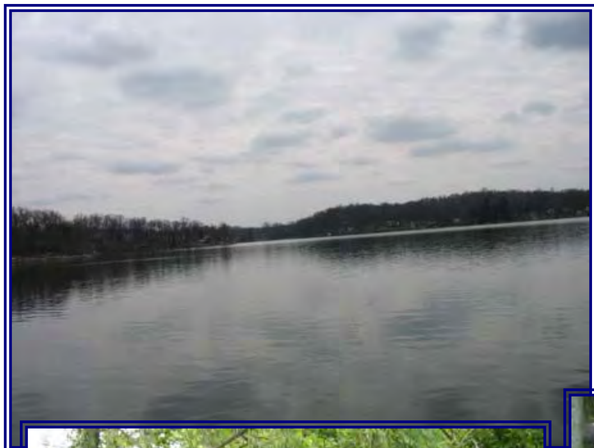
Wawasee Area Watershed Management Plan

Elkhart, Kosciusko, and Noble Counties, Indiana

April 13, 2007

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WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

EXECUTIVE SUMMARY

The Wawasee Area Watershed encompasses approximately 25,000 acres in southwestern Noble and northeastern Kosciusko Counties. The watershed lies in the headwaters of the Elkhart River basin. The watershed contains more than 25 lakes and many thousands of feet of streams. With funding from the Indiana Department of Natural Resources Division of Fish and Wildlife through the Lake and River Enhancement grant program the Wawasee Area Conservancy Foundation (WACF) initiated the development of a watershed management plan in an effort to improve water quality in the lake and streams in the Wawasee Area Watershed.

The WACF, along with their consultant, held several public meetings, reviewed available historical water quality data, and conducted current water quality sampling to identify water quality concerns in the Wawasee Area Watershed. Through the use of public notices and targeted mailings, property owners in the watershed as well as representatives from local, state, and federal natural resource agencies, not-for-profit organizations, and local governments were invited to attend the public meetings. Several common themes began to surface during the public meetings. Three concerns emerged as the top concerns of the watershed stakeholders: 1. the streams and lakes should support multiple uses such as water quality, biological habitat, and aesthetic value and water quality should be protected or improved; 2. watershed and lake users do not understand their impact on the lakes and their water quality; and 3. efforts should be made to protect the quality of the watershed's natural resources.

As a first step toward addressing their three top concerns, the watershed stakeholders agreed on the following vision statement. The watershed stakeholders will use this vision to guide management efforts in the Wawasee Area Watershed.

The Wawasee Area Watershed is a scenic healthy watershed with balanced uses.

Watershed stakeholders, along with their consultant, also identified the stressors associated with their top concerns and the sources of these stressors. High nutrient and sediment loads reaching the streams and lakes are the primary stressors driving the eutrophication of the waterbodies. The second stressor identified by watershed stakeholders was lack of knowledge by property owners living in and around the watershed. Pathogenic contamination, as evidenced by high *E. coli* concentrations, was the third stressor identified by watershed stakeholders. Finally, overuse through recreation was the fourth stressor identified by watershed stakeholders.

To reduce the identified stressors in the Wawasee Area Watershed and address other concerns identified by watershed stakeholders, the stakeholders developed five goals and developed an action plan for each of the goals. The goals in order of priority as agreed upon by the watershed stakeholders are as follows:

Goal 1: We want to reduce the nutrient load reaching Lake Wawasee by 25% over the next 10 years.

Goal 2: We want to reduce the sediment load to the waterbodies within the Wawasee Area Watershed by 50% over the next five years.

Goal 3: We want to reduce the concentration of E. coli within the Wawasee Area Watershed waterbodies so that water within the streams and lakes meets the state standard for E. coli. within 10 years.

Goal 4: Within five years, 50% of landowners within the Wawasee Area Watershed will attend one educational event and 25% of landowners implement one water quality improvement project.

Goal 5: Maintain and improve the recreational setting of the Wawasee Area Watershed by developing and implementing a recreational management plan for Lake Wawasee and Syracuse Lake within five years.

Where feasible, the goals list specific targets watershed stakeholders wish to reach. Additionally, the plan identifies who will assist with implementing the plan and indicates what measures will be used to identify successful achievement of the plan's goals and objectives.

ACKNOWLEDGEMENTS

The Wawasee Area Watershed Management Plan was made possible with funding from the Indiana Department of Natural Resources (IDNR) Division of Fish and Wildlife Lake and River Enhancement (LARE) Program and the Wawasee Area Conservancy Foundation. The Wawasee Area Watershed Management Plan was completed by JFNew and their subcontractor, Indiana University School of Public and Environmental Affairs. Contributors to this study included Gwen White, Angela Sturdevant, Cecil Rich, and Jed Pearson with the IDNR Division of Division of Fish and Wildlife and Ron Hellmich with the IDNR Division of Nature Preserves. Special thanks to the group of watershed stakeholders who faithfully attended all of the planning meetings and to Heather Harwood, Bob Myers, and David Brandes for their initiative and assistance in getting this study completed.

Wawasee Area Watershed stakeholders who participated in the study included: Heather Harwood, who served as the primary liaison between JFNew and WACF; Bob Myers and Dean Schwalm who provided JFNew with directions and information during the watershed tour; Russell Baker and Sam St. Clair, who provided agricultural information; Dick Kemper and Scott Zeigler, who provided invaluable information regarding legal drains and their history within the watershed; Doug Nusbaum and Kent Tracey, who provided directions and information on projects previously completed in the Wawasee Area Watershed; Jed Pearson, whose knowledge of the lakes and their fisheries' were invaluable; and to all of those who attended the planning meetings including: Russell Baker, Noble County NRCS; Dan Berkey; Todd Bowen, Enchanted Hills Association; David Brandes, WACF Director; Diana Castell; Nancy Duehmig, Syracuse Lake; Deborah Flanagan; Ken Fetters, Knapp Lake; Sherm Goldenberg; Susan Grivas, Kosciusko County SWCD; Jan Hackelman; Heather Harwood; David Heckaman, Sudlow's Pier Shop; Dick Kemper, Kosciusko County Surveyor; Betty Knapp; Stacey McGinnis, Noble County SWCD; Bob Myers; Jed Pearson; Jerry Riffle; Steve Roth, Property Mgr, Tri-County FWA; Dean Schwalm; Nick Stanger; and Angela Sturdevant, IDNR-DFW. Without your opinion and input this project would not have even gotten off the ground. Data for this report were provded by William Jones, Erin Miller, Aaron McMahon, Rachel Price, Emily Kara, and Melissa Clark at Indiana University. Authors of this report include Sara Peel, John Richardson, and Betsy Ewoldt at JFNew.

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1.0 INTRODUCTION

This watershed management plan addresses non-point source pollution and other water quality concerns facing the Wawasee Area Watershed. The Wawasee Area Watershed encompasses two 14-digit watersheds, the Turkey Creek-Headwaters (Noble County) watershed (HUC 04050001200010) and the Turkey Creek-Lake Wawasee watershed (HUC 04050001200020). In total, the Wawasee Area Watershed drains approximately 24,498 acres (9,914-ha) in southwestern Noble and northeastern Kosciusko Counties (Figures 1 and 2). 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 Turkey Creek. Turkey Creek combines with the Elkhart River immediately south of Goshen. The Elkhart River combines with the St. Joseph River within the city of Elkhart. Water from the St. Joseph River then flows into Lake Michigan at St. Joseph, Michigan. This watershed management plan documents the concerns watershed stakeholders have for the Wawasee Area Watershed 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.

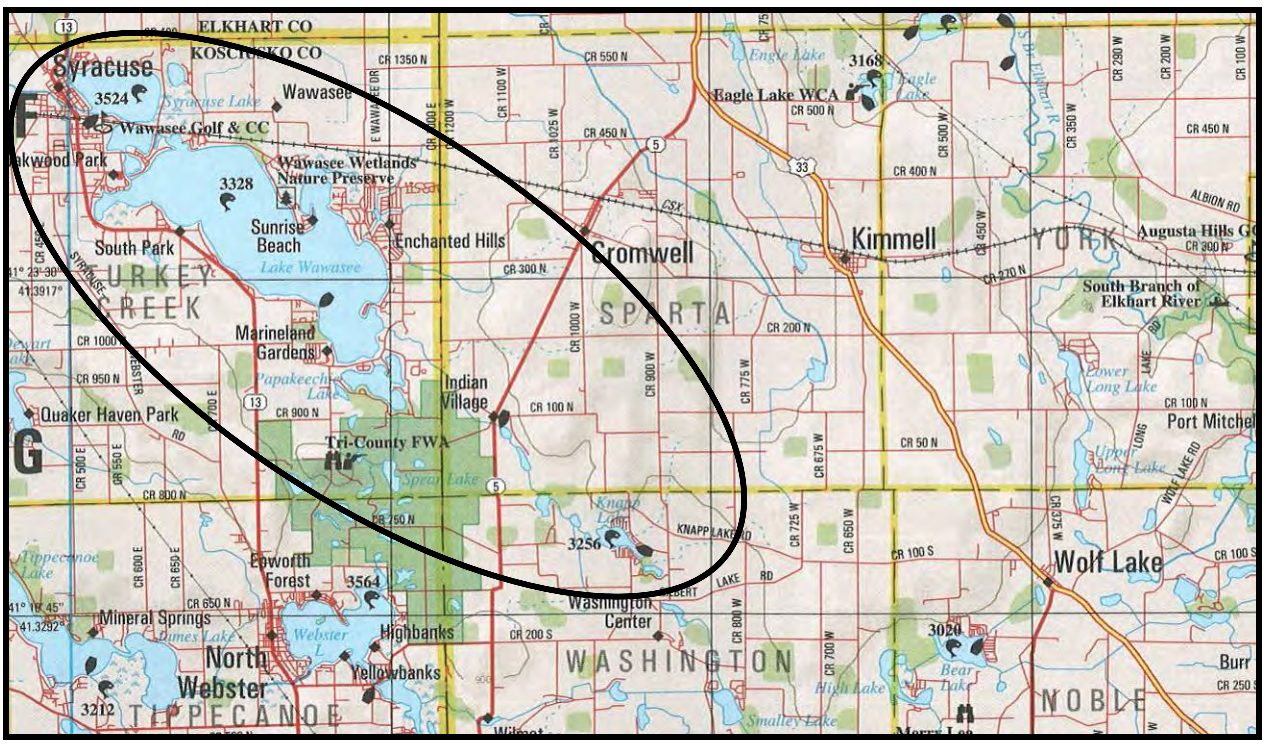

Figure 1. Wawasee Area Watershed location map. Source: DeLorme, 1998. Scale: 1"=approximately 2.5 miles.

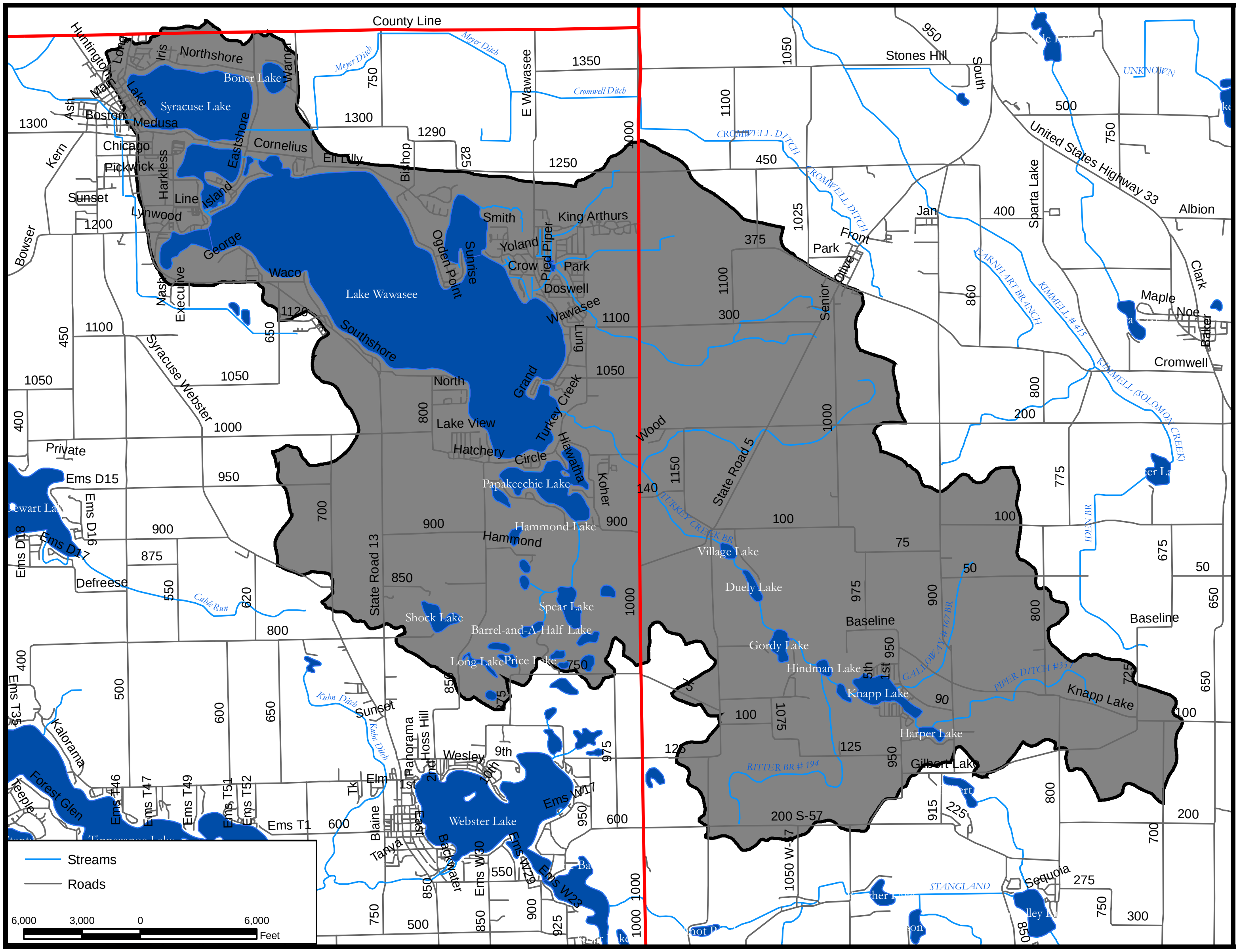

Figure 2. Wawasee Area Watershed.

Development of this watershed management plan grew out of efforts of the Wawasee Area Conservancy Foundation (WACF). In 2005, the WACF applied for and received funding from the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) Program to complete a strategic lakes management plan. In 2006, WACF began working with JFNew to identify stakeholders to participate in the strategic lake and watershed management planning process.

1.1 Watershed Partnerships

During the first meeting with the WACF, a list of stakeholders in the watersheds was developed. Organizations and individuals with a demonstrated interest in the planning activity (those active in watershed projects in the watershed) 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 WACF Ecology Committee, the Syracuse Lake Association, the Lake Papakeechie Association, Noble County SWCD and NRCS personnel, Kosciusko County SWCD and NRCS personnel, the Kosciusko County Surveyor, Kosciusko County Health Department, Noble County Surveyor, Noble County Health Department, IDNR Regional Fisheries Biologist, Tri-County Fish and Wildlife Area Property Manager, and Shoreline and Watershed residents. Every effort was made to include representatives from all stakeholder groups in the planning process.

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. All individuals identified during all phases of the planning process were invited to each meeting whether or not they attended the previous meeting. A complete list of the individuals invited to participate the watershed planning team and those in attendance at meetings throughout the planning process is located in Appendix A. Some individuals contained on this list did not attend any planning meetings. They did, however, continue to receive invitations to attend. 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 Stakeholder Meetings

Watershed stakeholders met on a monthly basis from March to November 2006 to develop the Wawasee Area Watershed Management Plan. Stakeholders were informed in writing of the meeting date and time a minimum of two weeks in advance of the meeting date. Following the meeting, meeting minutes were distributed to all watershed stakeholders included on the list in Appendix A. On average, twelve people attended the stakeholder meetings with the attendance ranging from eleven to fourteen individuals. The following list details the meeting date, discussion which occurred on that date, and the outcome of activities. Details for each of these items, including concerns, stressors, goals, and action items are discussed in subsequent sections. Copies of the meeting minutes which detail the meeting discussions are included in Appendix B.

Meeting 1: March 15, 2006	Project and general watershed management plan introduction; attendee introduction; historic watershed map discussion; historic data review; concern list development.

Meeting 2: April 12, 2006	Concern list review and addition; watershed tour results discussion; developed mission and vision for watershed management plan
Meeting 3: May 17, 2006	Water quality data review; concern prioritization
Meeting 4: June 14, 2006	Watershed map review; concern prioritization review; concern combination and problem statement development
Meeting 5: July 12, 2006	Problem statement review; concern and stressor links to available data discussion
Meeting 6: August 16, 2006	Goal development; problem statement finalization; stream water quality discussion
Meeting 7: September 13, 2006	Goal review and prioritization; began objective and action item review and responsible party designation determination
Meeting 8: October 18, 2006	Reviewed project work to date (mission, vision, concerns, problem statements, data collected, and goals developed); continued responsible party determination and objective/action item review
Meeting 9: November 15, 2006	Finalized responsible party determination and objective/action item review.

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.

Water Quality:

- Stakeholders indicated that they thought water quality was declining in Lake Wawasee and Syracuse Lake.
- Stakeholders expressed concern that water quality within the Ten Lakes Chain was declining.
- Watershed stakeholders thought that too many households were using fertilizer adjacent to the lakes.
- Stakeholders indicated that algae blooms were increasing in density and occurred for longer periods of time throughout the summer.
- Stakeholders indicated concern over the volume of sediment and nutrients carried to watershed waterbodies and the impact that these pollutants have on native plant communities, habitat, and biota using these areas.
- Stakeholders felt that the there was not an accurate map of individual storm drains or open drainages around the lakes and therefore the impact of these drain/drainages could not be quantified.

<u>*Water Quality (cont.):*</u>

- Watershed stakeholders questioned whether nutrients and sediment delivered to the lakes through storm drains are adequately addressed either at their source or through planning efforts.
- Stakeholders expressed concern over the maintenance of both county-owned and private storm drains around the lakes.
- Stakeholders felt that nutrient levels were increasing throughout the watershed resulting in declining water clarity and quality.
- One stakeholder expressed concern over elevated phosphorus concentrations in Lake Wawasee following the annual 4th of July fireworks.
- Stakeholders indicated that sediment has accumulated at the mouths of some of the lakes' inlets resulting in loss of habitat and usability.
- One stakeholder expressed concern over the accumulated sediment that has formed a sand bar between Gordy and Hindman lakes.
- Stakeholders expressed concern that the sources of *E. coli* and resulting impacts of *E. coli* concentrations in excess of the state standard (235 colonies/100 mL) on the lakes' water quality had not been identified.
- Stakeholders were concerned that *E. coli* samples in excess of the state standard had been recorded in Lake Wawasee.
- Stakeholders expressed concern that individuals did not know the correct application rates and uses for herbicides and pesticides along the shoreline. It was also indicated that this lack of education results in over-application of both herbicides and pesticides.
- Stakeholders expressed concern that a portion (200) of the households around Lake Wawasee remains on septic systems.
- Stakeholders agreed that the use of septic systems around the lakes in the Ten Lakes Chain was also of concern.
- Watershed stakeholders felt that a source of funding to complete the installation of sewers around the portion of Lake Wawasee where septic systems continue to be used needs to be identified. One stakeholder indicated that the landowners of these areas could be a source of funding for the implementation of sewers around this section of the lake.
- Stakeholders expressed concern over the continued filling of wetlands in and around Lake Wawasee and throughout the watershed and the resulting impact that this wetland loss could have on the lakes' water quality.

<u>*Habitat/Shoreline:*</u>

- Stakeholders indicated concern over the loss of fish and wildlife habitat adjacent to the lakes' shorelines due to the proliferation of piers, boat lifts, and structures along the shoreline.
- Stakeholders expressed a desire to protect the lakes' shoreline and restore the natural shoreline along those portions of the lakes where seawalls have been installed.
- Stakeholders felt that shoreline seawalls attract even more development around the lakes and reduces the attractiveness and available habitat for fish and wildlife.
- Watershed stakeholders expressed concern over the potential water quality impact of aquatic plant treatment (herbicide).
- Stakeholders indicated concern over the presence of exotic species, including Eurasian watermilfoil, curly-leaf pondweed, and zebra mussels, on the lakes' water quality and the potential impact that the presence of these species could have on the habitat and fish community present within the lakes.

Habitat/Shoreline (cont.):

- Stakeholders indicated that bulrushes were historically present in a number of locations throughout Lake Wawasee; however, many of these areas are no longer vegetated by bulrushes.
- Stakeholders expressed concern over the presence of purple loosestrife in the wetlands adjacent to the lakes and throughout the watershed and the impact of this species on habitat quality and native plant communities.
- Watershed stakeholders indicated that additional areas of Lake Wawasee should be considered for the creation of eco-zones. One specific location is the kettle along State Road 13. Stakeholders expressed desire for additional areas to be identified as necessary.
- Stakeholders expressed concern over the presence and density of exotic species within properties owned and managed by WACF.
- Stakeholders indicated the desire to maintain current WACF properties in their natural state and limit their development and use by others.
- One stakeholder expressed concern over the presence of beaver along the Ten Lakes Chain and the impact of these beaver on water levels within the lakes.
- Stakeholders felt that freshwater mussel populations are declining.
- Watershed stakeholders indicated that Canada goose populations appear to be increasing and expressed concern over the impact of larger populations on water quality.
- Stakeholders felt that the presence of zebra mussels throughout the watershed was of concern. The impact of the zebra mussels on water quality within the lakes was also concerning to watershed stakeholders.
- Watershed stakeholders thought that not enough individuals were interested in refacing their concrete seawalls with glacial stone or rock.

Watershed:

- Stakeholders generally agreed that the auto salvage yard was a potential source of pollutants to the watershed waterbodies.
- Stakeholders indicated that they were concerned over the long-term maintenance of watershed projects implemented in the past. A stakeholder noted that more than $300,000 worth of LARE funding has been used to implement water quality improvement projects; however, if these projects are not maintained, then the lakes are not any farther ahead than if the project had not been implemented.
- Stakeholders indicated that there are still water quality improvement projects that could be implemented in the watershed but that these sites had not yet been identified.
- Stakeholders expressed concern that manure management planning is not adequately used throughout the watershed.
- Stakeholders felt that the presence of large animal operations (confined feeding operations) throughout the watershed were negatively impacting both air and water quality.
- Watershed stakeholders indicated that livestock have access to waterbodies throughout the watershed and that efforts should be made to restrict the access of the livestock.
- Watershed stakeholders felt that additional development around the lakes would result in the creation of more hardscape which would result in poorer water quality within the lakes.
- Stakeholders expressed a desire to identify properties within the watershed that would benefit from protection and acquire these properties through WACF.
- Watershed stakeholders thought that erosion control practices were not adequately enforced throughout the watershed. This concern relates to both small developments (<1 acre) and larger developments (>1 acre; Rule 5).

Watershed (cont.):

- Watershed stakeholders expressed concern that once potential water quality improvements project sites were identified, landowners may not be willing to implement the identified practices or projects.
- Stakeholders indicated that shoreline and streambank erosion continues to be a problem throughout the watershed. Stakeholders agreed that specific locations where shoreline and streambank erosion is occurring needs to be identified.

Community/Development/Land Use:

- Stakeholders expressed concern over the number of individuals using the lakes and the impact that these users were having on lakes' water quality.
- Watershed stakeholders indicated that they were concerned over the potential impact of additional housing on recreation and water quality. Specifically, they felt that more residences would result in more boats and boaters on the lakes.
- Stakeholders felt that WACF should have a stronger education base and needed to develop an education plan and offer a facility to be used for education efforts.
- Watershed stakeholders expressed a desire to incorporate the Town of Syracuse's walking path with some of WACF's properties, if possible without changing the quality or protection level of the WACF properties.
- Stakeholders indicated that most users/residents at the lakes' campgrounds were not aware of boating rules and regulations and did not realize their impact on the lakes' water quality.
- Stakeholders indicated that the construction of new seawalls should be limited and that natural shorelines or the use of glacial stone or native plants should be encouraged.
- Stakeholders indicated that eco-zones are not adequately marked and/or are not marked on time and that lake users do not observe the rules and regulations associated with the eco-zones.
- Stakeholders expressed concern over the county zoning board's differing opinions on appropriate land uses adjacent to the lakes versus the opinions of the lake associations/lakeshore residents.
- Watershed stakeholders indicated that the county commissioners may lack the necessary perspective or lake-specific education required to improve water quality throughout the watershed.
- Stakeholders indicated that lake management plans are not always considered when developing county land use plans and expressed a desire for the two planning initiatives to work together.
- Stakeholders felt that some boaters do not respect other individual's rights to use the lakes.
- One stakeholder expressed concern as to the maintenance of the dam which controls water levels within Lake Wawasee and Syracuse Lake.
- Watershed stakeholders indicated that the general public does not understand how their actions impact water quality.
- Stakeholders felt that the public expects that water quality within the lakes will be good and their ability to use the lakes will go on indefinitely no matter what they as individuals do to the lakes.

Boating/Public Usage:

- Watershed stakeholders felt that funneling of additional individuals and lake users to the lakes (specifically Wawasee and Syracuse) was of concern due to the impact that the additional hardscape and the added users could have on the lakes' water quality. Stakeholders expressed a desire for the group to be involved with planning and zoning issues as they relate to funneling throughout the county.

Boating/Public Usage (cont.):

- Stakeholders expressed concern that weekend or off-shore boaters were not educated on the correct use of boats and the rules and regulations on the watershed lakes.
- Stakeholders felt that the testing of deep-hull boats was negatively impacting the water quality of Lake Wawasee and that education and possible restriction in location and duration of testing should be implemented.
- Stakeholders indicated concern over the number of boats moored around and in use on the watershed lakes and the potential impact of these boats on water quality.
- Watershed stakeholders expressed concern about the potential for boat fuel to contaminate the lakes.
- Stakeholders indicated that personal watercraft users may not be aware of boating rules and regulations and that noise from these watercraft and other boats may cause noise pollution.
- Stakeholders indicated that watercraft speed limits may be too high and that these limits should be reduced.
- Stakeholders felt that watercraft speed limits were not adequately enforced on evenings or weekends and that additional patrolling may be required on the lakes.
- Stakeholders indicated that most boaters do not follow boating rules and regulations including speed limits and the number of individuals per boat.
- Stakeholders expressed concern over the lack of boating rule and regulation enforcement within the channels.

1.4 Vision for the Future

As the Wawasee Area 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 especially through reasonable boating types and densities. The Wawasee Area Watershed stakeholders summarized these themes in one overarching vision for the watershed:

The Wawasee Area Watershed is a scenic healthy watershed with balanced uses.

This vision serves as the foundation for the Wawasee Area Watershed Management Plan.

2.0 WATERSHED CHARACTERISTICS

2.1 Watershed Location

The Wawasee Area Watershed encompasses approximately 24,498 acres (9,914-ha) south and east of Syracuse, Indiana (Figure 1). Specifically, the watershed is located in Sections 1 to 3 in Township 33 North, Range 7 East; Sections 1 to 12 in Township 33 North, Range 8 East; Sections 4 to 6, 8 to 17, 21 to 28, and 34 to 36 in Township 34 North, Range 7 East; Sections 7, 16 to 21, and 27 to 34 in Township 34 North, Range 8 East; and Section 32 in Township 35 North, Range 7 East. The Wawasee Area Watershed includes a number of lakes including Lake Wawasee, Syracuse Lake, Papakeechie Lake, the Ten Lakes Chain (Village, Duely, Rider, Gordy, Hindman, Moss, Knapp, Little Knapp, Harper, and Little Bause lakes), and the Tri-County Fish and Wildlife Area lakes (Hammond, Barrel and a Half, Spear, Long, Price, Shock, Rothenberger, Wyland, Allen, and Grindle lakes). The watershed stretches out to the east and south of the Lake Wawasee and Syracuse Lake covering portions of Sparta and Turkey Creek Townships in Elkhart, Kosciusko, and Noble Counties. Lake Wawasee has three main tributaries, Dillon Creek, Turkey Creek, and the Lake Papakeechie outlet and a number of minor tributaries (Figure 3). Dillon Creek drains water from 3,423 acres (1,385.2 ha) east of the lake including the entirety of Enchanted Hills. Turkey Creek receives water from the Village Lake Chain and the Knapp Lake Chain draining approximately 10,122 acres (4,096.2 ha) southeast of the lake. The Lake Papakeechie outlet carries water from Tri-County Fish and Wildlife Area north through Lake Papakeechie draining a total of 3,479 acres (1,407.9 ha). The remaining acreage (2,325 acres or 940.9 ha) includes minor drainage channels, such as the Golf Course Tributary, Bayshore Channel, and Martin Ditch (Leeland Channel), and direct drainage to the lake. All of Syracuse Lake's water (24,498 acres or 9,914 ha) drains through Lake Wawasee or enters Syracuse Lake via groundwater or minor drainages (1,323 acres or 535.4 ha).

Lake Wawasee, Lake Papakeechie, and Syracuse Lake are headwaters lakes in the Great Lakes Basin or the larger watershed which carries water to one of the five great lakes. The Wawasee Area Watershed is composed of two 14-digit watersheds, the Turkey Creek Headwaters (Noble) watershed and the Turkey Creek-Lake Wawasee watershed (HUC 04050001200010 and 04050001200020, respectively), which lies within the St. Joseph River basin (HUC 04050001; Figure 4). The lakes and their 24,498-acre (9,914-ha) watershed lie immediately north of the north-south continental divide. Similar to its more famous cousin, the east-west Continental Divide which divides the United States into two watersheds, one that drains to the Atlantic Ocean and one that drains to the Pacific Ocean, this north-south continental divide separates the Mississippi River Basin (land that drains south to the Mississippi River) from Great Lakes Basin (land that drains north to the Great Lakes). As part of the Great Lakes Basin, water from the Wawasee Area Watershed drains west then north through Turkey Creek. Turkey Creek combines with the Elkhart River south of Goshen. The Elkhart River flows into the St. Joseph River which eventually discharges into Lake Michigan near St. Joseph, Michigan.

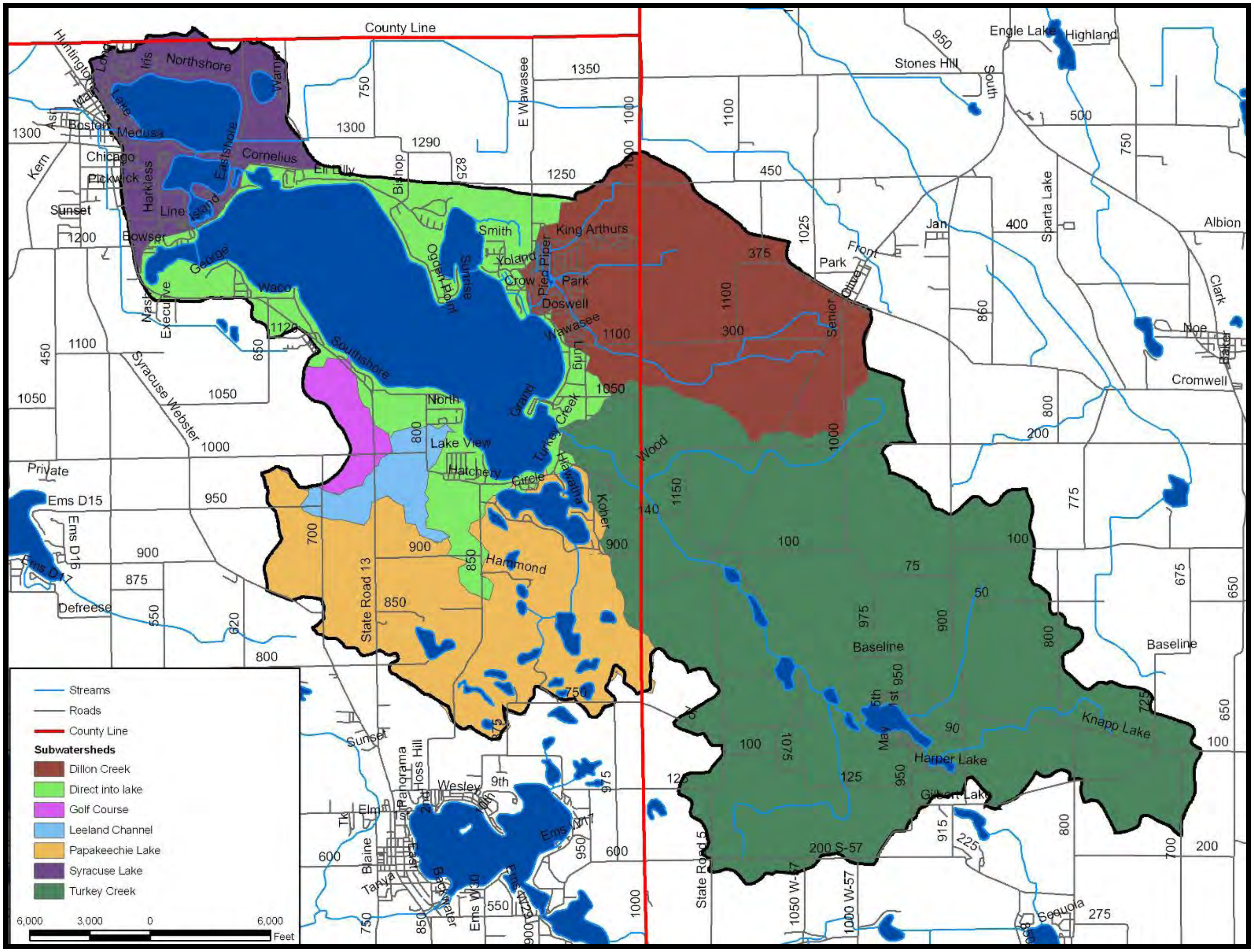

Figure 3. Lake Wawasee subwatersheds.

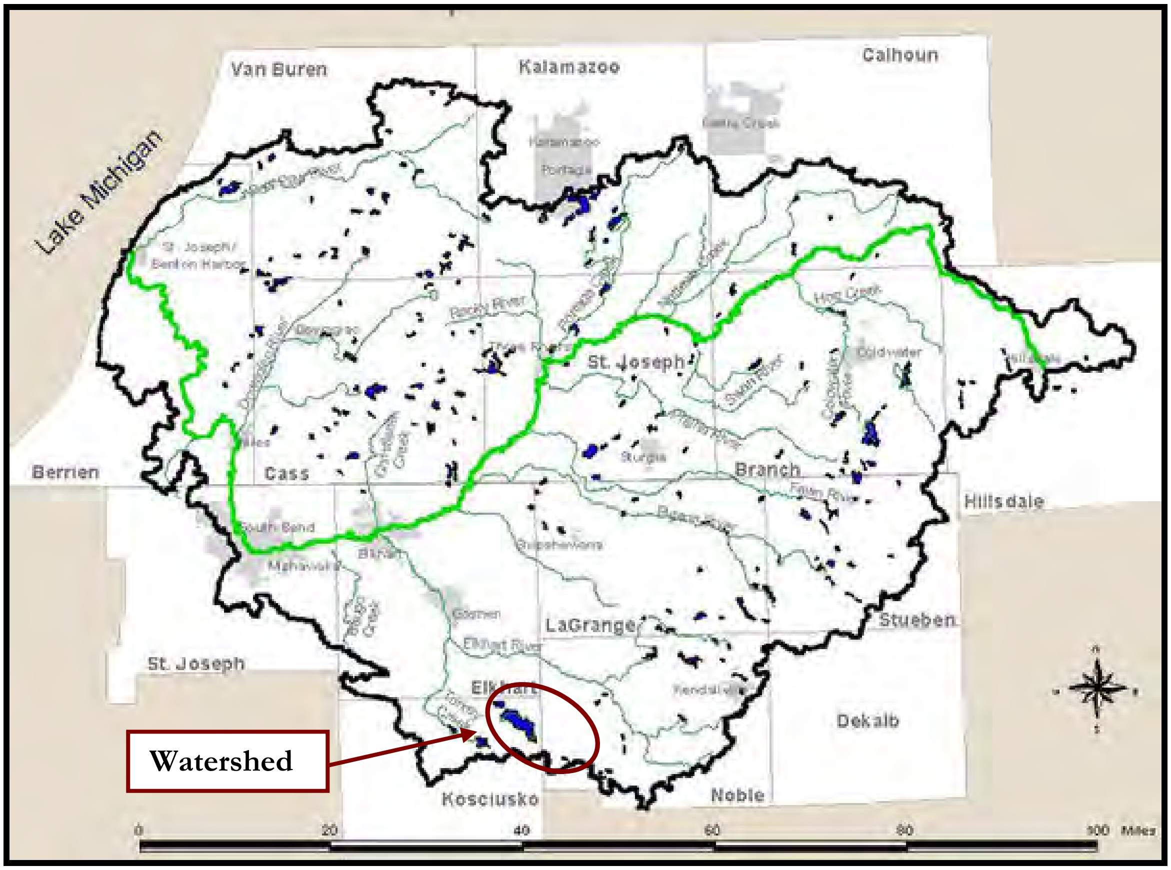

Figure 4. St. Joseph River watershed.

2.2 <u>Climate</u>

Indiana Climate

Indiana's climate can be described as temperate with cold winters and warm summers. The National Climatic Data Center summarizes Indiana weather well in its 1976 Climatology of the United States document no. 60: "Imposed on the well known daily and seasonal temperature fluctuations are changes occurring every few days as surges of polar air move southward or tropical air moves northward. These changes are more frequent and pronounced in the winter than in the summer. A winter may be unusually cold or a summer cool if the influence of polar air is persistent. Similarly, a summer may be unusually warm or a winter mild if air of tropical origin predominates. The action between these two air masses of contrasting temperature, humidity, and density fosters the development of low-pressure centers that move generally eastward and frequently pass over or close to the state, resulting in abundant rainfall. These systems are least active in midsummer and during this season frequently pass north of Indiana" (National Climatic Data Center, 1976). Prevailing winds in Indiana are generally from the southwest but are more persistent and blow from a northerly direction during the winter months.

Wawasee Area Watershed Climate

The climate of the Wawasee Area Watershed is characterized as having four well-defined seasons of the year. Winter temperatures average 26º F (-3.3º C), while summers are warm, with temperatures averaging 70º F (21.1º C). The growing season typically begins in early April and ends in September. Annual rainfall averages 36.65 inches (93 cm). Winter snowfall averages about 26 inches (66 cm). During summers, relative humidity varies from about 60 percent in mid-afternoon to near 80 percent at dawn. Prevailing winds typically blow from the southwest except during the winter when westerly and northwesterly winds predominate. (All of the proceeding statistics, except for the annual rainfall average, were taken from McCarter, 1977 and Staley, 1989.) In 2006, nearly 41 inches (104.1 cm) of precipitation (Table 1) was recorded at Warsaw in Kosciusko County. When compared with 30-year average for the area, the 2006 annual rainfall exceeded the 30-year average by more than 4 inches (10.1 cm).

Table 1. Monthly rainfall data (in inches) for year 2006 as compared to average monthly rainfall.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2006	2.93	1.42	3.05	2.86	6.12	3.83	6.35	4.1	1.88	4.03	2.88	1.49	**40.94**
Average	1.85	1.45	2.08	3.36	3.83	4.51	3.67	4.05	3.22	3.04	2.97	2.62	**36.65**

Source: Purdue Applied Meteorology Group, 2006. All data was recorded at Warsaw in Kosciusko County. Averages are 30-year normals based on available weather observations taken during the years of 1971-2000 at Warsaw.

2.3 Topography and Geology

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 Wawasee Area 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 Wawasee Area Watershed from Dewart and Waubee lakes' watershed is part of an end moraine left by the Saginaw Lobe. A similar ridge along the eastern edge of the watershed represents another end moraine left by the Saginaw Lobe. This ridge separates the Wawasee Area Watershed from the Solomon Creek watershed to the east. The lower, less distinct ridge separating the Wawasee Area Watershed from the Tippecanoe River Basin (Webster Lake watershed) may also be part of an end moraine left by the glacial lobe. (Figure 5 shows the areas of greater relief (in yellow) 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 Wawasee Area watershed, while two muck deposits indicate the locations of historic lake beds within the watershed (Figure 6). The southern half of the watershed is typical of sag/swell topography with rolling hills with many glacial moraines dissecting this portion of the watershed. The hills (unconsolidated mounds of glacial material), wetlands (poorly drained alluvium), and lakes (glacial depressions) present in Tri-County Fish and Wildlife Area typify this portion of the watershed. The northern portion of the watershed is somewhat flatter as is typical of inter-morainal areas.

The geology and resulting physiography of the Wawasee Area Watershed typify the physiographic region in which the watershed lies. The Wawasee Area 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 Wawasee Area Watershed landscape. Syracuse Lake, Lake Wawasee, and Knapp Lake are good examples of kettle lakes lying in an end moraine. Its part of the "knob and kettle" topography that is characteristic of end moraines. The flat area along the length of the Knapp Lake Chain likely demarcates the extent of the original waterbody that covered Knapp Lake and the area to the northwest and southeast of the lake many years ago. This waterbody has been reduced to a series of lakes along the length of Turkey Creek and their surrounding wetlands. As will be discussed in the next section, common soil types of aged lakes are the dominant soil types in this area, lending evidence to the idea that this area was once part of a larger lake. Till knobs and kames occur along the watershed's eastern edge. Many other reminders of the watershed's geologic history exist for those who look closely.

Approximately 300-350 feet (91-107 m) of unconsolidated glacial materials cover most of the Wawasee Area watershed (Clendenon and Beaty, 1987). These deposits are composed of sand and glacial outwash. The watershed's surficial geology covers a less complex bedrock foundation. Antrim shale from the Devonian-Mississippian Period underlies the unconsolidated glacial material in the Wawasee Area Watershed (Gutschick, 1966). This material is relatively pervious which allows a large amount of interaction between groundwater and surface water. Groundwater generally flows from the southeast toward the northwest in a similar fashion as surface water.

The watershed's geologic history is responsible for the watershed's topography (Figure 5). As noted previously, Syracuse Lake and Lake Wawasee are both kettle lakes, part of the characteristic knob and kettle topography of end moraines. The lakes occupy the low spot in the watershed at 859 feet above mean sea level (MSL). The highest elevations in the watershed reach over 990 feet above MSL and lie in the eastern portion of the watershed just east of Dillon Creek (Figure 5). As with most watersheds, the steepest slopes exist in the upper watershed. Steep slopes occur in the headwaters of the Dillon Creek and Turkey Creek. Historical maps and the hydric soil map suggest that areas around the shoreline of Syracuse Lake and Lake Wawasee were historically wetland habitat. Royse (1919) documents the fluctuation in lake level and resultant variation in shoreline morphology. Erosion of the outlet of Syracuse Lake lowered the lake by nearly 8 feet (2.4 m). The dropping water level resulted in historic lake bottom being exposed as the current wetlands along the shoreline of Lake Wawasee. In 1834, the grist mill and dam constructed at the outlet of Syracuse Lake stabilized the lake level at its current level which is approximately 7 feet (2.1 m) lower than the original lake level (Lilly, 1965).

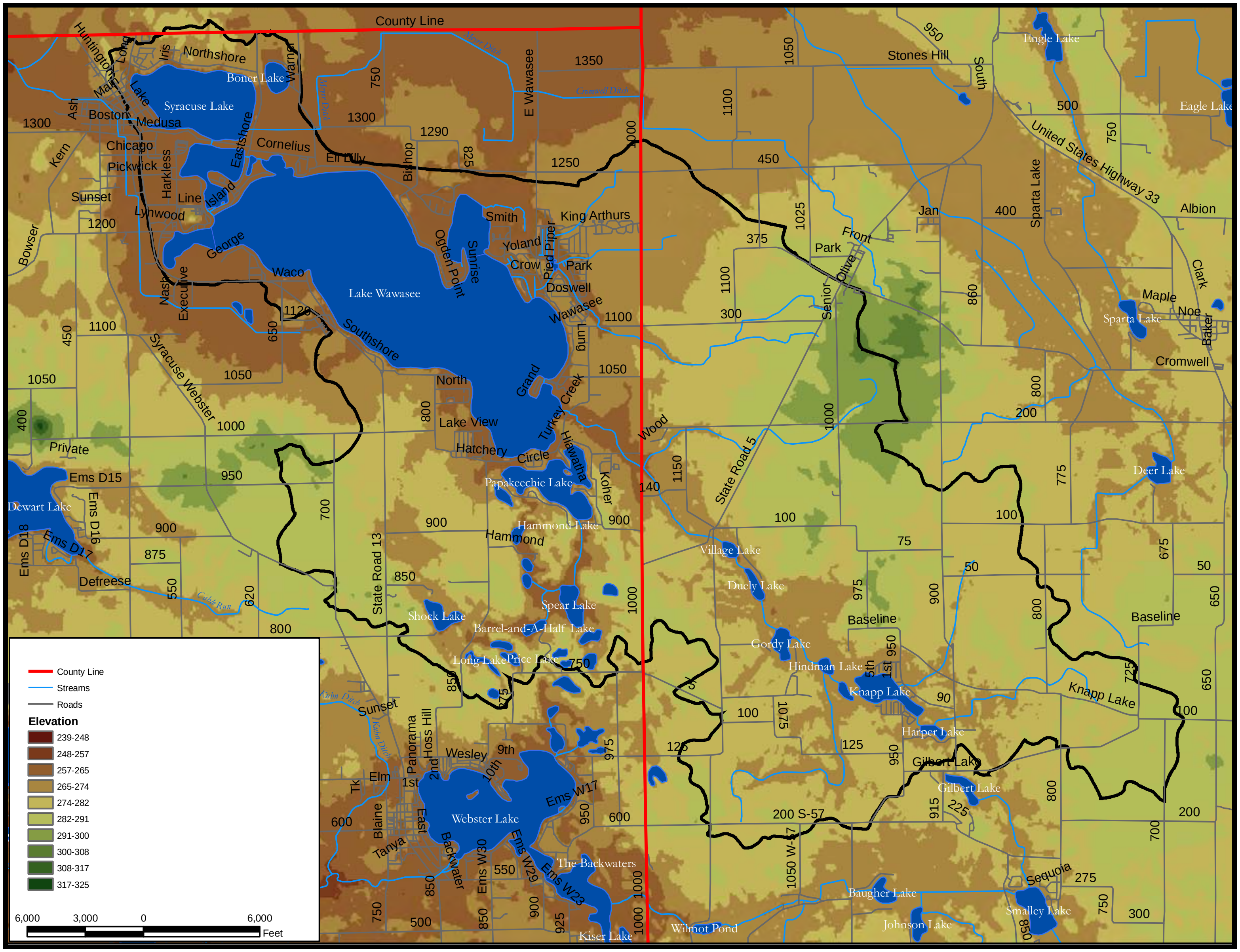

Figure 5. Topographical map of the Wawasee Area Watershed.

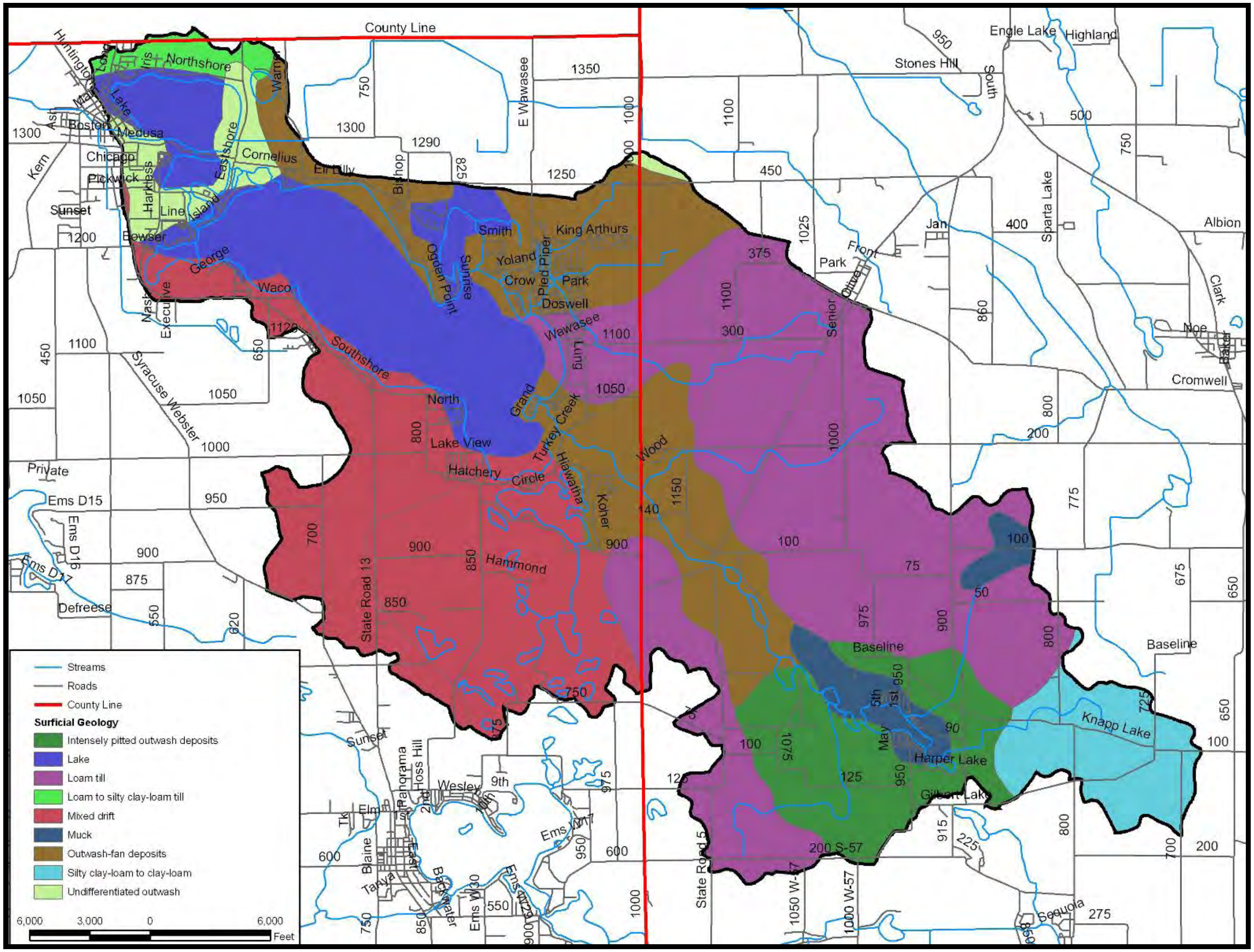

Figure 6. Surficial geology of the Wawasee Area watershed.

2.4 Soils

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

Because soil scientists developed county soil association maps at different times, soil associations in one county are not always consistent with soil associations in an adjacent county. McCarter (1977) points to three reasons for the differences observed in soil association maps published at different times: 1. changes in the concepts of soil series occur; 2. variations in the extent of the soils occur; and 3. variations in the slope range allowed in the association occur. Differences between county soil association maps can be the result of one or more of these reasons.

The Elkhart, Kosciusko, and Noble County soil association maps were published at different times. The *Soil Survey of Noble County* (McCarter, 1977) and *the Soil Survey of Elkhart County* (Kirshner and McCarter, 1974) were issued in the 1970s, while the *Soil Survey of Kosciusko County* (Staley, 1989) was published nearly 15 years later. Consequently, soil associations in these counties do not agree with one another. Because the Wawasee Area Watershed encompasses parts of all three counties, the soil associations covering the watershed end abruptly at the county line (Figure 7).

Despite the fact that several of the major soil associations of the Wawasee Area Watershed end abruptly at the Kosciusko County/Noble County and Elkhart/Kosciusko County lines, adjacent soil associations are somewhat similar in composition. In Kosciusko County, the Sebewa-Gilford soil association lies along the northern portion of the western edge of the Kosciusko County/Noble County line. The Homer-Sebewa association lies directly east of the Sebewa-Gilford soil association on the Noble County side of the Wawasee Area Watershed. Sebewa soils dominate both of these soil associations, accounting for 35 to 45% of each association. The other major component of each of these soil associations accounts for no more than 25% of the association. In essence, the dominance of Sebewa soils spreads across the northern portion of the two counties, covering much of the Launer Ditch and Norris Branch subwatersheds which drain to Dillon Creek. This does not hold true for most of the remaining portions of the Wawasee Area Watershed. Miami-Riddles-Brookston and Fox-Oshtemo soil associations dominate a majority of the Wawasee Area Watershed within Noble County, while Wawasee-Crosier-Miami and Ormas-Kosciusko soil associations dominate the majority of the watershed within Kosciusko County.

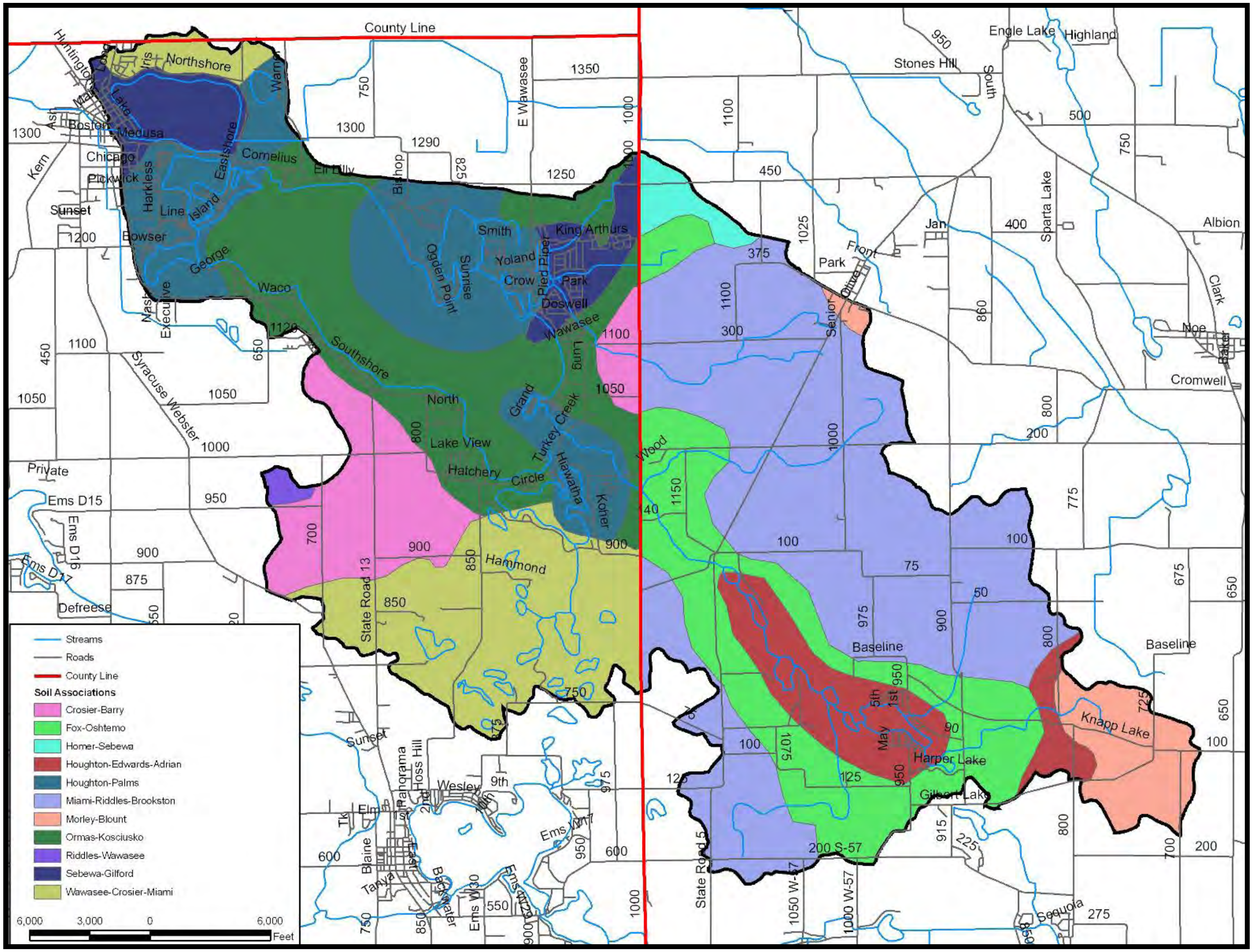

Figure 7. Soil associations present in the Wawasee Area Watershed.

Eleven (11) major soil associations cover the Wawasee Area Watershed (Figure 7). Six of these associations, Ormas-Kosciusko, Wawasee-Crosier-Miami, Sebewa-Gilford, Houghton-Palms, Crosier-Barry, and Riddles-Wawasee, lie within the Kosciusko County portion of the Wawasee Area Watershed. The Ormas-Kosciusko soil association covers the largest portion of the Wawasee Area Watershed within Kosciusko County. This association is the second most common soil association found in Kosciusko County covering approximately 19% of the county landscape. Generally, all of the remaining soil associations are equally proportioned throughout Kosciusko County portion of the watershed. The Wawasee-Miami-Crosier association is the most common soil association found in Kosciusko County covering approximately 28% of the county landscape. The other four associations are less common in Kosciusko County. Crosier-Barry, Riddles-Wawasee, Sebewa-Gilford, and Houghton-Palms soil associations each cover approximately 8 to 10% of the watershed (Staley, 1989). The following discussion on soil associations in the Kosciusko County portion of the Wawasee Area Watershed relies heavily on the *Soil Survey of Kosciusko County* (Staley, 1989). Readers should refer to this source for a more detailed discussion of soil associations covering Kosciusko County.

The Houghton-Palms soil association covers the southern shoreline of Syracuse Lake, all of Mud Lake, and forms the northwestern portion of Lake Wawasee. It is also present along the southeastern corner of Lake Wawasee and the northeastern corner of Lake Papakeechie and along the northern and eastern boundaries of Lake Wawasee. Very poorly drained, nearly level muck soils dominate the Houghton-Palms association. These soils developed from partially decaying organic matter that accumulated in depressional areas of the county. In general, Houghton soils account for 46% of the soils in the association, while Palms soils comprise 16% of the association. Minor components of the association include Gilford mucky sandy loam, Sebewa mucky loam, Edwards muck, and Histosols and Aquolls. Houghton soils are deep with the black muck extending to a depth of 51 inches (129.5 cm) or more. Palms soils contain layers of muck, sandy clay loam, and loam with gravelly coarse sand substrate. When drained, soils in this association may be utilized for agriculture; however, undrained soils in the Houghton-Palms association often hold water and serve best as wetland habitat. Soils in this association typically have severe limitations for use as septic system absorption fields.

The Wawasee-Crosier-Miami soil association lies along the southern portion of the watershed covering much of the Lake Papakeechie subwatershed and along the northern boundary of the watershed cover much of the Syracuse Lake subwatershed. Wawasee soils comprise 30% of the soil association, while Crosier and Miami soils account for 26% and 24% of the association, respectively. Wawasee soils occur in well-drained, gently to strongly sloped areas along ridge tops and side slopes. Fine sandy loam, loam, and sandy clay loam soils overlay fine sandy loam substrate. Crosier soils are poorly drained soils found at lower elevations on the landscape below Wawasee soils. Well drained Miami soils occur on knobs and low ridges and on swells. Both soils possess loam and/or clay loam textured surface and subsurface layers which overlay loam layers. Aubbeenaubbee sandy loam, Barry loam, Metea loamy sand, Rensselaer loam, Riddles fine sandy loam, and Washtenaw silt loam soils are minor components of the Wawasee-Crosier-Miami soil association. Like many of the other soils in the Wawasee Area Watershed, erosion is a concern on sloped areas. Wetness and slow percolation severely limit the use of Crosier soils as septic system leach fields. Slope and slow percolation moderately to severely limit Wawasee and Miami soils for use as septic system leach fields.

The Crosier-Barry soil association covers a portion of the Wawasee Area Watershed southwest of Lake Wawasee and along a portion of the Dillon Creek mainstem immediately west of the Kosciusko/Noble County line. Crosier soils comprise 54% of the association while Barry soils account for another 29%. Minor soil components, including Aubbeenaubbee sandy loam, Palms muck, Metea loamy sand, and Wawasee sandy loam account for the remaining 17% of this association. Crosier soils are typically located on swells and side slopes along drainageways. Barry soils lie in swales, on broad flats, and in drainageways. Both soils possess loam surface soils over loam and/or sandy loam subsoils. Wetness and ponding limit the usability of this soil association; however, subsurface drains installed in these soils improve their usefulness.

The Ormas-Kosciusko soil association covers a majority of the Wawasee Area Watershed. This association forms the southern boundary of Lake Wawasee and also covers the eastern edge of the watershed from Lake Wawasee east to the Kosciusko/Noble County line. Ormas soils comprise 33% of the association with Kosciusko soils accounting for an additional 30%. Minor soil components, including Boyer loamy sand, Riddles fine sandy loam, Homer sandy loam, Gilford sandy loam, and Sebewa loam soils, combine to form the remaining 37% of the association. Ormas soils are typically found on outwash plains, old river terraces and low moraines. While Kosciusko soils are generally found on outwash plains and moraines. The surface soils of this association are typically sandy loam over gravelly sandy loam and gravelly course sand. These soils are well suited to residential development and possess few limitations for dwellings or cultivation. However, this association is limited due to poor filter capacity and requires the installation of deep wells to limit potential water pollution due to septic effluent.

The Sebewa-Gilford soils association covers much of the Enchanted Hills Subdivision and lies adjacent to the Kosciusko/Noble County line along the northern portion of the watershed. Relatively flat topography with slight swells and depressions characterize this association. In undrained conditions, this soil association is also prone to ponded water during wet periods. Sebewa soils account for 47% of the association, while Gilford soils are present on about 18% of the association. Minor soil components comprise the remaining 35% of the soil association. Sebewa soils are poorly drained soils found on broad outwash plains and terraces. These soils are typically loams lying over clay loam, sand, and gravelly sand. Gilford soils are also found on outwash plains and rank as very poorly drained. The surface layer is typically sandy loam, which lies over sandy clay loam, sandy loam, loamy sand, and sand. Boyer, Bronson, Kosciusko, and Ormas soils comprise the minor soil components associated with this soil association. The minor components typically cover knolls, knobs, sloping breaks, and swells. Like many of the other associations in the Wawasee Area Watershed, the Sebewa-Gilford association is used mainly for crops, hay, or pasture. Wetness and ponding may limit the usefulness of this association for agricultural or residential purposes. However, the installation of subsurface drains improves the usability of this association.

The Riddles-Wawasee soil association covers the smallest portion of the Wawasee Area Watershed of any of the soil associations located within Kosciusko County. The only area of Riddles-Wawasee soils are along the extreme western edge of the watershed directly west of Lake Papakeechie. This soil association exists along broad ridges, on knobs, and in depressional areas that are dominated by small lakes and ponds. This soil association consists largely of Riddles (44%) and Wawasee (19%) soils. Both soils possess fine sandy loam surface layers that overlay fine sandy loam, sandy clay loam, and loam subsoil. Minor components of this association include Barry loam, Griswold loam, Martinsville sandy loam, Rensselaer loam, and Whitaker loam soils. Erosion is a concern with this soil association in sloping areas. Like many of the soil associations in the Wawasee Area Watershed, the Riddles-Wawasee association is moderately limited for septic system usage.

Five major soil associations, Fox-Oshtemo, Homer-Sebewa, Houghton-Edwards-Adrian, Morley Blount, and Miami-Riddles-Brookston, cover the Noble County portion of the Wawasee Area Watershed. Miami-Riddles-Brookston soils cover the majority of the Noble County portion of the Wawasee Area Watershed. This association covers 28% of Noble County and is the second most common association in the county (McCarter, 1977). Soils surrounding Knapp Lake and the Village Lake Chain belong to the Houghton-Edwards-Adrian association, while the Fox-Oshtemo association covers much of the length of the Turkey Creek drainage. Morley-Blount soils are present in the extreme southeastern corner of the watershed and also cover a small area near Cromwell. Homer-Sebewa soils form the northern portion of the Wawasee Area Watershed within Noble County.

The Miami-Riddles-Brookston soil association covers a majority of the Wawasee Area Watershed in Noble County. This association is typically found on nearly level and moderately steep knolls and along and in drainageways and depressions. A majority of the association is comprised of Miami soils (40%), while Riddles soils compose 25% and Brookston soils account for 10% of the association. The remaining 25% of the association is composed on minor soil components including Aubbeenaubbee fine sandy loam, Fox sandy loam, Crosier loam, Chelsea fine sand, and Metea loamy fine sand soils. Surface soils are typically loam, silt loam, or sandy loam, which overlay clay loam, sandy clay loam, and loam. Steep slopes associated with Miami and Riddles soils limit the ability of this association for use in agricultural production or for development. Brookston soils are limited by wetness. Organic material content is also relatively low throughout this soil association.

Soils in the Houghton-Edwards-Adrian association cover the areas around Knapp Lake and the Village Lakes Chain. Very poorly drained, nearly level muck soils dominate the Houghton-Edwards-Adrian association. These soils developed from partially decayed organic matter than accumulated in depressional areas of the county. In general, Houghton soils account for roughly 60% of the total soils in the association; Edwards soils account for 12%, while Adrian soils make up 7% of the association. Minor components of the association include Wallkill silt loam, Palms muck, Gilford sandy loam, and Sebewa loam. Houghton soils tend to be very deep, while Edwards and Adrian soils are deep to moderately deep. Edwards soils overlay marl deposits; Adrian soils cover sandy and gravelly outwash. When drained, soils in this association may be utilized for agriculture; however, undrained soils in the Houghton-Edwards-Adrian association often hold water and serve best as wetland habitat. Soils in this association typically have severe limitations for use as a septic system absorption field.

The Fox-Oshtemo soil association covers the length of the Turkey Creek drainage downstream of the Village Lakes Chain, surrounds the Houghton-Edwards-Adrian association around Knapp Lake and the Village Lakes Chain, and the covers tip of the middle branch of Dillon Creek. This soil association consists largely of Fox soils (60%) and Oshtemo soils (15%). Both soils possess sandy loam, clay loam, sandy clay loam, or loamy sand textures and overlay sand and gravelly sand subsoil layers. Both soils are also common on outwash plains and upland knolls on the landscape. Minor components of this soil association include Boyer loamy sand, Casco sandy clay loam, Homer loam, Riddles sandy loam, and Sebewa loam soils. Erosion can be a concern with this soil association in sloping areas. In contrast to the other soil associations covering the Noble County portion of the

Wawasee Area Watershed, however, Fox-Oshtemo soils are only slightly limited in their ability to serve as a septic tank absorption field.

The Morley-Blount association covers a small portion of the Wawasee Area Watershed in Noble County. This association is present in the extreme southeastern corner of the watershed and immediately south of Cromwell. Soils in this association reflect of geological heterogeneity that is characteristic of morainal depositional areas. Soils in the Morley-Blount association range from well drained to somewhat poorly drained and are found on nearly level to moderately sloping landscapes. Soils in this soil association typically cover fine textured (clay loam) to moderately fine textured (silt loam) subsoil. Morley and Blount soils comprise approximately 60% of the soil association. Morley soils lie on knolls and along drainageways, while Blount soils occupy lower elevation flats and drainages. Minor soil units in the association include Pewamo silty clay loam, Washtenaw silt loam, Rawson loam, Milford silty clay loam, Haskins loam, and Shoals silt loam. Erosion is a noted problem on Morley soils, and, in general, the soils in this association are severely limited in their use as a septic tank absorption field.

Soils in the Homer-Sebewa association are typically inundated due to the high water table found in context with this soil association. During some periods of the year, ponding occurs throughout this association. Homer soils account for 40% of the association with Sebewa soils covering an additional 30% and minor components covering the remaining 30% of the association. Both Homer and Sebewa soils are typically poorly drained loam, sand, and gravelly sand. These soils are typically present on broad outwash plains. Minor soil components, including Rensselaer loam, Gilford sandy loam, and Brady loamy sand soils, are found within drainageways and on flats between depressions throughout the association. Wetness limits the use of this association for agricultural production or development. Sand and gravel mining occurs on these soils.

Soils in the watershed, in particular their ability to erode or sustain certain land use practices, can impact the water quality of lakes and streams in the watershed. The dominance of Riddles and Miami soils throughout the Wawasee Area Watershed suggests that much of the watershed is prone to erosion; common erosion control methods should be implemented when the land is used for agriculture or during residential development to protect waterbodies in the Wawasee Area Watershed. Similarly, several soil units within the Wawasee Area Watershed are severely limited in their ability to serve as septic system leach fields. This needs to be considered as areas of the watershed are converted from agricultural use to residential use. More detailed discussions of highly erodible soils and soils used to treat septic tank effluent in the Wawasee Area Watershed follow below.

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 health. In addition, such soils carry attached nutrients, which further impair water quality by increasing plant and algae growth. Soil-associated chemicals, like some herbicides and pesticides, can kill aquatic life and damage water quality.

Highly erodible and potentially highly erodible are classifications used by the Natural Resources Conservation Service (NRCS) to describe the potential of certain soil units to erode from the landscape. The NRCS examines common soil characteristics such as slope and soil texture when classifying soils. The NRCS maintains a list of highly erodible soil units for each county. Table 2 lists the soil units in the Wawasee Area Watershed that the NRCS considers to be highly or potentially highly erodible. As Figure 8 indicates, potentially highly erodible soils cover a substantial portion (7,344 acres or nearly 30%) of the Wawasee Area Watershed. This acreage is mostly concentrated in the Noble County portion of the watershed, within the southern portion of the watershed located in Kosciusko County, and along the northern shoreline of Syracuse Lake. Highly erodible soils exist on 1,436 acres (approximately 6%) of the watershed. Most of these are located in the Lake Papakeechie subwatershed. In fact, highly erodible soils cover the entire shoreline of Lake Papakeechie. Other isolated patches of highly erodible soils are also scattered throughout Tri-County Fish and Wildlife Area and in the Noble County portion of the watershed.

Table 2. Highly erodible and potentially highly erodible soils units in the Wawasee Area Watershed.

Soil Unit	Soil Name	County	Detail*	Soil Description
BlB2	Blount silt loam	Noble	PHES	2 to 4% slopes, eroded
BoB	Boyer loamy sand	Noble	PHES	2 to 6% slopes
BoC	Boyer loamy sand	Kosciusko; Noble	PHES	6 to 12% slopes
BoD2	Boyer loamy sand	Noble	HES	12 to 18% slopes, eroded
CcC3	Casco sandy clay loam	Noble	HES	8 to 15% slopes, severely eroded
ChC	Chelsea fine sand	Noble	PHES	6 to 12% slopes
ClC	Coloma loamy sand	Kosciusko	PHES	6 to 12% slopes
FoB	Fox sandy loam	Noble	PHES	2 to 6% slopes
FoC2	Fox sandy loam	Noble	PHES	6 to 12% slopes, eroded
FsD2	Fox-Casco sandy loam	Noble	HES	12 to 18% slopes, eroded
KoB	Kosciusko sandy loam	Kosciusko	PHES	0 to 2% slopes
KoC	Kosciusko sandy loam	Kosciusko	PHES	6 to 12% slopes
KoE	Kosciusko sandy loam	Kosciusko	HES	18 to 30% slopes
KxC3	Kosciusko sandy clay loam	Kosciusko	HES	8 to 15% slopes, severely eroded
MbC	Metea loamy sand	Kosciusko	PHES	6 to 12% slopes
MdB	Martsinville fine sandy loam	Noble	PHES	2 to 6% slopes
MeC	Metea loamy fine sand	Kosciusko	PHES	6 to 12% slopes
MfB2	Miami loam	Noble	PHES	2 to 6% slopes, eroded
MfC2	Miami loam	Noble	PHES	6 to 12% slopes, eroded
MfD2	Miami loam	Noble	HES	12 to 18% slopes, eroded
MfE2	Miami loam	Noble	HES	18 to 25% slopes, eroded
MgC3	Miami clay loam	Noble	HES	6 to 12% slopes, severely eroded
MgD3	Miami clay loam	Noble	HES	12 to 18% slopes, severely eroded
MlB	Miami loam	Kosciusko	PHES	2 to 6% slopes
MlC	Miami loam	Kosciusko	PHES	6 to 12% slopes
MrB2	Morley silt loam	Noble	PHES	2 to 6% slopes, eroded
MrC2	Morley silt loam	Noble	PHES	6 to 12% slopes, eroded
MsB	Miami-Owosso-Metea complex	Kosciusko	PHES	2 to 8% slopes
MsC3	Morley silty clay loam	Noble	HES	6 to 12% slopes, severely eroded
MsD	Miami-Owosso-Metea complex	Kosciusko	HES	10 to 25% slopes
MsD3	Morley siltly clay loam	Noble	HES	12 to 18% slopes, severely eroded
MtE	Morley soils	Noble	HES	18 to 25% slopes
MzB	Morley-Glynwood complex	Kosciusko	PHES	1 to 4% slopes
OrC	Ormas loamy sand	Kosciusko	PHES	6 to 12% slopes
OsB	Oshtemo loamy sand	Noble	PHES	2 to 6% slopes

Soil Unit	Soil Name	County	Detail*	Soil Description
OsC	Oshtemo loamy sand	Noble	PHES	6 to 12% slopes
RaC2	Rawson sandy loam	Noble	HES	6 to 12% slopes, eroded
RbB	Rawson loam	Noble	PHES	2 to 6% slopes
RdB2	Rawson, Morley, and Miami loams	Noble	PHES	2 to 6% slopes, eroded
RlB	Riddles fine sandy loam	Kosciusko	PHES	2 to 6% slopes
RlC	Riddles fine sandy loam	Kosciusko	PHES	6 to 12% slopes
RlD	Riddles fine sandy loam	Kosciusko	HES	12 to 18% slopes
RopB	Riddles-Oshtemo fine sandy loam	Elkhart	PHES	1 to 5% slope
RsB	Riddles sandy loam	Noble	PHES	2 to 6% slopes
RsC2	Riddles sandy loam	Noble	PHES	6 to 12% slopes, eroded
RsD2	Riddles sandy loam	Noble	HES	12 to 18% slopes, eroded
RxC	Riddles-Ormas-Kosciusko complex	Kosciusko	PHES	6 to 12% slopes
WlB	Wawasee fine sandy loam	Kosciusko	PHES	2 to 6% slopes
WlC2	Wawasee fine sandy loam	Kosciusko	HES	6 to 12% slopes, eroded
WlD2	Wawasee fine sandy loam	Kosciusko	HES	12 to 18% slopes, eroded

*HES=Highly Erodible Soils; PHES=Potentially Highly Erodible Soils
Source: Kirshner and McCarter, 1974; McCarter, 1977; Staley, 1989; USDA/SCS Indiana Technical Guide II-C for Elkhart, Kosciusko, and Noble Counties.

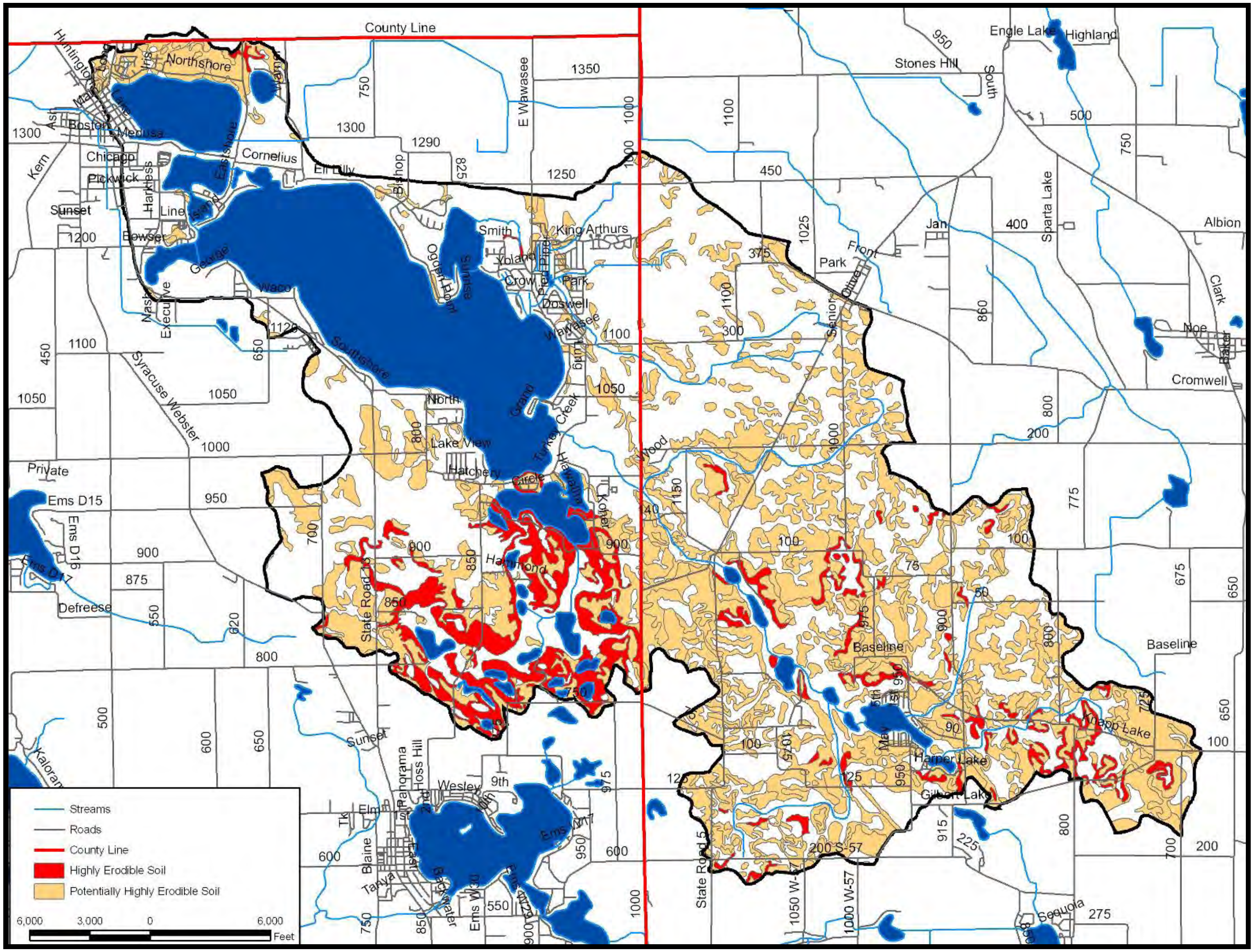

Figure 8. Highly erodible and potentially highly erodible soils in the Wawasee Area Watershed.

2.4.2 Soils Used for Wastewater Treatment

As is common in many areas of Indiana, septic tanks and septic tank absorption fields are utilized for wastewater treatment throughout much of the Wawasee Area Watershed. Use of septic systems occurs throughout much of the Wawasee Area Watershed; however, a majority of Lake Wawasee's shoreline residents utilize sewer systems to treat their wastewater. These areas will be discussed in more detail in subsequent sections. Septic systems rely on the septic tank for primary treatment to remove solids and the soil for secondary treatment to reduce the remaining pollutants in the effluent to levels that protect surface and groundwater from contamination. The soil's ability to sequester and degrade pollutants in septic tank effluent will ultimately determine how well surface and groundwater is protected.

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

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

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

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

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

The Natural Resources Conservation Service has ranked each soil series in terms of its limitations for use as a septic tank absorption field. Each soil series is placed in one of three categories: slightly limited, moderately limited, or severely limited. Use of septic absorption fields in moderately or severely limited soils generally requires special design, planning, and/or maintenance to overcome the limitations and ensure proper function. Table 3 summarizes the soil series in the Wawasee Area Watershed in terms of their suitability for use as septic tank absorption fields. Figure 9 displays the septic tank absorption field suitability of soils mapped in the Wawasee Area Watershed. Soils severely limited for use as septic tank absorption fields cover nearly 51% of the watershed (12,577 acres or 5,092 ha), while moderately limited soils cover 20% of the watershed (4,794 acres or 1,940 ha). In total, 7% of the Wawasee Area Watershed is covered by soils that are only slightly limited for use as septic tank absorption fields. (The remaining 21% of the watershed is covered by open water.)

2.4.3 Sewer Systems in the Wawasee Area Watershed

Figure 10 displays the portions of Lake Wawasee's shoreline where wastewater drains to a sewer system and is treated off-site. Additionally, although it is not shown, all residences within the incorporated portion of Syracuse are hooked into the city sewer system. Wastewater is collected at the treatment plant located west of town, cleaned, and discharged into Turkey Creek downstream of Syracuse. Residences along much of Lake Wawasee's shoreline are hooked into the regional sewer district. The sewer system was constructed over a twelve-year period (1989 to 2001; Figure 10). Most of the sewer system along the northern shoreline of Lake Wawasee was constructed in 1989; sewer system lines along the southern and eastern shorelines of the lake, excluding Enchanted Hills, were constructed in 1990. Small areas along the northeastern shoreline and on and adjacent to Ogden Island were constructed from 1990 to 1992; the Enchanted Hills portion of the sewer system was constructed from 1997 to 1998. Final portions along Kanata Manayunk were completed in 2001 (Figure 10). All wastewater is pumped north along the County Road 1200 West to the treatment plant east of Lake Wawasee. Residences along portions of Lake Wawasee's shoreline are not currently included in the sewer system. These include nearly 400 homes along portions of the lake's southern and eastern shorelines and many areas of the Enchanted Hills Subdivision.

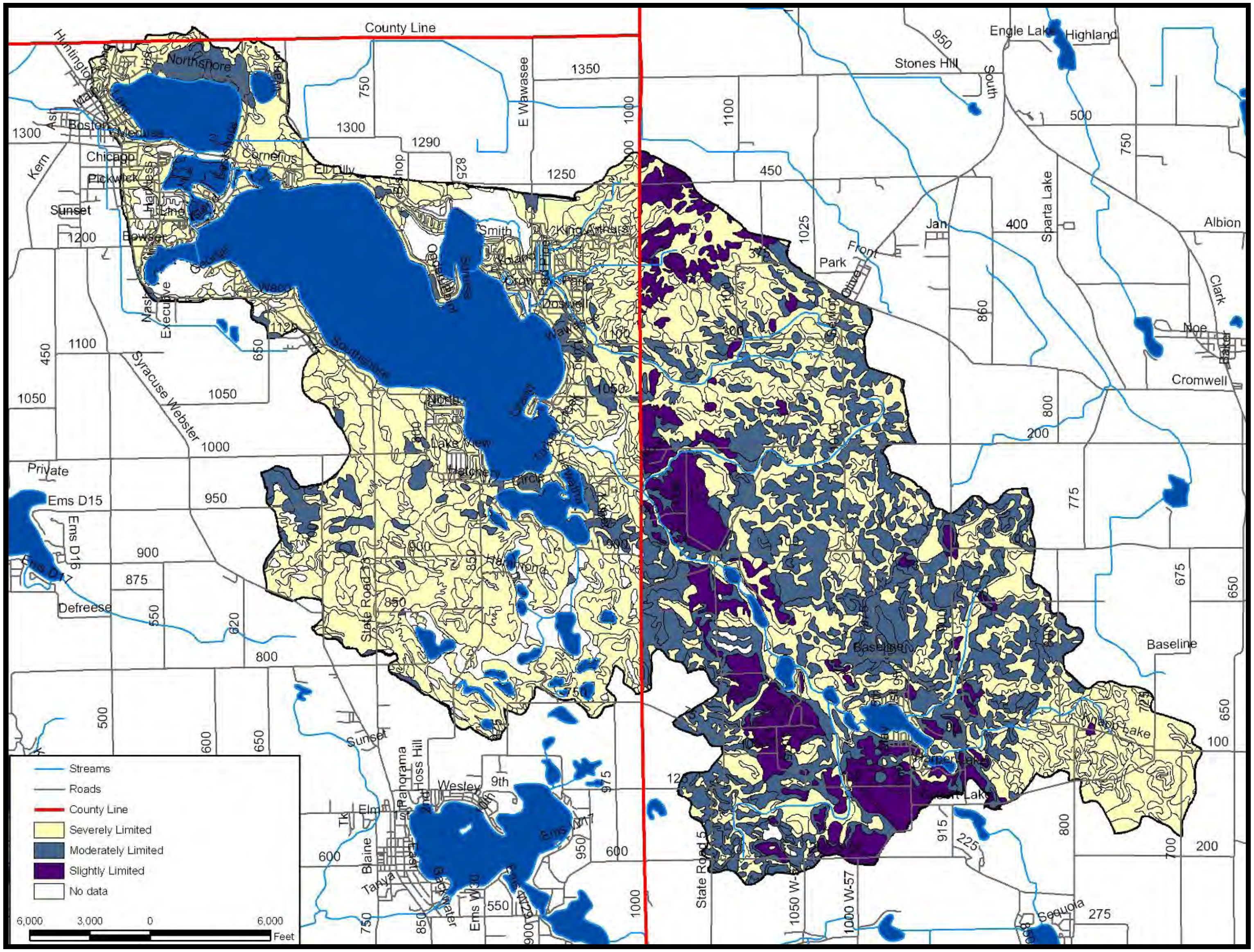

Figure 9. Soil series septic tank absorption field suitability in the Wawasee Area Watershed.

Table 3. Soil types present in the Wawasee Area Watershed.

