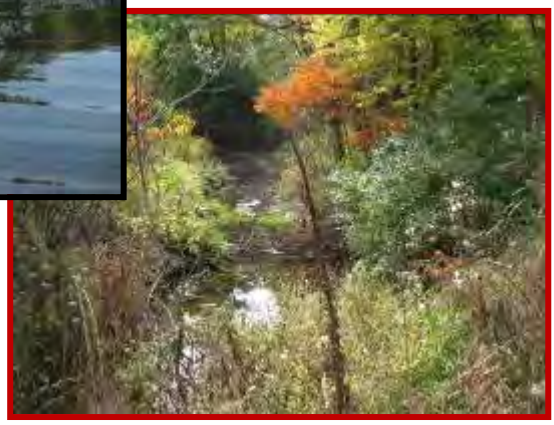
KOONTZ LAKE WATERSHED MANAGEMENT PLAN

Marshall and Starke Counties, Indiana

FEBRUARY 2010



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KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

EXECUTIVE SUMMARY

This watershed management plan addresses non-point source pollution and other water quality concerns facing the Koontz Lake watershed. The Koontz Lake watershed drains approximately 4,158 acres in western Marshall and eastern Starke counties and is part of the Robbins Ditch-Koontz Lake watershed (HUC 07120001040010). The lake is 346 acres in size, and though spring-fed, receives much of its water from Lawrence Pontius Ditch and Schoeder Ditch as well as from surface water runoff.

The Koontz Lake Association (KLA) and the Koontz Lake Aquatic Control Committee (KLACC) contracted JFNew in 2008 to develop an aquatic vegetation management plan (JFNew, 2009) and this watershed management plan, which included a water quality diagnostic study. In September of 2008, KLACC held a public meeting to present results from the aquatic plant survey and management plan and to initiate the watershed planning process. Fifty people attended the meeting, of which 12 individuals elected to become steering committee members and 22 became project overseers. KLACC held a total of nine meetings, 3 of which were public meetings, to discuss the aquatic vegetation management plan, the water quality diagnostic study and the watershed management plan. Attendance at the meetings ranged from 11 to more than 50 attendees. The last public meeting was held on December 5, 2009 where the draft results of the management plan were released.

From the beginning, the steering committee and public have expressed concern about the health of Koontz Lake and its watershed and formulated the following mission statement.

> *To protect, enhance and to promote wise use of the natural and recreational resources for the benefit of the Koontz Lake citizens through education, professional leadership and management. Engage in study of, and educate landowners and the public in general regarding enjoyment and use of, the natural resource in and contiguous to Koontz Lake, Indiana. All of which will be done with the proper and required permitting from the Indiana DNR, US Army Corps of Engineers and the State of Indiana and Counties of Starke and Marshall.*

To that end, the steering committee and public engaged in a discussion of their concerns regarding the lake and the watershed. Section 1.3 of the plan lists those concerns and reveals that aquatic plants, nutrient and sediment inputs from the watershed, education of residents, wildlife issues, and pollutants, among others top their list. Also, during the first meeting the attendees were surveyed about Koontz Lake. The main concern of Koontz Lake users was the desire to dredge the lake (91%). Too many aquatic plants in the lake were an issue for 77% of Koontz Lake users, while 58% of lake users thought Koontz Lake's poor water quality was a problem. Use of personal watercraft (PWC; 44%) and fish population problems (26%) were also of concern to Koontz Lake users. Only 12% of lake users had complaints about non-resident use

including noise pollution, speeding on and off the lake, and installation of docks at non-resident locations.

The steering committee also participated in a watershed tour in May 2009. They found six areas of focus that corroborated some of the concerns developed during earlier meetings (Section 4). The six focus areas (Figure 43) include: 1) internal nutrient loading and stormwater inputs to Koontz Lake; 2) areal nutrient loading from Schoeder Ditch; 3) Swan Lake Resort, where eroded streambanks and control structures require treatment; 4) Lawrence Pontius Ditch between the constructed wetland and the inlet to Koontz Lake, which warrants streambank stabilization and control of livestock; 5) the sediment trap and constructed wetland on 5th Road which require maintenance; and 6) the headwaters of Lawrence Pontius Ditch at Spruce Trail where the ditch surfaces and the general area is eroded.

The lake diagnostic study indicates that the lake is mesotrophic, i.e., moderately productive with moderate nutrient levels and sufficient dissolved oxygen (Section 3.2). The lake's algal population is dominated by blue-green algae, and though not prolific in the center of the lake, algae dominate the lake's perimeter. The lake's fishery is adequate; the most recent survey of Koontz Lake in 2009 collected 687 fish representing 19 species. Gizzard shad was the most abundant fish species collected by number (30%), followed by bluegill (27%), yellow perch (14%), white bass (5%) and largemouth bass (5%; see Section 3.3). Aquatic plants, which provide habit for fish and their food source, dominate the shallow waters of Koontz Lake; however, exotic aquatic vegetation is prevalent in the lake: Eurasian watermilfoil covered approximately 82 acres and curly-leaf pondweed covered 42 acres of Koontz Lake during the spring survey in 2008. Number of species declined in 2009 based on the IDNR fish and aquatic plant survey results.

The 2009 water quality diagnostic study on Lawrence Pontius Ditch, Schoeder Ditch and Koontz Lake also corroborates some of the stakeholders' concerns (See Section 3.5). Data from six sampling sites, 5 on Lawrence Pontius Ditch and 1 on Schoeder Ditch, revealed that under both storm and base flow conditions soluble reactive phosphorus, a limiting nutrient vital to the growth of aquatic plants and algae, exceeded the benchmark level of 0.005 mg/L. Total phosphorus, total suspended solids, total Kjeldahl Nitrogen, nitrates and ammonia also exceeded benchmark levels at some sites (See Section 3.5.2). *E. coli* bacteria concentrations exceeded state standards under storm and baseline conditions at all sites. Areal loading of nitrogen and phosphorus from Schoeder Ditch exceeded areal loads from all other sites. Though the absolute amount does not warrant alarm, the fact that the ditch per its relative watershed size carries more nutrients than Lawrence Pontius Ditch near the lake inlet suggests septic failure and agricultural inputs that were not revealed in the watershed tour.

A sediment trap and constructed wetland were designed for Lawrence Pontius Ditch in 1989 by the Indiana Department of Natural Resources to reduce sediment and nutrient loads to Koontz Lake. A phosphorus budget (Section 4.5) indicates that the constructed wetland and sediment trap on Lawrence Pontius Ditch reduces phosphorus and

sediment loads to Koontz Lake by 41 and 67 percent respectively. Coupling maintenance of these features with installation of the central sewage system around Koontz Lake would reduce the phosphorus loads to the lake considerably. The remaining issue then is the nutrients held in the lake sediments and the aquatic vegetation.

Stakeholders developed their goals to address their concerns through a collaborative effort which compared listed concerns to their watershed tour findings, to historical water quality data and to the 2009 diagnostic study (See Sections 4 and 5). The Stakeholders defined 5 goals (Section 6) for their watershed as follows:

Goal 1. Reduce phosphorus loads to the lake from 2009 levels by 3.6% to reach recommended phosphorus loadings to the lake of <0.427 g/m^2-yr by 2020.

Goal 2. Reduce total suspended solid loads to streams from 2009 levels to recommended concentrations of 30 mg/L (IDEM draft TMDL target) by 2020.

Goal 3. Reduce E. coli concentrations in waterbodies in the Koontz Lake watershed so that water within the streams and lakes meets the Indiana state standards of 235 colonies/100 ml by 2020.

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

Goal 5. Maintain and improve the recreational setting of the Koontz Lake watershed within five years through education and in-lake actions.

For each of the goals a number of objectives are provided. Installation of a central sewage system is important as is the stabilization of streambanks. Maintenance of the sediment trap and constructed wetland has already been mentioned. Installation of best management practices in the watershed will prevent nutrient and sediment from land use activities from entering Koontz Lake. Dredging of the lake and/or alum treatment will address internal cycling of nutrients, the loss of lake volume and a continuing nuisance aquatic plant problem. The goose population is already being addressed by some lake residents. Overall, provision of water quality education to watershed residents is paramount to achieving water quality in the watershed. It is very important to maintain a core group, which can guide the residents to this overall goal and to the vision for the watershed.

ACKNOWLEDGEMENTS

JFNew would like to extend their appreciation to the LARE program for funding the Koontz Lake Watershed Management Plan. Without the Koontz Lake Association and the oversight of the Koontz Lake Aquatic Control Committee, the plan and diagnostic study could not have been completed. More importantly, for any watershed plan, participation by its residents is required; JFNew expresses its sincere appreciation to all the participants at the nine meetings. Thank you to Jim Berger, Rita Berger, Loretta Dobuck, John Hnatovic, Jim Jackson, Janet Davidson, and Jon Ullrich for taking on watershed touring, boat driving, coffee and food making tasks. Thank you to Gene Fleming for providing the plan set for the control structures. These will be provided to KLACC. Thank you to Bill Jones and his students at Indiana University for completing the lake diagnostic study and analysis. Dr. Jones' input on management goals was very helpful. Thank you also to Betsy Ewoldt, Heather Cecrle and John Richardson for their assistance with this report.

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KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

1.0 INTRODUCTION

This watershed management plan addresses non-point source pollution and other water quality concerns facing the Koontz Lake watershed (Figure 1). In total, the Koontz Lake watershed drains approximately 4,158 acres (1,682.7 ha or 6.5 square miles; Figure 2) in western Marshall and eastern Starke counties (Figures 1 and 2). In addition, the immediate Koontz Lake watershed is encompassed by the 14-digit watershed Robbins Ditch-Koontz Lake watershed (HUC 07120001040010) (Figure 3). One navigable lake and over 3 miles of waterways are located within this watershed. Water flows into Koontz Lake via the Lawrence Pontius Ditch and Schoeder Ditch and flows out through a dam and weir structure into what is called the Robbins Ditch. Robbins Ditch flows into the Kankakee River below US Hwy 30 (Figure 3). This watershed management plan documents the concerns watershed stakeholders have for Koontz Lake and describes stakeholders' vision for the lake and contributing waters. 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.

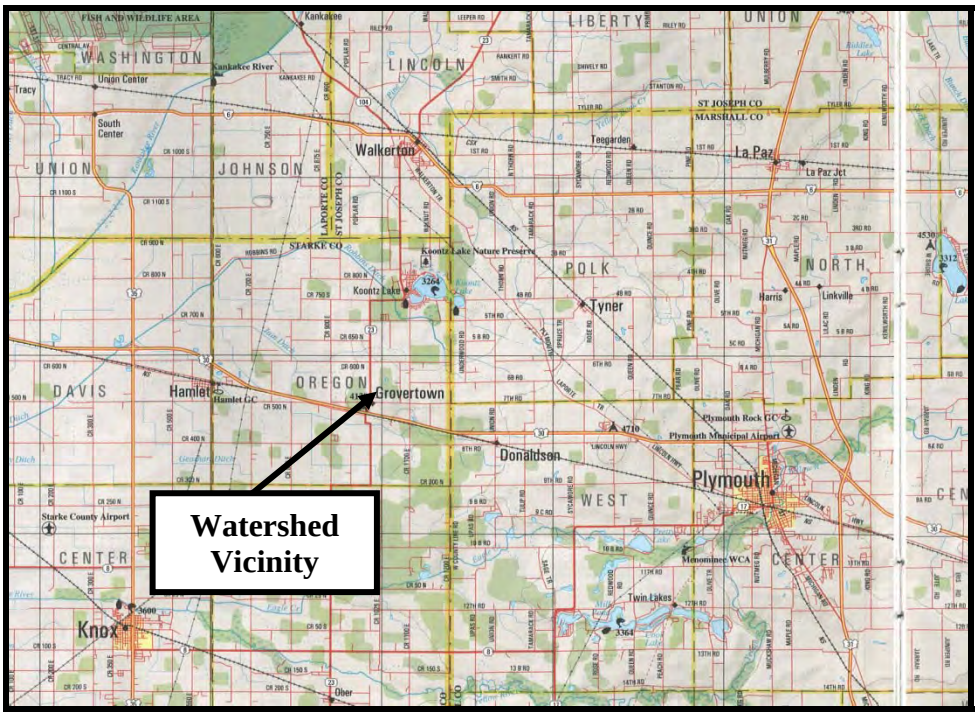


Figure 1. Koontz Lake watershed location map. Source: DeLorme, 1998.
Scale: 1"=approximately 2.5 miles.

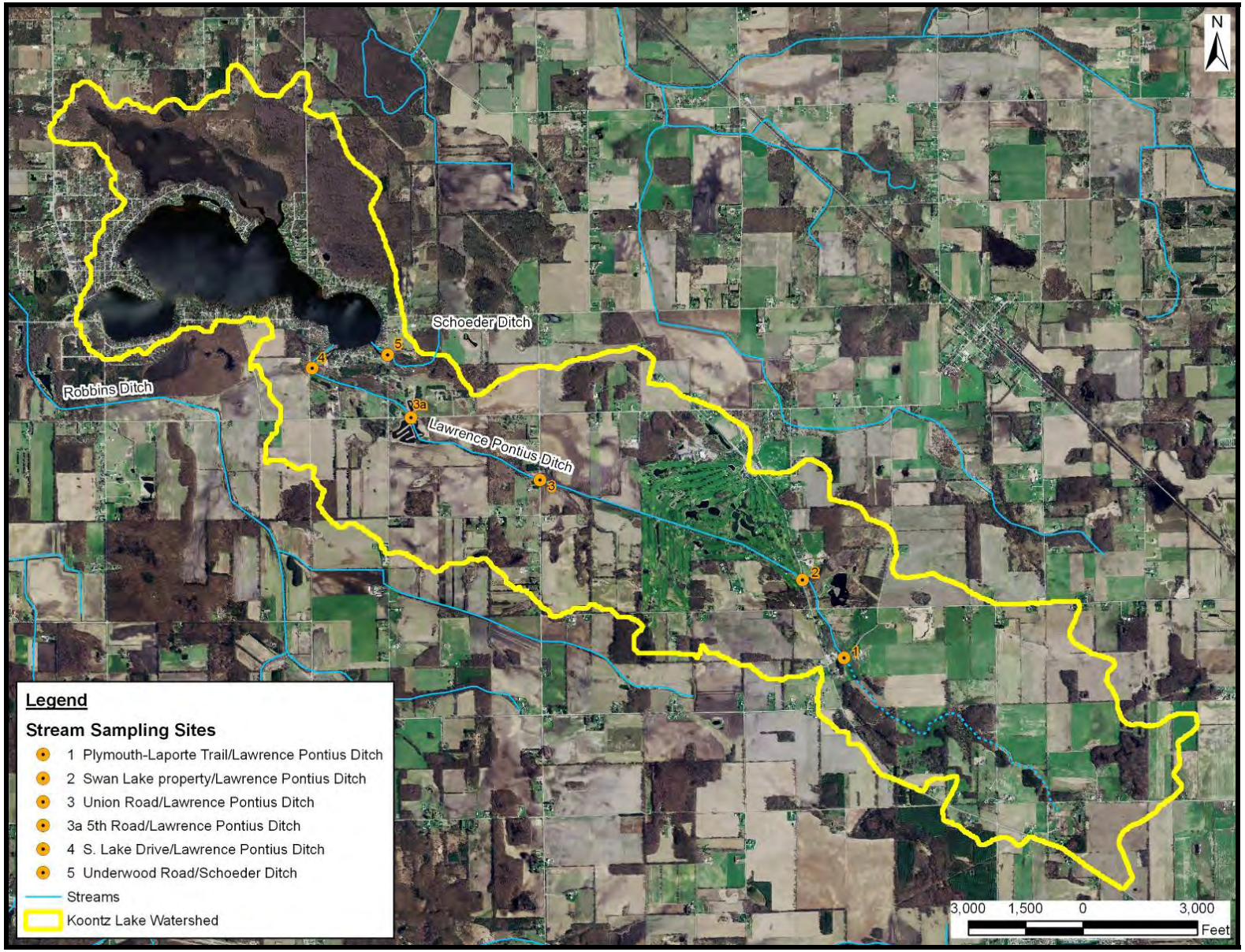


Figure 2. Koontz Lake watershed and 2009 stream water quality sampling sites. Source: FOTSJR, 2006.

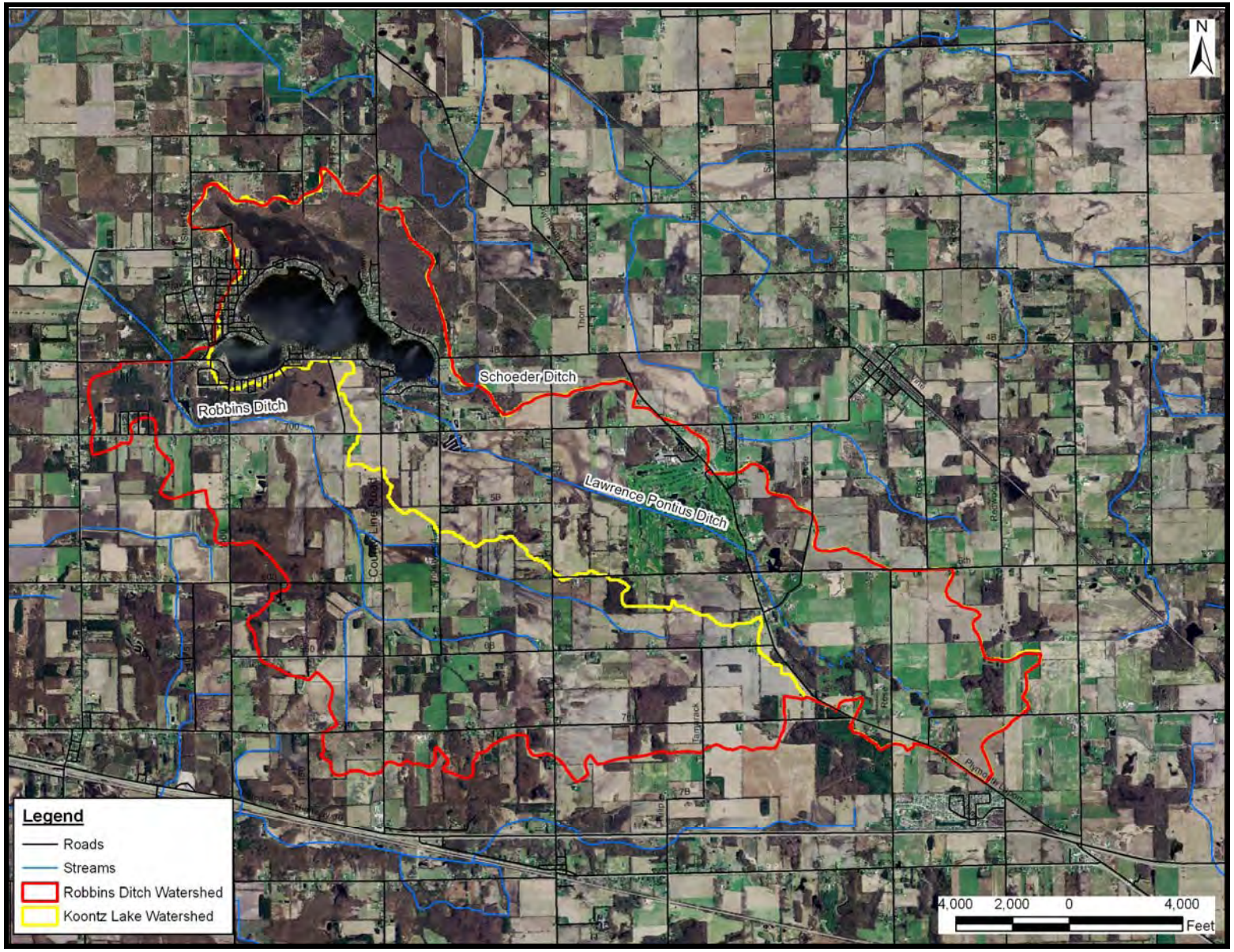


Figure 3. Robbins Ditch-Koontz Lake watershed. Source: FOTSJR, 2006.

Development of this watershed management plan grew out of efforts of the Koontz Lake Association (KLA or association). The association incorporated as a non-profit business in 1964 and concerns itself with the functions of the Koontz Lake community. The association's interests extend to water quality, fisheries and recreation on the lake, and to oversee these issues related to Koontz Lake water resources, the association organized a committee in 2007 called the Koontz Lake Aquatic Control Committee (KLACC or committee). The committee has been instrumental in developing a coordinated effort to control exotic aquatic plant species in the lake as well as overseeing the development of the aquatic vegetation management plan and the watershed management plan, which includes a water quality diagnostic study. Neither the association nor the committee is to be confused with the Koontz Lake Environmental Enhancement Committee (KLEEC) whose focus has included efforts to dredge the lake, reduction of sediment input through development of sediment basins, and the development of a sewage system for lake residents.

1.1 Watershed Partnerships

The Koontz Lake Conservation Association was the principal organization involved in developing the LARE proposal, securing the matching contribution, receiving grant monies from IDNR and contracting with the J. F. New & Associates (JFNew). JFNew was contracted for the facilitation of the watershed management plan, and water quality, habitat and biological assessment.

During the first administrative meeting with the Koontz Lake leadership and the subcontractors, a list of stakeholders in the watersheds was developed. Organizations and individuals with a demonstrated interest in the planning activity were added to the list as were state, local, and private agencies or organizations that are stakeholders or represented stakeholders in the watersheds.

The initial list included individuals from the Koontz Lake community, the Marshall County Soil and Water Conservation District, the engineering firm of Lawson-Fisher Associates, the Koontz Lake Environmental Enhancement Committee, and Swan Lake Resort.

These individuals were contacted by letter asking for their participation in the planning process for the aquatic plant management plan as well as the watershed management plan. 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 or individuals were then contacted and invited to join in the process. A complete list of the individuals invited to participate the watershed planning team is located in Appendix A. This watershed planning team was formed to identify issues and concerns, develop mission, goals, and objectives, and to solicit/coordinate public involvement in Watershed Management Planning process.

1.2 Public Participation

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

public meetings were announced in local newspapers, radio stations, and with posters located in community gathering places that had community bulletin boards. Additionally, a flyer was distributed to over 100 watershed residents describing the process and inviting them to attend public meetings. All stakeholders and the general public were invited and encouraged to attend public meetings. A total of 9 steering committee meetings, which included 3 public meetings, were held over 17 months to insure that all stakeholders' needs and perspectives were considered in the development of the WMP.

The public meetings were held on September 13, 2008, June 20, 2009 and December 5, 2009. Attendance was 50, more than 50 and 19, respectively. The June 20, 2009 meeting was combined with the annual Koontz Lake Association meeting, where a number of topics were discussed. JFNew presented an update of the watershed management plan and entertained questions. There was standing room only for this particular meeting. Other stakeholder meetings occurred on January 10, February 14, April 25, July 25 and October 10, 2009.

1.3 Watershed Stakeholder's Concerns

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

Process

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

- Ensure that stakeholders in watershed, and not just lake residents, are part of the process.
- Make sure that the whole picture is investigated including the lake and the watershed.
- Determine if there are issues in the watershed that need to be addressed.
- Provide opportunity for a watershed tour.
- Focus on area between constructed wetlands (at 5th and dam).
- Develop viable relationship between watershed and lake residents.
- Fix of problems is not occurring.
- Send KLA representatives to SWCD meetings to provide updates. SWCD can assist with watershed projects.

Information/education

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

- Need to exchange ideas and have an understanding of the water quality and watershed.
- Provide a "frequently asked questions" (FAQ) sheet or brochure for education purposes.
- We need to have more education for the lake residents especially on the over-application of lawn fertilizer.

Nutrients

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

- The over-application of lawn fertilizer.
- Algal blooms are a problem.
- Fertilizer should be phosphorus free.
- No dumping of lawn cuttings and leaves in lake and Lawrence Pontius Ditch.
- Dumping in lake occurs and this should be stopped unless permits are obtained.
- Control Canada geese at lake and at Swan Lake Resort – nest disruption.
- Internal cycling of nutrients is the problem.
- The problems with Koontz Lake are caused either internally or just upstream between lake and constructed wetland.
- Application of alum to control internal phosphorus cycling is a promising technique for Koontz Lake. Apply 10' and below.

