hosier, 2004).
Monitoring equipment: Equipment required for total phosphorus and discharge analysis following the QAPP protocol is identified in Appendix G. For equipment requirements for total phosphorus

using the Hoosier Riverwatch method, see the Hoosier Riverwatch Training Manual (Crighton and Hosier, 2004).
Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter total phosphorus and flow measurements in an electronic database.
Data evaluation: The local SWCD or NRCS staff can provide assistance in interpreting the data as needed. Additionally, Hoosier Riverwatch staff or local instructors may also be available to provide assistance with data analysis.

Goal 2. Reduce total suspended solid loads to streams 50% from 2004 levels by 2015.

Milestones: (Except for annual or continuous tasks, this goal should be reached by 2015.)

- Construction site erosion control practices identified.
- Erosion control ordinances implemented.
- Recognition program for county builders developed.
- Annual conservation program demonstration day held.
- Cost-share funding identified for conservation program implementation.
- Planning commission meeting attended.
- Drainage board meeting attended.

Goal Attainment: The goal is attained when the sediment load in each of the waterbodies in the Five Lakes watershed is less than half of its current load. This can be measured using either total suspended solids (TSS) or turbidity.
Indicator to be monitored: Sediment loading measuring half of current sediment loads within each waterbody.
Parameter assessed: Total suspended solids (streams); water clarity (lake)
Frequency of monitoring: Monthly during the growing season (May-September); Quarterly throughout the remainder of the year.
Location of monitoring: Each stream's sampling point as indicated in Figure 16.
Length of monitoring: The monitoring will be conducted for ten years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project (Appendix G) or utilizing the Hoosier Riverwatch protocol for measuring turbidity (Crighton and Hosier, 2004). Lake clarity will be measured using the Indiana Clean Lakes Program Volunteer monitoring protocol (ICLVMP, 2001).
Monitoring equipment: Equipment required for TSS and discharge analysis following the QAPP protocol is identified in Appendix G. For equipment requirements for turbidity measurements using the Hoosier Riverwatch method, see the Hoosier Riverwatch Training Manual (Crighton and Hosier, 2004).
Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter TSS or turbidity and flow measurements in an electronic database.
Data evaluation: The local SWCD or NRCS staff can provide assistance in interpreting the data as needed. Additionally, Hoosier Riverwatch staff or local instructors may also be available to provide assistance with data analysis.

Goal 3. Reduce *E. coli* concentrations in waterbodies in the Five Lakes watershed so that water within the streams and lakes meets the Indiana state standards of 235 colonies/100 ml by 2015.

Milestones: (Except for continuous or annual tasks, this is a long-term goal. The goal should be reached by 2015.)

- Total Maximum Daily Load development meetings attended.
- Meeting minutes distributed.
- Meeting with health department held.
- List of pathogenic Best Management Practices developed.
- Newspaper article published.

Goal attainment: The goal is attained when the *E. coli* concentration in each of the watershed waterbodies meets the state standard (235 colonies/100 ml).
Indicator to be monitored: *E. coli* concentration less than 235 colonies/100 ml for each watershed waterbody.
Parameter assessed: *E. coli* concentration
Frequency of monitoring: Monthly during the growing season.
Location of monitoring: Each stream's sampling point as indicated in Figure 16.
Length of monitoring: The monitoring will occur for ten years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project (Appendix G) or utilizing the Hoosier Riverwatch protocol for measuring *E. coli* (Crighton and Hosier, 2004).
Monitoring equipment: Equipment required for *E. coli* analysis following the QAPP protocol is identified in Appendix G. For equipment requirements for *E. coli* measurement using the Hoosier Riverwatch method, see the Hoosier Riverwatch Training Manual (Crighton and Hosier, 2004).
Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter *E. coli* concentrations in an electronic database.
Data evaluation: The local SWCD or NRCS staff can provide assistance in interpreting the data as needed. Additionally, Hoosier Riverwatch staff or local instructors may also be available to provide assistance with data analysis.

Goal 4. Within four years, each landowner within the Five Lakes watershed will learn and implement at least one water quality improvement practice/technique on his/her own property.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2010.)