Soil Unit	Soil Name	County	High Water Table	Suitability for Septic Tank Absorption Field
Ao	Aquents-Urban land complex	Kosciusko	--	--
ArA	Aubbeenaubbee sandy loam	Kosciusko	1 to 3 feet	Severe: wetness, percs slowly
AtA	Aubbeenaubbee fine sandy loam	Kosciusko	1 to 3 feet	Severe: wetness, seasonal high water table
Bc	Barry loam	Kosciusko	+1 to 1 feet	Severe: ponding
BlA	Blount sandy loam	Kosciusko	1 to 3 feet	Severe: wetness, percs slowly
BlA-BlB2	Blount silt loam	Noble	1 to 3 feet	Severe: seasonal high water table, percs slowly
BnB	Blount-Glynwood complex	Kosciusko	1 to 3.5 feet	Severe: wetness, percs slowly
BoB-BoC	Boyer loamy sand	Kosciusko	>6 feet	Severe: poor filter
BoB	Boyer loamy sand	Noble	>6 feet	Slight
BoC	Boyer loamy sand	Noble	>6 feet	Moderate: slope, permeability
BoD2	Boyer loamy sand	Noble	>6 feet	Severe: slope, permeability
Bp; Br	Brady sandy loam	Kosciusko; Noble	1 to 3 feet	Severe: wetness, seasonal high water table, permeability
BrA	Bronson sandy loam	Kosciusko	2 to 3.5 feet	Severe: wetness
BuuA	Brookston loam	Elkhart	0 to 2 feet	Severe: ponding, poor filter
Bx	Brookston silt loam	Noble	0 to 1 feet	Severe: seasonal high water table, ponding, permeability
CcC3	Casco sandy clay loam	Noble	>6 feet	Moderate: slope
ChB	Chelsea fine sand	Noble	>6 feet	Slight
ChC	Chelsea fine sand	Noble	>6 feet	Moderate: slope
ClB-ClC	Coloma loamy sand	Kosciusko	>6 feet	Severe: poor filter
CrA-CrB	Crosier loam	Kosciusko; Noble	1 to 3 feet	Severe: wetness, percs slowly, seasonal high water table
CvdA	Crosier loam	Elkhart	0.5 to 3 feet	Severe: depth to water table, percs slowly
Ed, Em	Edwards muck	Kosciusko; Noble	+1 to 1 feet	Severe: ponding, percs slowly
FoA-FoB	Fox sandy loam	Noble	>6 feet	Slight
FoC2	Fox sandy loam	Noble	>6 feet	Moderate: slope
FsD2	Fox-Casco sandy loam	Noble	>6 feet	Severe: slope
Gf	Gilford sandy loam, gravelly substratum	Kosciusko	+0.5 to 1 feet	Severe: ponding, poor filter
Gf	Gilford sandy loam	Noble	0 to 1 feet	Severe: seasonal high water table, permeability
Go	Gravelton loamy sand	Kosciusko	+0.5 to 1 feet	Severe: flooding, ponding, poor filter
HaA	Haskins loam	Noble	1 to 3 feet	Severe: seasonal high water table, permeability
He	Histosols and Aquolls	Kosciusko	+1 to 1 feet	
Hh	Homer loam	Noble	1 to 3 feet	Severe: seasonal high water table, permeability
Ho	Homer sandy loam	Kosciusko	1 to 3 feet	Severe: wetness, poor filter
Hm, Ho	Houghton muck	Noble	0 to 1 feet	Severe: organic material, high water table, ponding

Soil Unit	Soil Name	County	High Water Table	Suitability for Septic Tank Absorption Field
Ht, Hx	Houghton muck, undrained	Kosciusko	+1 to 1 feet	Severe: subsides, ponding, percs slowly
KoA-KoC	Kosciusko sandy loam	Kosciusko	>6 feet	Severe: poor filter
KoE	Kosciusko sandy loam	Kosciusko	>6 feet	Severe: poor filter, slope
KxC3	Kosciusko sandy clay loam	Kosciusko	>6 feet	Severe: poor filter
Mb	Marsh	Noble	--	Material too variable to be rated
MbA-MbC	Metea loamy sand	Kosciusko	>6 feet	Severe: poor filter
MdB	Martsinville fine sandy loam	Noble	>6 feet	Slight
MeA-MeC	Metea loamy fine sand	Kosciusko	>6 feet	Severe: poor filter, percs slowly
MeB	Metea loamy fine sand	Noble	>6 feet	Moderate: permeability, seepage at base of slope
MfB2	Miami loam	Noble	>6 feet	Moderate: permeability
MfC2	Miami loam	Noble	>6 feet	Moderate: permeability, slope, seepage at base of slope
MfD2-MfE2	Miami loam	Noble	>6 feet	Severe: slope
MgC3	Miami clay loam	Noble	>6 feet	Moderate: permeability, slope, seepage at base of slope
MgD3	Miami clay loam	Noble	>6 feet	Severe: slope
MlB-MlC	Miami loam	Kosciusko	>6 feet	Severe: percs slowly
MsB	Miami-Owosso-Metea complex	Kosciusko	>6 feet	Severe: percs slowly, poor filter
MsD	Miami-Owosso-Metea complex	Kosciusko	>6 feet	Severe: percs slowly, poor filter, slope
Mn	Milford silty clay loam	Noble	0 to 1 feet	Severe: seasonal high water table, ponding, permeability
MrB2	Morley silt loam	Noble	3 to 6 feet	Severe: slow permeability
MrC2	Morley silt loam	Noble	3 to 6 feet	Severe: slow permeability, slope, seepage at base of slope
MsC3-MsD3	Morley silty clay loam	Noble	3 to 6 feet	Severe: slow permeability, slope, seepage at base of slope
MtE	Morley soils	Noble	3 to 6 feet	Severe: slow permeability, slope, seepage at base of slope
MzB	Morley-Glynwood complex	Kosciusko	>6 feet	Severe: percs slowly, wetness
OrA-OrC	Ormas loamy sand	Kosciusko	>6 feet	Severe: poor filter
OsB	Oshtemo loamy sand	Noble	>6 feet	Slight
OsC	Oshtemo loamy sand	Noble	>6 feet	Moderate: slope
OtA	Oshtemo sandy loam	Noble	>6 feet	Slight
Pa, Pb	Palms muck, drained	Kosciusko	+1 to 1 feet	Severe: subsides, ponding
Pb	Palms muck, drained	Noble	0 to 1 feet	Severe: organic material, high water table, ponding
Pe	Pewamo silty clay loam	Kosciusko; Noble	+1 to 1 feet	Severe: percs slowly, ponding, seasonal high water table
Pg	Pits, gravel	Kosciusko	--	--
RaC2	Rawson sandy loam	Noble	3 to 6 feet	Severe: percs slowly
RbA-RbB	Rawson loam	Noble	3 to 6 feet	Severe: percs slowly
RdB2	Rawson, Morley, and Miami loams	Noble	3 to 6 feet	Severe: percs slowly

Soil Unit	Soil Name	County	High Water Table	Suitability for Septic Tank Absorption Field
Re	Rensselaer loam	Kosciusko; Noble	+0.5 to 1 feet	Severe: seasonal high water table, ponding, permeability
RlA-RlB	Riddles fine sandy loam	Kosciusko	>6 feet	Moderate: percs slowly
RlC	Riddles fine sandy loam	Kosciusko	>6 feet	Moderate: percs slowly, slope
RlD	Riddles fine sandy loam	Kosciusko	>6 feet	Severe: slope
RopB	Riddles-Oshtemo fine sandy loam	Elkhart	1.5 to 3 feet	Severe: percs slowly, poor filter
RsA	Riddles sandy loam	Noble	>6 feet	Moderate: permeability
RsB	Riddles sandy loam	Noble	>6 feet	Moderate: permeability
RsC2-RsD2	Riddles sandy loam	Noble	>6 feet	Moderate: permeability, slope
RxB	Riddles-Ormas-Kosciusko complex	Kosciusko	>6 feet	Moderate: percs slowly; Severe: poor filter
RxC	Riddles-Ormas-Kosciusko complex	Kosciusko	>6 feet	Moderate: percs slowly, slope; Severe: poor filter
Se	Sebewa loam	Kosciusko; Noble	+1 to 1 feet	Severe: seasonal high water table, ponding, percs slowly
Sf	Sebewa mucky loam	Kosciusko	+1 to 1 feet	Severe: poor filter, percs slowly
To	Toledo silty clay loam	Noble	0 to 1 feet	Severe: seasonal high water table, ponding, permeability
Ud	Udorthents, loamy	Kosciusko	--	--
Uf	Urdorthents-Urban land complex	Kosciusko	--	--
Wa	Wallkill silt loam	Kosciusko; Noble	+0.5 to 1 feet	Severe: ponding, poor filter, seasonal high water table
Wc	Washtenaw silt loam	Kosciusko	+0.5 to 1 feet	Severe: ponding, percs slowly
We	Washtenaw loam, gravelly substratum	Kosciusko	+1 to 1 feet	Severe: ponding, percs slowly
WlB	Wawasee fine sandy loam	Kosciusko	>6 feet	Moderate: percs slowly
WlC2	Wawasee fine sandy loam	Kosciusko	>6 feet	Moderate: percs slowly, slope
WlD2	Wawasee fine sandy loam	Kosciusko	>6 feet	Severe: slope
WobB	Williamston-Crosier complex	Elkhart	0.5 to 3 feet	Severe: depth to water table, percs slowly
Ws	Washtenaw silt loam	Noble	0 to 1 feet	Severe: seasonal high water table, ponding, percs slowly, organic matter
Wt	Whitaker loam	Kosciusko; Noble	1 to 3 feet	Severe: seasonal high water table, permeability, wetness

*Different counties may use the same symbol for different soil units. Similarly, different counties may use different symbols for the same soil units.
Source: Kirshner and McCarter, 1974; McCarter, 1977; Staley, 1989.

Figure 10. Sewer system installation date and location adjacent to Lake Wawasee.

2.5 Natural History

Geographic location, climate, geology, topography, soils, and other factors play a role in shaping the native floral and faunal communities in a particular area. Various ecologists (Deam, 1921; Petty and Jackson, 1966; Homoya et al., 1985; Omernik and Gallant, 1988) have divided Indiana into several natural regions or ecoregions, each with similar geographic history, climate, topography, and soils. Because the groupings are based on factors that ultimately influence the type of vegetation present in an area, these natural areas or ecoregions tend to support characteristic native floral and faunal communities. The Wawasee Area Watershed is located in the Northern Lakes Natural Region (Homoya et al., 1985). The Northern Lakes Natural Region occupies the north central and northeastern portion of Indiana. The Eel River marks the Northern Lakes Natural Region boundary on the southeast and the Maxinkuckee Moraine serves as the Region's western boundary. Similarly, the Wawasee Area Watershed lies within Omernik and Gallant's Southern Michigan/Northern Indiana Till Plains ecoregion. The Wawasee Area Watershed also lies mainly within Petty and Jackson's Oak-Hickory Climax Forest Association; however, a small portion of the headwaters area lies within the Beech-Maple Climax Forest Association. As a result of the varying ecoregions, natural regions, and forest associations, the native floral community of the Wawasee Area Watershed likely consisted of components of neighboring natural areas and ecoregions in addition to components characteristic of the natural area and ecoregion in which it is mapped.

Homoya et. al (1985) noted that prior to European settlement, the region was a mixture of numerous natural community types, including bog, fen, marsh, prairie, sedge meadow, swamp, seep spring, lake, and deciduous forest. The dry to dry-mesic uplands were likely forested with red oak, white oak, black oak, shagbark hickory, and pignut hickory. More mesic areas probably harbored beech, sugar maple, black maple, and tulip poplar. Omernick and Gallant (1988) describe the region as consisting mostly of cropland agriculture, with remnants of natural forest cover. Mesic forests are dominated by American beech and sugar maple, with a significant component of white oak, black oak, northern red oak, yellow poplar, hickory, white ash, and black walnut. Petty and Jackson (1966) list pussy toes, common cinquefoil, wild licorice, tick clover, blue phlox, waterleaf, bloodroot, Joe-pye-weed, woodland asters and goldenrods, wild geranium, and bellwort as common components of the forest understory in the watershed's region.

Several of these natural community types likely covered the Wawasee Area Watershed landscape in pre-settlement times. For example, upland forest dominated by red oak, white oak, black oak, shagbark hickory, and/or pignut hickory likely covered areas currently covered by Lake Papakeechie and areas east and west of Lake Wawasee. The lower elevation areas such as the corridor along Turkey Creek and the variety of wetland complexes along the shorelines of Lake Wawasee and Syracuse Lake were likely forested with tree species that are more tolerant of wet soil conditions. Common species may have included sycamore, American elm, red elm, green ash, silver maple, and red maple. Marsh habitat rather than open water was more common along the shallow edge of Lake Wawasee in pre-settlement times (Blatchley, 1899). Royse (1919) documents the attraction of Syracuse Lake and Lake Wawasee to passing travelers and settlers. The swamps, streams, and forest-covered hills provided a variety of fish and game for settlers consumption (Royse, 1919).

Historical records support the observation that prior to European settlement of Turkey Creek and Sparta Townships dense oak-hickory forests covered the Wawasee Area Watershed (Petty and Jackson, 1966). Chamberlain (1849) described the area as possessing undulating topography covered by fields of heavy timber interspersed with oak openings, barrens, prairie, and marshland. The state legislature (1938) noted that Kosciusko and Noble Counties were dotted with beautiful lakes, the largest of which was Nine Mile Lake (later known as Turkey Creek Lake). A series of rich marshland and deep, clear water covered much of the area immediately adjacent to Turkey Creek and was interspersed with lakes south of Lake Wawasee along Jarrett's Creek (Blatchley, 1899; State Legislature, 1938). White oak was the dominant component of the heavily timbered areas with shagbark hickory, maple, beech, elm, walnut, butternut, and red and black oak as subdominants (Petty and Jackson, 1966; Omernik and Gallant, 1988). Historical accounts document the presence of unbroken forests and heavily timbered areas along the shores of the six small lakes that lie within the current Lake Papakeechie basin. The six lakes, Jarrett's, Gan's, Hooper's, and three known as Hartzell's, were surrounded by thick marshland (Lilly, 1965). Dense oak-hickory forest covered the adjacent hills. In 1913, an 8-foot (2.4-m) earthen dam was constructed across Jarrett's Creek thereby creating Lake Papakeechie.

Wet habitat (ponds, marshes, and swamps) intermingled with the upland habitat throughout the Wawasee Area Watershed. The hydric soil map and an 1876 map of Kosciusko and Noble Counties indicate that wetland habitat existed along portions of the entire shoreline of Lake Wawasee, along the eastern shoreline of Syracuse Lake, and in small openings throughout the watershed. These wet habitats supported very different vegetative communities than the drier portions of the landscape. Swamp loosestrife, cattails, soft stem bulrush, marsh fern, marsh cinquefoil, pickerel weed, arrow arum, and sedges dominated the marsh habitat throughout the watershed. Within the lake itself, common species included pondweeds, spatterdock, white water lilies, watershield, eel grass, and coontail. Swamp habitat likely covered the scattered shallow depressions at higher topographical elevations in the watershed. Typical dominant swamp species in the area included red and silver maple, green and black ash, and American elm (Homoya et al., 1985).

2.6 <u>Natural Communities and Endangered, Threatened, and Rare Species</u>

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

Appendix B presents the results from the database search for the Wawasee Area Watershed. (For additional reference, Appendix C provides a listing of endangered, threatened, and rare species (ETR) documented in Elkhart, Kosciusko, and Noble Counties.) Only one federally listed endangered, threatened, and rare species is known to exist in the watershed. This is the Indiana bat (*Myotis sodalis*) which was last observed in the Tri-County Fish and Wildlife Area in 1955. Multiple state listed species inhabit Lake Wawasee, its watershed, and its watershed lakes. The state of Indiana uses the following definitions when listing species:

- *Endangered*: Any species whose prospects for survival or recruitment with the state are in immediate jeopardy and are in danger of disappearing from the state. This includes all species classified as endangered by the federal government which occur in Indiana. Plants currently known to occur on five or fewer sites in the state are considered endangered.

- *Threatented*: Any species likely to become endangered within the foreseeable future. This includes all species classified as threatened by the federal government which occur in Indiana. Plants currently known to occur x on six to ten sites in the state are considered threatened.
- *Rare*: Plants and insects currently known to occur on from eleven to twenty sites.

The Indiana Natural Heritage Data Center database contains nearly sixty records for the area encompassed by the Wawasee Area Watershed (Appendix A). The database records the presence or historical presence of three state endangered animal species including one mammal, one fish, and two reptiles: the Indiana bat, lake sturgeon (*Acipenser fulvescens*), spotted turtle (*Clemmys guttata*), and Blanding's turtle (*Emydoidea blandingii*). The lake sturgeon was last observed in the Wawasee Area Watershed in 1991, while Blanding's turtle was observed once without a recorded date and again in 1989 and the spotted turtle was last seen in 1953. One state rare insect, the Baltimore (*Euphydryas phaeton*), was last found in the watershed in 1930. The database also documents the historical presence of one state extirpated and four state endangered plant species. The state extirpated species, twinflower (*Linnaea borealis*), was last sighted in the Wawasee Area Watershed in 1916. The state endangered plant species include Oakes pondweed (*Potamogeton oakesianus*), which was last observed in 1985, American Scheuchzeria (*Scheuchzeria palustris ssp. americana*) and wild calla (*Calla palustris*), both of which were last observed in 1938, and Bicknell northern crane's bill (*Geranium bicknellii*), which was last found in 1931.

A number of state threatened and state rare plant species are also included on the Indiana Heritage Database listing for the Wawasee Area Watershed. State threatened plants include: horned bladderwort (*Utricularia cornuta*), straight-leaf pondweed (*Potamogeton strictifolius*), beck water-marigold (*Bidens beckii*), Fries' pondweed (*Potamogeton friesii*), and small cranberry (*Vaccinium oxycoccos*). The observations of small cranberry (1993), beck water-marigold (1979, 1985), and Fries' pondweed (1962) are relatively recent, while horned bladderwort (1938) and straight-leaf pondweed (1934, 1935) observations occurred much earlier. State rare plants once identified in the Wawasee Area Watershed include: whorled water-milfoil (*Myriophyllum verticillatum*), American wintergreen (*Pyrola rotundifolia var. americana*), water bulrush (S*cirpus subterminalis*), marsh arrow-grass (*Triglochin palustris*), Richardson's pondweed (*Potamoegon richardsonii*), false asphodel (*Tofieldia glutinosa*), ostrich fern (*Matteuccia struthiopteris*), and bog rosemary (*Andromeda glaucophylla*). Observations of bog rosemary (1993), whorled water-milfoil (1985), Richardson's pondweed (1985), American wintergreen (1984), and ostrich fern (1984) occurred relatively recently, while water bulrush (1934) and marsh arrow-grass (1938) have not been observed in the Wawasee Area Watershed recently. False asphodel's sighting is not dated in the database.

The Natural Heritage Database also documents the presence of a number of high quality natural communities. Many of these areas are located in the Turkey Creek headwaters including acid bog, circumneutral bog, marsh, sedge meadow, and shrub swamp. Within Tri-County Fish and Wildlife Area, marsh, sedge meadow, and lake communities are documented for their high quality status.

2.7 Hydrology

As is characteristic of much of the glaciated portion of the state, hydrological features, including wetlands, lakes, and streams, are important components of the Wawasee Area Watershed landscape. A variety of high quality wetlands, lakes and streams are present throughout the Wawasee Area Watershed.

2.7.1 Wetlands

In general, wetlands, including lake systems, cover roughly 20 to 25% of the Wawasee Area Watershed. The USGS Land Cover Data Set suggests that wetlands cover approximately 6% of the Wawasee Area Watershed and open water covers an additional 17% 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 11) shows that wetlands cover approximately 26% of the Wawasee Area Watershed. (Table 4 presents the acreage of wetlands by type according to the National Wetland Inventory.) The differences in reported wetland acreage in the Wawasee Area Watershed reflect the differences in project goals and methodology used by the different agencies to collect land use data.

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 12 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 (5,215 acres) and the area of the watershed mapped as water (lakes, ponds, etc.; 3,890 acres) indicates that historically, 9,105 acres of wetland and/or open water existed within the Wawasee Area Watershed. When this acreage is compared to the acreage of existing wetlands (6,455 acres), this calculation suggests that nearly 70% of the original wetland or open water acreage still exists today.

Table 4. Acreage and classification of wetland habitat in the Wawasee Area Watershed.

Wetland Type	Area (acres)	Area (ha)	Percent of Watershed
Lacustrine (Lake)	3,922.1	1,587.9	16.0%
Palustrine emergent (Herbaceous wetland)	1,314.9	532.3	5.4%
Palustrine forested (Forested wetland)	667.6	270.3	2.7%
Palustrine scrub/shrub (Shrubby wetland)	325.3	131.7	1.3%
Palustrine submergent (Herbaceous wetland)	5.1	2.0	0.0%
Ponds	219.7	88.9	0.9%
Total Area	**6,454.6**	**2,613.2**	**26.4%**

Wetland loss in the Wawasee Area 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 38% and 35% of the land in Kosciusko and Noble Counties, respectively (cited in Hudak, 1995). The WACF and watershed residents have undertaken efforts to protect and restore wetland acreage and functionality in the Wawasee Area Watershed. Because of these protection efforts, the wetland along the shorelines of Lake Wawasee and Syracuse Lake and along the length of Turkey Creek remains largely intact. Most of the wetland loss that has occurred within the Wawasee Area Watershed is located away from the lakes both south and east of Lake Wawasee. Efforts by the WACF have led to the conservation of many of the important wetland features located in the Wawasee Area Watershed. Since 1993, WACF protected more than 460 acres of wetland adjacent to Lake Wawasee, Bonar Lake, and Syracuse Lake's shoreline. This translates to approximately 5.25 miles of protected shoreline around these lakes (WACF, 2006). This acreage accounts for a portion of the overall wetland acreage present in the Wawasee Area Watershed (Table 4).

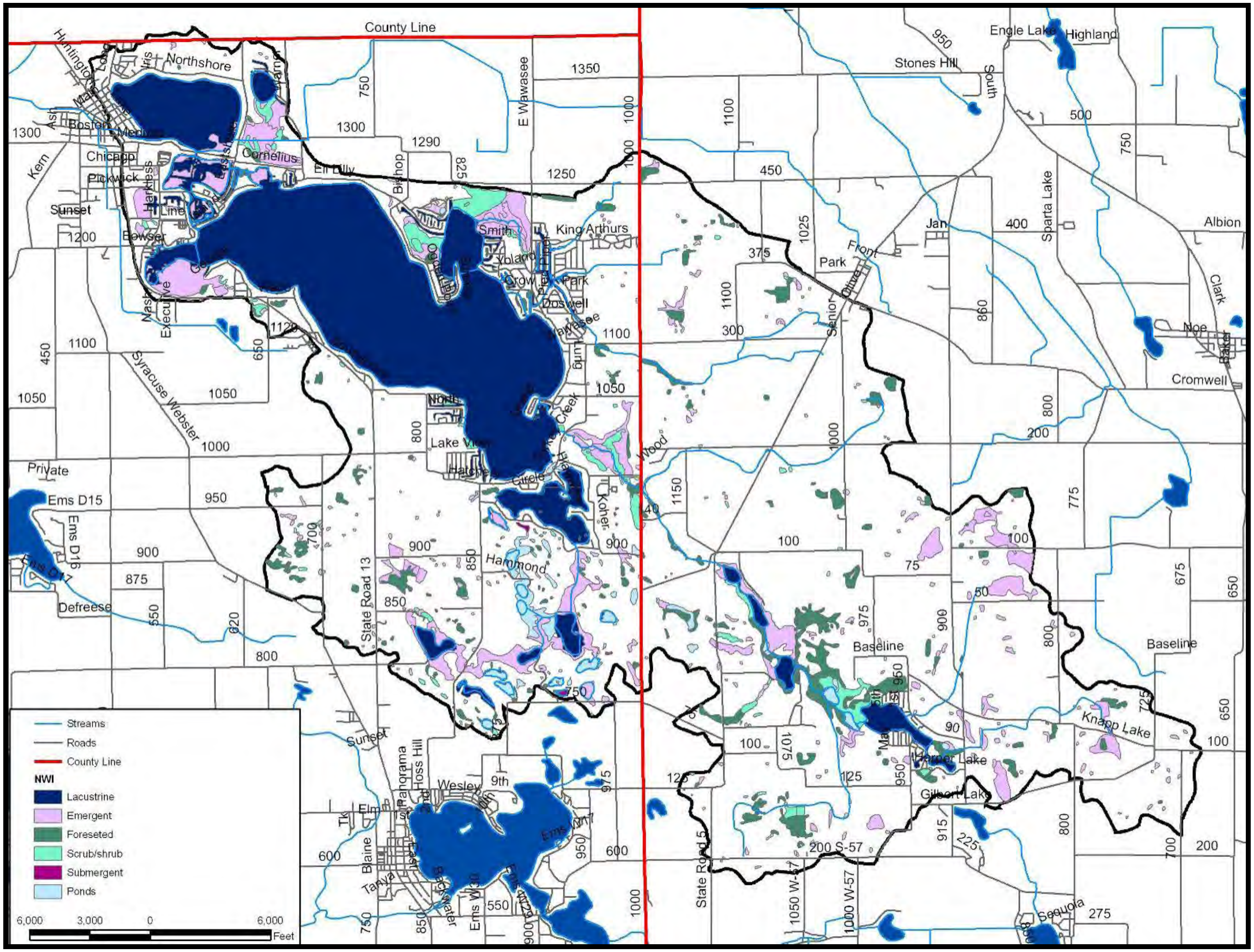

Figure 11. Wetland locations within the Wawasee Area Watershed.

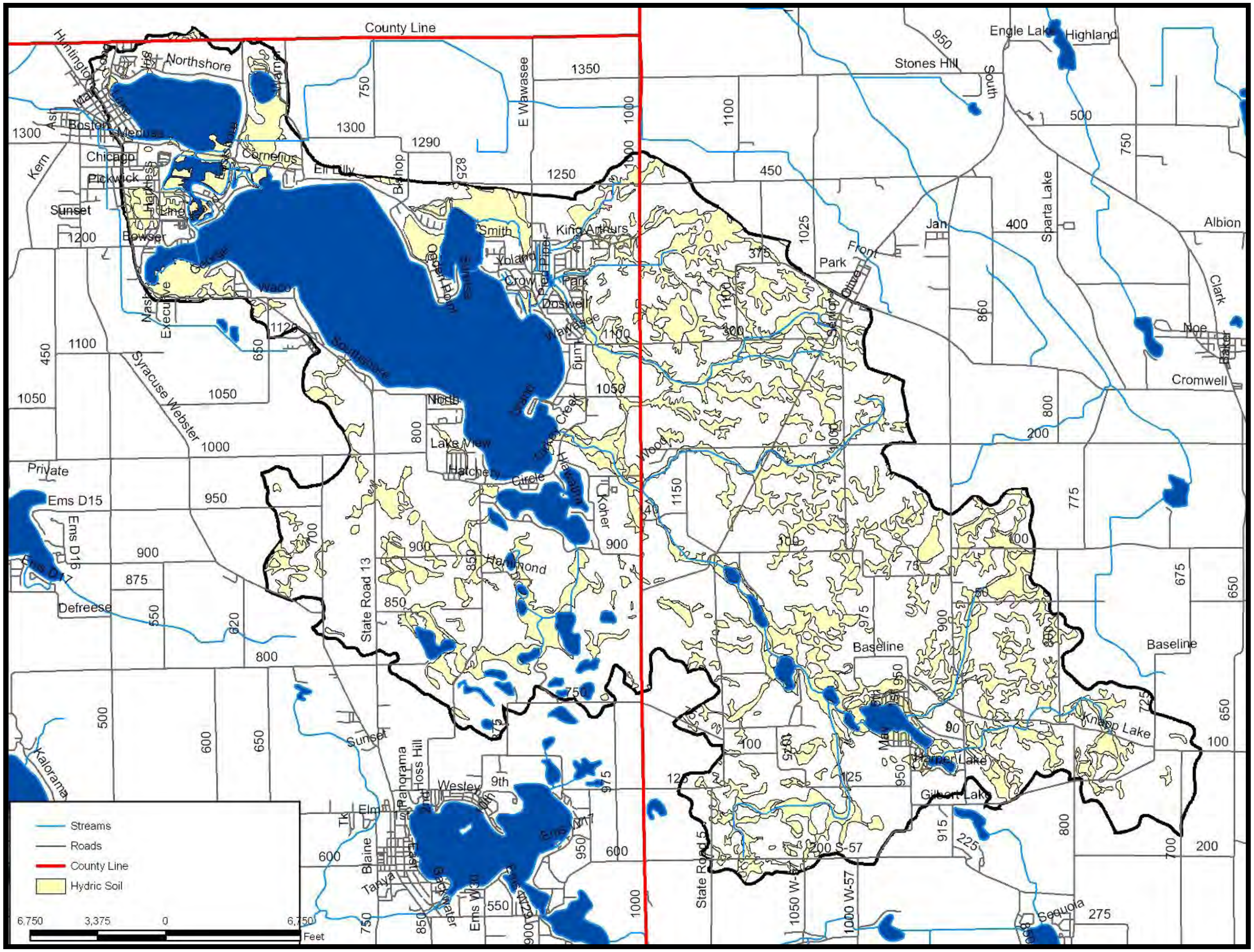

Figure 12. Hydric soils in the Wawasee Area Watershed.

2.7.2 Lakes

More than 20 lakes are located within the Wawasee Area Watershed. These include the state's largest natural lake (Lake Wawasee), a natural lake to its north (Syracuse Lake), and a man-made lake to its south (Lake Papakeechie). Two additional chains of lakes, the Ten Lakes Chain and the Tri-County Fish and Wildlife Area Lakes, are also located within the watershed. The size, shape, maximum depth, average depth, volume, and shoreline length of the lakes all play an important role in determining the lakes' water quality. Many changes occurred adjacent to the lakes following settlement of the area. Each morphological change impacts water quality. Appendix D includes aerial photographs of Lake Wawasee and the Ten Lakes Chain in an effort to document changes in the size, shape, and shoreline development of these lakes over the past 75 years.

Lake Wawasee

Lake Wawasee is the largest natural lake in Indiana covering 3,410 acres (1,380 ha; Figure 13). The lake possesses a volume of 75,020 acre-feet (995,836,352 m^3) and a mean depth of 22 feet (6.7 m; Table 5). The lake extends to a depth of 77 feet (23.4 m) immediately east of South Park. Lake Wawasee reaches 75 feet (22.8 m) at no less than three other locations within the lake and reaches 40 feet (12.1 m) at a minimum of 20 locations throughout the lake. The lake's convoluted shape and mixture of deep and shallow holes likely influences the lake's water quality. Some lakes with multiple deep holes like Lake Wawasee exhibit anoxia in these deep holes that is not necessarily due to eutrophication. Hypolimnetic (bottom waters) anoxia is often associated with eutrophication. However, mesotrophic and oligotrophic lakes can experience anoxia in their hypolimnia if the shape of the lake does not allow for complete mixing of the lake layers during turnover. This was observed in Lake Maxinkuckee, an oligotrophic-mesotrophic lake in Marshall County, even in the early part of the 1900's (Evermann and Clark, 1920; Crisman, 1986).

Table 5. Morphological characteristics of Lake Wawasee.

Lake Wawasee	
Surface Area	3,410 acres (1,380 ha)
Volume	75,020 acre-feet (995,836,352 m^3)
Maximum Depth	77 feet (23.4 m)
Mean Depth	22 feet (6.0 m)
Shoreline Length	193,586 feet (59,005 m)
Shoreline Development Ratio	4.5:1
Residence Time	2.5 years

Figure 13. Aerial photograph (2005) of Lake Wawasee, Syracuse Lake, and Lake Papakeechie.

The shoreline development ratio is a measure of the development potential of a lake. It is calculated by dividing the shoreline length by the circumference of a circle that has the same area as the lake. A perfectly circular lake with the same area as Lake Wawasee (3,410 acres or 1,380 ha) would have a circumference of 43,204 feet (13,168 m). Dividing Lake Wawasee's shoreline length (193,586 feet or 59,005 m) by 43,204 feet yields a ratio of 4.5:1. This ratio is fairly high compared to the shoreline development ratios observed on many other developed, northern Indiana lakes. The ratio is also more than double the ratio (1.9:1) calculated from the observed shoreline length (83,054 feet or 25,314 m) of Lake Wawasee in the early 1920's (Scott et al., 1928). Lake Wawasee possesses a number of shoreline channels that were not present in the 1920's. These channels are especially popular on developed lakes like Lake Wawasee and Lake Tippecanoe. Shoreline channels increase the lakes' shoreline development ratios and increase potential for the development around the lakes. Given the immense popularity of lakes in northern Indiana this potential is often realized.

Surface water drains to Lake Wawasee by four primary routes (Figure 3; Table 6). These routes include three main tributaries, Dillon Creek, Turkey Creek, the Lake Papakeechie outlet, and direct drainage to the lake. A number of minor tributaries also carry water to Lake Wawasee. Dillon Creek drains approximately 3,423 acres (1,385 ha or 15%) of the watershed directly east of Lake Wawasee (Table 6). Three smaller tributaries contribute water to Dillon Creek including the Norris Branch (north), Launer Ditch (middle), and Dillon Creek headwaters (south). (Appendix E details the subwatersheds for the Dillon Creek tributaries.) The flow of Dillon Creek was altered during the construction of the subdivision. Previously, water flowed north and east from Dillon Creek reaching

Lake Wawasee in Johnson Bay after having filtered through a large wetland complex east of the lake. Currently, the three tributaries combine near the center of the Enchanted Hills Subdivision and carry water east into Lake Wawasee immediately east of Cedar Point. Turkey Creek is the largest tributary to Lake Wawasee carrying water from 10,122 acres (4,098 ha or nearly 45%) of the watershed. Turkey Creek drains the entire southeastern portion of the watershed. A number of smaller tributaries flow into a series of lakes combining to form Turkey Creek (Appendix E). The Lake Papakeechie outlet carries water from the Tri-County Fish and Wildlife Area lakes north through Lake Papakeechie draining a total of 3,479 acres (1,409 ha). Two other minor tributaries, the golf course tributary (313 acres or 127 ha) and Martin Ditch (394 acres or 160 ha). The remainder of the land in the Lake Wawasee watershed (1,618 acres or 655 ha) drains directly to the lake via small tributaries or as subsurface flow.

Table 6. Watershed and subwatershed sizes for the Lake Wawasee watershed.

Subwatershed/Lake	Area (acres)	Area (hectares)	Percent of Watershed
Dillon Creek	3,423	1,386	15.0%
Turkey Creek	10,122	4,098	44.5%
Lake Papakeechie outlet	3,479	1,409	15.3%
Leeleand Channel	394	160	1.7%
Golf Course	313	127	1.4%
Direct to lake	1,618	655	7.1%
Watershed Draining to Lake	**19,349**	**7,830**	**85.0%**
Lake Wawasee	3,410	1,381	15.0%
Total Watershed	**22,759**	**9,210**	**100.0%**
Watershed to Lake Area Ratio	6.7:1		

Table 6 also provides the watershed area to lake area ratio for Lake Wawasee. Watershed size and watershed to lake area 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.

Lake Wawasee possesses a watershed area to lake area ratio of approximately 6.7:1. This is a fairly typical watershed area to lake area ratio 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).

Syracuse Lake

Syracuse Lake possesses a surface area of 414 acres (167.5 ha) and a volume of 5,362 acre-feet (71,176,679 m^3; Table 7). The lake's maximum depth is 34 feet (10.4 m) and the average depth is 13 feet (3.9 m; Table 8). The shoreline development ratio is a measure of the development potential of a lake. A perfectly circular lake with the same area as Syracuse Lake (414 acres or 167.5 ha) would have a circumference of 15,053 ft (4,588 m). Dividing Syracuse Lake's shoreline length (18,561 ft or 3,828 m) by 5,053 feet yields a ratio of 1.2:1. This ratio is fairly low compared to the shoreline development ratios observed on many other developed, northern Indiana lakes. Syracuse Lake lacks a number of shoreline channels observed on other popular Indiana lakes such as lakes in the Barbee Chain, Lake Wawasee, and Lake Tippecanoe. Shoreline channels increase the lakes' shoreline development ratios and increase potential for the development around the lakes.

Table 7. Morphological characteristics of Syracuse Lake.

Syracuse Lake	
Surface Area	414 acres (167.5 ha)
Volume	5,362 acre-feet (71,176,679 m^3)
Maximum Depth	34 feet (10.4 m)
Mean Depth	13 feet (3.9 m)
Shoreline Length	12,561 ft (3,828 m)
Shoreline Development Ratio	1.2
Residence Time	0.2 years (73 days)

Surface water drains to Syracuse Lake by three primary routes (Figure 3). These routes include drainage from Lake Wawasee, a small unnamed tributary north of Syracuse Lake, and direct drainage to the lake (Table 8). The northern unnamed tributary drains 86 acres (34.8 ha) from the Rogers Court and Shore Lane areas immediately north of Syracuse Lake. The remaining 992.7 acres (401.7 ha) flows directly to Syracuse Lake, while an additional 22,759 acres (9,210 ha) drains through Lake Wawasee before reaching Syracuse Lake. The watershed area to lake area ratio for Syracuse Lake (59:1) is somewhat elevated for glacial lakes; however, the ratio does not approach levels typical of reservoirs (100:1 to 300:1; Vant, 1987).

Table 8. Watershed and subwatershed sizes for the Syracuse Lake watershed.

Subwatershed/Lake	**Area (acres)**	**Area (hectares)**	**Percent of Watershed**
Bonar Lake Watershed	86	34.8	0.4%
Direct to lake	1,179	477.1	4.8%
Watershed Draining to Lake	**1,265**	**511.9**	**5.2%**
Lake Wawasee Watershed	22,759	9,210	93.1%
Syracuse Lake	414	167.5	1.7%
Total Watershed	**24,438**	**9,890**	**100.0%**
Watershed to Lake Area Ratio	59:1		

Lake Papakeechie

The dam creating Lake Papakeechie was completed in 1913 by impounding what was formerly known as Jarrett's Creek. Lake Papakeechie possesses a surface area of 178 acres (72 ha) and a volume of 890 acre-feet (11,814,107 m^3; Table 9). The lake's maximum depth is 40 feet (12.2 m) and the average depth is 5 feet (1.5 m; Table 10). The shoreline development ratio is a measure of the development potential of a lake. A perfectly circular lake with the same area as Lake Papakeechie (178 acres or 40 ha) would have a circumference of 9,870 ft (3,008.4 m). Dividing Lake Papakeechie's shoreline length (18,270 feet (5,568.7 m) by 9,870 feet yields a ratio of 1.8:1. This ratio is fairly low compared to the shoreline development ratios observed on many other developed, northern Indiana lakes. Like Syracuse Lake, Lake Papakeechie lacks a number of shoreline channels observed on other popular Indiana lakes.

Table 9. Morphological characteristics of Lake Papakeechie.

Lake Papakeechie	
Surface Area	178 acres (72 ha)
Volume	890 acre-feet (11,814,107 m^3)
Maximum Depth	40 feet (12.2 m)
Mean Depth	5 feet (1.5 m)
Shoreline Length	18,270 feet (5,568.7 m)
Shoreline Development Ratio	1.8:1
Residence Time	0.22 years (80.3 days)

Surface water drains to Lake Papakeechie by two primary routes (Figure 3). These routes include drainage from the Tri-Lakes Fish and Wildlife Area through Spear Lake and direct drainage to the lake (Table 10). The Spear Lake tributary drains 2915 acres (1180 ha) from the Tri-County Fish and Wildlife Area lakes. The remaining 386 acres (156 ha) flows directly to Lake Papakeechie. The watershed area to lake area ratio for Lake Papakeechie (19.5:1) is relatively normal for glacial lakes and is much lower than typical ratios for reservoirs (100:1 to 300:1; Vant, 1987).

Table 10. Watershed and subwatershed sizes for the Lake Papakeechie watershed.

Subwatershed/Lake	**Area (acres)**	**Area (hectares)**	**Percent of Watershed**
Unnamed tributary (Spear Lake)	2,915	1,180	83.7%
Direct to lake	386	156	11.1%
Watershed Draining to Lake	**3,301**	**1,335.9**	**94.9%**
Lake Papakeechie	178	40	5.1%
Total Watershed	**3,479**	**1,409**	**100.0%**
Watershed to Lake Area Ratio	19.5:1		

Turkey Creek Lakes (Ten Lakes Chain)

Two chains of lakes occur along the length of Turkey Creek within Noble County; these lakes are commonly referred to as the Ten Lakes Chain (Figure 14). These lakes can roughly be divided into the Knapp Lake Chain and the Indian Village Lake Chain. The Knapp Lake Chain consists of Hindman, Moss, Knapp, Little Knapp, Harper, and Little Bause lakes. Harper and Little Knapp lakes form the headwaters of Turkey Creek. Harper Lake receives water from one intermittent stream called Piper Branch which flows east into Harper Lake. From Harper Lake, water flows north and west to Little Bause Lake and then into Knapp Lake. Knapp Lake receives water from four main sources, Little Bause Lake, Little Knapp Lake, an unnamed tributary from the north, and direct drainage to the lake (Table 11). Water exits Knapp Lake at its western end flowing west into Moss Lake and then into Hindman Lake. Hindman Lake also receives water from an unnamed tributary from the south. Similarly, the Village Lake Chain receives a majority of its water from the Knapp Lake Chain. Water flows from Gordy Lake north and west to Rider Lake, then on to Duely Lake, and Village Lake. Two intermittent drainages flow into Rider Lake and Village Lake, respectively. Water exits Village Lake through Turkey Creek which continues on north and west to Lake Wawasee.

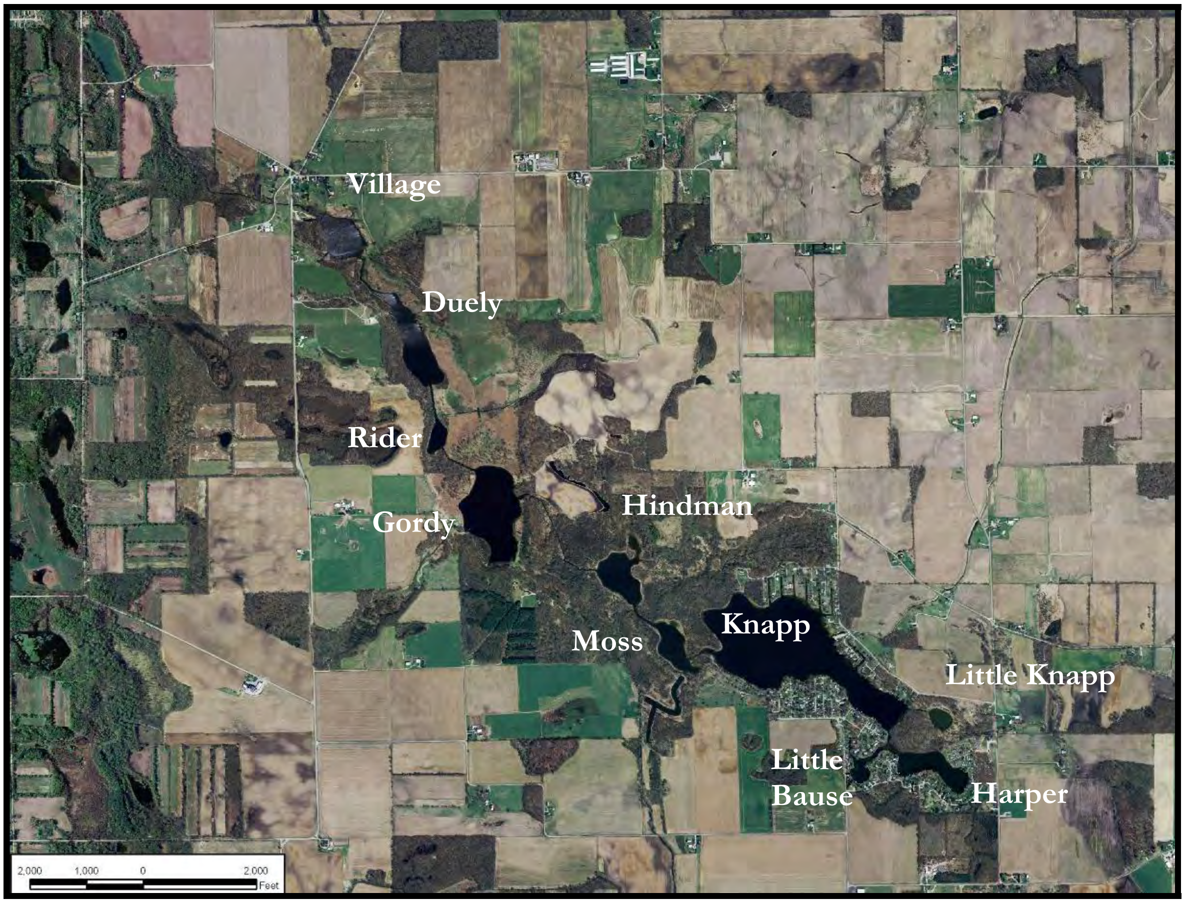

Figure 14. Aerial photograph (2005) of the lakes within the Ten Lakes Chain located along the length of Turkey Creek.

Table 11. Morphological information for the Ten Lakes Chain.

Lake	Surface Area (ac)	Max. Depth (ft)	Drainage Area (ac)	Watershed Area: Lake Area
Harper Lake	11	25	1,905	173.2
Little Bause Lake	15	13	1314	87.6
Little Knapp Lake	11	--	94	8.5
Knapp Lake	88	59	4,091	46.5
Moss Lake	10	19	5,390	539.0
Hindman Lake	13	20	5,368	412.9
Gordy Lake	31	35	6,664	214.9
Rider Lake	5	16	6,968	1,393.6
Duely Lake	21	19	7,362	350.6
Village Lake	12	22	7,743	645.3

Table 11 summarizes the morphological characteristics of lakes within the Ten Lakes Chain. Rider Lake possesses the smallest surface area (5 acres or 2 ha), while Knapp Lake possesses the largest surface area (88 acres or 35.6 ha). As a headwater lake, Little Knapp Lake's subwatershed is the smallest of any of the lakes along Turkey Creek measuring 94 acres (38 ha). As the most downstream lake, Village Lake possesses the largest watershed (7,743 acres or 3,133.5). Many of the lakes along the length of Turkey Creek possess extremely large watershed area to lake area ratios. Only the ratios for Little Knapp Lake (8.5:1) and Knapp Lake are within the typical range for glacial lakes (10:1 to 50:1). Most of the other lakes have watershed area to lake area ratios that are more typical for reservoirs including Harper Lake (173:1), Gordy Lake (215:1), Duely Lake (351:1), Hindman Lake (413:1), Moss Lake (539:1), and Village Lake (645:1). However, the large watershed area (6,968 acres or 2,820 ha) and small surface area of Rider Lake (5 acres or 2 ha) leads to an extremely high watershed area to lake area ratio (1,394:1). This means that for every surface acre of water in Rider Lake there are nearly 1,400 acres of watershed drainage.

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.

Tri-County Fish and Wildlife Area Lakes

The 3,546 acre Tri-County Fish and Wildlife Area (FWA) is home to a variety of lakes and wetlands. In total, the Tri-County FWA houses ten natural lakes (Figure 15), including Hammond, Barrel and a Half, Spear, Long, Price, Shock, Rothenberger, Wyland, Allen, and Grindle lakes, thirty-two man-made impoundments, and more than 200 acres of open water wetlands. (Grindle Lake's outlet flows south to Lake Webster; therefore, this lake is not discussed in reference to the Wawasee Area Watershed.) The primary wetland (Flatbelly Marsh) was created in 1963 when a dam was constructed at the outlet of six of the natural lakes (IDNR, 2006). The drainage area of the lakes is difficult to determine based on the knob and kettle topography and groundwater interaction as the main source of flow between these lakes; therefore, only the surface area and maximum depth for each of the lakes is listed in Table 12. Wyland Lake is the smallest of the Tri-County FWA lakes measuring only 6 acres (2.4 ha), while Spear Lake is the largest covering 40 acres (16.2 ha). Shock Lake is the deepest lake measuring 59 feet (17.9 m), while Rothenberger Lake is the shallowest (28 feet or 8.5 m).

Table 12. Morphological information for the Tri-County Fish and Wildlife Area lakes.

Lake	Surface Area (ac)	Max. Depth (ft)
Allen Lake	10	46
Barrel and a Half Lake	12	36
Hammond Lake	12	40
Long Lake	13	--
Price Lake	12	--
Rothenberger Lake	7	23
Shock Lake	37	59
Spear Lake	40	28
Wyland Lake	6	36

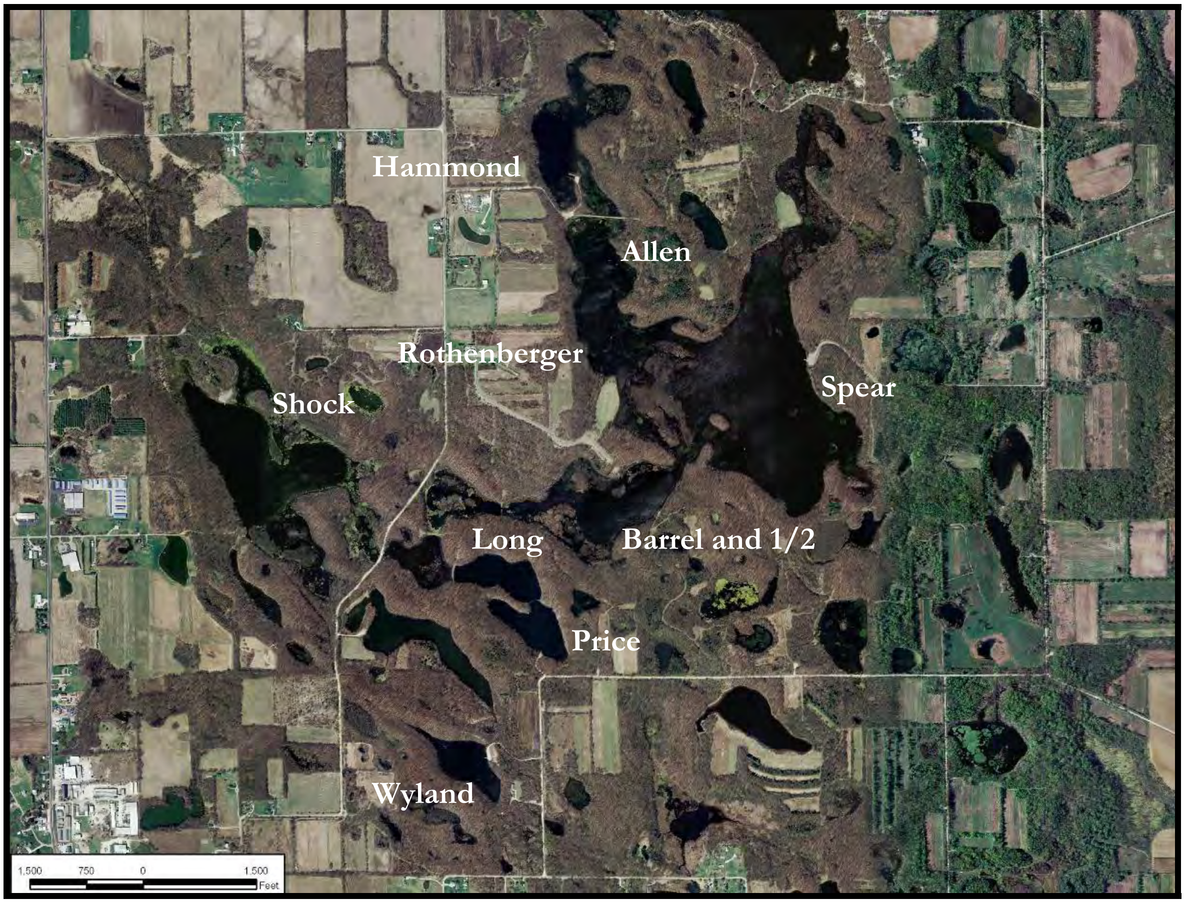

Figure 15. Aerial Photograph (2005) of lakes located in the Tri-County Fish and Wildlife Area.

2.7.3 Streams and Legal Drains

As previously mentioned, three main drains carry water to Lake Wawasee. These include Turkey Creek, Dillon Creek, and from Lake Papakeechie through an unnamed tributary. Turkey Creek originates as drainage tile within the Turkey Creek headwaters south and east of Little Knapp and Little Bause lakes (Figure 16). Water from these drainage tiles carry water into Piper Branch, Galloway Branch, and Ritter Branch. Dillon Creek also begins as county-regulated tile prior to flowing into county-maintained legal drains. These drains are maintained via the Noble County Surveyors Office under the direction of the Noble County Drainage Board. Ultimately, this means that the Noble County Surveyor's office can collect ditch assessment fees along this portion of the drain in order to maintain proper drainage. In Kosciusko County, two small stretches of drain which flow into Enchanted Hills (Launer Ditch and Howard Bentz Ditch), Warner Drain, which enters Lake Wawasee near the Sleepy Owl, and the portion of Turkey Creek upstream of Lake Wawasee within Kosciusko County are all legal drains. Although Turkey Creek is considered a legal drain, there are currently no county assessments for properties along the drain. Additionally, no drain maintenance has occurred or is planned to occur along Turkey Creek any time in the near future (Dick Kemper, Kosciusko County Surveyor, personal communication). Other small drainages carry water to Lake Wawasee within Kosciusko County as well; however, these drains are not maintained by the county. In total, more than 99,000 feet (30,175 m) of county-maintained tile drains and more than 109,000 feet (33,223 m) of open legal drains are located throughout the Wawasee Area Watershed.

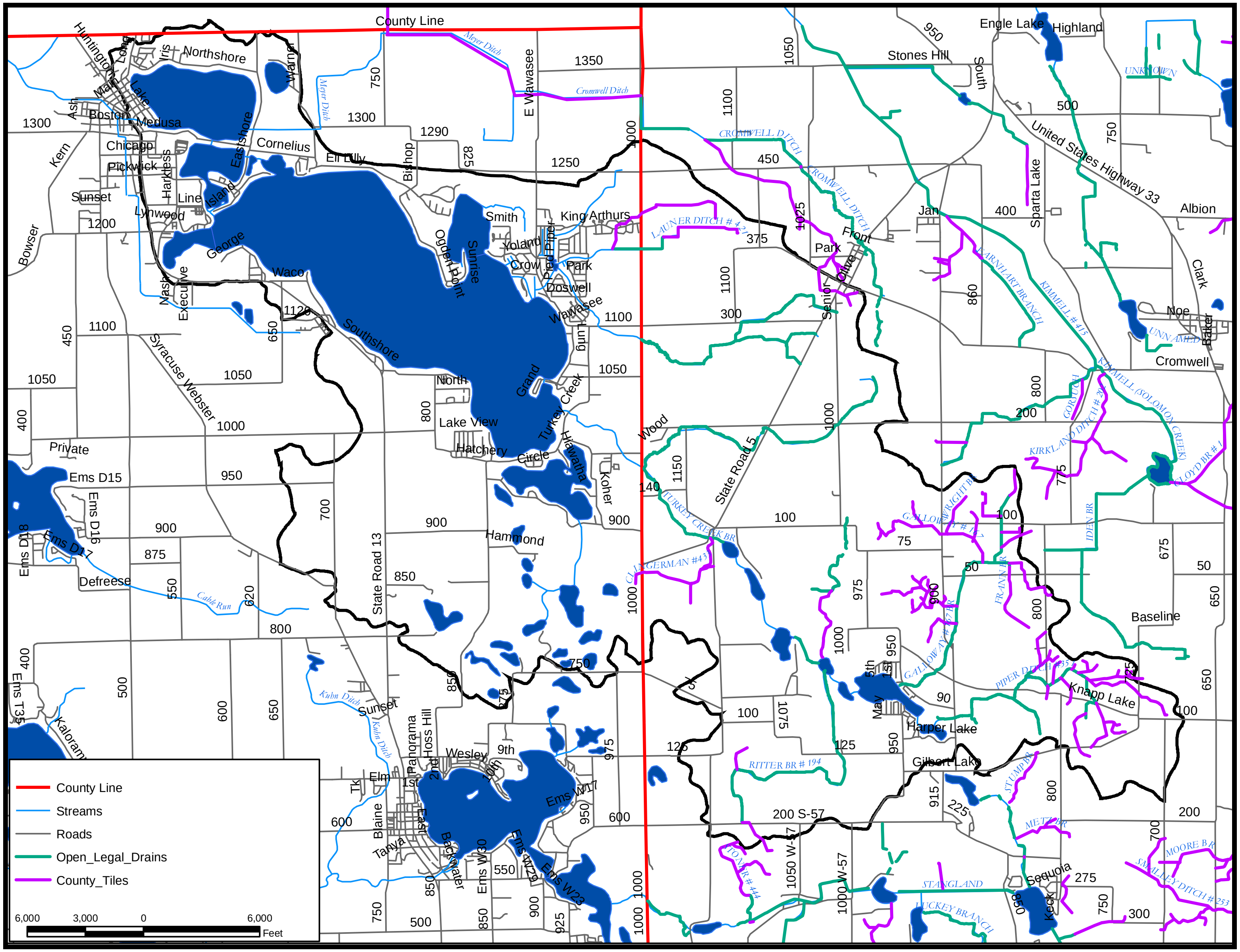

Figure 16. Legal drains located within the Wawasee Area Watershed.

2.8 Land Use

Just as soils, climate, and geology shape the native communities within the watershed, how the land in a watershed is used can impact the water quality of a waterbody. Different land uses have the potential to contribute different amounts of nutrients, sediment, and toxins to receiving water bodies. For example, Reckhow and Simpson (1980) compiled phosphorus export coefficients (amount of phosphorus lost per unit of land area) for various land uses by examining the rate at which phosphorus loss occurred on various types of land. Several researchers have also examined the impact of specific urban and suburban land uses on water quality (Bannerman et. al, 1992; Steuer et al., 1997; Waschbusch et al., 2000). Bannerman et al. (1992) and Steuer et al. (1997) found high mean phosphorus concentrations in runoff from residential lawns (2.33 to 2.67 mg/l) and residential streets (0.14 to 1.31 mg/l). These concentrations are well above the threshold at which lakes might begin to experience algae blooms. (Lakes with total phosphorus concentrations greater than 0.03 mg/l will likely experience algae blooms.) Finally, the Center for Watershed Protection has estimated the association of increased levels of impervious surface in a watershed with increased delivery of phosphorus to receiving waterbodies (Caraco and Brown, 2001). Land use directly affects the amount of impervious surface in a watershed. Because of the effect watershed land use has on water quality of the receiving lakes, mapping and understanding a watershed's land use is critical in directing water quality improvement efforts.

Figure 17 and Table 13 present current land use information for the Wawasee Area Watershed. Agricultural land uses dominate the Wawasee Area Watershed. Row crop agricultural areas cover approximately 51% of the watershed. Pasture occupies an additional 9% of the watershed. Most of the agricultural land in the Wawasee Area Watershed and throughout Elkhart, Kosciusko, and Noble Counties (USDA, 2002) is used for growing soybeans and corn. County-wide tillage transect data for Kosciusko and Noble Counties provides an estimate for the portion of cropland in conservation tillage for the Wawasee Area Watershed. In 2004, Kosciusko County corn producers utilized no-till methods on 24% and some form of reduced tillage methods on 68% of corn fields. The percentage of corn fields on which no-till methods were used in Kosciusko County was above the statewide median percentage (IDNR, 2005a). Soybean farmers utilize no-till on 68% of fields in Kosciusko County and reduced tillage methods on 28% of fields. In Noble County, corn producers utilized no-till methods on 29% and some form of reduced tillage methods on 50% of corn fields. Usage of no-till methods on corn fields in Noble County was above the statewide median percentage of acreage in no-till (IDNR, 2005a). Soybean farmers use no-till methods on 70% of fields and reduced till methods on 23% of fields within Noble County. Use of no-till on soybean fields in both counties is above the state median percentage (IDNR, 2005b).

The natural landscape remains on a smaller portion in the watershed. Forested land exists on approximately 11% of the watershed. Wetlands cover nearly 6% of the watershed and open water accounts for nearly 17% of the watershed. (This number differs slightly from the one in the Hydrology section since different data sources were utilized.) Most of the wetlands in the watershed lie in the vicinity of Mud Lake, are adjacent to Conklin Bay, surround the length of Turkey Creek, and cover the majority of the Lake Papakeechie subwatershed. Lake Wawasee, Syracuse Lake, Lake Papakeechie, Knapp Lake, the Village Lakes Chain, and lakes within the Tri-County Fish and Wildlife Area account for the open water acreage (4,188 acres).

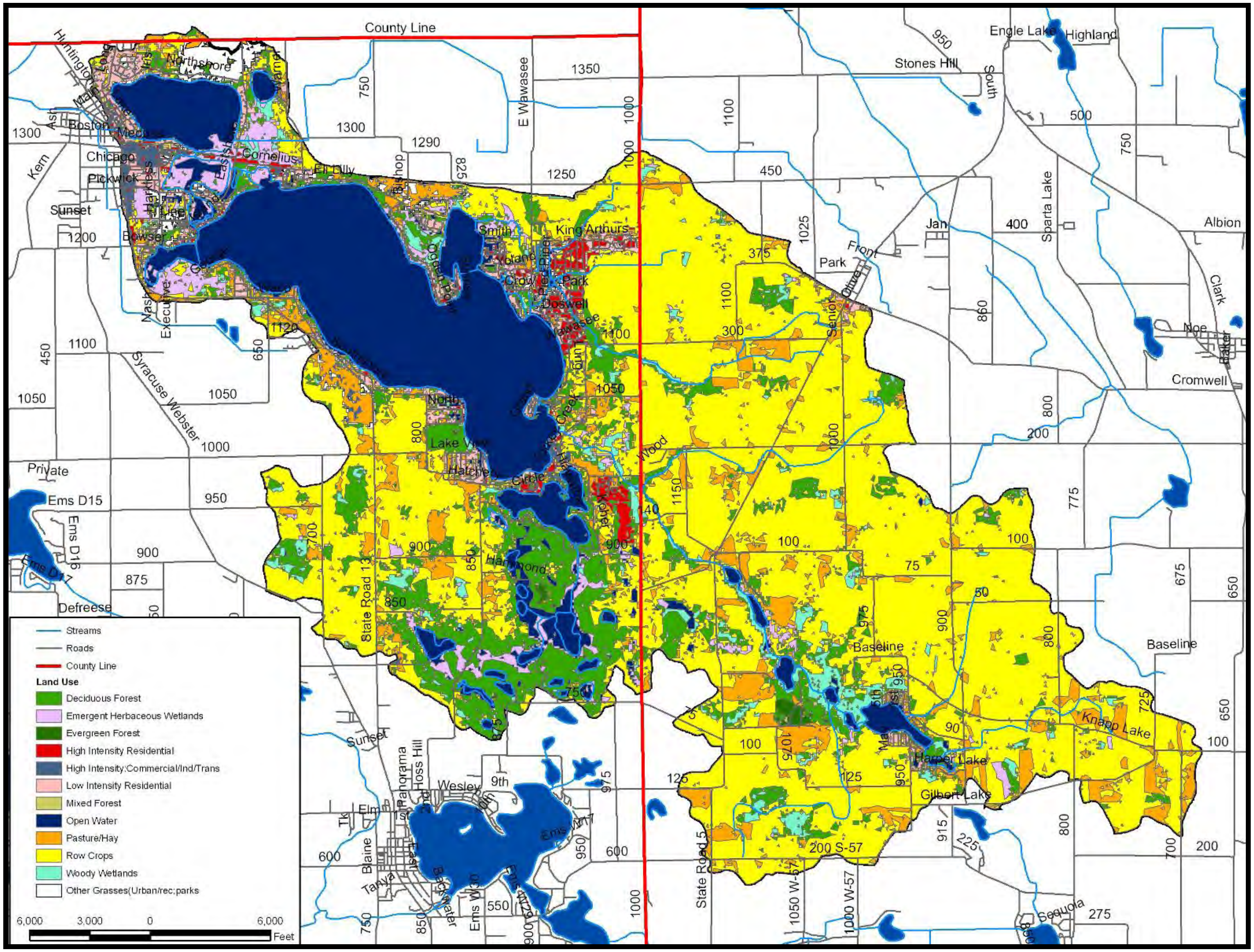

Figure 17. Land use in the Wawasee Area Watershed.

Table 13. Detailed land use in the Wawasee Area Watershed.

Classification	Area (acres)	Area (ha)	Percent of Watershed
Row Crops	12,420.0	5,028.3	50.8%
Open Water	4,188.2	1,695.6	17.1%
Deciduous Forest	2,808.0	1,136.8	11.5%
Pasture/Hay	2,124.1	860.0	8.7%
Emergent Herbaceous Wetlands	741.8	300.3	3.0%
Woody Wetlands	678.8	274.8	2.8%
Low Intensity Residential	640.0	259.1	2.6%
Other Grasses (Urban/Recreational)	320.0	129.6	1.3%
High Intensity Commercial	282.7	114.5	1.2%
High Intensity Residential	162.2	65.7	0.7%
Evergreen Forest	63.8	25.8	0.3%
Mixed Forest	7.8	3.2	<0.1%
Entire Watershed	**24,437.6**	**9893.75**	**100.0%**

Developed areas, including a portion of Syracuse, Enchanted Hills, and residences around the shoreline of the lakes, cover more than 5% of the watershed. Most of the developed land use consists of low intensity residential land use and urban parkland. In the Indiana Land Cover Data Set, the USGS defines high intensity residential areas as areas with high densities of multi-family residences (apartment complexes, condominiums, etc.). Hardscape covers approximately 80-100% of the landscape in the high intensity residential land use category. Low intensity residential areas consist largely of single family homes and hardscape covers only 30-80% of the landscape. Impervious surface coverage was calculated using adapted impervious values for selected land used in Lee and Toonkel (2003), but does not include road surfaces. Impervious surfaces cover approximately 2.5% of the watershed. This estimate of impervious surface coverage is below the threshold at which the Center for Watershed Protection has found an associated decline in water quality. The land uses contributing to the impervious surface coverage in the Wawasee Area Watershed are agricultural (1.2%), residential (0.9%), and commercial (0.5%).

2.9 Population

As the land use map (Figure 17) suggests, the Wawasee Area Watershed supports a variety of densely populated and sparsely populated areas. Measuring and tracking population growth in the watershed is difficult since governmental and other agencies measuring this data often report their findings on a township, county, or census tract basis rather than by watershed. The reported data can, however, be utilized to estimate the current watershed population and track its growth over the past century. Table 14 presents the U.S. Census data for the Wawasee Area Watershed from 1900 to 2000. The northwestern portion of the Wawasee Area Watershed lies in Turkey Creek Township, while the southeastern portion of the watershed lies within Sparta Township. Table 14 also provides Noble and Kosciusko County population data for reference.

Table 14. U.S. Census data for Sparta and Turkey Creek Townships in Noble and Kosciusko Counties.

	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Noble County	23,533	24,009	22,470	22,404	22,776	25,075	28,162	31,382	35,443	37,877	46,275
Sparta Township	1,533	1,665	1,527	1,553	1,547	1,426	1,505	1,611	1,867	2,497	3,111
Kosciusko County	29,109	27,936	27,120	27,488	29,561	33,002	40,373	48,127	59,555	65,294	74,057
Turkey Creek Twp	2,037	2,398	1,976	2,166	2,458	3,125	4,010	5,081	6,587	7,695	9,032

Source: Stats Indiana, 2006.

Generally, both Sparta and Turkey Creek Townships have shown steady growth over the past 100 years (Figure 18). Sparta Township, within which lies the southeastern portion of the watershed, experienced it greatest growth rate between 1980 and 1990 when the township's population grew by nearly 34%. Sparta Township's population increase occurred at a much slower pace than that observed in Turkey Creek Township. Prior to 1980, Sparta Township experienced growth; however, increases were typically less than 10% per decade. Conversely, growth in Turkey Creek Township was at its greatest from 1940 to 1980 increasing 27 to 30% within each 10-year period. In total, Sparta Township supports approximately 86 people per square mile. A majority of these individuals are clustered around lakes scattered throughout the township. Conversely, Turkey Creek Township supports approximately 250 people per square mile. Many of these individuals are located adjacent to Lake Wawasee and Syracuse Lake or within the Town of Syracuse.

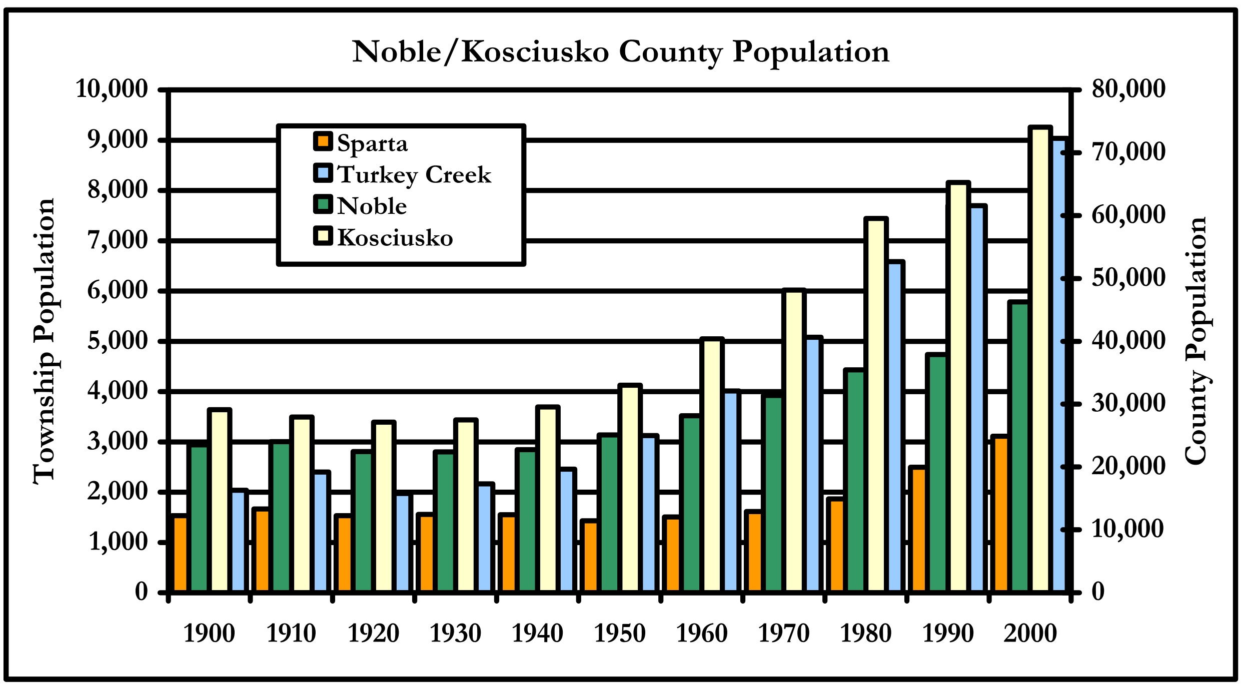

Figure 18. Populations of Sparta and Turkey Creek Townships in Noble and Kosciusko Counties, which encompass the Wawasee Area Watershed from 1900 through 2000.

2.10 Land Ownership

Properties owned by the Wawasee Area Conservancy Foundation and the Indiana Department of Natural Resources Division of Nature Preserves are detailed in Figure 19. Both entities own multiple tracts scattered throughout the watershed. A majority of WACF's land is located adjacent to Lake Wawasee, Syracuse Lake, Bonar Lake, or along the Turkey Creek corridor. Much of the IDNR's land is contained within the Tri-County Fish and Wildlife Area, which is located along the watershed's southern boundary near North Webster. Additional small tracts belonging to both entities are scattered throughout the watershed.

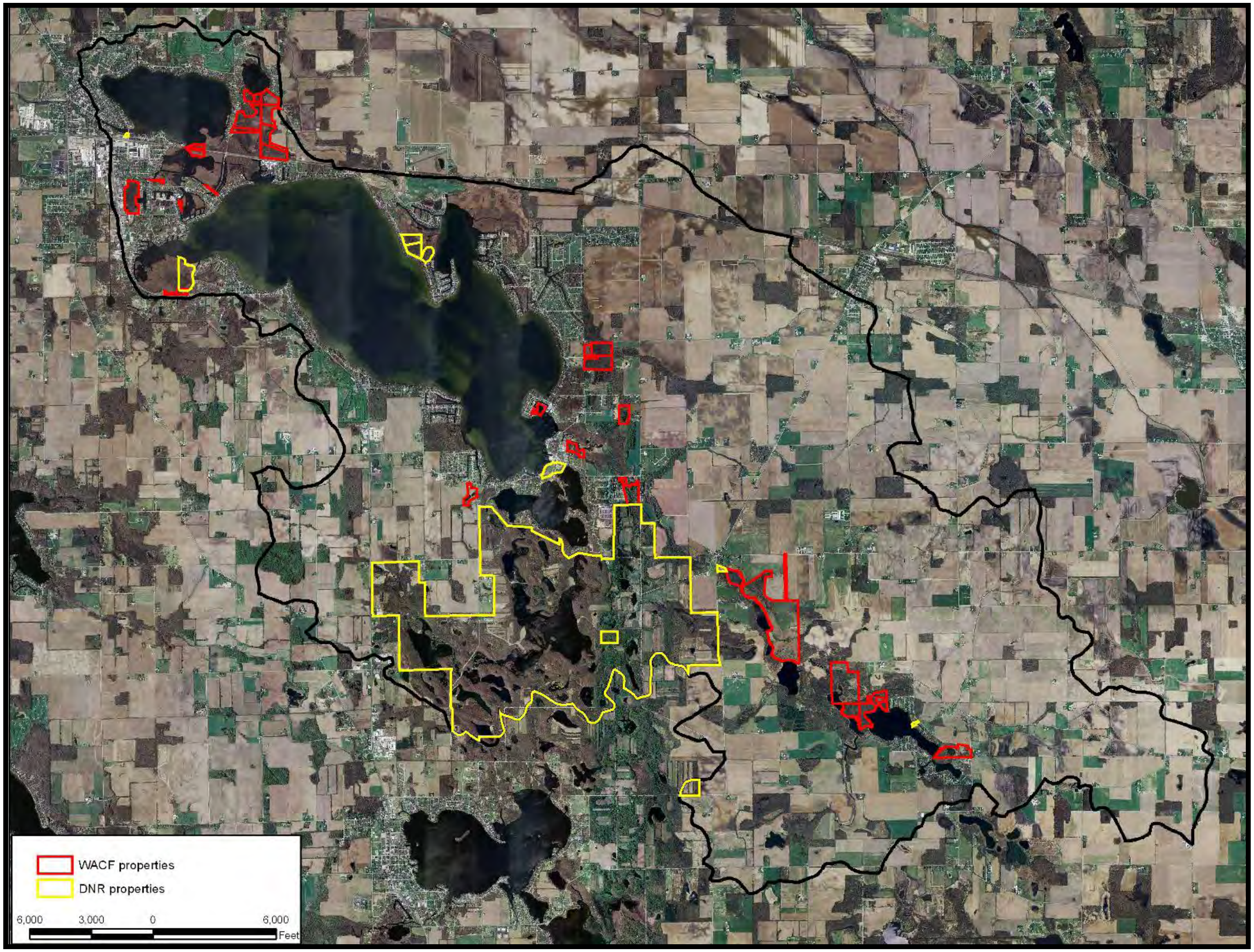

Figure 19. Tracts of land owned by public entities within the Wawasee Area Watershed.

3.0 BASELINE WATER QUALITY CONDITIONS

Data contained in this section documents current water quality conditions in the Wawasee Area Watershed. This compilation includes all data identified during completion of the Watershed Management Plan for the watershed's 23 lakes and their tributaries. Understanding the waterbodies' current conditions will help watershed stakeholders set realistic goals for future water quality conditions. This data will also serve as the benchmark against which future water quality conditions can be compared to measure stakeholder success in achieving their vision for the future of these waterbodies.

A variety of resources were reviewed to establish the existing or baseline water quality conditions within the watershed lakes. The USEPA assessed Lake Wawasee's water quality as part of their National Eutrophication Survey (USEPA, 1976). 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 the Wawasee Area Watershed were sampled in the 1970s as part of this effort. Subsequently, the Indiana Department of Environmental Management's Clean Lakes Program (CLP) sampled many of the lakes in the Wawasee Area Watershed. Sampling typically occurred in 1993, 2000 and 2003. Water quality data from CLP monitoring includes all of the parameters required to compute the Indiana Trophic State Index (ITSI). (See IDEM, 1986 for more details on the ITSI.) A subset of these parameters, including Secchi depth, percent water column oxic (containing oxygen concentration greater than 0.1 mg/L), mean total phosphorus, and chlorophyll *a* concentrations are included in this discussion. (Additional data from these assessments are contained in Appendix F.) 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. Annual mean data is included in the following discussion; all data is included in Appendix F. Finally, details of each of the parameters and their impact on lake water quality are located in Appendix G1.

Over 100 studies or assessments characterize water quality, fisheries, aquatic plants, or watershed issues within the Wawasee Area Watershed. (Raw data from these assessments are included in Appendix F). Over 60 of the studies document the lakes' fisheries. The Indiana Clean Lakes Program completed numerous assessments on the lakes throughout the watershed on a five-year rotating basis. WACF, Syracuse Lake Association, and Knapp Lake Association volunteers monitored in-lake and stream water quality within Wawasee and Syracuse lakes and their tributaries. A number of LARE-funded projects have been completed to document watershed water quality, identify projects for implementation, and detail implementation efforts and results. Finally, JFNew collected additional data from three lakes (Wawasee, Syracuse, and Papakeechie) and fifteen stream sites throughout the watershed during the summer of 2006 as part of the plan's development and to supplement existing data. Before examining individual lake water quality, a brief overview of data sources and comparative parameters is necessary. Additionally, Appendix G1 details specific water quality parameter information for lakes.

3.1 Historic Lake Water Chemistry Assessments

As a preface to discussing the individual lakes, there are some guidelines and indices that may be helpful in understanding the water quality. Table 15 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 15. Water quality characteristics of 456 Indiana lakes sampled from 1994 through 2004 by the Indiana Clean Lakes Program.

	Secchi Disk (ft (m))	Total Phosphorus (mg/L)	Chlorophyll *a* (μg/L)
Median	6.5 ft (1.98m)	0.17	12.9
Maximum	32.8 ft (9.99m)	2.81	380.4
Minimum	0.3 ft (0.09m)	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 16. 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, sufficient 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 16. 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 H contains a breakdown of the point values for each parameter. Table 17 shows the lake trophic category for ITSI score ranges.

Table 17. 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

3.1.1 Lake Wawasee

The Indiana Department of Natural Resources, Indiana State Pollution Control Board, U.S. Environmental Protection Agency, Tri-State University, private consultants (Harza, Commonwealth Biomonitoring, etc.), and the Indiana Clean Lakes Program staff and volunteer monitors have all collected water quality samples from Lake Wawasee. Table 18 presents some of these results.

Table 18. Summary of historic data for Lake Wawasee.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
5/3/1973	12.0	8.3	--	0.006	--	3.4	--	USEPA, 1976
8/4/1973	12.0	8.6	--	0.014	--	6.9	--	USEPA, 1976
10/15/1973	12.0	8.2	--	0.011	--	3.9	--	USEPA, 1976
6/1/1975	--	--	--	--	--	--	16	ISPCB, 1975
6/1/1975	7.5	--	--	0.040	--	--	--	Hippensteel, 1989
7/7/1975	13.4	9.1	94%	--	--	--	--	Shipman, 1975
7/14/1985	11.0	9.5	65%	--	--	--	--	Pearson, 1985d
6/1/1988	8.0	--	--	0.010	--	--	--	Hippensteel, 1989
1989*	10.0	--	--	--	--	--	--	Volunteer monitor
1990*	11.6	--	--	--	--	--	--	Volunteer monitor
1991*	11.4	--	--	--	--	--	--	Volunteer monitor
1992*	10.3	--	--	0.040	--	1.2	--	Volunteer monitor
1993*	9.1	--	--	0.014	--	1.0	--	Volunteer monitor
1994*	8.2	--	--	0.032	--	0.5	--	Volunteer monitor
8/1/1994	7.8	8.4	36%	0.032	3,126	1.4	17	CLP,1994
1995*	7.5	--	--	--	--	--	--	Volunteer monitor
7/3/1995	14.0	--	70%	<0.030	143	--	3	Commonwealth, 1996
7/21/1995	9.0	--	43%	0.040	441	--	10	Commonwealth, 1996
1996*	6.9	--	--	--	--	--	--	Volunteer monitor
1997*	7.1	--	--	0.020	--	5.3	--	Volunteer monitor
1998*	7.4	--	--	0.015	--	2.4	--	Volunteer monitor
1999*	10.2	--	--	0.044	--	1.2	--	Volunteer monitor
7/31/2000	7.2	8.6	50%	0.081	2,804	2.3	16	CLP, 2000
9/13/2000	8.5	--	--	--	--	--	--	Harza, 2001
2000*	15.2	--	--	0.040	--	2.8	--	Volunteer monitor
2001*	12.3	--	--	0.037	--	0.4	--	Volunteer monitor
2002*	6.0	--	--	0.021	--	3.1	--	Volunteer monitor
8/5/2003	5.6	8.7	35%	0.041	18,193	4.4	22	CLP, 2003
2003*	8.5	--	--	0.024	--	4.0	--	Volunteer monitor
7/12/2004	6.5	9.0	58%	--	--	--	--	Fink, 2005
2004*	9.5	--	--	0.031	--	3.8	--	Volunteer monitor
2005*	10.1	--	--	--	--	--	--	Volunteer monitor
7/12/2006	8.2	8.6	32%	0.051	1,594	0.02	20	Current assessment
Median	10.0	8.6	50%	0.025	3,126	2.4	17	
Minimum	4.0	8.2	35%	0.006	2,804	0.02	3	
Maximum	32.0	9.5	94%	0.069	18,193	7.5	22	

*Average of all volunteer data recorded during that calendar year.

Water quality within Lake Wawasee is relatively good compared with other Indiana lakes. Furthermore, the quality of water within Lake Wawasee has fluctuated over time, but has not changed much over the lifetime of observations. Secchi disk transparency varied from 4.0 feet (1.2 m) as collected by a volunteer monitor in June 2001 to 32.0 feet (9.7 m) as collected by a volunteer monitor in July 2001. As is typical of lakes in Indiana, transparency is better in Lake Wawasee in the early spring and late fall than transparency measured in mid-summer (July to August). Long-term trends suggest that transparency may be declining slightly over the lifetime of measurements collected (Figure 20). Early season surface pH measurements collected in 1975, 1985, and 2004 suggest that algae blooms may have been occurring at the time of sampling. (During the process of photosynthesis, algae remove carbon dioxide, a weak acid, from the water column, thereby increasing the water's pH.) Total phosphorus concentrations typify the good water quality present in Lake Wawasee. All total phosphorus concentrations measured in the lake were less than concentrations measured in most Indiana lakes (0.17 mg/L). Chlorophyll *a* concentrations are also relatively low for Indiana lakes. Both plankton densities and chlorophyll *a* concentrations indicate that typically algal density in Lake Wawasee is lower than most Indiana lakes. Furthermore, the Indiana Trophic State Index (ITSI) score suggests that Lake Wawasee possesses low to moderate productivity (oligotrophic to eutrophic). And, although ITSI scores have increased over time, the change is not significant and does not indicate a change in trophic (productivity) status.

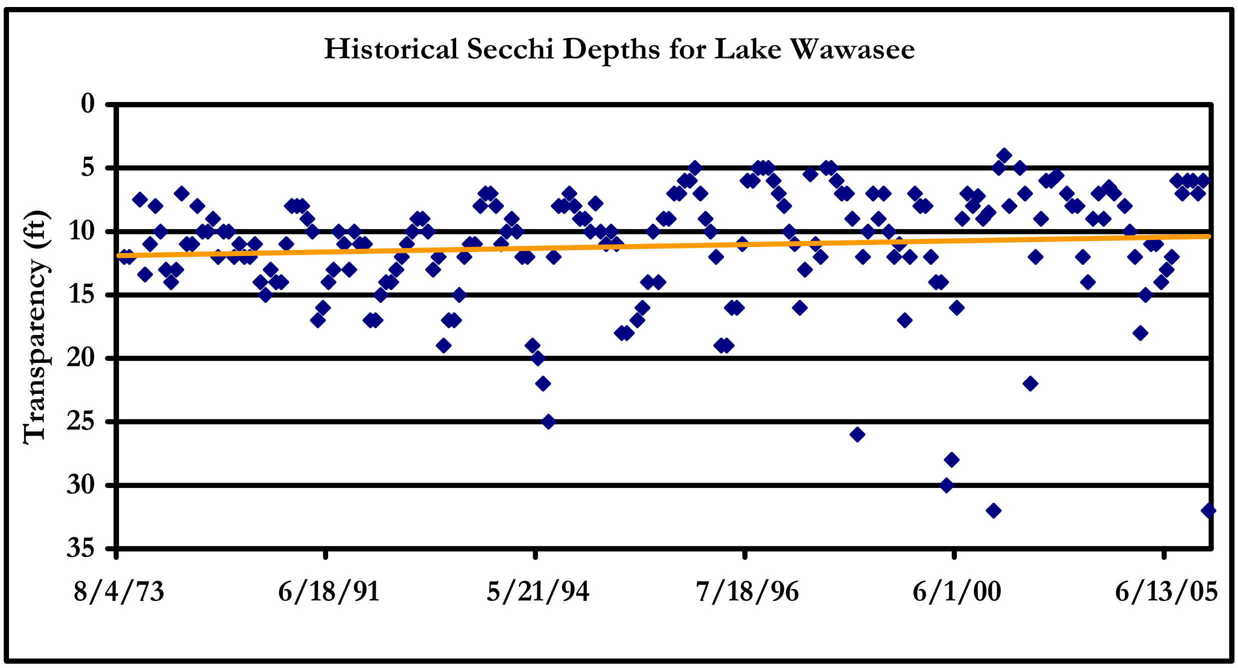

Figure 20. Secchi disk transparencies measured in Lake Wawasee, 1973 to 2005.

3.1.2 Syracuse Lake

The Indiana Department of Natural Resources, Indiana State Pollution Control Board, Tri-State University, and the Indiana Clean Lakes Program staff and volunteer monitors have all collected water quality samples from Syracuse Lake. Table 19 presents some of these results.

Table 19. Summary of historic data for Syracuse Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
6/1/1975	--	--	--	--	--	--	14	ISPCB, 1975
7/1/1975	9.5	--	--	--	--	--	--	Pearson, 2004
1975	13.0	--	--	0.010	--	--	--	Hippensteel, 1989
7/29/1985	9.5	9.5	74%	--	--	--	--	Pearson, 1986e
1988	8.0	--	--	0.060	--	--	--	Hippensteel, 1989
8/1/1994	2.0	8.5	50%	--	4,244	1.1	18	CLP, 1994
7/20/1995	12.0	--	100%	0.170	307	--	10	Commonwealth, 1996
1996*	9.0	--	--	--	--	--	--	Volunteer monitor
1997*	9.5	--	--	--	--	--	--	Volunteer monitor
1998*	8.8	--	--	--	--	--	--	Volunteer monitor
1999*	9.8	--	--	0.056	--	1.0	--	Volunteer monitor
2000*	10.6	--	--	0.041	--	1.0	--	Volunteer monitor
7/31/2000	3.6	8.4	89%	--	860	1.1	15	CLP, 2000
9/13/2000	12.5	--	100%	--	--	--	--	Harza, 2001
2001*	8.3	--	--	0.031	--	1.5	--	Volunteer monitor
2002*	13.0	--	--	0.027	--	1.7	--	Volunteer monitor
2003*	10.3	--	--	0.038	--	2.5	--	Volunteer monitor
8/4/2003	3.2	8.6	56%	--	4,268	2.8	19	CLP, 2003
2004*	13.0	--	--	0.038	--	2.5	--	Volunteer monitor
2005*	5.0	--	--	0.045	--	2.7	--	Volunteer monitor
7/12/06	8.8	8.5	70%	0.023	853	1.0	16	Current assessment
Median	9.3	8.5	50%	0.039	4,244	1.1	18	
Minimum	2.0	8.5	50%	0.010	307	0.02	10	
Maximum	19.0	9.5	89%	0.170	4,268	4.5	19	

*Average of all volunteer data recorded during that calendar year.

Syracuse Lake's water quality is also better than most Indiana lakes. Furthermore, data suggest no major change in Syracuse Lake's water quality over the period of record (Figure 21). Transparency measured within Syracuse Lake ranged from 6.0 feet in June and July of 2001 and June of 2002 to 19.0 feet in June 2000. (All of this data were collected by volunteer monitors and are not shown in the table above.) Syracuse Lake exhibits good oxygen levels with typically more than half of the water column containing sufficient dissolved oxygen for aquatic biota. Total phosphorus concentrations are relatively low for lakes in Indiana. Concentrations range from 0.010 mg/L in 1975 and 2003 to 0.170 mg/L measured in 1995. Only this measurement (Commonwealth Engineers, 1996) approached the median concentration measured in Indiana lakes. None of the mean total phosphorus concentrations measured in Syracuse Lake exceeded the median concentration measured in lakes throughout the state. Plankton densities and chlorophyll *a* concentrations are also lower than concentrations typically present in Indiana lakes. TSI scores reflect the low to moderate productivity present in the lake.