Sampling

Stakeholders expressed concerned about identifying water quality issues throughout the watershed.

- Sampling should occur on all ditches and tributaries to Koontz Lake.
- Sampling should occur at the highest point in the watershed.

Point source

Stakeholders wanted to insure that point sources were identified when possible, and to prevent their contribution to lake water quality pollution.

- Swan Lake STP effluent pipe goes into Lawrence Pontius Ditch. Locate public records.
- Identify point sources, especially culverts, and other storm water point sources to lakes.
- Gray water flows from pipes from houses and may flow into lake.
- Sewer infrastructure will cause more building, more lake use and funneling.

Pollutants

Stakeholders wanted to insure that pollutants were identified when possible, and to prevent their contribution to lake water quality pollution.

- Oil and grease inputs are a concern.
- Scum is present on lake.
- Foam and detergent identified in lake and at constructed wetland dam on 5th Road.

Sedimentation/erosion

Stakeholders expressed concerns about the erosion of shoreline.

- Lake shore erosion issues in general and at hotel.
- Seawall restoration needed.
- Repair/restore vegetation around lake – aquatic plant installation where they will do well.
- Wind driven wave action causes lakeshore erosion.
- Carp cause re-suspension of sediment.
- Wave runners and need for boats that cause large waves causing re-suspension of sediment.
- Boaters inside buoys.
- Wind driven waves are a concern.

Values

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

- Aesthetic problems with algal blooms
- Turbidity is a problem for fishing, aesthetics.

Recreation

Stakeholders expressed concerns about fish populations of carp and gizzard shad, health concerns for swimming, and wake boarding

- Algal blooms and aquatic vegetation make it difficult to swim at the beach.
- Wake boarding is a problem and contributes to sediment re-suspension.
- There are no cleaning facilities available for boaters as they come off of lake.
- Many people access the lake and it is important to have boat wash stations. Locate them at the marina and public access and make sure it doesn't drain into the lake.
- Oil and grease film apparent in eastern basin during high motorboat use times.
- Bass tournament open to public making lake too busy.
- Carp are present in lake.

Implementation

Stakeholders had a concern about funding related to wash stations at the lake and control of exotic aquatic vegetation.

- How could boat wash stations be funded?
- If whole-lake treatment is not funded by LARE, but instead spot treatment.

Health

Concerns were expressed about coliform bacteria and safety of swimming at beach.

- Check with Health Board for bacteriological testing in lake.
- Ensure safe swimming area at beach.

Wildlife

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

- Control the geese population in lake and at Swan Lake Resort – nest disruption.

Current efforts to maintain lake and watershed

Stakeholders noted current efforts to maintain their lake and watershed.

- The beach is cleaned by the KLA.
- KLA has a yearly community clean-up which potentially prevents dumping into lake.
- Regional sewage treatment facility is planned for the lake residents.
- Dredging of lake to reduce sediments and nutrient cycling – money appropriated, permit issued but permit expired.

In addition, at the first meeting held on September 13, 2008, attendees were asked to express their concerns about the lake. Figure 4 details the responses of users in regards to perceived problems in Koontz Lake. Forty-three lake users responded to the survey. The main concern of Koontz Lake users are dredging needs in the lake (91%). Concerns regarding too many aquatic plants in the lake are an issue for 77% of Koontz Lake users, while 58% of lake users think Koontz Lake's poor water quality is a problem. Use of personal watercraft (PWC; 44%) and fish population problems (26%) are also of concern to Koontz Lake users. Only 12% of lake users had complaints about non-resident use including noise pollution, speeding on and off the lake, and installation of docks at non-resident locations.

A few lake users commented on the need for weed control in the lake and realize that they may have too many invasive aquatic plant species and not enough native plant species. The need to treat Eurasian watermilfoil will continue to be a priority for this lake if it is to be used for recreation. There were no specific comments about dredging even though 91% of users think it is a problem.

Individuals who responded to the survey were also asked to note what their primary use of the lake is. The majority of people who responded to the survey use Koontz Lake for boating (93%). Eighty-four percent of individuals use the lake for swimming and seventy percent of lake users fish on Koontz Lake. Another 19% of individuals on Koontz Lake use it for irrigation purposes. No one who responded to the survey admitted to using the lake for drinking water. A small percentage of lake users (2%) responded with "other" activities as their primary use on Koontz Lake. The public access site for Koontz Lake is located on the south side of the lake off of South Lake Drive.

Overall, the use of Koontz Lake is for high and low-speed watercraft recreation and swimming. As such, the public does not prioritize specific areas for high or low-impact recreation. Furthermore, no specific areas were identified by the public survey where aquatic plant densities or communities interfere with lake use, but one person did suggest that a whole-lake treatment is needed to control the aquatic plants.

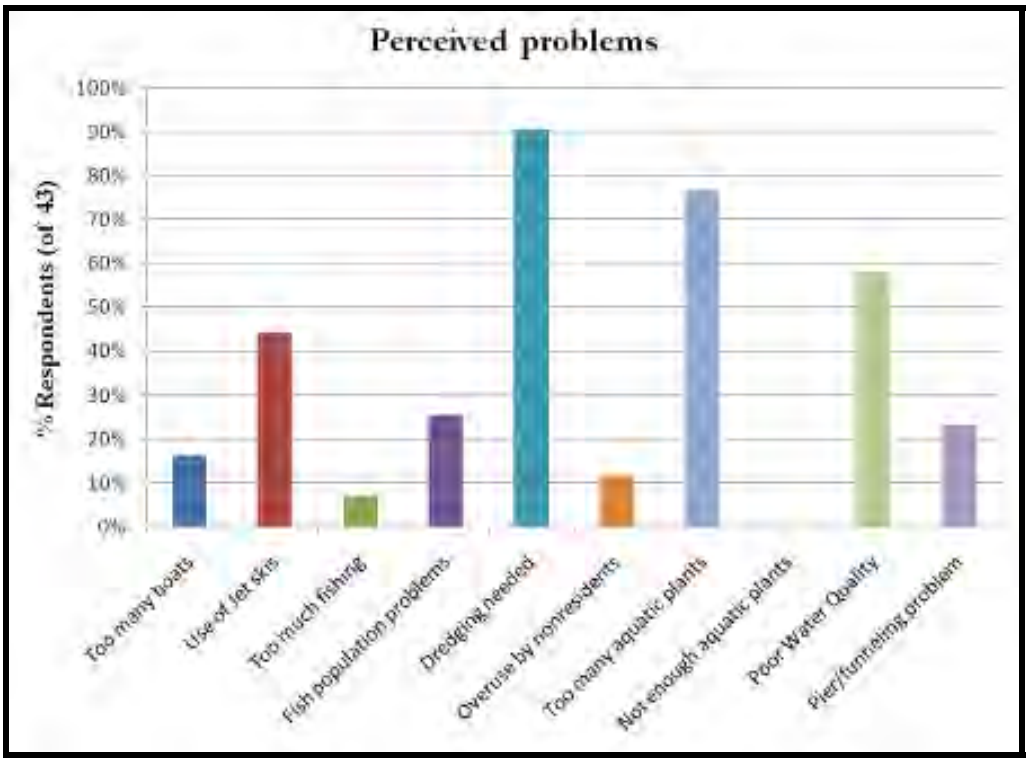


Figure 4. Perceived problems from Koontz Lake users.

1.4 Vision for the Future

The Koontz Lake Aquatic Control Committee and the public at large have developed a vision for Koontz Lake and its watershed. The Koontz Lake watershed stakeholders' vision is:

> *To protect water quality through a monitoring and reporting program and to actively pursue follow-up activities required to improve and sustain the health of the lake.*
>
> *To offer experiences and education for the youth of the area in subjects relating to safe recreation activities on the lake and an appreciation for the watershed.*
>
> *To protect the natural functions of a diverse native plant community, which provide fish and waterfowl habitat, by eliminating the invasion of non-native species.*
>
> *To educate lake residents and visitors about the role of aquatic plants in the lake, management strategies and appropriate plant management actions.*
>
> *To gain expertise in areas that may positively influence members, homeowners, and other member of our community*
>
> *To build and maintain relationships with other organizations and individual that have similar objects, purposed and values.*

This vision serves as the foundation for the Koontz Lake Watershed Management Plan. Watershed stakeholders also selected their mission, and it follows:

> *To protect, enhance and to promote wise use of the natural and recreational resources for the benefit of the Koontz Lake citizens through education, professional leadership and management. Engage in study of, and educate landowners and the public in general regarding enjoyment and use of, the natural resource in and contiguous to Koontz Lake, Indiana. All of which will be done with the proper and required permitting from the Indiana DNR, US Army Corps of Engineers and the State of Indiana and Counties of Starke and Marshall.*

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

2.0 THE KOONTZ LAKE WATERSHED

2.1 Watershed Location

Koontz Lake encompasses 346 acres (140-ha) and is comprised of three basins. Koontz Lake lies in both Marshall and Starke counties, Indiana (Figure 1) in Sections 1, 2, 11, 12, and 13 of Township 34 North, Range 1 West in Starke County and Sections 6, 7, 8, 15, 16, 17, 18, 20, 21, 22, 23, 26, 27, and 28 of Township 34 North, Range 1 East in Marshall County. The immediate Koontz Lake watershed is encompassed by the 14-digit Robbins Ditch-Koontz Lake watershed (HUC 07120001040010) and stretches out to the east and south of the lake encompassing approximately 4,158 acres (1,682.7 ha or 6.5 square miles; Figure 2). There are over three miles of waterways located within the watershed. Water flows into Koontz Lake via the Lawrence Pontius Ditch and Schoeder Ditch, and flows out through a dam and weir structure into what is called the Robbins Ditch (Figure 3). Robbins Ditch flows into the Kankakee River below US Hwy 30, whose waters and tributaries form the Kankakee Watershed (HUC 07120001).

To facilitate discussion of the water resource issues, the Koontz Lake watershed is divided into three separate sub-basins (Figure 5). Surface water drains to Koontz Lake through three primary routes: through Lawrence Pontius Ditch, through Schoeder Ditch, and through an unnamed drainage which enters on the north side of the lake, and via direct surface drainage. Lawrence Pontius Ditch drains approximately 3,006.5 acres (1,216.7 ha or 72%) of the watershed south of Koontz Lake. This ditch empties into Koontz Lake in the lake's southern corner. Schoeder Ditch drains approximately 57.4 acres (23.2 ha or 1%) of the watershed southeast of Koontz Lake. This stream empties into Koontz Lake in the lake's southeast corner. An unnamed tributary transports water to Koontz Lake from the watershed north of the lake emptying into the lake along its northern boundary. In total, this tributary drains 561.8 acres (227.4 ha or 14%) of the Koontz Lake watershed. The remaining 13% of the land in the Koontz Lake watershed (533 acres or 215.7 ha) drains directly to Koontz Lake. Figure 4 illustrates the boundaries of each of these subwatersheds of Koontz Lake.

2.2 Koontz Lake History

Prior to the 1930s, Koontz Lake was solely spring-fed with no substantive, defined inlets. The earliest survey maps of 1933-34 identify Koontz Lake as two shallow, non-connected kettle lakes. In 1848 the entrepreneurial endeavors of Mr. Samuel Koontz resulted in the construction of an earthen dam at the western end of Woodworth Lake. The dam, used in the powering of a grist mill, raised the level of water in the two separate kettle lakes causing the formation of Koontz Lake with its current shoreline and depth configuration. By 1915 numerous cottages existed along the south shore of the lake, and by 1950 approximately 700 cottages had been constructed around the lake, most likely all served by individual sewage disposal system, i.e., septic system. Today approximately 500 residences exist around the lake, half of which are year-round residents.

During the mid-1930s, the Lawrence-Pontius Ditch was excavated to drain nearby agricultural fields, and its excavated outlet flowed into the eastern basin of Koontz Lake. This served as a point source for nutrients and sediment and a direct link between the landscape and the lake. As early as 1940, sediment accumulation in Koontz Lake was noticeable. Though never implemented, the Indiana Department of Natural Resources (IDNR) in 1956 proposed a diversion dam on the Lawrence Pontius Ditch to direct its flows from Koontz Lake to Robbins Ditch.

The fisheries in Koontz Lake have always been of interest; in 1965 based on their lake survey, the INDR questioned the reproductive success of game fish, while noticing that the carp population was increasing. In 1970 in order to kill the carp population, the IDNR released rotenone to the lake and re-stocked it with game fish. Though fish abundance increased for a short period, it declined for many species. In 1984 the DNR instituted a 14-inch size limit on bass to increase predation on small-bodied fish. Most of the fish surveys in Koontz Lake took place in the 1970s, while the most recent fish survey in Koontz Lake was in 2000. A more complete discussion of the Koontz Lake fishery is presented in Section 3.3.

In 1986, IDNR's T for 2000 program funded a diagnostic study of the lake. Completed in 1988, Earth Source reported on the biological, chemical and physical characteristics of the lake with specific emphasis on the evaluation of the lake bathymetry and sediment accumulation. An increase in the amount of aquatic plants since 1965 was documented, and the study indicated that sediments accumulated in the lake at the rate of 0.73 inches/year with the lake having lost approximately 21% of its volume between 1955 and 1988. As a result of the study, in 1989 the IDNR and the Koontz Lake Environmental Enhancement Committee (KLEEC) constructed 11-drop structures, a sediment trap, a wetland and a public access point. In addition, buoys were put in place to slow boat traffic near the shoreline.

Issues with aquatic plant abundance and sedimentation remained the focus of the lake users, and in 1992 and 1993, requests for money by Congressman Roemer to study Koontz Lake were met with appropriation but not authorization to spend the money. In 1996, section 421 of the Water Resources Development Act, gave the U.S. Army Corps

of Engineers (Corps) the authority to conduct a study on the feasibility of implementing measures to restore Koontz Lake. In 1998 the Corps responded to the authorization and completed an environmental assessment, which recommended that unconsolidated sediments between the 3 and 7-foot contours be dredged, and that no impacts to wetlands or endangered or threatened species or their habitat would occur as a result of the dredging (U.S. Army Corps of Engineers, 1998). In response in 1999, the IDNR indicated that they only wanted the eastern basin dredged.

Though warranted through the studies, no permit was issued for dredging until 2002 and then only for the eastern basin of the lake. The permit was limited to 2 years and the money allotted for the project by the Corps was pulled. At this time the Corps is still working to towards dredging of the lake, while KLEEC is still active in working towards a regional sewage treatment facility around the lake, and received funding in 2009 for its installation.

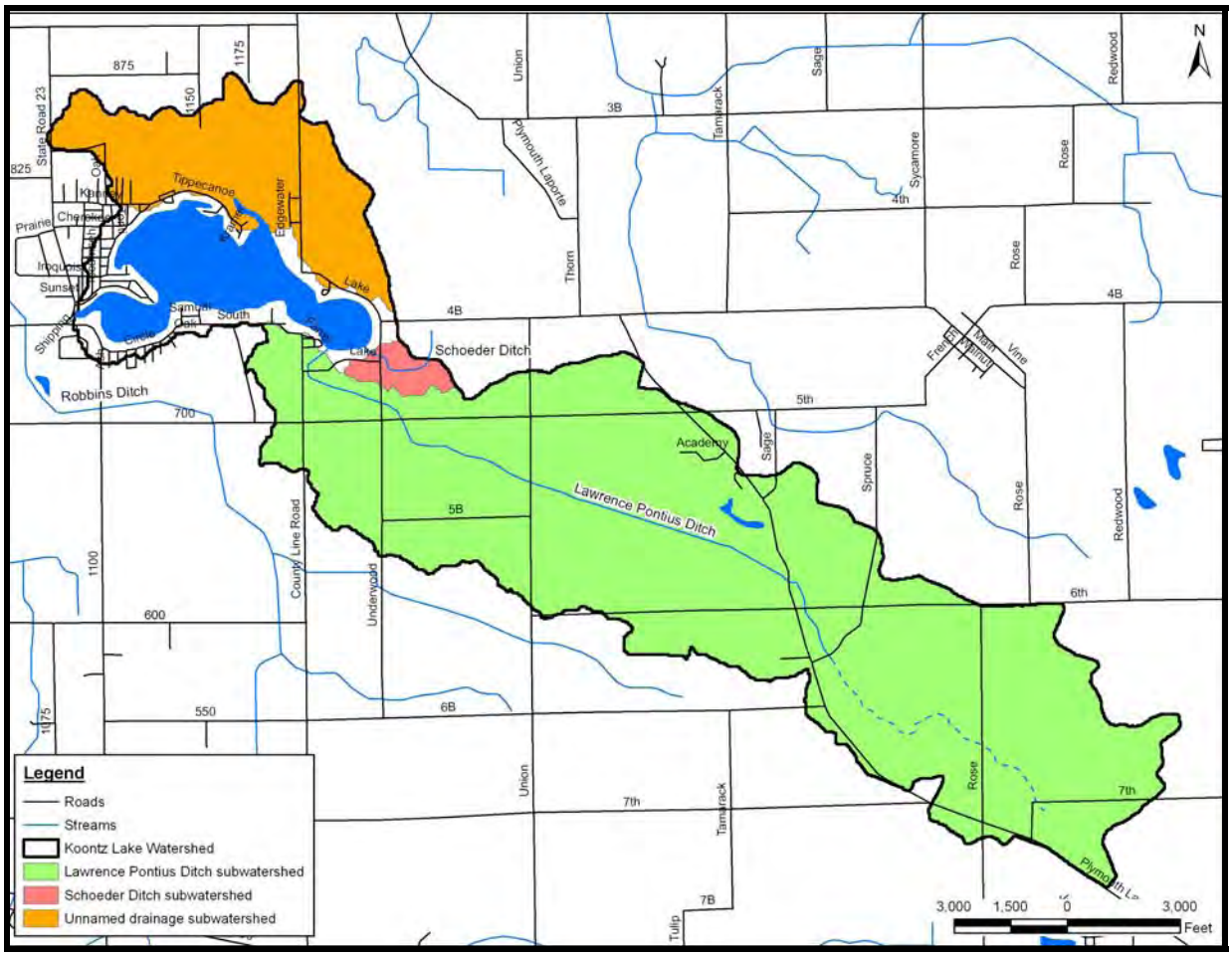


Figure 5. Koontz Lake subwatersheds.

2.3 Climate

The climate in Marshall and Starke counties typically consists of cold winter months and warm, occasionally hot, summer months. In winter, the average temperature in Starke County is approximately 27° F. In summer, the average temperature is approximately

72° F. The record low of -24° F was recorded on January 28, 1963 in Plymouth, and the record high is 109° F recorded on June 20, 1953. Winter precipitation in Starke County is usually sufficient to minimize drought conditions for most soils during the summer months with annual snowfalls averaging 36 inches. (Water content of snow as measured in inches is much less that 36 inches and is totaled with inches of rainfall in order to report average total annual precipitation.) Approximately 60% of the total annual precipitation occurs between April and September, which corresponds to the growing season of most crops (Barnes, 1982; Smallwood, 1980). The average total annual precipitation for Starke County is 36 inches.

2.4 Geology and Topography

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

Several glacial lobes rather than a single sheet of ice covered northern Indiana during the last glacial age. The Huron and Saginaw Lobe of the Wisconsin glacial age covered most of north central Indiana. The movement, stagnation, and melting of the glaciers is largely responsible for the landscape covering the Koontz Lake watershed. Many lakes and swamps or bogs formed from melting blocks of glacial ice. Wind erosion of the Kankakee outwash plain created dunes in the northern Indiana landscape.

The surficial geology of the Koontz Lake area is complex, consisting of 11 geologic deposits ranging from course grained outwash and beach deposits in the west and central portion to fine grained ground and end moraines in the east. Sand dunes and marshes are interspersed throughout the Koontz Lake watershed, which is located in the Kankakee Outwash and Lacustrine Plain.

Koontz Lake is likely a water table lake, though surface inputs are currently present and predominate. In other words, it is a partially spring-fed, and water-based pollutants introduced into the ground water of the Koontz Lake watershed may manifest themselves in the lake; this includes contaminants from adjacent septic systems. The unconsolidated aquifer of the Koontz Lake watershed is relatively productive due to the

high rate of permeability and abundant rainfall, which recharges the system. Bedrock wells are not common in the watershed since the unconsolidated layers produce adequate supply to meet the needs of the area. In addition, the shale bedrock material is typically a poor aquifer source due to its high rate of mineralization.

Approximately 125 to 275 feet of unconsolidated glacial materials cover most of the Koontz Lake watershed (Hartke, 1986) The watershed's surficial geology (Figure 6) covers a less complex bedrock foundation (Figure 7) of Antrim shale, part of the Devonian System, and Ellsworth shale, part of the Devonian and Mississippian systems).

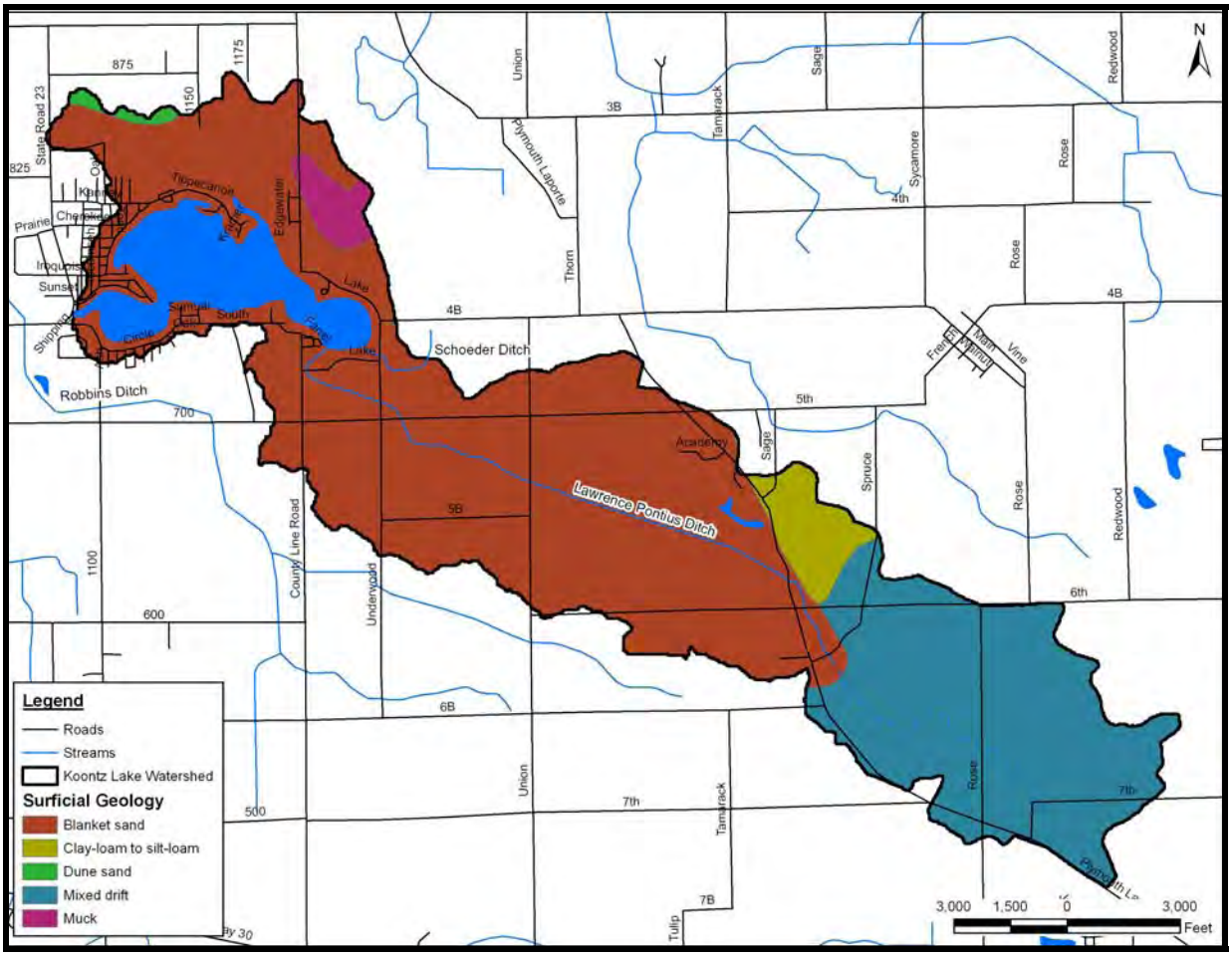


Figure 6. Surficial geology of the Koontz Lake Watershed.