- Identification of a point person to lead the implementation of the plan.
- Five Lakes watershed group formed.
- Watershed group meetings held.
- Watershed group meeting minutes published.
- Watershed group newsletter published.
- Watershed group website developed.
- Website updates noting new members and participants.
- Value of the watershed and watershed group summarized and promoted.
- Property owners implementing conservation projects identified.

- Local experts invited to speak at field days.
- Field days advertised and held.
- List of agricultural Best Management Practices developed.
- Agricultural demonstration day held.
- List of residential Best Management Practices developed.
- Annual newsletter published.
- Property owners using conservation land programs identified.
- Local SWCD meeting attended.
- Residential demonstration day held.
- List of grants for residential water quality projects developed.
- Program materials and handouts regarding the watershed group and water quality developed.
- Table or booth established at the Noble and Lagrange County Fairs.
- Conservation practices implemented.
- Hoosier Riverwatch volunteer training attended.
- Hoosier Riverwatch data collected and submitted.
- Clean Lakes Program volunteer training attended.
- Clean Lakes Program data collected and submitted

Goal Attainment: The goal is attained when each landowner learns about and/or implements one water quality improvement project or technique on his or he property. This does not involve a specific water quality target. This goal will be a continual effort by watershed stakeholders.

Goal 5. Maintain and improve the recreational setting of the Five Lakes watershed by developing and implementing a recreational management plan within five years.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2011.)

- Aquatic plant surveys completed.
- Meeting regarding aquatic plant treatment held.
- Work plan for aquatic plant management developed.
- Funding for implementation or future plant surveys identified and obtained.
- Literature search regarding watercraft capacity and boating impacts completed.
- Survey regarding the impact of watercraft on the Five Lakes completed.
- Boater's education course held.
- Law enforcement contacted in regards to lake patrols.
- Educational materials regarding boating in shallow water distributed.
- Dredging needs identified and addressed.
- Information regarding the impacts of boat fuel distributed.
- Funneling, group piers, and boat speed issues information distributed.
- ILMS meetings/workshops attended.

Goal Attainment: The goal is attained when an aquatic plant management plan and a recreational plan are developed. This does not involve a specific water quality target. This goal will be a continual effort by watershed stakeholders.

8.0 FUTURE CONSIDERATIONS

There are several considerations stakeholders should keep in mind as they implement the Five Lakes Watershed Management Plan. Many of these considerations are noted in the proceeding sections of this text, but due to their importance, they warrant reiteration.

Permits, Easements, and Agreements

Revegetation of Lake Perimeter: Permission to improve the buffer around any of the lakes or along any of the streams through supplemental tree plantings and/or shoreline/shallow water plantings must be obtained from the property owners before any plantings occur.

Operation and Maintenance

Wetland Restoration: Wetland restoration projects were identified in the watershed. In the long term, these areas will provide water quality benefits while requiring little maintenance. In the short term, certain management activities may be employed to help these areas recover faster than they would if they were left alone. Such activities included prescribed burns, spot herbicide treatments, and supplemental plantings. These maintenance activities which are designed to increase the plant diversity of the wetland will also increase functionality of the wetland. They also increase the pace of wetland restoration. Additional burns, herbicide spot treatments, and plantings may further increase the wetland's recovery. As wetland recovery progresses, additional maintenance activities may be deemed necessary in the future.

Monitoring

Monitoring is an important component of this watershed management plan. Without monitoring, stakeholders will not know when or whether they have achieved their goals; or worse, they will not make timely refinements to their actions to ensure the actions they are taking will achieve their goals. The **MEASURING SUCCESS** Section details how stakeholders will monitor their progress toward achieving the goals set in this watershed management plan.

Plan Revisions

This watershed management plan is meant to be a living document. Revisions and updates to the plan will be necessary as stakeholders begin to implement the plan and as other stakeholders become more active in implementing the plan. The FLCA will be responsible for holding and revising the Five Lakes Watershed Management Plan as appropriate based on stakeholder feedback. To assist with record keeping and to ensure action items outlined in the plan are being completed, stakeholders should complete the simple Action Tracker form provided in Appendix M. This form should be returned to the FLCA. The FLCA will keep completed action registers in three ring binder and review action registers to ensure tasks are being completed. The forms will also help document the success of actions taken in the watershed.

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