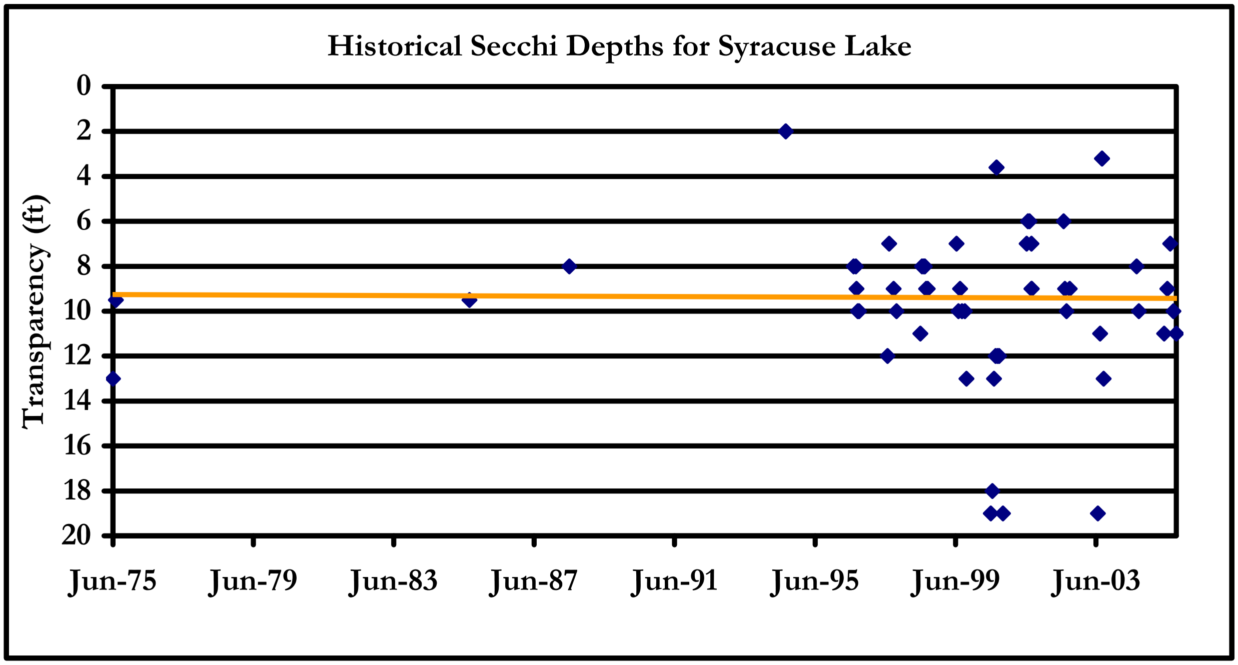

Figure 21. Secchi disk transparencies measured in Syracuse Lake, 1975 to 2005.

3.1.3 Lake Papakeechie

No data could be located for Lake Papakeechie.

3.1.4 Bonar Lake

3.1.5 Ten Lakes Chain

A variety of data has been collected for lakes within the Ten Lakes Chain. The following sections details lake water quality for these lakes on a lake-by-lake basis.

Harper Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff and volunteer monitors have all collected water quality samples from Harper Lake. Table 20 presents some of these results.

Water quality within Harper Lake is typically better than most lakes in Indiana. However, quality may be declining in this headwaters lake. Transparency measurements suggest that current water quality is poorer than that measured historically. Transparencies declined from a high of 12.8 feet (3.9 m) measured by a volunteer monitor in 1990 to a low of 4.6 feet (1.4 m) measured in 2003. Total phosphorus concentrations declined from 0.08 mg/L in 1991 and 1993 to 0.04 mg/L in 2000 and 2003. Current concentrations still exceed concentrations measured in 1975. Declines in total phosphorus concentration from the early 1990s to the 2000/2003 period suggests a reduction in available nutrients; however, plankton densities increased over the same period. The poorer transparency measured in 2000 and 2003 could be attributed to the increased plankton density observed during the same time period. Overall, the productivity level of the lake remained relatively constant over the past 15 years. With the exception of the 1975 assessments, Harper Lake rates as moderately to very productive (mesotrophic to eutrophic) based on the ITSI. The elevated ITSI score calculated for the 1975 sampling event is likely largely based on the plankton density present in the lake at the time of the assessment. This suggests that Harper Lake has the capacity to be extremely productive; however, the lake maintains moderate productivity levels on a normal basis.

Table 20. Summary of historic data for Harper Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
7/3/1972	11.0	8.5	--	--	--	--	--	ISPCB, 1975
8/31/1972	8.5	8.7	--	--	--	--	--	ISPCB, 1975
6/1/1975	5.1	--	--	0.030	6,900,000	--	60	ISPCB, 1975
7/16/1984	5.5	9.5	60%	--	--	--	--	Pearson, 1985b
1990*	10.1	--	--	--	--	--	--	Volunteer monitor
7/1/1991	7.6	--	100 %	0.084	10,412	--	29	CLP, 1991
7/1/1993	10.8	--	69%	0.085	28,624	--	25	CLP, 1993
6/9/1999	9.7	8.7	100%	--	--	--	--	Pearson, 1999c
8/8/2000	7.6	8.5	83%	0.045	41,879	3.0	25	CLP, 2000
8/12/2003	4.6	8.6	58%	0.046	37,525	3.8	34	CLP, 2003
Median	8.3	8.6	78%	0.065	33,074	3.4	29	
Minimum	4.6	8.5	58%	0.045	10,412	3.0	25	
Maximum	12.8	9.5	100%	0.085	41,879	3.8	60	

*Average of all volunteer data recorded during that calendar year.

Little Bause Lake

The Indiana Clean Lakes Program staff collected water quality samples from Little Bause Lake (Table 21). Little Bause Lake possesses better transparency and lower total phosphorus and chlorophyll *a* concentrations than most lakes in Indiana. ITSI scores indicate that Little Bause Lake is moderately productive. Additional data are necessary to determine any trends in Little Bause Lake's water quality.

Table 21. Summary of historic data for Little Bause Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
8/8/2000	9.8	8.1	82%	0.072	27,161	1.2	23	CLP, 2000
8/12/2003	11.2	8.1	77%	0.028	36,746	3.7	17	CLP, 2003

Little Knapp Lake

The Indiana Clean Lakes Program staff collected water quality samples from Little Knapp Lake (Table 22). Little Knapp Lake also possesses relatively good water quality when compared with other lakes throughout the state. Little Knapp Lake's ITSI score indicates that the lake exhibits low to moderate productivity.

Table 22. Summary of historic data for Little Knapp Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
8/21/2000	6.3	--	71%	--	--	--	--	Pearson, 2000
8/12/2003	8.8	7.8	100%	0.037	3,574	4.2	12	CLP, 2003

Knapp Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff and volunteer monitors have all collected water quality samples from Knapp Lake. Table 23 presents some of these results.

Table 23. Summary of historic data for Knapp Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
6/30/1969	11.7	--	--	--	--	--	--	Hudson, 1969d
7/1/1972	9.0	--	89%	--	--	--	--	Pearson, 1999c
8/1/1972	11.0	--	78%	--	--	--	--	Pearson, 1999c
8/1/1980	8.5	--	39%	--	--	--	--	Pearson, 1999c
8/1/1982	10.5	--	30%	--	--	--	--	Pearson, 1999c
7/16/1984	6.5	9.5	41%	--	--	--	--	Pearson, 1984d
7/1/1989	3.9	--	35%	0.178	29,195	--	31	CLP, 1989
1990*	5.2	--	--	--	--	--	--	Volunteer monitor
6/18/1990	6.0	8.7	98%	--	--	--	--	Pearson, 1990
7/1/1991	6.9	--	67%	0.121	16,562	--	31	CLP, 1991
7/1/1993	5.6	--	22%	0.317	65,080	--	40	CLP, 1993
6/1/1999	10.0	--	100%	--	--	--	--	Pearson, 1999c
8/1/1999	4.5	--	85%	--	--	--	--	Pearson, 1999c
8/8/2000	6.2	8.4	53%	0.349	55,157	3.3	39	CLP, 2000
8/21/2000	7.5	--	--	--	--	--	--	Pearson, 2000
8/12/2003	3.9	8.6	27%	0.312	753,170	3.0	68	CLP, 2003
Median	6.2	8.65	81%	0.312	29,195	3.2	39.5	
Minimum	3.9	8.4	31%	0.121	16,562	3.0	31	
Maximum	11.7	9.5	100%	0.349	753,170	3.3	68	

*Average of all volunteer data recorded during that calendar year.

Knapp Lake possesses some of the poorest quality water of the Ten Lakes Chain lakes. Additionally, water quality within Knapp Lake appears to be declining. Transparency within Knapp Lake declined from a high of 11 feet (3.4 m) in 1972 to a low of 3.9 feet (1.2 m) measured during the latest assessment (2003). Overall, transparency within Knapp Lake is poorer than most lakes in Indiana (6.9 feet). Figure 22 displays the declining transparency trend observed in Knapp Lake. Total phosphorus concentrations are higher in Knapp Lake than most lakes in Indiana. The median concentration measured in Knapp Lake is more than one and one-half times the median concentration measured in Indiana lakes (0.17 mg/L). Total phosphorus concentrations appear to be increasing over time. Concentrations ranged from 0.121 mg/L in 1991 to 0.349 mg/L in 2000. Plankton densities also appear to be increasing as total phosphorus concentrations increase and transparency decreases. The most recent plankton density (753,170/L) indicated extremely high productivity within Knapp Lake. The ITSI scores indicate an increase in productivity as well. ITSI score calculated during the 1990s ranged from 31 to 40 suggesting moderately productive to productive conditions present within Knapp Lake. The 2003 assessment suggests high productivity rates. Additional sampling should occur within Knapp Lake to determine if this sampling event occurred during a periodic algal bloom or if the data collected represents normal conditions for Knapp Lake.

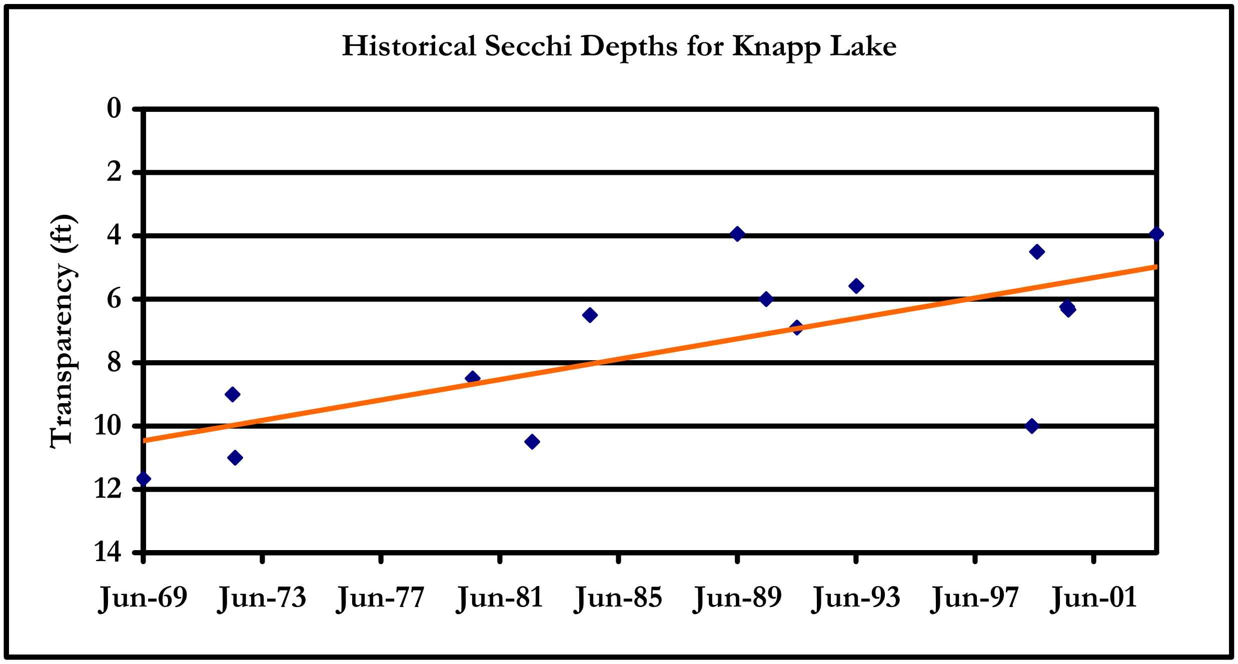

Figure 22. Secchi disk transparencies measured in Knapp Lake, 1969 to 2004.

Moss Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from Moss Lake. Table 24 presents some of these results.

Table 24. Summary of historic data for Moss Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
7/3/1972	9.5	8.0	95%	--	--	--	--	ISPCB, 1975
8/31/1972	10.0	8.7	95%	--	--	--	--	ISPCB, 1975
6/1/1975	--	--	--	--	--	--	51	ISPCB, 1975
7/18/1984	6.5	8.5	74%	--	--	--		Pearson, 1984e
7/1/1991	7.2	--	100%	0.059	2,214	--	13	CLP, 1991
7/1/1993	6.2	--	55%	0.081	58,350	--	31	CLP, 1993
6/21/1999	9.0	9.2	89%	--	--	--	--	Pearson, 1999d
8/8/2000	8.5	8.2	80%	0.066	91,497	1.8	35	CLP, 2000
8/12/2003	6.2	8.2	78%	0.049	69,625	1.3	36	CLP, 2003
Median	7.2	8.5	85%	0.062	63,987	1.5	35	
Minimum	6.2	8.2	74%	0.049	2,214	1.3	13	
Maximum	10.0	9.2	95%	0.081	91,497	1.8	51	

Moss Lake's water quality is better than water quality in most lakes in Indiana. Furthermore, no trend towards either improving or declining water quality can be discerned from the available data. Moss Lake's transparency is better than most lakes in Indiana. Transparency ranged from 6.2 feet (1.9 m) in July 1993 and August 2003 to 10 feet (3.0 m) in August of 1972, which indicates a slight declining trend in water transparency. Total phosphorus concentrations are relatively low when compared with other lakes throughout the state. Total phosphorus concentrations ranged from 0.049 mg/L in 2003 to 0.081 mg/L in 1993. No pattern is discernable for Moss Lake's total phosphorus concentrations. Plankton densities present within Moss Lake mimic the variable pattern of total phosphorus concentrations. Again, no discernable trend towards increasing or decreasing plankton densities can be determined for Moss Lake. Based on ITSI scores, Moss Lake's water quality appears to have improved since 1975. In 1975, Moss Lake rated as extremely productive, since that time ITSI scores indicate the lake is moderately productive to productive.

Hindman Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from Hindman Lake. Table 25 presents some of these results.

Table 25. Summary of historic data for Hindman Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
7/3/1972	10.0	8.5	--	--	--	--	--	ISPCB, 1975
8/31/1972	11.0	8.7	95%	--	--	--	--	ISPCB, 1975
6/1/1975	--	--	--	--	--	--	52	ISPCB, 1975
7/18/1984	7.0	9.5	85%	--	--	--	--	Pearson, 1984b
7/1/1991	9.2	--	100%	0.055	23,342	--	26	CLP, 1991
7/1/1993	6.2	--	52%	0.073	29,262	--	23	CLP, 1993
6/21/1999	8.0	8.6	100%	--	--	--	--	Pearson, 1999b
8/8/2000	2.3	8.8	80%	0.124	100,229	20.0	44	CLP, 2000
8/11/2003	6.9	8.3	55%	0.046	202,376	9.5	48	CLP, 2003
Median	8.1	8.7	85%	0.064	64,7456	14.8	44	
Minimum	2.3	8.3	52%	0.042	23,342	9.5	23	
Maximum	11.0	9.5	100%	0.126	202,376	20.0	52	

Hindman Lake possesses better water quality than most lakes in Indiana; however, water quality appears to have declined since the original assessment completed in 1972. Transparency declined from a high of 11 feet (3.4 m) in 1972 to a low of 2.3 feet (0.7 m) in 2000. Despite this decline, Hindman Lake's transparency is typically better than most lakes in Indiana. Total phosphorus concentrations are also lower than concentrations present in most Indiana lakes. However, there is no apparent trend in total phosphorus concentrations over time. Concentrations ranged from a low of 0.046 mg/L in 2004 to a high of 0.124 mg/L in 2000. Plankton densities increased by a factor 5 to 10 from the 1991 and 1993 samples to densities measured in 2000 and 2003. Based on ITSI scores, the productivity level increased from moderately productive to extremely productive (mesotrophic to eutrophic). Additional sampling is recommended to determine if the trophic status as observed during the 2000 and 2003 sampling events is the typical productivity level for Hindman Lake.

Gordy Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from Gordy Lake. Table 26 presents some of these results.

Table 26. Summary of historic data for Gordy Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
9/1/1972	8.5	--	66%	--	--	--	--	Brindza, 1998
6/1/1975	--	--	--	--	--	--	42	ISPCB, 1975
6/28/1976	9.0	9.0	66%	--	--	--	--	Shipman, 1976b
6/18/1984	9.5	9.5	69%	--	--	--	--	Pearson, 1985a
9/1/1990	3.0	--	77%	--	--	--	--	Brindza, 1998
7/1/1991	9.5	--	57%	0.109	27,410		25	CLP, 1991
8/1/1992	5.5	--	74%	--	--	--	--	Brindza, 1998
8/17/1993	10.5	7.9	57%	1.272	72,793	3.0	37	CLP, 1993
6/21/1998	9.5	8.5	43%	--	--	--	--	Brindza, 1998
8/14/2000	4.6	8.5	50%	0.179	6,766	4.2	33	CLP, 2000
7/29/2003	9.8	8.3	38%	0.112	32,156	3.6	26	CLP, 2003
Median	9.5	8.5	69%	0.179	32,156	3.6	33	
Minimum	3.0	7.9	38%	0.109	6,766	3.0	25	
Maximum	10.5	9.5	86%	1.272	72,793	4.3	42	

Water quality within Gordy Lake does not show any increasing or decreasing trend. With relation to transparency, Gordy Lake typically possesses better transparency than most lakes in Indiana. Water transparency ranged from a low of 3 feet (0.9 m) in 1990 to a high of 10.5 feet (3.2 m) in 1993. Total phosphorus concentrations are typically at or above the median concentration for most lakes in Indiana. During the 1993 assessment, Gordy Lake possessed the highest total phosphorus concentrations measured in any of the lakes in the Wawasee Area Watershed in the past 35 years. Plankton densities and chlorophyll *a* concentrations vary but do not reflect any trend of increasing or decreasing productivity. ITSI scores also indicate that quality within Gordy Lake does not follow any particular pattern. In general, Gordy Lake rates as moderately to highly productive (mesotrophic to eutrophic). Additional sampling should occur to better understand the trend of Gordy Lake's water quality.

Rider Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from Rider Lake. Table 27 presents some of these results.

Table 27. Summary of historic data for Rider Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
6/1/1975	--	--	--	--	--	--	55	ISPCB, 1975
6/28/1976	7.5	9.0	100%	--	--	--	--	Shipman, 1976d
6/18/1984	9.5	9.5	81%	--	--	--	--	Pearson, 1984f
6/7/1998	9.0	8.5	100%	--	--	--	--	Hudson, 1998
7/1/1991	8.5	--	100%	0.055	23,675	--	14	CLP, 1991
8/17/1993	7.9	--	67%	0.088	19,127	--	16	CLP, 1993
8/14/2000	6.6	8.2	80%	0.066	166,657	5.0	43	CLP, 2000
7/29/2003	9.8	8.3	66%	0.028	35,508	3.6	25	CLP, 2003
Median	8.5	8.5	81%	0.060	29,592	4.3	16	
Minimum	6.6	8.2	67%	0.028	19,127	3.6	14	
Maximum	9.8	9.5	100%	0.088	166,657	5.0	55	

Overall, Rider Lake possesses better water quality than most lakes in Indiana. Additionally, water quality within the lake fluctuates but shows no definable trend towards improving or declining water quality. Transparency measured within Rider Lake is better than that measured in most Indiana lakes. Transparency ranged from 6.6 feet (2.0 m) to 9.8 feet (2.8 m). The poorest transparency measured in Rider Lake corresponds with the highest plankton density and highest productivity level measured within the lake (2000). Total phosphorus concentrations varied over time ranging from 0.028 mg/L in 2003 to 0.088 mg/L in 1993. ITSI scores varied as well indicating the Rider Lake was slightly productive during the 1991 and 1993 assessments, moderately productive during the 2003 assessment, and extremely productive during the 1975 and 2000 assessments. Additional assessments need to be completed to determine whether Rider Lake's typical water quality is more similar to the 1991, 1993, and 2003 assessments or the higher productivity that was present during the 2000 assessment.

Duely Lake

The Indiana State Pollution Control Board, IDNR, and the Indiana Clean Lakes Program staff have all collected water quality samples from Duely Lake. Table 28 presents some of these results.

Table 28. Summary of historic data for Duely Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
6/28/1978	7.5	9.0	100	--	--	--	--	Shipman, 1976a
6/18/1984	9.5	9.5	74%	--	--	--	--	Pearson, 1984a
7/1/1991	4.6	--	52%	0.083	6,432	--	25	CLP, 1991
7/1/1993	4.9	--	100%	0.098	30,123	--	37	CLP, 1993
6/15/1998	6.5	8.5	74%	--	--	--	--	Brindza, 1998
8/14/2000	5.9	8.3	52%	0.104	68,238	6.8	33	CLP, 2000
7/29/2003	8.5	8.2	80%	0.028	14,336	3.8	13	CLP, 2003
Median	6.5	8.5	74%	0.090	22,292	5.3	33	
Minimum	4.6	8.2	52%	0.028	6,432	3.8	13	
Maximum	9.5	9.5	100%	0.104	68,238	6.8	42	

Water quality within Duely Lake is on par or slightly better than water quality present in most Indiana lakes. However, there is no apparent trend of improving or declining water quality within Duely Lake. Transparency measurements within the lake indicate that water quality is relatively stable. Transparencies varied from 4.6 feet (1.4 m) in 1991 to 9.5 feet (2.9 m) in 1984. Total phosphorus concentrations vary over time and show no distinct trend. However, higher total phosphorus concentrations typically occur in concert with lower transparency measurements while, lower total phosphorus concentrations occur under higher available phosphorus concentrations. Productivity levels also vary within Duely Lake. The highest productivity occurred when transparency was poorest and total phosphorus concentrations and plankton densities were highest (1993 and 2000). Additional sampling should occur within Duely Lake to determine the typical productivity of the lake.

(Indian) Village Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from (Indian) Village Lake. Table 29 presents some of these results.

Table 29. Summary of historic data for (Indian) Village Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
6/1/1975	--	--	--	--	--	--	59	ISPCB, 1975
6/28/1976	4.5	9.0	86%	--	--	--	--	Shipman, 1976c
6/18/1984	9.0	9.5	86%	--	--	--	--	Pearson, 1984c
8/17/1993	5.3	8.4	60%	0.027	656,634	8.5	58	CLP, 1993
6/7/1998	2.5	8.5	86%	--	--	--	--	Pearson, 1998
8/14/2000	5.3	8.2	--	0.096	71,533	3.2	33	CLP, 2000
6/1/2003	4.9	8.1	50%	0.033	92,575	12.8	34	CLP, 2003
Median	5.3	8.6	86%	0.033	92,575	8.5	46	
Minimum	2.5	8.2	59%	0.027	71,533	3.2	33	
Maximum	9.5	9.5	86%	0.096	656,634	12.8	59	

Village Lake possesses relatively poor water clarity. Only one clarity measurement recorded in Village Lake is better than the median value for lakes in Indiana. Furthermore, Village Lake possesses the poorest transparency of any of the lakes within the Ten Lakes Chain. Water clarity typically ranges from 2.5 feet (0.7 m) to 9.5 feet (2.9 m) with only one recorded measurement being better than the transparency of most Indiana lakes (6.9 feet or 2.1 m). Total phosphorus concentrations present in Village Lake are relatively low for Indiana lakes (median concentration of 0.033 mg/L compared with a state median of 0.17 mg/L). Chlorophyll *a* concentrations are also relatively low. However, plankton densities are elevated especially during the 1993 assessment. This assessment could have occurred during an algal bloom as reflected by the higher chlorophyll *a* concentration. ITSI scores indicate that Village Lake is typically productive to extremely productive (eutrophic to hypereutrophic). With respect to plankton densities and ITSI scores, water quality within Village Lake appears to have improved from assessments completed in 1975 and 1993 to more current assessments (2000 and 2003). Additional sampling should occur within Village Lake to determine if the increasing water quality observed during the two most recent assessments is in fact a trend.

3.1.5 Tri-County FWA

A variety of data has been collected for lakes within the Tri-County Fish and Wildlife Area. The following sections details lake water quality for these lakes on a lake-by-lake basis.

Allen Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from Allen Lake. Table 30 presents some of these results.

Table 30. Summary of historic data for Allen Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
6/23/1969	5.8	--	57%	--	--	--	--	Hudson, 1969a
11/6/1969	--	--	--	0.200	--	--	--	Hudson, 1969a
6/24/1985	10.0	9.0	59%	--	--	--	--	Pearson, 1986a
6/1/1995	7.2	7.7	56%	0.039	10,938	7.8	33	CLP, 1995
6/1/2000	7.5	8.3	56%	0.028	39,830	0.7	31	CLP, 2000
7/2/2002	10.0	--	91%	--	--	--	--	Pearson, 2002a
6/1/2003	3.6	7.6	31%	0.345	32,273	18.3	36	CLP, 2003
Median	10.0	8.3	57%	0.039	32,273	7.8	33	
Minimum	5.8	7.7	55%	0.028	10,938	0.7	31	
Maximum	10.5	9.0	91%	0.200	39,830	18.3	36	

Allen Lake typically possesses better water clarity than most lakes in Indiana. The only exception to this occurred during the 1969 early summer assessment (Hudson, 1969a). There is no apparent trend of improving or declining water clarity based on the available data. This is to be expected based on the limited land use changes that have occurred over the length of sampling history. However, based on total phosphorus and chlorophyll *a* concentrations, water quality within Allen Lake appears to have declined from the 1975 assessment to the more recent assessments. Typically, Allen Lake rates as moderately productive to productive (mesotrophic to eutrophic).

Barrel and a Half Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from Barrel and a Half Lake. Table 31 presents some of these results.

Transparency in Barrel and a Half Lake is rarely better than transparency in most Indiana lakes. Transparency in Barrel and Half Lake ranged from 2.5 feet (0.7 m) in 1975 to 8 feet (2.4 m) in 1993. Transparency appears to have improved from 1962 to 1993 before declining to its most recent measurement of 4.3 feet (1.3 m). Total phosphorus concentrations are also relatively high for Indiana lakes. Total phosphorus concentrations in Barrel and a Half Lake typically exceed the median concentration found in Indiana lakes. Concentrations ranged from 0.17 mg/L in 1975 to 0.633 mg/L in 1994. Concentrations declined slightly from 1994 to the most recent assessment (0.488 mg/L) but have not returned to levels measured in 1966 and 1975. Concentrations varied slightly but overall remained stable during assessments occurring during the previous 15 years. Plankton densities and chlorophyll *a* concentrations also indicate a trend of declining water quality. Plankton concentrations measured during the most recent assessment (113,695/L) are nearly double those present during the initial Clean Lakes Program assessment (79,664/L). Chlorophyll *a* concentrations have also increased measuring nearly five times higher during the 2003 assessment than those present during the 1994 assessment. Plankton densities and chlorophyll *a* concentrations are still lower than concentrations observed in most Indiana lakes. ITSI scores reflect the increasing productivity evidenced by the elevated plankton density. ITSI scores increased from productive during the 1994 and 2000 assessments to extremely productive during the 2003 assessment. Additional monitoring should be completed to determine if the declining water quality trend suggested by the most recent CLP assessments is in fact the trend or if the poor water quality measured during that assessment was an anomaly.

Table 31. Summary of historic data for Barrel and a Half Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
8/1/1962	--	--	67%	--	--	--	--	Pearson, 1993a
6/26/1966	4.0	--	69%	0.200	--	--	--	Hudson, 1966a
12/28/1966	--	--	--	0.200	--	--	--	Hudson, 1966a
6/1/1969	5.8	--	69%	--	--	--	--	Pearson, 1993a
6/16/1969	3.7	--	64%	--	--	--	--	Hudson, 1969b
6/1/1973	6.0	--	100%	--	--	--	--	Pearson, 1993a
6/11/1973	6.0	7.7	75%	--	--	--	--	Pearson, 1978
6/1/1975	2.5	9.0	42%	0.170	--	--	--	Pearson, 1993a
6/19/1985	8.0	9.5	56%	--	--	--	--	Pearson, 1986b
6/21/1993	8.0	8.4	56%	--	--	--	--	Pearson, 1993a
8/2/1994	7.8	8.5	--	0.633	79,664	1.8	38	CLP, 1994
6/8/1998	7.0	8.2	97%	--	--	--	--	Cwalkinski,1998a
8/8/2000	6.2	7.8	--	0.594	7,713	3.8	32	CLP, 2000
8/4/2003	4.3	7.6	--	0.488	113,695	9.8	54	CLP, 2003
Median	6.0	8.4	67%	0.344	79,664	3.9	35	
Minimum	2.5	7.6	42%	0.170	7,713	1.7	32	
Maximum	8.0	9.5	100%	0.633	113,695	9.8	46	

Hammond Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from Hammond Lake. Table 32 presents some of these results.

Hammond Lake contains poorer water quality than most lakes in Indiana. This is especially of concern with regard to total phosphorus concentrations. Transparency measurements are better than most lakes in Indiana. However, transparency measurements dropped from 12.4 feet (3.8 m) in 1969 to 6.6 feet (2.0 m) in 1994 and 2000 before improving to 8.5 feet (2.6 m) in 2003. Total phosphorus concentrations have fluctuated over time, but have remained relatively stable during the period of assessment. Concentrations fluctuated from a low of 0.274 mg/L in 2003 to a high of 0.353 mg/L in 2000. All measured total phosphorus concentrations exceed the median concentration measured in Indiana lakes. Plankton density fluctuated over time and more than doubled from assessments that occurred in 1994 and 2000 to the latest assessment in 2004. These variations do not correspond to changes in phosphorus concentration. In fact, the highest phosphorus concentrations correspond with the lowest plankton densities and vice versa. ITSI scores also indicate declining water quality. A ten point change in productivity occurred from the 1994 assessment to the 2003 assessment. As most of the parameters were within similar ranges during both assessments, it is possible to attribute the elevated ITSI score observed in 2003 to increased plankton density. Whether this is an anomaly in the data is something that can be determined with additional water quality monitoring. Hammond Lake rates as productive to extremely productive (mesotrophic to eutrophic).

Table 32. Summary of historic data for Hammond Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
8/15/1962	--	--	52%	--	--	--	--	Pearson, 1993b
6/23/1969	12.4	--	85%	--	--	--	--	Hudson, 1969c
11/6/1969	--	--	--	0.300	--	--	--	Hudson, 1969c
6/23/1985	12.4	--	76%	--	--	--	--	Pearson, 1993b
6/26/1985	12.0	9.0	76%	--	--	--	--	Pearson, 1986c
6/1/1993	11.3	8.0	66%	--	--	--	--	Pearson, 1993b
8/2/1994	6.6	8.2	--	0.280	31,822	2.8	32	CLP, 1994
8/7/2000	6.6	7.5	--	0.353	17,335	2.5	35	CLP, 2000
7/2/2002	9.5	--	73%	--	--	--	--	Pearson, 2002b
8/4/2003	8.5	7.6	--	0.274	82,314	4.2	42	CLP, 2003
Median	10.4	8.0	74%	0.290	31,822	2.8	38.5	
Minimum	6.6	7.5	52%	0.274	17,335	2.5	35	
Maximum	12.4	9.0	85%	0.353	82,314	4.2	42	

Long Lake

The Indiana Clean Lakes Program staff collected water quality samples from Long Lake (Table 33).

Table 33. Summary of historic data for Long Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
8/9/1994	15.1	8.8	100%	0.068	40,990	1.5	25	CLP, 1994

Long Lake possesses better water quality than most lakes in Indiana. Transparency in Long Lake is more than double the transparency present in most Indiana lakes. Total phosphorus concentrations are also relatively low measuring one-third the concentrations present in most Indiana lakes. Furthermore, chlorophyll *a* concentrations are nearly one-tenth the concentration present in most Indiana lakes. Overall, Long Lake rates as moderately productive or mesotrophic.

Price Lake

The Indiana State Pollution Control Board and the Indiana Clean Lakes Program collected water quality samples from Price Lake. Table 34 presents some of these results.

Table 34. Summary of historic data for Price Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
6/1/1975	--	--	--	--	--	--	50	ISPCB, 1975
7/1/1991	12.1	--	100%	0.091	30,277	--	28	CLP, 1991
8/9/1994	10.2	7.6	60%	0.113	29,499	2.2	29	CLP, 1994
7/6/2004	8.9	7.8	67%	0.051	3,944	2.3	9	CLP, 2004
Median	13.7	7.7	67%	0.081	21,240	2.2	28	
Minimum	8.9	7.6	60%	0.051	3,944	2.2	9	
Maximum	12.1	7.8	100%	0.113	30,277	2.3	50	

Price Lake possesses good water quality that appears to be better than most lakes in Indiana. Although water transparency dropped from 12.1 feet (6.4 m) in 1991 to 8.9 feet (2.7 m) in 2004, transparency is still better than most Indiana lakes. Total phosphorus concentrations fluctuated over time ranging from 0.051 mg/L in 2004 to a high of 0.113 mg/L in 1994. All of the recorded total phosphorus concentrations are less than the median concentration for Indiana lakes. Plankton densities appear to mimic phosphorus concentrations in that elevated plankton densities coincide with elevated phosphorus concentrations while lower plankton densities coincide with lower phosphorus concentrations. Price Lake's ITSI score has also changed over time. In 1975, Price Lake rated as extremely productive (hypereutrophic). Since that time, the trophic state improved to moderately productive (mesotrophic) during the 1991 and 1994 assessments, while the lake rated as slightly productive (oligotrophic) in 2004.

Rothenberger Lake

The Indiana Department of Natural Resources and the Indiana Clean Lakes Program staff have all collected water quality samples from Rothenberger Lake. Table 35 presents some of these results.

Table 35. Summary of historic data for Rothenberger Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
6/23/1969	5.8	--	100%	--	--	--	--	Hudson, 1969e
6/24/1986	12.5	9.0	100%	--	--	--	--	Pearson, 1986d
8/2/1994	4.9	8.4		0.029	105,829	3.4	44	CLP, 1994
8/7/2000	5.9	7.5	--	0.091	37,570	4.9	24	CLP, 2000
8/4/2003	5.9	7.6	--	0.125	101,420	3.8	45	CLP, 2003
Median	5.9	8.0	100%	0.091	101,420	3.8	44	
Minimum	4.9	7.5	100%	0.029	37,570	3.4	24	
Maximum	12.5	9.0	100%	0.125	105,829	4.9	45	

Rothenberger Lake typically possesses water quality that rates as moderately productive to productive. Transparency measurements recorded at Rothenberger Lake are typically poorer than most lakes in Indiana. There is one exception to this statement: early in 1986 transparency measured more than double the typical transparency (12.5 feet or 3.8 m compared to 5 to 6 feet or 1.5 to 1.8

m). Total phosphorus concentrations increased from the initially recorded level in 1994 (0.029 mg/L) to the most recent measurement (0.125 mg/L in 2003). Concentrations remain below (better than) the level measured in most Indiana lakes. Plankton are relatively dense in Rothenberger Lake; however, chlorophyll *a* concentrations are relatively low. Measured chlorophyll *a* concentrations were always less than the median concentration present in Indiana lakes. Rothenberger Lake's productivity level varies between moderately productive (mesotrophic) and productive (eutrophic). Additional sampling should occur within Rothenberger Lake to determine the typical productivity level present in this lake.

Shock Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from Shock Lake. Table 36 presents some of these results.

Table 36. Summary of historic data for Shock Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
7/1/1962	--	--	76%	--	--	--	--	Cwalinski, 1996a
6/1/1969	5.7	--	--	--	--	--	--	Cwalinski, 1996a
6/16/1969	5.8	--	--	--	--	--	--	Hudson, 1969f
11/6/1969	--	6.9	--	0.400	--	--	--	Hudson, 1969f
7/1/1972	5.4	--	76%	--	--	--	--	Cwalinski, 1996a
6/1/1973	6.4	--	76%	--	--	--	--	Cwalinski, 1996a
6/11/1973	6.5	8.5	72%	--	--	--	--	Pearson, 1978
6/1/1975	--	--	--	--	--	--	28	ISPCB, 1975
7/1/1975	8.0	9.0	85%	0.110	--	--	--	Cwalinski, 1996a
6/1/1979	9.3	--	42%	--	--	--	--	Cwalinski, 1996a
6/1/1985	6.0	--	59%	--	--	--	--	Cwalinski, 1996a
7/1/1991	5.9	--	--	0.270	73,242	--	35	CLP, 1991
6/1/1993	6.4	--	76%	--	--	--	--	Cwalinski, 1996a
8/2/1994	14.4	8.4	--	0.410	21,873	0.8	32	CLP, 1994
6/1/1996	5.5	7.7	59%	--	--	--	--	Cwalinski, 1996a
6/6/1997	4.4	8.5		--	--	--	--	Cwalinski, 1997a
6/1/1998	6.0	7.8	95%	--	--	--	--	Cwalinski,1998b
6/14/1999	6.5	8.7	42%	--	--	--	--	Cwalinski,1999a
7/5/2000	11.5	8.0	54%	--	--	--	--	Cwalinski, 2000a
8/8/2000	7.2	8.1	--	0.730	47,219	1.9	32	CLP, 2000
6/5/2001	11.5	8.4	51%	--	--	--	--	Cwalinski, 2001a
8/5/2003	7.6	8.0	--	0.330	36,388	9.6	37	CLP, 2003
Median	6.4	8.4	76%	0.370	41,804	1.9	32	
Minimum	4.4	7.7	42%	0.110	21,873	0.7	28	
Maximum	14.4	9.0	95%	0.730	73,242	9.6	37	

Shock Lake possesses relatively poor water quality when compared with other lakes in the state. Additionally, Shock Lake's water quality fluctuates but shows no increasing or decreasing trend over time. Transparency measurements generally range from 5.5 to 6.5 feet (1.7 to 2.0 m); however, transparencies as deep as 14.4 feet (4.4 m; 1994) have been recorded in the past. Transparencies typically present in Shock Lake are on par with or slightly poorer than transparencies in most Indiana lakes. Furthermore, when plotted over time (Figure 23), the trend indicates that transparency is increasing over time. Total phosphorus concentrations varied over time; overall there has been very little change in total phosphorus concentrations. Concentrations ranged from 0.110 mg/L in 1974 to a high of 0.730 mg/L in 2000. Plankton densities have also fluctuated over time; however, elevated plankton densities do not typically correspond with elevated total phosphorus concentrations and vice versa. Overall, the trophic status or productivity level of Shock Lake typically rated as eutrophic. In total, ITSI scores varied less than 10 points from the first collection (1975) to the most recent collection (2003).

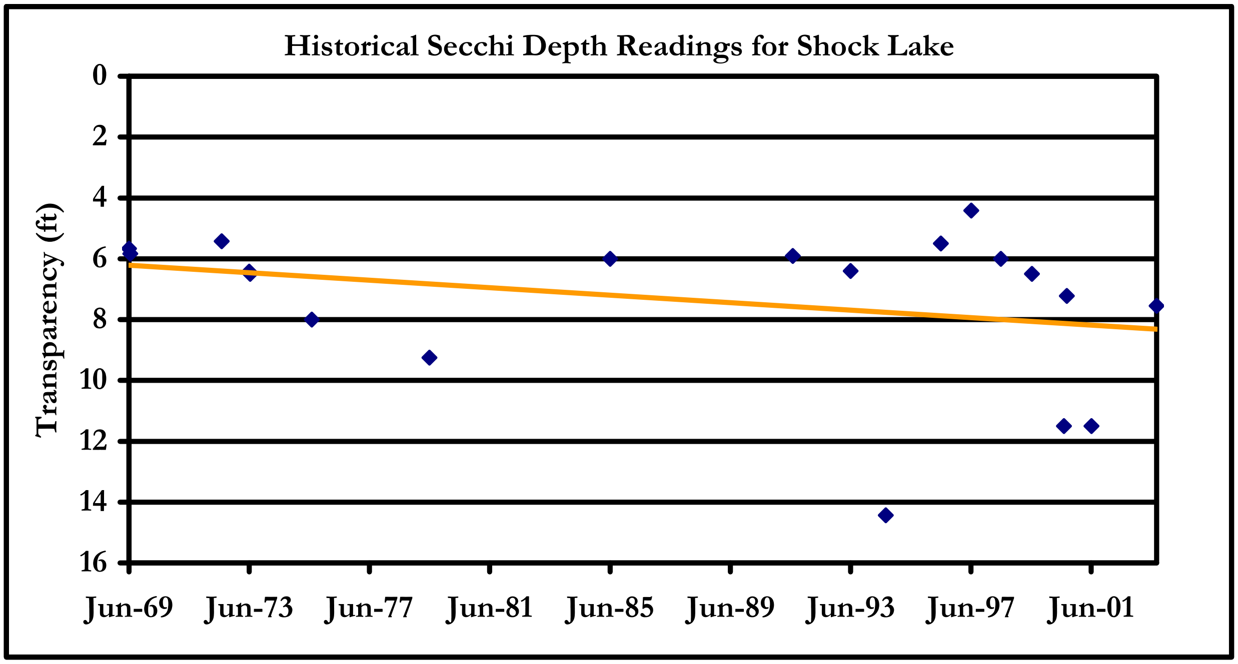

Figure 23. Secchi disk transparencies measured in Shock Lake, 1969 to 2004.

Spear Lake

The Indiana State Pollution Control Board, Indiana Department of Natural Resources, and the Indiana Clean Lakes Program staff have all collected water quality samples from Hammond Lake. Table 37 presents some of these results.

Like most of the other lakes in the Tri-County FWA, water quality with Spear Lake is relatively stable. Secchi disk transparency in Spear Lake typically ranges from 6.5 to 8 feet (2.0 to 2.4 m); however, transparencies as deep as 11.5 feet (3.5 m) have been measured in Spear Lake. Over the entire period of measure, transparency appears to be improving (Figure 24). Secchi disk transparency is generally better than transparency in most Indiana lakes; transparency was poorer during only two of the 18 assessments. Total phosphorus concentrations fluctuate, but appear relatively stable. Two measurements (0.05 mg/L in 1975 and 0.112 mg/L in 2004) were better than total phosphorus concentrations present in most Indiana lakes. However, phosphorus concentrations typically exceed levels found in most Indiana lakes. Chlorophyll *a* concentrations are relatively low within Spear Lake and are always better than concentrations measured in most Indiana lakes. Productivity varies within Spear Lake, but remains in the moderately productive (mesotrophic) to productive (eutrophic) range.

Table 37. Summary of historic data for Spear Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
8/1/1962	--	--	50%	--	--	--	--	Cwalinski,1997b
6/1/1966	--	--	38%	--	--	--	--	Cwalinski,1997b
12/8/1966	--	--	38%	0.200	--	--	--	Hudson, 1966b
6/16/1969	3.5	--	50%	--	--	--	--	Hudson, 1969g
6/1/1973	9.5	--	50%	--	--	--	--	Cwalinski,1997b
6/1/1975	--	--	--	--	--	--	36	ISPCB, 1975
7/1/1975	6.5	9.0	50%	0.050	--	--	--	Cwalinski,1997b
6/11/1978	9.5	8.0	78%		--	--	--	Pearson, 1978
6/25/1979	6.5	9.0	38%		--	--	--	Pearson, 1979b
6/10/1985	10.0	9.5	38%		--	--	--	Pearson, 1985c
7/1/1991	6.9	--	--	0.225	66,092	--	38	CLP, 1991
6/1/1993	11.5	--	50%	--	--	--	--	Cwalinski,1997b
8/2/1994	7.5	8.5	--	0.328	13,375	0.6	31	CLP, 1994
1/10/1996	8.3	8.0	64%	--	--	--	--	Cwalinski,1996b
6/10/1996	8.3	8.0	--	--	--	--	--	Cwalinski,1997b
6/16/1997	11.0	8.3	62%	--	--	--	--	CLP, 1997
6/9/1998	8.0	8.0	62%	--	--	--	--	Cwalinski, 1998c
6/21/1999	5.3	7.6	38%	--	--	--	--	Cwalinski,1999b
6/1/2000	--	--	--	--	--	--	--	ISPCB, 2000
6/12/2000	7.0	8.2	83%	--	--	--	--	Cwalinski,2000b
8/7/2000	8.2	7.9	--	0.252	20,577	1.3	34	CLP, 2000
6/11/2001	7.0	8.9	78%	--	--	--	--	Cwalinski,2001b
7/6/2004	8.7	7.9	--	0.112	16,531	4.6	28	CLP, 2004
Median	8.2	8.1	50%	0.212	18,554	1.3	35	
Minimum	3.5	7.6	38%	0.050	13,375	0.6	28	
Maximum	11.5	9.5	83%	0.328	66,092	4.6	38	

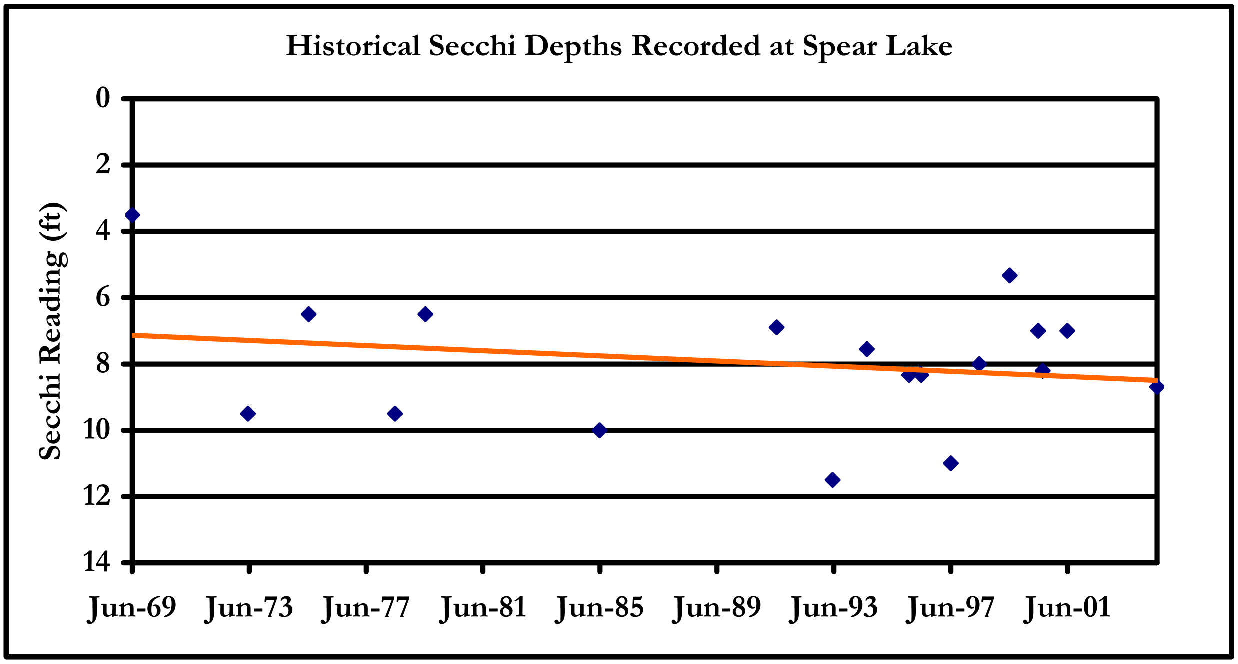

Figure 24. Secchi disk transparency measurements recorded in Spear Lake.

Wyland Lake

The Indiana Clean Lakes Program staff collected water quality samples from Wyland Lake (Table 38). Wyland Lake possesses relatively good water quality. Transparency measurements, total phosphorus concentrations, and chlorophyll *a* concentrations are better than levels found in most Indiana lakes. Wyland Lake rates as moderately productive (mesotrophic).

Table 38. Summary of historic data for Wyland Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
8/7/2000	7.8	7.6	--	0.24	4,178	1.5	25	CLP, 2000
7/6/2004	12.5	7.5	--	0.08	7,536	1.6	14	CLP, 2004

3.2 Current Lake Water Quality Assessments

To supplement the base of existing data, JFNew assessed the water quality in Lake Wawasee, Syracuse Lake, and Lake Papakeechie by examining water chemistry and biological parameters. Sampling followed the protocol utilized by the Indiana Clean Lakes Program to allow for comparison to data gathered for other Indiana lakes. Water samples were collected and analyzed for various parameters from Lake Wawasee, Syracuse Lake, and Lake Papakeechie on July 12, 2006 from the surface waters (**epilimnion**) and from the bottom waters (**hypolimnion**) of the lakes at a location over the deepest water. These parameters include conductivity, total phosphorus, soluble reactive phosphorus, nitrate-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen, and organic nitrogen. In addition to these parameters, several other measurements of lake health were recorded. Secchi disk, light transmission, and oxygen saturation are single measurements made in the epilimnion. Chlorophyll was determined only for an epilimnetic sample. Dissolved oxygen and temperature were measured at one-meter intervals from the surface to the bottom. A tow to collect plankton was made from the 1% light level depth up to the water surface. Conductivity, temperature, and dissolved oxygen were measured in situ with an YSI Model 85 meter. Details of each of the parameters and their impact on lake water quality are located in Appendix G1.

3.2.1 Lake Wawasee

Based on its most recent assessment, Lake Wawasee is best classified as a mesotrophic lake (Table 39). Mesotrophic lakes often exhibit good water clarity, moderate nutrient concentrations, and moderate productivity levels. Lake Wawasee's nutrient concentrations were higher than Vollenweider's concentrations for mesotrophic lakes, but did not reach levels determined for eutrophic (highly productive) lakes (Vollenweider, 1975). Likewise, total phosphorus concentrations were greater than those determined by Carlson (1977) to be high enough for algal blooms to occur. Lake Wawasee's chlorophyll *a* (an indicator of algae) concentration, however, was comparable to chlorophyll *a* concentrations found in oligotrophic lakes (Carlson, 1977). Similarly, Lake Wawasee's water clarity was on par with that found in many mesotrophic lakes suggesting the lake is likely mesotrophic in nature.

Table 39. Water quality characteristics of Lake Wawasee, July 12, 2006.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.6	7.6	-
Alkalinity	115 mg/L	115 mg/L	-
Conductivity	338.2 μmhos	314.3 μmhos	-
Secchi Depth Transparency	8.2 feet	-	0
Light Transmission @ 3 ft.	29%	-	4
1% Light Level	24.6 feet	-	-
Total Phosphorus	0.058 mg/L	0.044 mg/L	2
Soluble Reactive Phosphorus	0.010 mg/L*	0.010 mg/L*	0
Nitrate-Nitrogen	0.015 mg/L*	0.015 mg/L*	0
Ammonia-Nitrogen	0.018 mg/L*	0.516 mg/L	0
Organic Nitrogen	0.537 mg/L	1.096 mg/L	1
Total Suspended Solids	2.00 mg/L	2.20 mg/L	-
Oxygen Saturation @ 5ft.	100.6%	-	0
% Water Column Oxic	32%	-	3
Plankton Density	1,594/L	-	0
Blue-Green Dominance	55.9%	-	10
Chlorophyll *a*	0.02 μg/L	-	-
		TSI Score	**20**

*Method detection limit

Despite the relatively good water quality apparent in Lake Wawasee, the water quality data indicates a few areas of concern. Elevated ammonia-nitrogen and organic nitrogen concentrations were found in the lake's hypolimnion. Ammonia-nitrogen is a by-product of bacterial decomposition. When ammonia occurs in high concentrations, it is evidence of high biological oxygen demand. This biological oxygen demand comes from organic waste, such as dead algae and rooted plants, within the sediment, which provides evidence of elevated algal populations during at least a portion of the year. Of additional concern is the low percentage of the water column which contains sufficient dissolved oxygen levels. Only 32% of the water column contains dissolved oxygen sufficient for aquatic biota. This means that fish are typically present in only one-third of the water column. The anoxia, or low dissolved oxygen levels, present in the depths of Lake Wawasee allows phosphorus to be released from the sediment. Based on current data, phosphorus was not being released from sediment during the current assessment. However, historic data (Table 39) indicates that phosphorus is released from the lake's bottom sediments during at least a portion of the year. (This is calculated by dividing the hypolimnetic SRP concentration by the epilimnetic SRP concentration. If the result is greater than 1, then phosphorus release is occurring within the lake's bottom waters.)

3.2.2 Syracuse Lake

Based on its most recent assessment, Syracuse Lake is best classified as a mesotrophic lake (Table 40). As previously discussed, mesotrophic lakes often exhibit good water clarity, moderate nutrient concentrations, and moderate productivity levels. Like Lake Wawasee, Syracuse Lake's nutrient concentrations were higher than Vollenweider's concentrations for mesotrophic lakes, but did not reach levels determined for eutrophic lakes (Vollenweider, 1975). Likewise, total phosphorus concentrations were greater than those determined by Carlson (1977) to be high enough for algal blooms to occur. Syracuse Lake's chlorophyll *a* concentration was higher than that present in Lake Wawasee at the time of the assessment, however, both concentrations were comparable to chlorophyll *a* concentrations found in oligotrophic lakes (Carlson, 1977). Similarly, Syracuse Lake's water clarity was on par with that found in many mesotrophic lakes suggesting the lake is likely mesotrophic in nature. Additionally, Syracuse Lake possessed relatively low ammonia-nitrogen and soluble reactive phosphorus concentrations throughout the water column; approximately 70% of the water column contained dissolved oxygen levels sufficient to support aquatic biota. Finally, Syracuse Lake's ITSI score indicates that the lake falls in the mesotrophic category.

Table 40. Water quality characteristics of Syracuse Lake, July 12, 2006.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.5	8.6	-
Alkalinity	127 mg/L	127 mg/L	-
Conductivity	359.1 μmhos	324.9 μmhos	-
Secchi Depth Transparency	8.8 feet	-	0
Light Transmission @ 3 ft.	21%	-	4
1% Light Level	23.8 feet	-	-
Total Phosphorus	0.019 mg/L	0.027 mg/L	0
Soluble Reactive Phosphorus	0.010 mg/L*	0.010 mg/L*	0
Nitrate-Nitrogen	0.015 mg/L*	0.015 mg/L*	0
Ammonia-Nitrogen	0.030 mg/L	0.018mg/L*	0
Organic Nitrogen	0.573 mg/L	0.585 mg/L	1
Total Suspended Solids	2.00 mg/L	1.71 mg/L	-
Oxygen Saturation @ 5ft.	98.9%	-	0
% Water Column Oxic	70%	-	1
Plankton Density	853/L	-	0
Blue-Green Dominance	65.4%	-	10
Chlorophyll *a*	1.04 μg/L	-	-
		TSI Score	**16**

*Method detection limit

3.2.3 Lake Papakeechie

Like Lake Wawasee and Syracuse Lake, Lake Papakeechie would best be described as a mesotrophic lake (Table 41). Lake Papakeechie possessed higher nutrient concentrations (specifically soluble reactive and total phosphorus and ammonia-nitrogen) than either Lake Wawasee or Syracuse Lake. Lake Papakeechie's total phosphorus concentration exceeds the concentration for Vollenweider's eutrophic lakes, but is not as high as concentrations found in his hypereutrophic lakes. Epilimnetic soluble reactive and total phosphorus concentrations were lower than concentrations present in the hypolimnion suggesting that phosphorus is being released from the lake's sediment. The phosphorus release factor (hypolimnetic SRP concentrations/epilimnetic SRP concentration) indicates that this is occurring. Likewise, Lake Papakeechie's hypolimnetic ammonia-nitrogen concentration is more than two orders of magnitude higher than the lake's epilimnetic concentration. This suggests that organic matter is accumulating in the lake's hypolimnion. The low percentage of the water column containing sufficient dissolved oxygen further supports this premise.

Lake Papakeechie's water clarity was the poorest of the three lakes (4.2 feet) and is also poorer than most lakes in Indiana. Poor water clarity is further supported by the lake's 1% light level or the depth at which point only 1% of the available light is transmitted. Only 1% of available light is transmitted to 11 feet in Lake Papakeechie; this is less than one-quarter of the lake's water column. Additionally, only one-third of the water column contains sufficient dissolved oxygen to support aquatic biota. Nonetheless, the lake is not utilizing all of its available nutrients. Low chlorophyll *a* concentrations and limited plankton density further support the premise that Lake Papakeechie is not fully utilizing nutrients available in its water column. All of this translates to Lake Papakeechie's ITSI score indicating that the lake falls in the mesotrophic category.

Table 41. Water quality characteristics of Lake Papakeechie, July 12, 2006.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.5	7.7	-
Alkalinity	133 mg/L	198 mg/L	-
Conductivity	313.3 μmhos	300.3 μmhos	-
Secchi Depth Transparency	4.3 feet	-	6
Light Transmission @ 3 ft.	11.3%	-	4
1% Light Level	11.1 feet	-	-
Total Phosphorus	0.038 mg/L	0.219 mg/L	3
Soluble Reactive Phosphorus	0.013 mg/L	0.040 mg/L	0
Nitrate-Nitrogen	0.019 mg/L	0.018 mg/L*	0
Ammonia-Nitrogen	0.018 mg/L*	2.047 mg/L	4
Organic Nitrogen	0.706 mg/L	0.727 mg/L	2
Total Suspended Solids	2.890 mg/L	8.500 mg/L	-
Oxygen Saturation @ 5ft.	92.6%	-	0
% Water Column Oxic	33%	-	3
Plankton Density	6,189/L	-	2
Blue-Green Dominance	37.1%	-	0
Chlorophyll *a*	0.98 μg/L	-	-
		TSI Score	**24**

*Method detection limit

3.3 Lake Water Quality Summary

Table 42 and Figures 25 to 27 display variations in water quality within the Wawasee Area Watershed lakes over the past 30 years. Water quality with Lake Wawasee and Syracuse Lake appears to be holding steady over time with only minor variations in ITSI scores. (Jones (1996) indicates that only a score change of 10 points or greater reflects actual changes in water quality whereas score changes less than 10 points are merely a reflection of temperature and precipitation variations or due to minor localized events.) Figure 25 displays the fluctuation that occurred within these two lakes from 1975 to 2006. These two lakes possess the highest water quality present within the Wawasee Area Watershed generally falling in the oligotrophic to mesotrophic range. This is likely due to two main factors: the other lakes and plethora of wetlands present in the watershed act as filters for sediment and nutrients before they reach Lake Wawasee and Syracuse Lake; and both lakes contain relatively large volumes compared to other lakes in the watershed. This allows nutrient and sediment to be diluted, resulting in less overall impact from the watershed.

Table 42. Indiana Trophic State Index (ITSI) scores for lakes in the Wawasee Area Watershed.

Lake	1975	1991	1993	1994	2000	2003	2004	2006
Papakeechie	--	--	--	--	--	--	--	24
Syracuse	14	--	--	18	15	19	--	16
Wawasee	16	--	--	17	16	22	--	20
Tri-County FWA Lakes								
Allen	--	--	--	33	31	--	36	--
Barrel and a Half	46	--	--	38	--	54	--	--
Hammond	--	--	--	--	--	42	--	--
Long	--	--	--	25	--	--	--	--
Price	50	28	--	29	--	--	9	--
Rothenberger	--	--	--	44	24	45	--	--
Shock	28	35	--	32	32	37	--	--
Spear	36	--	--	31	34	--	28	--
Wyland	--	--	--	--	25	--	14	--
Ten Lakes Chain								
Village (Indian)	59	--	58	--	33	34	--	--
Duely	42	25	37	--	33	13	--	--
Rider	55	14	16	--	43	25	--	--
Gordy	42	25	37	--	33	26	--	--
Hindman	52	26	23	--	44	48	--	--
Moss	51	13	31	--	35	36	--	--
Harper	60	29	25	--	25	34	--	--
Knapp	--	--	40	--	39	68	--	--
Little Bause	--	--	--	--	23	17	--	--
Little Knapp	--	--	--	--	--	12	--	--

ITSI Score <15=oligotrophic; 16-31=mesotrophic; 32-46=eutrophic; >47=hypereutrophic.

Water quality also fluctuated within the Tri-County Fish and Wildlife Area lakes (Figure 26; Table 42). These lakes typically possess poorer water quality than Lake Wawasee or Syracuse Lake rating mesotrophic to eutrophic. The two largest lakes, Spear and Shock lakes, typically contain the lowest nutrient concentrations and possess the highest water clarity, while Barrel and a Half and Rothenberger lakes contain the highest nutrient concentrations and poorest water clarity; therefore, these lakes possess the highest ITSI scores.

Lakes in the Ten Lakes Chain possess the poorest water quality of any of the Wawasee Area Watershed Lakes (Figure 27; Table 42). These lakes all drain relatively large areas compared to their surface area and volume. Therefore, any activities that allows nutrients or sediment to reach the lake result in an almost immediate impact on water quality. Because these lakes are not able to buffer against changes in the watershed, variations in climactic conditions, or address localized disturbances, their water quality changes quickly and does not follow any recognizable pattern. Many of these lakes rate as mesotrophic during one assessment, then rate as hypereutrophic during subsequent assessments. This does not mean that water quality truly changed in that time frame; rather the ITSI score reflects the immediate algal bloom or lack thereof that is occurring at the time of the assessment.

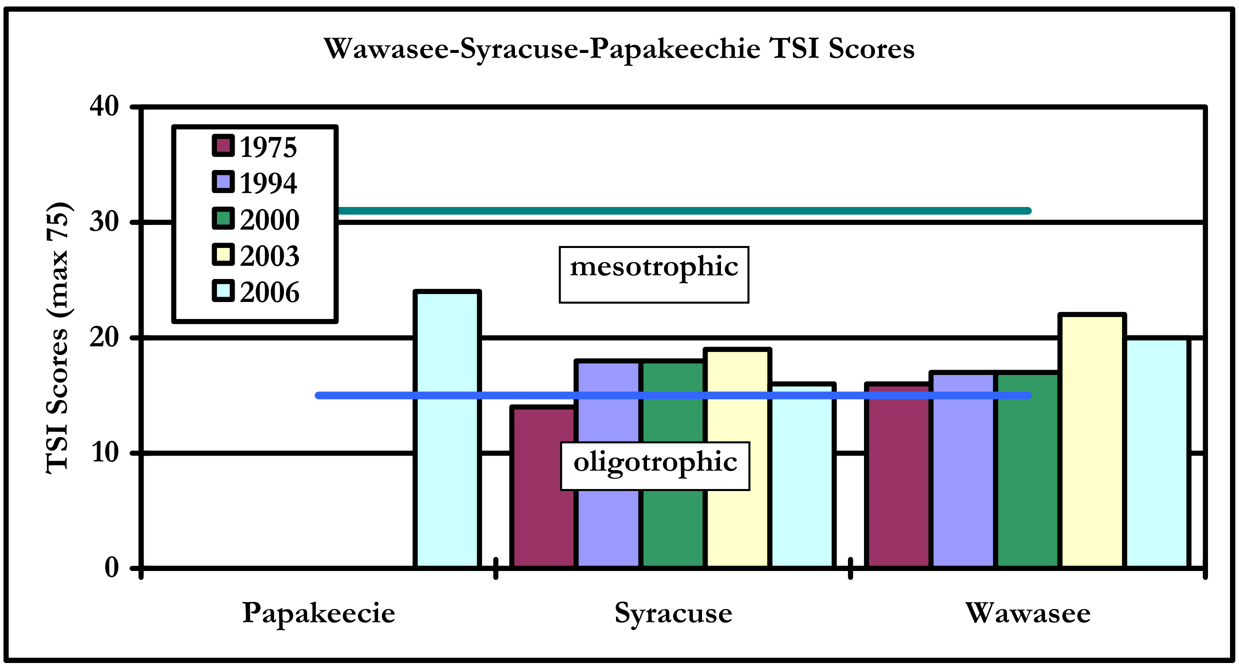

Figure 25. Variation in ITSI scores in Lake Papakeechie, Syracuse Lake, and Lake Wawasee, 1975 to 2006.

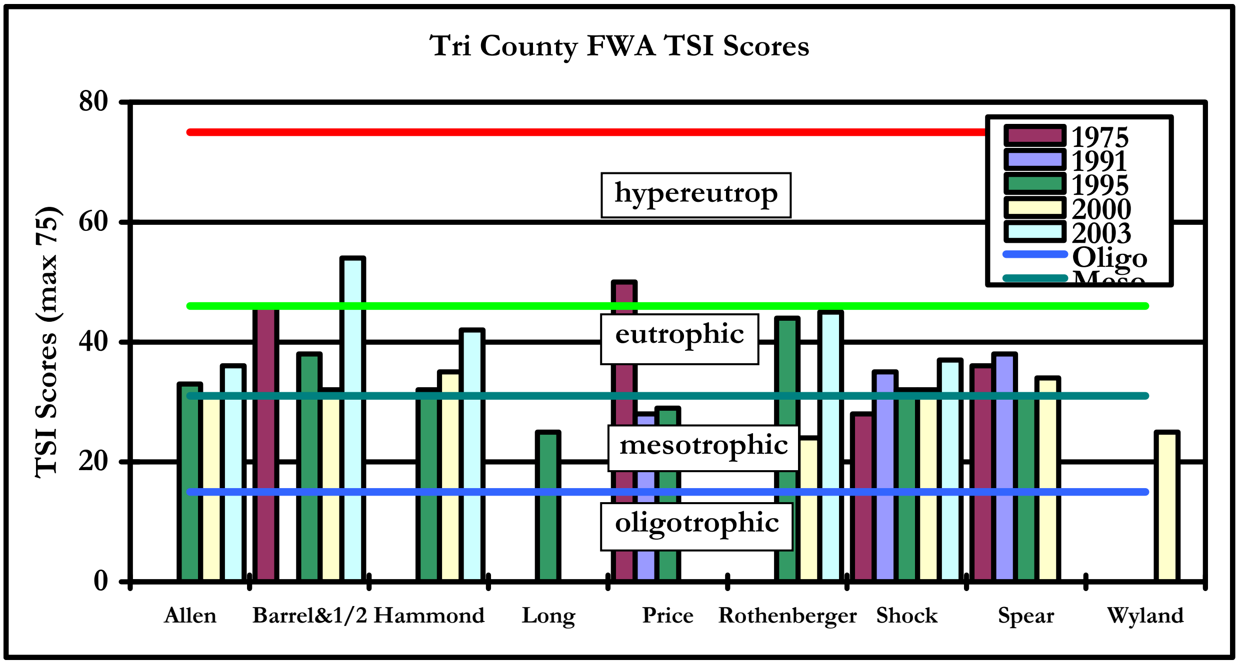

Figure 26. Variation in Tri-County Fish and Wildlife Area lake ITSI scores, 1975 to 2003.

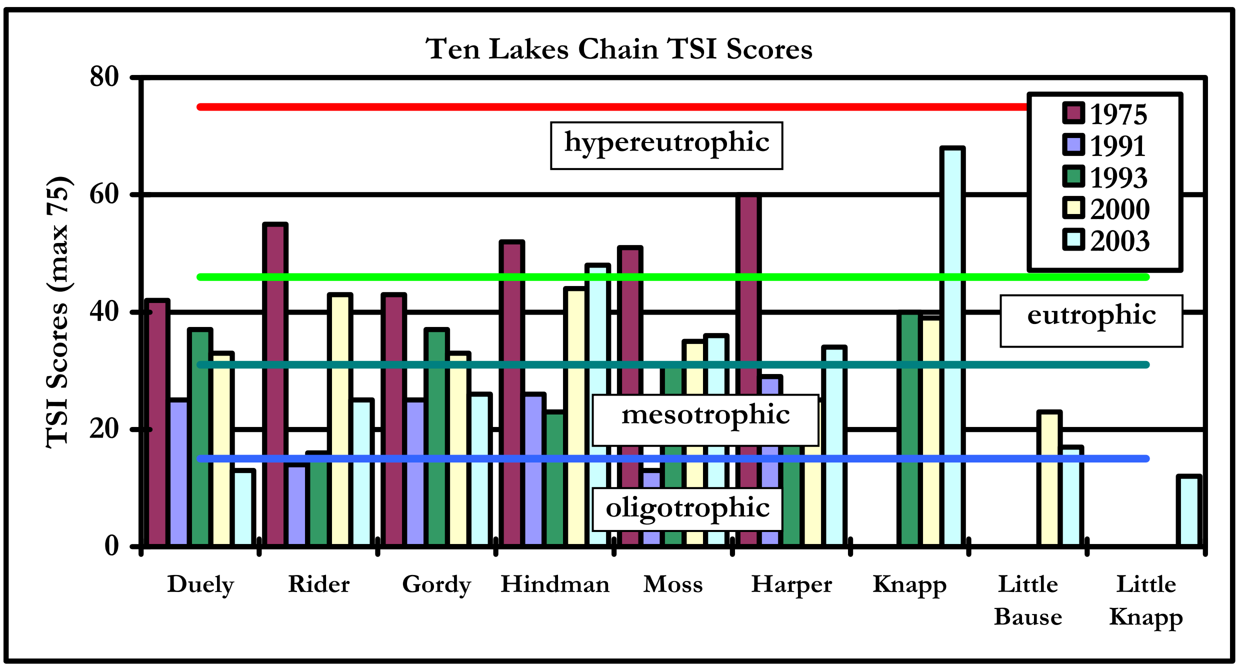

Figure 27. Variation in Ten Lakes Chain lake ITSI scores, 1975 to 2003.

3.4 In-Lake Biotic Assessments

Hundreds of biotic assessments occurred in the Wawasee Area Watershed from the early 1930s to present day. Most of these occurred through the IDNR Division of Fish and Wildlife fisheries assessment program. Each assessment has been developed into an individual report with many of the lakes possessing summary reports that were developed in the last three to five years. Furthermore, all fisheries management decisions are made by the IDNR DFW and are not subject to planning efforts through this forum; therefore, recommendations and specific data are not repeated here. Readers should refer to the IDNR Division of Fish and Wildlife District 3 Fisheries Biologist for more detailed information regarding the fish communities present within each of the lakes. Additionally, aquatic plant assessments were completed for Syracuse Lake and Lake Wawasee through the IDNR Division of Fish and Wildlife Lake and River Enhancement Program's aquatic plant management planning process. As these reports describe specific recommendations for aquatic plant community treatment, there is little reason to re-evaluate this information or report the recommendations. Additionally, stakeholders expressed desire for this plan to not address aquatic plan management planning as this was being addressed through other means. Refer to the IDNR LARE website (www.in.gov/dnr/fishwild/lare) for copies of the 2006 plant management plan updates for Lake Wawasee and Syracuse Lake. Therefore, this information is not repeated here. With this in mind, subsequent sections detail highlights of the fish, mussel, and zebra mussel communities in relation to their effect or impact on water quality.

3.4.1 Fisheries Data

The presence of cisco (*Coregonus artedii*) within lakes in the Wawasee Area Watershed has been documented in the past. The known historical distribution of the species has been limited to 41 lakes located throughout northern Indiana (Frey, 1955). Frey (1955) documented that lakes known as "cisco lakes" typically contain a thick stratum of water with temperatures below 20^{o} C and an oxygen concentration greater than 3 mg/L. The earliest record of ciscos in the Ten Lakes Chain occurred in 1931 when Hile documented 62 cisco in Indian Village Lake, 24 in Gordy Lake, and 11 in Hindman Lake. Scott (1931) and Koelz (1931) further supported these assessments. Assessment data compiled during by the Indiana Lake and Stream Survey in 1951 and 1952 indicate the presence of cisco in the Ten Lakes Chain as well. These assessments resulted in netting a total of 18 cisco in Indian Village, Gordy, Hindman, and Knapp lakes (Frey, 1955). Frey further noted the marginal cisco conditions present in the Ten Lakes Chain. More recent assessments documented by Pearson (IDNR file notes) document the presence of cisco in the Ten Lakes Chain. Nonetheless, the limited recent data and apparent lack of viable cisco populations led to four lakes (Indian Village, Hindman, Knapp, and Gordy lakes) being listed on Indiana's 2006 list of impaired waterbodies (303(d) list) for impaired biotic communities (IDEM, 2006).

3.4.2 Mussel Data

Relatively few assessments of the freshwater mussel community have occurred throughout Wawasee Area Watershed waterbodies. The IDNR Division of Fish and Wildlife Non-game biologists conducted a survey of Lake Wawasee, Syracuse Lake, and Lake Papakeechie in 2000 (IDNR data files, 2006). The assessment results are listed in Table 43. The native mussel species identified (fatmucket, giant floater, creeper, paper pondshell, and cylindrical papershell) are relatively common species that are present throughout most lakes in northern Indiana. Only two individuals were found alive; both of these sightings occurred in Lake Papakeechie.

Of greater concern is the presence of two exotic species: Asian clam and zebra mussels. Garton and Johnson (2000) report that zebra mussels were first identified in Lake Wawasee in 1991, less than three years after their initial discovery in North America at Lake St. Clair. By 1995, zebra mussels occupied all shallow areas of Lake Wawasee less than 33 feet (10 m) in depth. Additionally, zebra mussels covered macrophytes and all natural and manmade hard surfaces within the lake. Peak mussel densities in 1995 measured 70,000 individuals/m^2 in water less than 23 feet (7 m) deep (Garton and Johnson, 2000). Only soft sediments were not covered by zebra mussels during the 1995 assessment. Subsequent assessments indicate that zebra mussel populations may be declining within Lake Wawasee, Syracuse Lake, and Lake Papakeechie (Bobeldyk et al., 2005). Additionally, Johnson et al. (2006) indicate that not only have zebra mussel densities declined within these three lakes, but the colonization of adjacent lakes that are considered less suitable for zebra mussel invasion. Ten Lakes Chain and Tri-County FWA Lakes are also being colonized at a slower rate.

Table 43. Freshwater mussel species identified during assessments of Lake Wawasee, Syracuse Lake, and Lake Papakeechie in 2000.

Lake	Best Condition	Common Name	Scientific Name
Lake Wawasee	found dead	Asian clam	*Corbicula fluminea*
	live	Zebra mussel	*Dreissena polymorpha*
	weathered dead	Fatmucket	*Lampsilis siliquoidea*
	weathered dead	Giant floater	*Pyganodon grandis*
	weathered dead	Creeper	*Strophitus undulatus*
Lake Papakeechie	1	Giant floater	*Pyganodon grandis*
	1	Paper pondshell	*Utterbackia imbecillis*
Syracuse Lake	weathered dead	Cylindrical papershell	*Anodontoides ferussacianus*
	found dead	Asian clam	*Corbicula flumineac*
	live	Zebra mussel	*Dreissena polymorpha*
	weathered dead	Fatmucket	*Lampsilis siliquoidea*
	weathered dead	Giant floater	*Pyganodon grandis*
	weathered dead	Creeper	*Strophitus undulatus*

3.5 Historic Stream Water Quality Assessments

Data contained in this section documents historic water quality conditions in the three main tributaries to Lake Wawasee (Turkey Creek, Dillon Creek, and the unnamed tributary from Lake Papakeechie). Additional supplementary data from headwaters sites within each of these main tributaries and from the lake's minor tributaries are included as well. Understanding the waterbodies' historic conditions will help watershed stakeholders better understand current conditions (included in subsequent sections) and set realistic goals for future water quality conditions. This data will also serve as the benchmark against which future water quality conditions can be compared to measure stakeholder success in achieving their vision for the future of these waterbodies.

A variety of resources were reviewed to establish the existing or baseline water quality conditions within the streams in the Wawasee Area Watershed. The U.S. Environmental Protection Agency (USEPA) assessed water quality at five stream locations throughout the Wawasee Area Watershed in 1973 and 1974 (USEPA, 1976). Hippensteel documented water quality within Lake Wawasee, Syracuse Lake, and three of Lake Wawasee's tributaries during his county-wide assessment in 1988 (Hippensteel, 1989). Many of Lake Wawasee's watershed streams were sampled during completion of the Diagnostic/Feasibility Study for the Wawasee Area Watershed (Commonwealth Engineers, 1996). The Kosciusko County Health Department monitored water quality at three locations throughout the Kosciusko County portion of the watershed from 1996 to 1998 (KCHD, 1998). The Indiana Department of Environmental Management assessed the water chemistry at two locations in 2000 (IDEM data files, 2006). Harza (2001) and Commonwealth Biomonitoring (2003) again surveyed portions of the Wawasee Area Watershed stream systems during 2000 and 2003, respectively. The WACF continues to monitor water quality throughout the watershed through the Hoosier Riverwatch program. Details of each of the parameters analyzed and their impact on stream water quality are located in Appendix G2.

Detailed water quality analysis based on historic stream water quality data cannot be fully completed due to the variety of methods utilized for water quality assessment. Therefore, results of available stream water quality data are discussed on a per project basis.

3.5.1 Water Chemistry Assessment (Commonwealth Engineers, 1995)

Commonwealth Biomonitoring assessed water quality at fifteen locations throughout the Wawasee Area Watershed during completion of the *Lake Enhancement Diagnostic/Feasibility Study for the Wawasee Area Watershed* (Commonwealth Engineers, 1995). Samples were collected from six main sites three times in 1995 and one time at an additional nine sites in 1995. (Data area not repeated herein. Refer to the Commonwealth Engineers (1995) report for more detailed data.) Commonwealth Engineers determined that nutrient and sediment concentrations increased in Wawasee Area Watershed streams following precipitation events. Typically, Dillon Creek's south tributary possessed the highest nutrient and suspended solids concentrations observed within the watershed. Nitrate-nitrogen concentrations were also elevated within the central and southern tributaries to Dillon Creek. Additionally, potential septic tank leachate draining into a stream adjacent to Lake Wawasee's public boat ramp was identified during the assessment. Nonetheless, concentrations for all nutrients and solids were relatively low when compared with other regional stream data sets.

Commonwealth concluded that Turkey Creek was the primary source of phosphorus, nitrogen, and sediment loading to Lake Wawasee. As this stream drains nearly 40% of the watershed, the largest portion of any of the tributaries, it is not surprising that it would possess the highest loading rates. Dillon Creek and the South Shore tributary were also identified as major sources of sediment to the lake. Dillon Creek was also identified as the primary source of nitrogen to Lake Wawasee. Finally, water quality entering Lake Wawasee from Lake Papakeechie was considered to be of the highest quality. All efforts to maintain this water quality were identified as a high priority by Commonwealth Engineers (1995).

3.5.2 Kosciusko County Health Department Assessments (KCHD, 1998)

From 1996 to 1998, the Kosciusko County Health Department conducted sampling using Hoosier Riverwatch sampling protocols at more than 40 locations throughout Kosciusko County. Two of these sites were located in the Wawasee Area Watershed including sampling Turkey Creek at County Road 675 East and again at County Road 1100 North. Dissolved oxygen, temperature, pH, and BOD concentrations all rated as excellent; phosphorus concentrations typically rated good; and nitrogen and *E. coli* concentrations rated as bad to medium. *E. coli* concentrations exceeded the state standard (235 colonies/100 mL) in two of the five samples. Overall, Turkey Creek's water quality rated as good (70 to 90%).

3.5.3 IDEM Assessment

IDEM assessed water quality five times at two locations in Lake Wawasee's watershed in 2000. These included the tributary adjacent to the public access sites on Lake Wawasee and Martin Creek at Leeland Channel. Both sites possessed adequate dissolved oxygen, temperature, pH, and conductivity levels. Additionally, turbidity and *E. coli* concentrations were low at both sites during all five assessments (IDEM data files, 2006). All samples contained *E. coli* concentrations below the Indiana state standard. Total coliform concentrations were, however, elevated during the first assessment (September 27, 2000) at both sites. Concentrations did not exceed historic state standards (4,000 colonies/100 mL).

3.5.4 Water Quality and Habitat Assessment (Harza, 2001)

Harza assessed water quality from a number of locations throughout the Wawasee Area Watershed in the fall of 2000 in concert with the completion of the *Lake Wawasee Engineering Feasibility Study* (Harza, 2001). Initial assessments were completed at the mouths of four tributaries (Bayshore, Marineland Garden, South Shore Golf Course, and Dillon Creek) to determine total phosphorus and total suspended solids concentrations. These samples were collected in an effort to identify sources of sediment and nutrients to the lake. Samples were collected following a rain event (0.53 inches during an 18-hour period on November 26, 2000). Sample results indicate low total phosphorus concentrations (all below the detection level) and low total suspended solids concentrations (<14 mg/L). Waters (1998) indicated that TSS concentrations greater than 80 mg/L are cause for concern; however, concentrations less than this level are typical for Midwestern streams. Additionally, Harza noted that the accumulated rainfall was likely not substantial enough to produce the requisite sediment load that originally concerned WACF members.

During completion of this project, Harza also assessed the water quality and biological community of Dillon Creek at three locations. Temperature, conductivity, pH, and dissolved oxygen concentrations were all within normal levels with the exception of dissolved oxygen at one location. It was suggested that low dissolved oxygen concentrations observed within Dillon Creek at the time of the assessment were due to limited stream flows and an accumulation of decaying organic material at the sampling location. Habitat was assessed using the QHEI. Scores indicate that all three sites are capable of supporting quality aquatic communities. Scores ranged from 51 to 61 with pool and riffle complex development and poor substrate limiting available habitat. Macroinvertebrate communities at each of the sites further support this assessment indicating that a variety of moderately pollution tolerant individuals are present along the length of Dillon Creek. Low densities of pollution intolerant taxa, including those representing the Ephemeroptera, Trichoptera, and Plecoptera orders (mayflies, caddisflies, and stoneflies), and elevated densities of Chironomids (pollution tolerant taxa) indicate that water quality within Dillon Creek is moderate as was suggested by the available habitat. However, it cannot be determined from this limited dataset whether the moderate macroinvertebrate community identified within Dillon Creek is due to available habitat or water quality issues.

3.5.5 Turkey Creek Assessment (Commonwealth Biomonitoring, 2003)

Commonwealth Biomonitoring assessed the water quality of Turkey Creek within the Ten Lakes Chain to determine the status of aquatic plants, fish, and mussel communities and assess the habitat available within this portion of the Turkey Creek Watershed. Commonwealth completed their assessment of habitat at three sites on September 18, 2003. These three sites (between Moss and Hindman lakes; between Hindman and Gordy lakes; and between Rider and Duely lakes) were assessed using the QHEI. Results indicate that habitat is readily available within this section of Turkey Creek with scores ranging from 59 to 69 (Commonwealth Biomonitoring, 2003). At the time of the assessment, the riparian corridor was plentiful and covered by wetland or forested land uses. Additionally, Commonwealth biologists identified 17 aquatic plant species representing submerged, emergent, and floating strata. Twelve fish species were collected from within the faster flowing portions of the stream channel. Of special note was the collection of the Iowa darter and the tadpole madtom. Although neither species is considered state endangered, threatened, or rare, these species are limited to aquatic systems, which possess excellent water clarity and good water quality. Finally, Commonwealth identified three freshwater mussel species including the fat mucket, fragile papershell, and giant floater. All three of these species are relatively common throughout Indiana waterbodies.

3.6 Current Stream Water Quality Assessments

Grab samples were collected from fifteen sampling sites (Figure 28; Table 44) in the Wawasee Area Watershed twice during the study period. Samples were collected once during base flow (normal) conditions and once following a storm event (0.75 inches of precipitation or greater). Base flow conditions are sampled to determine the typical conditions in the stream. Following storm events, the increased overland water flow results in increased erosion of soil and nutrients from the land. In addition, precipitation washes pollutants from hardscape in the watershed. Thus, stream concentrations of nutrients and sediment are typically higher following storm events. In essence, storm sampling presents a "worst case" picture of watershed pollutant loading. Storm flow sample collection occurred on July 12, 2006, while base flow sample collection occurred on July 25, 2006.

Table 44. Detailed sampling location information for the Wawasee Area Watershed streams.

Site #	Stream Name	Road Location	Sampling Location	UTM northing	UTM easting
1	Norris Branch	Crooked Mile Road	Upstream of bridge	611550.39	4585007.30
2	Launer Ditch	CR 1000 East	Upstream of bridge	611724.27	4584485.68
3	Dillon Creek	CR 1100 North	Downstream of bridge	611749.11	4583674.26
4	Dillon Creek	Fish Hatchery Road	Upstream of bridge	611019.47	4584012.71
5	Turkey Creek	Fish Hatchery Road	Upstream of bridge	611475.94	4582061.16
6	Papakeechie outlet	Fish Hatchery Road	Upstream of bridge	611154.41	4581418.48
7	Martin Creek	South Road	Upstream of bridge (dry)	609528.69	4582169.18
8	South Shore Tributary	Southshore Drive	Downstream of bridge	608054.82	4583095.81
9	Main channel	Pickwick Drive	Downstream of bridge	605774.45	4586240.60
10	Turkey Creek	County Line Road	Upstream of bridge	612615.77	4581217.33
11	Turkey Creek Branch	CR 1150 West	Upstream of bridge	613288.35	4581811.09
12	Turkey Creek	State Road 5	Downstream of bridge	613759.72	4580115.29
13	Galloway Branch	At public access site		616793.23	4577852.70
14	Piper Branch	CR 900 West	Upstream of bridge	617592.04	4577351.49
15	Ritter Branch	CR 125 South	Upstream of bridge	615775.14	4576740.63

Base flow and stormwater runoff sampling included measurement of physical, chemical, and bacteriological parameters. Conductivity, pH, temperature, and dissolved oxygen were measured *in situ* at each sampling site during base and storm flow with a YSI Model 85 meter. Water velocity was measured using a Marsh-McBirney Flo-Mate current meter. Cross-sectional areas of the stream channel at each site were measured. Discharges were calculated by multiplying water velocity by the cross-sectional areas. In addition, water samples were collected from just below the water surface and analyzed for the parameters described in Appendix G2. (Data are listed in Tables 45-50.) Additionally, habitat was assessed at each site using the Qualitative Habitat Evaluation Index (QHEI) and macroinvertebrate communities were assessed at three sites along Dillon and Turkey Creeks.