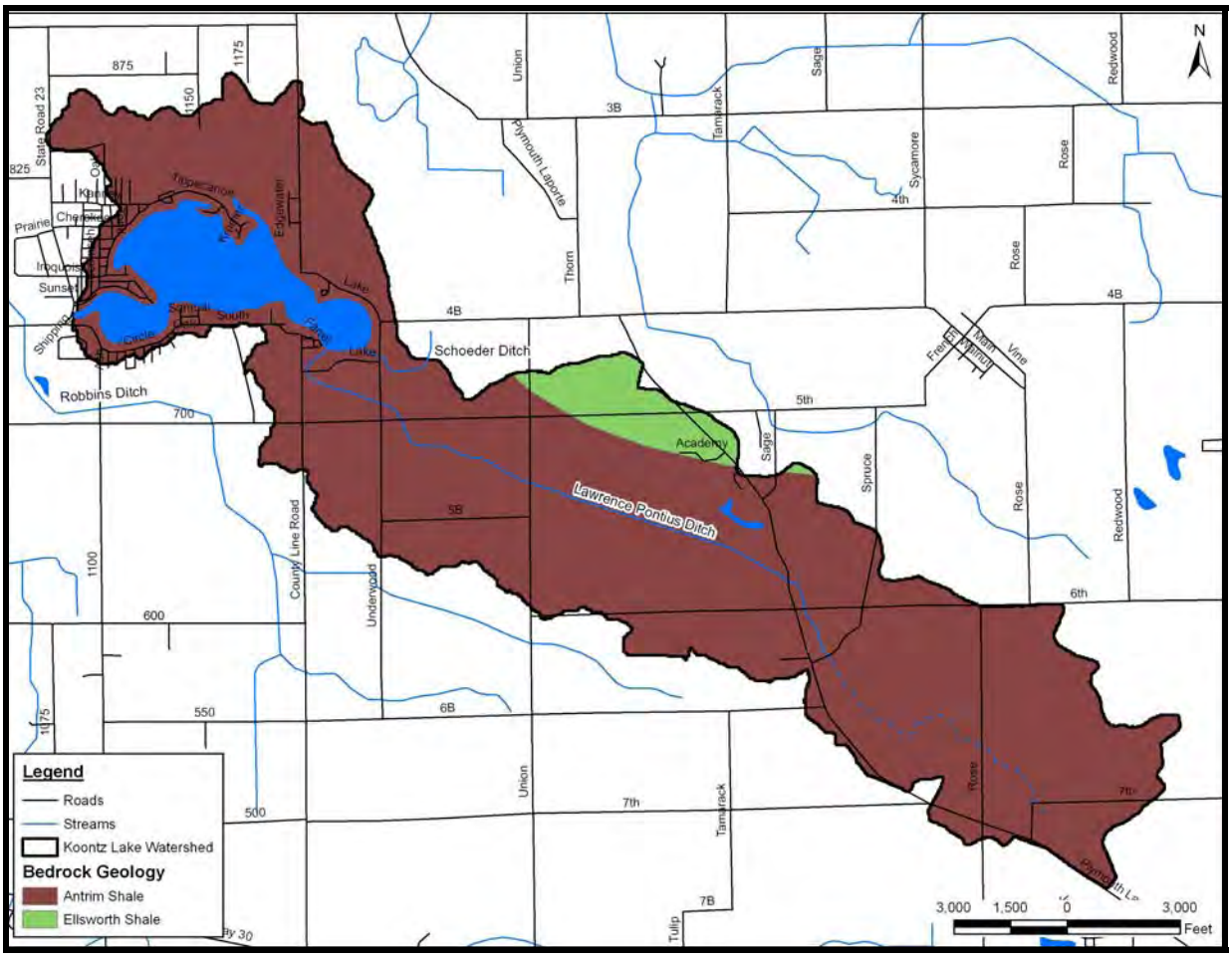


Figure 7. Bedrock geology of the Koontz Lake Watershed.

2.5. Soils

The Koontz Lake watershed's geologic history described in the previous sections determined the soil types found in the watershed and is reflected in the major soil associations that cover the Koontz Lake watershed (Figure 8). The soil types found in the Koontz Lake watershed in Marshall and Starke Counties are a product of the original parent material deposited by the glaciers in this area 10,000 to 12,000 years ago. The main parent materials found in the watershed are glacial till, outwash deposits, lacustrine deposits, and organic material that were left as the glaciers receded (Figure 6). The interaction of these parent materials with the physical, chemical, and biological variables found in the area (climate, plant and animal life, time, landscape relief, and the physical and mineralogical composition of the parent material) formed the soils found in Marshall and Starke counties today.

Before detailing the major soil associations covering the Koontz Lake watershed, it may be useful to examine the concept of soil associations. Major soil associations are determined at the county level. Soil scientists review the soils, relief, and drainage patterns on the county landscape to identify distinct proportional groupings of soil units. The review process typically results in the identification of 8 to 15 distinct patterns of soil units. These patterns are the major soil associations of the county. Each soil association

typically consists of two or three soil units that dominate the area covered by the soil association and several soil units (minor soils) that occupy only a small portion of the soil association's landscape. Soil associations are named for their dominant components. For example, the Plainfield-Chelsea-Tyner soil association consists primarily of Plainfield sand, Chelsea fine sand and Tyner loamy sand. The following paragraphs provide more detailed information on each of the major soil association covering the Koontz Lake watershed. The discussion relies heavily on Smallwood (1980) for Marshall County and Barnes (1982) for Starke County. Readers should refer to those texts for more information.

Smallwood (1980) and Barnes (1982) map three soil associations in the Koontz Lake watershed: the Plainfield-Chelsea-Tyner soil association in Marshall County comprising 59 percent of the watershed and the Plainfield-Brems-Morocco soil association in Starke County comprising 22 percent of the watershed and the Riddles-Metea-Wawasee soil association rounding out the watershed at 19 percent (Figure 8).

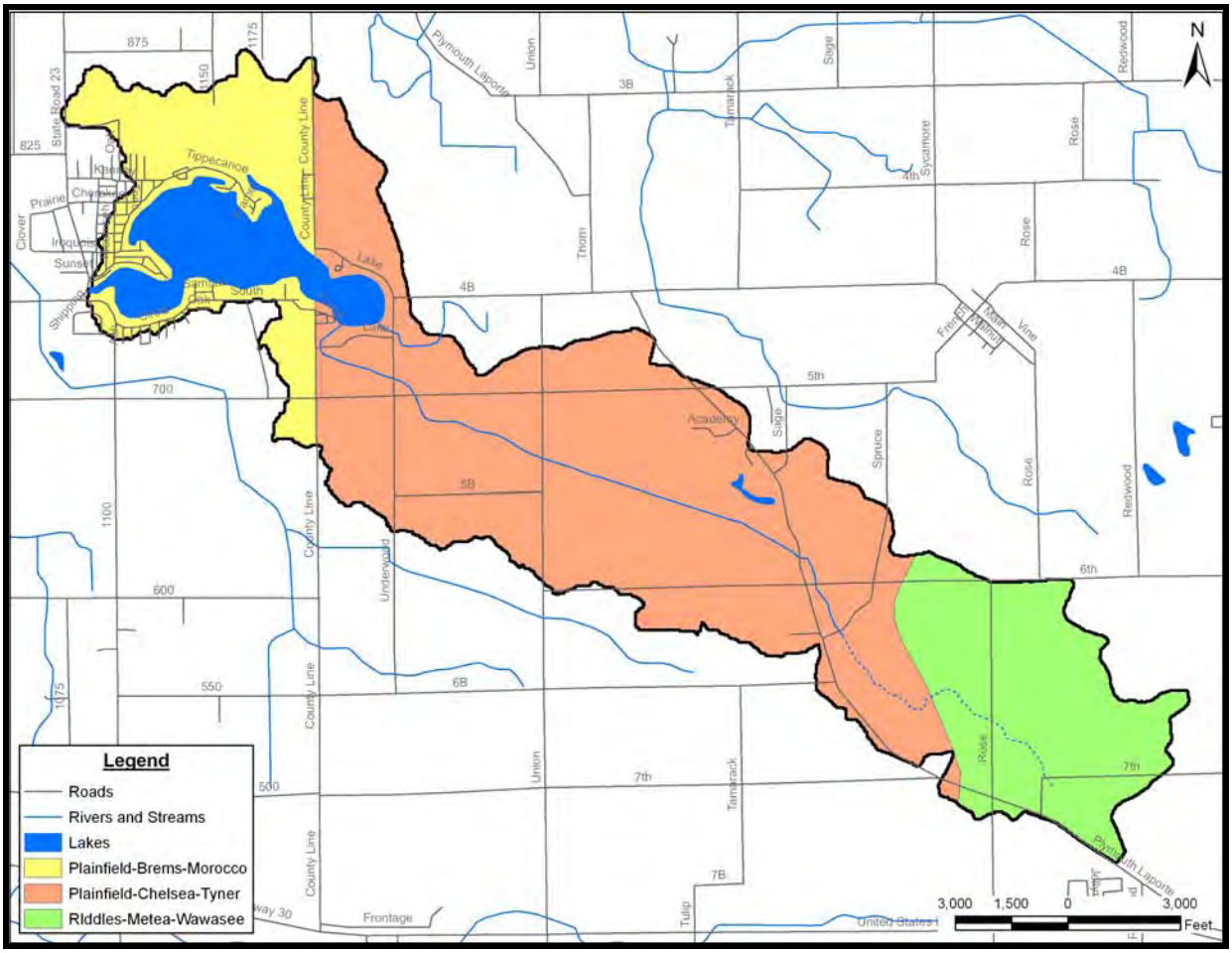


Figure 8. The major soil associations covering the Koontz Lake Watershed.

The Plainfield-Chelsea-Tyner soil association consists of deep, coarse-grained soils located on glacial outwash plains where the topography ranges from flat to rolling. The soils are excessively well-drained to well-drained and are poorly suited to cultivated

crops and sanitary facilities, but suitable for building. The Plainfield-Brems-Morocco soil association consists of soils found in upland areas ranging from nearly level to strongly sloping. They formed in sandy deposits on outwash plains and are excessively drained to somewhat poorly-drained in nature making them less suitable for cultivation and woodlands. The Riddles-Metea-Wawasee soil association is located on knolls and ridges of moraines suggesting a rolling topography. The soils are well drained and moderately coarse to coarsely-textured. The soils are well suited for trees, building sites and sanitary facilities.

The Houghton-Adrian-Palms and Houghton-Adrian soil associations cover a small area within the Koontz Lake watershed. The Houghton-Adrian association lies north of Koontz Lake, and along a small portion of the Lawrence Pontius Ditch. Soils in this association developed from deep deposits of decomposed plant remains. These soils are found in bogs and other depressional areas. The soils in this unit are suited to cultivated crops and poorly suited to residential and other uses.

2.5.1 Highly Erodible Soils

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

Highly erodible and potentially highly erodible are classifications used by the Natural Resource 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 1 lists the soil units in the Koontz Lake watershed that the NRCS considers to be highly erodible. Figure 9 indicates 11.91 percent (495.32 acres) of the watershed consists of highly erodible soils. These soils are prone to erosion and when exposed will likely be transported during rain events. Rill and gully formation can occur quickly, and any time these soils are tilled especially on steep slopes, the soil and the adsorbed nutrients and chemicals have the opportunity to impair water quality by being transported into the ditches, streams and lakes.

Table 1. Highly and potentially highly erodible soils in the Koontz Lake Watershed.

		Watershed		Lawrence Pontius		Schroeder	
		Area (ac)	*%*	*Area (ac)*	*%*	*Area (ac)*	*%*
HES/PHES	*HES*	495.32	11.91%	426.18	14.18%	38.14	66.43%
	PHES	0.00	0.00%	0.00	0.00%	0.00	0.00%
	Not HES/PHES	3316.62	79.76%	2563.01	85.25%	18.91	32.94%
Septic Suitability	*Severe*	3236.08	77.82%	2419.56	80.48%	57.05	99.37%
	Moderate	574.92	13.83%	568.69	18.91%	0.00	0.00%
	Slight	0.94	0.02%	0.94	0.03%	0.00	0.00%
Hydric	*Hydric*	1382.98	33.26%	1017.32	33.84%	11.67	20.33%
	Not Hydric	2775.39	66.74%	1971.87	65.59%	45.38	79.04%
Watershed Size (ac)		4158.37		3006.54		57.41	

Areas and % do not include soil units without information for the soil characteristic (for example water was disregarded from all sums). Therefore, individual categories will not sum to the total watershed size.

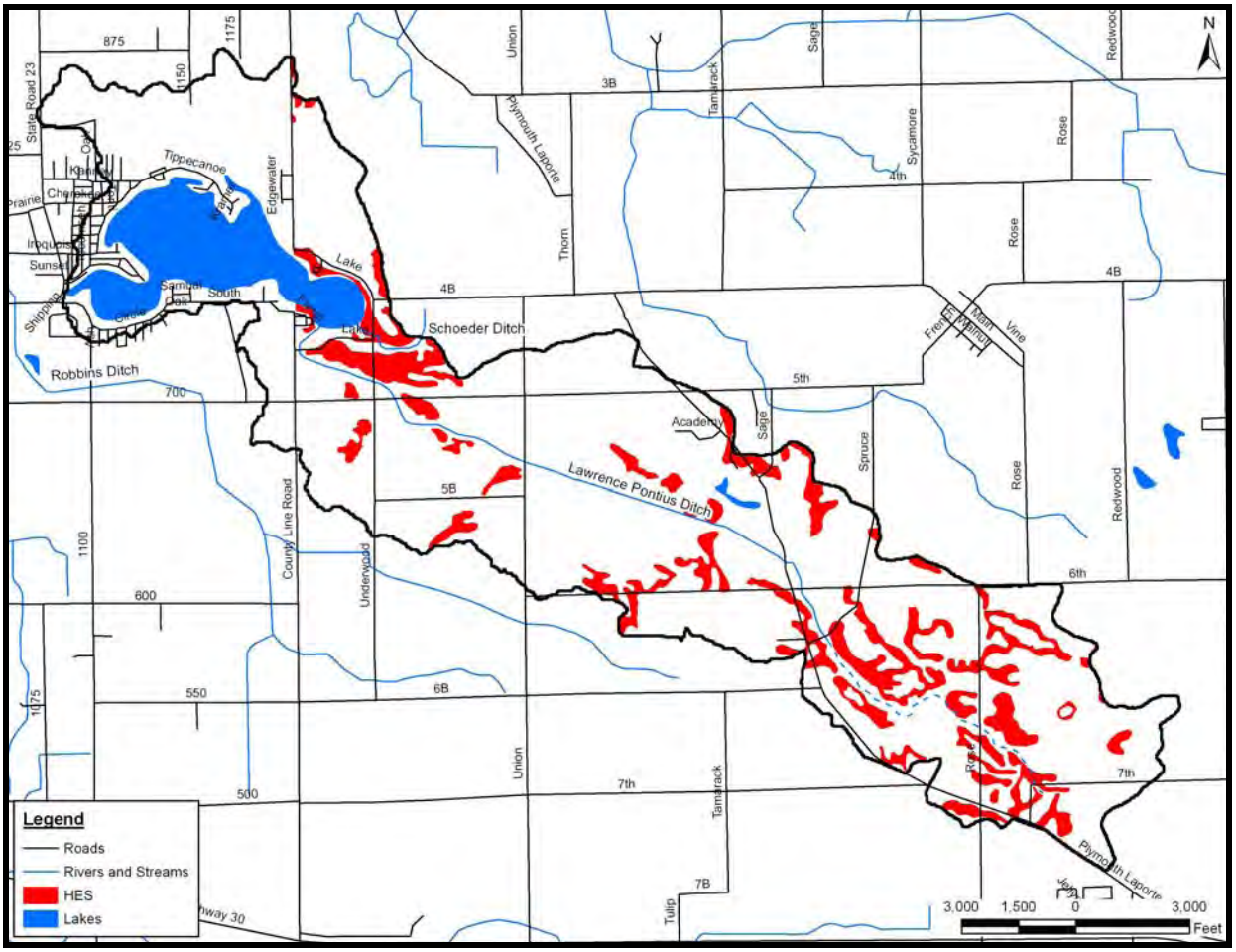


Figure 9. Highly erodible (red) soils in the Koontz Lake Watershed.

2.5.2 Soils Used for Septic Tank Absorption Fields

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

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

Many of the nutrients and pollutants of concern are removed safely if a septic system is sited correctly. Most soils have a large capacity to hold phosphate. On the other hand, nitrate (the end product of nitrogen metabolism in a properly functioning septic system) is very soluble in soil solution and is often leached to the groundwater. Care must be taken in siting the system to avoid well contamination. Nearly all organic matter in wastewater is biodegradable as long as oxygen is present. Pathogens can be both retained and inactivated within the soil as long as conditions are right. Bacteria and viruses are much smaller than other pathogenic organisms associated with wastewater; and therefore, have a much greater potential for movement through the soil. Clay minerals and other soil components may absorb them, but retention is not necessarily permanent. During storm flows, they may become re-suspended in the soil solution and transported in the soil profile. Inactivation and destruction of pathogens occurs more rapidly in soils containing oxygen because sewage organisms compete poorly with the natural soil microorganisms, which are obligate aerobes requiring oxygen for life. Sewage organisms live longer under anaerobic conditions (without oxygen) and at lower soil temperatures because natural soil microbial activity is reduced.

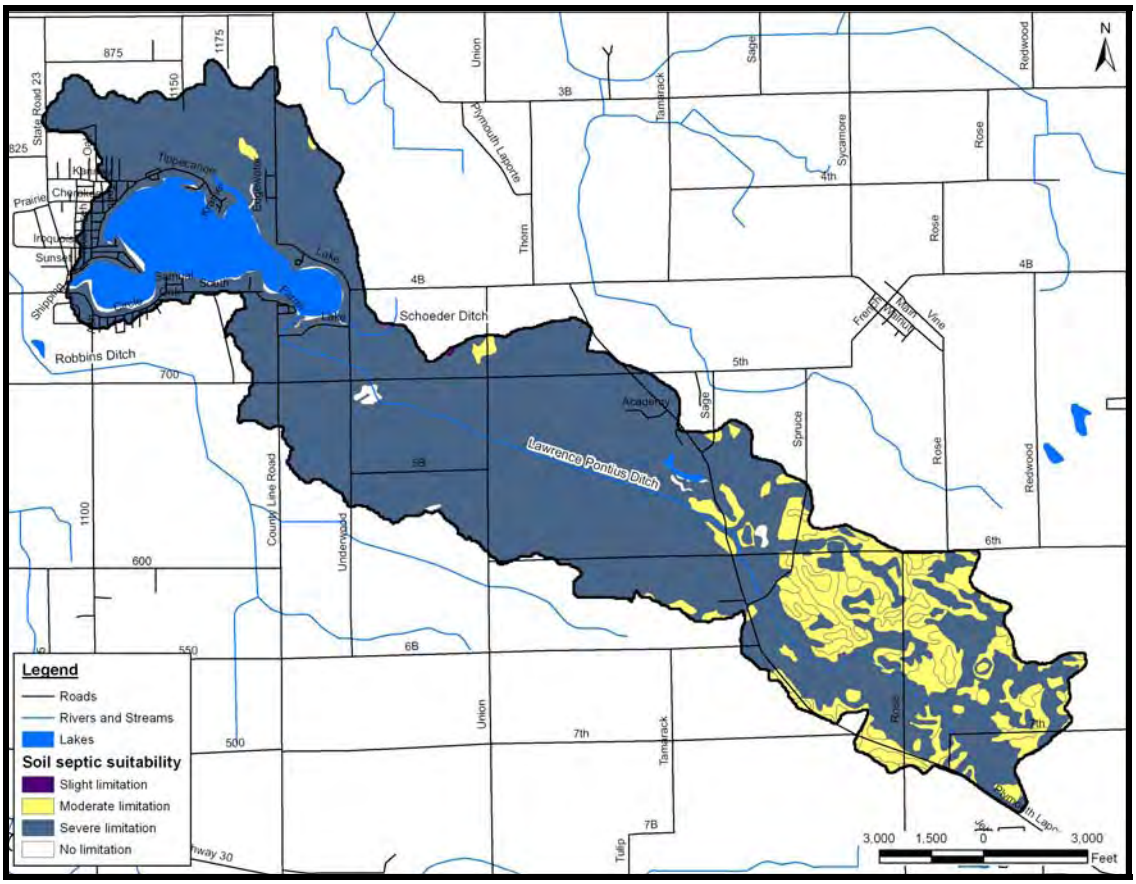


Figure 10. Soil septic field absorption suitability in the Koontz Lakes Watershed.

The NRCS has ranked each soil series in terms of its limitations for use as a septic tank absorption field. Each soil series is placed in one of three categories: slightly limited, moderately limited, or severely limited. Use of septic absorption fields in moderately or severely limited soils generally requires special design, planning, and/or maintenance to overcome the limitations and ensure proper function. Table 1 summarizes the soil series mapped in the Koontz Lake watershed in terms of their suitability for use as septic tank absorption fields (Figure 10). As Table 1 indicates, 77.82 percent (3,236.08 acres) of the watershed consists of soils rated as severely limited for their use as septic sites. Only 13.85% (575.86 acres) are rated as moderate or slight limited for septic system location. Figure 10 displays the location and extent of soils slightly, moderately, and severely limited for use as a septic tank absorption field.

2.6 Natural History

Geographic location, climate, geology, topography, soils, hydrology, and other factors play a role in shaping the native floral and faunal communities in a particular area. Various ecologists (Deam, 1921; Petty and Jackson, 1966; Homoya et al., 1985; Omernik and Gallant, 1988) have divided Indiana into several natural regions or ecoregions, each with similar geologic history, climate, topography, and soils. Because the groupings are based on factors that ultimately influence the type of vegetation present in an area, these natural areas or ecoregions tend to support characteristic

native floral and faunal communities. Under many of these classification systems, the Koontz Lake Watershed lies within Homoya's Grand Prairie Natural Region.

Prior to European settlement, prairie, beech-maple forest and oak savanna covered portions of the watershed. The prairie component might support prairie violet, puccoon, shooting star, yellow and red paint-brushes and cream indigo, leadplant, prairie clover, coneflower, feverfew, mountain mint, blazing star and prairie dock not to mention the tall grasses including big bluestem, little bluestem, Indian grass and switch grass. For the oak-hickory forest, white oak was the dominant component, with red oak, black oak, shagbark hickory, and bitternut hickory as subdominants (Petty and Jackson, 1966; Homoya et al., 1985). Petty and Jackson (1966) list pussy toes, common cinquefoil, wild licorice, tick clover, blue phlox, waterleaf, bloodroot, Joe-pye weed, woodland asters and goldenrods, wild geranium, and bellwort as common components of the forest under story in the watershed's region. The dominant component of the beech-maple forest was sugar maple with beech, tulip poplar, white ash, and cork elm as subdominants (Petty and Jackson, 1966; Homoya et al., 1985).

2.7 Natural Communities and Endangered, Threatened, and Rare Species

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

Appendix B presents the results from the database search for endangered, threatened, or rare species and high quality natural communities in the Koontz Lake Watershed. Appendix B also includes a listing of endangered, threatened, and rare species and high quality natural communities documented in Starke County and Marshall County. Cross-referencing these documents will provide guidance on which species are located in which county.

There are numerous state listed species within the watershed and, in particular, in the Koontz Lake Nature Preserve. The Koontz Lake Nature Preserve is located in the northern portion of the watershed (Figure 11) and encompasses 148 acres. Its upland communities combine open areas of little bluestem (*Schizachyrium scoparium*) and areas of savanna characterized by black oaks (*Quercus velutina*), blueberries (*Vaccinium* spp.) and Pennsylvania sedge (*Carex pensylvanica*). The lowland communities are diverse, ranging from small open pockets of water to marsh to shrub bogs and remnant stands of tamarack (*Larix laricina*).

There are no federally listed endangered or threatened species within the Koontz Lake Watershed. However, white-stemmed pondweed (*Potamogeton praelongus*) was observed during the Tier II aquatic plant survey, which took place on 8/29/2008 in Koontz Lake. It is a state endangered species, and recognized as globally widespread but scarce and critically imperiled in the state. The plant's frequency of occurrence was 11 and its location at 22 sites is documented as GPS coordinates in the Koontz Lake Aquatic Vegetation Management Plan 2008-2012 (JFNew, 2009).

Other state listed species exclusive of the nature preserve include two species of mammal – the American badger of state concern and the Franklin's ground squirrel noted as state endangered – and five vascular plant species. The plant species include tower-mustard, Atlantic sedge, long-bract green orchis, Missouri rockcress and tree clubmoss. Within the nature preserve, the listed species include three amphibians (blue-spotted salamander, four-toed salamander, northern leopard frog), two reptiles (Blanding's turtle, spotted turtle); eleven species in the butterfly family including the figured grammia, two moths with no identified common names (*Macrochilo absorptalis and Lesmone detrahens*), a noctuid moth, white-striped dart, royal fern borer moth, pearly dune moth, huckleberry eye-spot moth, sand barrens grammia, and praeclara underwing; and three vascular plants (chamomile grape-fern, Atlantic sedge, little prickly sedge). Examples of two high quality natural communities are also present within the watershed; they are the dry-mesic sand savanna and the wetland marsh.

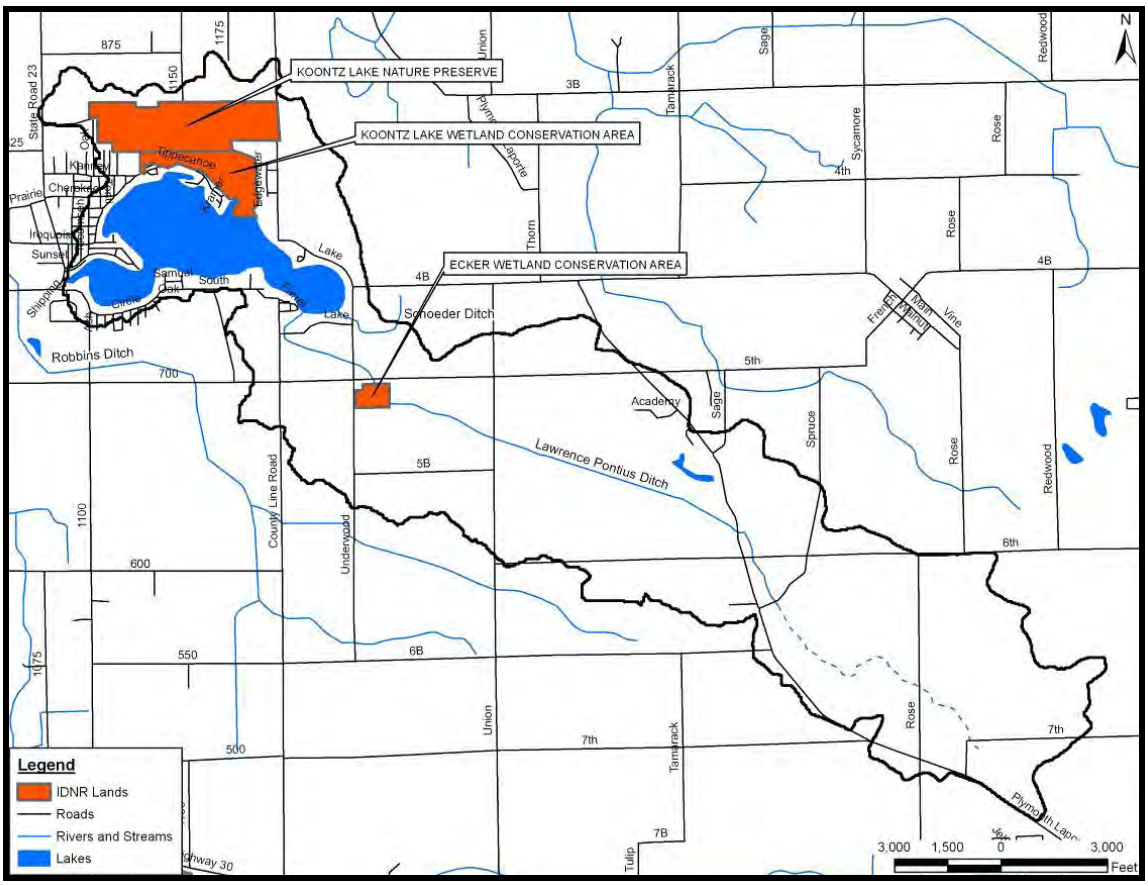


Figure 11. Location of Koontz Lake Nature Preserve.

2.8 Hydrology

Figures 12 and 13 present Koontz Lake's moderately complex morphology (IDNR, 1955; Earth Source, 1988). The lake consists of three basins and is dammed at the western side of the lake where a weir-type outlet is located along State Road 23. Based on the most recent bathymetric map (Figure 13), the lake's deepest point lies in the center of the 346-acre (140-ha) lake. Here, the lake extends to its maximum depth of 30 feet (9.1 m; Table 3). The basin in the southeast part of the lake reaches a depth of 20 feet (6.1 m) and receives the water coming in from Lawrence Pontius Ditch and Schoeder Ditch. The basin on the southwest side of the lake is shallow reaching a maximum depth of 10 feet (3.1 m) (Earth Source, 1988).

The Earth Source (1988) bathymetric map shows that the east basin has lost about 30% of its volume, the central basin has lost 18.3% of its volume and the west basin has lost 38.8% of its volume due to sedimentation (Figure 13). Based on Earth Source's study the lake is no deeper than 30 feet. The comparison of the DNR bathymetric map features to the Earth Source bathymetric map are discussed in Section 3.0.

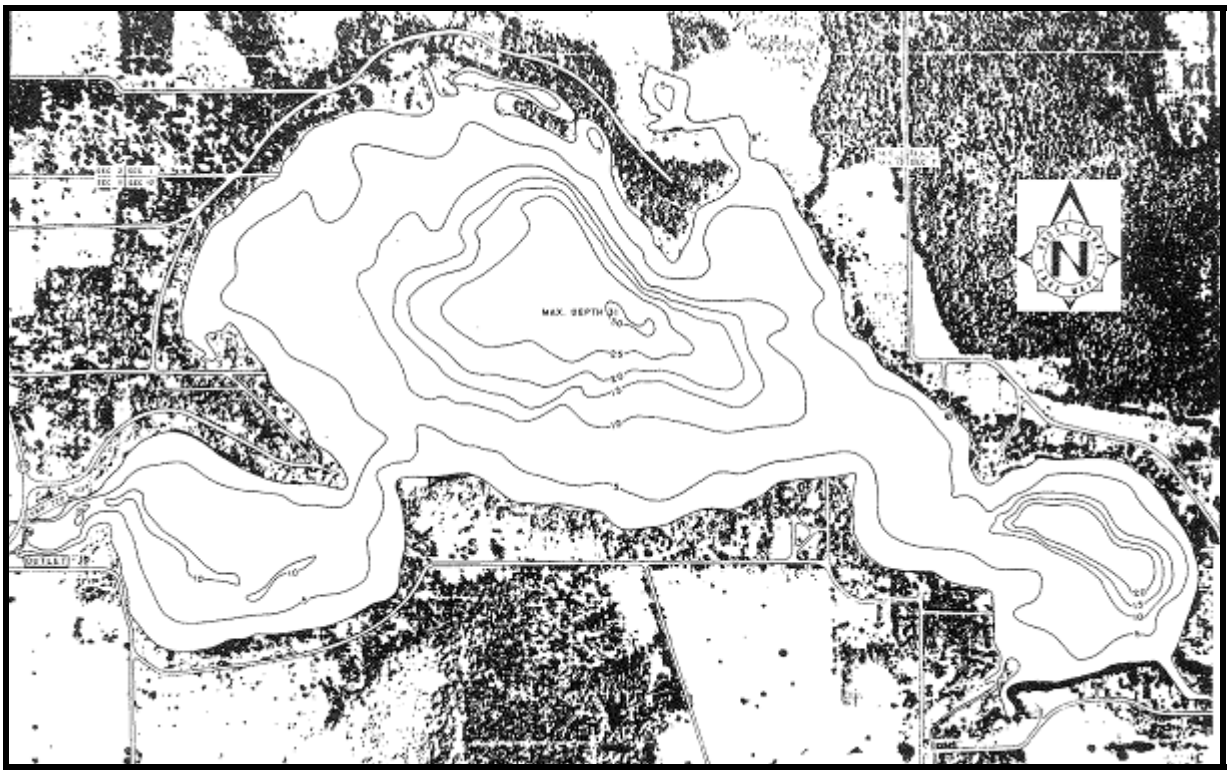


Figure 12. Koontz Lake bathymetric map. Source: IDNR, 1955.

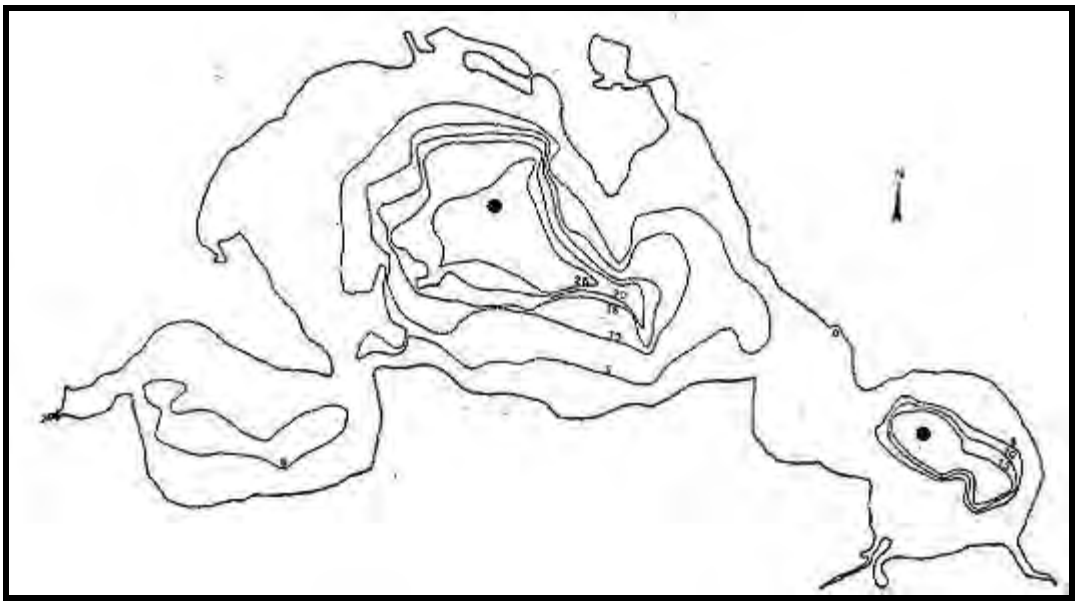


Figure 13. Koontz Lake bathymetric map. Source: Earth Source, 1988, no scale.

Table 2. Morphological characteristics of Koontz Lake.
Based on Earth Source 1988 bathymetric map.

Characteristic	Value
Surface Area	346 acres (140 ha)
Volume	3,182.98 acre-ft (3,927,822 m^3)
Maximum Depth	30 feet (9.1 m)
Mean Depth	12 feet (3.7 m)
Shallowness Ratio	0.28
Shoalness Ratio	0.84
Shoreline Length	36,448.9 feet (11,109.6 m)
Shoreline Development Ratio	1.22

One source of surface water for the lake is the Lawrence Pontius Ditch, which prior to the 1930s did not exist and was excavated to drain nearby agricultural lands. It flows approximately 17,809 feet from its initiation at a tile outlet at Spruce Trail (Site #1) to its terminus at the southeastern end Koontz Lake. Above Spruce Trail the Lawrence Pontius Drain extends upstream in a tile for another 8,123 feet. Some surface flow overlies the tiled portion of the drain. From its point of daylighting at Spruce Trail Lawrence Pontius Ditch flows through agricultural lands, then through the Swan Lake Resort, which is comprised of a golf course, hotel and restaurant facilities, and an individual sewage treatment facility. Downstream of the resort, the ditch flows through agricultural, forested and residential areas before it reaches state-owned land at the inlet to the lake. Approximately 0.86 miles (4,541 feet; 1,384 m) upstream from the lake inlet off of 5th Road, the Marshall County Drainage Board in 1989-1990 installed a sediment trap and a constructed wetland on Lawrence Pontius Ditch in order to reduce sediment introduction into the lake. Also, the ditch flows through a series of 14 drop structures intended to slow stream velocity and to reduce streambed erosion, which generally results from water flowing in straight channels. The other main source of

surface water to Koontz Lake's eastern basin is Schoeder Ditch. It is relatively short (approximately 1,920 feet; 585 m) and drains forested and agricultural land.

A wetland discharges water into the north of the central lake basin. Encompassing part of the wetland and associated uplands is the Koontz Lake Nature Preserve which is managed by the Indiana Department of Natural Resources. South of the preserve is the Koontz Lake Wetland Conservation Area. Other wetlands exist throughout the watershed and they are depicted in Figure 14. Functioning wetlands filter sediments and nutrients in runoff, store water for future release, provide opportunities for groundwater discharge, and serve as nesting habitat for waterfowl and spawning sites for fish. By performing these roles, healthy, functioning wetlands often improve the water quality and biological health of streams and lakes located downstream of the wetlands. In general, wetlands including lakes cover about 14.5% of the watershed. The USGS Land Cover Data Set suggests that wetlands cover roughly 6% of the Koontz Lake watershed and open water covers an additional 8% of the watershed. The United States Fish and Wildlife Service National Wetland Inventory Map (Figure 14) shows that wetlands cover approximately 10% of the Koontz Lake watershed. (Table 3 presents the acreage of wetlands by type according to the National Wetland Inventory.) The differences in reported wetland acreage in the Koontz Lake watershed reflect the differences in project goals and methodology used by the different agencies to collect land use data.

The last glacial retreat in this area 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 15 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 (1,383 acres; 560 ha) and the area of the watershed mapped as water (lakes, ponds, etc.; 345 acres; 140 ha) indicates that historically, 1,728 acres (699 ha) of wetland and/or open water existed within the Koontz Lake watershed. When this acreage is compared to the acreage of existing wetlands (434 acres; 176 ha), this calculation suggests that only 25% of the original wetland or open water acreage still exists today.

Table 3. Watershed hydrology by area in acres, hectares and percent of watershed by wetland classification.

	Entire Watershed		**Lawrence Pontius**		**Schroeder**	
Lacustrine	329.99	7.94%	0.00	0.00%	0.25	0.44%
Palustrine emergent	91.21	2.19%	69.77	1.68%	0.55	0.01%
Palustrine forested	275.65	6.63%	62.47	1.50%	7.03	0.17%
Palustrine scrub/shrub	56.74	1.36%	14.79	0.36%	0.00	0.00%
Palustrine submergent	10.06	0.24%	8.72	0.21%	0.00	0.00%
Ponds	18.51	0.45%	18.12	0.44%	0.39	0.01%
Uplands	3376.20	81.19%	2832.66	68.12%	49.19	1.18%
Total	**4158.37**	**100.00%**	**3006.54**	**72.30%**	**57.41**	**1.38%**

Wetland loss in the Koontz Lake watershed is similar to losses 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). Some wetlands have been preserved in the watershed, including the Koontz Lake Wetland Preserve, located to the north of the lake. Other opportunities to conserve and restore wetlands exist, with the potential to increase water quality in Koontz Lake. These are discussed in Sections 5 and 6.

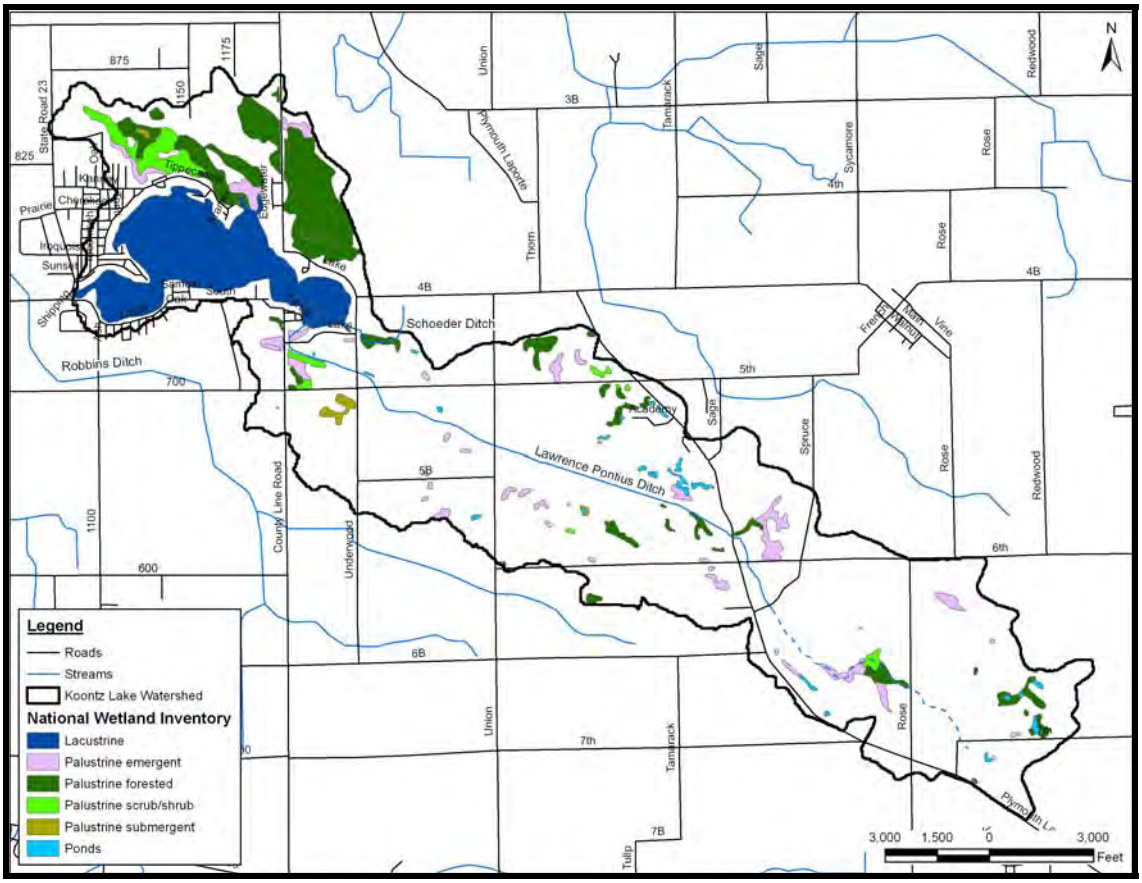


Figure 14. National Wetland Inventory (NWI) map.

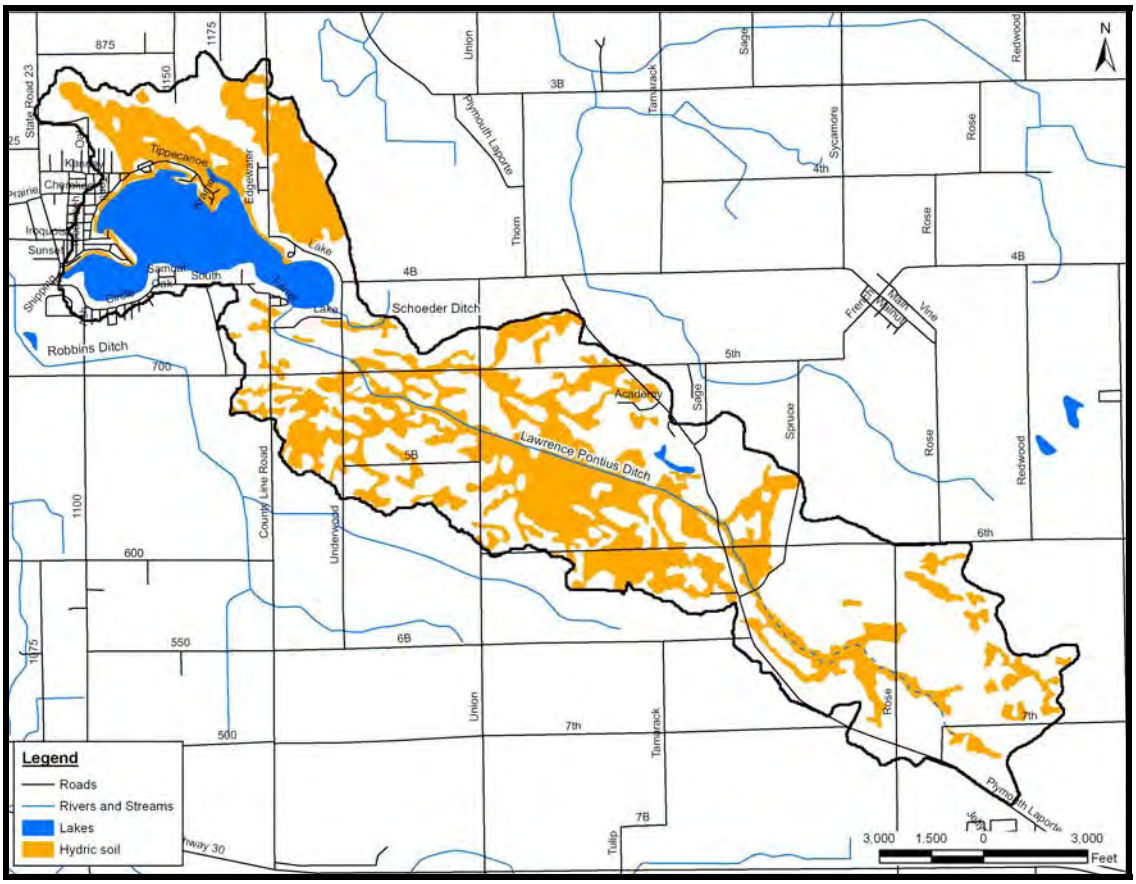


Figure 15. Hydric soils within the Koontz Lake Watershed.

A floodplain map of the Koontz Lake watershed is shown in Figure 16. Lawrence Pontius and Schoeder ditches do not garner a Zone A designation which means they are not in the 100-year floodplain. The lake itself is zoned AE, and the shaded area adjacent to Robbins Ditch is zoned A (100-year floodplain), which is outside of the Koontz Lake Watershed.

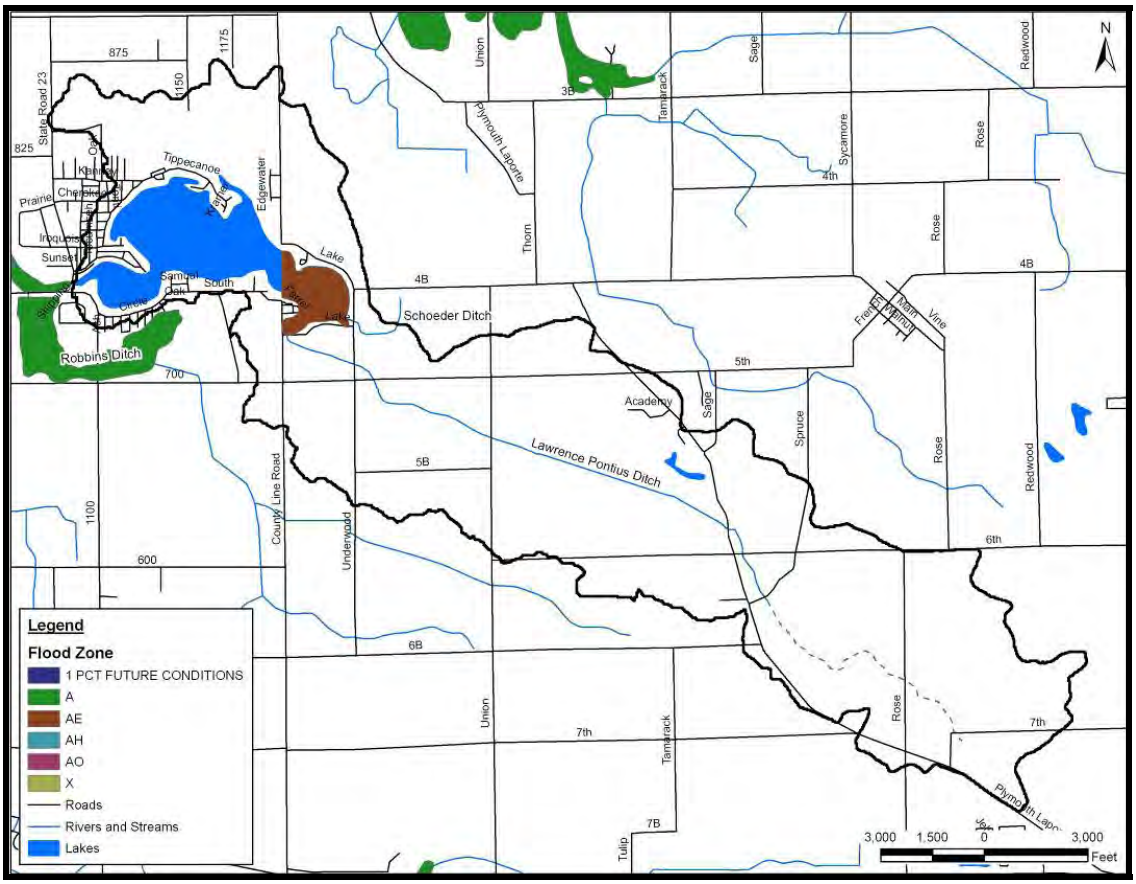


Figure 16. Floodplain map of Koontz Lake Watershed.