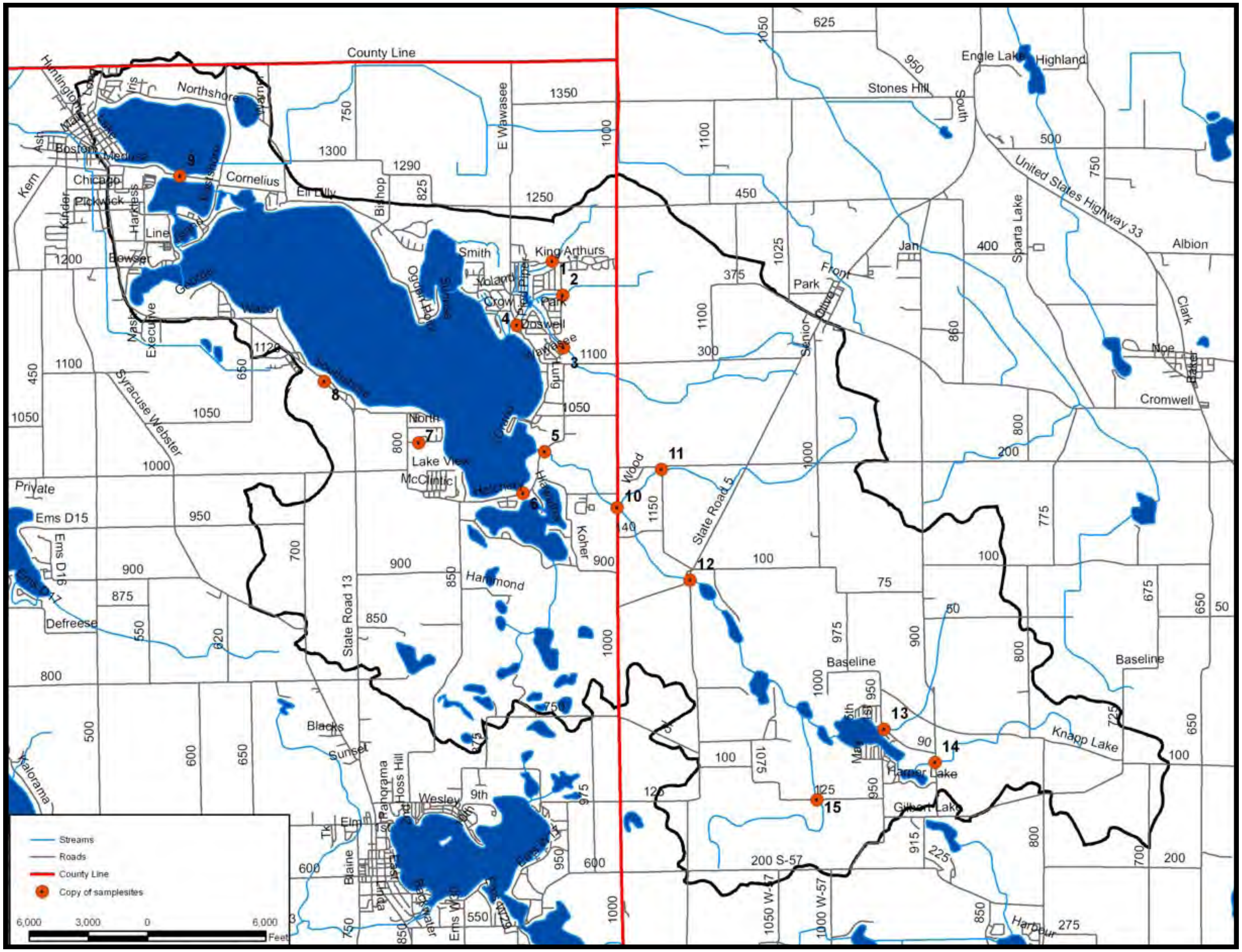

Figure 28. Sampling locations in the Wawasee Area Watershed.

Table 45. Selected physical and chemical parameter data collected from the Wawasee Area Watershed streams during 2006 water chemistry sampling events. Shaded squares represent those in violation of state standards ( ) or recommended target values ( ).

Site	Date	Timing	Flow (cfs)	Temp (°C)	DO (mg/L)	% Sat.	Cond (μmhos)	pH	Turb (NTU)	TSS (mg/L)
1	7/25/06	base	0.04	19.6	5.6	60.5	673	7.5	1.1	3.8
	7/12/06	storm	0.18	20.5	5.9	65.6	255	8.0	1.2	0.02
2	7/25/06	base	0.48	19.8	8.5	91.9	635	8.0	1.6	2.9
	7/12/06	storm	0.80	21.8	8.3	93.0	563	8.3	1.4	3.1
3	7/25/06	base	0.09	22.6	6.9	78.5	671	8.2	1.7	13.2
	7/12/06	storm	0.78	21.6	7.4	84.5	541	7.6	8.9	14.2
4	7/25/06	base	--	25.7	8.1	99.0	544	8.0	1.2	4.2
	7/12/06	storm	--	25.1	6.2	75.6	553	7.6	2.4	1.7
5	7/25/06	base	5.13	24.5	4.7	55.8	538	7.6	1.1	1.8
	7/12/06	storm	900	23.9	5.0	60.9	540	7.9	1.2	1.4
6	7/25/06	base	0.12	27.3	6.9	86.5	415	7.6	1.8	1.4
	7/12/06	storm	0.18	24.0	7.1	84.5	421	7.8	1.7	0.2
7	7/25/06	base	Dry							
	7/12/06	storm	Dry							
8	7/25/06	base	0.05	20.7	2.9	29.5	675	7.4	2.0	6.1
	7/12/06	storm	--	21.4	2.1	24.0	573	7.7	2.0	2.9
9	7/25/06	base	NW	25.9	5.1	60.5	360	7.6	0.8	1.2
	7/12/06	storm	--	25.4	6.6	82.2	361	8.3	1.3	2.8
10	7/25/06	base	4.30	27.4	7.8	98.5	520	8.0	1.0	7.3
	7/12/06	storm	4.33	24.3	7.2	86.9	528	8.1	2.8	7.1
11	7/25/06	base	0.42	24.0	9.5	110.0	634	8.0	0.8	2.1
	7/12/06	storm	0.23	21.5	7.8	88.7	540	8.1	2.5	2.8
12	7/25/06	base	3.16	27.9	9.5	118.0	493	8.1	1.4	0.9
	7/12/06	storm	4.58	26.2	7.4	72.2	520	8.2	0.9	1.3
13	7/25/06	base	0.42	21.8	8.0	89.3	670	7.6	0.5	0.3
	7/12/06	storm	1.08	20.3	6.3	71.1	589	8.0	0.7	1.7
14	7/25/06	base	0.43	20.0	6.8	74.1	795	7.8	0.6	--
	7/12/06	storm	0.77	17.4	7.1	74.4	658	7.9	1.8	4.2
15	7/25/06	base	0.29	20.4	3.1	37.0	809	7.1	1.0	1.0
	7/12/06	storm	--	19.3	5.1	55.0	642	7.6	1.2	1.1

Table 46. Nutrient, sediment, and bacterial parameter concentration data from the Wawasee Area Watershed sites collected in 2006. Shaded squares represent those in violation of state standards ( ) or recommended target values ( ).

Site	Date	Timing	Nit.-N (mg/L)	Amm.-N (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	*E. coli* (col/100 mL)
1	7/25/06	base	2.392	0.018	0.302	0.032	0.059	2,800
	7/12/06	storm	2.190	0.025	0.372	0.034	0.061	830
2	7/25/06	base	10.115	0.021	0.253	0.015	0.028	540
	7/12/06	storm	8.720	0.053	0.230	0.010	0.017	460
3	7/25/06	base	4.917	0.018	0.520	0.032	0.073	2,900
	7/12/06	storm	3.780	0.018	0.743	0.032	0.075	4,100
4	7/25/06	base	1.857	0.018	0.843	0.010	0.045	620
	7/12/06	storm	2.333	0.138	0.730	0.010	0.041	126
5	7/25/06	base	1.490	0.123	0.845	0.034	0.066	810
	7/12/06	storm	1.368	0.076	0.699	0.039	0.067	890
6	7/25/06	base	0.062	0.113	0.611	0.013	0.045	360
	7/12/06	storm	0.042	0.018	0.418	0.010	0.027	1,900
7	7/25/06	base	Dry					
	7/12/06	storm	Dry					
8	7/25/06	base	0.075	0.390	0.673	0.158	0.287	1,700
	7/12/06	storm	0.082	0.278	0.727	0.125	0.171	12,400
9	7/25/06	base	0.015	0.018	0.605	0.010	0.028	16
	7/12/06	storm	0.013	0.018	0.461	0.010	0.181	78
10	7/25/06	base	3.202	0.021	0.739	0.019	0.049	3,000
	7/12/06	storm	2.481	0.048	0.686	0.021	0.020	17,000
11	7/25/06	base	5.560	0.028	0.490	0.052	0.140	1,510
	7/12/06	storm	5.792	0.018	0.386	0.024	0.051	51,000
12	7/25/06	base	1.315	0.018	1.008	0.010	0.035	134
	7/12/06	storm	1.659	0.041	0.737	0.012	0.031	560
13	7/25/06	base	3.142	0.075	1.128	0.040	0.100	114
	7/12/06	storm	4.561	0.018	0.672	0.092	0.106	660
14	7/25/06	base	3.177	0.041	0.279	0.031	0.056	630
	7/12/06	storm	3.511	0.018	0.394	0.034	0.055	14,500
15	7/25/06	base	3.810	0.075	0.609	0.019	0.035	370
	7/12/06	storm	4.090	0.018	1.035	0.021	0.048	1,700

Table 47. Chemical and bacterial parameter loading data collected in the Wawasee Area Watershed streams in 2006. Shaded squares represent those with the highest loading rate (■) and second highest loading rate (□) within each sampling event.

Site	Date	Timing	Nit-N (kg/d)	Amm-N (kg/d)	TKN (kg/d)	SRP (kg/d)	TP (kg/d)	TSS (kg/d)
1	7/25/06	base	0.251	0.002	0.032	0.003	0.006	0.403
	7/12/06	storm	0.964	0.011	0.164	0.015	0.027	0.011
2	7/25/06	base	11.896	0.025	0.298	0.018	0.033	3.411
	7/12/06	storm	17.057	0.104	0.450	0.020	0.033	6.113
3	7/25/06	base	1.106	0.004	0.117	0.007	0.016	2.969
	7/12/06	storm	7.209	0.034	1.417	0.061	0.143	27.178
4	7/25/06	base	No flow data collected.					
	7/12/06	storm	No flow data collected.					
5	7/25/06	base	18.701	1.544	10.605	0.427	0.828	22.214
	7/12/06	storm	30.104	1.672	15.382	0.858	1.474	30.809
6	7/25/06	base	0.018	0.032	0.173	0.004	0.013	0.397
	7/12/06	storm	0.018	0.008	0.184	0.004	0.012	0.098
7	7/25/06	base	Dry					
	7/12/06	storm	Dry					
8	7/25/06	base	0.009	0.009	0.081	0.019	0.034	0.726
	7/12/06	storm	Stream stagnant; no flow collected.					
9	7/25/06	base	No flow data collected.					
	7/12/06	storm	No flow data collected.					
10	7/25/06	base	33.775	0.222	7.795	0.200	0.517	76.475
	7/12/06	storm	26.267	0.508	7.263	0.222	0.212	75.625
11	7/25/06	base	5.737	0.029	0.506	0.054	0.144	2.201
	7/12/06	storm	3.257	0.010	0.217	0.013	0.029	1.575
12	7/25/06	base	10.173	0.139	7.798	0.077	0.271	7.032
	7/12/06	storm	18.579	0.459	8.253	0.134	0.347	14.398
13	7/25/06	base	3.242	0.077	1.164	0.041	0.103	0.295
	7/12/06	storm	12.044	0.048	1.775	0.243	0.280	4.423
14	7/25/06	base	3.348	0.043	0.294	0.033	0.059	--
	7/12/06	storm	6.610	0.034	0.742	0.064	0.104	7.949
15	7/25/06	base	2.692	0.053	0.430	0.013	0.025	0.707
	7/12/06	storm	Stream not flowing; no flow data collected.					

Table 48. Chemical and bacterial parameter loading data collected in the Wawasee Area Watershed streams in 2006. Shaded squares represent those with the highest loading rate (■) and second highest loading rate (□) within each sampling event.

Site	Date	Timing	Nit-N (kg/ha-yr)	Amm-N (kg/ha-yr)	SRP (kg/ha-yr)	TP (kg/ha-yr)	TKN (kg/ha-yr)	TSS (kg/ha-yr)
1	7/25/06	base	0.40	0.00	0.05	0.01	0.01	0.64
	7/12/06	storm	1.54	0.02	0.26	0.04	0.02	0.02
2	7/25/06	base	19.02	0.04	0.48	0.05	0.03	5.45
	7/12/06	storm	27.27	0.17	0.72	0.05	0.03	9.77
3	7/25/06	base	1.77	0.01	0.19	0.03	0.01	4.75
	7/12/06	storm	11.52	0.05	2.27	0.23	0.10	43.44
4	7/25/06	base	No flow data collected.					
	7/12/06	storm	No flow data collected.					
5	7/25/06	base	29.89	2.47	16.95	1.32	0.68	35.51
	7/12/06	storm	48.12	2.67	24.59	2.36	1.37	49.25
6	7/25/06	base	0.03	0.05	0.28	0.02	0.01	0.63
	7/12/06	storm	0.03	0.01	0.29	0.02	0.01	0.16
7	7/25/06	base	Dry					
	7/12/06	storm	Dry					
8	7/25/06	base	0.01	0.01	0.13	0.05	0.03	1.16
	7/12/06	storm	Stream stagnant, no flow data collected.					
9	7/25/06	base	No flow data collected.					
	7/12/06	storm	No flow data collected.					
10	7/25/06	base	53.99	0.35	12.46	0.83	0.32	122.24
	7/12/06	storm	41.99	0.81	11.61	0.34	0.36	120.89
11	7/25/06	base	9.17	0.05	0.81	0.23	0.09	3.52
	7/12/06	storm	5.21	0.02	0.35	0.05	0.02	2.52
12	7/25/06	base	16.26	0.22	12.47	0.43	0.12	11.24
	7/12/06	storm	29.70	0.73	13.19	0.55	0.21	23.02
13	7/25/06	base	5.18	0.12	1.86	0.16	0.07	0.47
	7/12/06	storm	19.25	0.08	2.84	0.45	0.39	7.07
14	7/25/06	base	5.35	0.07	0.47	0.09	0.05	0.00
	7/12/06	storm	10.57	0.05	1.19	0.17	0.10	12.71
15	7/25/06	base	4.30	0.08	0.69	0.04	0.02	1.13
	7/12/06	storm	Stream not flowing; no flow data collected.					

Table 49. Qualitative Habitat Evaluation Index (QHEI) assessment results for Wawasee Area Watershed streams.

	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Score	20	20	20	10	12	8	10	**100**
Site 1	13	14	13	7.5	0	1	10	58.5
Site 2	10	10	13	8.5	0	1	8	50.5
Site 3	9	6	10	9	4	2	10	50
Site 4	17	7	8	6	9	0	2	49
Site 5	0	11	9	9	9	0	10	48
Site 6	11	13	6	8.3	0	0	8	46.3
Site 7	No assessment completed.							
Site 8	10	10	7	7	3	1	10	48
Site 9	13	6	5	4	7	0	2	37
Site 10	14	13	14	9.5	7	4	10	71.5
Site 11	1	14	7	4	4	1	8	39
Site 12	15	6	8	8.5	3	4	8	52.5
Site 13	12	9	6	8	4	4	8	51
Site 14	7	10	10	8.5	5	1	8	49.5
Site 15	4	9	8	7.5	4	0	6	38.5

Table 50. Macroinvertebrate Index of Biotic Integrity (mIBI) assessment results for Wawasee Area Watershed streams.

mIBI Metric	**Site 3**		**Site 5**		**Site 12**	
HBI	5.33	2	5.68	0	5.41	2
Number of Taxa (family)	18	8	16	6	20	8
Total Count (Number of individuals)	79	0	80	2	153	4
% Dominant Taxa	26.6	6	31.3	4	37.3	4
EPT Index (Number of families)	3	2	2	0	4	4
EPT Count (Number of individuals)	26	2	4	0	71	4
EPT Count/Total Count	0.33	4	0.05	0	0.46	4
EPT Abundance/Chironomid Abundance	2.00	2	4.00	4	23.67	8
Chironomid Count	13	8	1	8	3	8
mIBI Score		**3.8**		**2.7**		**5.1**
	Moderately impaired		**Moderately impaired**		**Slightly impaired**	

There are two useful ways to report water quality data in flowing water. ***Concentrations*** express the mass of a substance per unit volume, for example milligrams of total suspended solids per liter (mg/L). ***Mass loading*** describes the mass of a particular material being carried per unit time (kg/d). Loading is important when comparing among sites and among sampling dates because: 1) Flow can be highly variable; therefore, normalizing concentrations to flow eliminates variability. 2) Delivery of materials is important to consider. For example, a stream with high discharge but low pollutant concentration may deliver a larger portion of a pollutant to its receiving body than a stream with higher pollutant concentration but lower discharge. The total amount of nutrients, suspended solids, and pathogens entering the stream is of the greatest concern when considering the effects of these materials downstream. A third method for reporting water quality data in flowing water is the use of areal loading. Areal loading details the mass of a particular material being carried per unit area per unit time. More specifically, areal loading amount is the amount of material reaching a water body from each unit area draining to that water body within the specified time frame. All data and graphics associated with water chemistry sampling are included in Appendix I1.

3.6.1 Drainage to Lake Wawasee

Four streams Dillon Creek (S4), Turkey Creek (S5), Palestine Lake drain (S6), and South Shore drain (S8) drain directly to Lake Wawasee. Therefore, these streams directly influence the water quality of Lake Wawasee. Additional water quality samples were collected from streams in the Turkey Creek and Dillon Creek headquarters. These data are discussed in subsequent sections. Temperature, pH, conductivity, and turbidity measurements were all within normal ranges for Indiana streams from the four sample sites draining directly to Lake Wawasee. Dissolved oxygen concentrations were sufficient to support a healthy biotic community in three of the four sites; however, dissolved oxygen concentrations were below the state standard during both assessments conducted in the South Shore Tributary. Elevated ammonia-nitrogen concentrations present at this location suggest that organic material is accumulating at this site. The accumulation of organic material leads to increased decomposition, which in turn, leads to lower dissolved oxygen concentrations. Additionally, low flows present in the South Shore Tributary during 2006 likely added to the low dissolved oxygen concentrations measured.

Some parameter concentrations were elevated within the streams draining to Lake Wawasee. None of the ammonia-nitrogen or nitrate-nitrogen concentrations measured in the watershed streams exceeded the state standard. However, nitrate-nitrogen concentrations in Turkey Creek exceeded the median concentration observed in Ohio streams (1.0 mg/L) known to support healthy warmwater fauna (Ohio EPA, 1999). Total phosphorus concentrations were also elevated, especially during the storm event. Concentrations measured in the South Shore Tributary exceeded the concentration (0.1 mg/L) at which the Ohio EPA (1999) observed impairment in the aquatic biota. *E. coli* concentrations measured in all four of the streams exceeded the state standard (235 colonies/100 mL) during both sampling events. The South Shore Tributary possessed the highest *E. coli* concentration observed during both assessments measuring 1700 and 12400 colonies/100 mL during base and storm flow, respectively.

Turkey Creek possessed the highest loading rates for all parameters measured during both base and storm flow. This is not surprising as Turkey Creek drains the largest area of any of the tributaries to Lake Wawasee. Surprisingly, Turkey Creek also possessed the highest loading rates when the data was normalized by drainage area.

All of the tributaries possessed moderate habitat when assessed using the Qualitative Habitat Evaluation Index (QHEI). All of the streams rated habitat scores of 46.3 to 49, which suggests that the streams are only partially supporting of their aquatic life use designation. As the South Shore Tributary was relatively stagnant during the assessment and the Lake Papakeechie outlet stream does not possess adequate instream or canopy cover, it is not surprising that these sites rated poorly. In general, Lake Wawasee's tributaries are limited by their lack of riffle development, poor substrate, and limited instream cover and channel development.

Data from the Lake Wawasee Tributaries suggest that efforts to limit nutrient loading should focus on the Turkey Creek and South Shore Tributary. These streams contained the highest levels of nutrients during both base and storm flow assessments. Dillon Creek and Turkey Creek should be targeted to reduce the flow of sediment to Lake Wawasee.

3.6.2 Turkey Creek watershed

Temperature, pH, conductivity, dissolved oxygen, and turbidity measurements were all within normal ranges for Indiana streams within the Turkey Creek headwaters sample sites. (Note: Only the Turkey Creek headwaters sample sites are discussed herein.) None of the ammonia-nitrogen or nitrate-nitrogen concentrations measured in the watershed streams exceeded the state standard. However, nitrate-nitrogen concentrations in all of the Turkey Creek headwaters sites exceeded the median concentration observed in Ohio streams (1.0 mg/L) known to support healthy warmwater fauna (Ohio EPA, 1999). The Turkey Creek Branch (Site 11) possessed the highest nitrate-nitrogen concentrations. Total phosphorus concentrations were also elevated, especially within the Turkey Creek Branch (Site 11) and within Galloway Ditch (Site 13). Concentrations measured in both of these streams exceeded the concentration (0.1 mg/L) at which the Ohio EPA (1999) observed impairment in the aquatic biota. *E. coli* concentrations measured in Turkey Creek at County Road 1000 East (Site 10), Turkey Creek Branch (Site 11), Galloway Ditch (Site 13), Piper Branch (Site 14), and Ritter Branch (Site 15) exceeded the state standard (235 colonies/100 mL) during at least one of the sampling events. Turkey Creek Branch (Site 11) possessed the highest *E. coli* concentration observed in the tributaries to Turkey Creek during both assessments measuring 1,510 and 51,000 colonies/100 mL during base and storm flow, respectively.

Overall, Turkey Creek at County Road 1000 East (Site 10) contained the highest loading and areal loading rates for the Turkey Creek watershed. However, efforts to curtail nutrient and sediment loading should focus on individual tributaries. Galloway Ditch (Site 13) possessed the highest loading rates for all parameters measured during both base and storm flow. This is especially concerning for the health of Knapp Lake, which receives most of its surface water from Galloway Ditch. The Turkey Creek Branch (Site 11) also possessed high nitrate-nitrogen loading rates during base and storm flow sampling events. When the data were normalized for drainage area, Turkey Creek Branch (Site 11) and Galloway Ditch (Site 13) possessed the highest areal loading rates for all parameters.

Data from the Turkey Creek headwaters streams suggest that efforts to limit nutrient loading should focus on the Turkey Creek Branch and Galloway Ditch. These streams contained the highest levels of nutrients and sediment during both base and storm flow assessments.

3.6.3 Dillon Creek watershed

Like the rest of the Wawasee Area Watershed streams, temperature, pH, conductivity, and turbidity measurements were all within normal ranges for Indiana streams from the four Dillon Creek sample sites. Additionally, dissolved oxygen concentrations were sufficient to support a healthy biotic community at all four sites. Habitat scored relatively high within the Dillon Creek tributaries. The Norris Branch (Site 1) possessed the best habitat scoring 58.5 of a possible 100 points. Limited instream cover, lack of pool-riffle complex development, and poor channel development negatively impacted habitat availability at this site. The two other streams, Launer Ditch (Site 2) and Dillon

Creek (Site 3), scored lower rating score of 49 and 50, respectively. Nonetheless, all streams rated at least partially supporting of supporting aquatic biota.

Some parameter concentrations were elevated within the streams draining to Dillon Creek. Ammonia-nitrogen or nitrate-nitrogen concentrations were elevated within the Dillon Creek tributaries. All three streams contained nitrate-nitrogen concentrations in excess of the median concentration observed in Ohio streams (1.0 mg/L) known to support healthy warmwater fauna (Ohio EPA, 1999). Additionally, Launer Ditch's nitrate-nitrogen concentration during base flow exceeded the state standard (10 mg/L). Total phosphorus concentrations were relatively normal for Indiana streams. None of the concentrations exceeded concentrations recommended by the Ohio EPA for the protection of aquatic biota. Dillon Creek (Site 3) contained the highest concentration; concentrations measured the level at which Dodd et al. (1998) indicated that eutrophication occurs within stream systems. *E. coli* concentrations measured in all three of the streams exceeded the state standard (235 colonies/100 mL) during both sampling events. Dillon Creek (Site 3) possessed the highest *E. coli* concentration observed during both assessments measuring 4,100 and 2,900 colonies/100 mL during base and storm flow, respectively.

This site also possessed the highest loading rates for most parameters measured during both base and storm flow. This is not surprising as this site drains the largest area of any of the tributaries to Dillon Creek. Despite this relatively large drainage area, Launer Ditch possessed the highest nitrate-nitrogen and ammonia-nitrogen loading rates during both base and storm flow. When the data was normalized by drainage area, these two sites (Launer Ditch and Dillon Creek) possessed the highest areal loading rates for all parameters. Launer Ditch contained higher nitrate-nitrogen and ammonia-nitrogen areal loading rates, but also possessed the highest total Kjeldahl nitrogen, total phosphorus, and total suspended solids loading rates during base flow. Dillon Creek possessed the highest total Kjeldahl nitrogen, total phosphorus, and total suspended solids during storm flow.

Data from the Dillon Creek tributaries suggest that efforts to limit nitrogen loading should focus on the Launer Ditch watershed. The Dillon Creek Headwaters should be targeted to reduce the flow of phosphorus and sediment to Dillon Creek and thus to Lake Wawasee.

3.7 Indiana Geological Survey

Data layers within the Indiana Geological Survey's GIS (Geographical Information Systems) Atlas for Indiana were reviewed to identify any additional water quality data or threats. A review of the data layers revealed that no known or permitted confined feeding operations, corrective action sites, construction demolitions waste sites, industrial waste sites, leaking underground storage locations, National Pollution Discharge Elimination System facilities or pipe locations, open dump sites, restricted waste sites, septage waste sites, solid waste landfills, Superfund sites, underground storage tank sites, or voluntary remediation program sites exist within the Wawasee Area Watershed (IDEM, 2002a-b; IDEM, 2004a-e; IDEM, 2004g-q). At least one automobile storage and disposal area is located within the watershed immediately east of Lake Papakeechie; however, this facility is not mapped by IDEM. The content and impact of this site is not entirely known at this time.

3.8 Other Sources

A variety of other sources were reviewed to assist in establishing baseline water quality conditions in the waterbodies of the Wawasee Area Watershed. The current and historical 305(b) reports were studied (IDEM, 1994; IDEM, 1996; IDEM, 2000; IDEM, 2004f). No data specific to the waterbodies of the Wawasee Area Watershed were found in these reports. However, four of the waterbodies in the Wawasee Area Watershed are listed on the 2006 303(d) list. These include Indian Village, Knapp, Hindman, and Gordy lakes, which are listed for impaired biotic communities due to the historic but not current cisco populations. Additionally, Turkey Creek downstream of Syracuse Lake is listed for *E. coli* (IDEM, 2006). The Watershed Restoration Action Strategies (WRAS) for the St. Joseph River Watershed (IDEM, 2001) and the Unified Watershed Assessment (UWA) (IDEM, 1999) do not contain specific recommendations for the Wawasee Area Watershed. However, the WRAS does list fish consumption advisories for two fish species (bullhead larger than 15 inches and largemouth bass greater than 9 inches in size) with the Wawasee Area Watershed. Without providing specific data, the WRAS suggests that streambank erosion and stabilization, failing septic systems and straight pipes, non-point source pollution (including lack of education on non-point source pollution), point source pollution, and data management are water quality issues of concern within the larger St. Joseph River Basin (HUC 04050001). The UWA suggests aquifer contamination and the high percent of agricultural land use may be water quality issues of concern within the eleven digit watershed containing the Wawasee Area Watershed. Again, neither the WRAS nor the UWA contain specific watershed data (less the fish consumption advisory) confirming the validity of these concerns within the Wawasee Area Watershed.

4.0 BASELINE WATERSHED AND IN-LAKE CONDITIONS

Identifying areas of concern and selecting sites for future water quality improvement projects both within Lake Wawasee and throughout its watershed were the goals for this visual, in-lake, and watershed inspection. The Wawasee Area Watershed was toured on multiple occasions throughout the completion of the watershed management plan. Inspections and tours included a watershed survey completed in March 2006; a tour of projects installed through the LARE Watershed Land Treatment Program, which was completed in May 2006; estimation of location and number of storm drains completed May 2006; and additional observations completed during stream and lake sampling trips in May and July of 2006 and a canoe trip in November 2006. In-lake issues assessed during the completion of this watershed management plan include boating issues and an assessment of the impact of boating on wetlands within Conklin Bay.

4.1 Watershed Survey

In general, the watershed survey provided an assessment of locations where water quality improvement projects could be implemented. The headwaters of Turkey and Dillon creeks were the main focus of the tour; however, efforts were made to cover the entire watershed. A variety of projects were identified during completion of the tour. Additionally, areas identified during previous projects completed by Commonwealth Engineers (1996), Kosciusko County and Noble County SWCDs (no date), and Harza (2001) were revisited to determine whether the areas needed to be addressed as part of this planning process. The areas targeted for water quality improvement projects are mapped in Figure 29. Appendix J1 contains photographs of representative locations where problem areas were identified during the windshield tour and projects could be implemented.

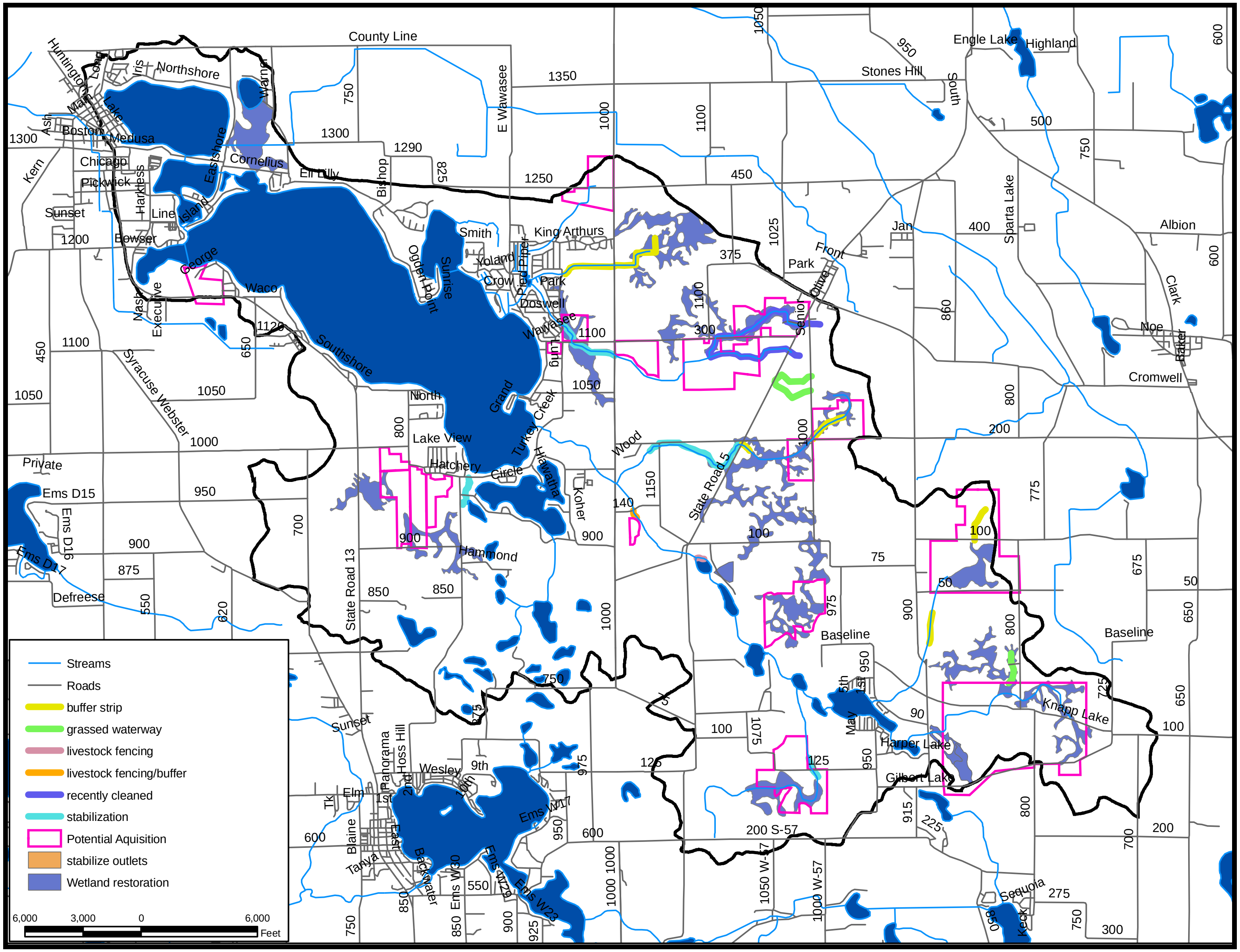

Figure 29. Watershed concerns identified during various watershed surveys in the Wawasee Area Watershed.

4.2 Installed Project Survey

At the request of the WACF, JFNew initiated a tour of projects installed through the Watershed Land Treatment Program. More than 50 projects were implemented through the WLT program from 1996 through 2004. In total, more than $220,000 was spent implementing projects throughout the watershed. Appendix J2 documents some of the practices installed through this program. The follow list details volumes of each practice installed through the program:

- 1,500 acres no-till farming initiated;
- 290 acres mulch till farming initiated;
- 110 acres cover crop planted;
- 8 acres critical area planted;
- 43 acres of filter strips installed;
- 47 acres pasture/hay planted;
- 4,030 feet of diversions installed;
- 290 feet fencing;
- 27 grade control structures installed;
- 26,500 feet of grassed waterway implemented
- 19 WASCOBs installed;
- 1 waste management system designed and installed;
- 1,481,000 gallons of waste allocated;
- 3,510 acres integrated crop management system designed and implemented; and

500 newsletters and 4 signs printed.

4.3 Other Observations

Observations of areas with water quality concerns were recorded throughout the completion of the watershed management plan. These areas were identified through information from watershed stakeholders during meetings and during stream and lake water quality assessment events. Additional observations occurred during a canoe trip along Turkey Creek. All observations identified through methods other than the watershed or watershed land treatment tours are included in this section. Specific areas are also mapped in Figure 29. Appendix J3 contains photographs of some of these areas observed during the completion of the watershed management plan.

4.4 Properties Targeted for Restoration

One of the WACF's primary activities is to acquire and subsequently restore natural conditions to properties throughout the watershed. Most of the areas identified are currently in wetland habitat or were historically wetlands that were subsequently converted to agricultural land uses. Figure 29 details those locations that watershed stakeholders identified as potential locations for wetland restoration, and therefore, as properties that are targeted for potential acquisition. WACF should meet with each of the landowners to determine if they are interested in restoration options and determine the best way to proceed. Identified properties are not prioritized at this point in time. This should occur only after individual property owner meetings occur.

4.5 Storm Drain Survey

One area of concern noted by watershed stakeholders was the presence of large numbers of storm drains draining to Lake Wawasee. It was suggested that most drains were not regularly cleaned or routinely maintained. Furthermore, these drains likely serve as sources of unknown volumes of sediment and nutrients to Lake Wawasee. In order to quantify the sediment and nutrient loading from these drains, stakeholders first decided that it was necessary to estimate the total number of storm drains carrying water, and thus sediment and nutrients, to Lake Wawasee. In order to complete this assessment, JFNew divided the shoreline of Lake Wawasee into 25 segments. (A map of the segments is included in Appendix K.) Each segment was driven to determine the prevalence of storm drains installed within that area. After a rough determination, individuals walked the areas around identified storm drains to determine whether other pipes were carrying water into the system and ascertain if there were any associated water quality or maintenance issues. In total, JFNew identified approximately 105 storm drains adjacent to Lake Wawasee (Table 51). More detailed notes and photographs from the survey are included in Appendix K. It should be noted that the actual number of drains is likely higher than this estimate due to the following factors: not all areas of the shoreline could be accessed; open drainages without grates or pipes were not included in the count even though they likely deliver high volumes of water, sediment, and nutrients to Lake Wawasee; and the survey was conducted over a three-day period. To adequately quantify the total number of drains, more time and energy must be dedicated to the survey. Additionally, once the number of drains are known, then efforts to quantify pollutant loads and determine potential water quality improvement solutions should occur.

Table 51. Estimates generated from storm drain survey.

Section #	# of Storm Drains	Comments
1	5	Mostly 1 foot and 2 foot diameter metal grates
2	2	2 foot diameter metal grates
3	1	2 foot diameter metal grate
4	1	2 foot diameter metal grate
5	12	Ditches and piped outlets connected with gutters on structures
6	18	Mostly 1 foot and 2 foot diameter metal grates; Ditches and piped outlets
7	3	Steep slopes with lots of runoff
8	11	Need buffer adjacent to public access site stream
9	11	Mostly 2 foot metal grates
10	1	2 foot diameter metal grate
11	3	Mostly 2 foot metal grates
12	0	Ditches and piped outlets
13	Did not survey	--
14	0	Ditches and piped outlets
15	0	Ditches and piped outlets
16	0	Ditches and piped outlets
17	1	2 foot diameter metal grate
18	6	1 open concrete drain into lake; 6 inch pipe diverting water from driveway
19	6	Mostly 2 foot metal grates
20	3	Mostly 2 foot metal grates
21	0	Many areas gated and inaccessible
22	0	Many areas gated and inaccessible
23	1	2 foot metal grate
24	5	All are 2 foot diameter metal grates
25	9	1 ditch pipe; rest are grated inlets
26	7	1 ditch pipe; rest are grated inlets
Total	**106**	

4.6 Boating Issues

One of the most common impacts associated with motor boating, and one of the primary concerns noted by watershed stakeholders, is a decrease in water clarity. As motor boats travel through shallow water, the energy from movement of the boat propeller may be sufficient to resuspend sediment from the lake bottom, decreasing the lake's water clarity. Several researchers have documented either an increase in turbidity or a decrease in Secchi disk transparency during and following motor boat activity (Wagner, 1990; Asplund, 1996; Yousef et al., 1980). Crisman (1986) reports a decrease in Secchi disk transparency following holiday weekend use of Lake Maxinkuckee in Culver, Indiana. Asplund (1996) also observed poorer water clarity in his study lakes following weekend boating and that this decrease in water clarity is more pronounced in lakes with generally better water clarity. This finding is particularly significant for many lakes throughout the watershed as they generally exhibit better water clarity than the typical Indiana lake.

The ability of a motor boat to resuspend sediment from the lake bottom depends on several factors. Some of these factors, such as boat length, motor size, and boat speed, are related to the boat itself and the boat's operator. Yousef et al. (1978) found that 10 horsepower (hp) motors were capable of mixing the water column to a depth of 6 feet (1.8 m), while 50 hp motors were capable of mixing the water column to a depth of 15 feet (4.6 m). While larger motor sizes have a greater potential to resuspend sediments than smaller motors, longer boats and higher speeds do not automatically translate to a greater ability to resuspend sediments. Boats that are 'planing' on the water actually have little impact on the lake's bottom. This is because the velocity of water at the lake bottom created by a motor boat depends on the boat's displacement, which is a function of boat length and speed. Beachler and Hill (2003) suggest that boat speeds in the range of 7 to 12 mph may have the greatest potential to resuspend sediment from the lake bottom. (This range is based on typical recreational boat length.)

Certain characteristics of lakes also influence the ability of motor boats to resuspend sediments. Shallow lakes are obviously more prone to water clarity degradation associated with motor boating than deeper lakes. Wagner (1990) suggests little impacts from motor boating are likely in water deeper than 10-15 feet (3.0-4.6 m). Lakes with soft fine sediments are more likely to suffer from sediment resuspension than lakes with coarser substrates. Lakes with extensive rooted plant coverage throughout the littoral zone are less prone to motor boat related resuspension problems than lakes with sparse vegetation since plants help hold the lake's bottom substrate in place.

Given this information, it is clear that some of Lake Wawasee's physical characteristics predispose it to water clarity problems associated with motor boating. First, because Lake Wawasee is over 300 acres in size, high speed boating is permissible on the lake. Furthermore, as the largest lake in the state, larger than normal size boats are in operation on Lake Wawasee. Consequently, the lake is a popular boating destination, and boats are likely to, at least during some portion of the time, travel at the rate of speed (7 to 12 mph) suggested above to have the greatest potential to resuspend sediment from the lake bottom. Second, while Lake Wawasee is deep relative to many Indiana lakes, very little water lies over the lake's deepest areas. Thus, a large portion of Lake Wawasee is potentially subject to impacts due to motor boating. Fortunately, aquatic vegetation covers large portions of Lake Wawasee's bottom sediment and sand is the dominate substrate type. However, these characteristics may not be sufficient to prevent the resuspension of bottom sediment during periods of heavy use.

It is important to note that the decrease in water clarity is not usually permanent. Once motor boating activity ceases, resuspended materials will sink to the lake bottom again. However, this process can take several days. Wagner (1990) found that while turbidity levels steadily decreased following boating activity in his shallow study lakes, the turbidity had not returned to baseline levels even two days after the activity. Crisman (1986) found similar lags on Lake Maxinkuckee. Thus, Lake Wawasee residents may need to wait several days before their lake returns to its baseline clarity following heavy weekend motor boating use.

In addition to a decrease in water clarity, several other potential ecological impacts from motor boating exist. Various researchers have documented increased phosphorus concentrations, damage to rooted plants, changes in rooted plant distribution, and increased shoreline erosion associated with motor boating activity (Asplund, 1996; Asplund, 1997; Schloss, 1990; Yousef et al., 1980). Less commonly studied concerns include potential increases in heavy metal and hydrocarbon pollution, changes in algal populations, and impacts to lake fauna.

Just as the potential impact of motor boating on a lake's water clarity depends in large part on the specific characteristics of the lake, the potential for other ecological impacts associated with motor boating often depend on characteristics of the specific lake (Wagner, 1990). For example, Yousef et al. (1980) found increases in total phosphorus concentrations associated with motor boating activity in all his study lakes. However, only one of Wagner's study lakes showed an increase in phosphorus concentrations associated with motor boating activity. This lake possessed a nutrient rich, fine particle substrate. Similarly, Schloss (1990) reported greater increases in phosphorus concentrations due to motor boat activities in those New Hampshire lakes with high levels of internal phosphorus loading. New Hampshire lakes with lower levels of internal phosphorus loading were less likely to see large increases in phosphorus concentration associated with motor boat activity.

As noted above, Lake Wawasee's extensive areas of shallow water and popularity predispose the lake to a decrease in water clarity associated with motor boat activity. Other characteristics that increase Lake Wawasee's potential for ecological damage due to motor boat activity include the presence of Eurasian watermilfoil and sensitive rooted plants in the lake, the prevalence of concrete seawalls along the lake's shoreline, and the lake's relatively long hydraulic residence time.

The presence of Eurasian watermilfoil combined with motor boating activity is a problem since motor boats driven through stands of Eurasian watermilfoil have the potential to spread the invasive plant throughout the lake. The species is found in limited locations within the lake; however, given time the species will only spread further. The spread of the species will likely impair recreation if it is allowed to grow unchecked. Increased growth of Eurasian watermilfoil might also result in the decline of some of the lake's more sensitive rooted plant species such as Richardson's pondweed. Eurasian watermilfoil has the potential to shade out other native plants. This would reduce the diversity of rooted plants in the lake and could, in turn, adversely affect the lake's fish community.

The prevalence of concrete seawalls around Lake Wawasee combined with motor boating is a problem since concrete seawalls do little to reduce the energy of waves traveling into the shoreline. Motor boating along with wind action are responsible for the generation of waves on most lakes. These waves can carry a significant amount of energy. Waves striking concrete seawalls reflect off the walls without releasing much of their energy. This energy simply returns to the lake where it can play a role in resuspending bottom sediments and reducing water clarity.

Lake Wawasee's relatively long residence time (2.5 years) means that any changes in the lake's water quality due to motor boating may have a greater impact on Lake Wawasee than they would in a lake with a shorter residence time. In lakes with very short hydraulic residence times (less than 2-3 months), water within the lake is constantly being replaced with new water from the watershed. Thus, any pollutants added to the water column from motor boating are quickly flushed from the lake. In lakes with longer residence times, like Lake Wawasee, these pollutants stay within the lake longer before being flushed downstream.

4.6.1 Carrying Capacity

Boat density on a lake influences the magnitude of effect possible from motor boating activity. Typically, more power watercraft utilizing a lake results in a greater potential for ecological damage to the lake. While there is little or no documentation available on exactly how many motor boats a lake can support without impairing its ecological health, several researchers have tackled the question of how many motor boats a given lake can support at one time without compromising user safety or what is the lake's safety-related carrying capacity. This estimate of a lake's safety-related motor boat carrying capacity may be used as a surrogate for the lake's ecological-related motor boat carrying capacity. It is important to note that a lake's safety-related carrying capacity is not necessarily directly related to its ecological-related carrying capacity. There is a certain amount of subjectivity with respect to a lake's safety-related carrying capacity since some users will feel safer than others at different levels of congestion. However, a lake's safety-related carrying capacity may be the best approximation we have for a lake ecological-related carrying capacity.

Dudiack (2004) suggests a conservative estimate of a lake's motor boat carrying capacity is around 15-20 acres of usable lake per boat, while an estimate that allows a little more congestion is around 10-15 acres of usable lake per boat. (A lake's "usable" acreage usually refers to those areas that are obstruction free and have sufficient depth to support motor boating.) Historic estimate of boat usage on Lake Wawasee indicates that more boats are present on Lake Wawasee on a typical symmer day than the number of boats that stormed Normandy during WWII. (Bob Myers, personal communication.) This means that more than 7,000 boats are typically present at Lake Wawasee. If all of these boats are in use and no area is excluded from use, then each boat has less than 0.5 acres of Lake available for personal usage. More specific calculations of available area and counts of boats present and in use will provide a better estimate of carrying capacity issues at Lake Wawasee.

4.7 <u>Eco-Zone Development</u>

In 2001, the WACF, the Syracuse Lake Association, and the Wawasee Property Owners Association worked with the IDNR to develop the state's first eco-zones. IDNR staff completed an assessment of the lake's plant community in the summer of 2001. Based on this assessment, a review of historical information and public opinion, a rule was drafted to create a number of eco-zones around Lake Wawasee. The buoy locations were established and their locations documented using a GPS. These locations were written into the Indiana Register in 2001. Most of these eco-zones are relatively successful and the plant communities continue to thrive; however, buoy locations (50 ft. from shoreline) determined by compromises reached during the original eco-zone process do not appear to be adequately addressing shoreline and plant erosion issues in the kettle. In the summer of 2006, concern over the continued erosion of the wetland shoreline with the "kettle" in Conklin Bay prompted watershed stakeholders to investigate the need for these boundaries to be revised. Specific boundary locations were not yet determined at the time this report was finalized. Figures 30 and 31 detail findings prompted by these concerns.

Figure 30. Variation in wetland fringe within Conklin Bay, 1938 to 2005. The historic (1938) location of the edge of the wetland fringe is displayed by the thick green line. Area previously covered by wetland plants is displayed by the red hatching.

Figure 31. Variation in wetland fringe within Conklin Bay, 2003 to 2005. The 2003 wetland extent is displayed in brown. The yellow hatching indicates the area of wetland loss in from 2003 to 2005.

A review of aerial photographs of the area in question revealed the concern over continued erosion of the wetland fringe was indeed an issue. Based on the photographs displayed in Figure 30, the wetland fringe receded 110 to 170 feet from 1938 to 2005. As stakeholder concerns focused more on the decline in this wetland fringe following enactment of the eco-zone in this area, JFNew examined more recent aerial photographs (2003 and 2005). Changes in the extent of the wetland fringe during this time period is displayed in Figure 31. The 2003 wetland extent is displayed in brown. Based on the yellow hatching, it is apparent that the wetland fringe receded an additional 40 to 55 feet after the eco-zone was enacted. Although the original date (2003) does not correspond with the date that eco-zones were enacted, it does provide a baseline by which comparison of recent historical and current wetland fringe extents in Conklin Bay. Further protection of this area is likely warranted to ensure that additional erosion of the wetland plant community does not occur within this location. At the current rate of erosion (approximately 20 to 25 feet per year), wetlands within the kettle of Conklin Bay will disappear in approximately 55 to 70 years.

5.0 CLARIFYING OUR PROBLEMS

5.1 Linking Concerns to the Existing Data

Throughout the planning process watershed stakeholders were invited to share their concerns for the Wawasee Area Watershed, its waterbodies, and their water quality. All of the stakeholder's concerns identified during the planning process are detailed in the Concerns Section. 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. Table 52 reflects the stakeholder's concerns, any existing data identified that supports or refutes those concerns, and identifies the problem statement developed for that particular concern.

Table 52. Linking watershed stakeholders' concerns with existing data to develop problem statements.

Concern	Existing Data	Problem Statement
Water Quality Issues		
Storm drains deliver elevated levels of nutrient and sediment to the lake – Accurate map of storm drains is lacking – Nutrients/sediment from storm drains are not addressed at their source – County and individual residents do not maintain storm drains	More than 100 storm drains were identified during a cursory tour of Lake Wawasee's shoreline (App. K). However, an exact map of storm drain locations has not been completed. Additionally, sediment and nutrient loads from these drains has not been quantified. Typical pollutant levels found in stormwater average 0.2-0.38 mg/L of total phosphorus and 69-101 mg/L total suspended solids (USEPA, 2005). Research suggests that if any of the drains are >60% full, then they no longer remove sediment from stormwater runoff (Pitt and Bissonnet, 1984).	1
Non-sewered areas of the watershed deliver elevated levels of nutrient and pathogen to the lake – Not all of Lake Wawasee residences are hooked into the sewer system – Residences around Ten Lakes Chain are not on a sewer system – Papakeechie Lake residents are not hooked into a sewer system – Potential funding sources for completing the Wawasee sewer have not been identified	Nearly 200 homes adjacent to Lake Wawasee are not currently connected to a sewer. Fig. 10 details the locations around Lake Wawasee where sewers are currently in place. None of the residences around Papakeechie or the Ten Lakes Chain are connected to a sewer system. More than 65% of the watershed soils are rated as severely limited for use as a septic absorption Field (Fig. 9). The ISDH estimates that 25% of septic systems throughout the state are failing and for every failing system, approximately 82,000 gallons of untreated wastewater is released annually (Lee et al., 2004). Even a properly functioning septic system has limited effect removing on average 57% of total phosphorus and 28% of total nitrogen (USEPA, 1993).	1
Sediment and nutrients are resuspended during boating	Exact data on the impact of boating on Lake Wawasee have not been calculated. However, research suggests that 10 hp motors are capable of mixing water to a depth of 6 feet, while 50 hp motors are capable of mixing water to a depth of 15 feet (Yousef et al., 1978). Beachler and Hill (2003) suggest that boat speeds of 7 to 12 mph offer the greatest potential to resuspend sediment from the lake bottom. Based on the lake's depth contours, 18% of the lake is covered by water less than 5 feet deep, while nearly 55% is covered by water less than 15 feet deep.	1
E. coli concentrations exceed the state standard and sources have not been identified	Elevated *E. coli* concentrations were documented by WACF at Waveland Cove (2,000 col/100 mL). During the storm event, 12 of the 15 stream sites possessed *E. coli* concentrations in excess of the state standard (235 col/100 mL). During base flow sampling, 11 of the 15 stream sample sites possessed *E. coli* concentrations in excess of the state standard. Concentrations ranged from 460 col/100 mL to 51,000 col/100 mL during storm flow and from 370 col/100 mL to 3,000 col/100 mL during base flow. Specific sources of *E. coli* have not yet been identified within the watershed.	3

Concern		Existing Data	Problem Statement
Fish consumption advisories limit consumption throughout the watershed; residents are not informed of the problem		Lake Wawasee is the only lake in the watershed with a fish advisory. The ISDH recommends limited consumption (no more than one per month) of bullhead greater than 15 inches in size.	5
Water quality is declining in lakes throughout the watershed		For many lakes in the watershed, water quality appears to be steady or improving. However, declining water quality trends can be observed in Harper, Knapp, Hindman, and Village Lakes within the Ten Lakes Chain. Barrel and a Half and Hammond lakes also experienced declining water transparency and increasing total phosphorus and chlorophyll *a* concentrations. Other lakes showed minor variations in water quality; however, a significant trend of improving or declining water quality could not be determined. Syracuse and Wawasee rate as high quality lakes.	1, 2
	Water quality is declining in the Tri-County FWA lakes		
	Water quality is declining in the Ten Lakes Chain		
	Water quality is perceived as declining in Lake Wawasee and Syracuse Lake		
Phosphorus concentrations are increasing in the lakes resulting in increased algal blooms and decreased transparency		Only three lakes (Knapp, Barrel and a Half, and Rothenberger) show significant trends of increasing phosphorus concentrations. Many of the lakes indicate a distinct trend of higher plankton densities occurring when phosphorus concentrations are elevated. This relationship is also true with respect to water clarity; many lakes exhibited their poorest water clarity when total phosphorus concentrations and plankton densities were at their highest. No trend towards increasing densities or durations of algae blooms with in the watershed lakes.	1
	Algae blooms are increasing in density and duration		
	Phosphorus concentrations increase in Lake Wawasee following fireworks		
	The impact of increased nutrients on water quality has not been quantified		
Sediment/silt fill waterbodies and limit their use		No data from the watershed were available to directly verify this concern. However, stakeholder observations indicate that sediment is accumulating in these areas. Additionally, several areas were identified where streambank stabilization, ditch stabilization or seeding, conservation tillage, and livestock restriction could result in less sediment being transported into watershed waterbodies (Fig. 9). These areas are listed as critical areas or hot spots in the following sections. The assessment of sediment accumulation or sand bar development is included as an action item as well.	2
	Sand bar developing between Gordy and Hindman Lakes		
	Sediment sources have not been identified within the watershed		
	Sediment is accumulating at the mouths of several lake inlets throughout the watershed		
Fertilizers and pesticides are improperly used along the lakeshore		No data from the watershed were available to directly verify this concern. However, the use of fertilizers and pesticides adjacent to the shoreline can negatively impact water quality.	1
	Too many residents use traditional fertilizer along the shoreline		
	Too much fertilizer/pesticide is applied along the shoreline		

Concern	Existing Data	Problem Statement
Shoreline and Habitat Issues		
Wetlands and littoral zone are being filled/lost adjacent to the lakes, along the shoreline and throughout the watershed	Based on hydric soils maps, it is estimated that nearly 70% of historic wetlands are still present within the watershed. However, a number of wetlands in the headwaters of the watershed were converted to agricultural ground. Furthermore, more than 25 permits were filed for wetland fill activities in and around Lake Wawasee and Syracuse Lake in the last 18 months.	1
Wetland fill is occurring within Lake Wawasee		
Fish and wildlife habitat is being lost throughout the watershed		
Historical bulrush communities have been lost in shallow areas of Lake Wawasee	Commonwealth Engineers (1996) noted the historic presence of bulrushes in most shallow areas of Lake Wawasee. Based on 2005 aerial photographs, bulrushes are no longer present in many of those areas.	
Existing eco-zone regulations are not enforced	No data are available to document the enforcement of eco-zone regulations. However, the variation in wetland boundary within the kettle as observed in 2003 and 2005 aerial photographs indicates that additional eco-zones may be necessary to protect this area of the lake.	1, 2
The installation of new eco-zones should be investigated (kettle at SR13)		
Natural shoreline is lacking along the lake	Based on aerial photographs, concrete, metal, and wooden sea walls cover a majority of Lake Wawasee and Syracuse Lake's shoreline. The percentage of shoreline in its natural state is minimal around the lakes, and given this and supporting research data, what natural shoreline is still present should be protected.	1
Natural shoreline should be protected around the lakes		
Degraded shoreline/seawalls should be restored to natural structure		
Unnatural structures cover too much of the shoreline	The exact number of piers, lifts, and structures around Lake Wawasee and Syracuse Lake has not been determined. However, Pearson (2003) notes the presence of a "large maze of private piers" within a specific treatment area. Based on observation, this information can be extrapolated to cover a majority of the lakeshore. Research suggests that increased lakeshore development results in a simplified littoral zone which ultimately leads to degraded fish communities (Beauchamp et al., 1994; Ward et al, 1994; Jennings et al., 2003).	5
Too many piers, lifts, and structures are present within the lakes		
Perpendicular piers in channels limits water flow and boat movement		
Residents are not interested in refacing their concrete seawalls and do not realize the benefits to fish, wildlife, and water quality		
The number and type of new seawalls should be limited		
Shoreline alteration reduces attractiveness and limits habitat		
Exotic species are present in high densities throughout the watershed lakes	Both the Syracuse Lake and Lake Wawasee Aquatic Plant Management Plans document the presence of exotic plant species within these lakes. Similar assessments have not been completed for lakes in the Tri-County FWA or along the Ten Lakes Chain. Purple loosestrife is present adjacent to the lakes and throughout the watershed. However, the coverage of this species has not been documented. Research indicates that there is no negative effect on fish or wildlife from long-term aquatic herbicide application.	5
Eurasian watermilfoil and purple loosestrife are present throughout the watershed		
Plant control for exotic species negatively impacts water quality and wildlife		
Limiting sediment and nutrient loading will impact the aquatic plant community		

Concern	Existing Data	Problem Statement
Resident geese populations are increasing	No data are available to support or refute 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
Freshwater mussel populations are declining Zebra mussel populations are negatively impacting freshwater mussel populations	Limited mussel community data prevents the determination of whether the presence of zebra mussels is negatively impacting the freshwater mussel population within Lake Wawasee. However, research suggests that zebra mussels preferentially utilize native mussels as substrate (Ricciardi, 1994) which likely results in declines in native freshwater mussel populations.	1, 2
Beaver populations are out of control Beavers causing ponding to occur within Ten Lakes Chain	No data are available to support or refute this concern. Due to the limited fall within this portion of Turkey Creek, beaver populations likely cause ponding issues.	
Watershed Management		
Livestock are negatively impacting water quality within the watershed Confined feeding operations present within the watershed are negatively impacting water quality Livestock access to watershed waterbodies are negatively impacting water quality Manure management is not adequately used throughout the watershed	Historically, livestock were present in relatively high densities in a number of locations in the watershed. However, most of the larger herds have been absent from the watershed for a number of years. Recent activities indicated that a confined feeding operation was planned for the Wawasee Area Watershed. However, the CFO did not receive permits and the project was not implemented. Nonetheless, a number of sites were observed where livestock have access to waterbodies within the watershed. These areas are mapped as critical areas or hot spots in later sections. Furthermore, literature suggests that livestock access to a waterbody increases turbidity, nutrients, and pathogen concentrations in the waterbody (Platts, 1991).	1
Shoreline erosion requirements are not followed and erosion continues along lake shorelines	No data is available to corroborate this statement. Rule 5 states that any activity which results in more than 1 acre of bare ground requires an erosion control plan. The local SWCD is tasked with documenting the plan; however, enforcement falls to the IDEM. IDEM personnel indicate that Rule 5 implementation and enforcement continues as designed.	1
Streambank erosion is occurring throughout the watershed	A number of locations where streambank erosion is occurring were identified during the watershed tour. These areas are included as critical areas or hot spots in later sections. Depending on soil type and phosphorus concentration, soil eroding from streambanks can be a major source of phosphorus to watershed waterbodies.	1
Properties need to be acquired to protect high quality areas	No data is available to support or refute this concern. However, WACF has already purchased and protected a number of high quality areas. Other areas that are recommended for acquisition are detailed in subsequent sections.	4

Concern	Existing Data	Problem Statement
Maintenance and use plans need to be developed for WACF properties	WACF properties are generally managed for limited access and use. Current plans indicate that these properties will remain in limited access. However, exotic species need to be controlled on these sites. An on-going WACF study details the extent and type of exotics present on their properties.	4
Types and densities of exotic species on WACF properties in not known		
Watershed and lake groups are not working together; coordination should occur	The Wawasee Property Owners Association, Syracuse Property Owners Association, and Knapp Lake residents are represented on WACF. However, other lakes in the watershed do not participate in WACF activities. Activities and actions identified for implementation would have greater opportunity for success if all watershed groups were working together.	4
Runoff from the auto salvage yard is negatively impacting water quality	Limited sampling has been completed to document the effect of the auto salvage yard on water quality within the watershed. These samples indicated no values of concern at the time of sampling. Auto salvage yards nationwide have been implicated in groundwater contamination. This yard should be further assessed to determine if any negative impact is occurring due to its proximity to the lakes.	
Community Use/Development/Land Use		
Zoning/planning commission interest and lake resident interest do not match	No data is available to support or refute this concern.	1, 2
County disregards zoning impacts to lakes		
County officials lack perspective necessary for water quality improvement		
Lake resident's concerns are not heard/addressed at county meetings		
Too large of a percentage of the lakes' shoreline is covered by hardscape	No data is available to support or refute this concern at this time. Furthermore, even with the percentage of shoreline covered by hardscape determined, a decision of "how much is too much" must be reached in order to either support or refute this concern.	1, 2
Erosion control ordinance enforcement is lacking	Rule 5 states that any activity which results in more than 1 acre of bare ground requires an erosion control plan. The local SWCD is tasked with documenting the plan; however, enforcement falls to the IDEM. IDEM personnel indicate that Rule 5 implementation and enforcement continues as designed	1, 2
Too many people use the lakes	No data is available to support or refute this concern. A count of boats and individuals per boat during different use periods could result in a baseline for which to determine the recommended use level for the lakes.	5
Individuals using campground are unaware of boating regulations	No data is available to support or refute this concern. However, an action item associated with this concern will be developed.	5

Concern	Existing Data	Problem Statement
Too many houses are located along the lakeshore • Hardscape from current and future housing units is negatively impacting water quality • The funneling of additional people to Lake Wawasee/Syracuse Lake's shoreline should be addressed • More housing units will increase boat use and density which will ultimately result in poorer water quality	A count of the housing units along the shores of Lake Wawasee and Syracuse Lake has not been completed. However, literature indicates that increases in urban development or hardscape result in more runoff occurring more rapidly. Schuler indicates that more than 5% of the watershed being utilized for high intensity residential or commercial uses results in declining in water quality. Furthermore, based on data collected from other area lakes, it is estimated that more housing units will result in more boats being moored at the lake. This does not necessarily translate into more boats being used on the lake.	5
Boating/Public Usage		
As no count of the number and type of boats present on the lake has been completed, it is difficult to determine the complete validity and impact of these concerns. All information included in this section comes from literature reviews rather than data collected from the Wawasee Area Watershed lakes.		
The type of boats present on the lake are not appropriate for the lakes' depth or shape • Agitation of sediment and nutrients from the lake bed due to boating is one of the largest sources of nutrients in the lake • Deep hull boats and boat testing are impairing water quality	A 10 hp motor can suspend sediment in water 6 feet deep, while a 50 hp motor can suspend sediment in water up to 15 feet deep. As Lake Wawasee is shallow in nature, it can be assumed that boats around the lake are resuspending sediment. However, the impact of these boats on water quality cannot be determined at this time. Additional information and research is necessary to identify the overall impact of this concern.	5
Boat numbers and densities are increasing on the lakes	No previous boat count data was identified. Without historic data, it cannot be stated that numbers are increasing. The 2003 aerial photograph shows 27 boats on Lake Wawasee and Syracuse Lake. The exact date of the photo can be obtained from Indiana University. However, initial surveys should be completed to determine the number of boats registered for mooring at the lake and the number of boats in use on the lake.	5
Boaters are unaware or do not observe boating regulations • Public generally disregards impact of their actions on the lakes • Individuals lack knowledge on their impact on the lakes' water quality • Boaters do not follow rules (number of people, speed limit, above water exhaust...) • No wake zones are not enforced within channels	No data is available to refute or support this request. Personal observations indicate that it is likely that individuals do not follow boating rules; however, it cannot be determined at this time if they are unaware of boating regulations or if they choose to disregard them. The number of patrols on the lakes is increasing; however, they may not be located in the areas of greatest concern.	5
Boating laws are not enforced • Reduce speed limits around the lake • More enforcement is required on evenings and weekends	There is no data to refute or support these concerns.	5

Concern	Existing Data	Problem Statement
The dam is not maintained/is in disrepair	The Town Manager and Syracuse Lake Association are working to improve or maintain the dam. There is no data available at this time with regards to the state of repair or disrepair of the dam.	5
Boat fuel contaminates the lakes	Motors all leak some fuel; however, the exact amount of fuel and its impact on water quality cannot be determined at this time.	5
WACF needs to provide educational opportunities to area residents	This is not a concern for which data can be attributed at this time. Surveys of watershed residents could be a future source of data for this concern.	4
WACF needs to strengthen its educational efforts		
WACF needs to develop an education plan and facility		

5.2 Developing Problem Statements and Identifying Potential Goals

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 Wawasee Area 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 Turkey Creek and Dillon Creek subwatersheds. It is likely that other critical areas are located within the watershed as the watershed touring process was not exhaustive.

For each of the problem statements developed throughout the planning process, a potential goal was developed and potential technique identified to assist in the reaching the goal. During the identification stage, goals were listed (see below) following the same pattern as that identified during the problem statement development stage. During the September 13, 2006 stakeholder meeting, watershed stakeholders reviewed and refined the goals, then prioritized the goals based on order of importance. The goals and potential techniques listed below were refined, and then utilized as a basis for the goals, objectives, and action items that were developed later in the planning process. The goals are listed below in the order that they were developed, which corresponds with the order that they were prioritized by watershed stakeholders. All critical areas listed were identified within the watershed. Those that could be mapped or were not pervasive are detailed on their respective figures.

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 Wawasee Area Watershed. During the water quality sampling portion of this project, both phosphorus and nitrogen concentrations present in watershed streams exceeded levels at which the Ohio EPA (1999) observed impairment to the aquatic biota within Ohio streams. Launer Ditch (Site 2) possessed nitrate-nitrogen concentrations greater than the Indiana state standard (10mg/L) during base flow. Eleven of the 15 stream sites possessed nitrate-nitrogen concentrations greater than the Ohio EPA recommended level (1.0mg/L). Total phosphorus concentrations in 5 of the 15 stream sites exceeded the level recommended by the US EPA (1.075mg/L). A review of historic lake water quality data revealed that Allen, Barrel and a Half, Hammond, Rothenberger, Shock, and Spear lakes within the Tri-County FWA and Indian Village, Hindman, Moss, Harper, and Knapp lakes in the Ten Lakes Chain all rated as eutrophic or hypereutrophic based on the Indiana Trophic State Index during the last Indiana Clean Lakes Program assessment (CLP, 2000; CLP, 2003). Furthermore, Barrel and a Half, Duely, Gordy, Hammond, Harper, Hindman, Indian Village, Knapp, Price, Rider, Rothenberger, Shock, Spear, and Wyland lakes contained phosphorus concentrations in excess of concentrations found in eutrophic lakes based on guidelines developed by Vollenweider (1975). Finally, all of the watershed lakes exceeded the USEPA recommended nutrient criteria (0.0375 mg/L) for total phosphorus. This may be an unrealistic target for many Indiana lakes as suggested by the state average (0.17 mg/L) and the average (0.092 mg/L) for lakes in the ecoregion in which the Wawasee Area Watershed is situated.

The primary cause of these problems is high levels of nutrients in the lakes' water column and within their inlet streams. Likely sources of these pollutants include fertilizers, human and animal waste, organic materials, yard waste and other plant material that reaches the waterbody, soil (nutrients are often attached to the soil), hardscape, internal lake processes, and atmospheric deposition. A tour of the watershed and mapping of the watershed revealed that all of these sources as well as some others may contribute to the eutrophication of the lake and streams in the Wawasee Area Watershed. Specific hot spots or critical areas were identified throughout the planning process (Figure 32). Management efforts aimed at reducing nutrient loading to the watershed's waterbodies should target these sources.

Stressor: Nutrients

Source: Fertilizers
Human and animal wastes
Organic materials
Soil erosion
Lake sediment

Hot spots/Critical areas: Residential land (particularly immediately adjacent to Wawasee Area Watershed waterbodies)
Livestock access to watershed waterbodies (Figure 3)
Manure disposal adjacent to waterbodies
Streambank erosion (Figure 29 and 34)
Residential lawn and agricultural fertilizer
Lack of buffers adjacent to streams or lakes (Figure 35)
Limited lakeshore buffers
Lack of buffers around tile risers in agricultural fields
Storm drains (Appendix K)
Failing septic systems (particularly adjacent to waterbodies)
Improper disposal of yard waste
Future residential development sites
In-lake sediment resuspension due to boating impact and wave action
Wetland fill/wetland loss
Boating

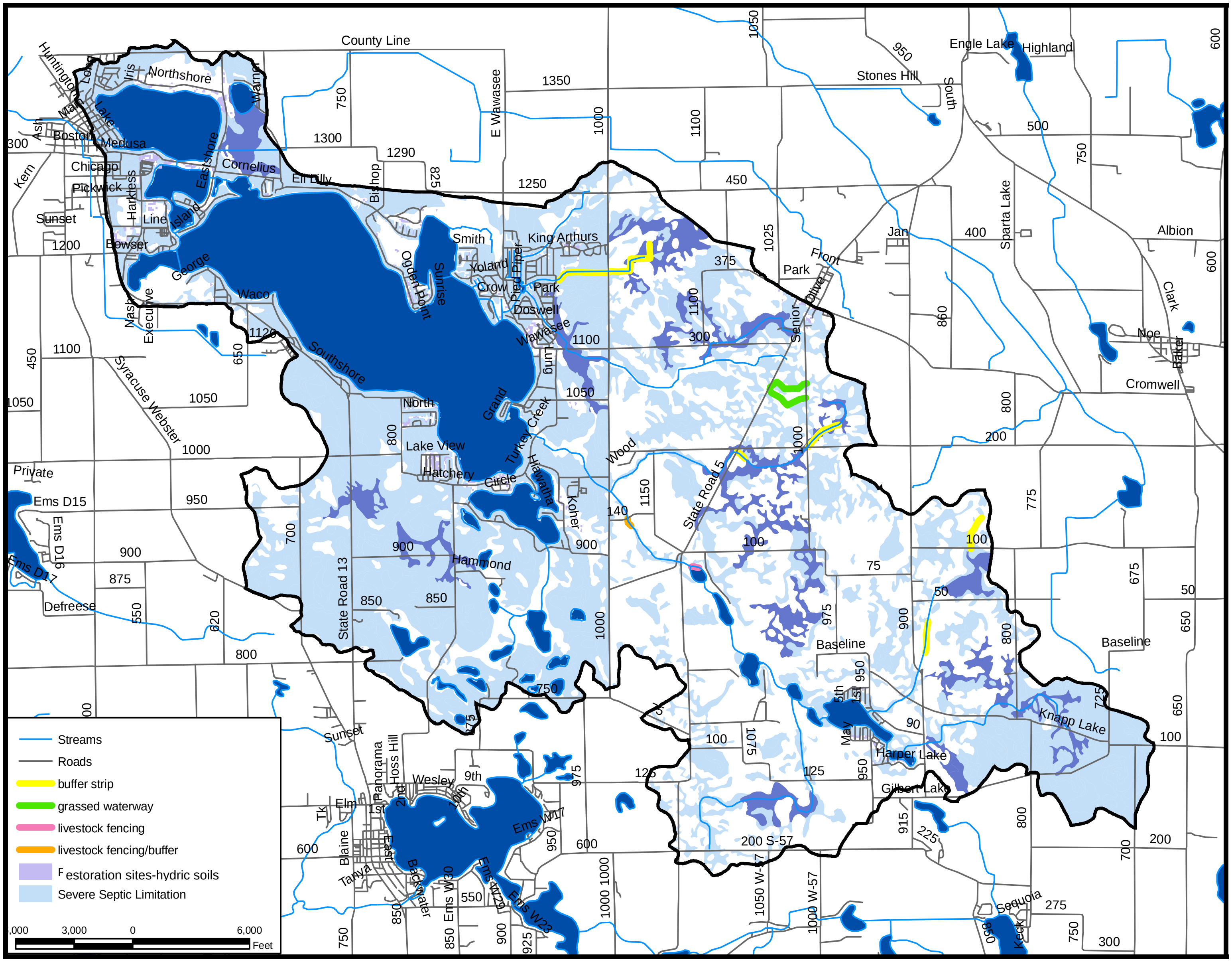

Figure 32. Critical areas targeted for nutrient loading and pathogen concentration reduction in the Wawasee Area Watershed.

Figure 33. Livestock access to Wawasee Area Watershed waterbodies.

Figure 34. Streambank erosion occurring within a Wawasee Area Watershed stream.

Figure 35. Narrow buffer adjacent to a Wawasee Area Watershed stream.

Potential Goal: We want to reduce the nutrient load reaching Lake Wawasee by 25% over the next 10 years.

Sub-Goals:

- We want to improve the trophic status of lakes within the Ten Lakes Chain so that they at a minimum score as mesotrophic using the Indiana TSI within 15 years.
- We want to improve the trophic status of lakes within the Tri-County FWA so that they score as mesotrophic using the Indiana TSI within 15 years.

Current Trophic Status (based on last assessment):

Syracuse (2006)	mesotrophic
Wawasee (2006)	mesotrophic
Papakeechie (2006)	mesotrophic

Allen (2003)	eutrophic	Indian Village (2003)	eutrophic
Barrel and ½ (2003)	hypereutrophic	Duely (2003)	oligotrophic
Hammond (2003)	eutrophic	Rider (2003)	mesotrophic
Long (1995)	mesotrophic	Gordy (2003)	mesotrophic
Price (1995)	mesotrophic	Hindman (2003)	hypereutrophic
Rothenberger (2003)	hypereutrophic	Moss (2003)	eutrophic
Shock (2003)	eutrophic	Harper (2003)	eutrophic
Spear (2000)	eutrophic	Knapp (2003)	hypereutrophic
Wyland (2000)	mesotrophic	Little Bause (2003)	mesotrophic
		Little Knapp (2003)	oligotrophic

Potential Techniques:

a. Streambank stabilization
b. Livestock exclusion from streams and lakes
c. Lakeside land management (phosphorus free fertilizer, proper pet and yard waste disposal)
d. Improve shoreline buffers
e. Reface seawalls with glacial stone/plant emergent shoreline buffer
f. Catalog storm drain locations and nutrient input; develop treatment plan
g. Install sewer systems in areas currently using septic systems
h. Complete routine septic system maintenance
i. Erosion control ordinance
j. Funneling ordinance
k. Shoreline development ordinance
l. Ditch buffers/grassed waterways
m. Open space ordinance
n. Wetland restoration (to improve water storage and nutrient filtration)
o. Littoral zone protection and wetland restoration
p. Boat size/capacity ordinance

Problem Statement 2. Silt and sediment are degrading and filling the watershed waterbodies and limiting their use for recreation, drainage, and aesthetic purposes. Poor water quality was a documented concern which, based on transparency, was confirmed for some of the lakes in the watershed, including Barrel and a Half, Duely, Indian Village, Knapp, Rothenberger, and Shock lakes. Turbidity concentrations were also elevated in some of the watershed streams including Dillon Creek and its tributaries; however, they did not exceed the accepted threshold (9.8 NTU recommended by USEPA, 2000). Total suspended solids concentrations were elevated in watershed streams during storm flow sampling; however, like turbidity, they did not exceed the accepted threshold (80 mg/L; Waters, 1998). It is estimated that loading from watershed streams contribute more than 23 tons of sediment to Lake Wawasee on an annual basis.

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 Wawasee Area Watershed. Active construction sites, active farm fields, and unvegetated streambanks are also sources of sediment in streams draining into the watershed's 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: drainage activities, streambank erosion, channel erosion, wildlife and livestock access to streams and lakes, urban development, lack of erosion control practices, over-development, and the presence of hardscape. Stakeholders also expressed concern that shoreline buffers along the lakes' edges were being removed. Watershed tours revealed specific locations where sediment or silt causes the greatest problems. Management efforts to reduce sediment input from the Wawasee Area Watershed should focus on the critical areas identified during the watershed tours (Figure 36). Furthermore, sediment accumulated at the mouths of several of the watershed's stream was also noted as a stakeholder concern.

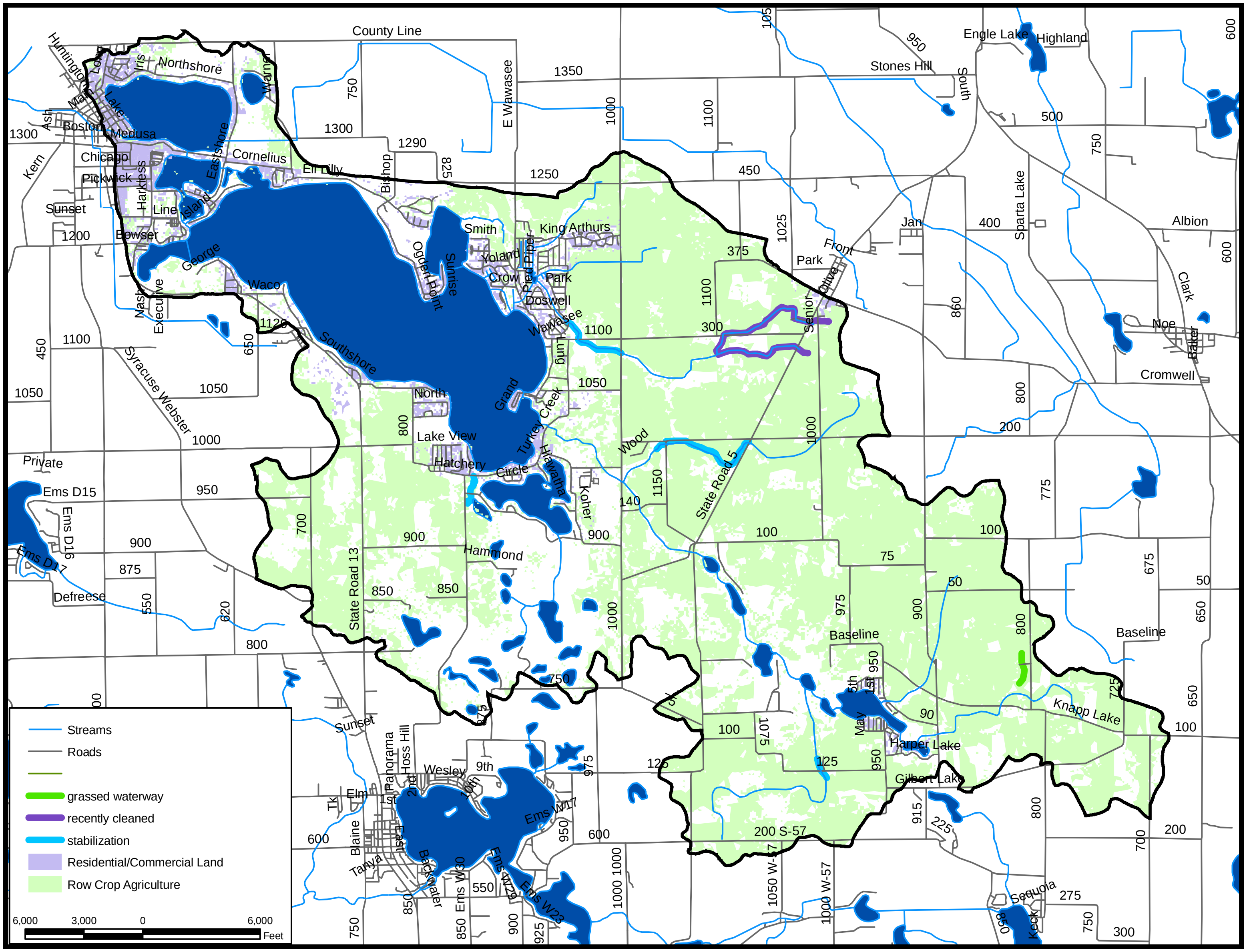

Figure 36. Critical areas targeted for sediment loading reduction in the Wawasee Area Watershed.

Stressor: Silt/sediment

Source:
Streambank erosion
Ravine erosion
Channel erosion
Active construction sites
Current land use (lack of buffers)
Changes in land use
Hydrological changes in watershed
Overland flow from agricultural fields
Lack of shoreline buffers
Wildlife and livestock access to streams and lakes
Surface runoff from residential areas
Resuspension from boating/wave action

Hot spots/Critical areas:
Residential land (particularly immediately adjacent to waterbodies)
Livestock access to watershed waterbodies
Streambank erosion
Lack of buffers adjacent to streams or lakes
Limited lakeshore buffers
Lack of buffers around tile risers in agricultural fields
Storm drains (Appendix K)
Future residential development sites
In-lake sediment resuspension due to boating impact and wave action
Wetland fill/wetland loss
Boating

Potential Goal: We want to reduce the sediment load to the waterbodies within the Wawasee Area Watershed by 50% over the next five years.

Potential Techniques:
a. Streambank stabilization
b. Ravine and gully stabilization
c. Channel stabilization
d. Erosion control ordinance
e. Ditch buffers/grassed waterways
f. Livestock exclusion from streams and lakes
g. Improve shoreline buffers
h. Reface seawalls with glacial stone/plant emergent shoreline buffer
i. Catalog storm drain locations and sediment input; develop treatment plan
j. Funneling ordinance
k. Tile buffers
l. Wetland restoration (to improve water storage and nutrient filtration)
m. Littoral zone protection and wetland restoration
n. Riparian corridor development
o. Shoreline development ordinance
p. Open space ordinance
q. Boat size and capacity ordinance

Problem Statement 3. Pathogen levels in the watershed streams are high enough to be a human health concern. *E. coli* measured in the Wawasee Area Watershed streams exceeds the state standard at all stream sampling sites during either base and storm flow sampling. Concentrations in excess of the state standard (235 colonies/100 mL) ranged from 360 to 51,000 colonies/100 mL. Of additional concern, an *E. coli* sample collected from within Lake Wawasee during the summer of 2006 exceeded the Indiana state standard. *E. coli* is used as the indicator for pathogenic organisms. The presence of elevated *E. coli* concentrations suggests the presence of other pathogens. These pathogens may impair the biota in the Wawasee Area Watershed waterbodies and limit human use of the streams. The sources of *E. coli* in the Wawasee Area Watershed have not been identified: however, wildlife, livestock, and/or domestic animal defecation; manure fertilizers; previously contaminated sediments; and failing or improperly sited septic systems are common sources of the bacteria.

Specific hot spots or critical areas were identified throughout the planning process (Figure 32). Management efforts aimed at reducing pathogen loading to the watershed's waterbodies should target these sources.

Stressor: *E. coli* (pathogens)

Source: Human and animal (domestic, livestock, wildlife) waste

Hot spots/Critical areas: Livestock access to watershed waterbodies
Manure disposal adjacent to waterbodies
Failing septic systems (particularly adjacent to waterbodies)
Wildlife access to watershed waterbodies
Waste from on-board boat restrooms

Potential Goal: We want to reduce the concentration of *E. coli* within the Wawasee Area Watershed waterbodies so that water within the streams and lakes meets the state standard for *E. coli*.

Potential Techniques:
a. Restrict livestock access to streams
b. Manure management planning
c. Address failing septic systems – particularly any immediately adjacent waterbodies
d. Septic system maintenance
e. Sewer system installation
f. Goose control
g. Pet waste control
h. Education for individuals owning on-boat restrooms

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 Wawasee Area 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 especially those that could negatively impact economic development throughout the region. Political, financial, social, and institutional road blocks were viewed as not always surmountable when trying to implement some of the projects. The stakeholders stated that they wanted results. Conservation efforts have been implemented through the Soil and Water Conservation District, Natural Resource Conservation Service, and LARE Watershed Land Treatment program; however, sediment, nutrients, and pathogens still reach the waterways.

Stressor: 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. However, there are targets for this goal. These include: residential property owners, agricultural property owners, agency personnel, and town officials

Hot spots/Critical areas: Residential property owners
Agricultural property owners not currently working with NRCS

Potential Techniques:
The subgoals identify potential techniques to meet this goal. More specific techniques will be developed during the educational plan development phase.

Potential Goal: Within five years, 50% of landowners within the Wawasee Area Watershed will attend one educational event and 25% of landowners implement one water quality improvement project.

Sub-Goal:
- We want to develop an education plan which targets a variety of topics including watershed water quality, fish consumption advisories, fertilizer and pesticide use, boating regulations, and individual's impact on water quality.
- We want to work with County officials to enact county-level ordinances that will protect and improve water quality and aesthetics within the watershed. Suggested ordinances include: funneling, erosion control, and lake use zones.
- We want to acquire high-quality properties and utilize these properties as demonstration areas for property management, riparian zone development, and wetland restoration and protection.

Problem Statement 5. Stakeholders indicated that use of lakes and development around the lakes, particularly Lake Wawasee, may be negatively impacting the lakes' water quality. The primary concerns target boat size, density, and speed and shoreline development; however, other concerns regarding lake use include users not observing eco-zone buoys, limited boating regulation enforcement, and the presence of aquatic-based exotic or invasive species. Section 5.1 (Boating Concerns) details the issues associated with high speed boating and lays out a method by which the carrying capacity can be determined for Lake Wawasee and other lake within the Wawasee Area Watershed.

Stakeholders also expressed concern over the presence of exotic species including purple loosestrife in wetlands throughout the watershed and adjacent to the lakes, Eurasian watermilfoil and curly-leaf pondweed in Syracuse Lake and Lake Wawasee, and zebra mussels in lakes throughout the watershed. The aquatic plant management plans for Syracuse Lake and Lake Wawasee guide treatment of Eurasian watermilfoil and curly-leaf pondweed in these two lakes and therefore, issues associated with these plants in these two lakes are not discussed here. However, currently there are no efforts to catalog aquatic plant communities within the Ten Lakes Chain or the Tri-County FWA lakes. If these lakes become infested with exotic or invasive species, these species will likely eventually travel to and become established within Lake Wawasee and Syracuse Lake due to the watershed's connectivity. Therefore, aquatic plant surveys are recommended for the Ten Lakes Chain and the Tri-County FWA lakes. These could be completed in concert with the next DNR fisheries surveys conducted on each lake. If exotic or invasive species or high quality species are identified, then the development of an aquatic plant management plan is recommended.

With regard to purple loosestrife and other terrestrial exotic or invasive species, WACF properties are currently being cataloged to document locations and types of exotic and invasive species. Therefore, treatment methodologies, costs, and timeframes are not laid out here. Rather than create a goal to implement this plan, the implementation of this plan is suggested as the action item associated with larger goal of creating and implementing a recreational plan for the two main lakes (Lake Wawasee and Syracuse Lake) and the entire watershed.

Stressor: Lake use

Source: Boat size, density, and speed
Exotic species
Lack of enforcement

Hot spots/Critical areas: Residents with boats
Lake users (boaters)
Boating industry/boat testing

Potential Techniques:
The subgoals identify potential techniques to meet this goal. More specific techniques will be developed during the boating use/recreational plan development phase.

Potential Goal: Maintain and improve the recreational setting of the Wawasee Area Watershed by developing and implementing a recreational management plan for Lake Wawasee and Syracuse Lake within five years.

Sub-Goals:
- Develop aquatic plan management plans for the Ten Lakes Chain and the Tri-County FWA lakes and implement the recommendations defined in these plans.
- Develop a boating use/recreation plan. A number of items should be included in this plan. The following list outlines just some of the information necessary to address boating issues on Lake Wawasee and Syracuse Lake.
    - Determine the number of users that are appropriate for the lakes.
    - Determine the size of boats appropriate for the lakes and work with the IDNR to limit the size of boats allowed on the lakes, if this is determined to be an appropriate action.

- Educate lakeshore residents and lake users in regards to Indiana's boating laws and develop a plan to ensure compliance with these laws.
- Educate lake users on the negative impacts (agitation and resuspension of sediment and nutrients from the lakebed) of boating in shallow waters.

- Implement the exotic species control measures laid out in the study recently completed by V3.

6.0 SETTING GOALS AND MAKING DECISIONS

The following goals and action plan are a result of several public meetings, which were held once monthly from March 2007 to November 2007. Once the watershed inventory was completed and the baseline water quality data was reviewed, watershed stakeholders met to identify those issues that were of greatest concern in the watershed: develop problem statements; identify sources of water quality and watershed impairment; and set goals to address those issues. The sources identified through this process are the ones targeted in the action plan. The plan includes measures to address each of the identified sources in the agricultural community and from residential and county-owned land. The plan also includes mechanisms to help identify and pinpoint additional sources where not enough existing data could be identified.