2.9 Land Use

Figure 17 and Table 4 present current land use information for the Koontz Lake watershed. Like many Indiana watersheds, agricultural land use dominates the Koontz Lake watershed, accounting for approximately 65% of the watershed. Row crop agriculture makes up the greatest percentage of agricultural land use at 49%, while pastures or hay account for another 16%. Land uses other than agriculture account for the remaining 35% of the watershed. Natural landscapes, including forests and wetland, cover approximately 21.4% of the watershed. Most of the natural acreage in the watershed is associated with the forested and emergent and woody wetland area around Koontz Lake. Open water, including Koontz Lake and a couple of small ponds, accounts for another 8% of the watershed. Most of the remaining 5% of the watershed is occupied by low intensity residential land, with less than 1% of high intensity residential or commercial land. The urban recreational grasses classification relates to the Swan Lake Golf Course located to the southeast of the lake. Much of the residential land lies directly adjacent to Koontz Lake. Three sites provide public access to Koontz Lake. One is the public beach on the northwestern side of the lake off of Tecumseh Road. The marina is located at the southwestern end of the lake in the western basin off of E. Circle Avenue, and the stated funded access is located on the southern side of the eastern basin off of S. Lake Drive; both of these latter sites have access ramps.

Table 4. Detailed land use in the Koontz Lake watershed.

Land Use	Area (acres)	Area (hectares)	% of Watershed
Row Crops	2,041.4	826.1	49.1%
Pasture/Hay	678.6	274.6	16.3%
Deciduous Forest	615.8	249.2	14.8%
Open Water	344.9	139.6	8.3%
Woody Wetlands	206.5	83.6	5.0%
Urban recreational grasses	133.6	54.1	3.2%
Low Intensity Residential	66.6	26.9	1.6%
Emergent Herbaceous Wetlands	49.3	19.9	1.2%
Evergreen Forest	17.1	6.9	0.4%
Commercial/Industrial/Transportation	3.6	1.4	0.1%
High Intensity Residential	2.8	1.1	0.1%
Mixed Forest	1.4	0.6	<0.1%
Entire Watershed	**4,158.4**	**1,682.8**	**100.0%**

Source: USGS EROS, 1992.

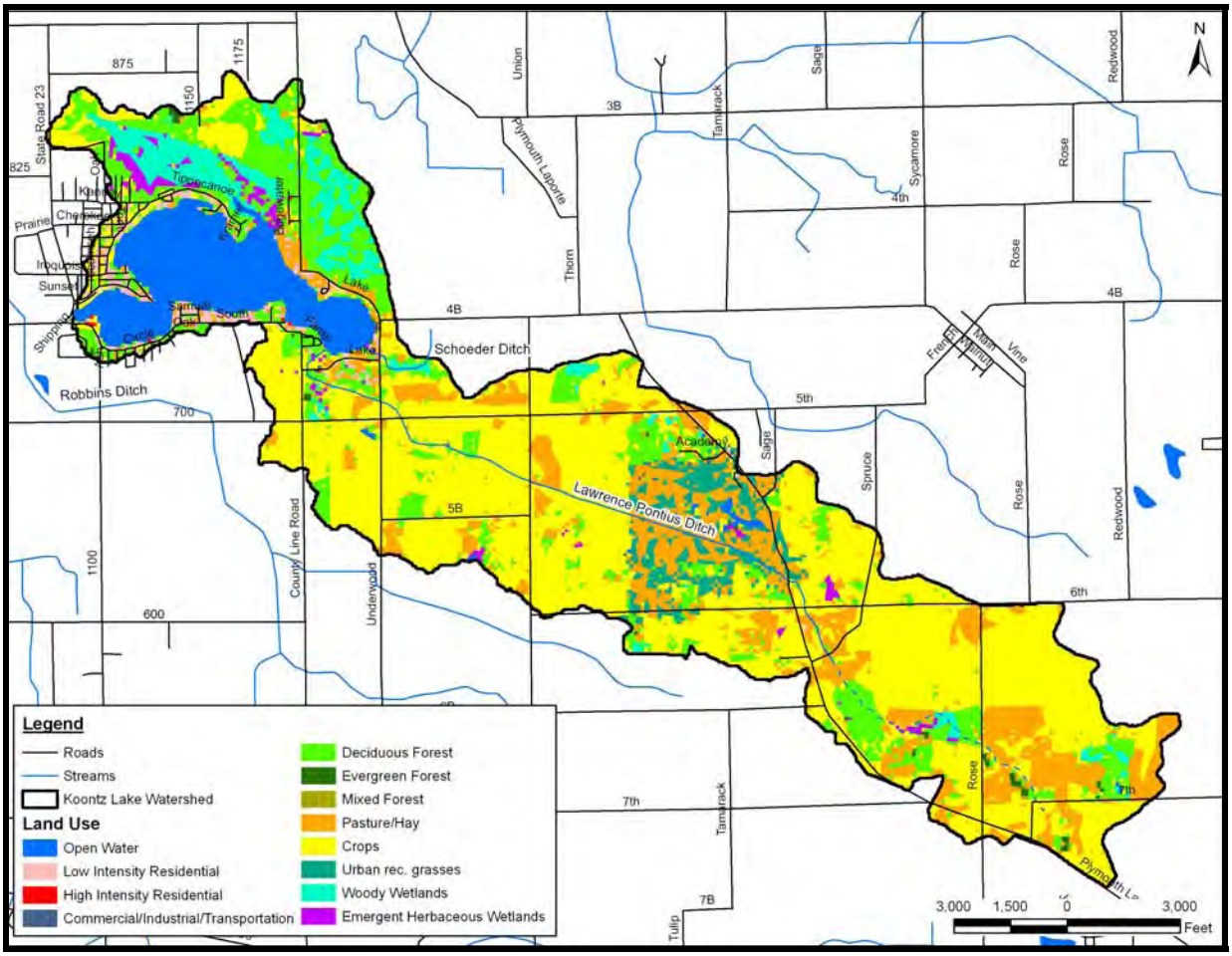


Figure 17. Land use in the Koontz Lake Watershed. Source: USGS EROS, 1992.

3.0 BASELINE WATER QUALITY CONDITIONS

Data contained in this section document the historic and current water quality conditions in the Koontz Lake watershed. It also includes important biological information about the lake fishery and the aquatic plants that are present in the lake, and this section also describes important physical features of the lake and ditches. This compilation includes all data identified during the undertaking of this Watershed Management Plan. Understanding the waterbodies' past and current conditions will help watershed stakeholders set realistic goals for future water quality conditions. These data will continue to serve as the benchmark against which future water quality conditions can be compared and 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 lake. The Indiana Trophic Status Index (ITSI) was developed by the Indiana Stream Pollution Control Board (ISPCB) and published in 1986 (IDEM, 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 Kankakee Watershed which encompasses Koontz Lake were sampled in the 1970s as part of this effort. Subsequently, the Indiana Department Environmental Management Clean Lakes Program's (CLP) sampled Koontz Lake in 1990, 1993, 1995, 2004. Water quality data from CLP monitoring includes all of the parameters required to compute the Indiana Trophic State Index (ITSI). Some of the parameters used to compute the index are those that the stakeholder is likely to be familiar with such as Secchi depth, total phosphorus, dissolved oxygen, nitrates, plankton counts among others (see IDEM, 1986 for more details on the ITSI). A subset of these parameters, including Secchi depth, percent water column oxic (percent of water column 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 C.) From 1990 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 are included in Appendix C. Finally, details of each of the parameters and their impact on lake water quality are located in Appendix D.

3.1 <u>Review of Historic Koontz Lake Studies</u>

Over 30 studies or assessments characterize water quality, bacteria, fisheries, aquatic plants, Koontz Lake sedimentation issues or other watershed issues within the Koontz Lake watershed (Appendix E). Over 13 of the studies document the lakes' fisheries, which include, in addition to the fishery information, water quality data. These reports date back to 1965, and cover much of the 1970s, some of the 80s, and only 1994, 2000 and 2009. Bacteriological sampling in the 1960s and 1970s (Earth Source, 1988) indicated contamination with a likely link to poorly functioning septic systems.

Work by Earth Source (1988) indicated that the lake was eutrophic and receiving pronounced amounts of sediment and nutrients from the Lawrence Pontius Ditch. They

also completed sediment depth and core sampling to establish a new bathymetric map and to evaluate possible contaminants in the sediment. There had been a doubling of the 0-5 foot depth contour interval largely at the expense of the 5-10 foot contour throughout the lake, resulting in an average lake volume loss of 21% over all basins.

During the fall of 1989, JFNew (1990) completed a sediment study which evaluated the location, depth and type of sediment in Koontz; location of a suitable disposal site for dredging: and evaluation of the feasibility of dredging the lake. The Snell Environmental Group, Inc. (1999) completed a diagnostic study of the lake and determined that the lake has received excess nutrients that have altered the lake's biological and chemical composition. The data indicated that the western portion of the lake was more impacted by nutrients than the eastern portion of the lake.

As mentioned, the Indiana Clean Lakes Program (CLP) completed 4 assessments with the last occurring in 2004. In addition, Jones and Fascher (2006, 2009) summarized the volunteer lake monitoring 2001-2004 and 2004-2008 data, respectively, which occurred throughout the entire state of Indiana. Volunteer sampling for transparency in the lake has occurred since 1990 through the Indiana Clean Lakes Volunteer Monitoring Program.

The U.S. Army Corps of Engineers (1998) summarized lake conditions as part of their environmental assessment (EA) for restoring the Koontz Lake aquatic habitat through dredging of sediments. The document reviewed information presented in the Earth Source (1988) report and the EA indicated that the no impacts to wetland resources or Federal and State of Indiana endangered and/or threatened species and their habitat would occur as a result of dredging.

The Koontz Lake Association (2001-2005) performed one of the only stream assessment surveys on the Lawrence Pontius Ditch. They collected data from 2001 to 2005. Selected parameters included nitrate-nitrites, total phosphorus and fecal coliform at 4 sites along the ditch. On several occasions fecal coliform bacteria exceeded state standards of 125 colony forming units (col)/100 ml sampled 5 times equally spaced over a 30-day period, or 235 col/100 ml within a 30-day period.

Finally, JFNew collected additional data from Koontz Lake and five stream sites along Lawrence Pontius Ditch and at one site on Schoeder Ditch during the summer of 2009 as part of the plan's development and to supplement existing data. In depth water quality, biotic and habitat assessments for the lake and ditches are presented in the following sections.

3.1.1 Lake Water Chemistry Assessment

As a preface to discussing Koontz Lake water quality, there are some guidelines and indices that may be helpful in understanding the water quality. Table 5 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 (top of the lake) and hypolimnetic (bottom of the lake) 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 5. Water quality characteristics of 456 Indiana lakes sampled from 1994 through 2004 by the Indiana Clean Lakes Program. Means of epilimnion and hypolimnion samples were used.

	Secchi Disk (ft)	NO_3 (mg/L)	NH_4 (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	Chl *a* (µg/L)	Plankton (NU/L)	Bl-Green Dominance (%)
Median	6.9	0.275	0.818	1.66	0.12	0.17	12.9	35,570	53.8
Maximum	32.8	9.4	22.5	27.05	2.84	2.81	380.4	753,170	100
Minimum	0.3	0.01	0.004	0.230	0.01	0.01	0.013	39	0.08

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 6. The study relates trophic state to total nitrogen, total phosphorus, and chlorophyll *a* concentrations. In general, oligotrophic lakes are considered to support low production. These lakes contain low nutrient levels, quality dissolved oxygen levels throughout the water column, and limited plant growth. Mesotrophic lakes are considered moderately productive and possess moderate nutrient levels and sufficient dissolved oxygen. Eutrophic lakes are considered productive and contain excess nutrients and low dissolved oxygen levels. Hypereutrophic lakes are considered highly productive. These lakes contain excessive nutrient levels; poor dissolved oxygen, and extremely heavy plant growth. These values and trophic states serve only as guidelines; similar concentrations in a particular lake may not cause problems if something else is limiting the growth of algae or rooted plants.

Table 6. Mean values of some water quality parameters and their relationship to lake production (after Vollenweider, 1975).

Parameter	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Total Phosphorus (mg/L)	0.008	0.027	0.084	>0.750
Total Nitrogen (mg/L)	0.661	0.753	1.875	-
Chlorophyll *a* (µg/L)	1.7	4.7	14.3	-

The Indiana Trophic State Index (ITSI) is also helpful in classifying the trophic state of the lakes. The ITSI uses ten parameters to calculate a score. Jones (1996) suggests that changes in an ITSI score of 10 or more points are indicative of a trophic status

change, while smaller changes may be attributed to natural fluctuations in water quality. Appendix F contains a breakdown of the point values for each parameter. Table 7 shows the lake trophic category for ITSI score ranges. The Indiana TSI has not been statistically validated. It tends to rely too heavily on algae and does not weigh poor transparency or nutrients high enough in the total score. For these reasons, the Carlson TSI may be more appropriate to use in evaluating Indiana lake data.

Table 7. Lake trophic category by Indiana Trophic State Index score.

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

The most widely used and accepted Trophic State Index is one developed by Carlson (1977) called the Carlson TSI. Using this index, a TSI value can be generated by one of three measurements: Secchi disk transparency, chlorophyll *a* or total phosphorus. Data for one parameter can also be used to predict a value for another. The TSI values range from 0 to 100. Each major TSI division (10, 20, 30, etc.) represents a doubling in algal biomass (See Appendix F).

As a further aid in interpreting TSI results, Carlson's scale is divided into four lake productivity categories: oligotrophic (least productive), mesotrophic (moderately productive); eutrophic (very productive) and hypereutrophic (extremely productive).

Using Carlson's index, a lake with a summertime Secchi disk depth of 3 feet would have a TSI of 60 points (located in line with the 1 meter). This lake would be in the mesotrophic category. Because the index was constructed using relationships among transparency, chlorophyll, and total phosphorus, a lake having a Secchi disk depth of 3 feet would also be expected to have approximately 20 µg/L chlorophyll and 50 µg/L total phosphorus.

Not all lakes have the same relationship between transparency, chlorophyll and total phosphorus as Carlson's lakes do. Other factors such as high suspended sediments or heavy predation of algae by zooplankton may keep chlorophyll concentrations lower than might otherwise be expected from the total phosphorus or chlorophyll concentrations. High suspended sediments would also make transparency worse than otherwise predicted by Carlson's index.

It is also useful to compare the actual trophic state points for a particular lake from one year to the next to detect any trends in changing water quality. While climate and other natural events will cause some variation in water quality over time (possibly 5-10 trophic points), larger point changes may indicate important changes in lake quality.

We will use information in Tables 5 through 8 as a reference for discussion of historical lake water quality, but more importantly later in this section we will compare Koontz Lake water quality to the median values for the 456 Indiana Lakes presented in Table 5

and other information in Tables 6-7. Following the discussion of historical lake data, we provide the results of the current lake conditions in Section 3.2.1 and use Tables 5 through 7 and Appendix F's presentation of the Indiana Trophic State Index and the Carlson's TSI as references.

3.1.2 Historic Koontz Lake Water Quality Assessment

The following discussion assesses Koontz Lake based on historical water quality data. Dissolved oxygen (DO) and temperature throughout the water column were measured during IDNR fisheries studies. Figures 18 and 19 provide the results of those investigations. Figure 18 indicates that the DO surface levels range from more than 6 mg/L to about 12 mg/L, then decrease rapidly through what is called the *metalimnion,* and then decrease to almost 0 mg/L at the bottom of the lake. The temperature profiles in Figure 19 show the same pattern. Stakeholders' attention is directed toward the bottom waters where oxygen levels area minimal, and where lack of oxygen precludes quality fish habitat.

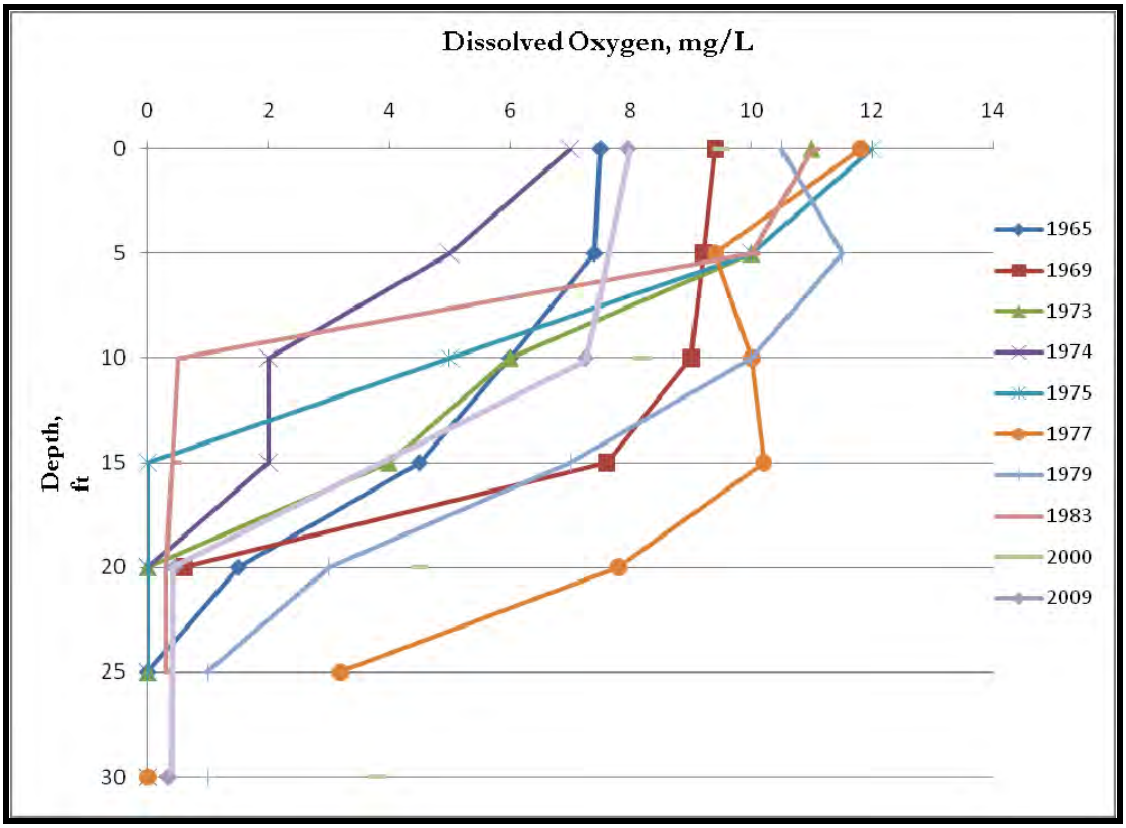


Figure 18. Dissolved oxygen profile from 1965 to 2009. Source: DNR Fisheries studies.

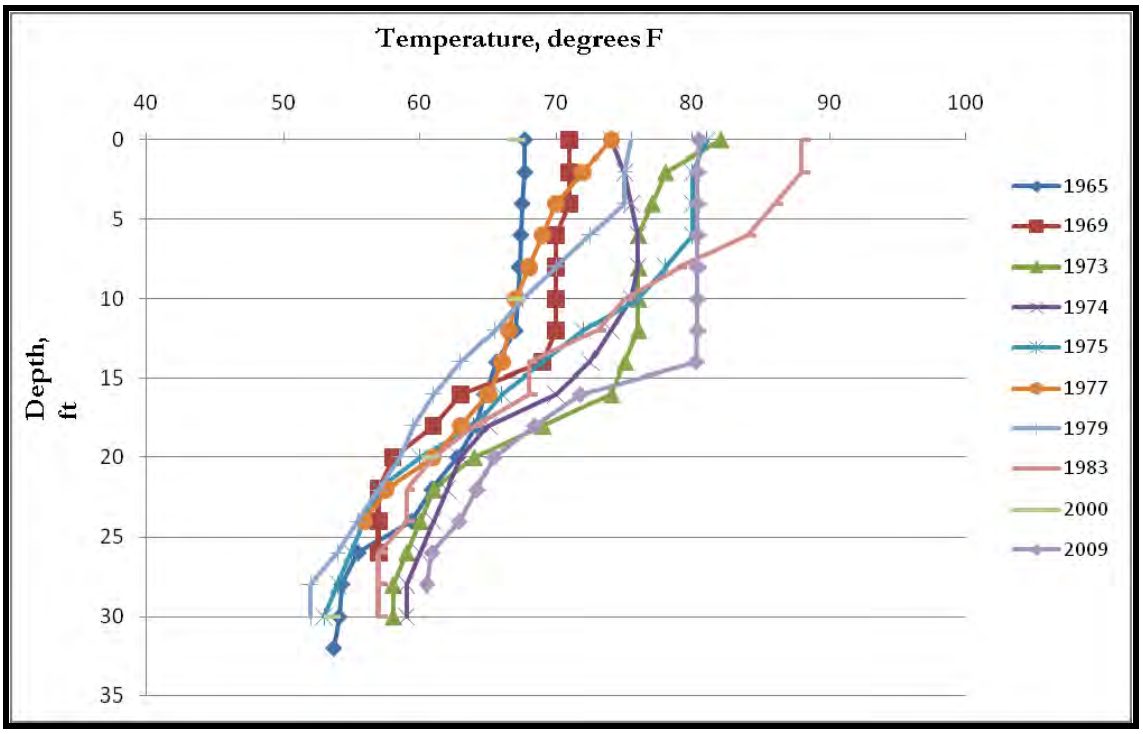


Figure 19. Temperature profile from 1965 to 2009. Source: DNR Fisheries studies.

Table 8 presents a selected set of water quality parameters common to many of the studies at Koontz Lake. The data set for the Indiana Trophic Status Indicator (ITSI) shows that the lake has ranged from oligotrophic with a total ITSI score of 16 in 1990 to eutrophic with a total ITSI score of 34 in 1995. The lake was, apparently, not productive and exhibited low nutrient levels according to the results of the first round of sampling through the Clean Lakes Program. In the following years, the lake reached an eutrophic state (ITSI = 34) in 1995 but reversed to a mesotrophic state in 1999 (ITSI =20), in 2004 (ITSI =26), and continued to be in a mesotrophic state in 2009 (ITSI=23).

Secchi depth, also known as water transparency, decreased from 5.25 feet (1.6 m) in 1990 to a low of 2.3 feet (0.7 m) in 1995, after which the Secchi depth increased with some variation to 5.9 feet (1.8 m) in 2008. In 2009 during the CLP effort, the lake clarity decreased to 3.6 feet (1.1 m), but the IDNR measured a depth of 4.5 feet (1.8 m). (Note that yearly volunteer data represent median values for multiple sampling during a given year. Appendix C lists all observations.) Figure 20 indicates a slight improvement in water clarity over the years with the exception of 2009. The median Secchi depth for the sampling period is 4.7 feet, which is less than the median level of 6.5 feet measured at 456 Indiana lakes sampled, indicating that the lake's water clarity is not as good as half of the Indiana lakes that were sampled.

Table 8. Selected historical water quality data for Koontz Lake.

Date	Secchi Depth (ft)	Mean TP *(mg/L)	Chl*a* (µg/L)	Plankton Density #/L	ITSI	% Oxic	Source
6/3/1965	5						Turner, 1967
6/16/1966	3						Robertson, 1969
1971	3.5	0.05					IDEM, 1986
7/25/1973	3.5						Robertson, 1974
7/29/1974	3.5						Robertson, 1975
8/4/1975	3						Robertson, 1975
6/13/1977	5						Robertson, 1978
6/4/1979	4.5						Robertson, 1980
6/18/1983	3						Robertson, 1984
8/7/1990	5.2	0.046		2,380	16	63	CLP, 1990
1990	6.5						Volunteer
1991	4						Volunteer
1992	5.3	0.034	2				Volunteer
7/28/1993	3.9	0.018	11.48	20,901	24	65.8	CLP, 1993
1993	6.1	0.028	11.5				Volunteer
1994	5.2	0.048	5.4				Volunteer
7/25/1995	2.3	0.045	20.07	10,6356	34	85.7	CLP, 1995
1995	4.6	0.042	7.1				Volunteer
1996	5.1	0.054	14.2				Volunteer
1997	4.5	0.07	13				Volunteer
1998	4.9	0.028	7.4				Volunteer
7/12/1999	4.9	0.064	7.01	3289	20	59	CLP, 1999
1999	5	0.061	9.1				Volunteer
9/21/1999	3	0.02	31.18	1,160,000			SEG, 1990
5/23/2000	5						Hudson, 2001
2000	4.4	0.052	7.6				Volunteer
2001	4.2	0.09	7.8				Volunteer
2002	4.7	0.048	5.4				Volunteer
2003	4.7	0.042	7.3				Volunteer
8/17/2004	3.6	0.045	12.66	22,116	26	88	CLP, 2004
2004	5	0.043	8.8				Volunteer
2005	4.5	0.054	9.1				Volunteer
2006	5.1	0.051	2.6				Volunteer
2007	5.1	0.045	7.8				Volunteer
2008	5.9						Volunteer
2009	3.6	0.048	8.0	29,385	23		CLP, 2009
2009	4.5						Bacula & Long, 2010

* Mean TP – Total phosphorus average of surface and bottom water column samples. ISTI – Indiana Trophic Status Indicator; Chl*a*- Chlorophyll *a*; %Oxic – percentage of water column oxygenated.
** Volunteer monitoring data collected through the Indiana Clean Lakes Volunteer Monitoring Program. Data displayed in table represent median values for all data collected annually.

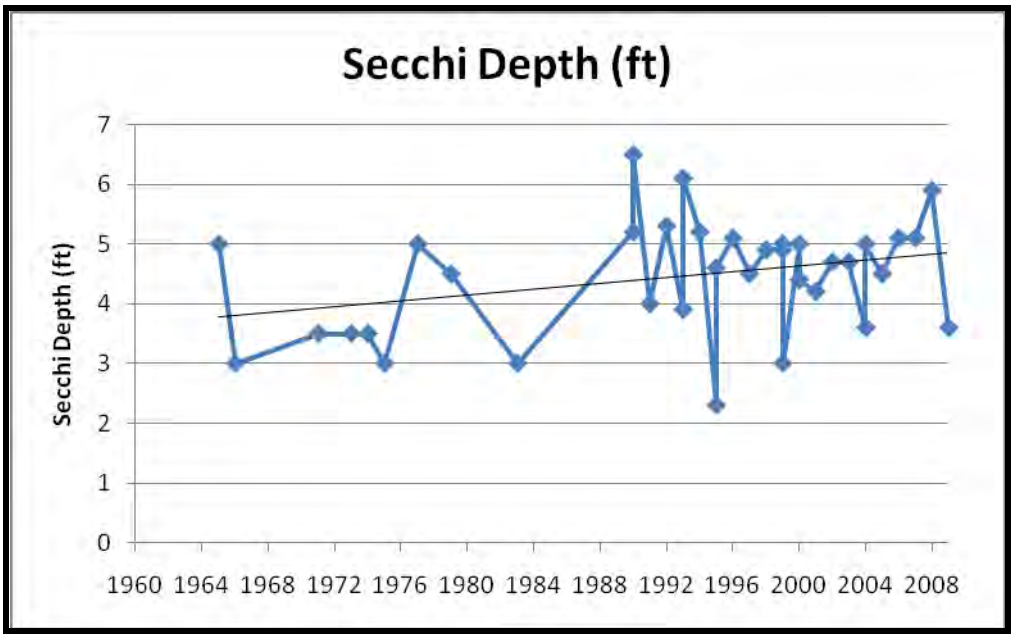


Figure 20. Secchi depth data collected from 1965 to 2009. Source: See Table 8.

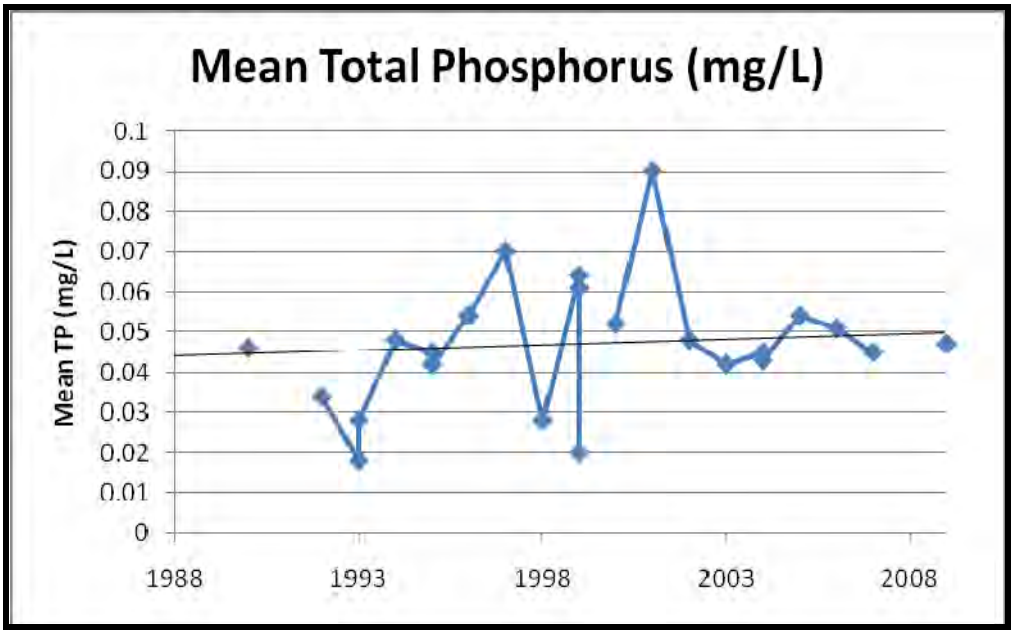


Figure 21. Mean total phosphorus data collected from 1965 to 2009. Source: See Table 8.

Over the years, mean total phosphorus (mg/L) has varied over time with an overall slight upward trend (Figure 21). (The mean total phosphorus measurement is the calculated average of surface and bottom waters' total phosphorus level.) Mean total phosphorus levels have ranged from a low of 0.018 mg/L in 1993 to a high of 0.09 mg/L in 2001. The median total phosphorus level for the sampling period is 0.046 mg/L, which is less than the median level of 0.17 mg/L measured at 456 Indiana lakes sampled from 1994 to 2004. Levels dropped below the Koontz Lake median in 1993 and in the late 1990s, and again only for a few years in the early 2000s. Though the

median level of mean total phosphorus is lower than the median level for 456 Indiana lakes, the total phosphorus concentration in Koontz Lake falls between the mesotrophic to eutrophic level of productivity identified by Vollenweider (1975).

Sampling for chlorophyll *a* in Koontz Lake began in 1992 and has continued through 2009. Figure 22 indicates a slight decrease in chlorophyll *a* levels over the period of sampling. Levels have ranged from a low of 2 µg/L in 1992 to a high of 31.18 µg/L in 1999. The latter data point is an average of 27 samples collected on September 20 by SEG (1990). They indicate that levels on that day ranged from 0 to 50 µg/L, and that elevated levels of chlorophyll *a* were detected in the western portion of the lake. The chlorophyll *a* levels were generally less than the median value of the 456 Indiana Lakes sampled from 1994-2004.

The Starke County Health Department (Indiana State Department of Health, 2005) collected bacteriological samples around the perimeter of Koontz Lake on July 29, 2005 and September 6, 2009. The latter samples exceeded the transit time of >6 hours for analysis and may not be valid per the actual report. *E. coli* counts (most probable number/ 100 ml – MPN) ranged from 1-66 MPN with a geometric mean of 3.3. The highest level of bacteria was encountered near the public beach (20 MPN) in the western basin and at the point on the southern shore in the western basin (66 MPN). The other area where a high level of bacteria was encountered was the Lawrence Pontius Ditch inlet (50 MPN). These levels are below the state water quality standards.

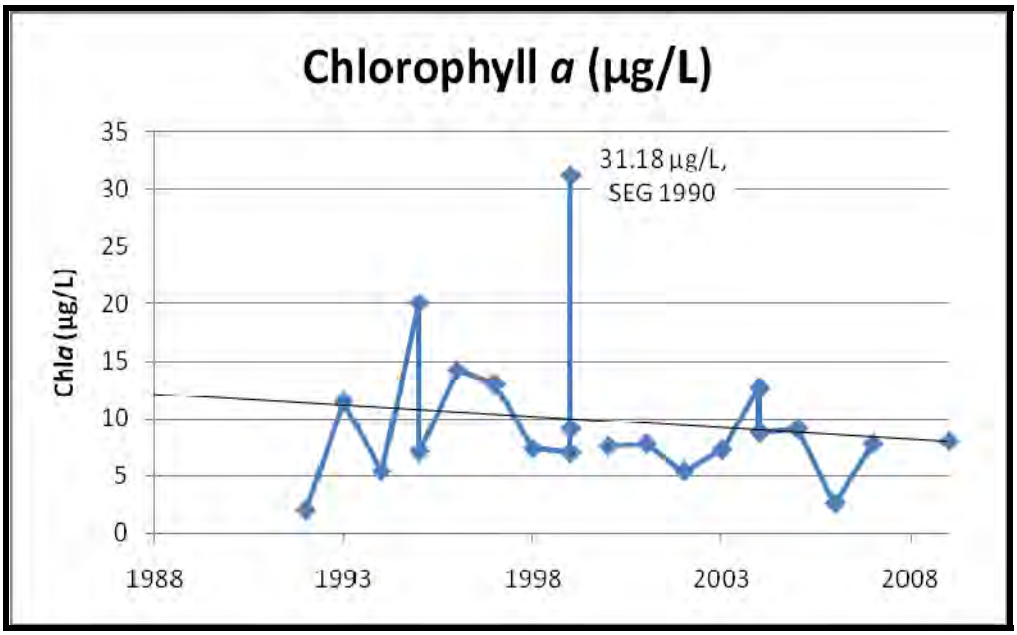


Figure 22. Chlorophyll *a* data collected from 1965 to 2009. Source: See Table 8.

3.2 <u>Koontz Lake Water Quality – Current Assessment 2009</u>

As a preface to reviewing the lake's current water quality it is important to review the morphometry of the Koontz Lake. Koontz Lake is a medium sized lake with a surface area of 346.02 acres (140.03 ha), and volume of 3,182.98 acre-ft. Using a bathymetric

map (Figure 12) prepared by the IDNR Division of Water in 1955 (IDNR 1955), depth-area and depth-volume curves for Koontz Lake were prepared (Figures 23 and 24). Figure 23 shows that Koontz Lake deepens very gradually until a depth of 10 feet, point at which the rate of depth increases to the lake's maximum depth of 31 feet deep (9.4 m). The lower slope of the curve from zero to five feet indicates that there is shallow water that can support rooted aquatic plants.

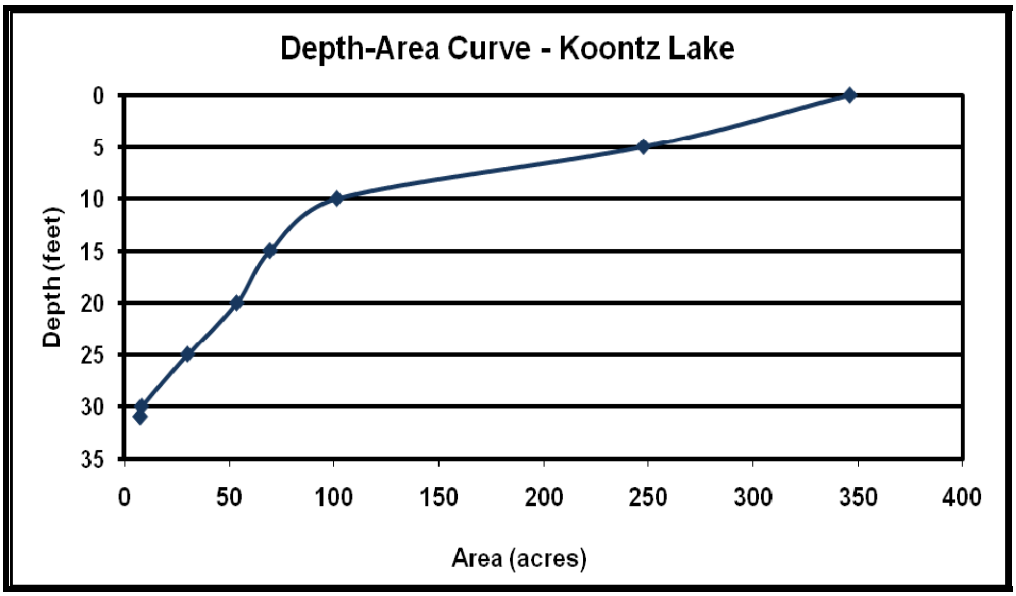


Figure 23. Depth-area curve for Koontz Lake. Source: IDNR 1955 Bathymetric Map

Figure 24 shows that volume steadily increases until about the 20-foot depth where the steeper curve indicates a greater change in depth per unit volume. Thus, there is only a small volume of water deeper than 20 feet in Koontz Lake.

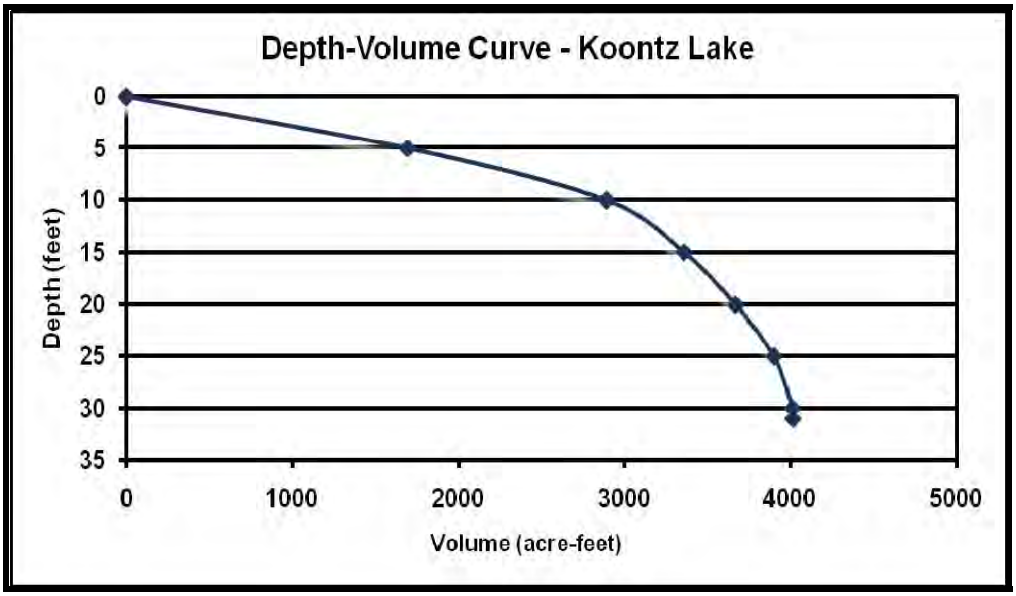


Figure 24. Depth-volume curve for Koontz Lake. Source: IDNR 1955 Bathymetric Map

The lake bathymetry has changed since 1955 and the change was documented by Earth Source (1988). The Earth Source 1988 bathymetric map is provided in Figure 13. Curves based on the 1988 data are presented in Figures 25 and 26 show that the 0-5-foot depth contour doubled from 1955 to 1988 and that the 5-10-foot contour for the entire lake decreased by about 60%. These more recent depth-area and depth-volume curves for Koontz Lake show that Koontz Lake, again, deepens very gradually until a depth of 10 feet, a point at which the rate of depth increases to the lake's maximum depth of 30 feet deep (9.1 m). The lower slope of the curve from zero to five feet indicates that there is shallow water that can support rooted aquatic plants.

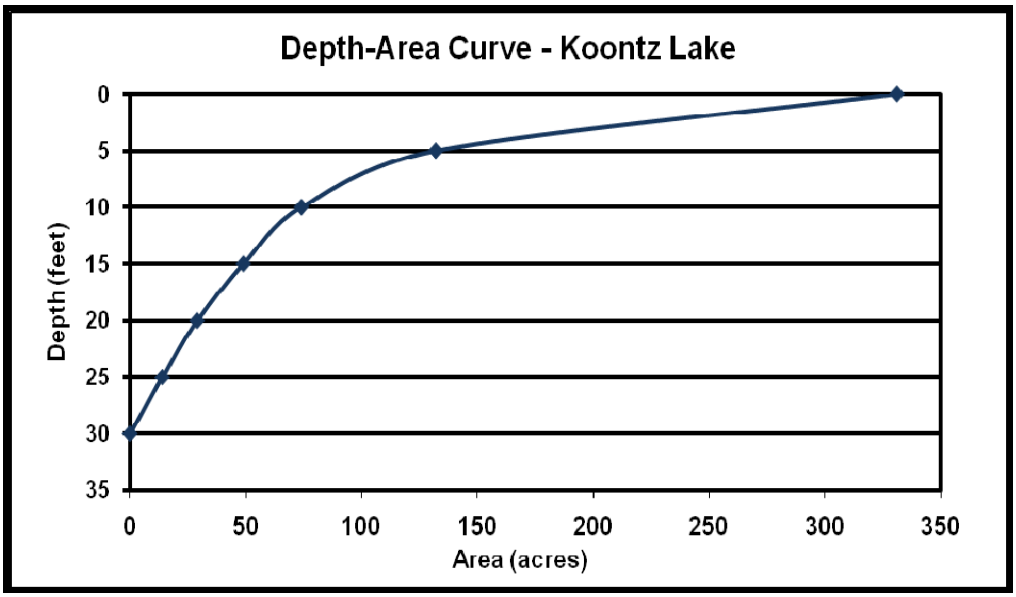


Figure 25. Depth-area curve for Koontz Lake. Source: Earth Source 1988

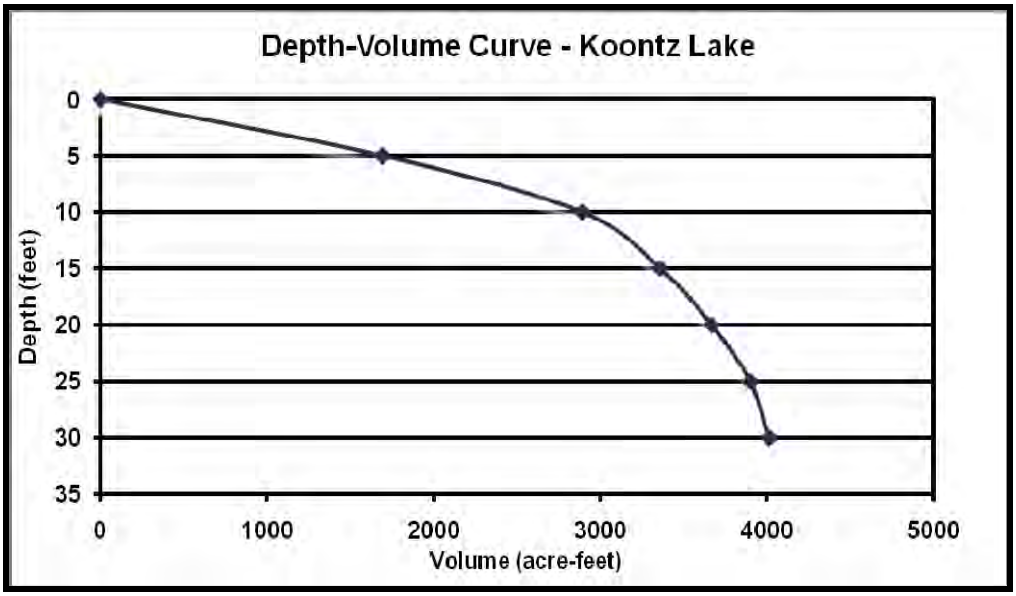


Figure 26. Depth-volume curve for Koontz Lake. Source: Earth Source 1988

3.2.1 2009 Lake Diagnostic Study Results

Dr. William Jones and students of the School of Public and Environmental Affairs, Indiana University conducted the Koontz Lake diagnostic sampling on July 20, 2009 using the methodology outlined in Appendix D. Results from the Koontz Lake water characteristics assessment are included in Table 9 and Figure 27.

Table 9. Water quality characteristics of Koontz Lake, 7/20/09.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.4	7.7	-
Alkalinity	143.5 ppm $CaCO_3$	154.5 ppm $CaCO_3$	-
Conductivity	340 µS/m	320 µS/m	-
Secchi depth	3.6 ft (1.1m)	-	6
Light Transmission @ 3 ft	7.0%	-	4
1% Light level	8.2 ft	-	-
Total Phosphorus	0.018 mg/L	0.077 mg/L	2
Soluble Reactive Phosphorus	0.010* mg/L	0.067 mg/L	1
NO_3	0.013* mg/L	0.013* mg/L	0
NH_4	0.018* mg/L	0.679 mg/L	1
TKN	1.026 mg/L	1.524 mg/L	3
Oxygen Saturation @ 5 ft.	86.5%	-	0
% Water column oxic	56.6%	-	2
Plankton Density	29385	-	4
Blue-Green Dominance	99.7%	-	0
Chl-a	7.98 ug/L	-	-
		TSI Score	**23**

*Method detection limit

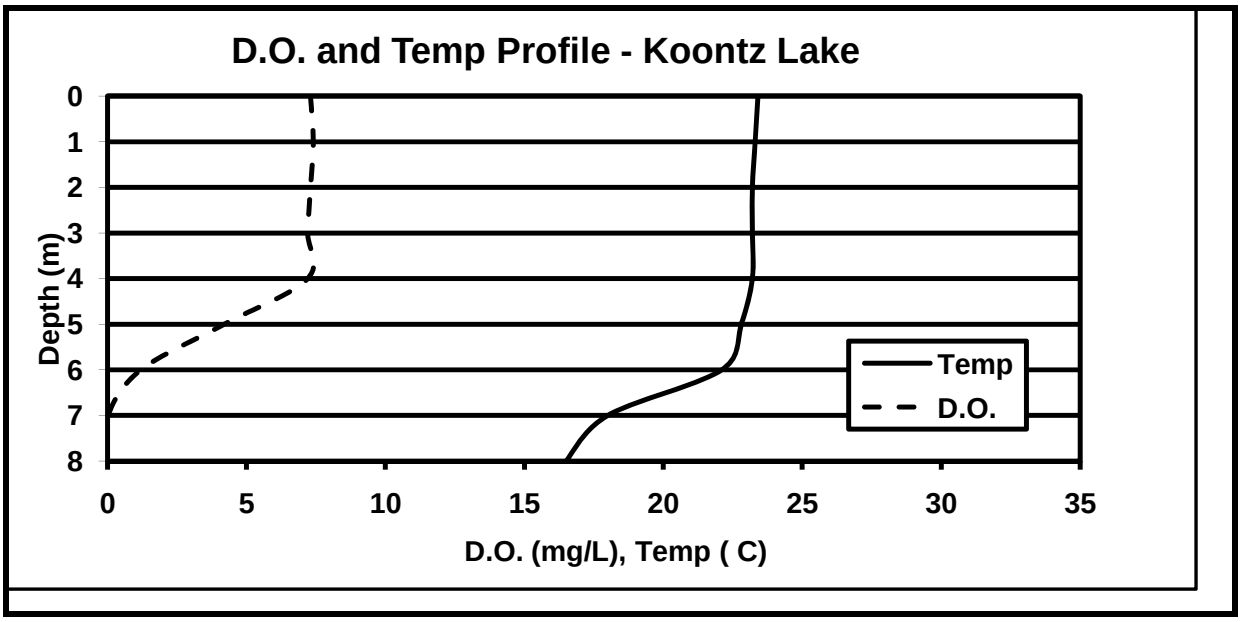


Figure 27. Temperature and dissolved oxygen profiles for Koontz Lake on 7/20/09.