As noted above, the stakeholders prioritized the goals over the course of two public meetings. Each stakeholder prioritized the goals individually. The results of the individual prioritizations were combined to achieve a final prioritization order. Stakeholders considered the environmental, economic, and social impacts of their actions. As noted above, the action plan was designed to target the specific stressors of concern (nutrients, sediment, *E. coli*, boating/public usage, education) to improve the environmental quality of the streams and lakes in the watershed. Stakeholders took economic concerns into consideration by designing a management plan that for the most part could be implemented by active volunteers. Additionally, the monitoring of the success of the plan could also be completed by volunteers. (See the **Measuring Success** Section.) Most of the actions items that cannot be completed by a volunteer work force can qualify for funding from a known source. This funding might be used to hire a consultant to complete the work that volunteers cannot undertake. The social impact of the plan was considered in the fourth goal. Stakeholders agreed increased stakeholder education and involvement in watershed management was of primary importance. The action plan also includes a number of action items designed to increase the public's awareness of the value of the natural resources in the Wawasee Area Watershed.

The following are the prioritized goals and agreed upon action plan for the Wawasee Area Watershed. Many of the objectives and action items overlap from one goal to another. All objectives and action items are listed under the first goal where they would have positive impact. Appendix L details estimated load reductions, total volume (length or acreage), and costs (in dollars and time) as they pertain to each goal, objective, or action item. Individuals responsible for ensuring each objective is completed and a detail of the implementation schedule are included in Appendix M.

Goal 1: We want to reduce the nutrient load reaching Lake Wawasee by 25% over the next 10 years.

Sub-Goals:

- We want to improve the trophic status of lakes within the Ten Lakes Chain so that they at a minimum score as mesotrophic using the Indiana TSI within 15 years.
- We want to establish a monitoring program to assess the water quality exiting Lake Papakeechie within the next two years and establish a monitoring program for the streams entering Lake Papakeechie and the Tri-County FWA lakes within the next five years.
- We want to improve the trophic status of lakes within the Tri-County FWA so that they score as mesotrophic using the Indiana TSI within 15 years.

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.

Objective 1-A: Implement stream bank stabilization techniques within the Wawasee Area Watershed.

Actions:

- Review properties identified for streambank stabilization and identify additional sites, if possible.
- Contact the respective landowners to determine their willingness to allow streambank stabilization projects.
- Apply for IDEM Section 319 funds or IDNR LARE Program funds to implement streambank stabilization techniques within the Wawasee Area Watershed.
- Apply for IDEM Section 319 funds or IDNR LARE Program funds to implement streambank stabilization techniques within the Wawasee Area Watershed.
- Once funding is obtained, hire an engineer to complete stabilization designs.
- Once the project is designed, hire a contractor to complete structural project implementation.

Objective 1-B: Exclude livestock from streambank and lakeside access.

Actions:
- Identify properties where livestock fencing should occur.
- Work with the SWCD, 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.
- Consider providing monetary benefits to landowners who exclude livestock from waterbodies.
- Investigate opportunities for livestock exclusion ordinance.

Objective 1-C: Promote responsible lakeside land management (phosphorous free fertilizer, proper pet, yard waste disposal etc.).

Actions:
- Test soils adjacent to shoreline to determine phosphorus concentrations.
- Follow dosing recommendations for fertilizer and pesticide usage.
- Encourage the responsible use of fertilizer and pesticides near hardscape and the lakeshore.
- Investigate marketing potential for phosphorus free fertilizers. Then, develop and implement marketing plan.
- Develop list of lawn care professionals using phosphorus free fertilizer.
- Encourage landowners to frequent professionals using phosphorus free fertilizer.
- Replace turf grass with native plant buffers.
- Encourage landowners to not rake or blow organic material (grass clippings, leaves, pet or animal waste) into the lake.

Objective 1-D: Implement shoreline buffers where absent and improve existing shoreline buffers.

Actions:
- Educate shoreline homeowners about the need for shoreline buffers and their impact on water quality within Lake Wawasee, Syracuse Lake, and other watershed lakes.
- Work with the NRCS/SWCD, DNR, or contractor to develop a planting plan for the shoreline of Lake Wawasee. A forested buffer would be best as it would help reduce wind mixing and resuspension of sediments that results from this mixing. However, an herbaceous buffer would also improve on the existing conditions.
- Meet with the appropriate individuals and lake shore owners to discuss the feasibility of improving the buffer around Lake Wawasee and other watershed lakes.
- Select appropriate sites to serve as demonstration projects and determine the appropriate buffer improvement technique and plants to be planted.
- Identify and apply for funding to purchase plants and conduct planting.
- Hold a volunteer field day to complete the recommended plantings in and around Lake Wawasee and other watershed lakes.
- Develop a system of recognition for Lake Wawasee and other lakeshore residents participating in the shoreline buffer installation program.

Objective 1-E: Reface seawalls with glacial stone and plant emergent shoreline buffer.

Actions:

- Protect or plant rushes (*Juncus* spp.), sedges (*Carex* spp.), pickerel weed (*Pontederia cordata*), arrowhead (*Sagittaria latifolia*) and blue-flag iris (*Iris viginica*) for an aesthetically attractive, low profile native community in wet areas along shorelines. (See Section 5.10.2 on invasive species)
- Encourage use of rock seawalls instead of concrete.
- Encourage residents to follow IDNR guidelines which currently recommend the placement of glacial stone in front of the seawall when refurbishing old walls.
- Encourage residents to re-establish aquatic plants in front of seawalls to restore habitat in shallow water where practical.
- Implement ecological protection zones where needed to protect bulrush and other emergent plant beds from disturbance by watercraft and wave action.
- Pass local or encourage state laws which would restrict the amount of space occupied by all types of temporary structures such as piers, rafts, and trampolines, to minimize the ecological impacts of these structures as well as minimize negative effects on safety, access, and aesthetics on the lake.

Objective 1-F: Quantify pollutant (sediment, nutrients, and bacteria) loads from all storm drains that discharge to lakes within the Wawasee Area Watershed and develop treatment plan.

Actions:

- Identify all storm drains entering Lake Wawasee 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.
- Develop a treatment plan for each drain or series of drains.

Objective 1-G: 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.

Actions:

- Meet with the Elkhart, Kosciusko, and Noble County Health Department personnel to determine what, if any, actions can be taken to reduce septic system inputs to the watershed's nutrient loads.
- Work with the Elkhart, Kosciusko, and Noble County Health Departments to identify any failing septic systems in the watershed, targeting the areas noted above first.
- Investigate the usage of a "Pooper Snooper" to determine sources of sewage in the lakes.
- Develop payment plan to assist landowners with replacing their failing septic system.
- 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 1-H: Reduce erosion from active construction sites.

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, reducing 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 construction sites.

Objective 1-I: Work with County Commissioners to developing laws that limit funneling.

Objective note: The funneling issue was addressed beginning in January 2006 when the Kosciusko County's professional planning staff presented a zoning ordinance amendment that would prevent or dramatically limit funneling by residential developers. At the same time, this new zoning amendment offered an additional change to enhance erosion control enforcement. It would suspend or void building permits and added a financial penalty for those who do not maintain erosion prevention controls. This erosion control change was specifically directed at violators whose control practices threatened a nearby lake or stream. The proposed ordinance was brought before the planning commission and the County Commissioners in August and was passed by both boards.

These actions still need to be addressed in Noble and Elkhart County and therefore, are still included as object items in this watershed management plan.

Actions:

- Draft a funneling ordinance for Noble and/or Elkhart Counties.
- Appoint individual or committee to work on supporting the drafted funneling ordinance.
- Follow up on all requests for public piers and funneling to keep a record of exemptions and allowances.
- Review and provide informed comment on group pier permits through the recently updated IDNR regulations regarding use of piers by multiple households.
- Change the zoning ordinance to limit the number of single-family residences that can be platted to use one lot for lake access. (All condominiums are already required to get a variance from the Board of Zoning Appeals.)
- Actively encourage support for local anti-funneling zoning ordinances.

Objective 1-J: Work with the County Commissioners to develop a shoreline development ordinance.

Actions:

- Draft a shoreline development ordinance for all three counties.
- Appoint individuals and gather support for the development of a committee to work on supporting this draft ordinance through the proper governmental channels.
- Limit the amount and impacts of impervious surface in developments through design features such as:
  - Roadways as narrow as safety allows.
  - Porous surfaces should be considered for driveways and other hard surfaces.
  - Grassed road shoulders should replace curb and gutter systems.
  - Stormwater conduits should be disconnected where possible.
  - Roof gutters should not channel water directly to storm drains.
  - Install filtration trenches, sand filters, and wetlands to treat the first flush of phosphorus and suspended solids that enters detention basins.
  - Investigate drainage pathways for local drains, roads, parking areas, driveways, and rooftops; slow or divert water through French drains (gravel filled trenches), wetland filters, catch basins, and native plant overland swales.
  - Install and maintain roadside swales, drop catch basins or retrofit sand filters on larger drains that lead directly to the lake.
  - Use cluster housing plans and other conservation designs to reduce the amount of impervious surface in a residential development.
- Work with local authorities to develop a zoning master plan for the watershed that establishes guidelines for future development through zoning laws. It could:
  - Require specific management techniques be employed to treat storm water.
  - Set specific limits on pollutant export from the site.
  - Limit housing density in the watershed and commercial development near the lakes.
  - Include an erosion control ordinance.
  - Review recommendations from the Indiana Lakes Management Work Group.

Objective 1-K: Improve stream/ditch buffers, grassed waterways, and the use of the Conservation Reserve Program (CRP) within the Wawasee Area Watershed.

Actions:

- Form a partnership with agricultural property owners who currently utilize conservation methods to sponsor educational forums to educate other agricultural property owners on how conservation methods work and their impact on the Wawasee Area Watershed.
- Place sensitive land in CRP, particularly areas that are highly erodible, riparian zones, and farmed wetlands.
- Maintain the grassed waterway at the headwaters of the all drainage (as necessary).
- Encourage landowners to maintain and increase development of riparian corridors through use of federal Farm Bill funds, watershed land treatment funds through Lake and River Enhancement, and other funding sources.
- Consider WACF purchase and restoration of lands adjacent to streams especially at locations in the headwaters of the watershed.
- Encourage implementation of a local ordinance to require stream buffers adjacent to streams and lakes.

Objective 1-L: Work with the County Commissioners to track planning and zoning changes and to develop an open space ordinance, if necessary.

Actions:

- Regularly request the Kosciusko and Noble County Planning Departments to provide WACF notice of rezoning or variance proposals within the watershed to assure lake residents are aware of variances or zoning changes that could impact lake ecosystems.
- Review and comment on rezoning proposals around the lake and in the watershed.
- Use survey tools or other methods to determine the level of development that would be acceptable to landowners in the county.
- Designate different levels of development for different lakes (similar to the regulation of boat speed based on lake size).
- Work with the Kosciusko and Noble Planning Departments to investigate the need for open space ordinances and identify a plan of action to enact the ordinance if necessary.

Objective 1-M: Implement wetland restoration to improve water storage and nutrient filtration.

Actions:

- Identify potential wetland protection, restoration, and creation sites. Particular attention should be paid to the location of the wetland relative to adjacent waterways. See Figure 29 for targeted potential wetland restoration sites in the Wawasee Area Watershed.
- 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 1-N: Work with State and County officials to protect shallow areas and plant beds within Lake Wawasee and other watershed lakes.

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

Objective 1-O: Work with the DNR, local and state legislators and regional entities to establish a boat size and capacity ordinance for Lake Wawasee and Syracuse Lake, if necessary.

Actions:

- Conduct residential survey annually to see how lake residents view lake use
- Conduct journal and on-line search for boat carrying capacity issues
- If results from a and b above find that Wawasee Area Watershed Lakes are at or near carrying capacity then take actions to establish a legal carrying capacity of boats for Lake Wawasee and Syracuse Lake.
- Work with County and State officials to establish a carrying capacity for boats at Lake Wawasee and Syracuse Lake. This ordinance should include a provision for size, speed, and motor size. It can also include limits in boating location or lake use zones as necessary to protect shallow areas within Lake Wawasee. This will require a state law change to be enforceable.

Objective 1-P: Educate local students about lake issues through a program targeted at local classrooms.

Actions:

- Identify potential techniques that students can do personally to improve water quality within the Wawasee Area Watershed. 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 students who are lakeshore residents can complete on their own.
- Identify groups (local schools, girl/boy scouts, girls and boys club, 4-H, etc.) that may be interested in participating in the Hoosier Riverwatch or Indiana Clean Lakes Programs to sample streams and lakes throughout the watershed. Some monitoring is already completed by the WACF; however, additional assistance is always helpful
    - Identify landowners along Wawasee Area Watershed tributaries that would be willing to allow a group to conduct Hoosier Riverwatch sampling on their property. Target property owners at sites sampled during development of the watershed management plan.
    - Attend a Hoosier Riverwatch training session.

- Identify individuals willing to complete Secchi disk monitoring on lakes throughout the watershed.
- Hold a watershed-wide or county-wide training session for CLP volunteers.

Objective 1-Q: Reduce resident waterfowl populations on lakeshore properties.

See Goal 3, Object 3-G for action items related to this objective.

Goal 2: We want to reduce the sediment load to the waterbodies within the Wawasee Area Watershed by 50% over the next ten years.

Objective 2-A: Implement stream bank stabilization techniques within the Wawasee Area Watershed.

See Objective 1-A of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-B: Implement ravine and gully stabilization techniques within the Wawasee Area Watershed.

Actions:
- Contact the respective landowners to determine their willingness to allow ravine/gully stabilization projects.
- Apply for Indiana Department of Environmental Management Section 319 Supplemental funds or Indiana Department of Natural Resources Lake and River Enhancement Program funds to implement streambank stabilization techniques within the Wawasee Area Watershed.
- Apply for Indiana Department of Environmental Management Section 319 Supplemental funds or Indiana Department of Natural Resources Lake and River Enhancement Program funds to implement ravine stabilization techniques within the Wawasee Area Watershed.
- Once funding is obtained, hire an engineer to complete stabilization designs.
- Once the project is designed, hire a contractor to complete structural stabilization technique installation.

Objective 2-C: Implement channel stabilization techniques within the Wawasee Area Watershed.

Actions:
- Identify channels around Lake Wawasee that require stabilization. Efforts should target Enchanted Hills, Leeland Channel, Highland Channel, and Kanata Manayunk.
- Identify and apply for funding to design stabilization techniques.
- Hire and engineer to design stabilization techniques.
- Hire a contractor to complete stabilization.

Objective 2-D: Enact an erosion control ordinance.

See Objective 1-H of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-E: Improve stream/ditch buffers, grassed waterways, and the use of the Conservation Reserve Program (CRP) within the Wawasee Area Watershed.

See Objective 1-K of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-F: Livestock exclusion from streams and lakes

See Objective 1-B of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-G: Improve shoreline buffers.

See Objective 1-D of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-H: Reface seawalls with glacial stone/plant emergent shoreline buffer.

See Objective 1-E of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-I: Catalog storm drain locations and sediment input; develop treatment plan.

See Objective 1-F of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-J: Enact funneling ordinance.

See Objective 1-I of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-K: Wetland restoration (to improve water storage and nutrient filtration)

See Objective 1-M of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-L: Littoral zone protection and wetland restoration.

See Objective 1-N of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-M: Enhance or enlarge riparian corridors.

Objective notes: Land use of the corridor adjacent to and along the entire length of stream plays a direct role in the quality of the water and the organisms that inhabit a stream. A wide forested or grassed corridor adjacent to streams will improve both water quality and habitat.

Actions:

- Encourage landowners to maintain and increase development of riparian corridors through use of federal Farm Bill funds, watershed land treatment funds through Lake and River Enhancement, and other funding sources.
- Consider foundation purchase and restoration of lands adjacent to streams.
- Encourage property owners within the Wawasee Area Watershed to purchase and protect drainage corridors.

Objective 2-N: Shoreline development ordinance.

See Objective 1-J of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-O. Open space ordinance.

See Objective 1-L of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-P. Boat size and capacity ordinance.

See Objective 1-O of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 2-Q. Implement soil conservation practices in rural and agricultural areas.

Actions:

- Identify agricultural producers using conservation practices throughout the watershed.
- Host an annual demonstration day targeting conservation practice implementation.
- Apply for cost-share funding to install soil conservation practices.

Objective 2-R. Encourage county officials to maintain buffers along legal drains.

Actions:

- Meeting with Elkhart, Kosciusko, and Noble County Surveyors to determine the maintenance schedule for legal drains within the watershed.
- Attend one county drainage board meeting for each county annually.

Goal 3: We want to reduce the concentration of *E. coli* within the Wawasee Area Watershed waterbodies so that water within the streams and lakes meets the state standard for *E. coli* within 10 years.

Objective 3-A: Restrict livestock access to streams.

See Objective 1-B of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 3-B: Implement manure management planning.

Actions:
- Work with the county SWCD and NRCS offices to identify manure management planning needs.
- Assist the SWCD and NRCS with identifying strategies to ensure manure management occurs, as necessary.

Objective 3-C: Address failing septic systems –particularly any immediate adjacent waterbodies.

See Objective 1-G of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 3-D: Septic system maintenance.

See Objective 1-G of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 3-E: Sewer system installation.

See Objective 1-G of Nutrient Goal (Goal 1) for information and action items relative to this objective.

Objective 3-F: Establish pet and wildlife waste control measures.

Actions:
- Educate landowners regarding proper disposal of pet waste.
- Educate landowner regarding washing waterfowl droppings into the lakes.
- Establish waste disposal protocols for lakeshore properties.

Objective 3-G: Reduce resident waterfowl populations on lakeshore properties.

Actions:
- Install native vegetation to inhibit geese from entering lawns from the lake.
- Relocate geese and/or implement egg treatment.
- Coordinate with Ducks Unlimited and the local IDNR biologist to remove geese.

Goal 4: Within five years, 50% of landowners within the Wawasee Area Watershed will attend one educational event and 25% of landowners implement one water quality improvement project.

Sub-Goals:
- We want to develop an education plan which targets a variety of topics including watershed water quality, fish consumption advisories, fertilizer and pesticide use, boating regulations, and individual's impact on water quality.

- We want to work with County officials to enact county-level ordinances that will protect and improve water quality and aesthetics within the watershed. Suggested ordinances include: funneling, erosion control, and lake use zones.
- We want to acquire high-quality properties and utilize these properties as demonstration areas for property management, riparian zone development, and wetland restoration and protection.

Objective 4-A: Promote the usage of alternative fertilizers and/or the reduction in use of fertilizer.

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 Wawasee Area Watershed.

Objective 4-B: Organize and hold one annual field day highlighting the value of the streams and lakes in the Wawasee Area 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 Wawasee Area 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.
- Create an incentive-based program to encourage individuals to attend. Suggestions include: a percent reduction for fireworks contributions, rate reduction for dues renewal, etcetera.
- Organize an ecology tour of projects previously implemented within the watershed. Include projects in adjacent watersheds to highlight variety of implementation techniques.
- Obtain sponsorship from local businesses to offset demonstration or field day costs.

Objective 4-C: Publicize the value of the Wawasee Area 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 Wawasee Area Watershed in language understood by a non-technical audience.
- 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-D: 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 Wawasee Area Watershed are using conservation tillage methods and/or land conservation programs. Where possible or appropriate, assist the NRCS and SWCD in encouraging agricultural property owners 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 4-E: 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 Wawasee Area 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 4-F: Establish and maintain a watershed and water quality education table at the Elkhart, Kosciusko, and Noble County Fairs.

Actions:
- Talk with fair representatives to determine the feasibility of establishing a table or booth at the Elkhart, Kosciusko, and Noble County Fairs to target watershed and water quality education.
- Work with the NRCS, SWCD, and other area lake associations 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 fairs and provide educational information to attendees on the watershed, water quality, and the watershed management planning process.

Objective 4-G: Develop an education plan.

Actions:

- Identify a source of funding for plan development.
- Hire a consultant to develop a plan targeting all areas of educational need (water quality, boater education, individual impacts, shoreline issues, etcetera).
- Identify educational needs using a survey.
- Identify locations for educational facilities within the watershed.
- Determine funding source for facility development or creation.
- Develop and implement an education plan.

Objective 4-H: Identify and acquire high quality properties or those that offer significant water quality improvement impact.

Actions:

- Identify high quality properties or those that offer large, positive water quality improvement impact (Figure 29).
- Identify funding sources to purchase properties.
- Work with landowners to acquire access or purchase properties.
- Complete property acquisition, if possible.
- Develop restoration plan for properties on an individual basis, if necessary.
- Identify and apply for restoration funding, if necessary.
- Implement restoration plan.

Goal 5: Maintain and improve the recreational setting of the Wawasee Area Watershed by developing and implementing a recreational management plan for Lake Wawasee and Syracuse Lake within five years.

Sub-Goals:

- Develop aquatic plan management plans for the Ten Lakes Chain and the Tri-County FWA lakes and implement the recommendations defined in these plans.
- Develop a boating use/recreation plan. A number of items should be included in this plan. The following list outlines just some of the information necessary to address boating issues on the Lake Wawasee and Syracuse Lake.
  - Determine the number of users that are appropriate for the lakes.
  - Determine the size of boats appropriate for the lakes and work with the IDNR and local and state government to limit the size of boats allowed on the lakes, if this is determined to be an appropriate action.
  - Educate lakeshore residents and lake users in regards to Indiana's boating laws and develop a plan to ensure compliance with these laws.
  - Educate lake users on the negative impacts (agitation and resuspension of sediment and nutrients from the lakebed) of boating in shallow waters.
- Implement the exotic species control measures laid out in the study recently completed by V3 Companies (2007 draft).
- Implement recommendations identified within the Syracuse Lake and Lake Wawasee Aquatic Plant Management Plans.

Objective 5-A: Develop an aquatic plan management plan and implement the recommendations defined in that plan for the Ten Lakes Chain and Tri-County Fish and Wildlife Area lakes.

Objective notes: Any treatment of exotic or invasive species that occurs within the Wawasee Area Watershed will serve to reduce the spread of the exotic or invasive species within the immediate chain. However, if lakes surrounding the Wawasee Area Watershed possess resident populations of these plants, the plants will eventually re-occur within the Wawasee Area Watershed. Steps should be taken to implement aquatic plant management efforts throughout the watershed to increase the impact of plant control efforts. Initial aquatic and wetland plant surveys completed by Ball State University's aquatic plant class have not revealed any exotic species in or around lakes within the Tri-County FWA (Donald Ruch, BSU professor, personal communication).

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 lake within the Wawasee Lake Watershed and their lake associations to discuss recommendations for aquatic plant treatment within the Wawasee Area Watershed.
- 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 Wawasee Area Watershed 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. The Stop the Hitchikers! Campaign (www.protectoryourwaters.net) should be used as an educational tool.
- 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 5-B: 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 within the Wawasee Area Watershed.

Objective notes: The Lakes Management Work Group (a working group of Indiana Lake leaders) 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. 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 5-B-1: Determine the number of users that are appropriate for the lakes within the Wawasee Lake Watershed.

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 lakes within the Wawasee Lake Watershed.
- 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 resident and non-resident use of the lake.
- Monitor transient use of lake for 3 – 5 years.

Sub-Objective 5-B-2: 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 Lake and River Enhancement Fee (IC-6-6-11-12) monies available to the County Sheriff to train deputy law enforcement officers specifically for patrolling the lakes.
- Obtain funding to employ a law enforcement person.
- Host boaters education classes and advertise class availability to regional lake associations.

Sub-Objective 5-B-3: 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 5-B-4: Address fuel contamination issues, including refueling stations and boats with poorly maintained or older engines.

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 5-B-5: Track the impact of group piers, funneling, and boating speed limits on lakes throughout northern Indiana. Participate in efforts of the Indiana Lakes Management Society to reduce the negative impact of these items on lakes throughout the Wawasee Area Watershed 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 5-C: Monitor and improve the fish community within lakes of the Wawasee Area 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 Wawasee Area Watershed.
- Implement water quality improvement projects as discussed in Nutrient, Sediment, and *E.coli* Goals to assist with improving water quality within the lakes.

Objective 5-D: 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 locations, funding sources, and mounts and characteristics of sediment to be removed
- Apply for and obtain funding for sediment removal
- Apply for and obtain necessary permits for sediment removal.
- Complete sediment removal.

Objective 5-E: Objective E: Implement actions identify by V3 Companies for the control of invasive species on properties owned by WACF. More details regarding treatments and recommendations in detailed in the V3 Companies plan (2007 draft).

Actions:
- Implement biological control of purple loosestrife in the wetlands adjacent to Lake Wawasee and Syracuse Lake through the use of *Galerucella* beetles.
- Use chemical treatment methods to control isolated purple loosestrife populations within wetlands and around lakes within the Ten Lakes Chain.

- Control the small common reed populations identified within the Conklin Bay and Bonar Lake parcels of WACF properties using chemicals.
- Implement chemical control of reed canary grass populations at the identified locations and parcels. Start treatment at the low to moderate density locations with high quality wetlands, then progress to treatment within the reed canary grass monocultures identified by V3 Companies.
- Begin control of glossy buckthorn populations.
- Educate landowners, watershed residents, and lake users about the impact and varieties of exotic and invasive species.

7.0 MEASURING SUCCESS

Measuring stakeholders' success at achieving their goals and assessing progress toward realizing their vision for the Wawasee Area 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 M. 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 N.

Goal 1: We want to reduce the nutrient load reaching Lake Wawasee by 25% over the next 10 years.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2017.)

- Landowners contacted regarding streambank stabilization/buffer installation.
- Grant monies applied for and obtained for streambank stabilization.
- Filter strips, buffer strips, and streambank stabilization implemented.
- Landowners contacted regarding potential livestock exclusion.
- Plans developed for livestock exclusion.
- Funding obtained for livestock exclusion.
- Contractor for livestock exclusion installation hired.
- Properties in need of buffer installation adjacent to the lakeshore identified.
- Landowners contacted regarding shoreline buffer installation.
- Planting plan for the Lake Wawasee shoreline developed.
- Information regarding phosphorus-free fertilizer disseminated.
- List of lawn care professionals utilizing phosphorus-free fertilizer developed.
- Incentive program for phosphorus-free fertilizer use developed and implemented.
- Seawalls identified for glacial stone replacement.
- Glacial stone replacement of concrete seawalls completed.
- Contractor for goose removal identified and contacted.
- Goose removal completed.
- Potential wetland restoration sites identified.
- Landowners contacted regarding potential wetland restoration.
- Wetland restoration designed.

Goal 1 Miletones (cont.):

- Funding for wetland restoration applied for and obtained.
- 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.
- 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.
- Boating size and capacity ordinance options identified.

Goal Attainment: The goal is attained when the phosphorus load to Lake Wawasee is reduced by 25% of its current load.
Indicator to be monitored: Phosphorus load of less than 75% of the current load for each waterbody (Dillon Creek, Turkey Creek, Lake Papakeechie outlet, South Shore Tributary).
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 28.
Length of monitoring: The monitoring will occur for ten years.
Protocol: Monitoring will be conducted according to the protocol utilized this project or in accordance with the Hoosier Riverwatch protocol for measuring total phosphorus (Crighton and Hosier, 2004).
Monitoring equipment: Equipment required for total phosphorus and discharge analysis following the protocol used in this project. 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, regional IDNR staff, or contractor 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: We want to reduce the sediment load to the waterbodies within the Wawasee Area Watershed by 50% over the next ten years.

Milestones: (Except for annual or continuous tasks, this goal should be reached by 2017.)

- 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 target waterbodies in the Wawasee Area Watershed is less than 50% of its current load. This can be measured using either total suspended solids (TSS) or turbidity.
Indicator to be monitored: Sediment loading measuring 50% 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 28.
Length of monitoring: The monitoring will be conducted for ten years.
Protocol: Monitoring will be conducted according to the protocol for this project 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: 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, local IDNR staff, or contractor 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: We want to reduce the concentration of *E. coli* within the Wawasee Area Watershed waterbodies so that water within the streams and lakes meets the state standard for *E. coli* within 10 years.

Milestones: (Except for continuous or annual tasks, this is a long-term goal. The goal should be reached by 2017.)

- Manure management planning implemented.
- Resident waterfowl population control methods utilized.
- Riparian or lakeshore buffers installed.
- 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 28.
Length of monitoring: The monitoring will occur for ten years.
Protocol: Monitoring will be conducted according to the protocol for this project or utilizing the Hoosier Riverwatch protocol for measuring *E. coli* (Crighton and Hosier, 2004).

Monitoring equipment: 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, IDNR staff, or contractor 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 five years, 50% of landowners within the Wawasee Area Watershed will attend one educational event and 25% of landowners implement one water quality improvement project.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2012.)

- 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 Elkhart, Noble, and Kosciusko 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.
- Education plan developed.
- Education facility constructed or remodeled to usable status.
- High quality properties acquired.

Goal Attainment: The goal is attained when half of the landowners learn about and one-quarter of landowners implement one water quality improvement project or technique on his or her 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 Wawasee Area Watershed by developing and implementing a recreational management plan for Lake Wawasee and Syracuse Lake within five years.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2012.)

- 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 Lake Wawasee and Syracuse Lake completed.
- Boater's education course held.
- Law enforcement contacted in regards to lake patrols.
- Educational materials regarding boating in shallow water distributed.
- Information regarding the impacts of boat fuel distributed.
- Funneling, group piers, and boat speed issues information distributed.
- ILMS meetings/workshops attended.
- Dredging needs identified and addressed.

Goal Attainment: The goal is attained when an aquatic plant management plan and a recreational plan are developed and exotic species controls are implemented throughout the watershed. 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 Wawasee Area 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

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. Likewise, any efforts to restore wetlands or stabilize streambanks will likely require permits.

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 WACF will be responsible for holding and revising the Wawasee Area 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 O. This form should be returned to the WACF. The WACF 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.

9.0 CONCLUSION

The Wawasee Area Watershed is a large area in which to implement a comprehensive management plan. In order to create a manageable watershed plan, specific sources of water quality impairments had to be explicitly targeted: pathogens, nutrients, sediment, public education, and recreational management. Wawasee Area Watershed residents have long focused water quality improvement efforts on tributaries and location in and around Lake Wawasee. Through this planning process, watershed stakeholders recognized the need for water quality improvement project implementation within the headwaters of their watershed. Below (Tables 53 and 54) are summary tables of the average pollutant values across the watershed as calculated by JFNew's sampling events and the areas and types of BMPs being recommended to help attain the reduction in pollutant loads and concentrations as delineated in the outlined above.

Table 53. Average pollutant values and goal pollutant values.

	E. coli Concentration (col/100mL)	Total Nutrient Load (tons/year)	Sediment Load (tons/year)
Average Values	3,918	13.8*	13.5
Goal Value	235	10.4	6.8

** Total nutrient load is sum of 13.5 tons/year of total phosphorus and 0.3 tons/year of total nitrogen*

Table 54. BMP installation required to meeting target levels.

Best Management Practice Used	Nutrient Load	Sediment Load
Streambank stabilization	1,000 lineal feet	1,300 lineal feet
Livestock exclusion	300 lineal feet (>50 head of livestock)	
Filter strips (streams/ditches)	100 acres	75 acres

In the water quality analysis, it was noted that the tributaries to Lake Wawasee that showed the poorest water quality, and thus highlighted as "critical areas," were Dillon Creek and Turkey Creek. Although nonpoint pollution BMPs are recommended throughout the watershed, the watershed stakeholders should consider these tributaries "priority areas" where BMPs should be implemented first.

As more water quality data is collected through the implementation of this plan, the type and amount of appropriate BMPs or action items may need to change. In light of this, it will be important to remember throughout the implementation stages that this Watershed Management Plan is meant to be a "living document" that will be subject to revision as progress toward attaining goals one through four is tracked over the next five or ten years. Additional BMPs will also need to be considered that can achieve similar results to those proposed in lesser quantities and with lower associated costs.

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APPENDICES

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

APPENDIX A:

WATERSHED STAKEHOLDERS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Wawasee Area Watershed Strategic Management Plan
Watershed Stakeholder Steering Committee

Russell Anderson, Watershed Landowner
Russell Baker, Noble County NRCS
Dan Berkey, Syracuse Lake
Todd Bowen, Enchanted Hills Association
David Brandes, WACF Director
Diana Castell, Lake Wawasee
Nancy Duehmig, Syracuse Lake
Deborah Flanagan, WACF
Bob Dumford, WACF,
Ken Fetters, Knapp Lake
Sherm Goldenberg, WACF
Susan Grivas, Kosciusko County SWCD
Bob Gunn, Enchanted Hills
Jan Hackelman, Syracuse Lake
Heather Harwood, WACF
David Heckaman, Sudlow's Pier Shop
John Heckaman, WACF
Dick Kemper, Kosciusko County Surveyor
Betty Knapp, WACF
Tim Kroeker, IDEM Watershed Specialist
Tina Leatherman, WACF
Randy Mast, Lake Papakeechie
Stacey McGinnis, Noble County SWCD
Bob Myers, WACF
Doug Nusbaum, IDNR-DFW
Jed Pearson, IDNR-DFW
Cecil Rich, IDNR-DFW
Jerry Riffle, WACF
Steve Roth, Property Mgr, Tri-County FWA
Dean Schwalm, WACF
Nick Stanger, Knapp Lake
Angela Sturdevant, IDNR-DFW
Sam St. Clair, Kosciusko County NRCS
Scott Zeigler, Noble County Surveyor
Darcie Zolman, Kosciusko County SWCD

APPENDIX B:

STAKEHOLDER MEETING MINUTES

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Meeting Notes:

Wawasee Area Watershed Management Plan
Steering Committee Meeting I
March 15, 2006

Attendees: Sara Peel, JFNew; Heather Harwood, WACF Coordinator; David Brandes, WACF Chairman; Ken Fetters, WACF Land Management & Knapp Lake Rep.; Sherm Goldenberg, WACF Eco Committee and Lake Zone Rep.; Betty Knapp, WACF Eco Committee; Nick Stanger, WACF Eco Committee and Knapp Lake Rep.; Jed Pearson, IDNR Regional Fisheries Biologist; Steve Roth, IDNR Tri-County Property Manager; Susan Grivas, Kosciusko County SWCD; Tim Kroeker, IDEM; Bob Myers, WACF Eco Committee Chairman.

Attendees introduced themselves and detailed their interest in the Wawasee Area Watershed.

A brief review of the existing studies was conducted.

- Sara indicated that JFNew would be collecting fisheries reports on the Turkey Creek lakes and lakes within Tri-County Fish and Wildlife Area.
- Additional report needs were discussed including: planning documents from the Wawasee Sewer Project; reports and/or studies completed on the Turkey Creek lakes, Tri-County FWA lakes, Bonar Lake, and Lake Papakeechie; and master plan documents for Tri-County FWA.
- All individuals with report copies should forward them to Sara at JFNew for inclusion in the documentation of the existing conditions within the Wawasee Area Watershed.

Initial watershed stakeholder concerns and opinions were documented. These include:

- Wastewater treatment
  - 200 homes around Lake Wawasee are not currently connected to the sewer system;
  - Knapp Lake and others in the Turkey Creek Chain are not on sewer systems
- Development issues/concerns
  - Overdevelopment;
  - Funneling;
  - Too many piers and boats;
  - Hardscape from seawalls and housing units
- Boats
  - Deep hull boats (Rinker testing) and their impact on water quality;
  - Too many boats moving at too high of speed;
  - What process is required to change speed limits or limit the types of boats that are present on the lakes;
  - Enforcement issues-added enforcement is helping but evenings and weekends are still extremely busy
- Seawalls
  - Too many seawalls;
  - Promote refacing more seawalls with glacial stone;
  - Limit the number and type of new seawalls
  - Zoning opportunities as they relate to seawalls
  - Evaluation of impacts of refacing seawalls with glacial stone

- Storm sewers and/or storm drains
  - Effectiveness of individual storm drains;
  - Maintenance by county;
  - Location and maintenance of private drainages;
  - Need to map existing storm sewers and determine treatment requirements;
  - Underground storm drains-aerial photos document storm drains that extend up to 200 feet offshore before draining water into the lake
- Aquatic plant management
  - Small Eurasian watermilfoil beds are currently present in Lake Wawasee, continue to monitor these to track the spread of milfoil throughout the lake;
  - Is milfoil present in any of the other lakes and if so, what impact will this have on Lake Wawasee and Syracuse Lake;
  - Bulrushes behind Morrison Island (and in other areas throughout the lake) have disappeared-is this due to boating issues or changes in water quality, wave action, or other indeterminate reasons
- Eco-zones
  - Potential new eco-zone within the kettle at State Road 13;
  - Existing eco-zones-buoys are not in the lake in time; individuals boat or ski through these areas without buoys being present;
  - Need funding options to hire contractor to install buoys (Lake Manitou)
- Existing projects installed by WACF and through land treatment program
  - How are they functioning;
  - Is maintenance required;
  - Are there other areas that require treatment
- Dredging wants and/or needs
  - Enchanted Hills channel dredging and in-lake (at mouth);
  - Wawasee Harbor Estates-may require dredging
- Education
  - Need to strengthen WACF's education efforts by providing a location for education;
  - General need for lawn chemical impact, goose control, residential development, and individual residence impact on water quality education;
  - Develop an educational plan or series of presentations
- Long-term planning and zoning issues in both Noble and Kosciusko Counties
  - Seawalls,
  - Development,
  - Funneling,
  - Residential development of former agricultural lands
- Shoreline/streambank erosion
  - Streambanks along Turkey Creek,
  - within Enchanted Hills,
  - along Dillon Creek,
  - and at Martin Ditch (upstream of Leeland Channel project)
- Wetland issues
  - North end of Conklin Bay-channel dredging and wetland fill
  - Dredging/cattail removal within the kettle adjacent to SR 13, dredging has progressed into lily pad pond
  - Protection of Turkey Creek and the lakes along its length-wetlands and biodiversity

- Beaver problems
  - Upstream of State Road 5 very little fall in Turkey Creek and beavers cause ponding within the lakes;
  - Downstream of State Road 5 lots of fall and beaver dams hold back sediment
- Freshwater mussels
  - Population appears to have declined;
  - Zebra mussels impact on water quality and freshwater mussels;
  - What are the short term and long term impacts of this species
- Fisheries-has development, changes in plant bed density and diversity, boating activities, etc. impacted fisheries within the lakes
- Geese-increased numbers appearing earlier in the year;
  - Knapp Lake-sand bar area over-populated/over-utilized by geese
- Livestock issues
  - Confined feeding operation-impact on water and air quality
  - Manure management planning-needed throughout the watershed especially in the Knapp Lake area where there are often strong manure smells
  - Cows are present in Turkey Creek-Noble County side upstream of confluence with minor tributary
- Water quality concerns
  - Elevated *E. coli* readings are present in Turkey Creek and its tributary
  - July 4th activities-increased phosphorus concentrations present between Ogden Point and Vawter Park following fireworks and heavy boating activity
  - Algal blooms appear to be increasing in density and duration; first algal blooms documented a few years ago-no institutional memory of blooms occurring historically
- Syracuse Parks Department are working on a walking path; WACF property may tie in with this
- Land usage and development at WACF properties
- Water level measurements within lakes are no longer occurring; need to determine whether continued level measurements are necessary
- Changes in water storage capacity at Tri-County FWA
  - Replaced water control structure which will reduce the storage capacity on the property, more water will now discharge north to Lake Wawasee;
  - Add this site as a water quality sampling point to compare existing water quality data with data from other locations in the watershed

Meeting Notes:

Wawasee Area Watershed Management Plan
Steering Committee Meeting II
April 12, 2006

Attendees: Sara Peel, JFNew; Heather Harwood, WACF Coordinator;; Ken Fetters, WACF Land Management & Knapp Lake Rep.; Sherm Goldenberg, WACF Eco Committee and Lake Zone Rep.; Betty Knapp, WACF Eco Committee; Nick Stanger, WACF Eco Committee and Knapp Lake Rep.; Steve Roth, IDNR Tri-County Property Manager; Bob Myers, WACF Eco Committee Chairman; Todd Bowen, Enchanted Hills Rep.; Jan Hackelman; Jerry Riffle; David Heckaman, Sudlow's Pier Shop.

A detailed review of the stakeholder was conducted.

- Notations of revisions to the concerns identified during the first meeting were made. (The revised concerns list is enclosed with this mailing.)
- Previously identified issues were reviewed. Those that are still concerns were added to the overall list of concerns.

Individuals discussed their vision for Lake Wawasee and its watershed.
The following is a list of general visions:

- Clear lake
- Minimal boat traffic
- Good water quality
- Slow eutrophication
- Controlled algae blooms/plant growth
- Controlled boating (limit large draft boats)
- Multi-use for as many groups as possible
- Fishing areas/plant beds/sand bars restored to former glory
- Minimize sediment deposition (implement Best Management Practices in the watershed)
- No further development without minimal impact assessment (group government)

Potential vision statements:

- Clean lake where limitations of balanced use/muli-use are recognized and enforced
- Lake Wawasee will look like it did in 1930
- Clean lake with balanced uses
- Moderately productive lake with balanced uses
- Oligotrophic/mesotrophic lake with balanced uses
- Scenic lake with natural shoreline where use is balanced

The selected working vision uses these potential statements, but expands them to include a more balanced focus on the watershed as well:

Scenic healthy watershed with balanced uses.

Initial watershed stakeholder concerns and opinions were documented during the March 15th stakeholder meeting and updated during the April 12th stakeholder meeting. Documented concerns include:

- Wastewater treatment
  - 200 homes around Lake Wawasee are not currently connected to the sewer system;
  - Knapp Lake and others in the Turkey Creek Chain are not on sewer systems
- Development issues/concerns
  - Overdevelopment;
  - Funneling;
  - Too many piers and boats;
  - Hardscape from seawalls and housing units
  - Erosion control ordinance/Rule 5 enforcement
- Boats
  - Deep hull boats (Rinker testing) and their impact on water quality;
  - Too many boats moving at too high of speed;
  - What process is required to change speed limits or limit the types of boats that are present on the lakes;
  - Enforcement issues-added enforcement is helping but evenings and weekends are still extremely busy
  - No wake rule is not enforced, especially within channels- impact on water quality?
  - What impact do boats from individuals at the campgrounds have on boat density and usage?
- Seawalls
  - Too many seawalls;
  - Promote refacing more seawalls with glacial stone;
  - Limit the number and type of new seawalls
  - Zoning opportunities as they relate to seawalls
  - Evaluation of impacts of refacing seawalls with glacial stone
- Storm sewers and/or storm drains
  - Effectiveness of individual storm drains;
  - Maintenance by county;
  - Location and maintenance of private drainages;
  - Need to map existing storm sewers and determine treatment requirements;
  - Underground storm drains-aerial photos document storm drains that extend up to 200 feet offshore before draining water into the lake
- Aquatic plant management
  - Small Eurasian watermilfoil beds are currently present in Lake Wawasee, continue to monitor these to track the spread of milfoil throughout the lake;
  - Is milfoil present in any of the other lakes and if so, what impact will this have on Lake Wawasee and Syracuse Lake;
  - Bulrushes behind Morrison Island (and in other areas throughout the lake-bulrushes were likely more prevalent than originally discussed) have disappeared-is this due to boating issues or changes in water quality, wave action, or other indeterminate reasons
- Eco-zones
  - Potential new eco-zone within the kettle at State Road 13;
  - Existing eco-zones-buoys are not in the lake in time; individuals boat or ski through these areas without buoys being present;
  - Need funding options to hire contractor to install buoys (Lake Manitou)

- Existing projects installed by WACF and through land treatment program
  - How are they functioning;
  - Is maintenance required;
  - Are there other areas that require treatment
- Dredging wants and/or needs
  - Enchanted Hills channel dredging and in-lake (at mouth);
  - Wawasee Harbor Estates-may require dredging
  - Gordy-Hindman sand bar
  - Knapp Lake (potential)
  - Hindman Lake at the mouth of its inlet streams
- Education
  - Need to strengthen WACF's education efforts by providing a location for education;
  - General need for lawn chemical impact, goose control, residential development, and individual residence impact on water quality education;
  - Develop an educational plan or series of presentations
- Long-term planning and zoning issues in both Noble and Kosciusko Counties
  - Seawalls,
  - Development,
  - Funneling,
  - Residential development of former agricultural lands
- Shoreline/streambank erosion
  - Streambanks along Turkey Creek,
  - within Enchanted Hills,
  - along Dillon Creek,
  - and at Martin Ditch (upstream of Leeland Channel project)
- Wetland issues
  - North end of Conklin Bay-channel dredging and wetland fill
  - Dredging/cattail removal within the kettle adjacent to SR 13, dredging has progressed into lily pad pond
  - Protection of Turkey Creek and the lakes along its length-wetlands and biodiversity
- Beaver problems
  - Upstream of State Road 5 very little fall in Turkey Creek and beavers cause ponding within the lakes;
  - Downstream of State Road 5 lots of fall and beaver dams hold back sediment
- Freshwater mussels
  - Population appears to have declined;
  - Zebra mussels impact on water quality and freshwater mussels;
  - What are the short term and long term impacts of zebra mussels
- Fisheries-has development, changes in plant bed density and diversity, boating activities, etc. impacted fisheries within the lakes
- Geese-increased numbers appearing earlier in the year;
  - Knapp Lake-sand bar area over-populated/over-utilized by geese

- Livestock issues
  - Confined feeding operation-impact on water and air quality
  - Manure management planning-needed throughout the watershed especially in the Knapp Lake area where there are often strong manure smells
  - Cows are present in Turkey Creek-Noble County side upstream of confluence with minor tributary
- Water quality concerns
  - Elevated *E. coli* readings are present in Turkey Creek and its tributary
  - July 4^{th} activities-increased phosphorus concentrations present between Ogden Point and Vawter Park following fireworks and heavy boating activity
  - Algal blooms appear to be increasing in density and duration; first algal blooms documented a few years ago-historically blooms occurred; however, there is little record of bloom duration
  - Elevated total phosphorus concentration approximately 200' from mouth of the Golf Course inlet in October 2005
- Syracuse Parks Department are working on a walking path; WACF property may tie in with this
- Land usage and development at WACF properties
- Water level measurements within lakes are no longer occurring; need to determine whether continued level measurements are necessary
- Exotic species
  - WACF has an on-going survey being conducted on their properties to determine the location and density of any exotic herbaceous species
  - *Galerucella* beetles have been released within the Wawasee Area Watershed-Bob Myers will follow up with Rich Dunbar to determine location and positive/negative impact on purple loosestrife within the vicinity
- Dam maintenance needs-is the dam working efficiently and effectively
- What areas should be focused on for land acquisition? Need to update priority list.
- Auto salvage yard-close proximity to surface waters;
  - what impact does this salvage yard have on water quality
  - historic sampling yielded non detection for oil or coolant (one sample event only)
- Changes in water storage capacity at Tri-County FWA
  - Replaced water control structure which will reduce the storage capacity on the property, more water will now discharge north to Lake Wawasee;
  - Add this site as a water quality sampling point to compare existing water quality data with data from other locations in the watershed

Meeting Notes:

Wawasee Area Watershed Management Plan
Steering Committee Meeting III
May 17, 2006

Attendees: Sara Peel, JFNew; Heather Harwood, WACF Coordinator;Nick Stanger, WACF Eco Committee and Knapp Lake Rep.; Steve Roth, IDNR Tri-County Property Manager; Bob Myers, WACF Eco Committee Chairman; Todd Bowen, Enchanted Hills Rep.; Jerry Riffle; David Heckaman, Sudlow's Pier Shop; Diana Castell; David Brandes, WACF Chairman; Dan Berkey; Jed Pearson, IDNR Fisheries Biologist.

A review of water quality data collected from within the watershed lakes was conducted.

- Indiana Trophic State Index scores and general water quality parameters were discussed. These parameters included percent of the water column that was oxygenated, surface pH, transparency, total phosphorus concentrations, and ITSI scores.
- Graphs of the lakes' ITSI scores were also presented.

Questions/Comments:

- **Why is there not any data from Papakeechie included?** Papakeechie is a private lake and data has not yet been located for this lake. We're still working on obtaining available data for the lake. We will be sampling the lake as part of the watershed management plan.

- **Why is Knapp Lake's ITSI 2003 score 68?** The sample was collected in the middle of a blue-green algae bloom (>750,000 organisms/L compared to typically <50,000 organisms/L). Almost 100% of the total phosphorus present in the lake was in its soluble (usable) form. Additionally, oxygen levels indicate the presence of an oxygen-rich layer within 5 feet of the surface. This is typically observed in lakes undergoing an algae bloom.

- **What are the trophic states and what do they mean?** The lowest shown on the graphs is oligotrophic or slightly productive followed in increasing order: mesotrophic (moderately productive), eutrophic (productive), hypereutrophic (very productive).

- **What trends are apparent for Wawasee and Syracuse?** Wawasee and Syracuse lakes both possess great water quality; however, the trend suggests that water quality may be declining in these lakes. Based on information from the Indiana Clean Lakes Program, a change of 10 or more ITSI points indicates a change in water quality. This has not yet happened within either of these lakes.

- **Based on the land use and limited human impacts of the Tri-County Fish and Wildlife Area Lakes, why is their water quality poorer than that found in Syracuse, Wawasee, or the Ten Lakes Chain?** The wetland soils in which these lakes are located is a natural source of nitrogen and phosphorus. Additionally, the tall trees and wind action cause multiple mixing events to occur during the year. This means that the lakes are almost continuously mixing. Most lakes in Indiana are dimictic or mix twice (spring and fall) during the year.

- **Why is there not much water quality data reported for the Ten Lakes Chain?** Some of the lakes have only been assessed once during Indiana Clean Lakes Program history. Some of the smaller lakes have not been assessed by the DNR Division of Fish and Wildlife due to accessibility and information return (Fish in these lakes are also present within the lakes that they are attached to; an additional assessment will not yield much net information for the additional effort.) Most of the lakes are not monitored by volunteer monitors; using the CLP to train these volunteers or training them and maintaining a database internally.

The remaining time was spent prioritizing previously cataloged concerns. The results of this prioritization are included with these notes.

Meeting Notes:

Wawasee Area Watershed Management Plan
Steering Committee Meeting IV
June 14, 2006

Attendees: Sara Peel, JFNew; Heather Harwood, WACF Coordinator; Nick Stanger, WACF Eco Committee and Knapp Lake Rep.; Bob Myers, WACF Eco Committee Chairman; David Heckaman, Sudlow's Pier Shop; Diana Castell, WACF Eco Committee; David Brandes, WACF Chairman; Dan Berkey WACF Eco Committee; Nancy Deuhmig, Syracuse Lake; Betty Knapp, WACF Eco Committee Ken Fetters, WACF Land Management Committee and Knapp Lake Rep.

A review of watershed mapping completed to date was conducted.

- Stakeholders reviewed land use, soils (septic suitability, soil erodibility, hydric soil type), and wetland maps. The most recent aerial photograph (2005) was also presented.
- Stakeholders discussed wetland loss throughout the watershed and commented on the presence of various septic capacities throughout the watershed.

A discussion of data collected to date was also completed.

- Sara indicated that JFNew personnel had completed a tour of the lake and identified more than 150 storm drains around Lake Wawasee. Bob questioned whether the drains counted were just pipes at sea walls as those are simply "vents" for water from behind the sea wall. Sara indicated that these storm drains were counted along the roadside and generally discussed how the mapping was completed. Sara suggested that WACF may want to apply for a LARE grant in the future to complete a more in depth map of drains and develop specific treatment options for each of these drains. Heather, Bob, and David agreed that this should be discussed more in the future as these are mostly private drains that are not maintained. Betty and Bob indicated concern that some of these drains may actually be tied into septic systems. Nancy offered die pellets from when the Syracuse Lake Association purchased die tests to check septic systems on Syracuse Lake. Bob requested the JFNew investigate the opportunity to purchase/rent a septic leachate detector. More discussion of the storm drains and items associated with them will occur during subsequent meetings when objectives and action items are developed for this item.

- Sara questioned the best methodology for determining the number of boats on the lakes. David and Bob will contact an individual that routinely flies over the lake to have him photograph the lake. Boats will then be counted to determine the number in use at that time. JFNew will contact the BMV to determine the number of boats registered to Wawasee and Syracuse lakeshore residents. This will not be a perfect count, but will provide a rough estimate of users. A historic count of only those users directly on the lake indicated that 5000 boats were moored along the shoreline (Bob).

- David expressed that the impact of boats is more the question. What are the impacts on natural areas, habitat, and sediment with deep draft boats? Rinker testers do not know where they should be boating and even if they did, the boats they have on the lake are too large for what the lake can handle. Will Indiana change their laws? Could Wawasee be granted special status to limit size, speed, boating at specific depths (5 ft or 10 ft depth, 100 ft from shoreline, etc.)? Ultimately, what is the right number and size of boats to be on the lake? Again, this will be discussed in more detail during subsequent meetings.

- David expressed concern regarding current and future funneling issues. The Kosciusko County BZA is currently working on this issue as well. Changes in the zoning ordinances may arise from these discussions.

- Nancy reported that the Town of Syracuse reported at the Syracuse Lake Association's meeting that the Syracuse dam was unsafe. Heather and David are going to contact the Town manager to discuss this. They will also contact Dave Nance with IDNR.

The number and prioritization of larger subsets of concerns were discussed. Sara indicated that for each set of concerns, a problem statement and thus a goal would be developed. It was determined that there were too many items for which goals would need to be written. Categories were combined in the following manner to create five new categories. They are listed below in priority order.

Issue 1: Water Quality
Combines former categories: 1, 3, and 11
Includes: water quality, clarity, and depth; septic systems and sewers, storm drains

Issue 2: Shoreline/Habitat
Combines former categories: 4, 6, and 10
Includes: shoreline and in-lake habitat, aquatic plant management, nuisance wildlife and invasive species

Issue 3: Watershed Management
Combines former categories: 2 and 8
Includes: watershed management and erosion control and land usage/acquiring land

Issue 4: Community/Development/Land Use
Combines former categories: 5 and 9
Includes: urban development and local control

Issue 5: Boating/Public Usage
Combines former categories 7, 12, 13, and 14
Includes: boats and personal watercraft, community/stakeholder involvement, law enforcement and compliance, and public expectation and use of lake

These five issues will be developed into problem statements for discussion at the next meeting. These will then turn into goals for which objectives and action items will be developed during the planning process. The goal is to address all cataloged concerns with an objective or action item.

Note: An E-Coli test was taken at pier # 207 and was positive, showing approx. 2,000 colonies/100 mL. The Kosciusko County Health Department also took two E-Coli tests and both were positive, with one showing 9,600 colonies/100mL. The Health Department is going to test upstream in Enchanted Hills as well as neighboring beaches. There is concern about boats dumping sewage.

Meeting Notes:

Wawasee Area Watershed Management Plan
Steering Committee Meeting V
July 12, 2006

Attendees: Sara Peel, JFNew; Heather Harwood, WACF Coordinator; Nick Stanger, WACF Eco Committee and Knapp Lake Rep.; Bob Myers, WACF Eco Committee Chairman; Diana Castell, WACF Eco Committee; Dan Berkey WACF Eco Committee; Nancy Duehmig, Syracuse Lake; Betty Knapp, WACF Eco Committee; Ken Fetters, WACF Land Management Committee and Knapp Lake Rep; Dean Schwalm, Syracuse Lake; Bob Gunn, WACF Eco Committee; Jan Hackelman, WACF Eco Committee; Jerry Riffle, WACF Eco Committee; Gwen White, LARE Staff Biologist.

Watershed stakeholders discussed problem statements and prioritized issues. Groupings and priorities are included below:

Issue 1: External Water Quality Issues

Water Quality (total 22 concerns)
Houses (approx. 200) are not currently sewered around Lake Wawasee
We do not have an accurate map of individual drains and open drainages
Sources and impacts of E. coli have not been identified/determined
Nutrients and sediment from storm drains are not adequately addressed at the source
Ten Lakes Chain lakes are not sewered
Water quality is declining within Lake Wawasee/Syracuse Lake
Identify potential funding sources for sewer installation
The county does not maintain their storm drains around the lakes
Impacts of nutrients on water clarity/quality
Conduct a survey to determine if owners of non-sewered areas would pay for installation
Storm drains/storm sewers around the lakes
Improper use of herbicides/pesticides along the lakeshore
Individuals do not maintain their storm drains around the lakes
Water quality is declining within the Ten Lakes Chain
Sediment (decreased depth) accumulated in lakes/at stream outlets
The number of households using fertilizer adjacent to the lakes
Algae blooms are increasing in duration and intensity
Sediment is a source of nutrients that has not been addressed within the watershed
Water quality is declining within the Tri-County FWA lakes
Increased phosphorus concentrations within the lake following 4th of July fireworks
Sand bar has accumulated between Gordy-Hindman Lakes
Elevated E. coli concentration measured in Lake Wawasee (Enchanted Hills)
Papakeechie is unsewered
Little water quality data has been gathered/is readily available for Lake Papakeechie
Fish consumption advisories for watershed lakes (see note below for lakes effected)

Overall water quality issues and priorities:
1. Storm drains deliver elevated levels of phosphorus, nitrogen, and sediment to the lakes.
2. Non-sewered areas deliver elevated levels of phosphorus, nitrogen, and pathogens (*E. coli*) to the lakes.
3. Sediment and nutrients are resuspended due to boating.
4. *E. coli* concentrations exceed the state standard.
5. Fish consumption advisories limit the consumption of fish in watershed lakes; watershed residents lack information on these advisories.
6. Phosphorus concentrations could be increasing in the lakes resulting in poor transparency and increased algal blooms.
7. Sediment/silt is filling waterbodies and limiting their use.
8. Fertilizer and pesticide are used improperly/excessively adjacent to the lakes.

Lakes in the watershed with fish consumption advisories:
- Lake Wawasee-PCBs; bullhead 15+ inches in size; no more than one meal per month

Issue 2: Shoreline and Habitat Issues

Shoreline/Habitat (total 23 concerns)
Geese populations are increasing in number and are impacting water quality
Wetland fill occurring within Lake Wawasee
Impacts of aquatic plant control on water quality
Impact of zebra mussels on water quality and freshwater mussels within Lake Wawasee
Presence of exotic species (milfoil) within Lake Wawasee/Syracuse Lake/Ten Lakes Chain
Loss of fish and wildlife habitat
Beavers cause ponding to occur within Ten Lakes Chain
Loss of bulrushes from shallow areas throughout the lakes
Protection of natural shorelines and restore degraded areas
Decline in freshwater mussel population
Presence of purple loosestrife within wetlands adjacent to the lakes
Proliferation of piers, lifts, and structures within the lake
Impacts of aquatic plant control on fish community
Not enough people were interested in refacing their concrete seawall with glacial rock
Impact of sediment and nutrient controls on the aquatic plant community
The number and type of new seawalls should be limited
Existing eco-zones are not enforced (individuals ski through buoys; buoys not in on time)
Evaluation of refacing seawalls with glacial rock should continue
Need for new eco-zones (kettle at SR13)
Shoreline alteration reduces attactiveness and available habitat
Shoreline seawalls attracts greater development
Seawalls around the lake
Shoreline attractiveness declines with increasing shoreline alteration
Perpendicular piers in channels limit shoreline and increase development

Overall shoreline and habitat issues and priorities:

1. Wetland fill/wetland and littoral zone loss adjacent to the lakes, along the shoreline, and throughout the watershed.
2. Lack of natural shoreline.
3. Proliferation of unnatural structures along the shoreline.
4. Exotic species (Eurasian watermilfoil, curly-leaf pondweed, purple loosestrife, zebra mussels) presence within the lakes.
5. Increasing numbers of resident geese around the lakes.
6. Declines in freshwater mussel populations.
7. Beaver control issues.

Question: What is in "goose gone" and other goose repellants?

Goose Chase (http://www.bird-x.com/products/goose.htm)
Goose repellent made from bitter, smelly part of concord grapes to solve goose problems.

What is Goose Chase geese control? It's a biodegradable, food-grade taste aversion agent, made from a bitter tasting, smelly part of concord grapes (active ingredient methyl anthranilate). It renders food sources unpalatable and inedible to problem geese.

Issue 3: Watershed Management

Watershed Management (total 12 concerns)
Identify areas for future acquisition
Long term maintenance of new and existing watershed projects
Location and density of exotic species on WACF properties
Pinpoint problem areas within the watershed
Development of WACF property for public use
Enforcement of erosion control ordinances (Rule 5)
Shoreline and streambank erosion should be addressed
Manure management planning is necessary throughout the watershed
Presence of livestock within watershed lakes and streams
Identify landowners willing to install erosion control/water quality improvement projects
Impact of confined feeding operations on water and air quality
Impact of auto salvage yard on lake quality

Overall shoreline and habitat issues and priorities:

1. Livestock access and impact of confined operations to watershed waterbodies
2. Shoreline erosion and development (Rule 5 enforcement)
3. Streambank erosion
4. Future acquisitions
5. Maintenance and use of WACF properties
6. Coordination with watershed-wide lake groups
7. Impact of auto salvage yard on watershed water quality

Meeting Notes:

Wawasee Area Watershed Management Plan
Steering Committee Meeting VI
August 16, 2006

Attendees: Sara Peel, JFNew; Heather Harwood, WACF Coordinator; Bob Myers, WACF Eco Committee Chairman; Diana Castell, WACF Eco Committee; Nancy Duehmig, Syracuse Lake; Betty Knapp, WACF Eco Committee; Ken Fetters, WACF Land Management Committee and Knapp Lake Rep; Dean Schwalm, Syracuse Lake; Jan Hackelman, WACF Eco Committee; Jerry Riffle, WACF Eco Committee; David Brandes, WACF Chairman; Jed Pearson, IDNR Regional Fisheries Biologist; Susan Grivas, Kosciusko County SWCD; Todd Bowen, WACF Eco Committee and Enchanted Hills Representative.

Watershed stakeholders discussed problem statements and prioritized issues. Groupings and priorities are included below:

Issue 4: Community/Development/Land Use Issues

Community/Development/Land Use (total 12 concerns)
County disregard for zoning impact on lakes (county interest differs from lake interests)
The funneling of additional people to Lake Wawasee/Syracuse Lake should be addressed.
County commissioners lack perspective necessary for water quality improvement
Additional housing units will be additional boaters to the lakes.
Lake management plans should be considered in development of county land use plans
The number of people using the lake
Develop common objectives with individuals distributing funds for land use/water quality improvement
Number of houses around Lake Wawasee/Syracuse Lake
Lake resident's concerns need to be heard/understood at zoning meetings
Erosion control ordinances are not followed or enforced.
Hardscape from housing units/seawalls impair water quality.
Impact of individuals using campgrounds around the lake on water quality

Overall community and development issues:
1. Zoning/planning commission interest and lake resident interest do not match.
2. Funneling of additional residents/lake users to the lake needs to be controlled.
3. Too large of a percentage of the shoreline is covered by hardscape and erosion control ordinances are not enforced.
4. Too many residences are located around the lakes.

Some ways to influence zoning and planning commission activities in Kosciusko and Noble Counties was discussed. As a seat is potentially opening on the zoning and/or planning boards, WACF should investigate options for filling that seat with a lake resident or lake activist. This will allow the lakes' opinion to be represented on these boards. The model used by the Lagrange County Lakes Council and several lakes in Michigan were discussed.

Note: It was determined during the meeting that boating and public usage were one issue and education needs were a separate issue. These two sets of concern are therefore divided into issues 5 and 6.

Issue 5: Boating and Public Usage Issues

Boating/Public Usage (total 14 concerns)
Public disregard for how their actions affect the lakes
Agitation of nutrients in lake bed by power boating in shallow areas
Speed limits around the lakes need to be reduced
Public overuse and abuse of the lake
Deep hull boats (and boat testing) are impairing water quality
More enforcement is required on evenings and weekends to enforce speed limits
Number of boats on lakes
Boaters do not follow rules (number of people, speed limits)
Fuel contaminating the lakes
No wake zones are not enforced within the channels
Noise from jet skis or loud boats
Boaters do not respect other individual's use of the lakes
Dam is not maintained as necessary
Law enforcement compliance

Overall boating and public usage issues:
1. Increasing numbers of and types of boats on the lake are not appropriate for the lake's depth and shape.
2. Boaters lack respect of boating regulations and enforcement is required to correct this.
3. Law enforcement (sound) and compliance (speed) is lacking.
4. Maintenance of the lakes' water control structure is necessary to maintain the existing lake water level and condition.
5. The number of individuals and water craft presently using the lake is at inappropriate levels.

Issue 6: Education Issues

Education (total 5 concerns)
Strengthen WACF's education effort
Develop an education plan and facility
Public has unrealistic expectations for quality and use of the lake
Tie Town of Syracuse's walking path in with WACF owned properties
Visitors or weekend boaters are unaware of watercraft rules

Overall education issues:
1. An education plan needs to be developed and an education facility for administration of the plan needs to be obtained.
2. Individual's lack knowledge on their impact to the lakes' water quality.
3. Boaters are not aware of and do not observe boating rules and regulations.

Maps of stream water quality data were distributed and data discussed. The following items were included in the review:

- The main parameters were identified as listed on the maps. These include: flow (how fast the water is moving), DO (dissolved oxygen), NO_3-N (nitrate-nitrogen: the dissolved portion of nitrogen), TP (total phosphorus: the particulate and dissolved phosphorus), TSS (total suspended solids), and E. coli (indicator of pathogens).
- Almost all E. coli concentrations were in excess of the Indiana state standard (235 colonies/100 mL). The only exceptions to this were the outlet of Dillon Creek at the lake during both storm and base flow and Turkey Creek at SR 5 during base flow.
- The elevated E. coli concentrations present throughout Noble County sites were also of concern. A copy of the data will be forwarded to the Noble County Health Department and their participation in the next stakeholder meeting will be requested.
- Nitrate-nitrogen concentrations exceeded the state standard for drinking water (10 mg/L) in Launer Ditch during base flow and were elevated but not above the standard during storm flow. Most nitrate-nitrogen concentrations were in excess of levels recommended for aquatic biota.
- Total phosphorus concentrations were also elevated at most sites. Many exceeded levels recommended for aquatic biota and levels at which eutrophication occurs.

Stakeholders were asked to review the data and if anyone had questions or concerns to please contact Sara or bring the concerns to the next meeting.

A draft set of problem statements with sources, critical areas, and potential goals and action items were distributed. Stakeholders were requested to read this information, write down any comments or concerns, and be prepared to discuss these issues at the next meeting. If anyone who was not in attendance would like a copy, please contact Sara prior to next month's meeting.

<u>Meeting Notes:</u>

Wawasee Area Watershed Management Plan
Steering Committee Meeting VII
September 13, 2006

Attendees: Sara Peel, JFNew; Heather Harwood, WACF Coordinator; Bob Myers, WACF Eco Committee Chairman and WACF Board member; Diana Castell, WACF Eco Committee; Nancy Duehmig, Syracuse Lake Association and WACF Board member; Betty Knapp, WACF Eco Committee and WACF Board member; Dean Schwalm, Syracuse Lake and WACF Eco Committee; David Brandes, WACF Chairman; Todd Bowen, WACF Eco Committee and Enchanted Hills Representative; Dan Berkey, WACF Eco Committee and WACF Board member; Dick Kemper, Kosciusko County Surveyor; Nick Stanger, WACF Eco Committee and Knapp Lake Representative; and Deborah Flanagan, WACF Eco Committee and WACF Board member.

Dick Kemper provided an overview of his role within the county and recent developments of the anti-funneling ordinance.

Stakeholders discussed the draft set of problem statements with sources, critical areas, and potential goals and action items that were distributed during the previous meeting.

Stakeholders also discussed data provided in the linking concerns to existing data table. Areas of concern or discussion included:

- The need for sediment loading reduction/stream stabilization along the ditch draining to Village Lake on WACF property. JFNew agreed to walk the length of the drain to determine what, if any, projects could be completed.
- Lake Papakeechie-no erosion control along shoreline; lack of septic system control or enforcement. Both of these are a big concern based on the subwatershed's contribution of 15% of Lake Wawasee's water.
- The location and presence of county-maintained drains was also discussed. There are a limited number of these in Kosciusko County; however, there are a large number of drains in Noble County.
- *E. coli* concentrations in the South Shore drainage. Based on its small size, it was thought that there shouldn't be a lot going into this drain which would contribute to elevated E. coli concentrations. However, the drain starts as a large length of drainage tile before flowing into a couple of ponds on the golf course. The presence of large numbers of water fowl adjacent to these ponds may be a source of *E. coli*. JFNew will get permission from the landowners and walk this drain as well to determine what, if anything, can be done to improve water quality.
- There are large numbers of livestock within the Turkey Creek drainage that are allowed direct access to the stream and other waterbodies (Duely Lake, Village Lake). Livestock restriction is imperative.
- How do we get more fertilizer companies to utilize P-free fertilizer? Target the lawn companies, offer an incentive to those companies that change. Why don't they use P-free fertilizer already-is it due to effectiveness or lack thereof or is P-free fertilizer more expensive? JFNew will follow up on these questions.

Finally, stakeholders reviewed the potential goals and sub-goals. The following pages detail the change as made during the meeting. These goals will be used for plan development.

Potential Goal: We want to reduce the nutrient load reaching Lake Wawasee by 25% over the next 10 years.
Sub-Goals:

- We want to improve the trophic status of lakes within the Ten Lakes Chain so that they at a minimum score as mesotrophic using the Indiana TSI within 15 years.
- We want to establish a monitoring program to assess the water quality exiting Lake Papakeechie within the next two years and establish a monitoring program for the streams entering Lake Papakeechie and the Tri-County FWA lakes within the next five years.

Deleted: We want to improve the trophic status of lakes within the Tri-County FWA so that they score as mesotrophic using the Indiana TSI within 15 years.

Potential Techniques:

a. Streambank stabilization
b. Livestock exclusion from streams and lakes
c. Lakeside land management (phosphorus free fertilizer, proper pet and yard waste disposal)
d. Improve shoreline buffers
e. Reface seawalls with glacial stone/plant emergent shoreline buffer
f. Catalog storm drain locations and nutrient input; develop treatment plan
g. Install sewer systems in areas currently using septic systems
h. Complete routine septic system maintenance
i. Erosion control ordinance
j. Funneling ordinance
k. Shoreline development ordinance
l. Ditch buffers/grassed waterways
m. Open space ordinance
n. Wetland restoration (to improve water storage and nutrient filtration)
o. Littoral zone protection and wetland restoration
p. Boat size/capacity ordinance
q. Education (develop a program targeted at local classrooms)

Potential Goal: We want to reduce the sediment load to the waterbodies within the Wawasee Area Watershed by 50% over the next ten years.

Deleted: five

Potential Techniques:

a. Streambank stabilization
b. Ravine and gully stabilization
c. Channel stabilization
d. Erosion control ordinance
e. Ditch buffers/grassed waterways
f. Livestock exclusion from streams and lakes
g. Improve shoreline buffers
h. Reface seawalls with glacial stone/plant emergent shoreline buffer
i. Catalog storm drain locations and sediment input; develop treatment plan
j. Funneling ordinance
k. Ditch buffers/grassed waterways
l. Wetland restoration (to improve water storage and nutrient filtration)
m. Littoral zone protection and wetland restoration
n. Riparian corridor development
o. Shoreline development ordinance
p. Open space ordinance

q. Boat size and capacity ordinance

Potential Goal: We want to reduce the concentration of *E. coli* within the Wawasee Area Watershed waterbodies so that water within the streams and lakes meets the state standard for *E. coli*.

Potential Techniques:

a. Restrict livestock access to streams
b. Manure management planning
c. Address failing septic systems – particularly any immediately adjacent waterbodies
d. Septic system maintenance
e. Sewer system installation
f. Goose control
g. Pet waste control

Potential Goal: Within five years, 50% of landowners within the Wawasee Area Watershed will attend one educational event and 25% of landowners implement one water quality improvement project.

Sub-Goals:

- We want to develop an education plan which targets a variety of topics including watershed water quality, fish consumption advisories, fertilizer and pesticide use, boating regulations, and individual's impact on water quality.
- We want to work with County officials to enact county-level ordinances that will protect and improve water quality and aesthetics within the watershed. Suggested ordinances include: funneling, erosion control, and lake use zones.
- We want to acquire high-quality properties and utilize these properties as demonstration areas for property management, riparian zone development, and wetland restoration and protection.

Potential Goal: Maintain and improve the recreational setting of the Wawasee Area Watershed by developing and implementing a recreational management plan for Lake Wawasee and Syracuse Lake within five years.

Sub-Goals:

- Develop aquatic plant management plans for the Ten Lakes Chain and the Tri-County FWA lakes and implement the recommendations defined in these plans.
- Develop a boating use/recreation plan. A number of items should be included in this plan. The following list outlines just some of the information necessary to address boating issues on the Lake Wawasee and Syracuse Lake.
  - Determine the number of users that are appropriate for the lakes.
  - Determine the size of boats appropriate for the lakes and work with the IDNR to limit the size of boats allowed on the lakes, if this is determined to be an appropriate action.
  - Educate lakeshore residents and lake users in regards to Indiana's boating laws and develop a plan to ensure compliance with these laws.
  - Educate lake users on the negative impacts (agitation and resuspension of sediment and nutrients from the lakebed) of boating in shallow waters.

APPENDIX C:

ENDANGERED, THREATENED, AND RARE SPECIES LIST, WAWASEE AREA WATERSHED AND ELKHART, KOSCIUSKO, AND NOBLE COUNTIES

WAWASEE AREA WATERSHED MANAGEMENT PLAN ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Endangered, threatened and rare species and significant areas documented from the Lake Wawasee Watershed, Noble, Kosciusko and Elkhart Counties, Indiana

TYPE	SPECIES NAME	COMMON NAME	FED	STATE	TOWN RANGE	DATE	COMMENTS
Amphibian	Necturus maculosus	Common mudpuppy		SSC	034N007E 16 SWQ SEQ NEQ	1989-06	
Bird	Ardea herodias	Great Blue Heron			034N008E 28 SEQ NWQ	1990-04-29	
Bird	Ardea herodias	Great Blue Heron			034N008E 27 NWQ	1993-04-20	
Fish	Acipenser fulvescens	Lake Sturgeon		SE	034N007E 23 SH SH SEQ	1991-05-10	
Fish	Coregonus artedi	Cisco		SSC	034N008E 32 SEQ SEQ SWQ	1990	
Fish	Coregonus artedi	Cisco		SSC	033N008E 04 SH	1975	
Fish	Coregonus artedi	Cisco		SSC	033N008E 05 SH NEQ	1975	
Fish	Coregonus artedi	Cisco		SSC	034N008E 21 NEQ NEQ	1955	
Fish	Notropis heterolepis	Blacknose Shiner			034N007E LAKE WAWASEE AREA.	1985-09-07	
Fish	Notropis heterolepis	Blacknose Shiner			034N007E 04	1985-09-07	
Reptile	Clemmys guttata	Spotted Turtle		SE	034N007E LAKE WAWASEE	1953	
Reptile	Emydoidea blandingii	Blanding's Turtle		SE	034N007E LAKE WAWASEE AREA	NO DATE	
Reptile	Emydoidea blandingii	Blanding's Turtle		SE	034N007E 16 NWQ SEQ	1989-06-12	
High Quality Natural Community	Lake - lake	Lake		SG	033N007E 01 SWQ	NO DATE	
High Quality Natural Community	Wetland - bog acid	Acid Bog		SG	033N008E 12 NEQ	1979	
High Quality Natural Community	Wetland - bog acid	Acid Bog		SG	033N008E 09 NWQ SEQ	1979	
High Quality Natural Community	Wetland - bog circumneutral	Circumneutral Bog		SG	034N008E 31 SEQ SEQ	1984-10-02	
High Quality Natural Community	Wetland - marsh	Marsh		SG	033N007E 01 SWQ	1983-03-01	
High Quality Natural Community	Wetland - meadow sedge	Sedge Meadow		SG	034N007E 024 SH	NO DATE	
High Quality Natural Community	Wetland - swamp shrub	Shrub Swamp		SG	033N008E 12 NEQ	1979	
Insect Lepidoptera	Euphydryas phaeton	Baltimore		SR	034N008E 16	1930-06-26	
Vascular Plant	Linnaea borealis	Twinflower		SX	034N008E 31 N HALF SEQ SEQ	1916-09	
Vascular Plant	Andromeda glaucophylla	Bog Rosemary		SR	033N008E 12 CTR SH NEQ	1993-06	
Vascular Plant	Vaccinium oxycoccos	Small Cranberry		ST	033N008E 12 SH NEQ	1993	

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Endangered, threatened and rare species and significant areas documented from the Lake Wawasee Watershed, Noble, Kosciusko and Elkhart Counties, Indiana

TYPE	SPECIES NAME	COMMON NAME	FED	STATE	TOWN RANGE	DATE	COMMENTS
Vascular Plant	Myriophyllum verticillatum	Whorled Water-milfoil		SR	034N007E 11	1985-08-14	
Vascular Plant	Utricularia cornuta	Horned Bladderwort		ST	033N008E 10	1938-07-16	
Vascular Plant	Pyrola rotundifolia var. americana	American Wintergreen		SR	034N008E 31 SEQ SEQ	1984-10-02	
Vascular Plant	Scirpus subterminalis	Water Bulrush		SR	034N007E 08	1934-07	
Vascular Plant	Triglochin palustris	Marsh Arrow-grass		SR	033N008E 09	1938-07	
Vascular Plant	Tofieldia glutinosa	False Asphodel		SR	034N007E LAKE WAWASEE AREA	NO DATE	
Vascular Plant	Potamogeton oakesianus	Oakes Pondweed		SE	034N007E 11	1985-08-14	
Vascular Plant	Potamogeton richardsonii	Redheadgrass		SR	034N007E 11	1985-08-14	
Vascular Plant	Potamogeton strictifolius	Straight-leaf Pondweed		ST	034N007E 08	1934-07	
Vascular Plant	Potamogeton strictifolius	Straight-leaf Pondweed		ST	034N007E 24	1935-07	
Vascular Plant	Scheuchzeria palustris ssp. americana	American Scheuchzeria		SE	033N008E 09	1938-08-15	
Vascular Plant	Matteuccia struthiopteris	Ostrich Fern		SR	034N008E 31 SEQ SEQ	1984-10-02	
GREIDER'S WOODS NATURE PRESERVE							
Vascular Plant	Juglans cinerea	Butternut		WL	034N007E 36 SEQ	NO DATE	
MERRY LEA ENVIRONMENTAL CENTER							
Vascular Plant	Calla palustris	Wild Calla		SE	033N008E 12	1938-07-02	
MERRY LEA NATURE PRESERVE ADDITION							
Bird	Wilsonia citrina	Hooded Warbler		SSC	033N008E 12	2004-06-20	
High Quality Natural Community	Forest - upland dry-mesic	Dry-mesic Upland Forest		SG	033N008E 12	1980	
TRI - COUNTY STATE FISH AND WILDLIFE AREA							
Bird	Dendroica cerulea	Cerulean Warbler		SSC	033N007E 02 NEQ	1994-06-18	
Fish	Coregonus artedi	Cisco		SSC	034N007E 34 EH SEQ SEQ & SEQ NEQ SEQ	1955	
Mammal	Condylura cristata	Star-nosed Mole		SSC	033N007E 2 MI NW OF NORTH WEBSTER	1959-10	
Mammal	Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	034N007E 34	1955-07-20	
Mammal	Taxidea taxus	American Badger			034N007E 34 NWQ NEQ	1993-04-06	
High Quality Natural Community	Forest - upland mesic	Mesic Upland Forest		SG	034N007E 36 SEQ NWQ SEQ	1980	
Vascular Plant	Bidens beckii	Beck Water-marigold		ST	033N007E TRI-COUNTY FWA	1962-07	
Vascular Plant	Bidens beckii	Beck Water-marigold		ST	033N007E 02 NWQ SEQ NEQ	1979-08	
Vascular Plant	Bidens beckii	Beck Water-marigold		ST	033N007E 02 NWQ SEQ	1985-08-02	
Vascular Plant	Geranium bicknellii	Bicknell Northern Crane's-bill		SE	034N008E 31 SEQ	1931-07-25	
Vascular Plant	Potamogeton friesii	Fries' Pondweed		ST	034N007E 35	1962-06	

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Endangered, threatened and rare species and significant areas documented from the Lake Wawasee Watershed, Noble, Kosciusko and Elkhart Counties, Indiana

TYPE	SPECIES NAME	COMMON NAME	FED	STATE	TOWN RANGE	DATE	COMMENTS
Vascular Plant	Potamogeton friesii	Fries' Pondweed		ST	033N007E 02	1962-06	
Vascular Plant	Potamogeton strictifolius	Straight-leaf Pondweed		ST	034N007E 36	1963-05	
WAWASEE WETLANDS NATURE PRESERVE							
High Quality Natural Community	Lake - lake	Lake		SG	034N007E 15 NEQ	1980	
High Quality Natural Community	Wetland - marsh	Marsh		SG	034N007E 15 NEQ	1980	
High Quality Natural Community	Wetland - meadow sedge	Sedge Meadow		SG	034N007E 15 NEQ	1980	

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Indiana County Endangered, Threatened and Rare Species List

County: Elkhart

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Venustaconcha ellipsiformis	Ellipse		SSC	G3G4	S2
Mollusk: Gastropoda					
Campeloma decisum	Pointed Campeloma		SSC	G5	S2
Insect: Coleoptera (Beetles)					
Nicrophorus americanus	American Burying Beetle	LE	SX	G2G3	SH
Insect: Lepidoptera (Butterflies & Moths)					
Apamea lignicolora	The Wood-colored Apamea		ST	G5	S1S2
Apamea nigrior	Black-dashed Apamea		SR	G5	S2S3
Capis curvata	A Noctuid Moth		ST	G4	S2S3
Catocala praeclara	Praeclara Underwing		SR	G5	S2S3
Crambus girardellus	Orange-striped Sedge Moth		SR	GNR	S2S3
Dasychira cinnamomea	A Moth		SR	G4	S1
Exyra rolandiana	Pitcher Window Moth		SE	G4	S1S2
Iodopepla u-album	A Noctuid Moth		SR	G5	S2
Leucania multilinea			ST	G5	S1S2
Macrochilo absorptalis	A Moth		SR	G4G5	S2S3
Macrochilo hypocritalis	A Noctuid Moth		SR	G4	S2
Melanomma auricinctaria	Huckleberry Eye-spot Moth		SR	G4	S2S3
Papaipema appassionata	The Pitcher Plant Borer Moth		SE	G4	S1
Papaipema speciosissima	The Royal Fern Borer Moth		ST	G4	S2S3
Insect: Odonata (Dragonflies & Damselflies)					
Sympetrum semicinctum	Band-winged Meadowhawk		SR	G5	S2S3
Insect: Tricoptera (Caddisflies)					
Setodes oligius	A Caddisfly		SE	G5	S1
Fish					
Coregonus artedi	Cisco		SSC	G5	S2
Moxostoma carinatum	River Redhorse			G4	S3
Moxostoma valenciennesi	Greater Redhorse		SE	G4	S2
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Clonophis kirtlandii	Kirtland's Snake		SE	G2	S2
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Macrochelys temminckii	Alligator Snapping Turtle		SE	G3G4	S1
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Bird					
Ardea herodias	Great Blue Heron			G5	S4B
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Botaurus lentiginosus	American Bittern		SE	G4	S2B
Certhia americana	Brown Creeper			G5	S2B
Circus cyaneus	Northern Harrier		SE	G5	S2
Cistothorus palustris	Marsh Wren		SE	G5	S3B
Cistothorus platensis	Sedge Wren		SE	G5	S3B
Empidonax alnorum	Alder Flycatcher			G5	S2B
Grus canadensis	Sandhill Crane	No Status	SSC	G5	S2B,S1N
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Rallus elegans	King Rail		SE	G4	S1B
Rallus limicola	Virginia Rail		SE	G5	S3B
Mammal					
Condylura cristata	Star-nosed Mole		SSC	G5	S2?
Lynx rufus	Bobcat	No Status		G5	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					

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SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

Indiana County Endangered, Threatened and Rare Species List

County: Elkhart

Species Name	Common Name	FED	STATE	GRANK	SRANK
Actaea rubra	Red Baneberry		SR	G5	S2
Amelanchier humilis	Running Serviceberry		SE	G5	S1
Andromeda glaucophylla	Bog Rosemary		SR	G5	S2
Arabis drummondii	Drummond Rockcress		SE	G5	S1
Arabis missouriensis var. deamii	Missouri Rockcress		SE	G4G5QT3?Q	S1
Arenaria stricta	Michaux's Stitchwort		SR	G5	S2
Aster borealis	Rushlike Aster		SR	G5	S2
Besseya bullii	Kitten Tails		SE	G3	S1
Carex bebbii	Bebb's Sedge		ST	G5	S2
Carex debilis var. rudgei	White-edge Sedge		SR	G5T5	S2
Carex straminea	Straw Sedge		ST	G5	S2
Chimaphila umbellata ssp. cisatlantica	Pipsissewa		ST	G5T5	S2
Eleocharis equisetoides	Horse-tail Spikerush		SE	G4	S1
Eleocharis robbinsii	Robbins Spikerush		SR	G4G5	S2
Epigaea repens	Trailing Arbutus		WL	G5	S3
Eriocaulon aquaticum	Pipewort		SE	G5	S1
Eriophorum gracile	Slender Cotton-grass		ST	G5	S2
Eriophorum viridicarinatum	Green-keeled Cotton-grass		SR	G5	S2
Fuirena pumila	Dwarf Umbrella-sedge		ST	G4	S2
Geranium robertianum	Herb-robert		ST	G5	S2
Gnaphalium macounii	Winged Cudweed		SX	G5	SX
Iliamna remota	Kankakee Globe-mallow		SE	G1Q	S1
Juniperus communis	Ground Juniper		SR	G5	S2
Linum striatum	Ridged Yellow Flax		WL	G5	S3
Lycopodium hickeyi	Hickey's Clubmoss		SR	G5	S2
Lycopodium obscurum	Tree Clubmoss		SR	G5	S2
Malaxis unifolia	Green Adder's-mouth		SE	G5	S1
Matteuccia struthiopteris	Ostrich Fern		SR	G5	S2
Milium effusum	Tall Millet-grass		SR	G5	S2
Pinus strobus	Eastern White Pine		SR	G5	S2
Platanthera leucophaea	Prairie White-fringed Orchid	LT	SE	G3	S1
Platanthera psycodes	Small Purple-fringe Orchis		SR	G5	S2
Poa paludigena	Bog Bluegrass		WL	G3	S3
Psilocarya scirpoides	Long-beaked Baldrush		ST	G4	S2
Pyrola rotundifolia var. americana	American Wintergreen		SR	G5	S2
Quercus prinoides	Dwarf Chinquapin Oak		SE	G5	S1
Rhynchospora macrostachya	Tall Beaked-rush		SR	G4	S2
Scirpus purshianus	Weakstalk Bulrush		SR	G4G5	S1
Selaginella rupestris	Ledge Spike-moss		ST	G5	S2
Spiranthes lucida	Shining Ladies'-tresses		SR	G5	S2
Stipa avenacea	Blackseed Needlegrass		SR	G5	S2
Tofieldia glutinosa	False Asphodel		SR	G5	S2
Utricularia cornuta	Horned Bladderwort		ST	G5	S2
Utricularia minor	Lesser Bladderwort		ST	G5	S1
Utricularia purpurea	Purple Bladderwort		SR	G5	S2
Vaccinium oxycoccos	Small Cranberry		ST	G5	S2
Xyris difformis	Carolina Yellow-eyed Grass		ST	G5	S2
High Quality Natural Community					
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3
Lake - lake	Lake		SG	GNR	S2
Prairie - sand dry-mesic	Dry-mesic Sand Prairie		SG	G3	S3
Wetland - beach marl	Marl Beach		SG	G3	S2
Wetland - bog acid	Acid Bog		SG	G3	S2
Wetland - bog circumneutral	Circumneutral Bog		SG	G3	S3