Temperature and oxygen profiles for Koontz Lake show that the lake was thermally stratified at the time of sampling (Figure 27). Koontz Lake had abundant dissolved oxygen in the surface waters. Below 5 meters (16 ft) there is little oxygen available to support fish, and the lake reaches fully anoxic conditions ([DO] < 1.0 mg/L) conditions at 6 meters (20 ft). During thermal stratification, the bottom waters (*hypolimnion*) of the lake are isolated from the well-mixed epilimnion by temperature-induced density differences. The boundary between these two zones, where temperature changes most rapidly with depth is called the *metalimnion*. At the time of our sampling, the epilimnion (well-mixed surface waters) was confined to the upper 6 meters (20 ft) of water. The decline in temperature between 6 and about 8 meters (20-26 ft) defines the metalimnion or transition zone. Because the rate of temperature change exceeds one degree C per meter, by definition there technically is no hypolimnion. However, we will refer to our bottom water sample as a hypolimnion sample. Historic profiles from DNR fisheries studies (Figures 18 and 19) are similar to temperature profile measured in 2009. Note that the profile in 2009 is measured in meters and the historical profiles are in feet.

The 1% light level, which limnologists use to determine the lower limit where photosynthesis can occur, extended to 8.2 ft (~2.5 m). Based on the depth-area curve in Figure 25 approximately 56.6% of lake bottom (approximately 150 acres) is shallower than 8.2 ft. This represents the <u>area</u> of the lake bottom with sufficient light to support rooted plants. This area is called the *littoral zone*. Furthermore, based on the depth-volume curve (Figure 26), we see that a <u>volume</u> of greater than 2,540 acre-feet of Koontz Lake (79% of total lake volume) lies above the 8.2-foot 1% light level. This area, referred to as the *photic zone*, represents the amount of water with sufficient light to support algal growth.

Phosphorus and nitrogen are the primary plant nutrients in lakes. Total phosphorus (TP) is a measure of the total phosphorus present in organic and inorganic forms. Total phosphorus concentrations (0.018 mg/L) are relatively low in the surface waters (epilimnion) of Koontz Lake but are higher (0.077 mg/L) in the hypolimnion (bottom waters). Soluble reactive phosphorus (SRP) is inorganic phosphorus which is available for biological uptake. The SRP concentration was at or below the detection limits (0.010 mg/L) in the epilimnion, but was higher in the hypolimnion (0.067 mg/L). The phosphorus concentration in the epilimnion is below the 0.03 mg/L concentration of TP and SRP that is considered high enough to support eutrophic conditions. The hypolimnion concentrations exceeded the 0.03 mg/L concentration that is considered high enough to support eutrophic conditions. Higher phosphorus concentrations within the hypolimnion are usually associated with nutrient release from the sediments under anoxic conditions. However, sedimentation of particulates and plankton also provide a source of phosphorus to the hypolimnion.

Nitrate-nitrogen was at the detection limits (0.013 mg/L) of the analytical methods in the epilimnion and hypolimnion. Nitrate undergoes a reduction reaction to ammonia when oxygen is low and ammonia undergoes the reverse reaction when oxygen is high. In the well-oxygenated epilimnion ammonia concentrations were below the 0.018 mg/L detection limit and in the hypolimnion were much higher at 0.679 mg/L. The higher

hypolimnetic ammonia concentrations indicate that a high biochemical oxygen demand (BOD) is producing the ammonia and the low amount of dissolved oxygen maintains these relatively high ammonia concentrations.

Values for pH are within the normal range for Indiana lakes, pH 8.4 for the epilimnion and pH 7.7 for the hypolimnion. pH values for most fresh waters fall between pH 6-9 (Kalff, 2002). The alkalinity values of 143.5 mg/L and 154.5 mg/L, for the epilimnion and hypolimnion, indicate that Koontz Lake is a well-buffered system.

Plankton enumerated from the sample collected from Koontz Lake are shown in Table 10. *Anabaena*, a blue-green algae, was the most dominant genera found, and accounted for over half the plankton density. In addition to this particular blue-green alga, other blue-green species contributed to the overall plankton dominance by blue-greens of 99.7%. Blue-greens are usually associated with degraded water quality. Blue-green algae are less desirable in lakes because they: 1) may form extremely dense nuisance blooms; 2) may cause taste and odor problems; 3) are unpalatable as food for many zooplankton grazers; and 4) may produce toxins.

Koontz Lake's values for Secchi disk transparency and % dominance by blue-greens were worse than the median statewide values (Compare Table 5 to Table 9). Koontz Lake's plankton was dominated by blue-green algae. While these are not the most desirable algae, their densities and resulting chlorophyll concentrations were low enough to not cause a discernable problem in the lake at the time of the sampling. However, it is recognized that algae is a serious problem around the perimeter of the lake where the 2009 lake sampling did not occur (Photograph 1).

Photograph 1. Algae mixed with sediment at perimeter of Koontz Lake (Source: Don O'Barski Photography, August 17, 2007)

Table 10. The plankton sample representing the species assemblage on July 20, 2009.

SPECIES	ABUNDANCE (N.U./L)
Blue-Green Algae (Cyanophyta)	
Anabaena	14912
Aphanizomenon	3112
Aphanocapsa	8395
Chroococcus	59
Coelosphaerium	117
Microcystis	587
Pseudanabaena	2055
Woronichinia	59
Zooplankton	
Bosmina	39
Calanoid	3
Cyclopoid	1
Daphnia	7
Nauplius	41

The 2009 results were between the mesotrophic and eutrophic ranges for total phosphorus when compared to trophic levels reported by Vollenweider in Table 6. Total nitrogen results were within the oligotrophic range while chlorophyll results were slightly above the oligotrophic range. Based upon the Vollenweider model Koontz Lake shows no indication of internal loading of phosphorus from the sediments; the hypolimnion is a phosphorus sink rather than a source. The source of the higher measured concentration of SRP in the hypolimnion is likely due to phosphorus settling down through the water column and to aquatic plant decay in the hypolimnion.

The Indiana Trophic State Index values calculated for Koontz Lake from assessments conducted under the Indiana Clean Lakes Program are shown in Table 8. Koontz Lake was assessed in 1990, 1993, 1995, 1999, and 2004 by the Clean Lakes Program and in 2009 under the current study. Based on the 2009 diagnostic study, Carlson's Secchi Disk and Total Phosphorus TSIs for Koontz Lake fell into the eutrophic category and into the mesotrophic category for chlorophyll *a*. A review of the Indiana TSI scores over the last three sampling periods indicates that Koontz Lake is classified as mesotrophic.

Overall, the water quality of Koontz Lake is much better than most of Indiana's lakes. The lake can be considered mesotrophic based upon the 2009 data, and the relatively large volume of Koontz Lake helps to dilute nutrients washing into the lake from its watershed. While Koontz Lake enjoys good water quality today, the signs suggest that the lake will degrade in the future. The very deepest water contained diminished oxygen concentrations. This is due to the decomposition of organic matter on the sediments by bacteria that consume oxygen in the process. The sources of this organic matter are likely algae and rooted plants produced within the lake, and organic material washed

into the lake from the watershed. The production of algae and rooted plants in the lake are based upon the level of available nutrients, and in Koontz Lake, excessive loading of nutrients to the lake will cause excessive algal and aquatic plant growth. Taking it a step further, phosphorus loadings to Koontz Lake from its watershed exceed permissible rates needed to maintain good water quality. As a cautionary note, the lake's deep volume has mitigated these loadings in the past, but for the long-term health of the lake, external phosphorus loadings should be reduced. Section 4.5 provides a lengthy discussion of phosphorus loading and recommendations for management of phosphorus loads to the lake.

3.3 Koontz Lake Fisheries

The Koontz Lake fishery was initially surveyed by the Indiana Department of Natural Resources (IDNR) in 1965 and in 1969, with subsequent surveys in 1971-1975, 1977, 1979, 1983, 2000 and 2009 (Turner,1967; Robertson, 1973-1975, 1977, 1979, 1984; Brindza, 2001; Bacula and Long, 2009). Koontz Lake was renovated and restocked in 1970 due to an observed over abundance of small yellow perch and low abundances of bluegill and largemouth bass during the 1965 and 1969 general fish surveys. Fish species restocked included largemouth bass, bluegill, redear, northern pike, channel catfish, black crappie, and walleye. Success of the renovation/restocking effort was investigated during the 1971-1975 general fish surveys. In 1984, Koontz Lake implemented a 14 inch (35.6 cm) minimum size limit on largemouth bass. To assess the impact of the minimum size limit on the largemouth bass population surveys were conducted from 1984 to 1987 and in 1989 targeting largemouth bass specifically during May and June utilizing electrofishing techniques Robertson, 1985, 1986,1988; 1990). In 1994, IDNR carried out a study on Koontz Lake investigating the impact of largemouth bass on bluegill abundance, size structure, and growth (Hudson, 1995).

Koontz Lake can be described as a panfish-largemouth bass fishery with additional angling opportunities for northern pike and yellow perch (Figure 28). Historically, the Koontz Lake fishery has provided anglers with less than desirable to adequate fishing opportunities. Largemouth bass catch rates from sampling efforts overtime have ranged from a high of 251.8 individuals per hour in 1989 to 5 individuals per hour in 1975. The most recent survey in 2009 collected 29 bass per hour.

Growth and condition of bluegill and largemouth bass have been average to above average during all sampling events. This would suggest that Koontz Lake provides a sufficient forage base, and species population sizes are at levels where intra-specific competition (within a species) is not limiting growth.

Proportional stock density (PSD), a measure of the balance between stock and quality sized individuals within a species population, was determined for bluegill in 1992 and largemouth bass as of the 1984 survey. Stock size is generally defined as the minimum size at which a species becomes available to anglers while quality size is generally defined as the minimum size anglers consider the species harvestable. PSDs indicative of balance in a target species population are based on sustainable harvest of sizes preferred by anglers (Kohler and Hubert, 1999). Different species have varying

desirable PSD value ranges. For example, the desired PSD range in bluegill is 20-40 while largemouth bass is 40-70. From 1984 to 1989 the calculated PSD value for the largemouth bass population ranged from 7-15 suggesting the population was dominated by smaller individuals. In 1992, largemouth bass PSD increased to 44 and increased again to 53 in 2000, but declined to 50 in 2009, suggesting during those years the largemouth bass population was balanced. Bluegill PSD was determined during the 1992 survey and was calculated at 26 and in 2009 the PSD was calculated at 28, suggesting the population continues to be balanced.

While the Koontz Lake fishery has been surveyed a number of times the majority of those events took place in the 1970s and 1980s. Additional surveys took place in 1994 and 2000 with the most recent survey of Koontz Lake occurring in 2009. During the 2009 survey a total of 687 fishing representing 19 species and one hybrid sunfish were collected (Bacula and Long, 2010). Comparing the 2000 and 2009 surveys, the data indicate a decline of 42% in total number of fish collected. In 2000, IDNR collected 1,176 fish representing 18 species; however, the total weight of fish collected was higher in 2009 at 500.5 lbs, but only 370.2 lbs in 2000 (Bacula and Long, 2010). As in 2000, gizzard shad was the most abundant fish species collected by number (30%) followed by bluegill (27%), yellow perch (14%), white bass (5%) and largemouth bass (5%; Figure 28). While green sunfish represented 11% of the total fish numbers in 2000, they were not present in the 2009 survey. In 2009, gizzard shad was the most abundant species collected by weight (47%), followed by carp (12%), channel catfish (10%), bluegill (7%), and white bass (7%). Largemouth bass was the fifth most abundant species collected by number and sixth most abundant species by weight accounting for 4.6% and 4.5% of the sample, respectively. This represents little change from the 2000 survey, and it appears that the largemouth bass population has stabilized in abundance since the 1980s and 1990s.

Other findings of the 2009 survey show that relative abundance of yellow perch, white bass and channel catfish increased from 2000 to 2009, and northern pike were absence in the survey. Also, one large walleye was captured, and the IDNR surmises that it was illegally introduced since there is no stocking information for the species. Bacula and Long (2010) summarize the 2009 survey stating that there are some changes to the lake fishery between 2000 and 2009; however, no management actions are indicated. Likewise no management actions are warranted for rough fish species such as common carp and bullheads as they are in low abundance. In addition, the majority (65%) of gizzard shad collected in 2000 were between a total length of 6.5 and 8.0 inches, whereas 84% of gizzard shad were between a total length of 11.5 and 13.0 inches in 2009. The decline in smaller gizzard shad predicts a better sport fishery, because small gizzard shad can out-compete sportfish for food, thus limiting growth and recruitment of the sportfish populations, namely largemouth bass and bluegill (Bacula and Long, 2010).

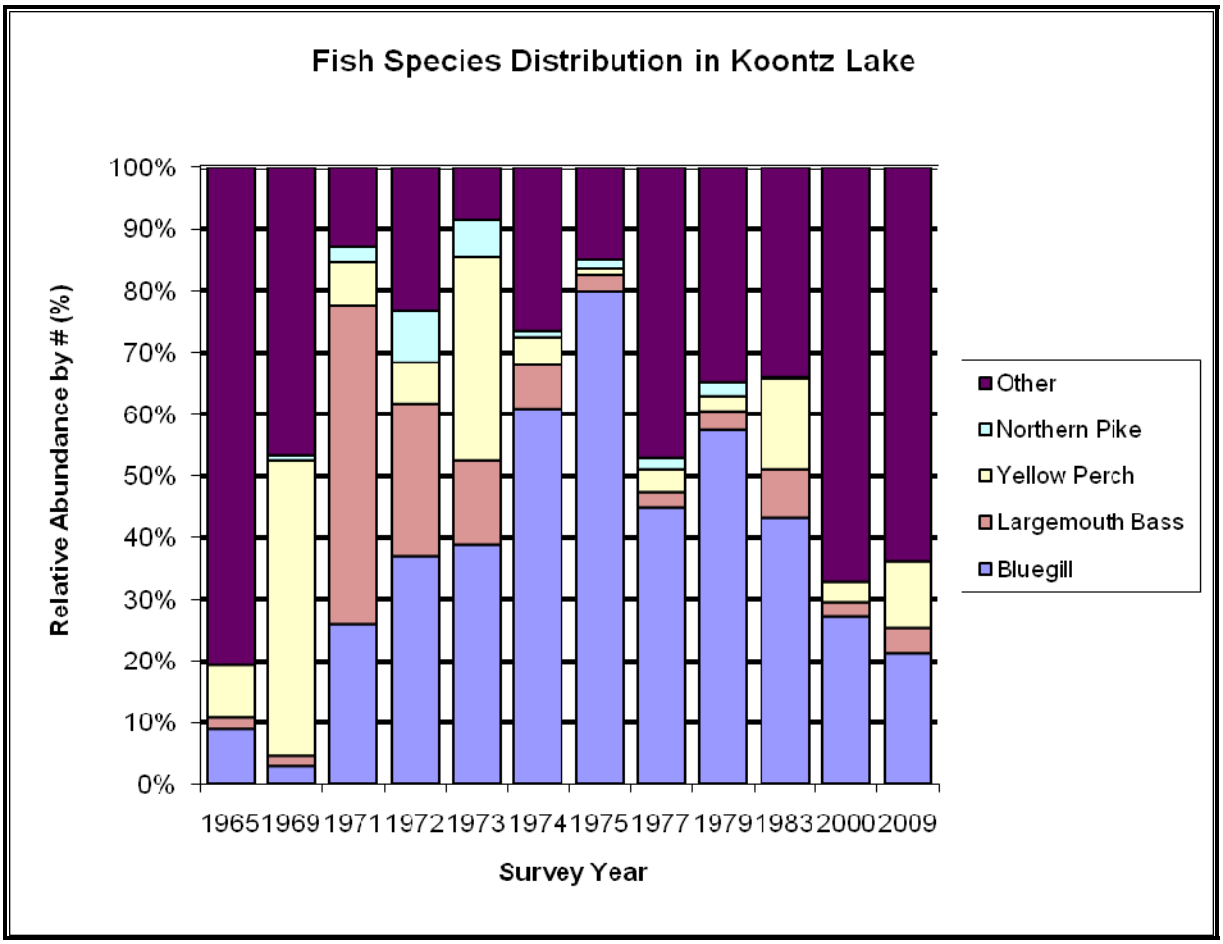


Figure 28. Percent community composition by number of fish collected for Koontz Lake. Source: IDNR, 1965; Hudson, 2001; Robertson, 1969, 1974, 1975a, 1975b, 1978, 1980, 1984; Turner, 1967.

3.4 Aquatic Plants in Koontz Lake

The composition and structure of the lake's rooted plant community often provide insight into the long term water quality of a lake. While sampling the lake water's chemistry (dissolved oxygen, nutrient concentrations, etc.) is important, water chemistry sampling offers a single snapshot of the lake's condition. Because rooted plants live for many years in a lake, the composition and structure of this community reflects the water quality of the lake over a longer term.

The composition and structure of a lake's rooted plant community also help determine the lake's fish community composition and structure. Submerged aquatic vegetation provides cover from predators and is a source of forage for many different species of fish (Valley et al., 2004). However, extensive and dense stands of exotic aquatic vegetation can have a negative impact on the fish community. For example, a lake's bluegill population can become stunted because dense vegetation reduces their foraging ability, resulting in slower growth. Additionally, dense stands reduce predation by largemouth bass and other piscivorous fish on bluegill which results in increased intraspecific competition among both prey and predator species (Olsen et al., 1998).

Vegetation removal can have variable results on improving fish growth rates (Cross et al., 1992, Olsen et al., 1998). Conversely, lakes with lacking plant communities may have difficulty supporting some top predators that require emergent vegetation for spawning. In these and other ways, the lake's rooted plant community illuminates possible reasons for a lake's fish community composition and structure.

A lake's rooted plant community impacts the recreational uses of the lake. Swimmers and power boaters desire lakes that are relatively plant-free, at least in certain portions of the lake. In contrast, anglers prefer lakes with adequate rooted plant coverage, since those lakes offer the best fishing opportunity. Before lake users can develop a realistic management plan for a lake, they must understand the existing rooted plant community and how to manage that community. This understanding is necessary to achieve the recreational goals lake users may have for a given lake.

Because several nuisance and/or exotic aquatic plant species grow in Koontz Lake, KLACC funded an aquatic plant survey and development of an aquatic plant management plan in 2008 in anticipation of receiving funding for treatment of exotic species in Koontz Lake. The plant survey revealed the presence of two submerged, aggressive exotics: Eurasian watermilfoil (Figure 29) and curly-leaf pondweed (Figure 30). Koontz Lake supports purple loosestrife (Figure 31; located during the 2009 IDNR survey), but does not support reed canary grass (Figure 32). It is important for lake residents to beware of these species. As exotic invasive species, all of these species have the potential to proliferate if left unmanaged.

Figure 29. Eurasian watermilfoil (*Myriophyllum spicatum*) and Figure 30. Curly-leaf pondweed (*Potamogeton crispus*).

Figure 31. Purple loosestrife (*Lythrum salicaria*) and Figure 32. Reed canary grass (*Phalaris arundinacea*).

In total, Eurasian watermilfoil covered approximately 82 acres and 42 acres of curly-leaf pondweed of Koontz Lake during the spring survey in 2008. During the summer survey Eurasian watermilfoil was identified in a total of 82 acres of Koontz Lake. No curly-leaf pondweed was found in Koontz Lake during the summer survey. No endangered, threatened, or rare species were identified within Koontz Lake during the spring and summer assessments (JFNew, 2008).

In addition to surveying for aquatic plant species in 2008, JFNew biologists also surveyed for the presence of algae. Their survey indicated that the lake experiences extensive algal blooms. Filamentous algae was encountered at 65% and 74% of the sites sampled in spring and summer, respectively (JFNew, 2009). The plankton community present in Koontz Lake is dominated by blue-green algae per plankton counts conducted in 2009 (Table 10 and discussion in Section 3.2.1)

Lake residents have traditionally applied for and received permits from the DNR to control exotic aquatic vegetation; however, in 2008 KLACC pursued funding for whole-lake treatment of exotic aquatic vegetation and was denied. KLACC will again pursue funding for whole-lake treatment, and in the meantime the lake residents continued to treat the vegetation through their own private permits. The infestation of Eurasian watermilfoil and curly-leaf pondweed continues to be a problem.

Koontz Lake supports native aquatic vegetation, which as described above provides habitat for fish and takes up nutrients. During the 2008 summer survey, JFNew biologists observed that coontail (*Ceratophyllum demersum*) was the most abundant species in Koontz Lake (JFNew, 2008). Coontail was found at the highest percentage of sites throughout the entire sampled water column (24%). Eurasian watermilfoil was identified at only 14% of the sites throughout the entire sampled water column, but had the highest dominance of 12.6. Sago pondweed (*Stuckenia pectinatus*) dominated the shallowest stratum (0-5 foot) and was identified at 46% of the sites at this depth range. Southern naiad (*Najas guadalupensis*), chara (*Chara* spp.), eel grass (*Vallisneria americana*), and coontail were also prevalent in the 0-5 foot stratum and were all present at 38.5% of the sample sites (JFNew, 2008). The abundance of aquatic

vegetation in Koontz Lake indicates that there is a more than adequate nutrient source to support their growth.

IDNR conducted a Tier II aquatic plant survey in 2009 during their fish survey (Bacula and Long, 2010). They encountered 9 identified species and one unidentified species of aquatic plant. The most common species was chara (16%), followed by northern water milfoil (11%), eelgrass (9%) and coontail (7%). Both curly-leaf pondweed and Eurasian watermilfoil were identified during the survey, but were not abundant most likely as a result of effective herbicide application. Filamentous algae were collected at 71% of sampling sites and the maximum depth that plants were encountered was 9 feet. The mean rake score was 0.56 and the maximum number of species found per site was four. IDNR also encountered spatterdock, white water lily, water willow, purple loosestrife, arrowhead, bulrush, and cattail during their survey (Bacula and Long, 2010).

The primary goals of the Aquatic Vegetation Management Plan (JFNew, 2009) are to maintain a stable and diverse aquatic plant community and to reduce the impacts of the invasive plant species. Eurasian watermilfoil frequency of occurrence and dominance was 1.4 and 0.9 for 2009, whereas, in 2008 occurrence and dominance was 14.3 and 12.6, respectively. According to the IDNR, even though there was a decline in invasive species, the native plant community sustained impacts as well by the 2009 herbicide applications. Invasive aquatic and terrestrial plant species need to be controlled, but treatment should minimize impacts to native plant communities. IDNR suggested in their report (Bacula and Long, 2010) that a spring Tier II survey should be conducted in May 2010 to determine species composition before herbicide treatments are approved. KLACC may consider conducting the survey earlier in order to effectively assess populations of curly-leaf pondweed as this species usually appears very early in the season, but dies back readily in late spring and summer.

3.5 Baseline Stream Water Quality Assessments

Under the Clean Water Act, all waterbodies, with a few exceptions, must be capable of supporting aquatic life and recreational beneficial uses. In other words, waterbodies must be "*fishable and swimmable.*" Indiana state law has similar requirements. For purposes of determining whether a stream's chemical water quality meets state or federal standards or recommendations for nutrients in support of the fishable and swimmable goals, Table 11 provides a summary of state standards, EPA guidelines, and recommended concentrations or benchmarks for nutrients. The nutrients with their statutory or recommended levels are presented since one of the major concerns regarding the lake is abundant growth of aquatic plants and algae, which is triggered in large part by nutrient inputs.