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GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank

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Indiana County Endangered, Threatened and Rare Species List

County: Elkhart

Species Name	Common Name	FED	STATE	GRANK	SRANK
Wetland - fen	Fen		SG	G3	S3
Wetland - flat muck	Muck Flat		SG	G2	S2
Wetland - flat sand	Sand Flat		SG	G2	S1
Wetland - marsh	Marsh		SG	GU	S4
Wetland - swamp shrub	Shrub Swamp		SG	GU	S2

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Indiana County Endangered, Threatened and Rare Species List

County: Kosciusko

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Alasmidonta viridis	Slippershell Mussel			G4G5	S2
Epioblasma obliquata perobliqua	White Cat's Paw Pearlymussel	LE	SE	G1T1	S1
Epioblasma torulosa rangiana	Northern Riffleshell	LE	SE	G2T2	S1
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G4	S2
Lampsilis ovata	Pocketbook			G5	S2
Ligumia recta	Black Sandshell			G5	S2
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot		SE	G3T3	S1
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Toxolasma parvum	Lilliput			G5	S2
Villosa fabalis	Rayed Bean	C	SSC	G1G2	S1
Villosa lienosa	Little Spectaclecase		SSC	G5	S2
Insect: Lepidoptera (Butterflies & Moths)					
Capis curvata	A Noctuid Moth		ST	G4	S2S3
Catocala praeclara	Praeclara Underwing		SR	G5	S2S3
Chortodes inquinata	Tufted Sedge Moth		ST	GNR	S1S2
Dasychira cinnamomea	A Moth		SR	G4	S1
Euphydryas phaeton	Baltimore		SR	G4	S2
Euphyes bimacula	Two-spotted Skipper		ST	G4	S2
Exyra rolandiana	Pitcher Window Moth		SE	G4	S1S2
Fixsenia favonius	Northern Hairstreak		SR	G4	S1S2
Hemileuca sp. 3	Midwestern Fen Buckmoth		ST	G3G4Q	S1?
Hesperia leonardus	Leonard's Skipper	No Status	SR	G4	S2
Iodopepla u-album	A Noctuid Moth		SR	G5	S2
Leucania multilinea			ST	G5	S1S2
Lycaena helloides	Purplish Copper		SR	G5	S2S4
Lytrosis permagnaria	A Lytrosis Moth		ST	G3G4	S2
Macrochilo absorptalis	A Moth		SR	G4G5	S2S3
Papaipema appassionata	The Pitcher Plant Borer Moth		SE	G4	S1
Papaipema speciosissima	The Royal Fern Borer Moth		ST	G4	S2S3
Pieris oleracea	Eastern Veined White		SE	G4G5	S1
Fish					
Acipenser fulvescens	Lake Sturgeon		SE	G3G4	S1
Ammocrypta pellucida	Eastern Sand Darter			G3	S2
Coregonus artedi	Cisco		SSC	G5	S2
Hybopsis amblops	Bigeye Chub			G5	S2
Notropis heterolepis	Blacknose Shiner			G4	S2
Percina evides	Gilt Darter		SE	G4	S1
Amphibian					
Ambystoma laterale	Blue-spotted Salamander		SSC	G5	S2
Hemidactylium scutatum	Four-toed Salamander		SE	G5	S2
Necturus maculosus	Common mudpuppy		SSC	G5	S2
Rana pipiens	Northern Leopard Frog		SSC	G5	S2
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Clonophis kirtlandii	Kirtland's Snake		SE	G2	S2
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Nerodia erythrogaster neglecta	Copperbelly Water Snake	PS:LT	SE	G5T2T3	S2
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Bird					
Ardea herodias	Great Blue Heron			G5	S4B
Botaurus lentiginosus	American Bittern		SE	G4	S2B
Certhia americana	Brown Creeper			G5	S2B

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Indiana County Endangered, Threatened and Rare Species List

County: Kosciusko

Species Name	Common Name	FED	STATE	GRANK	SRANK
Chlidonias niger	Black Tern		SE	G4	S1B
Circus cyaneus	Northern Harrier		SE	G5	S2
Cistothorus palustris	Marsh Wren		SE	G5	S3B
Cistothorus platensis	Sedge Wren		SE	G5	S3B
Dendroica cerulea	Cerulean Warbler		SSC	G4	S3B
Empidonax alnorum	Alder Flycatcher			G5	S2B
Falco peregrinus	Peregrine Falcon	No Status	SE	G4	S2B
Grus canadensis	Sandhill Crane	No Status	SSC	G5	S2B,S1N
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Mniotilta varia	Black-and-white Warbler		SSC	G5	S1S2B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Rallus elegans	King Rail		SE	G4	S1B
Rallus limicola	Virginia Rail		SE	G5	S3B
Vermivora chrysoptera	Golden-winged Warbler		SE	G4	S1B
Mammal					
Condylura cristata	Star-nosed Mole		SSC	G5	S2?
Lutra canadensis	Northern River Otter			G5	S2
Mustela nivalis	Least Weasel		SSC	G5	S2?
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Actaea rubra	Red Baneberry		SR	G5	S2
Andromeda glaucophylla	Bog Rosemary		SR	G5	S2
Arethusa bulbosa	Swamp-pink		SX	G4	SX
Aster borealis	Rushlike Aster		SR	G5	S2
Bidens beckii	Beck Water-marigold		ST	G4G5T4	S1
Carex aurea	Golden-fruited Sedge		SR	G5	S2
Carex bebbii	Bebb's Sedge		ST	G5	S2
Carex chordorrhiza	Creeping Sedge		SE	G5	S1
Carex disperma	Softleaf Sedge		SE	G5	S1
Carex echinata	Little Prickly Sedge		SE	G5	S1
Carex flava	Yellow Sedge		ST	G5	S2
Carex pseudocyperus	Cyperus-like Sedge		SE	G5	S1
Cornus amomum ssp. amomum	Silky Dogwood		SE	G5T5	S1
Cornus canadensis	Bunchberry		SE	G5	S1
Cypripedium calceolus var. parviflorum	Small Yellow Lady's-slipper		SR	G5	S2
Cypripedium candidum	Small White Lady's-slipper		WL	G4	S2
Drosera intermedia	Spoon-leaved Sundew		SR	G5	S2
Eleocharis geniculata	Capitate Spike-rush		ST	G5	S2
Eriophorum angustifolium	Narrow-leaved Cotton-grass		SR	G5	S2
Eriophorum gracile	Slender Cotton-grass		ST	G5	S2
Eriophorum viridicarinatum	Green-keeled Cotton-grass		SR	G5	S2
Geranium robertianum	Herb-robert		ST	G5	S2
Juglans cinerea	Butternut		WL	G3G4	S3
Lathyrus ochroleucus	Pale Vetchling Peavine		SE	G4G5	S1
Lemna perpusilla	Minute Duckweed		SX	G5	SX
Lemna valdiviana	Pale Duckweed		SE	G5	S1
Malaxis unifolia	Green Adder's-mouth		SE	G5	S1
Matteuccia struthiopteris	Ostrich Fern		SR	G5	S2
Myriophyllum verticillatum	Whorled Water-milfoil		SR	G5	S2
Panax trifolius	Dwarf Ginseng		WL	G5	S2
Panicum boreale	Northern Witchgrass		SR	G5	S2
Platanthera psycodes	Small Purple-fringe Orchis		SR	G5	S2
Potamogeton epihydrus	Nuttall Pondweed		SE	G5	S1
Potamogeton friesii	Fries' Pondweed		ST	G4	S1

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Indiana County Endangered, Threatened and Rare Species List

County: Kosciusko

Species Name	Common Name	FED	STATE	GRANK	SRANK
Potamogeton oakesianus	Oakes Pondweed		SE	G4	S1
Potamogeton praelongus	White-stem Pondweed		ST	G5	S1
Potamogeton pusillus	Slender Pondweed		WL	G5	S2
Potamogeton richardsonii	Redheadgrass		SR	G5	S2
Potamogeton strictifolius	Straight-leaf Pondweed		ST	G5	S1
Prunus pensylvanica	Fire Cherry		SR	G5	S2
Scirpus subterminalis	Water Bulrush		SR	G4G5	S2
Selaginella apoda	Meadow Spike-moss		WL	G5	S1
Sparganium androcladum	Branching Bur-reed		ST	G4G5	S2
Spiranthes lucida	Shining Ladies'-tresses		SR	G5	S2
Stenanthium gramineum	Eastern Featherbells		ST	G4G5	S1
Tofieldia glutinosa	False Asphodel		SR	G5	S2
Utricularia resupinata	Northeastern Bladderwort		SX	G4	SX
Vaccinium oxycoccos	Small Cranberry		ST	G5	S2
Wolffiella gladiata	Sword Bogmat		SE	G5	S1
Zannichellia palustris	Horned Pondweed		SR	G5	S2
Zigadenus elegans var. glaucus	White Camas		SR	G5T4T5	S2
High Quality Natural Community					
Forest - upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3
Lake - lake	Lake		SG	GNR	S2
Wetland - beach marl	Marl Beach		SG	G3	S2
Wetland - bog acid	Acid Bog		SG	G3	S2
Wetland - bog circumneutral	Circumneutral Bog		SG	G3	S3
Wetland - fen	Fen		SG	G3	S3
Wetland - fen forested	Forested Fen		SG	G3	S1
Wetland - marsh	Marsh		SG	GU	S4
Wetland - meadow sedge	Sedge Meadow		SG	G3?	S1
Wetland - swamp shrub	Shrub Swamp		SG	GU	S2

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Indiana County Endangered, Threatened and Rare Species List

County: Noble

Species Name	Common Name	FED	STATE	GRANK	SRANK
Insect: Lepidoptera (Butterflies & Moths)					
Euphydryas phaeton	Baltimore		SR	G4	S2
Lycaena dorcas dorcas	Dorcas Copper		SR	G5TU	S2
Pieris oleracea	Eastern Veined White		SE	G4G5	S1
Fish					
Coregonus artedi	Cisco		SSC	G5	S2
Amphibian					
Ambystoma laterale	Blue-spotted Salamander		SSC	G5	S2
Necturus maculosus	Common mudpuppy		SSC	G5	S2
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Thamnophis butleri	Butler's Garter Snake		SE	G4	S1
Bird					
Ammodramus henslowii	Henslow's Sparrow		SE	G4	S3B
Ardea herodias	Great Blue Heron			G5	S4B
Aythya collaris	Ring-necked Duck			G5	SHB
Buteo lineatus	Red-shouldered Hawk		SSC	G5	S3
Buteo platypterus	Broad-winged Hawk	No Status	SSC	G5	S3B
Certhia americana	Brown Creeper			G5	S2B
Chlidonias niger	Black Tern		SE	G4	S1B
Cistothorus palustris	Marsh Wren		SE	G5	S3B
Dendroica cerulea	Cerulean Warbler		SSC	G4	S3B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Rallus limicola	Virginia Rail		SE	G5	S3B
Sturnella neglecta	Western Meadowlark		SSC	G5	S2B
Tyto alba	Barn Owl		SE	G5	S2
Wilsonia citrina	Hooded Warbler		SSC	G5	S3B
Mammal					
Condylura cristata	Star-nosed Mole		SSC	G5	S2?
Lutra canadensis	Northern River Otter			G5	S2
Lynx rufus	Bobcat	No Status		G5	S1
Mustela nivalis	Least Weasel		SSC	G5	S2?
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Actaea rubra	Red Baneberry		SR	G5	S2
Andromeda glaucophylla	Bog Rosemary		SR	G5	S2
Aralia hispida	Bristly Sarsaparilla		SE	G5	S1
Aristida intermedia	Slim-spike Three-awn Grass		SR	GNR	S2
Aster borealis	Rushlike Aster		SR	G5	S2
Calla palustris	Wild Calla		SE	G5	S1
Carex bebbii	Bebb's Sedge		ST	G5	S2
Crataegus prona	Illinois Hawthorn		SE	G4G5	S1
Cypripedium candidum	Small White Lady's-slipper		WL	G4	S2
Drosera intermedia	Spoon-leaved Sundew		SR	G5	S2
Dryopteris clintoniana	Clinton Woodfern		SX	G5	SX
Eriophorum gracile	Slender Cotton-grass		ST	G5	S2
Eriophorum viridicarinatum	Green-keeled Cotton-grass		SR	G5	S2
Gentiana alba	Yellow Gentian		SR	G4	S2
Geranium bicknellii	Bicknell Northern Crane's-bill		SE	G5	S1
Geum rivale	Purple Avens		SE	G5	S1
Hypericum pyramidatum	Great St. John's-wort		ST	G4	S1
Lathyrus ochroleucus	Pale Vetchling Peavine		SE	G4G5	S1

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Indiana County Endangered, Threatened and Rare Species List

County: Noble

Species Name	Common Name	FED	STATE	GRANK	SRANK
Lathyrus venosus	Smooth Veiny Pea		ST	G5	S2
Lemna perpusilla	Minute Duckweed		SX	G5	SX
Linnaea borealis	Twinflower		SX	G5	SX
Lycopodium hickeyi	Hickey's Clubmoss		SR	G5	S2
Lycopodium obscurum	Tree Clubmoss		SR	G5	S2
Malaxis unifolia	Green Adder's-mouth		SE	G5	S1
Matteuccia struthiopteris	Ostrich Fern		SR	G5	S2
Milium effusum	Tall Millet-grass		SR	G5	S2
Panax trifolius	Dwarf Ginseng		WL	G5	S2
Panicum leibergii	Leiberg's Witchgrass		ST	G5	S2
Platanthera ciliaris	Yellow-fringe Orchis		SE	G5	S1
Platanthera leucophaea	Prairie White-fringed Orchid	LT	SE	G3	S1
Platanthera orbiculata	Large Roundleaf Orchid		SX	G5	SX
Platanthera psycodes	Small Purple-fringe Orchis		SR	G5	S2
Potamogeton pusillus	Slender Pondweed		WL	G5	S2
Potamogeton strictifolius	Straight-leaf Pondweed		ST	G5	S1
Prunus pensylvanica	Fire Cherry		SR	G5	S2
Pyrola rotundifolia var. americana	American Wintergreen		SR	G5	S2
Salix serissima	Autumn Willow		ST	G4	S2
Scheuchzeria palustris ssp. americana	American Scheuchzeria		SE	G5T5	S1
Spiranthes lucida	Shining Ladies'-tresses		SR	G5	S2
Spiranthes romanzoffiana	Hooded Ladies'-tresses		ST	G5	S1
Stipa comata	Sewing Needlegrass		SX	G5	SX
Tofieldia glutinosa	False Asphodel		SR	G5	S2
Triglochin palustris	Marsh Arrow-grass		SR	G5	S2
Utricularia cornuta	Horned Bladderwort		ST	G5	S2
Utricularia resupinata	Northeastern Bladderwort		SX	G4	SX
Vaccinium oxycoccos	Small Cranberry		ST	G5	S2
Viburnum cassinoides	Northern Wild-raisin		SE	G5T5	S1
Zigadenus elegans var. glaucus	White Camas		SR	G5T4T5	S2
High Quality Natural Community					
Forest - floodplain wet	Wet Floodplain Forest		SG	G3?	S3
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3
Forest - upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3
Lake - lake	Lake		SG	GNR	S2
Lake - pond	Pond		SG	GNR	SNR
Wetland - beach marl	Marl Beach		SG	G3	S2
Wetland - bog acid	Acid Bog		SG	G3	S2
Wetland - bog circumneutral	Circumneutral Bog		SG	G3	S3
Wetland - fen	Fen		SG	G3	S3
Wetland - fen forested	Forested Fen		SG	G3	S1
Wetland - marsh	Marsh		SG	GU	S4
Wetland - meadow sedge	Sedge Meadow		SG	G3?	S1
Wetland - swamp forest	Forested Swamp		SG	G2?	S2
Wetland - swamp shrub	Shrub Swamp		SG	GU	S2

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APPENDIX D:

HISTORIC AERIAL PHOTOGRAPHS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

APPENDIX D1:

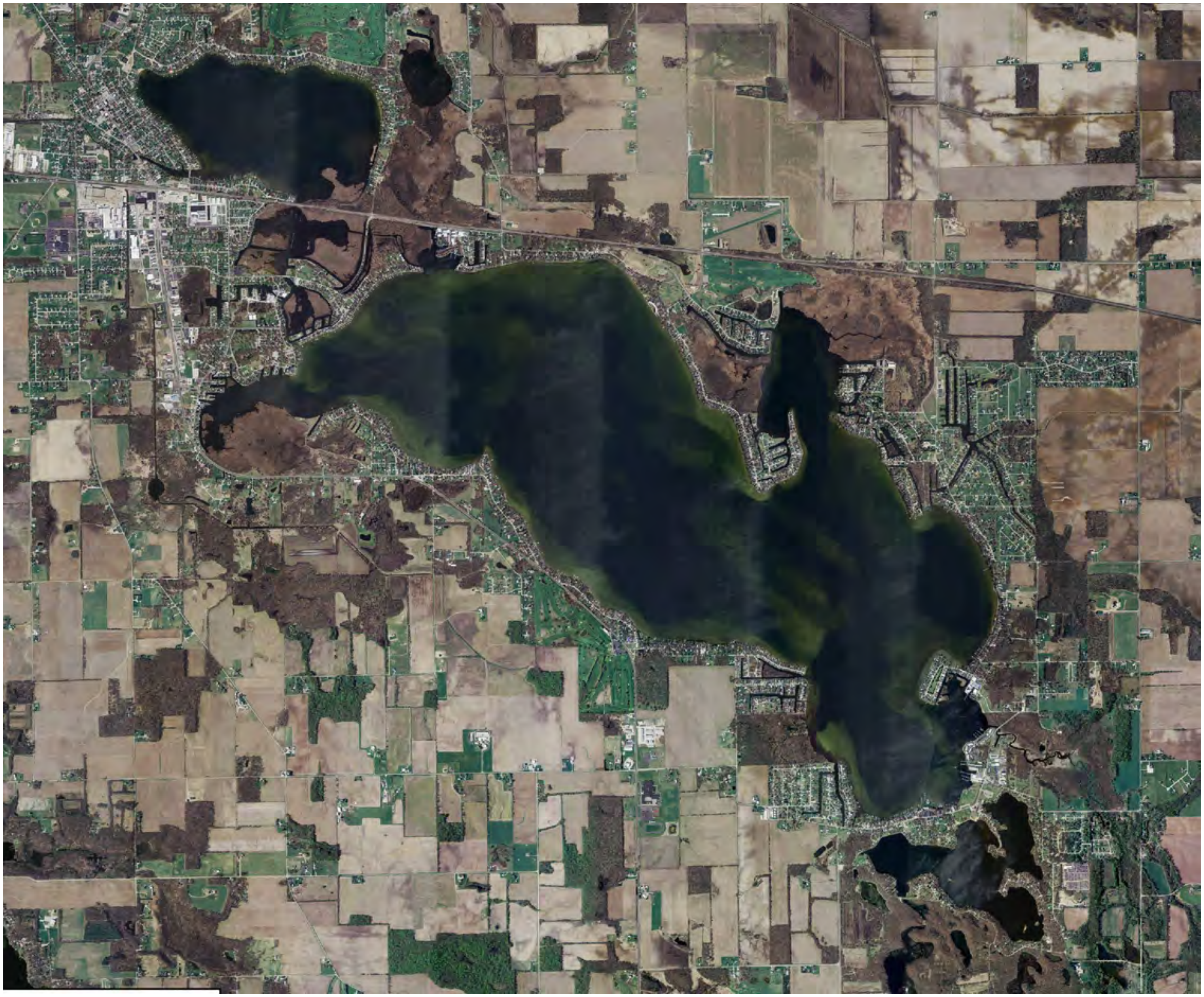
WAWASEE, SYRACUSE, AND PAPAKEECHIE AERIAL PHOTOGRAPHS

WAWASEE AREA WATERSHED MANAGEMENT PLAN ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

1938 aerial photograph.

1957 aerial photograph.

1973 aerial photograph.

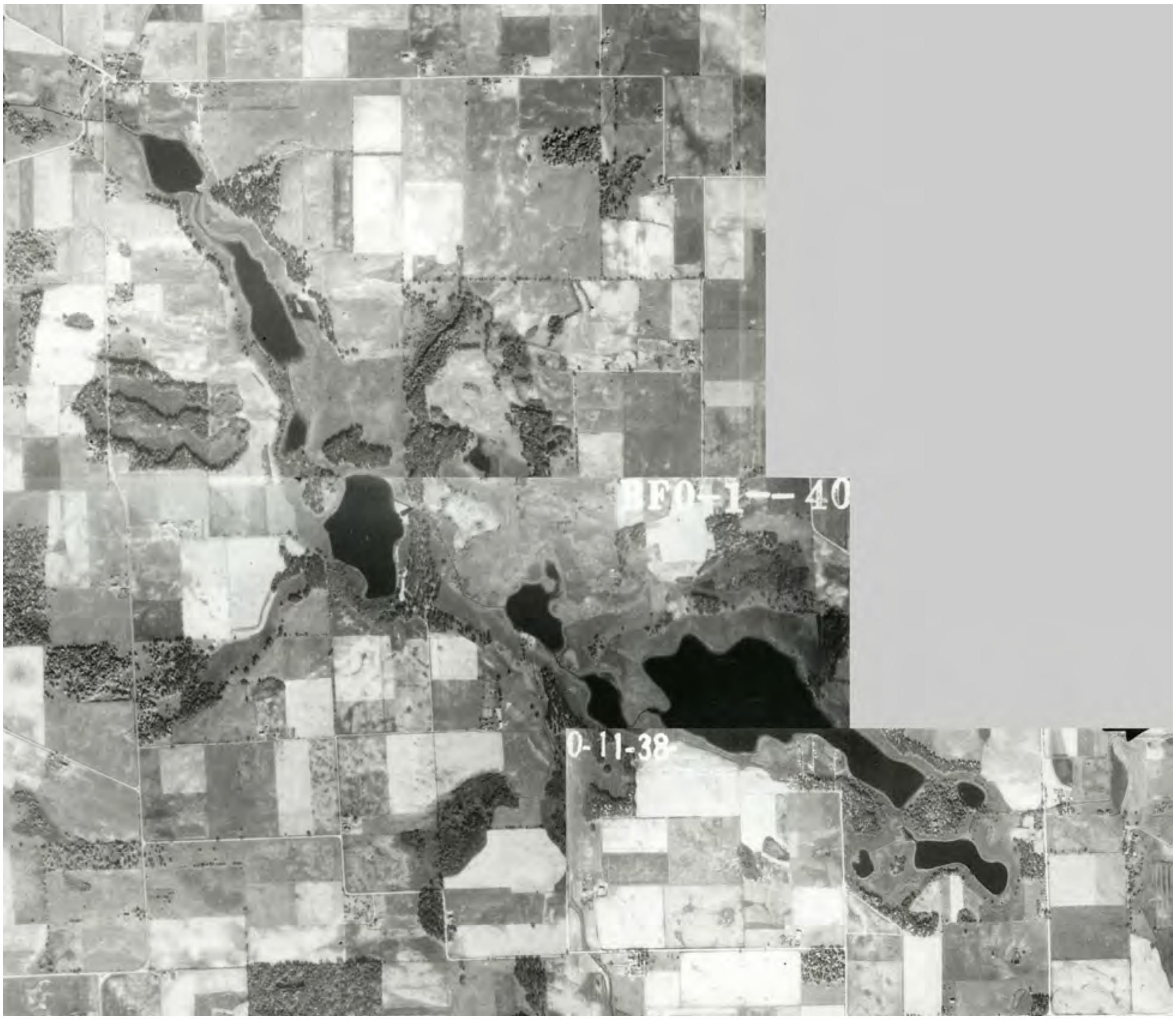


2005 aerial photograph.

APPENDIX D2:

TEN LAKES CHAIN AERIAL PHOTOGRAPHS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA



1938 Aerial Photograph-Ten Lakes Chain.

1957 Aerial Photograph-Ten Lakes Chain.

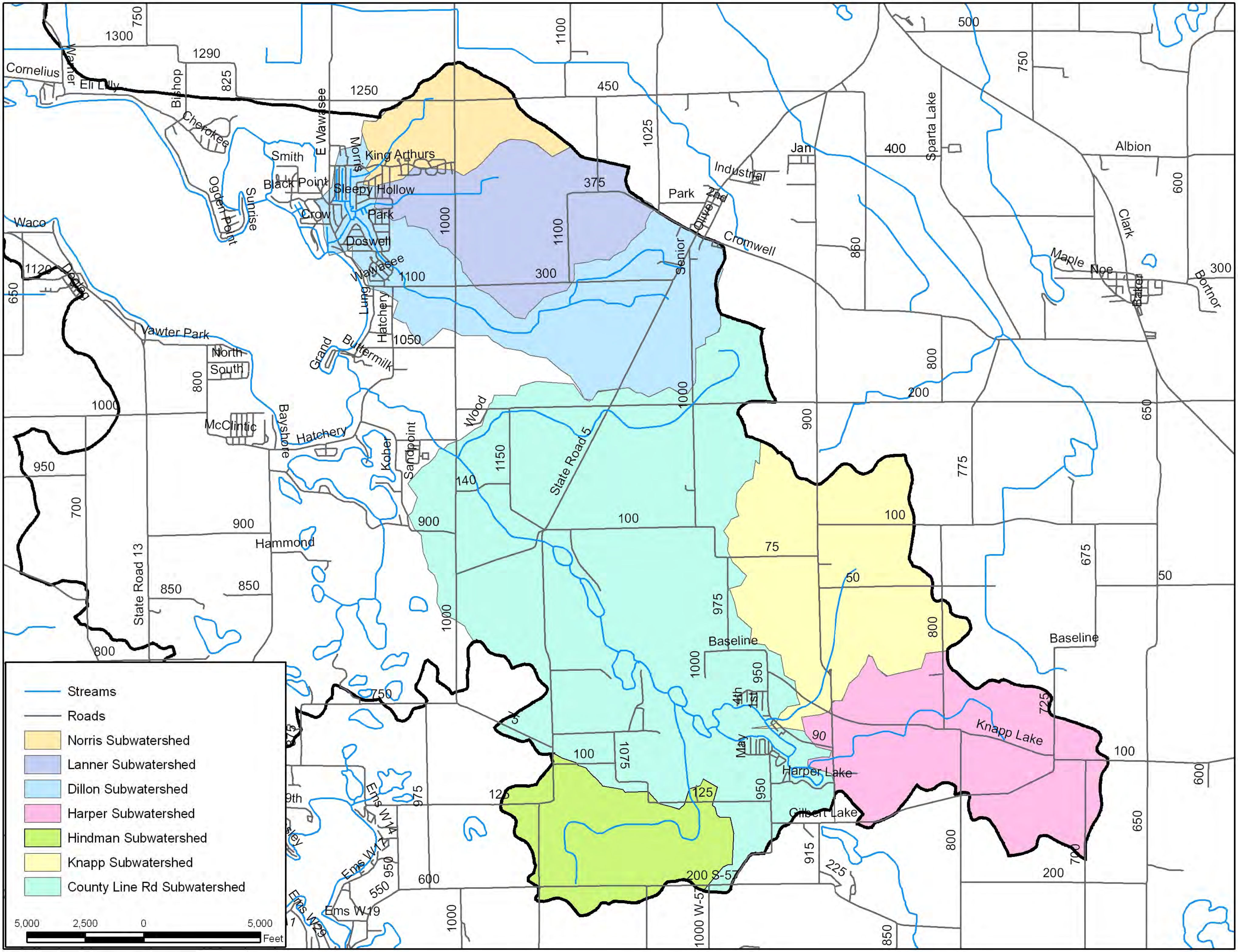
1965 Aerial Photograph-Ten Lakes Chain.

1973 Aerial Photograph-Ten Lakes Chain.

APPENDIX E:

SUBWATERSHED MAPS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA



Streams
Roads
Norris Subwatershed
Lanner Subwatershed
Dillon Subwatershed
Harper Subwatershed
Hindman Subwatershed
Knapp Subwatershed
County Line Rd Subwatershed
5,000
2,500
0
5,000
Feet
Cornelius
Eli Lilly
Bishop
Cherokee
Smith
E Wawasee
Morris
King Arthurs
Black Point
Sleepy Hollow
Ogden Point
Sunrise
Crow
Park
Doswell
Wawasee
Waco
Vawter Park
North
South
Grand
Buttermilk
Hatchery
Lung
McClintic
Bayshore
Kober
Sandpoint
Wood
State Road 5
State Road 13
Hammond
Industrial
Jan
Sparta Lake
Albion
Cromwell
Senior
Olive
2nd
Clark
Maple
Noe
Baker
Bortnor
Baseline
Knapp Lake
Harper Lake
Gilbert Lake
4th
1st
May
Ems W14
Ems W17
Ems W19
Ems W29
200 S-57
1000 W-57

APPENDIX F:

HISTORIC WATER QUALITY DATA

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Table F.1. Historic water quality data collected at Lake Wawasee.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
5/3/73	12.0	8.3	--	0.006	--	3.4	--	USEPA, 1976
5/3/73	12.0	8.3	--	0.005	--	3.4	--	EPA, 1973
8/4/73	--	8.6	--	0.014	--	6.9	--	USEPA, 1976
8/4/73	12.0	8.6	--	--	--	6.9	--	EPA, 1973
10/15/73	12.0	8.2	--	0.011	--	3.9	--	USEPA, 1976
6/1/75	--	--	--	--	--	--	16	ISPCB, 1975
6/1/75	7.5	--	--	0.040	--	--	--	Hippensteel, 1989
7/7/75	13.4	9.1	93.5	--	--	--	--	Shipman, 1975
7/14/85	11.0	9.5	64.9	--	--	--	--	Pearson, 1985
6/1/88	8.0	--	--	0.010	--	--	--	Hippensteel, 1990
4/30/89	10.0	--	--	--	--	--	--	Volunteer Monitor
5/14/89	13.0	--	--	--	--	--	--	Volunteer Monitor
5/21/89	14.0	--	--	--	--	--	--	Volunteer Monitor
5/28/89	13.0	--	--	--	--	--	--	Volunteer Monitor
6/5/89	7.0	--	--	--	--	--	--	Volunteer Monitor
6/19/89	11.0	--	--	--	--	--	--	Volunteer Monitor
6/27/89	11.0	--	--	--	--	--	--	Volunteer Monitor
7/5/89	8.0	--	--	--	--	--	--	Volunteer Monitor
7/14/89	10.0	--	--	--	--	--	--	Volunteer Monitor
7/26/89	10.0	--	--	--	--	--	--	Volunteer Monitor
8/2/89	9.0	--	--	--	--	--	--	Volunteer Monitor
8/13/89	12.0	--	--	--	--	--	--	Volunteer Monitor
8/24/89	10.0	--	--	--	--	--	--	Volunteer Monitor
9/5/89	10.0	--	--	--	--	--	--	Volunteer Monitor
9/11/89	12.0	--	--	--	--	--	--	Volunteer Monitor
9/18/89	11.0	--	--	--	--	--	--	Volunteer Monitor
9/27/89	12.0	--	--	--	--	--	--	Volunteer Monitor
10/4/89	12.0	--	--	--	--	--	--	Volunteer Monitor
10/13/89	11.0	--	--	--	--	--	--	Volunteer Monitor
5/15/90	14.0	--	--	--	--	--	--	Volunteer Monitor
5/31/90	15.0	--	--	--	--	--	--	Volunteer Monitor
6/16/90	13.0	--	--	--	--	--	--	Volunteer Monitor
7/2/90	14.0	--	--	--	--	--	--	Volunteer Monitor
7/17/90	14.0	--	--	--	--	--	--	Volunteer Monitor
8/1/90	11.0	--	--	--	--	--	--	Volunteer Monitor
8/14/90	8.0	--	--	--	--	--	--	Volunteer Monitor
9/4/90	8.0	--	--	--	--	--	--	Volunteer Monitor
9/18/90	8.0	--	--	--	--	--	--	Volunteer Monitor
9/27/90	9.0	--	--	--	--	--	--	Volunteer Monitor
10/11/90	10.0	--	--	--	--	--	--	Volunteer Monitor
5/20/91	17.0	--	--	--	--	--	--	Volunteer Monitor
6/3/91	16.0	--	--	--	--	--	--	Volunteer Monitor
6/18/91	14.0	--	--	--	--	--	--	Volunteer Monitor
7/2/91	13.0	--	--	--	--	--	--	Volunteer Monitor

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
7/15/91	10.0	--	--	--	--	--	--	Volunteer Monitor
8/1/91	11.0	--	--	--	--	--	--	Volunteer Monitor
8/13/91	13.0	--	--	--	--	--	--	Volunteer Monitor
9/2/91	10.0	--	--	--	--	--	--	Volunteer Monitor
9/21/91	11.0	--	--	--	--	--	--	Volunteer Monitor
10/3/91	11.0	--	--	--	--	--	--	Volunteer Monitor
5/19/92	17.0	--	--	--	--	--	--	Volunteer Monitor
5/27/92	17.0	--	--	--	--	--	--	Volunteer Monitor
6/8/92	15.0	--	--	--	--	--	--	Volunteer Monitor
6/11/92	14.0	--	--	0.053	--	0.02	--	Volunteer Monitor
6/22/92	14.0	--	--	--	--	--	--	Volunteer Monitor
7/9/92	13.0	--	--	0.035	--	1.96	--	Volunteer Monitor
7/21/92	12.0	--	--	--	--	--	--	Volunteer Monitor
7/28/92	11.0	--	--	--	--	--	--	Volunteer Monitor
8/6/92	10.0	--	--	--	--	--	--	Volunteer Monitor
8/21/92	9.0	--	--	0.045	--	0.42	--	Volunteer Monitor
8/31/92	9.0	--	--	--	--	--	--	Volunteer Monitor
9/8/92	10.0	--	--	0.048	--	1.99	--	Volunteer Monitor
9/23/92	13.0	--	--	--	--	--	--	Volunteer Monitor
10/4/92	12.0	--	--	--	--	--	--	Volunteer Monitor
5/21/93	19.0	--	--	--	--	--	--	Volunteer Monitor
6/4/93	17.0	--	--	--	--	--	--	Volunteer Monitor
6/11/93	17.0	--	--	0.022	--	2.22	--	Volunteer Monitor
6/22/93	15.0	--	--	--	--	--	--	Volunteer Monitor
7/2/93	12.0	--	--	--	--	--	--	Volunteer Monitor
7/7/93	11.0	--	--	0.015	--	0.37	--	Volunteer Monitor
7/13/93	11.0	--	--	--	--	--	--	Volunteer Monitor
7/22/93	8.0	--	--	--	--	--	--	Volunteer Monitor
7/27/93	7.0	--	--	--	--	--	--	Volunteer Monitor
8/3/93	7.0	--	--	0.024	--	1.6	--	Volunteer Monitor
8/12/93	8.0	--	--	--	--	--	--	Volunteer Monitor
8/19/93	11.0	--	--	--	--	--	--	Volunteer Monitor
8/28/93	10.0	--	--	--	--	--	--	Volunteer Monitor
9/7/93	9.0	--	--	0.031	--	3.55	--	Volunteer Monitor
9/18/93	10.0	--	--	--	--	--	--	Volunteer Monitor
9/24/93	12.0	--	--	--	--	--	--	Volunteer Monitor
10/5/93	12.0	--	--	0.022	--	2.4	--	Volunteer Monitor
5/12/94	19.0	--	--	--	--	--	--	Volunteer Monitor
5/21/94	20.0	--	--	0.030	--	0.25	--	Volunteer Monitor
6/2/94	22.0	--	--	--	--	--	--	Volunteer Monitor
6/10/94	25.0	--	--	--	--	--	--	Volunteer Monitor
6/20/94	12.0	--	--	0.023	--	2.96	--	Volunteer Monitor
7/4/94	8.0	--	--	--	--	--	--	Volunteer Monitor
7/13/94	8.0	--	--	--	--	--	--	Volunteer Monitor
7/21/94	7.0	--	--	0.032	--	1.025	--	Volunteer Monitor
8/3/94	8.0	--	--	--	--	--	--	Volunteer Monitor

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
8/12/94	9.0	--	--	--	--	--	--	Volunteer Monitor
8/22/94	9.0	--	--	0.032	--	1.09	--	Volunteer Monitor
8/31/94	10.0	--	--	--	--	--	--	Volunteer Monitor
9/1/94	7.8	8.4	36.4	--	3,126	1.42	17	CLP
9/9/94	10.0	--	--	--	--	--	--	Volunteer Monitor
9/19/94	11.0	--	--	0.025	--	2.57	--	Volunteer Monitor
9/30/94	10.0	--	--	--	--	--	--	Volunteer Monitor
10/4/94	11.0	--	--	--	--	--	--	Volunteer Monitor
5/19/95	18.0	--	--	--	--	--	--	Volunteer Monitor
5/26/95	18.0	--	--	0.025	--	0.77	--	Volunteer Monitor
6/5/95	17.0	--	--	--	--	--	--	Volunteer Monitor
6/14/95	16.0	--	--	0.028	--	--	--	Volunteer Monitor
6/23/95	14.0	--	--	--	--	--	--	Volunteer Monitor
7/4/95	10.0	--	--	--	--	--	--	Volunteer Monitor
7/11/95	14.0	--	--	--	--	--	--	Volunteer Monitor
7/17/95	9.0	--	--	0.028	--	3.605	--	Volunteer Monitor
7/27/95	9.0	--	--	--	--	--	--	Volunteer Monitor
8/2/95	7.0	--	--	--	--	--	--	Volunteer Monitor
8/11/95	7.0	--	--	--	--	--	--	Volunteer Monitor
8/17/95	6.0	--	--	--	--	--	--	Volunteer Monitor
8/23/95	6.0	--	--	0.010	--	1.39	--	Volunteer Monitor
8/30/95	5.0	--	--	--	--	--	--	Volunteer Monitor
9/8/95	7.0	--	--	--	--	--	--	Volunteer Monitor
9/15/95	9.0	--	--	0.020	--	1.17	--	Volunteer Monitor
9/27/95	10.0	--	--	0.020	--	0.20	--	Volunteer Monitor
10/3/95	12.0	--	--	--	--	--	--	Volunteer Monitor
6/3/96	19.0	--	--	--	--	--	--	Volunteer Monitor
6/13/96	19.0	--	--	--	--	--	--	Volunteer Monitor
6/20/96	16.0	--	--	--	--	--	--	Volunteer Monitor
6/27/96	16.0	--	--	--	--	--	--	Volunteer Monitor
7/11/96	11.0	--	--	--	--	--	--	Volunteer Monitor
7/18/96	6.0	--	--	--	--	--	--	Volunteer Monitor
7/25/96	6.0	--	--	0.020	--	0.82	--	Volunteer Monitor
8/1/96	5.0	--	--	--	--	--	--	Volunteer Monitor
8/9/96	5.0	--	--	--	--	--	--	Volunteer Monitor
8/16/96	5.0	--	--	--	--	--	--	Volunteer Monitor
8/20/96	6.0	--	--	0.020	--	2.79	--	Volunteer Monitor
8/29/96	7.0	--	--	--	--	--	--	Volunteer Monitor
9/6/96	8.0	--	--	--	--	--	--	Volunteer Monitor
9/17/96	10.0	--	--	0.022	--	4.68	--	Volunteer Monitor
10/1/96	11.0	--	--	--	--	--	--	Volunteer Monitor
6/17/97	16.0	--	--	0.021	--	0.73	--	Volunteer Monitor
6/27/97	13.0	--	--	0.011	--	1.79	--	Volunteer Monitor
7/7/97	11.0	--	--	--	--	--	--	Volunteer Monitor
7/11/97	12.0	--	--	--	--	--	--	Volunteer Monitor
7/16/97	5.0	--	--	0.020	--	3.15	--	Volunteer Monitor

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
8/1/97	5.0	--	--	--	--	--	--	Volunteer Monitor
8/19/97	6.0	--	--	0.019	--	7.52	--	Volunteer Monitor
8/29/97	7.0	--	--	--	--	--	--	Volunteer Monitor
9/4/97	7.0	--	--	--	--	--	--	Volunteer Monitor
10/8/97	9.0	--	--	--	--	--	--	Volunteer Monitor
4/20/98	26.0	--	--	--	--	--	--	Volunteer Monitor
5/26/98	12.0	--	--	0.013	--	1.4	--	Volunteer Monitor
6/21/98	10.0	--	--	0.017	--	3.96	--	Volunteer Monitor
7/17/98	7.0	--	--	0.019	--	1.09	--	Volunteer Monitor
8/13/98	9.0	--	--	0.010	--	3.77	--	Volunteer Monitor
8/17/98	7.0	--	--	--	--	--	--	Volunteer Monitor
9/3/98	10.0	--	--	--	--	--	--	Volunteer Monitor
9/10/98	12.0	--	--	--	--	--	--	Volunteer Monitor
10/14/98	11.0	--	--	--	--	--	--	Volunteer Monitor
5/19/99	17.0	--	--	0.040	--	0.55	--	Volunteer Monitor
6/8/99	12.0	--	--	--	--	--	--	Volunteer Monitor
6/16/99	7.0	--	--	0.060	--	2.82	--	Volunteer Monitor
7/13/99	8.0	--	--	--	--	--	--	Volunteer Monitor
7/21/99	8.0	--	--	0.036	--	--	--	Volunteer Monitor
8/6/99	12.0	--	--	--	--	--	--	Volunteer Monitor
8/25/99	14.0	--	--	0.043	--	1.16	--	Volunteer Monitor
9/17/99	14.0	--	--	--	--	--	--	Volunteer Monitor
4/30/00	30.0	--	--	--	--	--	--	Volunteer Monitor
5/24/00	28.0	--	--	0.031	--	2	--	Volunteer Monitor
6/1/00	16.0	--	--	--	--	--	--	ISPCB, 2000
6/26/00	9.0	--	--	0.069	--	4.27	--	Volunteer Monitor
7/11/00	7.0	--	--	--	--		--	Volunteer Monitor
7/24/00	8.0	--	--	0.025	--	2.89	--	Volunteer Monitor
7/31/00	7.2	8.6	50.0	--	2,804	2.29	16	CLP
8/25/00	9.0	--	--	0.035	--	2.41	--	Volunteer Monitor
9/13/00	8.5	--	--	--	--	--	--	HARZA, 2001
5/17/01	32.0	--	--	--	--	--	--	Volunteer Monitor
7/10/01	5.0	--	--	--	--	--	--	Volunteer Monitor
7/15/01	4.0	--	--	0.044	--	0.6	--	Volunteer Monitor
8/21/01	8.0	--	--	0.031	--	0.19	--	Volunteer Monitor
6/19/02	--	--	--	--	--	--	--	Volunteer Monitor
7/12/02	5.0	--	--	--	--	--	--	Volunteer Monitor
8/7/02	7.0	--	--	0.021	--	5.38	--	Volunteer Monitor
6/1/03	22.0	--	--	--	--	--	--	ISPCB, 2003
6/21/03	12.0	--	--	--	--	--	--	Volunteer Monitor
6/30/03	9.0	--	--	0.024	--	5.91	--	Volunteer Monitor
7/12/03	6.0	--	--	--	--	--	--	Volunteer Monitor
7/29/03	6.0	--	--	--	--	--	--	Volunteer Monitor
8/5/03	5.6	8.7	34.8	--	18,193	4.36	22	CLP
8/6/03	--	--	--	0.031	--	2.47	--	Volunteer Monitor
8/15/03	7.0	--	--	--	--	--	--	Volunteer Monitor

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
9/10/03	8.0	--	--	0.016	--	3.78	--	Volunteer Monitor
9/25/03	8.0	--	--	--	--	--	--	Volunteer Monitor
10/10/03	12.0	--	--	--	--	--	--	Volunteer Monitor
4/16/04	14.0	--	--	--	--	--	--	Volunteer Monitor
5/28/04	9.0	--	--	0.010	--	4.87	--	Volunteer Monitor
6/15/04	7.0	--	--	--	--	--	--	Volunteer Monitor
6/30/04	9.0	--	--	0.028	--	2.56	--	Volunteer Monitor
7/12/04	6.5	9	58.4	--	--	--	--	Pearson, 2004
7/15/04	7.0	--	--	0.044	--	3.59	--	Volunteer Monitor
8/17/04	--	--	--	0.041	--	4.05	--	Volunteer Monitor
9/13/04	8.0	--	--	--	--	--	--	Volunteer Monitor
9/29/04	10.0	--	--	--	--	--	--	Volunteer Monitor
10/6/04	12.0	--	--	--	--	--	--	Volunteer Monitor
4/6/05	18.0	--	--	--	--	--	--	Volunteer Monitor
5/6/05	15.0	--	--	--	--	--	--	Volunteer Monitor
5/13/05	11.0	--	--	--	--	--	--	Volunteer Monitor
5/13/05	11.0	--	--	--	--	--	--	Volunteer Monitor
6/1/05	14.0	--	--	--	--	--	--	Volunteer Monitor
6/13/05	13.0	--	--	--	--	--	--	Volunteer Monitor
6/13/05	12.0	--	--	--	--	--	--	Volunteer Monitor
7/7/05	6.0	--	--	--	--	--	--	Volunteer Monitor
7/7/05	7.0	--	--	--	--	--	--	Volunteer Monitor
8/17/05	6.0	--	--	--	--	--	--	Volunteer Monitor
8/17/05	6.0	--	--	--	--	--	--	Volunteer Monitor
9/13/05	7.0	--	--	--	--	--	--	Volunteer Monitor
9/14/05	6.0	--	--	--	--	--	--	Volunteer Monitor
Maximum	32.0	9.5	93.5	0.069	18,193	7.52	22	
Median	10.0	8.6	50.0	0.025	3,126	2.34	17	
Minimum	1.7	8.2	0.0	0.010	2,804	0.02	16	

Table F.2. Historic water quality data collected at Syracuse Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (μg/L)	TSI	Source
1975	13.0	--	--	0.010	--	--	--	Hippemsteel, 1989
6/1/1975	--	--	--	--	--	--	4	ISPCB, 1975
7/1/1975	9.5	--	--	--	--	--	--	Pearson, 2004
7/29/1985	9.5	9.5	74	--	--	--	--	Pearson, 1986
1988	8.0	--	--	0.060	--	--	--	Hippemsteel, 1990
8/1/1994	6.6	8.5	50	--	4,244	1.1	18	CLP
7/20/1995	12.0	--	100	0.170	307		10	Commonwealth, 2996
7/7/1996	8.0	--	--	--	--	--	--	Volunteer monitor
7/27/1996	8.0	--	--	--	--	--	--	Volunteer monitor
8/4/1996	9.0	--	--	--	--	--	--	Volunteer monitor
8/17/1996	10.0	--	--	--	--	--	--	Volunteer monitor
8/31/1996	10.0	--	--	--	--	--	--	Volunteer monitor
6/22/1997	12.0	--	--	--	--	--	--	Volunteer monitor
7/11/1997	7.0	--	--	--	--	--	--	Volunteer monitor
8/25/1997	9.0	--	--	--	--	--	--	Volunteer monitor
9/24/1997	10.0	--	--	--	--	--	--	Volunteer monitor
6/1/1998	11.0	--	--	--	--	--	--	Volunteer monitor
6/19/1998	8.0	--	--	--	--	--	--	Volunteer monitor
7/4/1998	8.0	--	--	--	--	--	--	Volunteer monitor
7/18/1998	8.0	--	--	--	--	--	--	Volunteer monitor
8/1/1998	9.0	--	--	--	--	--	--	Volunteer monitor
8/15/1998	9.0	--	--	--	--	--	--	Volunteer monitor
6/12/1999	7.0	--	--	0.05	--	0.02	--	Volunteer monitor
7/2/1999	10.0	--	--	--	--	--	--	Volunteer monitor
7/18/1999	9.0	--	--	--	--	--	--	Volunteer monitor
8/8/1999	10.0	--	--	0.062	--	2.05	--	Volunteer monitor
9/6/1999	10.0	--	--	--	--	--	--	Volunteer monitor
9/23/1999	13.0	--	--	--	--	--	--	Volunteer monitor
6/3/2000	19.0	--	--	--	--	--	--	Volunteer monitor
6/19/2000	18.0	--	--	0.039	--	0.72	--	Volunteer monitor
7/4/2000	13.0	--	--	--	--	--	--	Volunteer monitor
7/23/2000	--	--	--	0.046	--	1.15	--	Volunteer monitor
7/23/2000	12.0	--	--	--	--	--	--	Volunteer monitor
7/31/2000	11.8	8.4	89	--	860	1.1	15	CLP
8/10/2000	12.0	--	--	--	--	--	--	Volunteer monitor
8/27/2000	12.0	--	--	--	--	--	--	Volunteer monitor
9/13/2000	12.5	--	100	--	--	--	--	Harza, 2001
10/7/2000	19.0	--	--	--	--	--	--	Volunteer monitor
6/10/2001	7.0	--	--	0.044	--	1.3	--	Volunteer monitor
6/23/2001	6.0	--	--	--	--	--	--	Volunteer monitor
7/9/2001	6.0	--	--	0.034	--	0.71	--	Volunteer monitor
7/28/2001	7.0	--	--	--	--	--	--	Volunteer monitor
7/30/2001	9.0	--	--	--	--	--	--	Volunteer monitor
7/31/2001	9.0	--	--	--	--	--	--	Volunteer monitor
6/30/2002	6.0	--	--	0.043	--	0.08	--	Volunteer monitor

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
7/14/2002	9.0	--	--		--	--	--	Volunteer monitor
7/30/2002	10.0	--	--	0.019	--	2.85	--	Volunteer monitor
8/31/2002	9.0	--	--	0.019	--	2.21	--	Volunteer monitor
6/20/2003	19.0	--	--	--	--	--	--	Volunteer monitor
7/13/2003	11.0	--	--	0.01	--	--	--	Volunteer monitor
8/4/2003	10.5	8.6	56	--	4,268	2.8	19	CLP
8/20/2003	13.0	--	--	0.016	--	0.44	--	Volunteer monitor
7/29/2004	8.0	--	--	0.038	--	2.76	--	Volunteer monitor
8/21/2004	10.0	--	--	0.038	--	2.31	--	Volunteer monitor
5/10/2005	11.0	--	--	0.04	--	0.8	--	Volunteer monitor
6/13/2005	9.0	--	--	0.05	--	4.54	--	Volunteer monitor
7/11/2005	7.0	--	--	--	--	--	--	Volunteer monitor
8/16/2005	10.0	--	--	--	--	--	--	Volunteer monitor
9/13/2005	11.0	--	--	--	--	--	--	Volunteer monitor
Maximum	19.0	9.5	100.0	0.17	4268.0	4.5	19.0	
Median	10.0	8.6	81.3	0.04	2552.0	1.2	15.0	
Minimum	6.0	8.4	50.0	0.02	307.0	0.02	4.0	

Table F.3. Historic water quality data collected at Harper Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
7/3/72	11.00	8.5	--	--	--	--	--	ISPCB, 1986
8/31/72	8.50	8.7	--	--	--	--	--	ISPCB, 1986
7/16/84	5.50	9.5	--	--	--	--	--	Pearson, 1985
6/9/99	9.66	8.7	100	--	--	--	--	Pearson, 1999
6/16/90	11.75	--	--	--	--	--	--	Volunteer monitor
6/30/90	12.75	--	--	--	--	--	--	Volunteer monitor
8/4/90	8.00	--	--	--	--	--	--	Volunteer monitor
8/19/90	7.75	--	--	--	--	--	--	Volunteer monitor
6/1/75	--	--	--	--	--	--	60	ISPCB, 1975
6/1/91	--	--	--	--	--	--	29	ISPCB, 1991
6/1/93	--	--	--	--	--	--	25	ISPCB, 1993
6/1/00	--	--	--	--	--	--	25	ISPCB, 2000
6/1/03	--	--	--	--	--	--	34	ISPCB, 2003
7/1/91	7.55	--	--	0.084	10,412	--	--	CLP, 1991
7/1/93	10.83	--	--	0.085	28,624	--	--	CLP, 1993
8/8/00	7.55	8.52	--	0.044	41,879	3.01	--	CLP, 2000
8/12/03	4.59	8.6	--	0.046	37,525	3.78	--	CLP, 2003
Median	8.25	8.6	--	0.07	33,074	3.40	29	
Minimum	4.59	8.5	--	0.04	10,412	3.01	25	
Maximum	12.75	9.5	--	0.09	41,879	3.78	60	

Table F.4. Historic water quality data collected at Knapp Lake.

Date	Secchi (ft)	Epi pH	% Oxic	Mean TP (mg/L)	Plankton Density (#/L)	Chl a (µg/L)	TSI	Source
6/30/1969	11.7	--	--	--	--	--	--	Hudson, 1969
7/1/1972	9.0	--	89.8	--	--	--	--	Pearson, 1999
8/1/1972	11.0	--	78.0	--	--	--	--	Pearson, 1999
8/1/1980	8.5	--	39.0	--	--	--	--	Pearson, 1999
8/1/1982	10.5	--	30.5	--	--	--	--	Pearson, 1999
7/16/1984	6.5	9.5	40.7	--	--	--	--	Pearson, 1984
7/1/1989	3.9	--	--	0.178	29,195	--	--	CLP, 1989
6/16/1990	--	--	--	--	--	--	--	Volunteer monitor
6/18/1990	6.0	8.7	98.3	--	--	--	--	Pearson, 1990
6/30/1990	--	--	--	--	--	--	--	Volunteer monitor
8/4/1990	--	--	--	--	--	--	--	Volunteer monitor
8/19/1990	--	--	--	--	--	--	--	Volunteer monitor
6/1/1991	--	--	--	--	--	--	31	ISPCB, 1991
7/1/1991	6.9	--	--	0.1205	16,562	--	--	CLP, 1991
6/1/1993	--	--	--	--	--	--	40	ISPCB, 1993
7/1/1993	5.6	--		0.317	6,508	--	--	CLP, 1993
6/1/1999	10.0	--	100.0	--	--	--	--	Pearson, 1999
8/1/1999	4.5	--	84.7	--	--	--	--	Pearson, 1999
6/1/2000	--	--	--	--	--	--	39	ISPCB, 2000
8/8/2000	6.2	8.4	--	0.3485	55,157	3.31	--	CLP, 2000
8/21/2000	6.3		--	--	--	--	--	Pearson, 2000
6/1/2003	--	--	--	--	--	--	68	ISPCB, 2003
8/12/2003	3.9	8.6	--	0.312	753,170	3.01		CLP, 2003
Median	6.5	8.7	81.4	0.3	29,195	3.2	39	
Minimum	3.9	8.4	30.5	0.1	6,508	3.0	31	
Maximum	11.7	9.5	100.0	0.3	753,170	3.3	68	

APPENDIX G:

WATER QUALITY PARAMETER EXPLANATION

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

APPENDIX G1:

LAKE WATER QUALITY PARAMETERS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

The following is a brief description of the parameters analyzed during the lake sampling efforts:

Temperature. Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. For example, water temperature affects the amount of oxygen dissolved in the water column. Likewise, life associated with the aquatic environment in any location has its species composition and activity regulated by water temperature. Since essentially all aquatic organisms are 'cold-blooded' the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (USEPA, 1976). The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits to protect aquatic life for Indiana waters. For example, temperatures during the summer months should not exceed 90 °F (32.2 °C).

Dissolved Oxygen (DO). DO is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least 3 to 5 mg/L of DO. Coldwater fish such as trout generally require higher concentrations of DO than warmwater fish such as bass or bluegill. The IAC sets minimum DO concentrations at 4 mg/L for warmwater fish, but all waters must have a daily average of 5 mg/L. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth can over-saturate (greater than 100% saturation) the water with DO. Conversely, dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

Conductivity. Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions: on their total concentration, mobility, and valence (APHA, 1998). Rather than setting a conductivity standard, the Indiana Administrative Code sets a standard for dissolved solids (750 mg/L). Multiplying a dissolved solids concentration by a conversion factor of 0.55 to 0.75 μmhos per mg/L of dissolved solids roughly converts a dissolved solids concentration to specific conductance (Allan, 1995). Thus, converting the IAC dissolved solids concentration standard to specific conductance by multiplying 750 mg/L by 0.55 to 0.75 μmhos per mg/L yields a specific conductance range of approximately 1000 to 1360 μmhos. This report presents conductivity measurements at each site in μmhos.

Nutrients. Limnologists measure nutrients to predict the amount of algae growth and/or rooted plant (macrophyte) growth that is possible in a lake. Algae and rooted plants are a natural and necessary part of aquatic ecosystems. Both will always occur in a healthy lake. Complete elimination of algae and/or rooted plants is neither desirable nor even possible and should, therefore, never be the goal in managing a lake. Algae and rooted plant growth can, however, reach nuisance levels and interfere with the aesthetic and recreational uses of a lake. Limnologists commonly measure nutrient concentrations in aquatic ecosystem evaluations to determine the potential for such nuisance growth.

Like terrestrial plants, algae and rooted aquatic plants rely primarily on phosphorus and nitrogen for growth. Aquatic plants receive these nutrients from fertilizers, human and animal waste, atmospheric deposition in rainwater, and yard waste or other organic material that reaches the lake or stream. Nitrogen can also diffuse from the air into the water. This nitrogen is then "fixed" by certain algae species into a usable, "edible" form of nitrogen. Because of this readily available source of nitrogen (the air), phosphorus is usually the "limiting nutrient" in aquatic ecosystems. This means that it is actually the amount of phosphorus that controls plant growth in a lake or stream.

Phosphorus and nitrogen have several forms in water. The two common phosphorus forms are **soluble reactive phosphorus (SRP)** and **total phosphorus (TP)**. SRP is the dissolved form of phosphorus. It is the form that is "usable" by algae. Algae cannot directly digest and use particulate phosphorus. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. The most commonly measured nitrogen forms are **nitrate-nitrogen (NO_3)**, **ammonium-nitrogen (NH_4^+)**, and **total Kjeldahl nitrogen (TKN)**. Nitrate is a dissolved form of nitrogen that is commonly found in the upper layers of a lake or anywhere that oxygen is readily available. In contrast, ammonium-nitrogen is generally found where oxygen is lacking. ***Anoxia***, or a lack of oxygen, is common in the lower layers of a lake. Ammonium is a byproduct of decomposition generated by bacteria as they decompose organic material. Like SRP, ammonium is a dissolved form of nitrogen and the one utilized by algae for growth. The TKN measurement parallels the TP measurement to some extent. TKN is a measure of the **total organic nitrogen** (particulate) and ammonium-nitrogen in the water sample.

While the United States Environmental Protection Agency (USEPA) has established some nutrient standards for drinking water safety, it has not established similar nutrient standards for protecting the biological integrity of a lake. (The USEPA, in conjunction with the States, is currently working on developing these standards.) The USEPA has issued recommendations for numeric nutrient criteria for lakes (USEPA, 2000a). While these are not part of the Indiana Administrative Code, they serve as potential target conditions for which watershed managers might aim. Other researchers have suggested thresholds for several nutrients in lake ecosystems as well (Carlson, 1977; Vollenweider, 1975). Lastly, the Indiana Administrative Code (IAC) requires that all waters of the state have a nitrate concentration of less than 10 mg/L, which is the drinking water standard for the state.

With respect to lakes, limnologists have determined the existence of certain thresholds for nutrients above which changes in the lake's biological integrity can be expected. For example, Correll (1998) found that soluble reactive phosphorus concentrations of 0.005 mg/L are enough to maintain eutrophic or highly productive conditions in lake systems. For total phosphorus concentrations, 0.03 mg/L (0.03 ppm – parts per million or 30 ppb – parts per billion) is the generally accepted threshold. Total phosphorus concentrations above this level can promote nuisance algae blooms in lakes. The USEPA's recommended nutrient criterion for total phosphorus is fairly low, 14.75 μg/L (USEPA, 2000a). This is an unrealistic target for many Indiana lakes. It is unlikely that IDEM will recommend a total phosphorus criterion this low for incorporation in the IAC. Similarly, the USEPA's recommended nutrient criterion for nitrate-nitrogen in lakes is low at 8 μg/L. This is below the detection limit of most laboratories. In general, levels of inorganic nitrogen (which includes nitrate-nitrogen) that exceed 0.3 mg/L may also promote algae blooms in lakes. High levels of nitrate-nitrogen can be lethal to fish. The nitrate LC_{50} is 5 mg/L for logperch, 40 mg/L for carp, and 100 mg/L for white sucker. (Determined by performing a bioassay in the laboratory, the LC_{50} is the concentration of the pollutant being tested, in this case nitrogen, at which 50% of the test population died in the bioassay.) The USEPA's recommended criterion for total Kjeldahl nitrogen in lakes is 0.56 mg/L.

It is important to remember that none of the threshold or recommended concentrations listed above are state standards for water quality. They are presented here to provide a frame of reference for the concentrations found in Pretty Lake. The IAC sets only nitrate-nitrogen and ammonia-nitrogen standards for waterbodies in Indiana. The Indiana Administrative Code requires that all waters of the state have a nitrate-nitrogen concentration of less than 10 mg/L, which is the drinking water standard for the state. The IAC standard for ammonia-nitrogen depends upon the water's pH and temperature, since both can affect ammonia-nitrogen's toxicity. The Pretty Lake samples did not exceed the state standard for either nitrate-nitrogen or ammonia-nitrogen.

Secchi Disk Transparency. This refers to the depth to which the black and white Secchi disk can be seen in the lake water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Particulates (for example, soil or dead leaves) may be introduced into the water by either runoff from the land or from sediments already on the bottom of the lake. Many processes may introduce sediments from runoff; examples include erosion from construction sites, agricultural land, and riverbanks. Bottom sediments may be resuspended by bottom feeding fish such as carp, or in shallow lakes, by motorboats or strong winds. In general, lakes possessing Secchi disk transparency depths greater than 15 feet (4.5 m) have outstanding clarity. Lakes with Secchi disk transparency depths less than 5 feet (1.5 m) possess poor water clarity (ISPCB, 1976; Carlson, 1977). The USEPA recommended a numeric criterion of 10.9 feet (3.3 m) for Secchi disk depth in lakes (USEPA, 2000a).

Light Transmission. Similar to the Secchi disk transparency, this measurement uses a light meter (photocell) to determine the rate at which light transmission is diminished in the upper portion of the lake's water column. Another important light transmission measurement is determination of the 1% light level. The 1% light level is the water depth to which one percent of the surface light penetrates. This is considered the lower limit of algal growth in lakes. The volume of water above the 1% light level is referred to as the ***photic zone***.

Plankton. Plankton are important members of the aquatic food web. Plankton include the algae (microscopic plants) and the zooplankton (tiny shrimp-like animals that eat algae). Plankton are collected by towing a net with a very fine mesh (63-micron openings = 63/1000 millimeter) up through the lake's water column from the one percent light level to the surface. Of the many different planktonic species present in the water, the blue-green algae are of particular interest. Blue-green algae are those that most often form nuisance blooms and their dominance in lakes may indicate poor water conditions.

Chlorophyll *a*. The plant pigments in algae consist of the chlorophylls (green color) and carotenoids (yellow color). Chlorophyll *a* is by far the most dominant chlorophyll pigment and occurs in great abundance. Thus, chlorophyll *a* is often used as a direct estimate of algal biomass. In general, chlorophyll *a* concentrations below 2 μg/L are considered low, while those exceeding 10 μg/L are considered high and indicative of poor water quality. The USEPA recommended a numeric criterion of 2.6 μg/L as a target concentration for lakes in Aggregate Nutrient Ecoregion VII (USEPA, 2000a).

APPENDIX G2:

STREAM WATER QUALITY PARAMETERS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Appendix G2. Parameters utilized for assessment of strem water quality in the Wawasee Area Watershed.

Water Chemistry:

Temperature. Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. For example, water temperature affects the amount of oxygen dissolved in the water column. Water temperature also governs species composition and activity of aquatic biological communities. Since essentially all aquatic organisms are 'cold-blooded' the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (USEPA, 1976). The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits to protect aquatic life for Indiana streams according to the time of year. For example, temperatures during the summer months should not exceed 90 °F (32.2 °C).

Dissolved Oxygen (DO). DO is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least 3 to 5 mg/L of DO. Coldwater fish such as trout generally require higher concentrations of DO than warmwater fish such as bass or bluegill. The Indiana Administrative Code (IAC) sets minimum DO concentrations at 4 mg/L, but all waters must have a daily average of 5 mg/L. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth can over-saturate (greater than 100% saturation) the water with DO. Conversely, dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

Water quality researchers and monitoring programs often measure the amount of oxygen in the water and the potential substances in the waterbody that utilize this oxygen. Dissolved oxygen (DO) is a measure of how much oxygen is in the water, while **biochemical oxygen demand (BOD)** and **chemical oxygen demand (COD)** are measures of the potential for oxygen depletion in a waterbody. Specifically, BOD is a measure of the amount of oxygen consumed by microorganisms in a water sample over a 5-day period; COD is a measure of all the oxidizable wastes in a given water quality sample. Although the COD analysis is easier to conduct than the BOD analysis, it includes some organic wastes that do not typically contribute to the oxygen demand of a stream (Schueler, 1997). For this reason, only BOD samples were collected and analyzed for this project. A variety of sources contribute oxygen demanding organic wastes to a stream, including soil erosion, human/animal waste, vehicle emissions, household or industrial chemicals, lawn clippings, and pesticides (Horner et al., 1994).

Conductivity. Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions: on their total concentration, mobility, and valence (APHA, 1998). During low discharge, conductivity is higher than during high discharge because the water moves more slowly across or through ion containing soils and substrates during base flow. Carbonates and other charged particles (ions) dissolve into the slow-moving water, thereby increasing conductivity measurements.

Rather than setting a conductivity standard, the IAC sets a standard for dissolved solids (750 mg/L). Multiplying a dissolved solids concentration by a conversion factor of 0.55 to 0.75 μmhos per mg/L of dissolved solids roughly converts a dissolved solids concentration to specific conductance (Allan, 1995). Thus, converting the IAC dissolved solids concentration standard to specific conductance by multiplying 750 mg/L by 0.55 to 0.75 μmhos per mg/L yields a specific conductance range of approximately 1000 to 1360 μmhos. This report presents conductivity measurements at each site in μmhos.

pH. The pH of water describes the concentration of acidic ions (specifically H+) present in water. Water's pH determines the form, solubility, and toxicity of a wide range of other aqueous compounds. The IAC establishes a range of 6 to 9 pH units for the protection of aquatic life. pH concentrations in excess of 9 are considered acceptable when the concentration occurs as daily fluctuations associated with photosynthetic activity.

Nutrients. Scientists measure nutrients to predict the amount of algae growth and/or rooted plant (macrophyte) growth that is possible in a stream. Algae and rooted plants are a natural and necessary part of aquatic ecosystems. Both will always occur in a healthy stream system. Complete elimination of algae and/or rooted plants is neither desirable nor even possible and should, therefore, never be the goal in managing a stream. Algae and rooted plant growth can, however, reach nuisance levels and interfere with the aesthetic and recreational uses of a stream. Scientists commonly measure nutrient concentrations in aquatic ecosystem evaluations to determine the potential for such nuisance growth.

Nutrients themselves, as well as the primary producers (algae and plants) they feed, can also affect the composition of secondary producer communities such as macroinvertebrates and fish. Changes in secondary producer communities can, in turn, impact the way chemical constituents in the water are processed. This is an additional reason for examining nutrient levels in an aquatic ecosystem.

Phosphorus and nitrogen have several forms in water. The two common phosphorus forms are **soluble reactive phosphorus (SRP)** and **total phosphorus (TP)**. SRP is the dissolved form of phosphorus. It is the form that is "usable" by algae. Algae cannot directly digest and use particulate phosphorus. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. The most commonly measured nitrogen forms are **nitrate-nitrogen (NO_3)**, **ammonium-nitrogen (NH_4^+)**, and **total Kjeldahl nitrogen (TKN)**. Nitrate is a dissolved form of nitrogen that is commonly found anywhere that oxygen is readily available. Because oxygen should be readily available in stream systems, nitrate-nitrogen is often the dominant dissolved form of nitrogen in stream systems. In contrast, ammonium-nitrogen is generally found where oxygen is lacking. Ammonium is a byproduct of decomposition generated by bacteria as they decompose organic material. Like SRP, ammonium is a dissolved form of nitrogen and the one utilized by algae for growth. The TKN measurement parallels the TP measurement to some extent. TKN is a measure of the **total organic nitrogen** (particulate) and ammonium-nitrogen in the water sample.

While the United States Environmental Protection Agency (USEPA) has established some nutrient standards for drinking water safety, it has not established similar nutrient standards for protecting the biological integrity of a stream. (The USEPA, in conjunction with the States, is currently working on developing these standards.) The USEPA has issued recommendations for numeric nutrient criteria for streams (USEPA, 2000). While these are not part of the Indiana Administrative Code, they serve as potential target conditions for which watershed managers might aim. The Ohio EPA has also made recommendations for numeric nutrient criteria in streams based on research on Ohio streams (Ohio EPA, 1999). These, too, serve as potential target conditions for those who manage Indiana streams. Other researchers have suggested thresholds for several nutrients in aquatic ecosystems as well (Dodd et al., 1998). Lastly, the Indiana Administrative Code (IAC) requires that all waters of the state have a nitrate concentration of less than 10 mg/L, which is the drinking water standard for the state.

Researchers have recommended various thresholds and criteria for nutrients in streams. The USEPA's recommended targets for nutrient levels in streams are fairly low. The agency recommends a target total phosphorus concentration of 0.076 mg/L in streams (USEPA, 2000). Dodd et al. (1998) suggest the dividing line between moderately (mesotrophic) and highly (eutrophic) productive streams is a total phosphorus concentration of 0.07 mg/L. The Ohio EPA recommended a total phosphorus concentration of 0.08 mg/L in headwater streams to protect the streams' aquatic biotic integrity (Ohio EPA, 1999). (This criterion is for streams classified as Warmwater Habitat, or WWH, meaning the stream is capable of supporting a healthy, diverse warmwater fauna. Streams that cannot support a healthy, diverse community of warmwater fauna due to "irretrievable, extensive, man-induced modification" are classified as Modified Warmwater Habitat (MWH) streams and have a different criterion.) While the entire length of streams within the Wawasee Area Watershed may not fit the WWH definition, 0.08 to 0.1 mg/L is a good goal for the streams.

The USEPA sets aggressive nitrogen criteria recommendations for streams compared to the Ohio EPA. The USEPA's recommended criteria for nitrate-nitrogen and total Kjeldahl nitrogen concentrations for streams in Aggregate Nutrient Ecoregion VI are 0.633 mg/L and 0.591 mg/L, respectively (USEPA, 2000). In contrast, the Ohio EPA suggests using nitrate-nitrogen criteria of 1.0 mg/L in WWH wadeable and headwater streams and MWH headwater streams to protect aquatic life. Dodd et al. (1998) suggests the dividing line between moderately and highly productive streams using nitrate-nitrogen concentrations is approximately 1.5 mg/L.

It is important to remember that none of the threshold or recommended concentrations listed above are state standards for water quality. They are presented here to provide a frame of reference for the concentrations found in streams in the Wawasee Area Watershed. The IAC sets only nitrate-nitrogen and ammonia-nitrogen standards for waterbodies in Indiana. The Indiana Administrative Code requires that all waters of the state have a nitrate-nitrogen concentration of less than 10 mg/L, which is the drinking water standard for the state. The IAC standard for ammonia-nitrogen depends upon the water's pH and temperature, since both can affect ammonia-nitrogen's toxicity. The 2006 303(d) list of impaired waterbodies listing criteria indicates that the IDEM will include waterbodies with total phosphorus concentrations greater than 0.3 mg/L on subsequent lists of impaired waterbodies (IDEM, 2006).

Turbidity. Turbidity (measured in Nephelometric Turbidity Units) is a measure of particles suspended in the water itself. It is generally related to suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. According to the Hoosier Riverwatch, the average turbidity of an Indiana stream is 11 NTU with a typical range of 4.5 to 17.5 NTU (Crighton and Hosier, 2004). Turbidity measurements >20 NTU have been found to cause undesirable changes in aquatic life (Walker, 1978). As part of their effort to make numeric nutrient criteria recommendations, the USEPA set 6.3 NTUs as a target for turbidity in stream ecosystems (USEPA, 2000).

Total Suspended Solids (TSS). A TSS measurement quantifies all particles suspended and dissolved in water. Closely related to turbidity, this parameter quantifies sediment particles and other solid compounds typically found in water. In general, the concentration of suspended solids is greater in streams during high flow events due to increased overland flow. The increased overland flow erodes and carries more soil and other particulates to the stream. The sediment in water originates from many sources, but a large portion of sediment entering streams comes from active construction sites or other disturbed areas such as unvegetated stream banks, gravel roads, and farm fields.

Suspended solids impact streams in a variety of ways. When suspended in the water column, solids can clog the gills of fish and invertebrates. As the sediment settles to the creek bottom, it covers spawning and resting habitat for aquatic fauna, reducing the animals' reproductive success. Suspended sediments also impair the aesthetic and recreational value of a waterbody. Few people are enthusiastic about having a picnic near a muddy creek. Pollutants attached to sediment also degrade water quality. In general, TSS concentrations greater than 80 mg/L have been found to be deleterious to aquatic life (Waters, 1995).

E. coli **Bacteria.** *E. coli* is one member of a group of bacteria that comprise the fecal coliform bacteria and is used as an indicator organism to identify the potential for the presence of pathogenic organisms in a water sample. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. *E. coli* can come from the feces of any warm-blooded animal. Wildlife, livestock, and/or domestic animal defecation, manure fertilizers, previously contaminated sediments, and failing or improperly sited septic systems are common sources of the bacteria. The IAC sets the maximum concentration of *E. coli* at 235 colonies/100 mL in any one sample within a 30-day period or a geometric mean of 125 colonies per 100 mL for five samples collected in any 30-day period.

Habitat:
The physical habitat at the sampling sites for each of the streams was evaluated using the Qualitative Habitat Evaluation Index (QHEI). The Ohio EPA developed the QHEI for streams and rivers in Ohio (Rankin 1989, 1995). The QHEI is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic macrohabitat (Ohio EPA, 1989). While the Ohio EPA originally developed the QHEI to evaluate ***fish*** habitat in streams, IDEM and other agencies routinely utilize the QHEI as a measure of general "habitat" health. The QHEI is composed of six metrics including substrate composition, in-stream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle-run quality, and map gradient. Each metric is scored individually then summed to provide the total QHEI score. The QHEI score generally ranges from 20 to 100.

Substrate type(s) and quality are important factors of habitat quality and the QHEI score is partially based on these characteristics. Sites that have greater substrate diversity receive higher scores as they can provide greater habitat diversity for benthic organisms. The quality of substrate refers to the embeddedness of the benthic zone. Because the rocks (gravel, cobble, boulder) that comprise a stream's substrate do not fit together perfectly like pieces in a jigsaw puzzle, small pores and crevices exist between the rock in the stream's substrate. Many stream organisms can colonize these pores and crevices, or microhabitats. In streams that carry high silt loads, the pores and crevices between rock substrate become clogged over time. This clogging, or "embedding", of the stream's substrate eliminates habitat for the stream's biota. Thus, sites with heavy embeddedness and siltation receive lower QHEI scores for the substrate metric.

In-stream cover, another metric of the QHEI, refers to the type(s) and quantity of habitat provided within the stream itself. Examples of in-stream cover include woody logs and debris, aquatic and overhanging vegetation, and root wads extending from the stream banks. The channel morphology metric evaluates the stream's physical development with respect to habitat diversity. Pool and riffle development within the stream reach, the channel sinuosity, and other factors that represent the stability and direct modification of the site comprise this metric score.

A stream's buffer, which includes the riparian zone and floodplain zone, is a vital functional component of riverine ecosystems. It is instrumental in the detention, removal, and assimilation of nutrients. Riparian zones govern the quality of goods and services provided by riverine ecosystems (Ohio EPA, 1999). Riparian zone, floodplain zone, and bank erosion were examined at each site. The purpose was to evaluate the quality of the buffer zone of the stream, the land use within the floodplain that affects inputs to the waterway, and the extent of erosion in the stream. For the purposes of the QHEI, a riparian zone consists only of forest, shrub, swamp, or woody old field vegetation. Typically, weedy, herbaceous vegetation has higher runoff potential than woody components and does not represent an acceptable riparian zone type for the QHEI (Ohio EPA, 1989). Streams with grass or other herbaceous vegetation growing in the riparian zone receive low QHEI scores for this metric.

Metric 5 of the QHEI evaluates the quality of pool/glide and riffle/run habitats in the stream. These zones in a stream, when present, provide diverse habitat and, in turn, can increase habitat quality. The depth of pools within a reach and the stability of riffle substrate are some factors that affect the QHEI score in this metric.

The final QHEI metric evaluates the topographic gradient in a stream reach. This is calculated using topographic data. The score for this metric is based on the premise that both very low and very high gradient streams will have negative effects on habitat quality. Moderate gradient streams receive the highest score, 10, for this metric. The gradient ranges for scoring take into account the varying influence of gradient with stream size.

The QHEI evaluates the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of stream segments in Ohio have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 typify habitat conditions that have the ability to support exceptional warmwater faunas (Ohio EPA, 1999). IDEM indicates that QHEI scores above 64 suggest the habitat is capable of supporting a balanced warmwater community; scores between 51 and 64 are only partially supportive of a stream's aquatic life use designation (IDEM, 2000).

Macroinvertebrates:
Macroinvertebrate samples were collected at three sites in order to calculate Indiana's macroinvertebrate Index of Biotic Integrity (mIBI). The collection methods were altered slightly to improve collection of macroinvertebrates at sites with mucky substrates. The soft, mucky substrate in these ditches prohibited the use of a kick net. Instead, a D-frame dip net was swept through the

rooted macrophyte community at these sites. In addition, woody debris, if present, was washed to collect any invertebrates inhabiting the woody substrate.

The benthic community at each sample site was evaluated using two biological indices: the Hilsenhoff Family Level Biotic Index (HBI) (Hilsenhoff, 1988) and IDEM's macroinvertebrate Index of Biotic Integrity (mIBI) (IDEM, unpublished). The HBI uses the macroinvertebrate community to assess the level of organic pollution in a stream. The HBI is based on the premise that different families of aquatic insects possess different tolerance levels to organic pollution. Hilsenhoff assigned each aquatic insect family a tolerance value from 1 to 9; those families with lower tolerances to organic pollution were assigned lower values, while families that were more tolerant to organic pollution were assigned higher values. The HBI is calculated by multiplying the number of organisms from each family collected at a given site by the family tolerance value, summing these products, and dividing by the total number of organisms in the sample:

$$HBI = \frac{\Sigma x_i t_i}{n}$$

where x_i is the number of species in a given family, t_i is the tolerance values of that family, and n is the total number of organisms in the sample. Benthic communities dominated by organisms that are tolerant of organic pollution will exhibit higher HBI scores compared to benthic communities dominated by intolerant organisms. Table 22 correlates the HBI score with the level of organic pollution.

Table X. Water quality correlation to Hilsenhoff Biotic Index score.

Hilsenhoff Family Level Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very good	Possible slight organic pollution
4.26-5.00	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.00	Very poor	Severe organic pollution likely

IDEM's mIBI is a multi-metric index designed to provide a complete assessment of a creek's biological integrity. Karr and Dudley (1981) define biological integrity as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region". It is likely that this definition of biological integrity is what IDEM means by biological integrity as well. The mIBI consists of ten metrics which measure the species richness, evenness, composition, and density of the benthic community at a given site. The metrics include family-level HBI (Hilsenhoff's FBI), number of taxa, number of individuals, percent dominant taxa, EPT Index, EPT count, EPT count to total number of individuals, EPT count to chironomid count, chironomid count, and total number of individuals to number of squares sorted. (EPT stands for the Ephemeroptera, Plecoptera, and Trichoptera orders.) A classification score of 0, 2, 4, 6, or 8 is assigned to specific ranges for metric values. For example, if the benthic community being assessed supports nine different families, that community would receive a classification score of 2 for the "Number of Taxa" metric. The mIBI is calculated by averaging the classification scores for the ten metrics. mIBI scores of 0-2 indicate the sampling site is severely impaired; scores of 2-4 indicate the site is moderately impaired; scores of 4-6 indicate the site is slightly impaired; and scores of 6-8 indicate that the site is non-impaired.

Benthic macroinvertebrate scoring criteria used by IDEM in the evaluation of pool-riffle streams in Indiana.

	SCORING CRITERIA FOR THE FAMILY LEVEL MACROINVERTEBRATE INDEX OF BIOTIC INTEGRITY (mIBI) USING PENTASECTION AND CENTRAL TENDENCY ON THE LOGARITHMIC TRANSFORMED DATA DISTRIBUTIONS OF THE 1990-1995 RIFFLE KICK SAMPLES				
	CLASSIFICATION SCORE				
	0	**2**	**4**	**6**	**8**
Family Level HBI	≥5.63	5.62- 5.06	5.05-4.55	4.54-4.09	≤4.08
Number of taxa	≤7	8-10	11-14	15-17	≥18
Number of individuals	≤79	129-80	212-130	349-213	≥350
Percent dominant taxa	≥61.6	61.5-43.9	43.8-31.2	31.1-22.2	<22.1
EPT index	≤2	3	4-5	6-7	≥8
EPT count	≤19	20-42	43-91	92-194	≥195
EPT count to total number of individuals	≤0.13	0.14-0.29	0.30-0.46	0.47-0.68	≥0.69
EPT count to chironomid count	≤0.88	0.89-2.55	2.56-5.70	5.71-11.65	≥11.66
Chironomid count	≥147	146-55	54-20	19-7	≤6

Where: 0-2 = Severely Impaired, 2-4 = Moderately Impaired, 4-6 = Slightly Impaired, 6-8 = Non-impaired

APPENDIX H:

INDIANA TROPHIC STATE INDEX (ITSI) SCORING CRITERIA

WAWASEE AREA WATERSHED MANAGEMENT PLAN ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

The Indiana Trophic State Index.

Parameter and Range		Eutrophy Points
I.	Total Phosphorus (ppm)	
	A. At least 0.03	1
	B. 0.04 to 0.05	2
	C. 0.06 to 0.19	3
	D. 0.2 to 0.99	4
	E. 1.0 or more	5
II.	Soluble Phosphorus (ppm)	
	A. At least 0.03	1
	B. 0.04 to 0.05	2
	C. 0.06 to 0.19	3
	D. 0.2 to 0.99	4
	E. 1.0 or more	5
III.	Organic Nitrogen (ppm)	
	A. At least 0.5	1
	B. 0.6 to 0.8	2
	C. 0.9 to 1.9	3
	D. 2.0 or more	4
IV.	Nitrate (ppm)	
	A. At least 0.3	1
	B. 0.4 to 0.8	2
	C. 0.9 to 1.9	3
	D. 2.0 or more	4
V.	Ammonia (ppm)	
	A. At least 0.3	1
	B. 0.4 to 0.5	2
	C. 0.6 to 0.9	3
	D. 1.0 or more	4
VI.	Dissolved Oxygen: Percent Saturation at 5 feet from surface	
	A. 114% or less	0
	B. 115% to 119%	1
	C. 120% to 129%	2
	D. 130% to 149%	3
	E. 150% or more	4
VII.	Dissolved Oxygen: Percent of measured water column with at least 0.1 ppm dissolved oxygen	
	A. 28% or less	4
	B. 29% to 49%	3
	C. 50% to 65%	2
	D. 66% to 75%	1
	E. 76% to 100%	0

VIII. Light Penetration (Secchi Disk)

A.	Five feet or under	6

IX. Light Transmission (Photocell) : Percent of light transmission at a depth of 3 feet

A.	0 to 30%	4
B.	31% to 50%	3
C.	51% to 70%	2
D.	71% and up	0

X. Total Plankton per liter of water sampled from a single vertical tow between the 1% light level and the surface:

A.	less than 3,000 organisms/L	0
B.	3,000 - 6,000 organisms/L	1
C.	6,001 - 16,000 organisms/L	2
D.	16,001 - 26,000 organisms/L	3
E.	26,001 - 36,000 organisms/L	4
F.	36,001 - 60,000 organisms/L	5
G.	60,001 - 95,000 organisms/L	10
H.	95,001 - 150,000 organisms/L	15
I.	150,001 - 5000,000 organisms/L	20
J.	greater than 500,000 organisms/L	25
K.	Blue-Green Dominance: additional points	10

Values for each water quality parameter are totaled to obtain an ITSI score. Based on this score, lakes are then placed into one of five categories:

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

APPENDIX I:

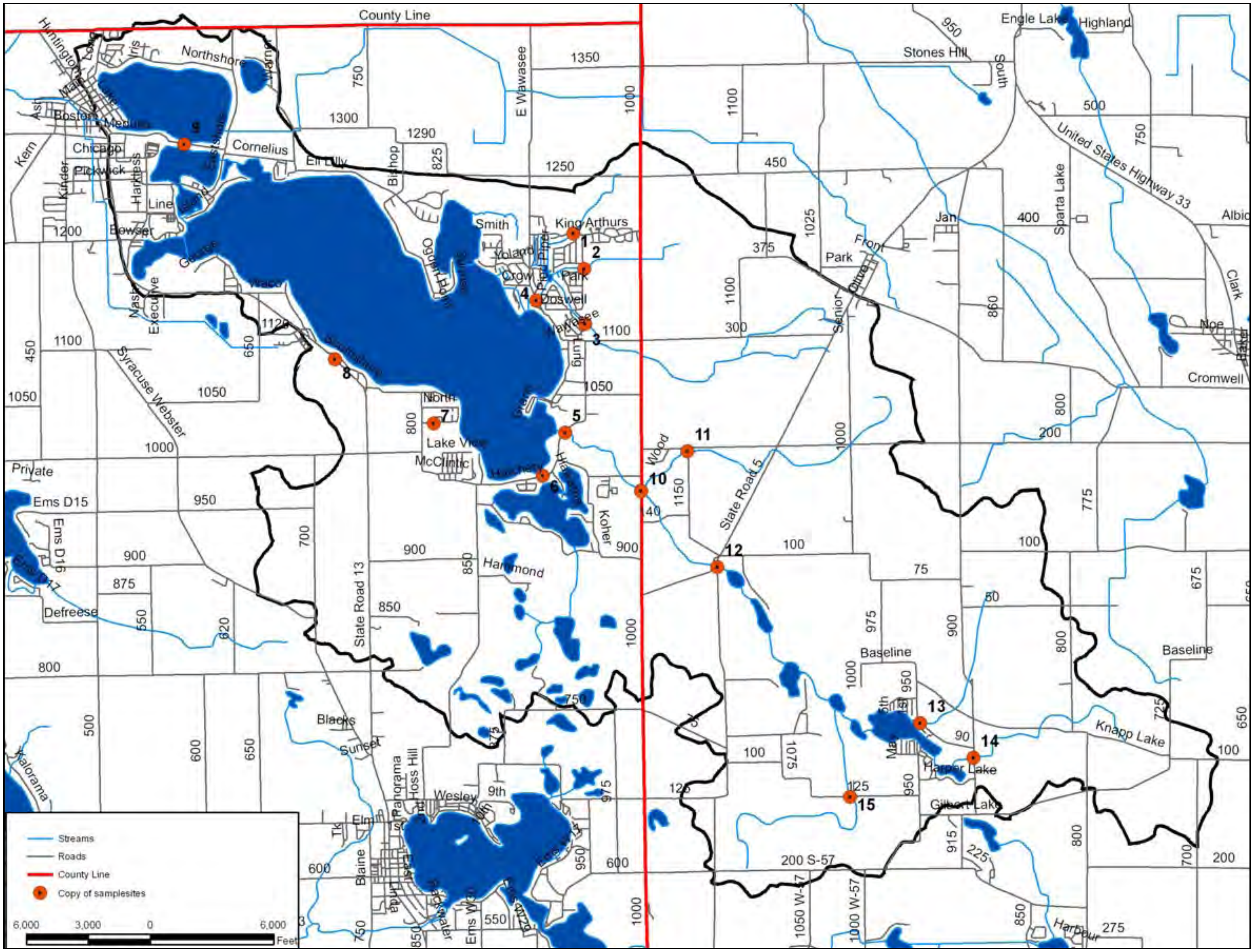
WATER QUALITY ASSESSMENT

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

APPENDIX I1:

STREAM DATA AND GRAPHICS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA



Map I1. Watershed sampling sites.

Table I1. Selected physical and chemical parameter data collected from the Wawasee Area Watershed streams during 2006 water chemistry sampling events. Shaded squares represent those in violation of state standards (■) or recommended target values (□).

Site	Date	Timing	Flow (cfs)	Temp (°C)	DO (mg/L)	% Sat.	Cond (μmhos)	pH	Turb (NTU)	TSS (mg/L)
1	7/25/06	base	0.04	19.6	5.6	60.5	673	7.5	1.1	3.8
	7/12/06	storm	0.18	20.5	5.9	65.6	255	8.0	1.2	0.02
2	7/25/06	base	0.48	19.8	8.5	91.9	635	8.0	1.6	2.9
	7/12/06	storm	0.80	21.8	8.3	93.0	563	8.3	1.4	3.1
3	7/25/06	base	0.09	22.6	6.9	78.5	671	8.2	1.7	13.2
	7/12/06	storm	0.78	21.6	7.4	84.5	541	7.6	8.9	14.2
4	7/25/06	base	--	25.7	8.1	99.0	544	8.0	1.2	4.2
	7/12/06	storm	--	25.1	6.2	75.6	553	7.6	2.4	1.7
5	7/25/06	base	5.13	24.5	4.7	55.8	538	7.6	1.1	1.8
	7/12/06	storm	900	23.9	5.0	60.9	540	7.9	1.2	1.4
6	7/25/06	base	0.12	27.3	6.9	86.5	415	7.6	1.8	1.4
	7/12/06	storm	0.18	24.0	7.1	84.5	421	7.8	1.7	0.2
7	7/25/06	base	dry							
	7/12/06	storm	dry							
8	7/25/06	base	0.05	20.7	2.9	29.5	675	7.4	2.0	6.1
	7/12/06	storm	--	21.4	2.1	24.0	573	7.7	2.0	2.9
9	7/25/06	base	NW	25.9	5.1	60.5	360	7.6	0.8	1.2
	7/12/06	storm	--	25.4	6.6	82.2	361	8.3	1.3	2.8
10	7/25/06	base	4.30	27.4	7.8	98.5	520	8.0	1.0	7.3
	7/12/06	storm	4.33	24.3	7.2	86.9	528	8.1	2.8	7.1
11	7/25/06	base	0.42	24.0	9.5	110.0	634	8.0	0.8	2.1
	7/12/06	storm	0.23	21.5	7.8	88.7	540	8.1	2.5	2.8
12	7/25/06	base	3.16	27.9	9.5	118.0	493	8.1	1.4	0.9
	7/12/06	storm	4.58	26.2	7.4	72.2	520	8.2	0.9	1.3
13	7/25/06	base	0.42	21.8	8.0	89.3	670	7.6	0.5	0.3
	7/12/06	storm	1.08	20.3	6.3	71.1	589	8.0	0.7	1.7
14	7/25/06	base	0.43	20.0	6.8	74.1	795	7.8	0.6	--
	7/12/06	storm	0.77	17.4	7.1	74.4	658	7.9	1.8	4.2
15	7/25/06	base	0.29	20.4	3.1	37.0	809	7.1	1.0	1.0
	7/12/06	storm	--	19.3	5.1	55.0	642	7.6	1.2	1.1

Table I2. Nutrient, sediment, and bacterial parameter concentration data from the Wawasee Area Watershed sites collected in 2006. Shaded squares represent those in violation of state standards (■) or recommended target values (■).

Site	Date	Timing	Nit.-N (mg/L)	Amm.-N (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	*E. coli* (col/100 mL)
1	7/25/06	base	2.392	0.018	0.302	0.032	0.059	2,800
	7/12/06	storm	2.190	0.025	0.372	0.034	0.061	830
2	7/25/06	base	10.115	0.021	0.253	0.015	0.028	540
	7/12/06	storm	8.720	0.053	0.230	0.010	0.017	460
3	7/25/06	base	4.917	0.018	0.520	0.032	0.073	2,900
	7/12/06	storm	3.780	0.018	0.743	0.032	0.075	4,100
4	7/25/06	base	1.857	0.018	0.843	0.010	0.045	620
	7/12/06	storm	2.333	0.138	0.730	0.010	0.041	126
5	7/25/06	base	1.490	0.123	0.845	0.034	0.066	810
	7/12/06	storm	1.368	0.076	0.699	0.039	0.067	890
6	7/25/06	base	0.062	0.113	0.611	0.013	0.045	360
	7/12/06	storm	0.042	0.018	0.418	0.010	0.027	1,900
7	7/25/06	base	Dry					
	7/12/06	storm	Dry					
8	7/25/06	base	0.075	0.390	0.673	0.158	0.287	1,700
	7/12/06	storm	0.082	0.278	0.727	0.125	0.171	12,400
9	7/25/06	base	0.015	0.018	0.605	0.010	0.028	16
	7/12/06	storm	0.013	0.018	0.461	0.010	0.181	78
10	7/25/06	base	3.202	0.021	0.739	0.019	0.049	3,000
	7/12/06	storm	2.481	0.048	0.686	0.021	0.020	17,000
11	7/25/06	base	5.560	0.028	0.490	0.052	0.140	1,510
	7/12/06	storm	5.792	0.018	0.386	0.024	0.051	51,000
12	7/25/06	base	1.315	0.018	1.008	0.010	0.035	134
	7/12/06	storm	1.659	0.041	0.737	0.012	0.031	560
13	7/25/06	base	3.142	0.075	1.128	0.040	0.100	114
	7/12/06	storm	4.561	0.018	0.672	0.092	0.106	660
14	7/25/06	base	3.177	0.041	0.279	0.031	0.056	630
	7/12/06	storm	3.511	0.018	0.394	0.034	0.055	14,500
15	7/25/06	base	3.810	0.075	0.609	0.019	0.035	370
	7/12/06	storm	4.090	0.018	1.035	0.021	0.048	1,700

Table I3. Chemical and bacterial parameter loading data collected in the Wawasee Area Watershed streams in 2006. Shaded squares represent those with the highest loading rate (■) and second highest loading rate (□) within each sampling event.

Site	Date	Timing	Nit-N (kg/d)	Amm-N (kg/d)	TKN (kg/d)	SRP (kg/d)	TP (kg/d)	TSS (kg/d)
1	7/25/06	base	0.251	0.002	0.032	0.003	0.006	0.403
	7/12/06	storm	0.964	0.011	0.164	0.015	0.027	0.011
2	7/25/06	base	11.896	0.025	0.298	0.018	0.033	3.411
	7/12/06	storm	17.057	0.104	0.450	0.020	0.033	6.113
3	7/25/06	base	1.106	0.004	0.117	0.007	0.016	2.969
	7/12/06	storm	7.209	0.034	1.417	0.061	0.143	27.178
4	7/25/06	base	No flow data collected.					
	7/12/06	storm	No flow data collected.					
5	7/25/06	base	18.701	1.544	10.605	0.427	0.828	22.214
	7/12/06	storm	30.104	1.672	15.382	0.858	1.474	30.809
6	7/25/06	base	0.018	0.032	0.173	0.004	0.013	0.397
	7/12/06	storm	0.018	0.008	0.184	0.004	0.012	0.098
7	7/25/06	base	Dry.					
	7/12/06	storm	Dry.					
8	7/25/06	base	0.009	0.009	0.081	0.019	0.034	0.726
	7/12/06	storm	Stream stagnant; no flow collected.					
9	7/25/06	base	No flow data collected.					
	7/12/06	storm	No flow data collected.					
10	7/25/06	base	33.775	0.222	7.795	0.200	0.517	76.475
	7/12/06	storm	26.267	0.508	7.263	0.222	0.212	75.625
11	7/25/06	base	5.737	0.029	0.506	0.054	0.144	2.201
	7/12/06	storm	3.257	0.010	0.217	0.013	0.029	1.575
12	7/25/06	base	10.173	0.139	7.798	0.077	0.271	7.032
	7/12/06	storm	18.579	0.459	8.253	0.134	0.347	14.398
13	7/25/06	base	3.242	0.077	1.164	0.041	0.103	0.295
	7/12/06	storm	12.044	0.048	1.775	0.243	0.280	4.423
14	7/25/06	base	3.348	0.043	0.294	0.033	0.059	--
	7/12/06	storm	6.610	0.034	0.742	0.064	0.104	7.949
15	7/25/06	base	2.692	0.053	0.430	0.013	0.025	0.707
	7/12/06	storm	Stream not flowing; no flow data collected.					

Table I4. Chemical and bacterial parameter areal loading data collected in the Wawasee Area Watershed streams in 2006. Shaded squares represent those with the highest areal loading rate (■) and second highest loading rate (□) within each sampling event.

Site	Date	Timing	Nit-N (kg/ha-yr)	Amm-N (kg/ha-yr)	SRP (kg/ha-yr)	TP (kg/ha-yr)	TKN (kg/ha-yr)	TSS (kg/ha-yr)
1	7/25/06	base	0.40	0.00	0.05	0.01	0.01	0.64
	7/12/06	storm	1.54	0.02	0.26	0.04	0.02	0.02
2	7/25/06	base	19.02	0.04	0.48	0.05	0.03	5.45
	7/12/06	storm	27.27	0.17	0.72	0.05	0.03	9.77
3	7/25/06	base	1.77	0.01	0.19	0.03	0.01	4.75
	7/12/06	storm	11.52	0.05	2.27	0.23	0.10	43.44
4	7/25/06	base	No flow data collected.					
	7/12/06	storm	No flow data collected.					
5	7/25/06	base	29.89	2.47	16.95	1.32	0.68	35.51
	7/12/06	storm	48.12	2.67	24.59	2.36	1.37	49.25
6	7/25/06	base	0.03	0.05	0.28	0.02	0.01	0.63
	7/12/06	storm	0.03	0.01	0.29	0.02	0.01	0.16
7	7/25/06	base	Dry.					
	7/12/06	storm	Dry.					
8	7/25/06	base	0.01	0.01	0.13	0.05	0.03	1.16
	7/12/06	storm	0.00	0.00	0.00	0.00	0.00	0.00
9	7/25/06	base	No flow data collected.					
	7/12/06	storm	No flow data collected.					
10	7/25/06	base	53.99	0.35	12.46	0.83	0.32	122.24
	7/12/06	storm	41.99	0.81	11.61	0.34	0.36	120.89
11	7/25/06	base	9.17	0.05	0.81	0.23	0.09	3.52
	7/12/06	storm	5.21	0.02	0.35	0.05	0.02	2.52
12	7/25/06	base	16.26	0.22	12.47	0.43	0.12	11.24
	7/12/06	storm	29.70	0.73	13.19	0.55	0.21	23.02
13	7/25/06	base	5.18	0.12	1.86	0.16	0.07	0.47
	7/12/06	storm	19.25	0.08	2.84	0.45	0.39	7.07
14	7/25/06	base	5.35	0.07	0.47	0.09	0.05	0.00
	7/12/06	storm	10.57	0.05	1.19	0.17	0.10	12.71
15	7/25/06	base	4.30	0.08	0.69	0.04	0.02	1.13
	7/12/06	storm	Stream not flowing; no flow data collected.					

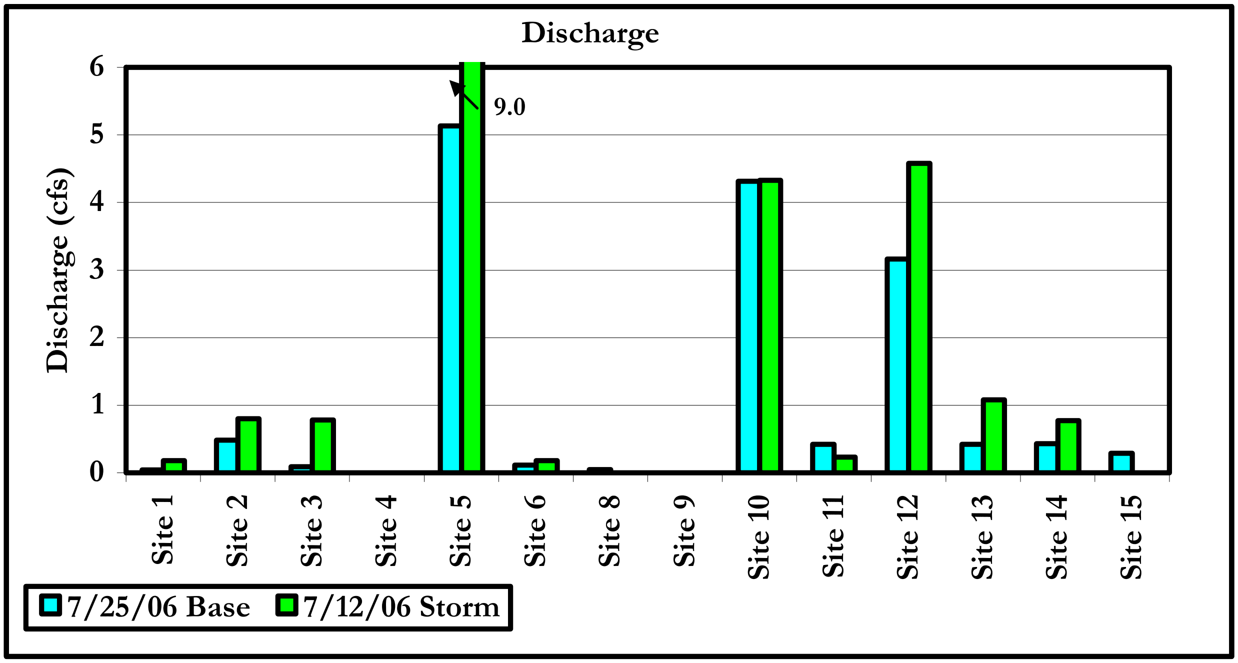


Figure I1. Discharge measurements during base flow and storm flow sampling of Wawasee Area Watershed streams.

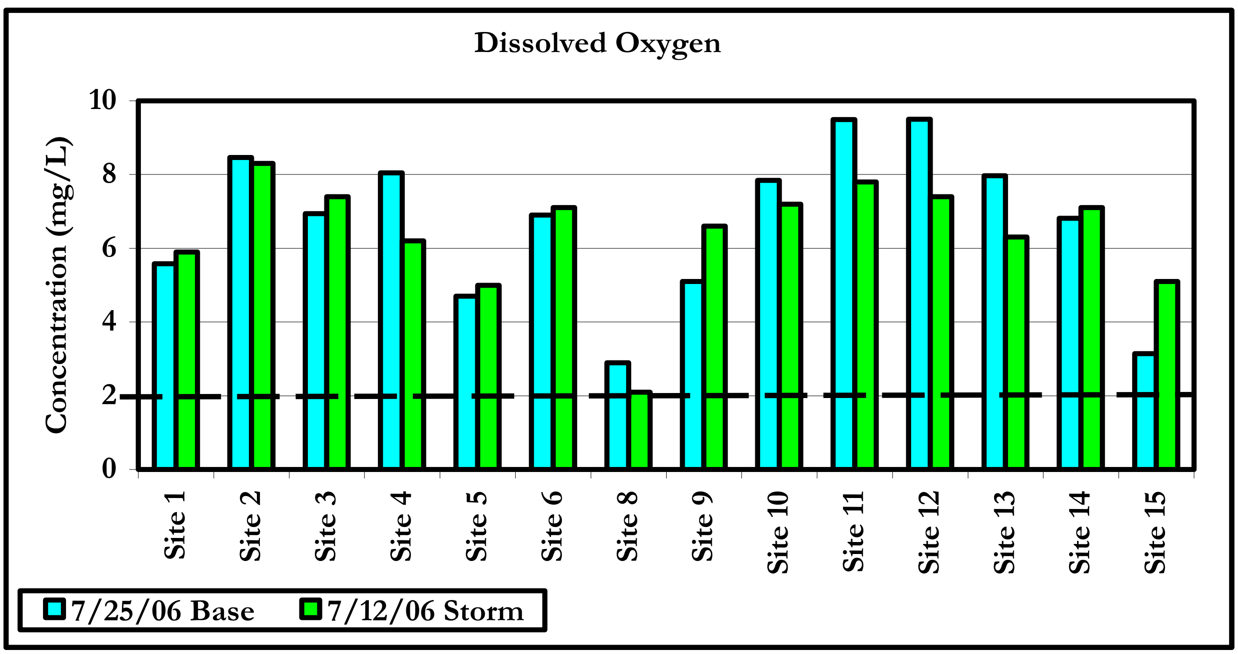


Figure I2. Dissolved oxygen concentrations measured during base flow and storm flow sampling of Wawasee Area Watershed streams.

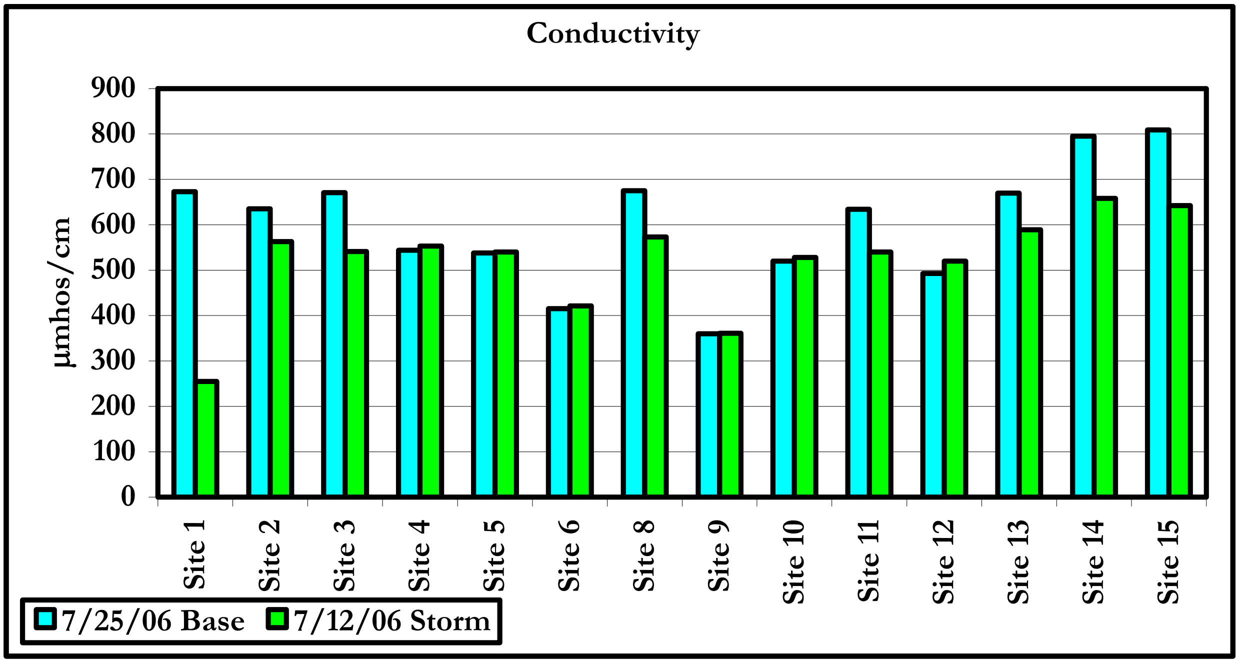


Figure I3. Conductivity measurements during base flow and storm flow sampling of Wawasee Area Watershed streams.

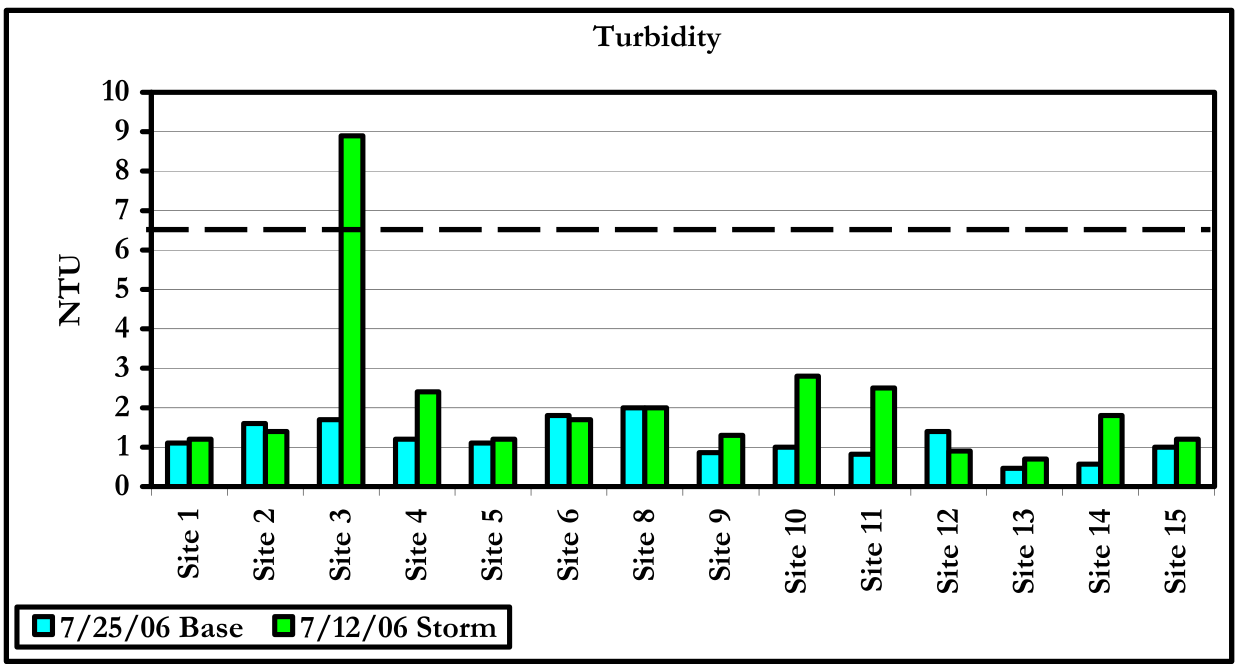


Figure I4. Turbidity measurements during base flow and storm flow sampling of Wawasee Area Watershed streams.

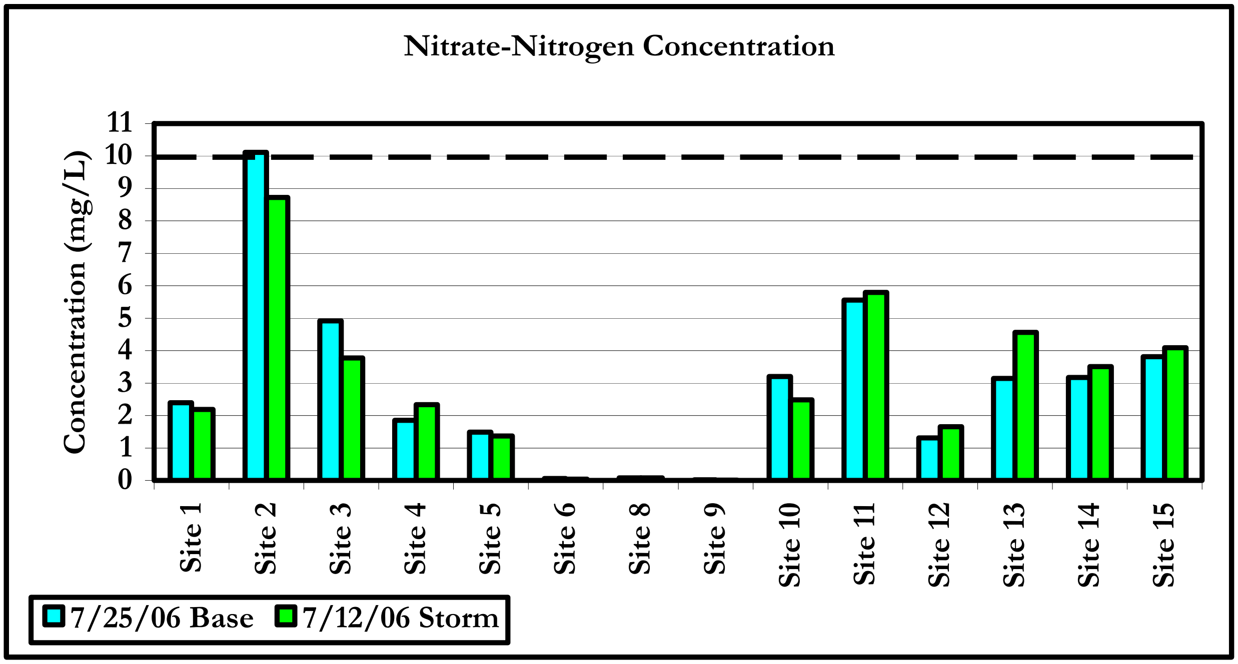


Figure I5. Nitrate-nitrogen concentrations measured during base flow and storm flow sampling of Wawasee Area Watershed streams.

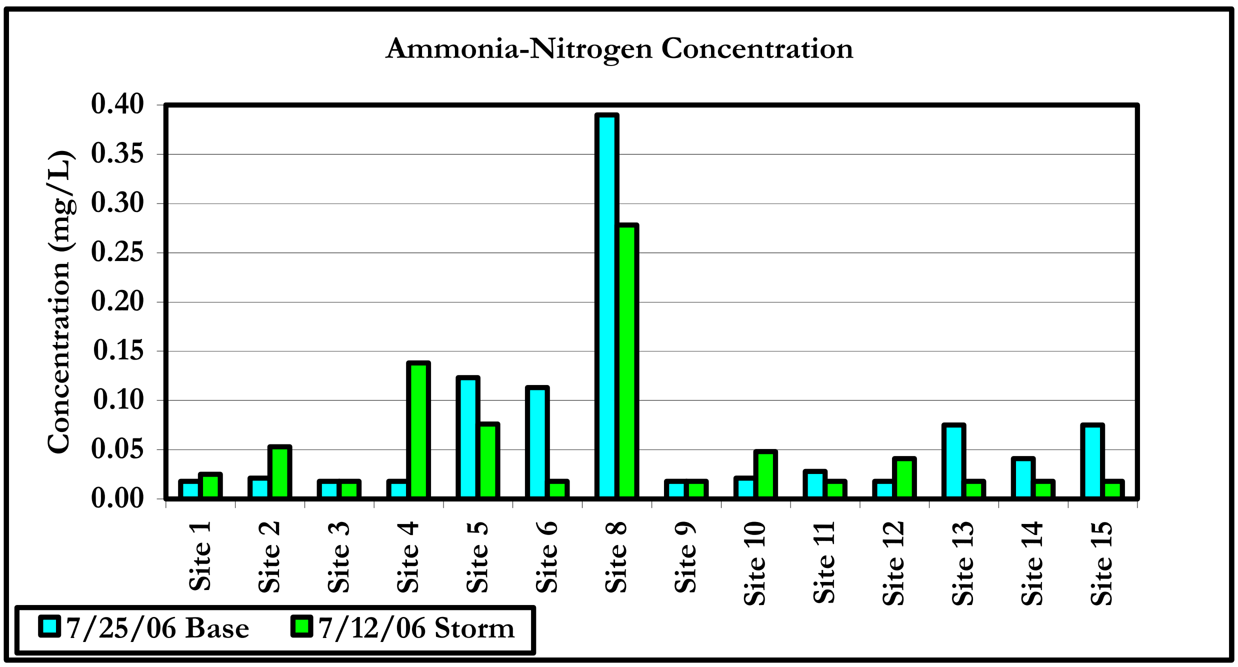


Figure I6. Ammonia-nitrogen concentrations measured during base flow and storm flow sampling of Wawasee Area Watershed streams.

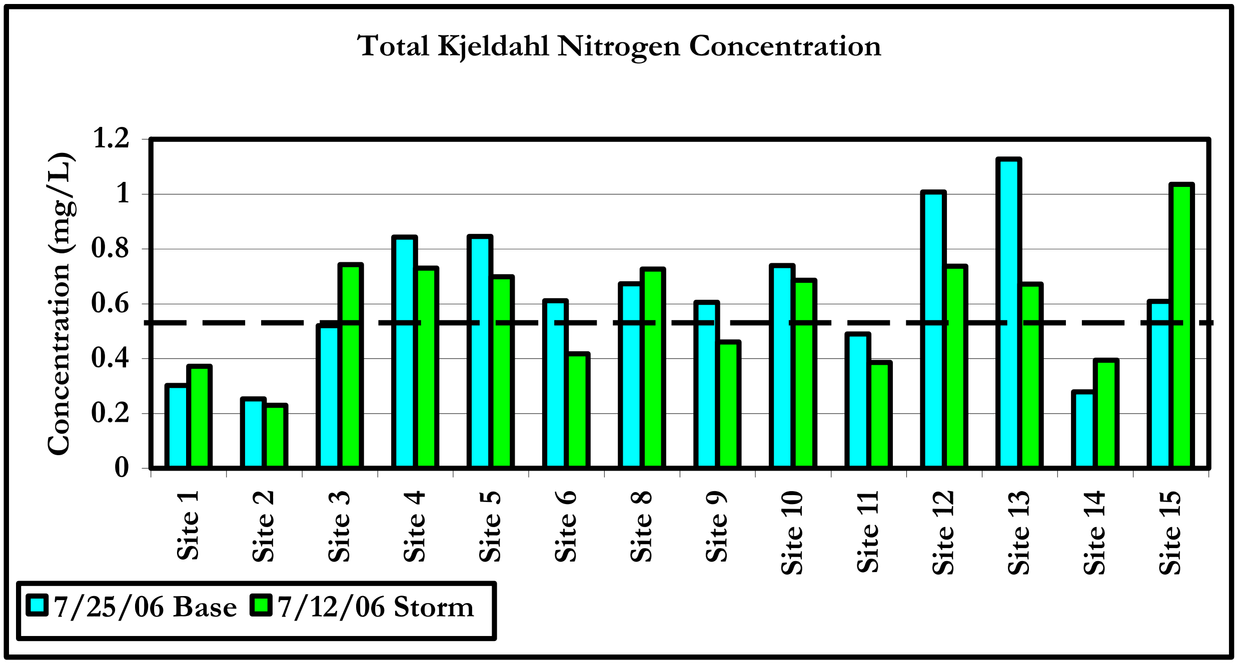


Figure I7. Total Kjeldahl nitrogen concentrations measured during base flow and storm flow sampling of Wawasee Area Watershed streams.

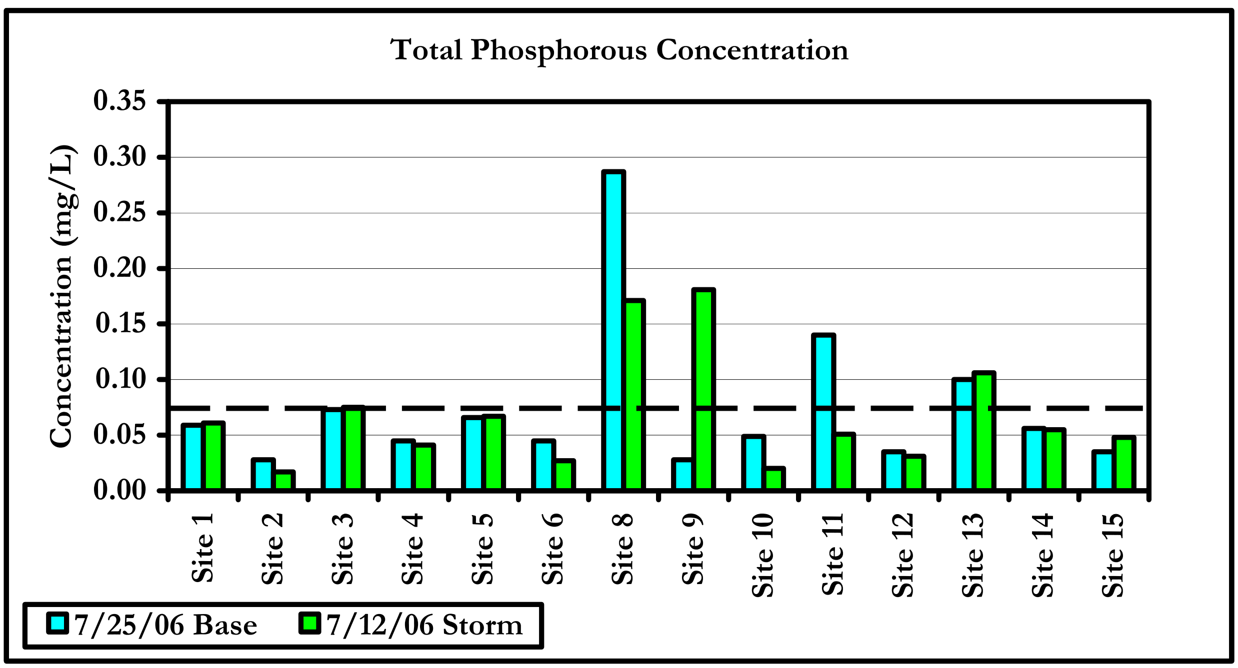


Figure I8. Total phosphorus concentrations measured during base flow and storm flow sampling of Wawasee Area Watershed streams.

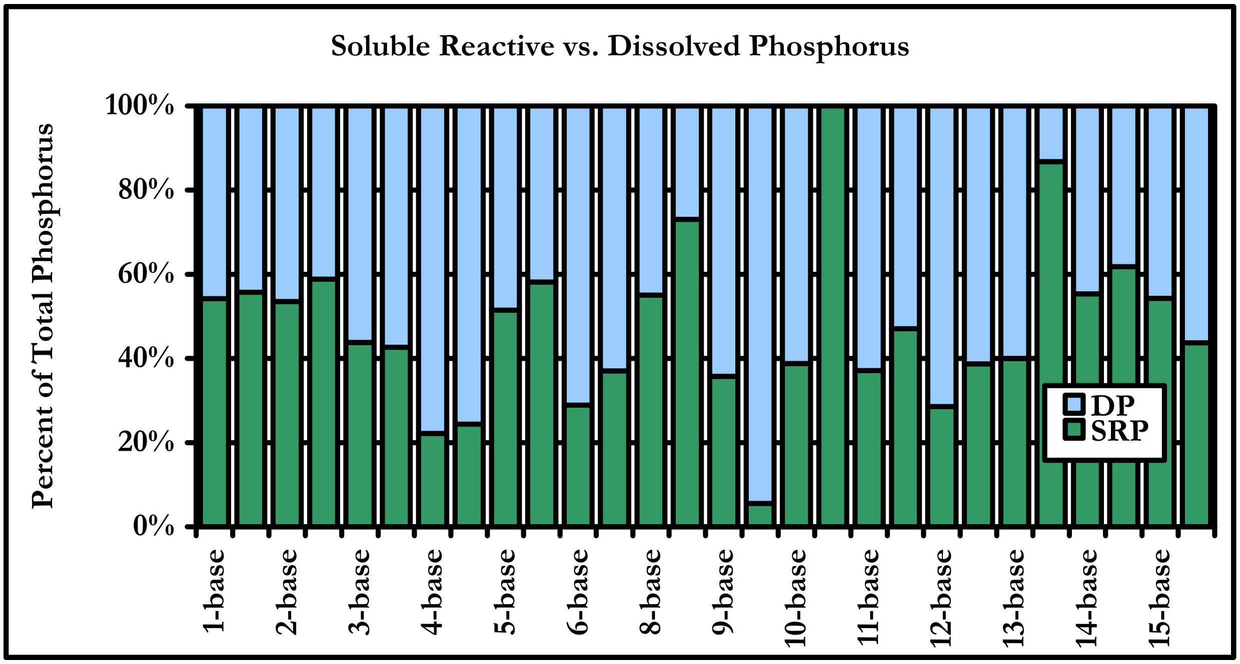


Figure I9. Soluble (SRP) and dissolved (DP) phosphorus concentrations as a total of available phosphorus during base flow and storm flow sampling of Wawasee Area Watershed streams.

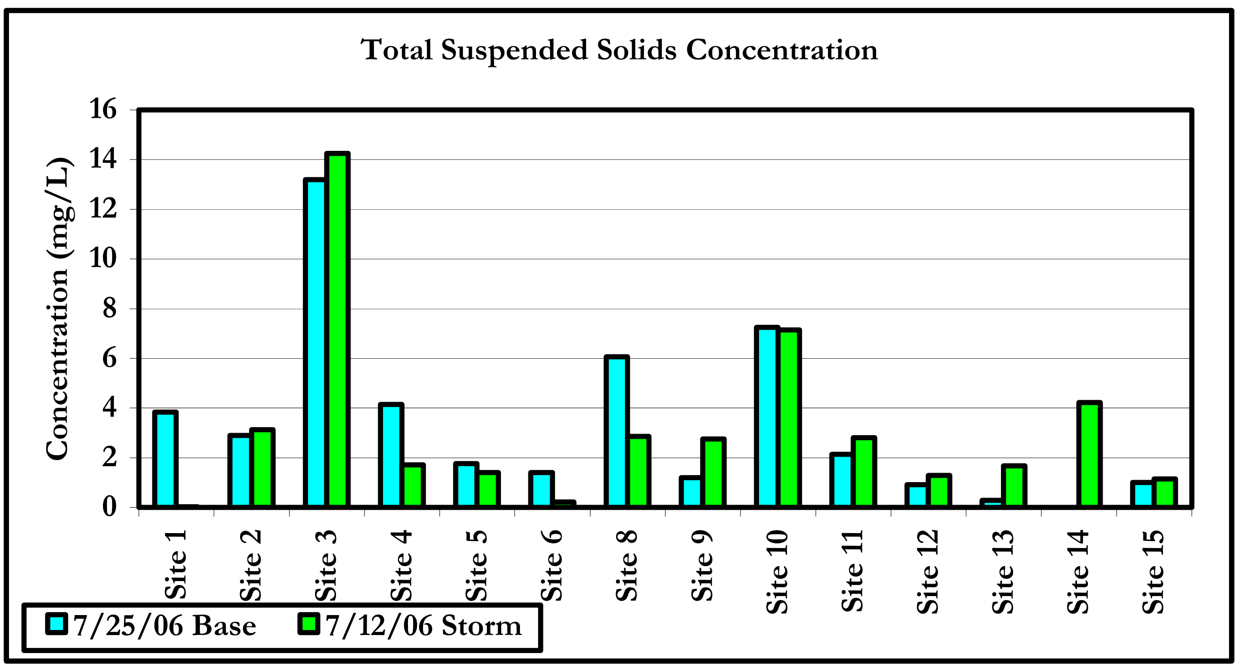


Figure I10. Total suspended solids concentrations measured during base flow and storm flow sampling of Wawasee Area Watershed streams.

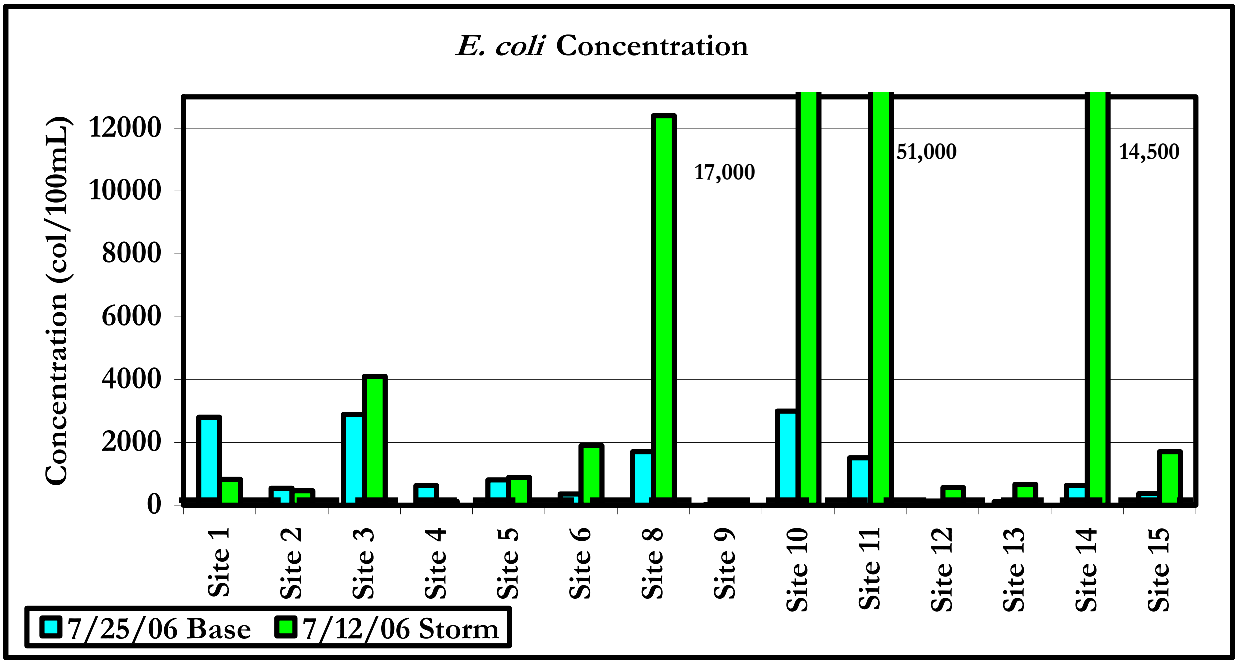


Figure I11. ***E. coli*** **concentrations measured during base flow and storm flow sampling of Wawasee Area Watershed streams.**

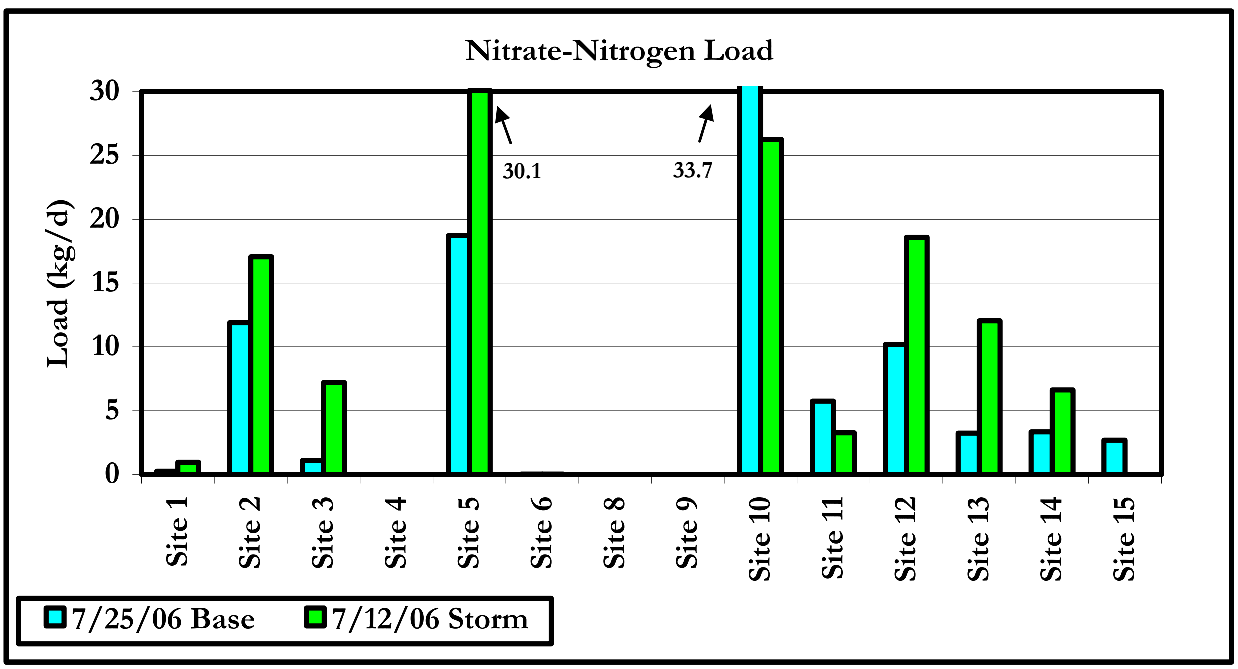


Figure I12. Nitrate-nitrogen loading rates calculated for base flow and storm flow sampling of Wawasee Area Watershed streams.

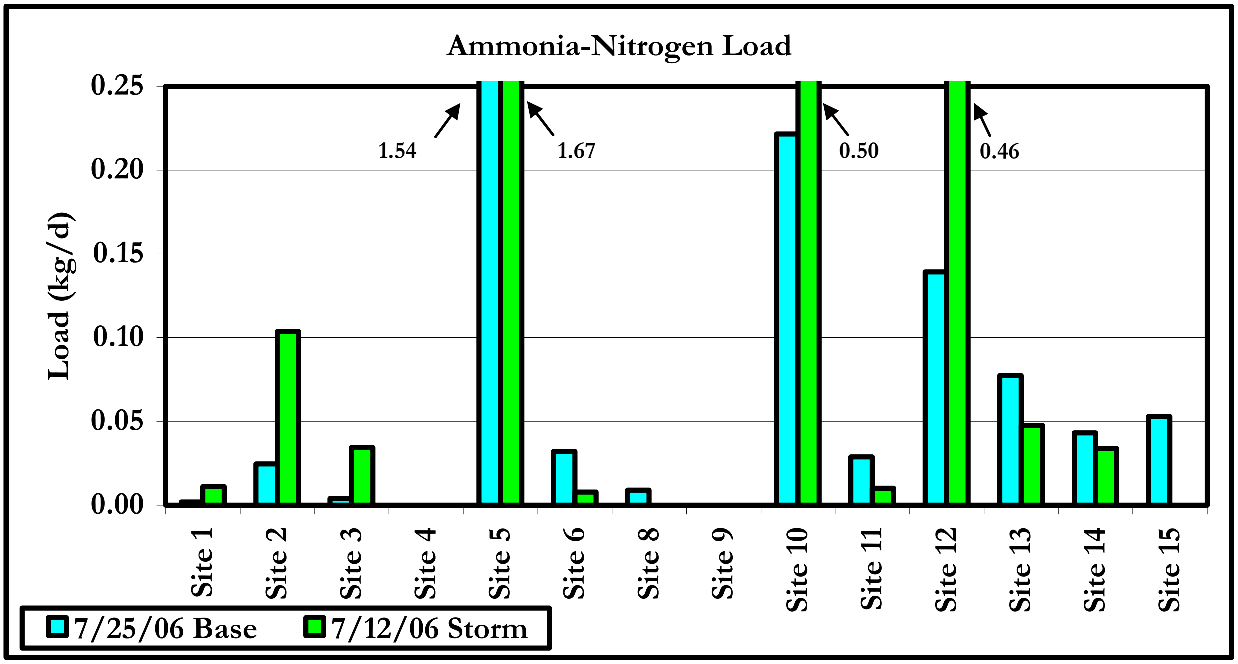


Figure I13. Ammonia-nitrogen loading rates calculated for base flow and storm flow sampling of Wawasee Area Watershed streams.

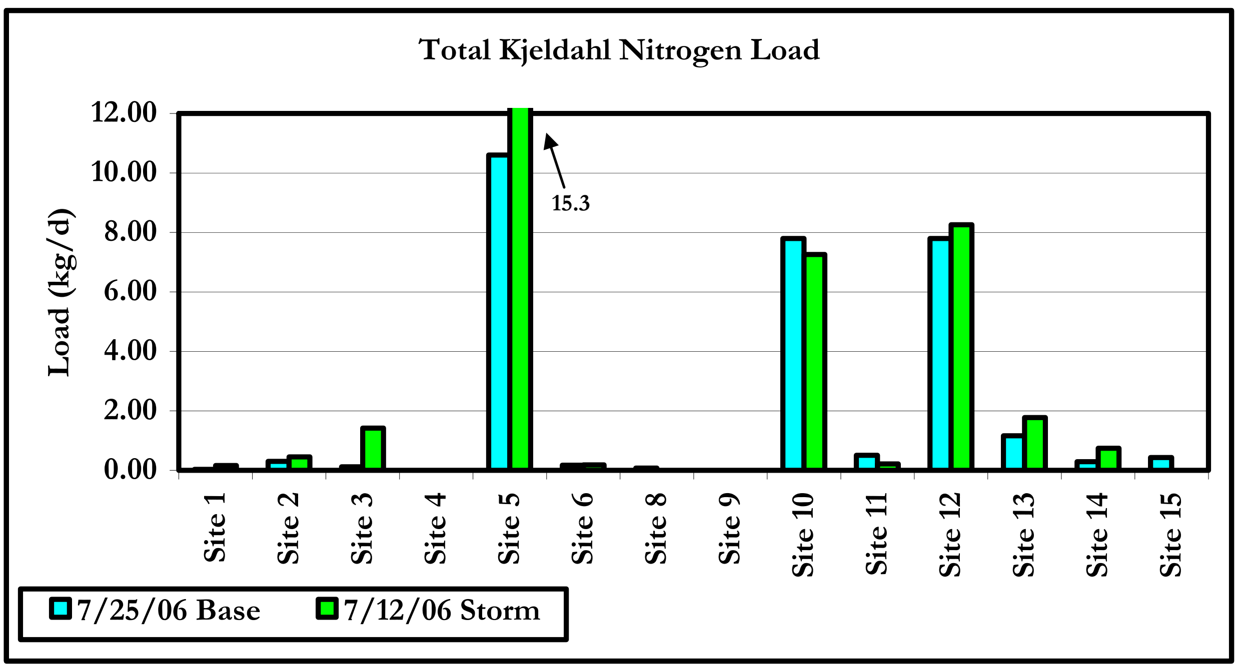


Figure I14. Total Kjeldahl nitrogen loading rates calculated for base flow and storm flow sampling of Wawasee Area Watershed streams.

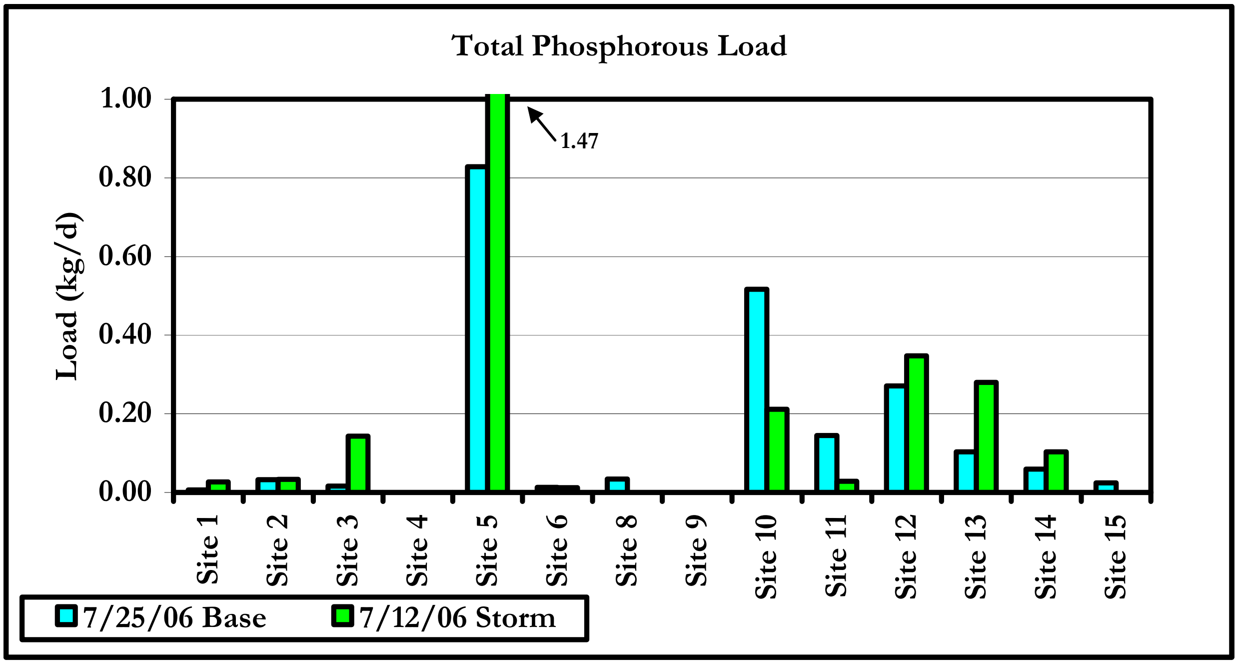


Figure I15. Total phosphorus loading rates calculated for base flow and storm flow sampling of Wawasee Area Watershed streams.

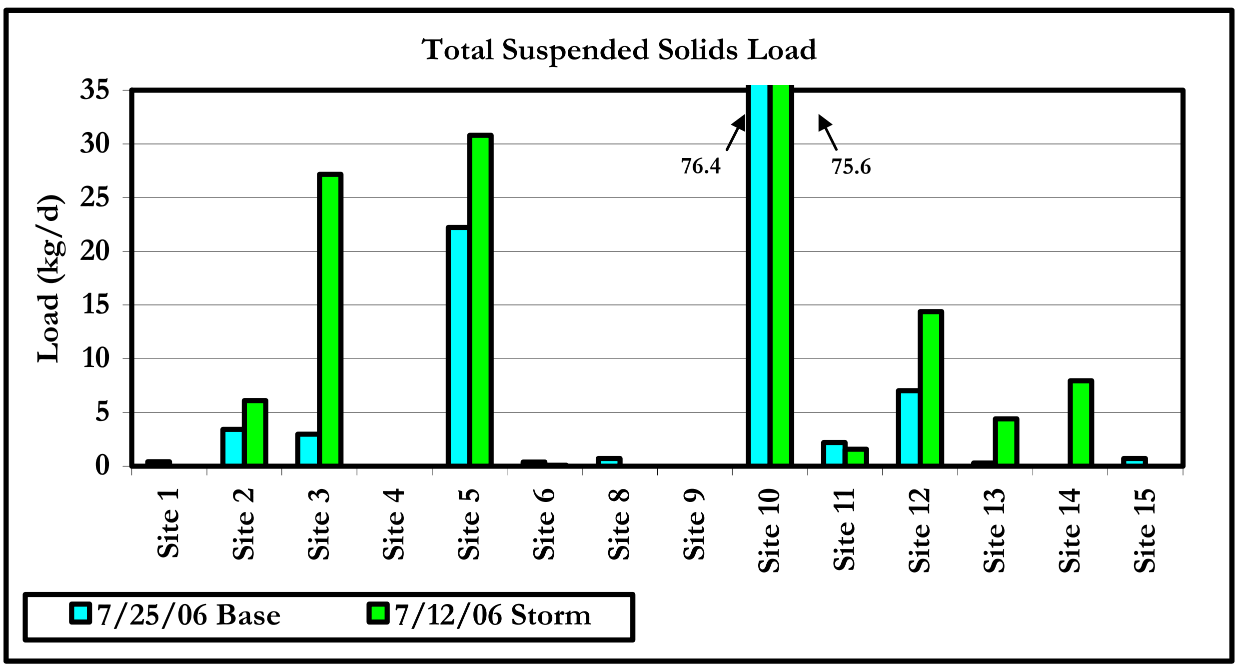


Figure I16. Total suspended solids loading rates calculated for base flow and storm flow sampling of Wawasee Area Watershed streams.

Table I5. Macroinvertebrate community and mIBI scoring calculation at Dillon Creek at CR 1000 West (Site 3), July 27, 2006.

Class/Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	8		8	4	32	10.13
Bivalvia	Sphaeriidae	1		1	8	8	1.27
Coleoptera	Elmidae	9		9	4	36	11.39
Diptera	Ceratopognidae	1		1	6	6	1.27
Diptera	Chironomidae	13		13	6	78	16.46
Diptera	Nematocera pupae	1				0	1.27
Ephemeroptera	Baetidae	2	2	2	4	8	2.53
Ephemeroptera	Caenidae	3	3	3	7	21	3.80
Gastropoda	Physidae	8		8	8	64	10.13
Hemiptera	Gerridae	1		1	5	5	1.27
Hemiptera	Mesoveliidae	1				0	1.27
Hemiptera	Veliidae	1				0	1.27
Hirudinea		1		1	10	10	1.27
Isopoda	Asillidae	4		4	8	32	5.06
Odonata	Coenagrionidae	1		1	6.1	6.1	1.27
Odonata	Corduliidae	2		2	5	10	2.53
Oligochaeta		1		1	5	5	1.27
Trichoptera	Hydropsychidae	21	21	21	4	84	26.58
TOTALS		**79**	**26**	**76**		**405.1**	**100.00**

Table I6. mIBI score calculation, Dillon Creek at CR 1000 West (Site 3), July 27, 2006.

mIBI Metric		Metric Score
HBI	5.33	2
No. Taxa (family)	18	8
Total Count (# individuals)	79	0
% Dominant Taxa	26.6	6
EPT Index (# families)	3	2
EPT Count (# individuals)	26	2
EPT Count/Total Count	0.33	4
EPT Abun./Chir. Abun.	2.00	2
Chironomid Count	13	8
mIBI Score		**3.8**

Table I5. Macroinvertebrate community and mIBI scoring calculation at Turkey Creek at Fish Hatchery Road (Site 5), July 27, 2006.

Class/Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	25		25	4	100	31.25
Bivalvia	Unionidae	6				0	7.50
Coleoptera	Elmidae	1		1	4	4	1.25
Coleoptera	Haliplidae	6		6	7	42	7.50
Diptera	Chironomidae	1		1	6	6	1.25
Ephemeroptera	Baetidae	3	3	3	4	12	3.75
Ephemeroptera	Caenidae	1	1	1	7	7	1.25
Gastropoda	Physidae	3		3	8	24	3.75
Gastropoda	Planorbidae	2		2	7	14	2.50
Gastropoda	Viviparidae	2		2	6	12	2.50
Hemiptera	Gerridae	3		3	5	15	3.75
Hemiptera	Pleidae	2				0	2.50
Hirudinea		1		1	10	10	1.25
Isopoda	Asillidae	14		14	8	112	17.50
Odonata	Coenagrionidae	8		8	6.1	48.8	10.00
Platyhelminthes	Planaria	2		2	1	2	2.50
TOTALS		**80**	**4**	**72**		**408.8**	**100.00**

Table I6. mIBI score calculation, Dillon Creek at CR 1000 West (Site 3), July 27, 2006.

mIBI Metric		Metric Score
HBI	5.68	0
No. Taxa (family)	16	6
Total Count (# individuals)	80	2
% Dominant Taxa	31.3	4
EPT Index (# families)	2	0
EPT Count (# individuals)	4	0
EPT Count/Total Count	0.05	0
EPT Abun./Chir. Abun.	4.00	4
Chironomid Count	1	8
mIBI Score		**2.7**

Table I7. Macroinvertebrate community and mIBI scoring calculation at Turkey Creek at at State Road 5 (Site 12), July 27, 2006.

Class/Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	16		16	4	64	10.46
Coleoptera	Curculionidae	2				0	1.31
Coleoptera	Dytiscidae	3		3	5	15	1.96
Coleoptera	Elmidae	1		1	4	4	0.65
Coleoptera	Haliplidae	3		3	7	21	1.96
Diptera	Chironomidae	3		3	6	18	1.96
Diptera	Culicidae	1		1	8	8	0.65
Ephemeroptera	Baetidae	1	1	1	4	4	0.65
Ephemeroptera	Caenidae	12	12	12	7	84	7.84
Gastropoda	Physidae	2		2	8	16	1.31
Gastropoda	Planorbidae	9		9	7	63	5.88
Hemiptera	Naucoridae	3				0	1.96
Hemiptera	Nepidae	2				0	1.31
Hemiptera	Notonectidae	3				0	1.96
Hirudinea		16		16	10	160	10.46
Megaloptera	Sialidae	2		2	4	8	1.31
Odonata	Coenagrionidae	12		12	6.1	73.2	7.84
Platyhelminthes	Planaria	4		4	1	4	2.61
Trichoptera	Hydropsychidae	57	57	57	4	228	37.25
Trichoptera	Hydroptilidae	1	1	1	4	4	0.65
TOTALS		**153**	**71**	**143**		**774.2**	**100.00**

Table I8. mIBI score calculation, Dillon Creek at CR 1000 West (Site 3), July 27, 2006.

mIBI Metric		Metric Score
HBI	5.41	2
No. Taxa (family)	20	8
Total Count (# individuals)	153	4
% Dominant Taxa	37.3	4
EPT Index (# families)	4	4
EPT Count (# individuals)	71	4
EPT Count/Total Count	0.46	4
EPT Abun./Chir. Abun.	23.67	8
Chironomid Count	3	8
	mIBI Score	**5.1**

Table I9. QHEI scores for Wawasee Area Watershed streams, July 27, 2006.

Site	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Possible Score	20	20	20	10	12	8	10	**100**
Site 1	13	14	13	7.5	0	1	10	**58.5**
Site 2	10	10	13	8.5	0	1	8	**50.5**
Site 3	9	6	10	9	4	2	10	**50**
Site 4	17	7	8	6	9	0	2	**49**
Site 5	0	11	9	9	9	0	10	**48**
Site 6	11	13	6	8.3	0	0	8	**46.3**
Site 7	Not assessed.							
Site 8	10	10	7	7	3	1	10	**48**
Site 9	13	6	5	4	7	0	2	**37**
Site 10	14	13	14	9.5	7	4	10	**71.5**
Site 11	1	14	7	4	4	1	8	**39**
Site 12	15	6	8	8.5	3	4	8	**52.5**
Site 13	12	9	6	8	4	4	8	**51**
Site 14	7	10	10	8.5	5	1	8	**49.5**
Site 15	4	9	8	7.5	4	0	6	**38.5**

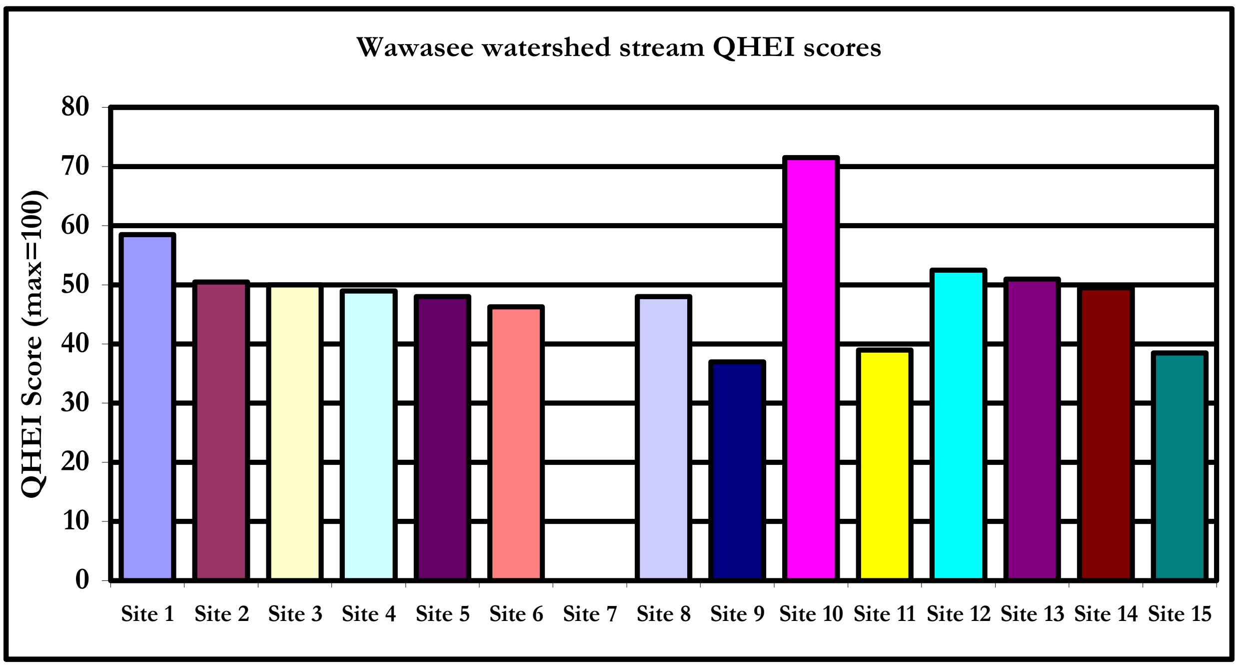


Figure I17. QHEI scores for Wawasee Area Watershed streams, July 27, 2006.

APPENDIX I2:

QUALITATIVE HABITAT EVALUATION INDEX (QHEI) DATASHEETS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

STREAM: Wawasee Site 1 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 58.5

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 13.0

TYPE		POOL	RIFFLE			POOL	RIFFLE
[ ] [ ]	BLDER/SLAB(10)			[x] [ ]	GRAVEL(7)	x	
[ ] [ ]	BOULDER(9)			[x] [ ]	SAND(6)	x	
[ ] [ ]	COBBLE(8)			[ ] [ ]	BEDROCK(5)		
[ ] [ ]	HARDPAN(4)			[ ] [ ]	DETRITUS(3)		
[ ] [ ]	MUCK/SILT(2)	x		[ ] [ ]	ARTIFIC(0)		

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

SUBSTRATE ORIGIN (all)
- [ ] LIMESTONE(1)
- [x] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one)
- [ ] SILT-HEAVY(-2)
- [ ] SILT-MOD(-1)
- [x] SILT-NORM(0)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one)
- [ ] EXTENSIVE(-2)
- [x] MODERATE(-1)
- [ ] LOW(0)
- [ ] NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 14.0

TYPE (Check all that apply)
- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [x] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [x] AQUATIC MACROPHYTES(1)
- [ ] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)
- [x] EXTENSIVE >75%(11)
- [ ] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: overgrown with grasses

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 13.0

SINUOSITY
- [ ] HIGH(4)
- [ ] MODERATE(3)
- [x] LOW(2)
- [ ] NONE(1)

DEVELOPMENT
- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [x] FAIR(3)
- [ ] POOR(1)

CHANNELIZATION
- [x] NONE(6)
- [ ] RECOVERED(4)
- [ ] RECOVERING(3)
- [ ] RECENT OR NO RECOVERY(1)

STABILITY
- [ ] HIGH(3)
- [x] MODERATE(2)
- [ ] LOW(1)

MODIFICATION/OTHER
- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [ ] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [ ] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 7.5

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
x	x	WIDE >150 ft.(4)
		MODERATE 30-150 ft.(3)
		NARROW 15-30 ft.(2)
		VERY NARROW 3-15 ft.(1)
		NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
		FOREST, SWAMP(3)			URBAN OR INDUSTRIAL(0)
		OPEN PASTURE/ROW CROP(0)			SHRUB OR OLD FIELD(2)
x	x	RESID.,PARK,NEW FIELD(1)			CONSERV. TILLAGE(1)
		FENCED PASTURE(1)			MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
x		NONE OR LITTLE(3)
	x	MODERATE(2)
		HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 0.0

MAX.DEPTH (Check 1)
- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [ ] 1.2-2.4 ft.(2)
- [ ] <1.2 ft.(1)
- [x] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
- [ ] POOL WIDTH>RIFFLE WIDTH(2)
- [ ] POOL WIDTH=RIFFLE WIDTH(1)
- [x] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [x] MODERATE(1)
- [ ] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 1.0

RIFFLE/RUN DEPTH
- [ ] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [x] GENERALLY 2-4 in.(1)
- [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [x] UNSTABLE (Gravel, Sand)(0)
- [ ] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
- [ ] EXTENSIVE(-1)
- [x] MODERATE(0)
- [ ] LOW(1)
- [ ] NONE(2)
- [ ] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 17.6 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 10

Conducted by:______

Project Number: ___________

STREAM: Wawasee Site 2 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 50.5

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 10.0

TYPE			POOL	RIFFLE				POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)			[x]	[ ]	GRAVEL(7)		x
[ ]	[ ]	BOULDER(9)			[ ]	[ ]	SAND(6)	x	
[ ]	[ ]	COBBLE(8)			[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)			[ ]	[ ]	DETRITUS(3)	x	
[x]	[ ]	MUCK/SILT(2)	x		[ ]	[ ]	ARTIFIC(0)	x	

SUBSTRATE ORIGIN (all)
- [ ] LIMESTONE(1)
- [ ] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one)
- [ ] SILT-HEAVY(-2)
- [x] SILT-MOD(-1)
- [ ] SILT-NORM(0)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one)
- [ ] EXTENSIVE(-2)
- [x] MODERATE(-1)
- [ ] LOW(0)
- [ ] NONE(1)

TOTAL NUMBER OF SUBSTRATE TYPES: [x] >4(2) [ ] <4(0)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 10.0

TYPE (Check all that apply)
- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [x] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [ ] AQUATIC MACROPHYTES(1)
- [x] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)
- [ ] EXTENSIVE >75%(11)
- [x] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 13.0

SINUOSITY
- [ ] HIGH(4)
- [ ] MODERATE(3)
- [x] LOW(2)
- [ ] NONE(1)

DEVELOPMENT
- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [x] FAIR(3)
- [ ] POOR(1)

CHANNELIZATION
- [x] NONE(6)
- [ ] RECOVERED(4)
- [ ] RECOVERING(3)
- [ ] RECENT OR NO RECOVERY(1)

STABILITY
- [ ] HIGH(3)
- [x] MODERATE(2)
- [ ] LOW(1)

MODIFICATION/OTHER
- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [ ] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [ ] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 8.5

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
[x]	[ ]	WIDE >150 ft.(4)
[ ]	[x]	MODERATE 30-150 ft.(3)
[ ]	[ ]	NARROW 15-30 ft.(2)
[ ]	[ ]	VERY NARROW 3-15 ft.(1)
[ ]	[ ]	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
[x]	[x]	FOREST, SWAMP(3)	[ ]	[ ]	URBAN OR INDUSTRIAL(0)
[ ]	[ ]	OPEN PASTURE/ROW CROP(0)	[ ]	[ ]	SHRUB OR OLD FIELD(2)
[ ]	[ ]	RESID.,PARK,NEW FIELD(1)	[ ]	[ ]	CONSERV. TILLAGE(1)
[ ]	[ ]	FENCED PASTURE(1)	[ ]	[ ]	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
[ ]	[ ]	NONE OR LITTLE(3)
[x]	[x]	MODERATE(2)
[ ]	[ ]	HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 0.0

MAX.DEPTH (Check 1)
- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [ ] 1.2-2.4 ft.(2)
- [ ] <1.2 ft.(1)
- [x] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
- [ ] POOL WIDTH>RIFFLE WIDTH(2)
- [ ] POOL WIDTH=RIFFLE WIDTH(1)
- [x] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [ ] MODERATE(1)
- [x] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 1.0

RIFFLE/RUN DEPTH
- [ ] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [x] GENERALLY 2-4 in.(1)
- [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [x] UNSTABLE (Gravel, Sand)(0)
- [ ] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
- [ ] EXTENSIVE(-1)
- [x] MODERATE(0)
- [ ] LOW(1)
- [ ] NONE(2)
- [ ] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 33 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 8

Conducted by:______

Project Number: ___________

STREAM: Wawasee Site 3 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 50.0

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 9.0

TYPE			POOL	RIFFLE
x		BLDER/SLAB(10)	x	
		BOULDER(9)		
		COBBLE(8)		
		HARDPAN(4)		
x		MUCK/SILT(2)	x	

TYPE			POOL	RIFFLE
		GRAVEL(7)		
		SAND(6)		
		BEDROCK(5)		
		DETRITUS(3)		
		ARTIFIC(0)		x

SUBSTRATE ORIGIN (all)

- [ ] LIMESTONE(1)
- [ ] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one)

- [x] SILT-HEAVY(-2)
- [ ] SILT-MOD(-1)
- [ ] SILT-NORM(0)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one)

- [x] EXTENSIVE(-2)
- [ ] MODERATE(-1)
- [ ] LOW(0)
- [ ] NONE(1)

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 6.0

TYPE (Check all that apply)

- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [ ] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [x] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [ ] AQUATIC MACROPHYTES(1)
- [x] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)

- [ ] EXTENSIVE >75%(11)
- [ ] MODERATE 25-75%(7)
- [x] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 10.0

SINUOSITY

- [ ] HIGH(4)
- [ ] MODERATE(3)
- [x] LOW(2)
- [ ] NONE(1)

DEVELOPMENT

- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [ ] FAIR(3)
- [x] POOR(1)

CHANNELIZATION

- [x] NONE(6)
- [ ] RECOVERED(4)
- [ ] RECOVERING(3)
- [ ] RECENT OR NO RECOVERY(1)

STABILITY

- [ ] HIGH(3)
- [ ] MODERATE(2)
- [x] LOW(1)

MODIFICATION/OTHER

- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [ ] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [ ] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 9.0

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
x	x	WIDE >150 ft.(4)
		MODERATE 30-150 ft.(3)
		NARROW 15-30 ft.(2)
		VERY NARROW 3-15 ft.(1)
		NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
x	x	FOREST, SWAMP(3)			URBAN OR INDUSTRIAL(0)
		OPEN PASTURE/ROW CROP(0)			SHRUB OR OLD FIELD(2)
		RESID.,PARK,NEW FIELD(1)			CONSERV. TILLAGE(1)
		FENCED PASTURE(1)			MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
		NONE OR LITTLE(3)
x	x	MODERATE(2)
		HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 4.0

MAX.DEPTH (Check 1)

- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [ ] 1.2-2.4 ft.(2)
- [x] <1.2 ft.(1)
- [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)

- [x] POOL WIDTH>RIFFLE WIDTH(2)
- [ ] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)

- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [ ] MODERATE(1)
- [x] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 2.0

RIFFLE/RUN DEPTH

- [ ] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [x] GENERALLY 2-4 in.(1)
- [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE

- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [x] UNSTABLE (Gravel, Sand)(0)
- [ ] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS

- [ ] EXTENSIVE(-1)
- [ ] MODERATE(0)
- [x] LOW(1)
- [ ] NONE(2)
- [ ] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 26.4 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 10

Conducted by: ______

Project Number: ______

STREAM: Wawasee Site 4 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 49.0

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 17.0

TYPE			POOL	RIFFLE				POOL	RIFFLE
x		BLDER/SLAB(10)	x				GRAVEL(7)		
		BOULDER(9)			x		SAND(6)	x	
		COBBLE(8)					BEDROCK(5)		
		HARDPAN(4)					DETRITUS(3)		
		MUCK/SILT(2)	x				ARTIFIC(0)		

SUBSTRATE ORIGIN (all)

	LIMESTONE(1)		RIP/RAP(0)
	TILLS(1)		HARDPAN(0)
	SANDSTONE(0)		
	SHALE(-1)		
	COAL FINES(-2)		

SILT COVER (one)

	SILT-HEAVY(-2)		SILT-MOD(-1)
x	SILT-NORM(0)		SILT-FREE(1)

Extent of Embeddedness (check one)

	EXTENSIVE(-2)		MODERATE(-1)
x	LOW(0)		NONE(1)

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS:

2) INSTREAM COVER: **COVER SCORE** 7.0

TYPE (Check all that apply)

	UNDERCUT BANKS(1)	x	DEEP POOLS(2)		OXBOWS(1)
x	OVERHANGING VEGETATION(1)		ROOTWADS(1)	x	AQUATIC MACROPHYTES(1)
	SHALLOWS (IN SLOW WATER)(1)		BOULDERS(1)		LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)

	EXTENSIVE >75%(11)
	MODERATE 25-75%(7)
x	SPARSE 5-25%(3)
	NEARLY ABSENT <5%(1)

COMMENTS:

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 8.0

SINUOSITY		DEVELOPMENT		CHANNELIZATION		STABILITY	
	HIGH(4)		EXCELLENT(7)		NONE(6)		HIGH(3)
	MODERATE(3)		GOOD(5)		RECOVERED(4)	x	MODERATE(2)
x	LOW(2)		FAIR(3)	x	RECOVERING(3)		LOW(1)
	NONE(1)	x	POOR(1)		RECENT OR NO RECOVERY(1)		

MODIFICATION/OTHER

	SNAGGING		IMPOUND
	RELOCATION		ISLAND
	CANOPY REMOVAL		LEVEED
x	DREDGING	x	BANK SHAPING
	ONE SIDE CHANNEL MODIFICATION		

COMMENTS:

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 6.0

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
		WIDE >150 ft.(4)
		MODERATE 30-150 ft.(3)
x	x	NARROW 15-30 ft.(2)
		VERY NARROW 3-15 ft.(1)
		NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
		FOREST, SWAMP(3)			URBAN OR INDUSTRIAL(0)
		OPEN PASTURE/ROW CROP(0)			SHRUB OR OLD FIELD(2)
x	x	RESID.,PARK,NEW FIELD(1)			CONSERV. TILLAGE(1)
		FENCED PASTURE(1)			MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
x	x	NONE OR LITTLE(3)
		MODERATE(2)
		HEAVY OR SEVERE(1)

COMMENTS:

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 9.0

MAX.DEPTH (Check 1)

x	>4 ft.(6)
	2.4-4 ft.(4)
	1.2-2.4 ft.(2)
	<1.2 ft.(1)
	<0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)

x	POOL WIDTH>RIFFLE WIDTH(2)
	POOL WIDTH=RIFFLE WIDTH(1)
	POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)

	TORRENTIAL(-1)		EDDIES(1)
	FAST(1)		INTERSTITIAL(-1)
	MODERATE(1)		INTERMITTENT(-2)
x	SLOW(1)		

COMMENTS:

RIFFLE SCORE 0.0

RIFFLE/RUN DEPTH

	GENERALLY >4 in. MAX.>20 in.(4)
	GENERALLY >4 in. MAX.<20 in.(3)
	GENERALLY 2-4 in.(1)
x	GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE

	STABLE (e.g., Cobble,Boulder)(2)
	MOD.STABLE (e.g., Pea Gravel)(1)
	UNSTABLE (Gravel, Sand)(0)
x	NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS

	EXTENSIVE(-1)		NONE(2)
	MODERATE(0)	x	NO RIFFLE(0)
	LOW(1)		

COMMENTS:

6) GRADIENT (FEET/MILE): ~0 **% POOL** ______ **% RIFFLE** _____ **% RUN** ______ **GRADIENT SCORE** 2

Conducted by:______

Project Number: ___________

STREAM: Wawasee Site 5 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 48.0

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present)

SUBSTRATE SCORE 0.0

TYPE (box 1)	TYPE (box 2)		POOL	RIFFLE	TYPE (box 1)	TYPE (box 2)		POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)			[ ]	[ ]	GRAVEL(7)		
[ ]	[ ]	BOULDER(9)			[ ]	[ ]	SAND(6)		
[ ]	[ ]	COBBLE(8)			[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)			[ ]	[ ]	DETRITUS(3)		
[ ]	[ ]	MUCK/SILT(2)	x		[x]	[x]	ARTIFIC(0)		

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

SUBSTRATE ORIGIN (all)
- [ ] LIMESTONE(1)
- [ ] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one)
- [ ] SILT-HEAVY(-2)
- [x] SILT-NORM(0)
- [ ] SILT-MOD(-1)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one)
- [ ] EXTENSIVE(-2)
- [ ] LOW(0)
- [x] MODERATE(-1)
- [ ] NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER:

COVER SCORE 11.0

TYPE (Check all that apply)
- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [ ] SHALLOWS (IN SLOW WATER)(1)
- [x] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [x] AQUATIC MACROPHYTES(1)
- [ ] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)
- [ ] EXTENSIVE >75%(11)
- [x] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE)

CHANNEL SCORE 9.0

SINUOSITY
- [ ] HIGH(4)
- [x] MODERATE(3)
- [ ] LOW(2)
- [ ] NONE(1)

DEVELOPMENT
- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [ ] FAIR(3)
- [x] POOR(1)

CHANNELIZATION
- [ ] NONE(6)
- [ ] RECOVERED(4)
- [x] RECOVERING(3)
- [ ] RECENT OR NO RECOVERY(1)

STABILITY
- [ ] HIGH(3)
- [x] MODERATE(2)
- [ ] LOW(1)

MODIFICATION/OTHER
- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [ ] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [x] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank)

RIPARIAN SCORE 9.0

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
[ ]	[x]	WIDE >150 ft.(4)
[x]	[ ]	MODERATE 30-150 ft.(3)
[ ]	[ ]	NARROW 15-30 ft.(2)
[ ]	[ ]	VERY NARROW 3-15 ft.(1)
[ ]	[ ]	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
[x]	[x]	FOREST, SWAMP(3)	[ ]	[ ]	URBAN OR INDUSTRIAL(0)
[ ]	[ ]	OPEN PASTURE/ROW CROP(0)	[ ]	[ ]	SHRUB OR OLD FIELD(2)
[x]	[ ]	RESID.,PARK,NEW FIELD(1)	[ ]	[ ]	CONSERV. TILLAGE(1)
[ ]	[ ]	FENCED PASTURE(1)	[ ]	[ ]	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
[x]	[x]	NONE OR LITTLE(3)
[ ]	[ ]	MODERATE(2)
[ ]	[ ]	HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY

NO POOL = 0 **POOL SCORE** 9.0

MAX.DEPTH (Check 1)
- [x] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [ ] 1.2-2.4 ft.(2)
- [ ] <1.2 ft.(1)
- [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
- [x] POOL WIDTH>RIFFLE WIDTH(2)
- [ ] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [ ] MODERATE(1)
- [x] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 0.0

RIFFLE/RUN DEPTH
- [ ] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [ ] GENERALLY 2-4 in.(1)
- [x] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [ ] UNSTABLE (Gravel, Sand)(0)
- [x] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
- [ ] EXTENSIVE(-1)
- [ ] MODERATE(0)
- [ ] LOW(1)
- [ ] NONE(2)
- [x] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 15

% POOL ______ % RIFFLE ______ % RUN ______ **GRADIENT SCORE** 10

Conducted by: ______

Project Number: ______

STREAM: Wawasee Site 6 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 46.3

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 11.0

TYPE			POOL	RIFFLE				POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)			[x]	[ ]	GRAVEL(7)	x	
[ ]	[ ]	BOULDER(9)			[ ]	[ ]	SAND(6)		
[ ]	[ ]	COBBLE(8)			[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)			[x]	[ ]	DETRITUS(3)	x	
[ ]	[ ]	MUCK/SILT(2)			[ ]	[ ]	ARTIFIC(0)	x	

SUBSTRATE ORIGIN (all): [ ] LIMESTONE(1) [ ] RIP/RAP(0) [ ] TILLS(1) [ ] HARDPAN(0) [ ] SANDSTONE(0) [ ] SHALE(-1) [ ] COAL FINES(-2)

SILT COVER (one): [ ] SILT-HEAVY(-2) [ ] SILT-MOD(-1) [ ] SILT-NORM(0) [ ] SILT-FREE(1)

Extent of Embeddedness (check one): [ ] EXTENSIVE(-2) [ ] MODERATE(-1) [ ] LOW(0) [ ] NONE(1)

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 13.0

TYPE (Check all that apply)

- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [ ] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [x] AQUATIC MACROPHYTES(1)
- [ ] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)

- [x] EXTENSIVE >75%(11)
- [ ] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 6.0

SINUOSITY: [ ] HIGH(4) [ ] MODERATE(3) [ ] LOW(2) [x] NONE(1)

DEVELOPMENT: [ ] EXCELLENT(7) [ ] GOOD(5) [ ] FAIR(3) [x] POOR(1)

CHANNELIZATION: [ ] NONE(6) [ ] RECOVERED(4) [ ] RECOVERING(3) [x] RECENT OR NO RECOVERY(1)

STABILITY: [x] HIGH(3) [ ] MODERATE(2) [ ] LOW(1)

MODIFICATION/OTHER: [ ] SNAGGING [ ] RELOCATION [ ] CANOPY REMOVAL [ ] DREDGING [ ] ONE SIDE CHANNEL MODIFICATION [ ] IMPOUND [ ] ISLAND [x] LEVEED [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 8.3

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
x	x	WIDE >150 ft.(4)
		MODERATE 30-150 ft.(3)
		NARROW 15-30 ft.(2)
		VERY NARROW 3-15 ft.(1)
		NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
		FOREST, SWAMP(3)			URBAN OR INDUSTRIAL(0)
		OPEN PASTURE/ROW CROP(0)		x	SHRUB OR OLD FIELD(2)
x	x	RESID.,PARK,NEW FIELD(1)			CONSERV. TILLAGE(1)
		FENCED PASTURE(1)			MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
x	x	NONE OR LITTLE(3)
		MODERATE(2)
		HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 0.0

MAX.DEPTH (Check 1): [ ] >4 ft.(6) [ ] 2.4-4 ft.(4) [ ] 1.2-2.4 ft.(2) [ ] <1.2 ft.(1) [x] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1): [ ] POOL WIDTH>RIFFLE WIDTH(2) [ ] POOL WIDTH=RIFFLE WIDTH(1) [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply): [ ] TORRENTIAL(-1) [ ] FAST(1) [ ] MODERATE(1) [x] SLOW(1) [ ] EDDIES(1) [ ] INTERSTITIAL(-1) [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 0.0

RIFFLE/RUN DEPTH: [ ] GENERALLY >4 in. MAX.>20 in.(4) [ ] GENERALLY >4 in. MAX.<20 in.(3) [ ] GENERALLY 2-4 in.(1) [x] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE: [ ] STABLE (e.g., Cobble,Boulder)(2) [x] MOD.STABLE (e.g., Pea Gravel)(1) [ ] UNSTABLE (Gravel, Sand)(0) [ ] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS: [x] EXTENSIVE(-1) [ ] MODERATE(0) [ ] LOW(1) [ ] NONE(2) [ ] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 74 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 8

Conducted by: ______
Project Number: ______

STREAM: Wawasee Site 8 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 48.0

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present)

SUBSTRATE SCORE 10.0

TYPE			POOL	RIFFLE				POOL	RIFFLE
x		BLDER/SLAB(10)		x			GRAVEL(7)		x
		BOULDER(9)					SAND(6)		
		COBBLE(8)					BEDROCK(5)		
		HARDPAN(4)			x		DETRITUS(3)		x
		MUCK/SILT(2)		x			ARTIFIC(0)		

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

SUBSTRATE ORIGIN (all)
- [ ] LIMESTONE(1)
- [ ] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one)
- [x] SILT-HEAVY(-2)
- [ ] SILT-MOD(-1)
- [ ] SILT-NORM(0)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one)
- [x] EXTENSIVE(-2)
- [ ] MODERATE(-1)
- [ ] LOW(0)
- [ ] NONE(1)

COMMENTS: ______

2) INSTREAM COVER:

COVER SCORE 10.0

TYPE (Check all that apply)
- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [x] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [ ] AQUATIC MACROPHYTES(1)
- [x] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)
- [ ] EXTENSIVE >75%(11)
- [x] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE)

CHANNEL SCORE 7.0

SINUOSITY
- [ ] HIGH(4)
- [ ] MODERATE(3)
- [x] LOW(2)
- [ ] NONE(1)

DEVELOPMENT
- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [ ] FAIR(3)
- [x] POOR(1)

CHANNELIZATION
- [ ] NONE(6)
- [ ] RECOVERED(4)
- [x] RECOVERING(3)
- [ ] RECENT OR NO RECOVERY(1)

STABILITY
- [ ] HIGH(3)
- [ ] MODERATE(2)
- [x] LOW(1)

MODIFICATION/OTHER
- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [ ] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [x] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank)

RIPARIAN SCORE 7.0

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
		WIDE >150 ft.(4)
x	x	MODERATE 30-150 ft.(3)
		NARROW 15-30 ft.(2)
		VERY NARROW 3-15 ft.(1)
		NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
		FOREST, SWAMP(3)			URBAN OR INDUSTRIAL(0)
		OPEN PASTURE/ROW CROP(0)			SHRUB OR OLD FIELD(2)
x	x	RESID.,PARK,NEW FIELD(1)			CONSERV. TILLAGE(1)
		FENCED PASTURE(1)			MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
x	x	NONE OR LITTLE(3)
		MODERATE(2)
		HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY

NO POOL = 0 **POOL SCORE** 3.0

MAX.DEPTH (Check 1)
- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [ ] 1.2-2.4 ft.(2)
- [x] <1.2 ft.(1)
- [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
- [x] POOL WIDTH>RIFFLE WIDTH(2)
- [ ] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [ ] MODERATE(1)
- [ ] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 1.0

RIFFLE/RUN DEPTH
- [ ] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [x] GENERALLY 2-4 in.(1)
- [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [ ] UNSTABLE (Gravel, Sand)(0)
- [x] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
- [ ] EXTENSIVE(-1)
- [ ] MODERATE(0)
- [ ] LOW(1)
- [ ] NONE(2)
- [x] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 17.6

% POOL ______ % RIFFLE ______ % RUN ______ **GRADIENT SCORE** 10

Conducted by:______

Project Number: ___________

STREAM: Wawasee Site 9 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 37.0

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 13.0

TYPE (Pool)	TYPE (Riffle)		POOL	RIFFLE	TYPE (Pool)	TYPE (Riffle)		POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)			[ ]	[ ]	GRAVEL(7)		
[ ]	[ ]	BOULDER(9)			[x]	[ ]	SAND(6)		
[ ]	[x]	COBBLE(8)			[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)			[ ]	[ ]	DETRITUS(3)		
[ ]	[ ]	MUCK/SILT(2)			[ ]	[ ]	ARTIFIC(0)		

SUBSTRATE ORIGIN (all)
- [ ] LIMESTONE(1)
- [ ] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one)
- [ ] SILT-HEAVY(-2)
- [x] SILT-MOD(-1)
- [ ] SILT-NORM(0)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one)
- [ ] EXTENSIVE(-2)
- [x] MODERATE(-1)
- [ ] LOW(0)
- [ ] NONE(1)

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 6.0

TYPE (Check all that apply)
- [ ] UNDERCUT BANKS(1)
- [ ] OVERHANGING VEGETATION(1)
- [ ] SHALLOWS (IN SLOW WATER)(1)
- [x] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [x] AQUATIC MACROPHYTES(1)
- [ ] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)
- [ ] EXTENSIVE >75%(11)
- [ ] MODERATE 25-75%(7)
- [x] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 5.0

SINUOSITY
- [ ] HIGH(4)
- [ ] MODERATE(3)
- [ ] LOW(2)
- [x] NONE(1)

DEVELOPMENT
- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [ ] FAIR(3)
- [x] POOR(1)

CHANNELIZATION
- [ ] NONE(6)
- [ ] RECOVERED(4)
- [ ] RECOVERING(3)
- [x] RECENT OR NO RECOVERY(1)

STABILITY
- [ ] HIGH(3)
- [x] MODERATE(2)
- [ ] LOW(1)

MODIFICATION/OTHER
- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [x] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [x] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 4.0

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
[ ]	[ ]	WIDE >150 ft.(4)
[ ]	[ ]	MODERATE 30-150 ft.(3)
[ ]	[ ]	NARROW 15-30 ft.(2)
[x]	[x]	VERY NARROW 3-15 ft.(1)
[ ]	[ ]	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
[ ]	[ ]	FOREST, SWAMP(3)	[ ]	[ ]	URBAN OR INDUSTRIAL(0)
[ ]	[ ]	OPEN PASTURE/ROW CROP(0)	[ ]	[ ]	SHRUB OR OLD FIELD(2)
[x]	[x]	RESID.,PARK,NEW FIELD(1)	[ ]	[ ]	CONSERV. TILLAGE(1)
[ ]	[ ]	FENCED PASTURE(1)	[ ]	[ ]	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
[ ]	[ ]	NONE OR LITTLE(3)
[x]	[x]	MODERATE(2)
[ ]	[ ]	HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 7.0

MAX.DEPTH (Check 1)
- [ ] >4 ft.(6)
- [x] 2.4-4 ft.(4)
- [ ] 1.2-2.4 ft.(2)
- [ ] <1.2 ft.(1)
- [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
- [x] POOL WIDTH>RIFFLE WIDTH(2)
- [ ] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [ ] MODERATE(1)
- [x] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 0.0

RIFFLE/RUN DEPTH
- [ ] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [ ] GENERALLY 2-4 in.(1)
- [x] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [ ] UNSTABLE (Gravel, Sand)(0)
- [x] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
- [ ] EXTENSIVE(-1)
- [ ] MODERATE(0)
- [ ] LOW(1)
- [ ] NONE(2)
- [x] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): ~0 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 2

Conducted by:______

Project Number: ___________

STREAM: Wawasee Site 10 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 71.5

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 14.0

TYPE			POOL	RIFFLE				POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)			[x]	[ ]	GRAVEL(7)	x	
[ ]	[ ]	BOULDER(9)			[ ]	[ ]	SAND(6)	x	
[x]	[ ]	COBBLE(8)			[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)			[ ]	[ ]	DETRITUS(3)		
[ ]	[ ]	MUCK/SILT(2)	x		[ ]	[ ]	ARTIFIC(0)	x	

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

SUBSTRATE ORIGIN (all): [ ] LIMESTONE(1) [ ] TILLS(1) [ ] SANDSTONE(0) [ ] SHALE(-1) [ ] COAL FINES(-2) [ ] RIP/RAP(0) [ ] HARDPAN(0)

SILT COVER (one): [ ] SILT-HEAVY(-2) [x] SILT-MOD(-1) [ ] SILT-NORM(0) [ ] SILT-FREE(1)

Extent of Embeddedness (check one): [ ] EXTENSIVE(-2) [x] MODERATE(-1) [ ] LOW(0) [ ] NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 13.0

TYPE (Check all that apply)

[x] UNDERCUT BANKS(1) [x] OVERHANGING VEGETATION(1) [ ] SHALLOWS (IN SLOW WATER)(1)
[x] DEEP POOLS(2) [x] ROOTWADS(1) [ ] BOULDERS(1)
[ ] OXBOWS(1) [ ] AQUATIC MACROPHYTES(1) [x] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)

[ ] EXTENSIVE >75%(11) [x] MODERATE 25-75%(7) [ ] SPARSE 5-25%(3) [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 14.0

SINUOSITY: [ ] HIGH(4) [x] MODERATE(3) [ ] LOW(2) [ ] NONE(1)

DEVELOPMENT: [ ] EXCELLENT(7) [x] GOOD(5) [ ] FAIR(3) [ ] POOR(1)

CHANNELIZATION: [ ] NONE(6) [x] RECOVERED(4) [ ] RECOVERING(3) [ ] RECENT OR NO RECOVERY(1)

STABILITY: [ ] HIGH(3) [x] MODERATE(2) [ ] LOW(1)

MODIFICATION/OTHER: [ ] SNAGGING [ ] RELOCATION [ ] CANOPY REMOVAL [ ] DREDGING [ ] ONE SIDE CHANNEL MODIFICATION [ ] IMPOUND [ ] ISLAND [ ] LEVEED [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 9.5

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
[x]	[x]	WIDE >150 ft.(4)
[ ]	[ ]	MODERATE 30-150 ft.(3)
[ ]	[ ]	NARROW 15-30 ft.(2)
[ ]	[ ]	VERY NARROW 3-15 ft.(1)
[ ]	[ ]	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
[x]	[x]	FOREST, SWAMP(3)	[ ]	[ ]	URBAN OR INDUSTRIAL(0)
[ ]	[ ]	OPEN PASTURE/ROW CROP(0)	[ ]	[ ]	SHRUB OR OLD FIELD(2)
[ ]	[ ]	RESID.,PARK,NEW FIELD(1)	[ ]	[ ]	CONSERV. TILLAGE(1)
[ ]	[ ]	FENCED PASTURE(1)	[ ]	[ ]	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
[ ]	[x]	NONE OR LITTLE(3)
[x]	[ ]	MODERATE(2)
[ ]	[ ]	HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 7.0

MAX.DEPTH (Check 1): [ ] >4 ft.(6) [x] 2.4-4 ft.(4) [ ] 1.2-2.4 ft.(2) [ ] <1.2 ft.(1) [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1): [x] POOL WIDTH>RIFFLE WIDTH(2) [ ] POOL WIDTH=RIFFLE WIDTH(1) [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply): [ ] TORRENTIAL(-1) [x] FAST(1) [ ] MODERATE(1) [ ] SLOW(1) [ ] EDDIES(1) [ ] INTERSTITIAL(-1) [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 4.0

RIFFLE/RUN DEPTH: [ ] GENERALLY >4 in. MAX.>20 in.(4) [x] GENERALLY >4 in. MAX.<20 in.(3) [ ] GENERALLY 2-4 in.(1) [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE: [ ] STABLE (e.g., Cobble,Boulder)(2) [x] MOD.STABLE (e.g., Pea Gravel)(1) [ ] UNSTABLE (Gravel, Sand)(0) [ ] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS: [ ] EXTENSIVE(-1) [x] MODERATE(0) [ ] LOW(1) [ ] NONE(2) [ ] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 15 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 10

Conducted by: ______
Project Number: ______

STREAM: Wawasee Site 11 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 39.0

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 1.0

TYPE			POOL	RIFFLE				POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)			[ ]	[ ]	GRAVEL(7)		
[ ]	[ ]	BOULDER(9)			[ ]	[ ]	SAND(6)		
[ ]	[ ]	COBBLE(8)			[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)			[ ]	[ ]	DETRITUS(3)		
x	x	MUCK/SILT(2)			[ ]	[ ]	ARTIFIC(0)	x	

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

SUBSTRATE ORIGIN (all):
- [ ] LIMESTONE(1)
- [ ] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one):
- [x] SILT-HEAVY(-2)
- [ ] SILT-MOD(-1)
- [ ] SILT-NORM(0)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one):
- [x] EXTENSIVE(-2)
- [ ] MODERATE(-1)
- [ ] LOW(0)
- [ ] NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 14.0

TYPE (Check all that apply)
- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [x] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [x] AQUATIC MACROPHYTES(1)
- [ ] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)
- [x] EXTENSIVE >75%(11)
- [ ] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 7.0

SINUOSITY
- [ ] HIGH(4)
- [ ] MODERATE(3)
- [x] LOW(2)
- [ ] NONE(1)

DEVELOPMENT
- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [ ] FAIR(3)
- [x] POOR(1)

CHANNELIZATION
- [ ] NONE(6)
- [ ] RECOVERED(4)
- [x] RECOVERING(3)
- [ ] RECENT OR NO RECOVERY(1)

STABILITY
- [ ] HIGH(3)
- [ ] MODERATE(2)
- [x] LOW(1)

MODIFICATION/OTHER
- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [x] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [ ] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 4.0

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
[ ]	[ ]	WIDE >150 ft.(4)
x	[ ]	MODERATE 30-150 ft.(3)
[ ]	[ ]	NARROW 15-30 ft.(2)
[ ]	x	VERY NARROW 3-15 ft.(1)
[ ]	[ ]	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
[ ]	[ ]	FOREST, SWAMP(3)	[ ]	x	URBAN OR INDUSTRIAL(0)
x	[ ]	OPEN PASTURE/ROW CROP(0)	[ ]	[ ]	SHRUB OR OLD FIELD(2)
[ ]	[ ]	RESID.,PARK,NEW FIELD(1)	[ ]	[ ]	CONSERV. TILLAGE(1)
[ ]	[ ]	FENCED PASTURE(1)	[ ]	[ ]	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
[ ]	[ ]	NONE OR LITTLE(3)
x	x	MODERATE(2)
[ ]	[ ]	HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 4.0

MAX.DEPTH (Check 1)
- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [ ] 1.2-2.4 ft.(2)
- [x] <1.2 ft.(1)
- [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
- [x] POOL WIDTH>RIFFLE WIDTH(2)
- [ ] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [ ] MODERATE(1)
- [x] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 1.0

RIFFLE/RUN DEPTH
- [ ] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [x] GENERALLY 2-4 in.(1)
- [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [ ] UNSTABLE (Gravel, Sand)(0)
- [x] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
- [ ] EXTENSIVE(-1)
- [ ] MODERATE(0)
- [ ] LOW(1)
- [ ] NONE(2)
- [x] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 37.7 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 8

Conducted by:______
Project Number: ___________

STREAM: Wawasee Site 12 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 52.5

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) — **SUBSTRATE SCORE** 15.0

TYPE	POOL	RIFFLE	TYPE	POOL	RIFFLE
[ ] [ ] BLDER/SLAB(10)		x	[x] [ ] GRAVEL(7)		
[ ] [ ] BOULDER(9)		x	[x] [ ] SAND(6)		
[ ] [ ] COBBLE(8)			[ ] [ ] BEDROCK(5)		
[ ] [ ] HARDPAN(4)			[ ] [ ] DETRITUS(3)		
[ ] [ ] MUCK/SILT(2)		x	[ ] [ ] ARTIFIC(0)		

SUBSTRATE ORIGIN (all): [ ] LIMESTONE(1) [ ] RIP/RAP(0) [ ] TILLS(1) [ ] HARDPAN(0) [ ] SANDSTONE(0) [ ] SHALE(-1) [ ] COAL FINES(-2)

SILT COVER (one): [ ] SILT-HEAVY(-2) [ ] SILT-MOD(-1) [x] SILT-NORM(0) [ ] SILT-FREE(1)

Extent of Embeddedness (check one): [ ] EXTENSIVE(-2) [x] MODERATE(-1) [ ] LOW(0) [ ] NONE(1)

TOTAL NUMBER OF SUBSTRATE TYPES: [x] >4(2) [ ] <4(0)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: — **COVER SCORE** 6.0

TYPE (Check all that apply): [ ] UNDERCUT BANKS(1) [x] OVERHANGING VEGETATION(1) [ ] SHALLOWS (IN SLOW WATER)(1) [ ] DEEP POOLS(2) [ ] ROOTWADS(1) [ ] BOULDERS(1) [ ] OXBOWS(1) [x] AQUATIC MACROPHYTES(1) [x] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE): [ ] EXTENSIVE >75%(11) [ ] MODERATE 25-75%(7) [x] SPARSE 5-25%(3) [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) — **CHANNEL SCORE** 8.0

SINUOSITY: [ ] HIGH(4) [ ] MODERATE(3) [ ] LOW(2) [x] NONE(1)

DEVELOPMENT: [ ] EXCELLENT(7) [ ] GOOD(5) [ ] FAIR(3) [x] POOR(1)

CHANNELIZATION: [ ] NONE(6) [x] RECOVERED(4) [ ] RECOVERING(3) [ ] RECENT OR NO RECOVERY(1)

STABILITY: [ ] HIGH(3) [x] MODERATE(2) [ ] LOW(1)

MODIFICATION/OTHER: [ ] SNAGGING [ ] RELOCATION [ ] CANOPY REMOVAL [ ] DREDGING [ ] ONE SIDE CHANNEL MODIFICATION [ ] IMPOUND [ ] ISLAND [ ] LEVEED [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) — **RIPARIAN SCORE** 8.5

River Right Looking Downstream

RIPARIAN WIDTH (per bank) — L R (per bank): [x] [x] WIDE >150 ft.(4); [ ] [ ] MODERATE 30-150 ft.(3); [ ] [ ] NARROW 15-30 ft.(2); [ ] [ ] VERY NARROW 3-15 ft.(1); [ ] [ ] NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY — L R (most predominant per bank): [ ] [ ] FOREST, SWAMP(3); [ ] [ ] OPEN PASTURE/ROW CROP(0); [ ] [ ] RESID.,PARK,NEW FIELD(1); [x] [ ] FENCED PASTURE(1)

L R (per bank): [ ] [ ] URBAN OR INDUSTRIAL(0); [ ] [x] SHRUB OR OLD FIELD(2); [ ] [ ] CONSERV. TILLAGE(1); [ ] [ ] MINING/CONSTRUCTION(0)

BANK EROSION — L R (per bank): [x] [x] NONE OR LITTLE(3); [ ] [ ] MODERATE(2); [ ] [ ] HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY — **NO POOL = 0** — **POOL SCORE** 3.0

MAX.DEPTH (Check 1): [ ] >4 ft.(6) [ ] 2.4-4 ft.(4) [ ] 1.2-2.4 ft.(2) [x] <1.2 ft.(1) [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1): [ ] POOL WIDTH>RIFFLE WIDTH(2) [x] POOL WIDTH=RIFFLE WIDTH(1) [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply): [ ] TORRENTIAL(-1) [ ] FAST(1) [x] MODERATE(1) [ ] SLOW(1) [ ] EDDIES(1) [ ] INTERSTITIAL(-1) [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 4.0

RIFFLE/RUN DEPTH: [x] GENERALLY >4 in. MAX.>20 in.(4) [ ] GENERALLY >4 in. MAX.<20 in.(3) [ ] GENERALLY 2-4 in.(1) [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE: [ ] STABLE (e.g., Cobble,Boulder)(2) [ ] MOD.STABLE (e.g., Pea Gravel)(1) [x] UNSTABLE (Gravel, Sand)(0) [ ] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS: [ ] EXTENSIVE(-1) [x] MODERATE(0) [ ] LOW(1) [ ] NONE(2) [ ] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 18.4 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 8

Conducted by: ______

Project Number: ______

STREAM: Wawasee Site 13 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 51.0

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 12.0

TYPE			POOL	RIFFLE				POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)			x	[ ]	GRAVEL(7)	x	
[ ]	[ ]	BOULDER(9)			x	[ ]	SAND(6)	x	
[ ]	[ ]	COBBLE(8)			[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)			[ ]	[ ]	DETRITUS(3)		
[ ]	[ ]	MUCK/SILT(2)	x		[ ]	[ ]	ARTIFIC(0)		

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

SUBSTRATE ORIGIN (all)
- [ ] LIMESTONE(1)
- [ ] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one)
- [ ] SILT-HEAVY(-2)
- [x] SILT-MOD(-1)
- [ ] SILT-NORM(0)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one)
- [ ] EXTENSIVE(-2)
- [x] MODERATE(-1)
- [ ] LOW(0)
- [ ] NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 9.0

TYPE (Check all that apply)
- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [ ] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [x] AQUATIC MACROPHYTES(1)
- [ ] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)
- [ ] EXTENSIVE >75%(11)
- [x] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 6.0

SINUOSITY
- [ ] HIGH(4)
- [ ] MODERATE(3)
- [x] LOW(2)
- [ ] NONE(1)

DEVELOPMENT
- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [ ] FAIR(3)
- [x] POOR(1)

CHANNELIZATION
- [ ] NONE(6)
- [ ] RECOVERED(4)
- [ ] RECOVERING(3)
- [x] RECENT OR NO RECOVERY(1)

STABILITY
- [ ] HIGH(3)
- [x] MODERATE(2)
- [ ] LOW(1)

MODIFICATION/OTHER
- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [ ] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [ ] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 8.0

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
[ ]	[ ]	WIDE >150 ft.(4)
x	x	MODERATE 30-150 ft.(3)
[ ]	[ ]	NARROW 15-30 ft.(2)
[ ]	[ ]	VERY NARROW 3-15 ft.(1)
[ ]	[ ]	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
[ ]	[ ]	FOREST, SWAMP(3)	[ ]	[ ]	URBAN OR INDUSTRIAL(0)
[ ]	[ ]	OPEN PASTURE/ROW CROP(0)	x	x	SHRUB OR OLD FIELD(2)
[ ]	[ ]	RESID.,PARK,NEW FIELD(1)	[ ]	[ ]	CONSERV. TILLAGE(1)
[ ]	[ ]	FENCED PASTURE(1)	[ ]	[ ]	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
X	X	NONE OR LITTLE(3)
[ ]	[ ]	MODERATE(2)
[ ]	[ ]	HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 4.0

MAX.DEPTH (Check 1)
- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [x] 1.2-2.4 ft.(2)
- [ ] <1.2 ft.(1)
- [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
- [ ] POOL WIDTH>RIFFLE WIDTH(2)
- [x] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [ ] MODERATE(1)
- [x] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 4.0

RIFFLE/RUN DEPTH
- [x] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [ ] GENERALLY 2-4 in.(1)
- [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [ ] UNSTABLE (Gravel, Sand)(0)
- [x] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
- [ ] EXTENSIVE(-1)
- [ ] MODERATE(0)
- [ ] LOW(1)
- [ ] NONE(2)
- [x] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 15 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 8

Conducted by:______
Project Number: ___________

STREAM: Wawasee Site 14 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 49.5

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 7.0

TYPE			POOL	RIFFLE	TYPE			POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)		x	[ ]	[ ]	GRAVEL(7)		
[ ]	[ ]	BOULDER(9)			[x]	[ ]	SAND(6)	x	
[ ]	[ ]	COBBLE(8)			[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)			[ ]	[ ]	DETRITUS(3)	x	
[x]	[ ]	MUCK/SILT(2)	x		[ ]	[ ]	ARTIFIC(0)		

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

SUBSTRATE ORIGIN (all)
- [ ] LIMESTONE(1)
- [ ] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one)
- [ ] SILT-HEAVY(-2)
- [x] SILT-MOD(-1)
- [ ] SILT-NORM(0)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one)
- [ ] EXTENSIVE(-2)
- [x] MODERATE(-1)
- [ ] LOW(0)
- [ ] NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 10.0

TYPE (Check all that apply)
- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [ ] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [x] AQUATIC MACROPHYTES(1)
- [x] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)
- [ ] EXTENSIVE >75%(11)
- [x] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 10.0

SINUOSITY
- [ ] HIGH(4)
- [ ] MODERATE(3)
- [x] LOW(2)
- [ ] NONE(1)

DEVELOPMENT
- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [x] FAIR(3)
- [ ] POOR(1)

CHANNELIZATION
- [ ] NONE(6)
- [x] RECOVERED(4)
- [ ] RECOVERING(3)
- [ ] RECENT OR NO RECOVERY(1)

STABILITY
- [ ] HIGH(3)
- [ ] MODERATE(2)
- [x] LOW(1)

MODIFICATION/OTHER
- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [ ] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [ ] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 8.5

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
[ ]	[x]	WIDE >150 ft.(4)
[x]	[ ]	MODERATE 30-150 ft.(3)
[ ]	[ ]	NARROW 15-30 ft.(2)
[ ]	[ ]	VERY NARROW 3-15 ft.(1)
[ ]	[ ]	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
[x]	[x]	FOREST, SWAMP(3)	[ ]	[ ]	URBAN OR INDUSTRIAL(0)
[ ]	[ ]	OPEN PASTURE/ROW CROP(0)	[ ]	[ ]	SHRUB OR OLD FIELD(2)
[ ]	[ ]	RESID.,PARK,NEW FIELD(1)	[ ]	[ ]	CONSERV. TILLAGE(1)
[ ]	[ ]	FENCED PASTURE(1)	[ ]	[ ]	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
[ ]	[ ]	NONE OR LITTLE(3)
[x]	[x]	MODERATE(2)
[ ]	[ ]	HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 5.0

MAX.DEPTH (Check 1)
- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [x] 1.2-2.4 ft.(2)
- [ ] <1.2 ft.(1)
- [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
- [x] POOL WIDTH>RIFFLE WIDTH(2)
- [ ] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [ ] MODERATE(1)
- [x] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 1.0

RIFFLE/RUN DEPTH
- [ ] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [x] GENERALLY 2-4 in.(1)
- [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [x] UNSTABLE (Gravel, Sand)(0)
- [ ] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
- [ ] EXTENSIVE(-1)
- [x] MODERATE(0)
- [ ] LOW(1)
- [ ] NONE(2)
- [ ] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 12.5 **% POOL** ______ **% RIFFLE** ______ **% RUN** ______ **GRADIENT SCORE** 8

Conducted by:______
Project Number: ___________

STREAM: Wawasee Site 15 **RIVER MILE:** ______ **DATE:** 7/12/2006 **QHEI SCORE** 38.5

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 4.0

TYPE			POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)		
[ ]	[ ]	BOULDER(9)		
[ ]	[ ]	COBBLE(8)		
[ ]	[ ]	HARDPAN(4)		
[ ]	[ ]	MUCK/SILT(2)		
[ ]	[ ]	GRAVEL(7)		
[ ]	[ ]	SAND(6)		
[ ]	[ ]	BEDROCK(5)		
[x]	[x]	DETRITUS(3)		
[ ]	[ ]	ARTIFIC(0)		

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

SUBSTRATE ORIGIN (all): [ ] LIMESTONE(1) [ ] TILLS(1) [ ] SANDSTONE(0) [ ] SHALE(-1) [ ] COAL FINES(-2) [ ] RIP/RAP(0) [ ] HARDPAN(0)

SILT COVER (one): [ ] SILT-HEAVY(-2) [x] SILT-MOD(-1) [ ] SILT-NORM(0) [ ] SILT-FREE(1)

Extent of Embeddedness (check one): [x] EXTENSIVE(-2) [ ] MODERATE(-1) [ ] LOW(0) [ ] NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: detritus up to knees

2) INSTREAM COVER: **COVER SCORE** 9.0

TYPE (Check all that apply)

- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [ ] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [ ] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [x] AQUATIC MACROPHYTES(1)
- [ ] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)

- [ ] EXTENSIVE >75%(11)
- [X] MODERATE 25-75%(7)
- [ ] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS:

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 8.0

SINUOSITY: [ ] HIGH(4) [ ] MODERATE(3) [ ] LOW(2) [x] NONE(1)

DEVELOPMENT: [ ] EXCELLENT(7) [ ] GOOD(5) [ ] FAIR(3) [x] POOR(1)

CHANNELIZATION: [ ] NONE(6) [x] RECOVERED(4) [ ] RECOVERING(3) [ ] RECENT OR NO RECOVERY(1)

STABILITY: [ ] HIGH(3) [x] MODERATE(2) [ ] LOW(1)

MODIFICATION/OTHER: [ ] SNAGGING [ ] RELOCATION [ ] CANOPY REMOVAL [ ] DREDGING [ ] ONE SIDE CHANNEL MODIFICATION [ ] IMPOUND [ ] ISLAND [ ] LEVEED [ ] BANK SHAPING

COMMENTS:

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 7.5

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
[ ]	[ ]	WIDE >150 ft.(4)
[x]	[x]	MODERATE 30-150 ft.(3)
[ ]	[ ]	NARROW 15-30 ft.(2)
[ ]	[ ]	VERY NARROW 3-15 ft.(1)
[ ]	[ ]	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
[ ]	[x]	FOREST, SWAMP(3)	[ ]	[ ]	URBAN OR INDUSTRIAL(0)
[x]	[ ]	OPEN PASTURE/ROW CROP(0)	[ ]	[ ]	SHRUB OR OLD FIELD(2)
[ ]	[ ]	RESID.,PARK,NEW FIELD(1)	[ ]	[ ]	CONSERV. TILLAGE(1)
[ ]	[ ]	FENCED PASTURE(1)	[ ]	[ ]	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
[x]	[x]	NONE OR LITTLE(3)
[ ]	[ ]	MODERATE(2)
[ ]	[ ]	HEAVY OR SEVERE(1)

COMMENTS:

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 4.0

MAX.DEPTH (Check 1): [ ] >4 ft.(6) [ ] 2.4-4 ft.(4) [ ] 1.2-2.4 ft.(2) [x] <1.2 ft.(1) [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1): [x] POOL WIDTH>RIFFLE WIDTH(2) [ ] POOL WIDTH=RIFFLE WIDTH(1) [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply): [ ] TORRENTIAL(-1) [ ] FAST(1) [ ] MODERATE(1) [x] SLOW(1) [ ] EDDIES(1) [ ] INTERSTITIAL(-1) [ ] INTERMITTENT(-2)

COMMENTS:

RIFFLE SCORE 0.0

RIFFLE/RUN DEPTH: [ ] GENERALLY >4 in. MAX.>20 in.(4) [ ] GENERALLY >4 in. MAX.<20 in.(3) [ ] GENERALLY 2-4 in.(1) [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE: [ ] STABLE (e.g., Cobble,Boulder)(2) [ ] MOD.STABLE (e.g., Pea Gravel)(1) [ ] UNSTABLE (Gravel, Sand)(0) [x] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS: [ ] EXTENSIVE(-1) [ ] MODERATE(0) [ ] LOW(1) [ ] NONE(2) [x] NO RIFFLE(0)

COMMENTS:

6) GRADIENT (FEET/MILE): 6.9 **% POOL** ____ **% RIFFLE** ____ **% RUN** ____ **GRADIENT SCORE** 6

Conducted by:______
Project Number: ___________

APPENDIX J:

WATERSHED PHOTOGRAPHS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

APPENDIX J1:

WINDSHIELD TOUR PHOTOGRAPHS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Livestock access issues:

Area along Turkey Creek where livestock have access to the stream.

Livestock adjacent to Village Lake. Livestock have access to the lake along its entire northern shoreline.

<u>**Tile drainage issues:**</u>

Erosion around tile lines in the Turkey Creek Headwaters.

Erosion around tile lines in Dillon Creek Headwaters.

Streambank erosion/stabilization issues:

Erosion along the mainstem of Dillon Creek.

Minor erosion along the Ritter Branch (tributary to Harper Lake).

Narrow/inadequate buffer/filter issues:

Narrow buffer strip adjacent to Launer Ditch (tributary to Dillon Creek).

Narrow buffer strip adjacent to Galloway Branch (inlet to Knapp Lake).

<u>Potential wetland restoration sites:</u>

Potential wetland restoration site located in the Ritter Branch Headwaters.

Potential wetland restoration site located in the Turkey Creek headwaters.

APPENDIX J2:

WATERSHED LAND TREATMENT PROJECT PHOTOGRAPHS

WAWASEE AREA WATERSHED MANAGEMENT PLAN ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Water and sediment control basin (WASCOB) outlet installed in the Turkey Creek Headwaters through the Watershed Land Treatment Program.

Contour buffer installed in the Piper Branch Headwaters through the Watershed Land Treatment Program.

Wetland restored in the Turkey Creek Headwaters through the Watershed Land Treatment Program.

Grade control structure installed along Dillon Creek through the Watershed Land Treatment Program with the cooperation of the Noble County Surveyor's office.

APPENDIX J3:

OTHER OBSERVATIONS

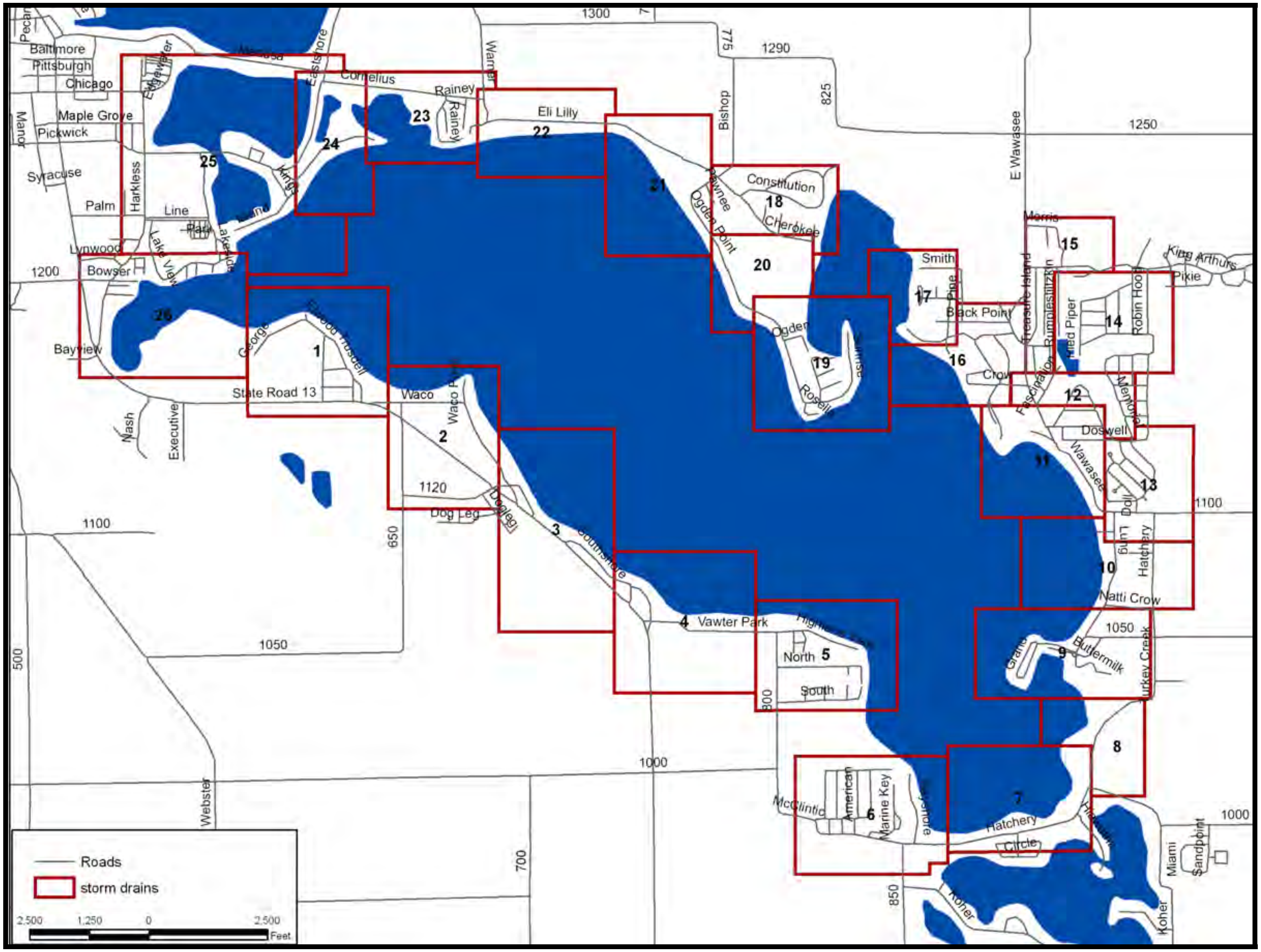
WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Erosion along tributary to Village Lake.

APPENDIX K:

STORM DRAIN SURVEY

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA



Storm Drain Sections.

Section	Number of observed storm drains	Notes about Specific Storm drains
1	5	1.1 Clean, surrounded by lawn, circular grate with a 1 foot diameter 1.2 Clean, surrounded by lawn, circular grate with a 1 foot diameter 1.3 Clean, surrounded by grass, circular grate with 2 foot diameter; road run-off likely to enter this drain 1.4 Clean, surrounded by grass, circular grate with 2 foot diameter; road run-off likely to enter this drain 1.5 Drain surrounded by asphalt 1.6 Drain surrounded by asphalt
2	2	2.1 Clean, surrounded by lawn, circular grate with a 1 foot diameter 2.2 Clean, surrounded by gravel and asphalt
3	1	3.1 Surrounded by asphalt; road runoff enters this drain
4	1	4.1 Surrounded by stones and ivy; filled with pine needles and leaves; road runoff enters this drain
5	12	5.1 Surrounded by asphalt 5.2 1 foot circular drain surrounded by gravel 5.3 Gravel filled storm drain? (See Figure 5.3) 5.4 7" circular drain surrounded by small stone 5.5 10" square drain surrounded by lawn and subjected to road runoff 5.6 4" diameter circular drain surrounded by grass and filled with leaves 5.7 1 foot square drain surrounded by gravel 5.8 Two 1 foot diameter culverts that drain East into Lake Wawasee and south into the channel; drain is surrounded by concrete and sediment; road runoff enters this drain (See Figure 5.8) 5.9 1 foot culvert filled with leaves draining to the east 5.10 1 foot square drain surrounded by gravel 5.11 1 foot square drain surrounded by gravel

Figure 5.3. Gravel-filled storm drain.

Figure 5.9. Storm drain draining road runoff into lake both directly and via the channel to the south.

Section	Number of observed storm drains	Notes
6	18	6.1 1 foot round culvert surrounded by grass 6.2 1 foot round culvert surrounded by grass 6.3 1 x 2 foot square drain on road surrounded by pavement 6.4 Two 2 foot diameter pipes drain ditch water into lake 6.5 Ditch drain surrounded by grass 6.6 Ditch drain 6.7 2 foot round drain surrounded by grass 6.8 3 x 2 foot road drains that drain into lake 6.9 Two 1 foot round drains on each side of road 6.10 Two 1 foot round drain on side of road 6.11 1 foot round drain on each side of road 6.12 1 foot round drain on each side of the road 6.13 2 x 1.5 foot drains covered by a flat metal grate 6.14 1.5 foot culvert draining directly into Lake Wawasee 6.15 1 foot round drain surrounded by concrete 6.16 Six inch round drain surrounded by gravel 6.17 Three converging culverts 6.18 Two 2 foot culverts converging covered by a non-perforated culvert section and wire mesh

Figure 6.4.

Figure 6.5.

Figure 6.6.

Figure 6.13.

Figure 6.17a.

Figure 6.17b.

Section	Number of observed storm drains	Notes about Specific Storm drains
7	3	7.1 1 foot square drain surrounded by asphalt 7.2 2 foot circular drain surrounded by concrete 7.3 2 foot circular drain surrounded by concrete 7.4 Not a storm drain: piping from condominium drains into Lake Wawasee 7.5 2 foot circular drain surrounded by concrete

Figure 7.4.

Section	Number of observed Storm drains	Notes about Specific Storm drains
8	6	8 Drain adjacent to IDNR public access site 8.1 to 8.5 5x2 foot circular drains surrounded by asphalt and grass with two associated outlets on the seawall 8.6 1 x 2 foot circular drain

Figure 8. Ditch at public access site

Section	Number of observed Storm drains	Notes about Specific Storm drains
9	12	9.1 2 foot circular drains surrounded by asphalt and grass 9.2 Campfire pit covering the bottom of a storm drain 9.3 2 foot circular drain surrounded by asphalt and grass 9.4 Storm drain and associated drain and pipe 9.5 2 foot circular raised drain 9.6 2 foot square drain 9.7 3 foot circular drain 9.8 2 foot circular raised drain 9.9 2 foot circular raised drain 9.10 2 foot circular raised drain 9.11 2 foot circular drain 9.12 Six inch drain pipe

Figure 9.4a. Upstream of road.

Figure 9.4b. Downstream of road.

Section	Number of observed Storm drains	Notes about Specific Storm drains
10	1	10.1 7foot x 2 foot metal grate covering 2x2 foot drain pipes (See figure10.1); the outlet to the pipes could not be identified

Figure 10.1. Metal grate covering 2x2 foot drain pipes.

Section	Number of observed Storm drains	Notes about Specific Storm drains
11	3	11.1 2 foot circular drain 11.2 2 foot circular drain 11.3 2 foot circular drain
12	0	Ditches and ditch pipes are present in abundance
13	0	This section containing Dillon Creek was not surveyed
14	0	No storm drains were identified
15	0	One ditch with a 2 foot pipe outlet was identified
16	0	One ditch with a 2 foot pipe outlet was identified
17	1	17.1 2 foot circular drain

Section	Number of observed Storm drains	Notes about Specific Storm drains
18	8	18.1 to 18.4 1 foot circular drains 18.5 to 18.6 2 foot circular drains 18.7 Six inch pipe redirecting water from driveway to channel 18.8 Open concrete waterway at end of Michigan Drive allowing road run-off into channel
19	6	19.1 2 foot circular drain 19.2 1 foot square drain 19.3 to 19.6 2 foot circular drain
20	3	20.1 to 20.3 2 foot circular storm drains
21	0	Gated and inaccessible
22	0	Gated and inaccessible
23	1	23.1 2 foot circular drain

Figure 23.1a

Section	Number of observed Storm drains	Notes about Specific Storm drains
24	5	24.1 to 24.5 2 foot circular drains
25	10	25.1 2 foot circular drain 25.2 2 foot circular drain 25.3 2.5 foot circular drain 25.4 2 foot circular drain 25.5 to 25.9 Parking lot: 5x2 foot circular drains 25.10 2 foot square drain
26	10	26.1 2 foot circular drain 26.2 1.5foot circular drain 26.3 2 foot square drain 26.4 to 26.6 2 foot circular drains 26.7 1 foot circular drain 26.8 2 foot ditch pipe

APPENDIX L:

ESTIMATED LOAD REDUCTIONS

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Goal 1: We want to reduce the nutrient load reaching Lake Wawasee by 25% over the next 10 years.

Current nutrient load: The current nutrient loads carried by Dillon Creek and Turkey Creek as estimated by two field samplings (base and storm flow) are 0.034 kg/d (27.4 lb/yr) and 0.642 kg/d (511 lb/yr), respectively. These tributaries account for 99% (0.676 kg/d or 538.4 tons/yr) of the total nutrient load to Lake Wawasee. Therefore, efforts to reduce nutrient loading within these tributaries will generate the largest reduction throughout the entire watershed.

Targeted load reduction: On average, a 25% reduction in total phosphorus loading results in concentrations that meet the USPA target for typical concentrations in streams (0.075 mg/L). A 50% reduction in nitrate-nitrogen loading results in streams which meet the Ohio EPA recommended concentration (1.0 mg/L).

Necessary load reduction: To meet the goal, nutrient loading from Dillon Creek should measure 20.5 lb/yr and nutrient loading from Turkey Creek should measure 383 lb/yr. Overall, phosphorus loads should measure 403.5 lb/yr.

Objective 1-A: Implement stream bank stabilization techniques within the Wawasee Area Watershed.

Estimated load reduction:
Using IDEM's load reduction worksheet (Steffen, 1982), it is estimated that stabilizing 1000 feet of streambank with a height of 4 feet and a lateral recession rate of 0.2 feet per year will result in a nutrient load reduction of approximately 37.4 lb/yr. (Length, height, and recession rate were estimated based on field observations.) These estimates result from stabilizing one-third of the streambanks identified for stabilization along Dillon Creek. This estimate indicates that a reduction in nutrient loading more than the 100% of the current loading rate will occur if 1,000 feet of streambank are stabilized. Similar results occur within the Turkey Creek portion of the watershed.

It is likely that 500 to 1,000 feet of streambank could be stabilized within the Dillon Creek and Turkey Creek watersheds. This will result in a 75% reduction in nutrient loading. Other objectives will further reduce nutrient loading.

Estimated cost: The total cost for streambank stabilization along watershed streams will depend upon the specific technique implemented. The specific technique implemented will depend upon the specific location and degree of erosion at that location. Cost estimates are provided for installation through a cost-share grant program using volunteer labor and for installation through a contractor. The following list details estimated costs per lineal foot for each bank stabilization technique as estimated by JFNew (2005): Palmiter methods-$45/foot without volunteer labor, $10/foot with volunteers; 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. If stabilization occurs with an engineering firm or using grant monies with a contractor, it is anticipated that additional fees could be incurred above the estimates included.

Objective 1-B: Exclude livestock from streambank 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 Wawasee Area 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 Wawasee Area Watershed results in and annual loading of 115 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 5 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.) 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 two of these areas, the load reduction worksheet estimates that phosphorus loading would decrease by approximately 115 lbs/yr (0.06 tons/yr). This would result in approximately 1% lower phosphorus loading to the Wawasee Area Watershed. However, if livestock were restricted from all areas where livestock have access waterbodies within the Wawasee Area Watershed, phosphorus loading is reduced by nearly 10%. Estimated reductions increase if filter strips are also placed adjacent to the livestock access area resulting in a phosphorus reduction of nearly 15%.

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 1.

Objective 1-C: Promote responsible lakeside land management (phosphorous free fertilizer, proper pet, yard waste disposal etc.).

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%.

Objective 1-D: Implement shoreline buffers where absent and improve existing shoreline buffers.

Estimated load reduction: 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.

Objective 1-E: Reface seawalls with glacial stone and plant emergent shoreline buffer.

Estimated load reduction: Load calculations cannot be provided for this objective.

Estimated cost: Education-based objective all cost are assumed to be time related and are not an estimated.

Objective 1-F: Quantify pollutant (sediment, nutrients, and bacteria) loads from all storm drains that discharge to lakes within the Wawasee Area Watershed and develop treatment plan.

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.

Objective 1-G: 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.

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. Hypothetically, a community with a connected sewer system would eliminate contribution of nutrients by 100%. However, nutrients held by soils could remain for some time and be released slowly.

Objective 1-H: Reduce erosion from active construction sites.

Estimated load reduction: Load calculations cannot be provided for this objective.

Objective 1-I: Work with County Commissioners to developing laws that limit funneling.

Estimated load reduction: Load calculations cannot be provided for this objective.

Objective 1-J: Work with the County Commissioners to develop a shoreline development ordinance.

Estimated load reduction: Load calculations cannot be provided for this objective.

Objective 1-K: Improve stream/ditch buffers and grassed waterways within the Wawasee Area Watershed.

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 Wawasee Area 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.

Objective 1-L: Work with the County Commissioners to track planning and zoning changes and to develop an open space ordinance.

Estimated load reduction: Load calculations cannot be provided for this objective.

Objective 1-M: Implement wetland restoration to improve water storage and nutrient filtration.

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 Wawasee Area 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.

Objective 1-N: Work with State and County officials to protect shallow areas and plant beds within Lake Wawasee and other watershed lakes.

Estimated load reduction: Load calculations cannot be provided for this objective.

Objective 1-O: Establish a boat size and capacity ordinance for Lake Wawasee and Syracuse Lake.

Estimated load reduction: Load calculations cannot be provided for this objective.

Objective 1-P: Educate local students about lake issues through a program targeted at local classrooms

Estimated load reduction: Load calculations cannot be provided for this objective.

Objective 1-Q: Reduce resident waterfowl 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 Wawasee Area 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.

Goal 2: We want to reduce the sediment load to the waterbodies within the Wawasee Area Watershed by 50% over the next ten years.

Current sediment load: The current sediment loads carried by Dillon Creek and Turkey Creek as estimated by two field samplings (base and storm flow) are 15.1 kg/d (6.1 tons/yr) and 26.5 kg/d (10.7 tons/yr), respectively. These tributaries account for 99% (41.6 kg/d or 16.8 tons/yr) of the total sediment load to Lake Wawasee. Therefore, efforts to reduce sediment loading within these tributaries will generate the largest reduction throughout the entire watershed.

Targeted load reduction: Sediment loading rates are relatively low throughout the watershed; therefore, an arbitrary reduction was selected. Stakeholders discussed a 25% reduction in 5 years, but chose a 50% reduction over 10 years to mimic the nutrient reduction time frame.

Necessary load reduction: To meet the goal, sediment loading from Dillon Creek should measure 7.55 tons/yr and nutrient loading from Turkey Creek should measure 13.25 tons/yr. Overall, sediment loads should measure 20.8 tons/yr.

Objective 2-A: Implement stream bank stabilization techniques within the Wawasee Area Watershed.

Estimated load reduction: Using IDEM's load reduction worksheet (Steffen, 1982), it is estimated that stabilizing 1000 feet of streambank with a height of 4 feet and a lateral recession rate of 0.2 feet per year will result in a sediment load reduction of approximately 22 tons/yr or reduce sediment loading by greater than 100% of the current load. Stabilizing larger portions of the streambank or ravine will likely result in a larger sediment loading reduction. Using IDEM's load reduction worksheet, it is estimated that by stabilizing 500 feet of the streambanks with a height of 2 feet and 300 feet of streambank with a height of 6 feet along Turkey Creek will result in a sediment load reduction of nearly 30 tons/yr; a reduction of more than 100% of the sediment loading within Turkey Creek. As mentioned for Dillon Creek above, stabilizing larger portions of the streambank will likely result in a greater reduction. It should be noted that the measured total suspended solids is an estimate of the annual load rather than a calculation of it. It was estimated from the two sampling events. Consequently there is likely error associated with the estimate. Regardless, it is reasonable to expect a reduction in total suspended solids if the banks along the eroding portions of Wawasee Area Watershed streams are stabilized.

Estimated cost: See nutrient goal objective A for detailed cost estimates.

Objective 2-B: Implement ravine and gully stabilization techniques within the Wawasee Area Watershed.

See Objective 2-A for more information.

Objective 2-C: Implement channel stabilization techniques within the Wawasee Area Watershed.

Estimated load reduction: Harza (2001) estimated that 20 lbs of sediment erode from slightly eroding channels on an annual basis. Additional estimates indicate that as erosion severity increases, the volume of erosion also increases with moderate erosive areas losing 30 lb/yr and severe erosive areas losing 40 lb/yr. These estimates were for portions of Enchanted Hills channels and are therefore valid for conditions within these areas. They likely approximate sediment loads from other channels around Lake Wawasee as well.

Objective 2-D: Enact an erosion control ordinance.

See Objective 1-H of Nutrient Goal for information and action items relative to this objective.

Objective 2-E: Ditch buffers/grassed waterways

See Objective 1-K of Nutrient Goal for information and action items relative to this objective.

Objective 2-F: Livestock exclusion from streams and lakes

See Objective 1-B of Nutrient Goal for information and action items relative to this objective.

Objective 2-G: Improve shoreline buffers

See Objective 1-D of Nutrient Goal for information and action items relative to this objective.

Objective 2-H: Reface seawalls with glacial stone/plant emergent shoreline buffer

See Objective 1-E of Nutrient Goal for information and action items relative to this objective.

Objective 2-I: Catalog storm drain locations and sediment input; develop treatment plan

See Objective 1-F of Nutrient Goal for information and action items relative to this objective.

Objective 2-J: Enact funneling ordinance

See Objective 2-I of Nutrient Goal for information and action items relative to this objective.

Objective 2-K: Wetland restoration

See Objective 1-M of Nutrient Goal for information and action items relative to this objective.

Objective 2-L: Littoral zone protection and wetland restoration

See Objective 1-N of Nutrient Goal for information and action items relative to this objective.

Objective 2-M: Enhance or enlarge riparian corridor

No load reductions were calculated for this objective.

Objective 2-N: Riparian corridor development

No load reductions were calculated for this objective.

Objective 2-O: Shoreline development ordinance

See Objective 1-J of Nutrient Goal for information and action items relative to this objective.

Objective 2-P: Open space ordinance

See Objective 1-L of Nutrient Goal for information and action items relative to this objective.

Objective 2-Q: Boat size and capacity ordinance

See Objective 1-O of Nutrient Goal for information and action items relative to this objective.

Objective 2-R: Implement soil conservation practices in rural and agricultural areas.

No load reductions were calculated for this objective.

Objective 2-S: Encourage county officials to maintain buffers along legal drains.

No load reductions were calculated for this objective.

Goal 3: We want to reduce the concentration of *E. coli* within the Wawasee Area Watershed waterbodies so that water within the streams and lakes meets the state standard for *E. coli.*

As this is a concentration goal, estimates of load reduction were not completed.

Goal 4: Within five years, 50% of landowners within the Wawasee Area Watershed will attend one educational event and 25% of landowners implement one water quality improvement project.

As this is an education goal, estimates of load reduction were not completed.

Goal 5: Maintain and improve the recreational setting of the Wawasee Area Watershed by developing and implementing a recreational management plan for Lake Wawasee and Syracuse Lake within five years.

As this is a planning goal, estimates of load reduction were not completed.

APPENDIX M:

ACTION REGISTER

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

<u>Nutrient Goal:</u> We want to reduce the nutrient load reaching Lake Wawasee by 25% over the next 10 years.

Sub-Goals:

- We want to improve the trophic status of lakes within the Ten Lakes Chain so that they at a minimum score as mesotrophic using the Indiana TSI within 15 years.
- We want to establish a monitoring program to assess the water quality exiting Lake Papakeechie within the next two years and establish a monitoring program for the streams entering Lake Papakeechie and the Tri-County FWA lakes within the next five years.

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Implement streambank stabilization techniques within the watershed	Contact landowners regarding using their land Apply for funding for stabilization Hire engineer to complete designs Hire contractor to install stabilization design	WACF Ecology Committee	Landowner contact: 2007 Funding application: 2009-2013 Design/Construction: by 2011-2015	Landowners contacted Funding applications submitted Designs completed Construction completed
Restrict livestock access to watershed streams	Identify a feasible solution to restrict livestock access to watershed waterbodies Work with NRCS to identify solution Identify an alternative watering source for the livestock Estimate fencing needed Apply for and obtain funding for restriction Complete the fence installation	WACF Land Management Committee	Solution identified: 2007 Watering source identified: 2008 Funding: 2009 Installation: 2010	# of solutions investigated Feasible alternative identified Volume of livestock restricted
Promote responsible lake side land management	Test soils to determine phosphorus level Investigate the market potential of phosphorus free fertilizer Encourage lawn care professionals and residents to use phosphorus free fertilizer Maintain natural landscape adjacent to shore Replace turf grass with native plants Establish a list of P-free fertilizer providers and lawn care professionals that use P-free fertilizer	WACF Ecology Committee	Test soils: 2008 Identify companies: 2009 Literature: 2012 Marketing plan: 2015	# of individuals receiving literature # of facilities carrying P-free fertilizer # of lbs. of P-free fertilizer sold # of linear feet of natural landscape maintained # of converted turf lawns
Implement shoreline buffers where absent or improve existing buffers around watershed waterbodies	Educate homeowners about shoreline buffers Develop a planting plan for watershed lakes Discuss the feasibility of improving the buffer Select appropriate demonstration project sites Apply for funding to conduct planting Hold a volunteer field day to plant buffer Develop recognition system	WACF Land Management Committee	Buffer education: 2007 Planting plan: 2008 Funding: 2009 Field day: 2009	# of homeowners receiving materials # of planting plans developed length of demonstration project # of volunteers attending field day amount of funding received

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Reface seawalls with glacial stone and plant emergent in-lake buffer	Plant aquatic emergent species adjacent to shorelines and in front of existing seawalls Encourage the use of rock rather than concrete seawalls Encourage residents to use IDNR guidelines for glacial rock placement in front of existing seawalls Implement new eco-zones in locations where they are currently needed but not present Enforce existing eco-zones Pass local and encourage state law to limit space occupied by temporary structures on or in front of the lakeshore	WACF Land Management and Ecology Committees	Identify seawalls: 2009 Plan developed: 2010 Eco-zones: 2008-2013 Pollutant loads determined: 2011 Temporary structures: 2017	# of linear feet aquatic emergent species installed # of linear feet rock seawall installed # of leaflets distributed to residents # of new eco-zones implemented Passing of local and/or state law
Quantify pollutant loads from all storm drains and develop treatment plan	Identify all storm drains around watershed waterbodies Develop a database to contain drain information Enter data and map storm drain locations Identify funding sources Develop a plan to measure pollutant loads Develop a spreadsheet to hold sampling results Disseminate results to watershed stakeholders Develop a treatment plan to reduce pollutant loading to watershed waterbodies	WACF; consultant	Identify drains: 2008 Identify landowners: 2009 Plan developed: 2009 Maps completed: 2010 Pollutant loads determined: 2011 Treatment plan developed: 2013	# of storm drains identified # of storm drains with a complete data matrix # of funding sources identified # of stakeholders receiving pollutant load results Treatment plan completed Treatment plan implemented
Work to identify any failing septic systems and promote proper septic system maintenance in the watershed	Identify any failing septic systems in the watershed Develop list of BMPs to reduce nutrient and pathogenic contamination from septics Disseminate BMP information Investigate opportunities for septic compliance county ordinance	WACF	Failing systems identified: 2013 BMP list: 2010 Info. distributed: 2011	# of septic systems tested # of BMPs identified # of individuals receiving information
Identify the need for and install sewer systems in the watershed	Complete a sewer feasibility study for areas needing sewer (Ten Lakes Chain; Wawasee) Develop cost estimates for sewer design and implementation Identify and apply for grant money for design Select firm to design efficient system Identify and apply for grant money to pay for implementation	WACF	Identify sewer needs: 2010 Cost estimates: 2011 Feasibility grant: 2012 Design completed: 2015 Implementation: 2017	Sewer feasibility study completed Cost estimates developed # of grants identified Amount of grant money received Firm selected

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Reduce erosion from active construction sites	Become familiar with erosion control practices Work to require erosion control on all construction sites Implement strict erosion control ordinances Work to ensure that Rule 5 is being implemented at all applicable sites Develop recognition for county builders implementing erosion control practices	Lake Associations	Meet with county officials: 2007 Meet with state officials: 2008 Recognition plan: 2008	Amount of erosion control materials installed # of ordinances enacted # of sites where Rule 5 is in use # of builders recognized
Develop a law to limit funneling	Draft a funneling ordinance for Noble and Elkhart Counties Appoint individuals to committee for anti-funneling Follow up on requests for public piers Review and provide comments on group pier permits Change zoning ordinance to limit the number of single-family residences that can be platted on a single property Actively support anti-funneling and zoning ordinances	WACF Eco Community	Completed in Kosciusko County; investigate need in Noble County	Ordinance completed # of individuals appointed to committee # of requests addressed # of group pier permits addressed Zoning ordinance changed
Develop shoreline development ordinance	Draft shoreline development ordinance Gather support for the ordinance Limit amount and impacts of impervious surface Require management for stormwater Set limits on pollutant export from sites Limit housing density near lakes Include an erosion control ordinance Review recommendations from the ILMWG	WACF; Lake Associations	Draft ordinance: 2012 Determine limits: 2008 Garner support: 2010	Draft of ordinance completed # of individuals appointed to committee Pollutant limits established Erosion control ordinance implemented Recommendations reviewed
Improve stream/ditch buffers and grassed waterways	Form a partnership with agricultural land owners Place sensitive lands in CRP Maintain grassed waterways and other installed practices Encourage landowners to maintain current and increase development of riparian corridors Consider WACF purchase and restoration of land adjacent to watershed streams	Noble and Kosciusko County SWCD offices; WACF	Meet with landowners: 2009 Identify parcels for protection: 2010 Develop plan: 2012	# of land owner partnerships established # of acres of land placed in CRP # of feet grassed waterways maintained # of acres riparian vegetation maintained # of WACF acres restored

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Work with the County to track planning and zoning changes and develop an open space ordinance	Request planning and zoning variance proposals Review and comment on proposals around the lake and in the watershed Use survey tools to determine the level of development that is acceptable to county residents Designate different levels of development for different lakes	WACF Planning Committee	Meet with county officials: 2007 Proposal review: 2008	Proposals requested # of proposals reviewed # of surveys completed by residents # of acres riparian vegetation maintained # of lakes designated an acceptable development level
Restore the watershed's wetlands	Identify potential restoration/protection sites Contact landowners to re: restoration feasibility Develop a restoration plan for the wetlands Design the wetland restorations Determine necessity of species control Identify and apply for funding	WACF Ecology Committee	Determine restoration locations: 2007 Plan established: 2009 Funding application: 2011 Construction completed: 2012	# of landowners contacted # of restoration plans developed # of funding sources identified Amount of funding received
Protect shallow areas and plant beds	Encourage boaters to use reduced speeds Explore establishment of eco-zones Dredge areas of accumulated sediment, as necessary	WACF Education and Ecology Committees	Boater education: 2008 Establish eco-zones: 2014	# of boating speed signs erected # of potential ecozones identified # of potential dredging areas identified
Establish boat size and capacity ordinance	Conduct resident survey re: lake use Conduct literature search for carrying capacity Take actions to limit the size and speed of boats, if necessary Work to establish a carrying capacity for lakes	WACF Ecology and Planning Committees	Conduct survey: 2008 Literature search : 2009 Determine carrying capacity: 2010	# of survey respondents # of research articles identified Boating limits established Carrying capacity determined
Educate local student about lake issues	Identify techniques to educate students Develop educational materials Host demonstration day Identify student groups to assist with sampling	WACF Ecology Committee	Techniques identified: 2009 Materials developed: 2010 Demonstration day: 2014	# of educational techniques identified # of educational materials developed Demonstration day completed # of student group identified
Implement water quality sampling program for watershed waterbodies	Identify groups to participate in stream sampling Identify landowners who will provide access Identify individuals to complete lake sampling Attend training session for Clean Lakes Program	WACF Ecology Committee	Identify individuals: Spring 2007 Begin monitoring/database set up: Spring 2007	# of groups identified for stream sampling # of cooperative landowners identified # of individuals identified for lake sampling

<u>Sediment Goal:</u> We want to reduce the sediment load to the waterbodies within the Wawasee Area Watershed by 50% over the next ten years.

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Implement ravine stabilization techniques	Identify ravines requiring stabilization Contact landowners regarding using their land Apply for funding for stabilization Hire engineer to complete designs Hire contractor to install stabilization design	WACF Ecology Committed	Contact landowners: 2012 Funding application: 2013 Design: 2014 Constructions: 2016	Landowners contacted Funding applications submitted Designs completed Construction completed
Stabilize eroding channels around Lake Wawasee and other watershed lakes	Identify channels that require stabilization Contact landowner to determine response to project Identify and apply for funding Hire an engineer to design stabilization techniques Hire a contractor to complete stabilization	WACF Ecology Committee with assistance from Channel Groups	Identify channels: 2010 Contact landowners: 2011 Funding application: 2012 Design: 2013 Constructions: 2015	# of channels identified # of landowners contacted # of grants applied for Engineer and contractor hired
Implement soil conservation practices in rural and agricultural areas	Identify agricultural producers using conservation practices Host annual demonstration day targeting conservation practice implementation Apply for cost-share funding to install practices	Noble and Kosciusko County SWCDs; Elkhart River Watershed Agriculture Conservations Specialist	Identify users: 2007 Demonstration Days: annual Funding application: 2008	# of producers identified # of individuals attending demonstration days # of cost-share funding sources identified and applied for # of individuals attending field days
Encourage county officials to maintain buffers along legal drains	Meet with County Surveyors to determine the maintenance schedule for legal drains within the watershed Attend one County Drainage Board meeting annually for each county	WACF	Meeting with surveyors: 2007 Meeting attendance: 2007-2015	# of meetings with county surveyors # of drainage board meetings attended
Monitor sediment load in the watershed streams and water clarity in watershed lakes	Identify individuals to complete monitoring training. Complete monitoring on a monthly or quarterly basis. Maintain a water quality sampling database Compare results from sampling. Publish sampling results	WACF Ecology Committee	Identify individuals: Spring 2007 Begin monitoring/database set up: Spring 2007	# of individuals interested in monitoring # of months monitoring completed % sediment load better than baseline # of individuals receiving information

***E. coli* Goal:** **We want to reduce the concentration of *E. coli* within the Wawasee Area Watershed waterbodies so that water within the streams and lakes meets the state standard for *E. coli*.**

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Implement manure management planning	Review grazing management for livestock Obtain funding for and implement manure management planning	Noble and Kosciusko County SWCD offices	Landowner mtg: 2010 Plans implemented: 2011	Grazing management reviewed Manure management plan implemented
Reduce goose populations adjacent to watershed waterbodies	Determine appropriate goose populations Hold a volunteer day to relocate geese Implement egg treatment Coordinate work with IDNR biologists	Lake Associations	Population determination: 2010 Volunteer day: 2011 Goose relocation: annual	Appropriate goose population determined # of geese relocated # of eggs treated
Establish pet/wildlife waste disposal protocols	Educate landowners regarding proper disposal of pet waste Educate landowners regarding washing goose droppings into the lakes Establish protocols for lakeshore properties	WACF Education Committee	Establish protocol: 2007 Education materials: 2008	# of landowners receiving information Protocols established
Monitor *E. coli* load in the watershed streams	Identify individuals to complete monitoring training. Complete monitoring on a monthly or quarterly basis. Maintain a water quality sampling database Compare results from sampling. Publish sampling results	WACF Water Testing Program	Identify individuals: Spring 2007 Begin monitoring/database set up: Spring 2007	# of individuals interested in monitoring # of months monitoring completed % *E. coli* load better than baseline # of individuals receiving information

Outreach Goal: Within five years, 50% of landowners within the Wawasee Area Watershed will attend one educational event and 25% of landowners implement one water quality improvement project.

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Organize one annual field day highlighting lake and stream values and protection	Identify members of the agricultural community that currently implement conservation projects Invite local experts to speak at field day Advertise the field day via newsletters, press release, and watershed stakeholders Create incentive program for attendees	WACF Education and Public Relations Committees	Agricultural community identification: 2008 Field Days: annual	# of agricultural community members identified # of people who receive information # of people attending field days
Publicize the value of the watershed and ways to protect water quality and aquatic life	Develop list of BMPs for agricultural land Develop list of BMPs for residential land Summarize value of the watershed and watershed group Publish annual newsletter highlighting this information Develop a website highlighting this information	WACF Public Relations Committees	Ag BMP list: 2009 Residential BMP list: 2008 Newsletter I: 2008 Newsletter II: 2009 Website: Fall 2008	# of agricultural BMPs identified # of residential BMPs identified # of layman who receive information # of people who receive newsletter # of people who visit website
Work with NRCS, SWCD, and ag property owners to promote BMP's	Identify property owners using conservation land programs. Hold one agricultural demonstration day annually to highlight landowners Attend one local SWCD meeting annually	WACF Ecology Committee; Noble and Kosciusko County SWCDs	Property identification: 2008 Dem. Day: annual	# landowners identified # of individuals attending demonstration day # of SWCD meetings attended
Work with NRCS, SWCD and residential property owners to promote BMP's	Develop a list of activities that residential property owners can do Hold one demonstration day annually on residential property Develop list of grants for residential water quality projects	WACF Ecology Committee	List development: 2008 Dem. Day: annual Grants: 2009	# of activities on list # of individuals attending demonstration day # of funding sources identified
Establish and maintain a watershed and water quality table at the County Fairs	Talk to fair representatives to establish a table or booth Develop program materials and handouts Develop group to manage table or booth during fair	WACF Education and Public Relations Committees; Lake Associations	Establish table: 2007 Program materials: 2007 Attend fair: 2007-2011	# of years table is established for amount of materials available for distribution volume of materials distributed
Develop an education plan	Identify a source and apply for funding Hire a consultant to develop education plan Identify educational needs using a survey Identify locations for educational facilities Determine funding source for facility creation Develop and implement education plan	WACF Education Committee	Identify funding: 2008 Education materials: 2009 Facility creation: 2010	Grant money received Consultant hired # of survey respondents Potential location for facility identified Educational plan implemented

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Identify and acquire high quality properties	Identify high quality properties Identify funding sources to purchase properties Work with landowners to acquire access or purchase properties Complete property acquisition, if possible Develop restoration plan, if necessary Identify and apply for restoration funding Implement restoration plan	WACF Ecology and Land Acquisition Committees	Properties identified: 2007 Landowners contacted: 2008 Restoration plan: 2009-2012	# of properties identified and purchased # of funding sources identified Restoration plan implemented using proper funding

<u>Recreational Goal</u>: Maintain and improve the recreational setting of the Wawasee Area Watershed by developing and implementing a recreational management plan for Lake Wawasee and Syracuse Lake within five years.

Sub-Goals:

- Develop aquatic plan management plans for the Ten Lakes Chain and the Tri-County FWA lakes and implement the recommendations defined in these plans.
- Develop a boating use/recreation plan. A number of items should be included in this plan. The following list outlines just some of the information necessary to address boating issues on the Lake Wawasee and Syracuse Lake.
    - Determine the number of users that are appropriate for the lakes.
    - Determine the size of boats appropriate for the lakes and work with the IDNR to limit the size of boats allowed on the lakes, if this is determined to be an appropriate action.
    - Educate lakeshore residents and lake users in regards to Indiana's boating laws and develop a plan to ensure compliance with these laws.
    - Educate lake users on the negative impacts (agitation and resuspension of sediment and nutrients from the lakebed) of boating in shallow waters.
- Implement the exotic species control measures laid out in the study recently completed by V3.

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Develop an aquatic plant management plan for the Ten Lakes Chain and the Tri-County FWA lakes	Complete aquatic plant surveys Host meeting to distribute survey information Develop work plan for aquatic plant treatment Review, update, and implement plan Educate property owners on invasive species and aquatic plant issues Apply for funding for future implementation and surveys	WACF Ecology Committee	Plant surveys: annual Meeting: annual Work plan: end of 2007 Education: 2008 Funding application: annual	# of plants identified # of people attending meetings Plan developed Plan updated # of individuals receiving education Amount of funding received
Develop a boating/recreation plan.				
Determine the number of users appropriate	Conduct literature search Design and conduct watercraft survey Determine if restrictions are required Use aerials and boat registrations to determine the current number of users Monitor off-shore users Publish information	WACF Ecology Committee	Harkless Grant application in process; begin project once funding is obtained	# of articles identified # of boats identified # of off-shore users identified articles published

Objective	Action Item	Potentially Responsible Party	Schedule	Indicators
Educate lakeshore residents re: boating laws and develop a plan to ensure compliance	Encourage boats to take boater education courses Sponsor boater education courses Provide boater education handouts Develop plans to enforce laws/increase patrols Utilize new LARE funds to increase deputy patrols Obtain funding for law enforcement	WACF Education and Public Relations Committees	Boaters class: 2007-2011 Handouts: continuous Plan developed: 2008 LARE fund application: 2007	# of individuals attending classes # of handouts provided Plan developed Funding applied for Amount of funding obtained
Educate lake users on negative impacts of boating in shallow waters	Encourage slow speeds in shallow water Establish eco-zones in areas needed Enforce eco-zones already present	WACF Education Committee; Conservation Officers	Slow speeds encourage: continuous Eco-zones: 2008	# of signs posted # of individuals obeying speed limit Area protected as eco-zone
Address fuel contamination issues	Place warning signs at marinas Encourage maintenance of old engines Minimize fuel spills during refueling Support group pier restrictions Submit fuel contamination proposal for county ordinance	WACF Education, Ecology, and Public Relations Committees	Signs posted: 2007 Maintenance info: 2008 Group pier info: 2009 Ordinance: 2010	# of signs posted # of older engines identified and maintained Ordinance developed
Track group pier, funneling, and boating speed limit legislation	Attend ILMS meetings or workshops to track progress Review ILMWG progress and educate lake residents re: updates	WACF Legislation Committee	ILMS meeting: 2007; continuous ILMS workshop: 2007; continuous ILMWG: continuous	# of individuals attending meeting # of individuals attending workshop # of information to which ILMWG information is distributed
Monitor and improve fish community	Monitor fish community with DNR input Determine resident actions to improve game fish community Implement water quality improvement projects	WACF Ecology Committee; IDNR Fisheries Biologist	Fish survey: schedule with DNR Game fish improvements: 2009 Projects: 2008-2012	# of fish identified # of water quality improvement projects implemented
Determine and remove accumulated sediment	Map accumulated sediment Determine appropriate method for sediment removal Develop sediment removal plan Apply for and obtain funding to remove sediment Complete sediment removal	WACF Ecology Committee	Maps: 2008 Sediment plan: 2009 Sediment removal: 2010	# of inlet mouths mapped Amount of accumulated sediment Areas for disposal identified Amount of funding received Sediment removal completed

APPENDIX N:

FUNDING SOURCES

WAWASEE AREA WATERSHED MANAGEMENT PLAN ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Potential Funding Sources.

There are several cost-share grants available from both state and federal government agencies specific to watershed management. Community groups and/or Soil and Water Conservation Districts can apply for the majority of these grants. The main goal of these grants and other funding sources is to improve water quality though the use of specific BMPs. As public awareness shifts towards watershed management, these grants will become more and more competitive. Therefore, any association interested in improving water quality through the use of grants must become active soon. Once an association is recognized as a "watershed management activist" it will become easier to obtain these funds repeatedly. The following are some of the possible major funding sources available to lake and watershed associations for watershed management.

Lake and River Enhancement Program (LARE)

LARE is administered by the Indiana Department of Natural Resources, Division of Fish and Wildlife. The program's main goals are to control sediment and nutrient inputs to lakes and streams and prevent or reverse degradation from these inputs through the implementation of corrective measures. Under present policy, the LARE program may fund lake and watershed specific construction actions up to $100,000 for a single project or $300,000 for all projects on a lake or stream. The LARE program also provides a maximum of $100,000 for the removal of sediment from a particular site on a lake and a cumulative total of $300,000 for all sediment removal projects on a lake. An approved sediment removal plan must be on file with the LARE office for projects to receive sediment removal funding. Finally, the LARE program will provide $100,000 for a one-time whole lake treatment to control aggressive, invasive aquatic plants. A cumulative total of $20,000 over a three year period may be obtained for additional spot treatment following the whole lake treatment. Additionally, aquatic plant management grants of up to $20,000 are available per year per lake for spot treatment where whole lake treatment is not appropriate. As with the sediment removal funding, an approved aquatic plant management plan must be on file with the LARE office for the lake association to receive funding. All approved projects require a 0 to 25% cash or in-kind match, depending on the project. LARE also has a "watershed land treatment" component that can provide grants to SWCDs for multi-year projects. The funds are available on a cost-sharing basis with landowners who implement various BMPs. All of the LARE programs are recommended as a project funding source for the Wawasee Area Watershed. More information about the LARE program can be found at http://www.in.gov/dnr/fishwild/lare/.

Clean Water Act Section 319 Nonpoint Source Pollution Management Grant

The 319 Grant Program is administered by the Indiana Department of Environmental Management (IDEM), Office of Water Management, Watershed Management Section. 319 is a federal grant made available by the Environmental Protection Agency (EPA). 319 grants fund projects that target nonpoint source water pollution. Nonpoint source pollution (NPS) refers to pollution originating from general sources rather than specific discharge points (Olem and Flock, 1990). Sediment, animal and human waste, nutrients, pesticides, and other chemicals resulting from land use activities such as mining, farming, logging, construction, and septic fields are considered NPS pollution. According to the EPA, NPS pollution is the number one contributor to water pollution in the United States. To qualify for funding, the water body must meet specific criteria such as being listed in the state's 305(b) report as a high priority water body or be identified by a diagnostic study as being impacted by NPS pollution. Funds can be requested for up to $300,000 for individual projects. There is a 25% cash or in-kind match requirement. To qualify for implementation projects, there must be a watershed management plan for the receiving waterbody. This plan must meet all of the current 319 requirements. This diagnostic study serves as an excellent foundation for developing a watershed management plan since it satisfies several, but not all, of the 319 requirements for a watershed management plan. More information about the Section 319 program can be obtained from http://www.in.gov/idem/water/planbr/wsm/319main.html.

Section 104(b)(3) NPDES Related State Program Grants
Section 104(b)(3) of the Clean Water Act gives authority to a grant program called the National Pollutant Discharge Elimination System (NPDES) Related State Program Grants. These grants provide money for developing, implementing, and demonstrating new concepts or requirements that will improve the effectiveness of the NPDES permit program that regulates point source discharges of water pollution. Projects that qualify for Section 104(b)(3) grants involve water pollution sources and activities regulated by the NPDES program. The awarded amount can vary by project and there is a required 5% match. For more information on Section 104(b)(3) grants, please see the IDEM website at: http://www.in.gov/idem/water/planbr/wsm/104main.html.

Section 205(j) Water Quality Management Planning Grants
Funds allocated by Section 205(j) of the Clean Water Act are granted for water quality management planning and design. Grants are given to municipal governments, county governments, regional planning commissions, and other public organizations for researching point and non-point source pollution problems and developing plans to deal with the problems. According to the IDEM Office of Water Quality website: "The Section 205(j) program provides for projects that gather and map information on non-point and point source water pollution, develop recommendations for increasing the involvement of environmental and civic organizations in watershed planning and implementation activities, and implement watershed management plans. No match is required. For more information on and 205(j) grants, please see the IDEM website at: http://www.in.gov/idem/water/planbr/wsm/205jmain.html.

Other Federal Grant Programs
The USDA and EPA award research and project initiation grants through the U.S. National Research Initiative Competitive Grants Program and the Agriculture in Concert with the Environment Program.

Watershed Protection and Flood Prevention Program
The Watershed Protection and Flood Prevention Program is funded by the U.S. Department of Agriculture and is administered by the Natural Resources Conservation Service. Funding targets a variety of watershed activities including watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in small watersheds (250,000 or fewer acres). The program covers 100% of flood prevention construction costs or 50% of construction costs for agricultural water management, recreational, or fish and wildlife projects.

Conservation Reserve Program

The Conservation Reserve Program (CRP) is funded by the USDA and administered by the Farm Service Agency (FSA). CRP is a voluntary, competitive program designed to encourage farmers to establish vegetation on their property in an effort to decrease erosion, improve water quality, or enhance wildlife habitat. The program targets farmed areas that have a high potential for degrading water quality under traditional agricultural practices or areas that might make good wildlife habitat if they were not farmed. Such areas include highly erodible land, riparian zones, and farmed wetlands. Currently, the program offers continuous sign-up for practices like grassed waterways and filter strips. Participants in the program receive cost share assistance for any plantings or construction as well as annual payments for any land set aside.

Wetlands Reserve Program

The Wetlands Reserve Program (WRP) is funded by the USDA and is administered by the NRCS. WRP is a subsection of the Conservation Reserve Program. This voluntary program provides funding for the restoration of wetlands on agricultural land. To qualify for the program, land must be restorable and suitable for wildlife benefits. This includes farmed wetlands, prior converted cropland, farmed wet pasture, farmland that has become a wetland as a result of flooding, riparian areas which link protected wetlands, and the land adjacent to protected wetlands that contribute to wetland functions and values. Landowners may place permanent or 30-year easements on land in the program. Landowners receive payment for these easement agreements. Restoration cost-share funds are also available. No match is required.

Grassland Reserve Program

The Grassland Reserve Program (GRP) is funded by the USDA and is administered by the NRCS. GRP is a voluntary program that provides funding the restoration or improvement of natural grasslands, rangelands, prairies or pastures. To qualify for the program the land must consist of at least a 40 acre contiguous tract of land, be restorable, and provide water quality or wildlife benefit. Landowners may enroll land in the Grassland Reserve Program for 10, 15, 20, or 30 years or enter their land into a 30-year permanent easement. Landowners receive payment of up to 75% of the annual grazing value. Restoration cost-share funds of up to 75% for restored or 90% for virgin grasslands are also available.

Community Forestry Grant Program

The U.S. Forest Service through the Indiana Department of Natural Resources Division of Forestry provides three forms of funding for communities under the Community Forestry Grant Program. Urban Forest Conservation Grants (UFCG) are designed to help communities develop long term programs to manage their urban forests. UFCG funds are provided to communities to improve and protect trees and other natural resources; projects that target program development, planning, and education are emphasized. Local municipalities, not-for-profit organizations, and state agencies can apply for $2,000-20,000 annually. The second type of Community Forestry Grant Program, the Arbor Day Grant Program, funds activities which promote Arbor Day efforts and the planting and care of urban trees. $500-1000 grants are generally awarded. The Tree Steward Program is an educational training program that involves six training sessions of three hours each. The program can be offered in any county in Indiana and covers a variety of tree care and planting topics. Generally, $500-1000 is available to assist communities in starting a county or regional Tree Steward Program. Each of these grants requires an equal match.

Forest Land Enhancement Program (FLEP)

FLEP replaces the former Forestry Incentive Program. It provides financial, technical, and educational assistance to the Indiana Department of Natural Resources Division of Forestry to assist private landowners in forestry management. Projects are designed to enhance timber production, fish and wildlife habitat, soil and water quality, wetland and recreational resources, and aesthetic value. FLEP projects include implementation of practices to protect and restore forest lands, control invasive species, and preserve aesthetic quality. Projects may also include reforestation, afforestation, or agroforestry practices. The IDNR Division of Forestry has not determined how they will implement this program; however, their website indicates that they are working to determine their implementation and funding procedures. More information can be found at http://www.in.gov/dnr/forestry.

Wildlife Habitat Incentive Program

The Wildlife Habitat Incentive Program (WHIP) is funded by the USDA and administered by the NRCS. This program provides support to landowners to develop and improve wildlife habitat on private lands. Support includes technical assistance as well cost sharing payments. Those lands already enrolled in WRP are not eligible for WHIP. The match is 25%.

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is a voluntary program designed to provide assistance to producers to establish conservation practices in target areas where significant natural resource concerns exist. Eligible land includes cropland, rangeland, pasture, and forestland, and preference is given to applications which propose BMP installation that benefits wildlife. EQIP offers cost-share and technical assistance on tracts that are not eligible for continuous CRP enrollment. Certain BMPs receive up to 75% cost-share. In return, the producer agrees to withhold the land from production for five years. Practices that typically benefit wildlife include: grassed waterways, grass filter strips, conservation cover, tree planting, pasture and hay planting, and field borders. Best fertilizer and pesticide management practices, innovative approaches to enhance environmental investments like carbon sequestration or market-based credit trading, and groundwater and surface water conservation are also eligible for EQIP cost-share.

Small Watershed Rehabilitation Program

The Small Watershed Rehabilitation Program provides funding for rehabilitation of aging small watershed impoundments that have been constructed within the last 50 years. This program is newly funded through the 2002 Farm Bill and is currently under development. More information regarding this and other Farm Bill programs can be found at http://www.usda.gov/farmbill.

Farmland Protection Program

The Farmland Protection Program (FPP) provides funds to help purchase development rights in order to keep productive farmland in use. The goals of FPP are: to protect valuable, prime farmland from unruly urbanization and development; to preserve farmland for future generations; to support a way of life for rural communities; and to protect farmland for long-term food security.

Debt for Nature

Debt for Nature is a voluntary program that allows certain FSA borrowers to enter into 10-year, 30-year, or 50-year contracts to cancel a portion of their FSA debts in exchange for devoting eligible acreage to conservation, recreation, or wildlife practices. Eligible acreage includes: wetlands, highly erodible lands, streams and their riparian areas, endangered species or significant wildlife habitat, land in 100-year floodplains, areas of high water quality or scenic value, aquifer recharge zones, areas containing soil not suited for cultivation, and areas adjacent to or within administered conservation areas.

Partners for Fish and Wildlife Program

The Partners for Fish and Wildlife Program (PFWP) is funded and administered by the U.S. Department of the Interior through the U.S. Fish and Wildlife Service. The program provides technical and financial assistance to landowners interested in improving native habitat for fish and wildlife on their land. The program focuses on restoring wetlands, native grasslands, streams, riparian areas, and other habitats to natural conditions. The program requires a 10-year cooperative agreement and a 1:1 match.

North American Wetland Conservation Act Grant Program

The North American Wetland Conservation Act Grant Program (NAWCA) is funded and administered by the U.S. Department of Interior. This program provides support for projects that involve long-term conservation of wetland ecosystems and their inhabitants including waterfowl, migratory birds, fish, and other wildlife. The match for this program is on a 1:1 basis.

National Fish and Wildlife Foundation (NFWF)

The National Fish and Wildlife Foundation is administered by the U.S. Department of the Interior. The program promotes healthy fish and wildlife populations and supports efforts to invest in conservation and sustainable use of natural resources. The NFWF targets six priority areas which are wetland conservation, conservation education, fisheries, neotropical migratory bird conservation, conservation policy, and wildlife and habitat. The program requires a minimum of a 1:1 match. More information can be found at http://www.nfwf.org/about.htm.

Bring Back the Natives Grant Program

Bring Back the Natives Grant Program (BBNG) is a NFWF program that provides funds to restore damaged or degraded riverine habitats and the associated native aquatic species. Generally, BBNP supports on the ground habitat restoration projects that benefit native aquatic species within their historic range. Funding is jointly provided by a variety of federal organizations including the U.S. Fish and Wildlife Service, Bureau of Land Management, and U.S. Department of Agriculture and the National Fish and Wildlife Foundation. Typical projects include those that revise land management practices to remove the cause of habitat degradation, provide multiple specie benefit, include multiple project partners, and are innovative solutions that assist in the development of new technology. A 1:1 match is required; however, a 2:1 match is preferred. More information can be obtained from http://www.nfwf.org.

Native Plant Conservation Initiative

The Native Plant Conservation Initiative (NPCI) supplies funding for projects that protect, enhance, or restore native plant communities on public or private land. This NFWF program typically funds projects that protect and restore of natural resources, inform and educate the surrounding community, and assess current resources. The program provides nearly $450,000 in funding opportunities annually awarding grants ranging from $10,000-50,000 each. A 1:1 match is required for this grant. More information can be found at http://www.nfwf.org/programs/grant_apply.htm.

Freshwater Mussel Fund

The National Fish and Wildlife Foundation and the U.S. Fish and Wildlife Service fund the Freshwater Mussel Fund which provides funds to protect and enhance freshwater mussel resources.

The program provides $100,000 in funding to approximately 5-10 applicants annually. More information can be found at http://www.nfwf.org/programs/grant_apply.htm.

Non-Profit Conservation Advocacy Group Grants
Various non-profit conservation advocacy groups provide funding for projects and land purchases that involve resource conservation. Ducks Unlimited and Pheasants Forever are two such organizations that dedicate millions of dollars per year to projects that promote and/or create wildlife habitat.

U.S. Environmental Protection Agency Environmental Education Program
The USEPA Environmental Education Program provides funding for state agencies, non-profit groups, schools, and universities to support environmental education programs and projects. The program grants nearly $200,000 for projects throughout Illinois, Indiana, Michigan, Minnesota, Wisconsin, and Ohio. More information is available at
http://www.epa.gov/region5/ened/grants.html.

Core 4 Conservation Alliance Grants
Core 4 provides funding for public/private partnerships working toward Better Soil, Cleaner Water, Greater Profits and a Brighter Future. Partnerships must consist of agricultural producers or citizens teaming with government representatives, academic institutions, local associations, or area businesses. CTIC provides grants of up to $2,500 to facilitate organizational or business plan development, assist with listserve or website development, share alliance successes through CTIC publications and other national media outlets, provide Core 4 Conservation promotional materials, and develop speakers list for local and regional use. More information on Core 4 Conservation Alliance grants can be found at
http://www.ctic.purdue.edu/CTIC/GrantApplication.pdf.

Indianapolis Power and Light Company (IPALCO) Golden Eagle Environmental Grant
The IPALCO Golden Eagle Grant awards grants of up to $10,000 to projects that seek improve, preserve, and protect the environment and natural resources in the state of Indiana. The award is granted to approximately 10 environmental education or restoration projects each year. Deadline for funding is typically in January. More information is available at
http://www.ipalco.com/ABOUTIPALCO/Environment/Golden_Eagle.html

Nina Mason Pulliam Charitable Trust (NMPCT)

The NMPCT awards various dollar amounts to projects that help people in need, protect the environment, and enrich community life. Prioritization is given to projects in the greater Phoenix, AZ and Indianapolis, IN areas, with secondary priority being assigned to projects throughout Arizona and Indiana. The trust awarded nearly $20,000,000 in funds in the year 2000. More information is available at www.nmpct.org

APPENDIX O:

ACTION TRACKER

WAWASEE AREA WATERSHED MANAGEMENT PLAN
ELKHART, KOSCIUSKO, AND NOBLE COUNTIES, INDIANA

Action Tracker

Date: ____

Goal (choose from goals listed below): ____

Task completed: ____

Type of task (circle appropriate task type):

Meeting Who attended: ____

Education Number attended: _____ Number distributed: _____
Distributed to: ____

Investigation Sources of information: ____

Field Work

Other

Provide a description of the task in the space below. Please include what portion of the goal(s) or objective(s) this task completes, a listing of other actions required based on this task, and any suggested future actions.

Additional notes:

Task completed by:____________________________________

Goals:

1. Reduce the nutrient load reaching Lake Wawasee.
2. Reduce sediment load reaching Lake Wawasee.
3. Reduce the concentration of *E. coli* within the waterbodies.
4. Educate watershed stakeholders.
5. Develop recreational and vegetation management plans.