Table 11. State or federal standards or recommendations for nutrient concentrations in streams.

Nutrient Species	Standard or Recommendation
Nitrate-nitrogen	• State drinking water standard < 10 mg/L (IAC, 2000) • Recommended nutrient criteria <0.633 mg/L in region (EPA, 2000) • Ohio EPA biotic criteria for warm water habitat streams <1mg/L (Ohio EPA, 1999) • Streams under mesotrophic conditions >0.7mg/L; under eutrophic conditions >1.5 mg/L (Dodd et al., 1998)
Ammonia-nitrogen	• 0.0 to <0.21mg/L based on temperature and pH (IAC, 2000).
Total Kjeldahl Nitrogen	• Recommended nutrient criteria <0.591 mg/L (EPA, 2000); unlikely to be met in Indiana lakes
Total Phosphorus	• Recommended criteria 0.076 mg/L (EPA, 2000); unlikely to be met in Indiana lakes • Ohio EPA recommendation to protect aquatic biota in WWH <0.08 mg/L (Ohio EPA, 1999) • Streams under eutrophic conditions 0.075 mg/L (Dodd et al., 1998)

3.5.1 KLA Stream Assessment

The Koontz Lake Association sponsored a water quality sampling program on Lawrence Pontius Ditch from 2001 to 2005 where field personnel sampled for nitrates, total phosphorus, and fecal coliform. No flow measurements were taken. Sites were selected based on ease of access and interest in measuring below various input points along the ditch. For example, sites were selected above and below Swan Lake Resort since a treatment facility had been installed to treat the resort wastewater. The sampling sites are similar those presented in Figure 1, except that no samples were taken at Spruce Trail Road (Site #1 of the 2009 assessment) or in Schoeder Ditch (See Table 12 for comparison). Samples were sent to Environmental Health Laboratories located in South Bend, Indiana, for analysis. The following table and figures provide the results of their study, and the data are presented such that the most downstream point in the Lawrence Pontius Ditch watershed is the site indicated on the very left of the figures and at the top of the table; this site is labeled “Lake Entrance”. Proceeding upstream, the sites are Dam & 5th (small dam below constructed wetland at 5th Road), Union below SLR (Swan Lake Resort), and 6th above SLR. Medians by year are presented for the nitrate-nitrite (NO_3-NO_2) and total phosphorus (TP) data and geometric means for fecal coliform (FC) by year are presented in Table 12 and Figures 33-35. The data set is presented in Appendix G. Samples for 2001 were only collected at the Dam & 5th site, while only one sample was collected in April during 2005 at each of the sites. During 2003, the Lake Entrance, and the above and below SLR sites were sampled from August through December. The Dam & 5th site was sampled from March through December. During 2004 all sites were monitored from March through December.

Table 12. Median nutrient values and geometric mean fecal coliform values collected during KLA water quality study on Koontz Lake from 2001-2005.

Site	Year	NO_3-NO_2 (mg/L)	TP (mg/L)	FC (MPN)
Lake Entrance	2002	0.05	0.05	34
(= #4 of 2009	2003	1.15	0.08	135
diagnostic study)	2004	1.25	0.05	76
	2005	1.3	0.05	320
Dam & 5th	2001	1.55	0.05	98
(= #3a of 2009	2002	0.9	0.06	358
diagnostic study)	2003	1.8	0.07	142
	2004	1.25	0.05	320
	2005	1.1	0.05	390
Union below SLR	2002	0.7	0.06	1327
(= #3 of 2009	2003	1.15	0.095	494
diagnostic study)	2004	1.6	0.085	394
	2005	1.5	0.05	340
6th above SLR	2002	0.5	0.05	320
(= #2 of 2009	2003	0.9	0.06	344
diagnostic study)	2004	1.3	0.065	151
	2005	1.3	0.05	190

Over all years and sites, nitrate levels ranged from 0.05 mg/L at the Lake Entrance site to 1.55 mg/L at the Dam & 5th Road site. In most cases the median yearly values for nitrates-nitrites exceed benchmark levels indicated in Table 11. Total phosphorus levels ranged from 0.05 mg/L at multiple sites (likely a result of lab detection limits) to a high of 0.095 at the Union below SLR site in 2003. Yearly total phosphorus levels do not appear to exceed the benchmark levels indicated in Table 11. Fecal coliform (FC) measured as most probable number using a filtration technique ranged from a low of 34 in 2001 at the Lake Entrance site to a high of 1,327 in 2001 at the Union below SLR site.

The configuration of Figures 33-35 is intended to show how the concentrations of nutrients and fecal coliform change as one progresses downstream. Figure 33 shows that during 2004 and 2005 nitrate-nitrite levels increased from above SLR to below, then decreased below the constructed wetland and then increased again before entering the lake. It is important to note that a wetland and a sediment trap were constructed on Lawrence Pontius Ditch in 1989 and 1990 to capture sediment and take up nutrients before entering the lake.

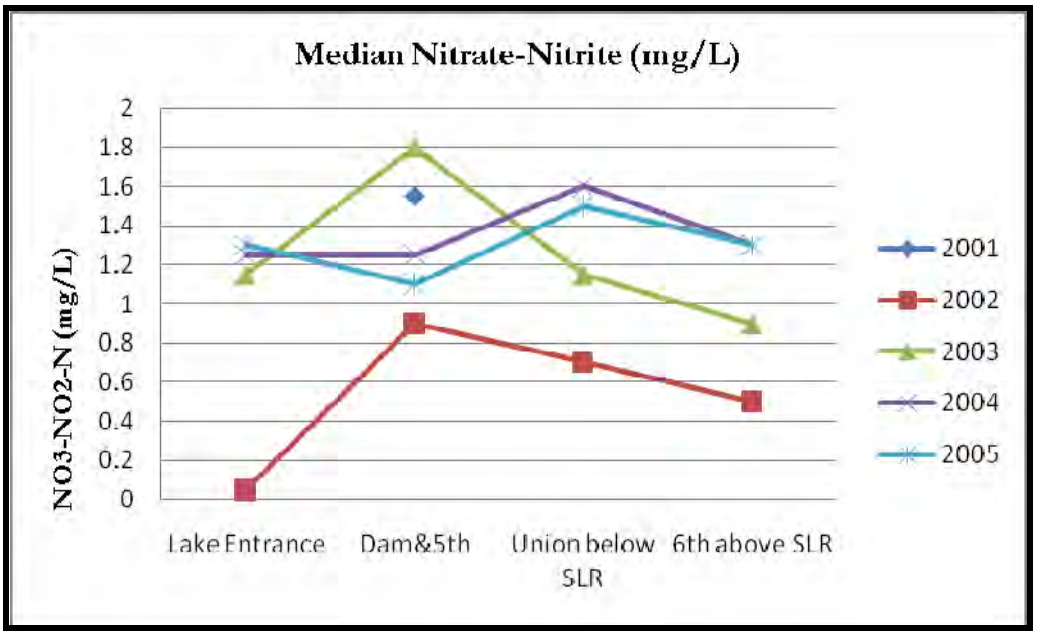


Figure 33. Median Nitrate-Nitrite (mg/L) measured during KLA study, 2001-2005.

Total phosphorus concentrations as shown in Figure 34 indicate that the sediment trap and constructed wetland may have been instrumental in lowering levels before the ditch enters the lake. However, it is also important to note that the ditch after flowing out of the constructed wetland and sediment trap area flows through private property where the horses, cows and other farm animals graze, all of which have access to the water.

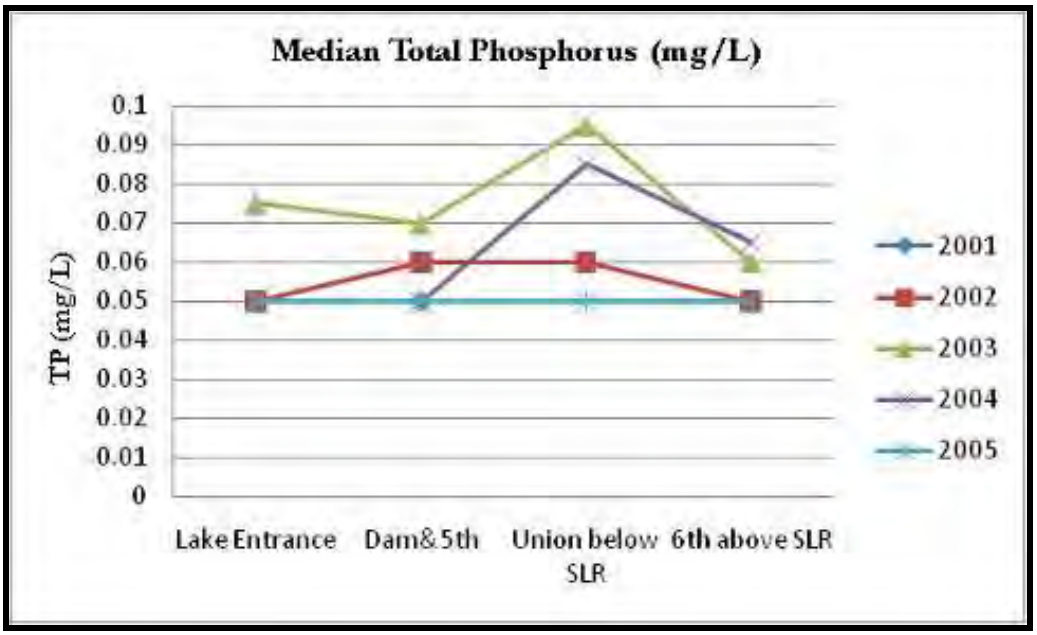


Figure 34. Median Total Phosphorus (mg/L) measured during KLA study, 2001-2005.

Fecal coliform concentrations as shown in Figure 35 appear, with the exception of the 2005 data, to decrease slightly from upstream to downstream.

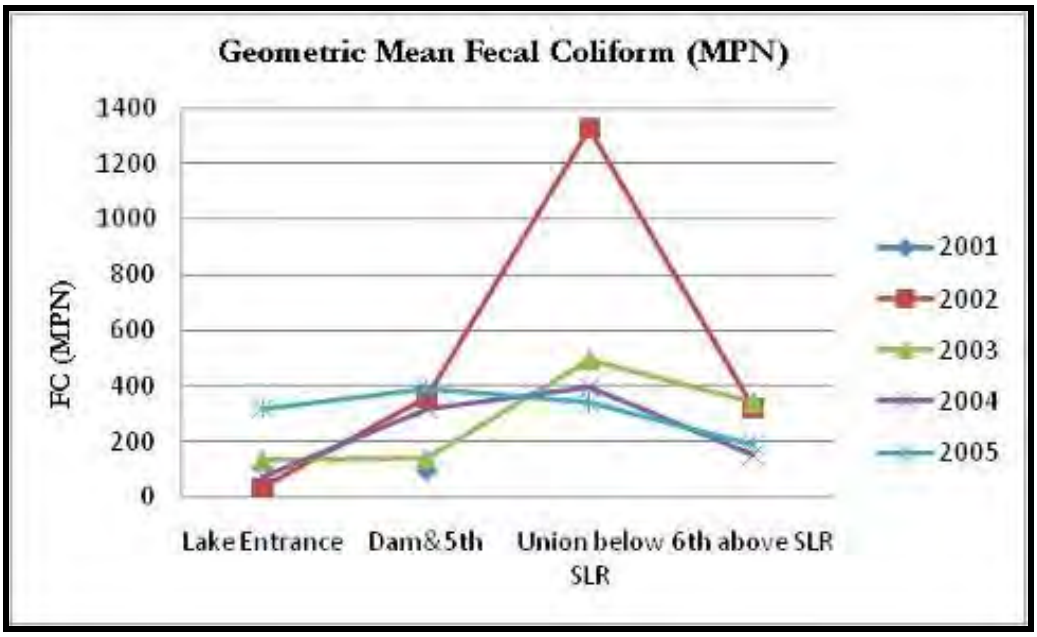


Figure 35. Median Fecal Coliform (MPN) measured during KLA study, 2001-2005.

No nutrient load information can be calculated from the KLA study. However, the study indicates that inputs from upstream may be diminished by the sediment trap and the constructed wetland, but their maintenance may be important to continued reduction of inputs, and that the area between the constructed wetland and the lake entrance may prove an area where additional nutrients are released to the ditch and then on to the lake.

3.5.2 Current Ditch Assessment - 2009

In 2009, JFNew completed a water quality sampling effort on Lawrence Pontius Ditch and Schoeder Ditch, which are the main sources of water to Koontz Lake. Water samples were collected after a storm event on May 14, 2009 and during base flow conditions on July 28, 2009 at sites depicted in Figure 2 and in Photographs 1-6. Water samples were sent to Indiana University for testing, with one exception; the bacteriological samples were sent to Sherry Laboratories in South Bend, Indiana. An additional site located at the dam below the constructed wetland on 5th Road (Site #3a, LPD-5th) was established during the base flow sampling event. The KLAAC felt it was important to distinguish between effects of the constructed wetland and sediment trap and influences from land use downstream of that point. Tables 13 and 14 provide a summary of the in-field physical data and the analyzed water quality samples.

Photograph 2. Site 1 (Spruce Trail) looking downstream on Lawrence Pontius Ditch.

Photograph 3. Site 2 (Plymouth LaPorte Tr.) looking upstream on Lawrence Pontius Ditch. Note adjacent farmland without riparian buffer.

Photograph 4. Site 3 (N Union Rd) looking downstream on Lawrence Pontius Ditch.

Photograph 5. Site 3a (5th below constructed wetland) looking at dam structure on Lawrence Pontius Ditch.

Photograph 6. Site 4 (S Lake Dr above inlet to lake) looking downstream on Lawrence Pontius Ditch.

Photograph 7. Site 5 (Schoeder Ditch) looking downstream on Schoeder Ditch.

Table 13. Physical water quality date collected at Lawrence Pontius (LPD) and Schoeder Ditches.

Site	Stream Name	Date	Event	Flow (cfs)	DO (mg/L)	%DO Sat	pH	Conductivity (µmhos/cm)	Turbidity (NTU)
1	LPD-Spruce Trail	5/15/2009	storm	0	5.9	61.3	7.12	220	15.5
		7/28/2009	base	0	6.37	64.1	7.5	511	4.4
2	LPD-Plymouth LaPorte Tr	5/15/2009	storm	5.01	7.6	78.4	7.5	324	16
		7/28/2009	base	0.578	7.81	85.6	8.08	500	5.3
3	LPD-N Union Rd	5/15/2009	storm	11.35	8.6	86.1	7.66	375	13.5
		7/28/2009	base	1.176	7.14	77	7.94	515	4.5
3a	LPD-5th	7/28/2009	base	0.661	6.18	69.8	7.76	499	9.2
4	LPD-S Lake Dr	5/15/2009	storm	16.73	7.6	76.1	7.45	350	22
		7/28/2009	base	0.061	5.33	59	7.6	485	9
5	Schoeder Ditch	5/15/2009	storm	0.81	5.9	57.0	7.4	377	6
		7/28/2009	base	0.09	7.12	74	7.93	516	4.55

Flow measurements indicate that base line flows are about ten times less than storm flows. None or very low flow was measured at Site #1 which is at the upper end of the watershed, just below Spruce Road and where Lawrence Pontius Ditch surfaces from a tile. At other sites, flows after the storm event ranged from 5 cubic feet per second (cfs)at Site #2 which is above Swan Lake Resort (same site as Union below SLR in KLA study) to 16.73 cfs at Site #4 (same site as the Lake Entrance site of the KLA study). Other than Site #1, flows under base conditions, ranged from as low as 0.061 cfs at Site #4 to 1.176 cfs at Site #3 at N. Union Road below Swan Lake Resort (same site as the Union below SLR site of the KLA study). Flows in Schoeder Ditch ranged from 0.09 to 0.81 cfs.

Benchmark levels for dissolved oxygen (DO) are an average of 5 mg/L over one day and not < 4 mg/L (IAC, 2000). At all sites DO levels are supportive of warm water fisheries, and the saturated oxygen levels indicate that no super-saturation of the water is apparent. The pH levels are also within the state water quality standards, which state that the pH shall be between 6 and 9, except for daily fluctuations above 9 due to photosynthesis (IAC, 2000). The pH ranged from 7.12 at Site #1 under storm conditions to 8.08 at Site #2 under base flow conditions. Conductivity in Lawrence Pontius Ditch ranged from 220µmhos/cm after the storm event at Site #1 to 515µmhos/cm under base flow conditions at Site #3. Conductivity in Schoeder Ditch ranged from 377 to 516µmhos/cm. Recommended levels for turbidity are <10.4 NTU (EPA, 2000). This level was exceeded at Site #1 and at Site #3 after the storm event, which indicates that the water is relatively clear under base flow conditions, but becomes muddy with higher flows.

Table 14. Chemical and biological water quality date collected at Lawrence Pontius and Schoeder Ditches.

Site	Stream Name	Date	Event	NH3-N (mg/L)	NO3-N (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
1	LPD-Spruce Trail	5/15/2009	storm	0.050	0.431	1.716	0.083	0.245	22.94	8300
		7/28/2009	base	0.145	0.092	0.692	0.025	0.049	5.00	855
2	LPD-Plymouth LaPorte Trail	5/15/2009	storm	0.052	0.792	1.317	0.045	0.165	50.94	6700
		7/28/2009	base	0.068	0.191	0.499	0.012	0.053	16.41	509
3	LPD-N Union Rd	5/15/2009	storm	0.099	0.661	1.384	0.026	0.107	49.75	6200
		7/28/2009	base	0.093	0.601	0.581	0.016	0.046	7.80	500
3a	LPD-5th	7/28/2009	base	0.171	0.390	1.000	0.011	0.091	24.24	609
4	LPD-S Lake Dr	5/15/2009	storm	0.011	0.688	1.595	0.017	0.186	91.43	8000
		7/28/2009	base	0.272	0.474	1.898	0.012	0.170	38.01	600
5	Schoeder Ditch	5/15/2009	storm	0.111	0.907	2.152	0.024	0.141	54.17	2200
		7/28/2009	base	0.086	0.954	1.064	0.028	0.091	31.50	800

Exceeds: NO3-N (mg/L) recommended criteria <0.633 mg/L based on 25th percentile of all streams in region (EPA, 2000).
NH_3-N (mg/L) Indiana water quality standards based on table values (Indiana Administrative Code).
TKN (mg/L) recommended criteria <0.591 mg/L based on 25th percentile for all stream in region (EPA, 2000).
SRP (mg/L) recommended level <0.005 mg/L per Wawasee Area Conservancy Foundation for lake systems.
TP (mg/L) recommended criteria of <0.076 mg/L based on 25th percentile for all stream in region (EPA, 2000).
TSS (mg/L) recommended criteria of < 30 mg/L per IDEM draft total maximum daily load target.
E.coli Indiana water quality standard of a geometric mean of < 125 from 5 equally spaced over a 30-day period or <235 colonies/100ml in any one sample in a 30-day period.

Table 14 provides concentrations of nutrients, total suspended solids and bacteria from samples taken at six sites. Numbers that are highlighted in the table indicate an exceedance of the state water quality standards or benchmarks noted by the 319(h) Project Management Guidance Documents (www.in.gov/idem/6242.htm) (See Table 11). Ammonia (NH_3-N) levels ranged from a low of 0.050 mg/L at Site #1 during the storm sampling to a high of 0.272 mg/L at Site #4 (lake entrance) during the base flow sampling. This latter site captures inputs from land use activities that include cattle, horse and other farm animal grazing and their access to the ditch. The Indiana water quality standards (IAC, 2000) for ammonia are based on a range from 0.0 to 0.21 mg/L dependent on temperature and pH levels. Figure 36 shows that ammonia levels generally increased downstream under base flow conditions, but under storm conditions, ammonia levels diminished downstream. (The upstream site is on the left of the graph and the downstream site is on the right.) Ammonia is a reduced form of nitrogen and can be toxic to aquatic organisms in its un-ionized form. Elevated levels may indicate an animal or wastewater source in the vicinity of the sampling site.

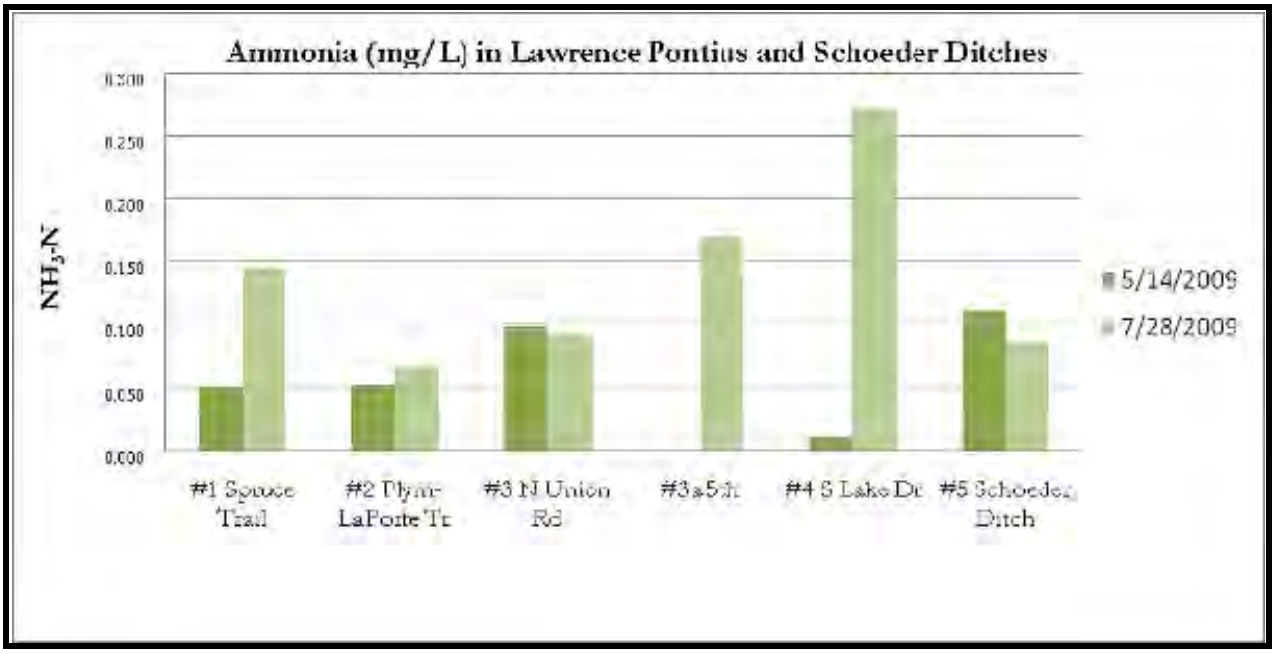


Figure 36. Ammonia levels (mg/L) on Lawrence Pontius and Schoeder Ditches under storm and base flow conditions sampled on 5/14/09 and 7/28/2009, respectively.

The nitrate levels ranged from a low of 0.092 mg/L at Site #1 under base flow conditions to a high of 0.954 mg/L in Schoeder Ditch under base flow conditions. The recommended level of <0.633 mg/L (EPA, 2000) is exceeded on 5 occasions, however, nitrate levels are below the <1.0 mg/L concentration recommended by the Ohio EPA for Warm Water Habitat (WWH) headwater streams and Modified Warm Water Habitat (MWH) headwater streams. Dodd et al. (1998) indicates that streams are under mesotrophic conditions when nitrate levels are greater than 0.7mg/L, and under eutrophic conditions when nitrate levels are greater than 1.5 mg/L; thus, Schoeder Ditch exhibits eutrophic conditions based on this criterion. Figure 37 indicates that under storm flow conditions, nitrates levels rose slightly at the upstream end on Lawrence Pontius Ditch, then fell downstream below the Swan Lake Resort (Site #3), and then rose slightly to a level of 0.688 mg/L at Site #4 S. Lake Dr (lake inlet or entrance). Under base flow conditions, nitrate concentrations rose until Site #3 (N. Union Rd which is below Swan Lake Resort), declined below the constructed wetland (Site #3a), then rose to a level of 0.474 mg/L at Site #4. This latter concentration does not exceed either the EPA (2000) recommended level of 0.633 mg/L or the Ohio EPA recommended level of 1.00 mg/L. Samples from Schoeder Ditch exceeded the recommended EPA (2000) level.

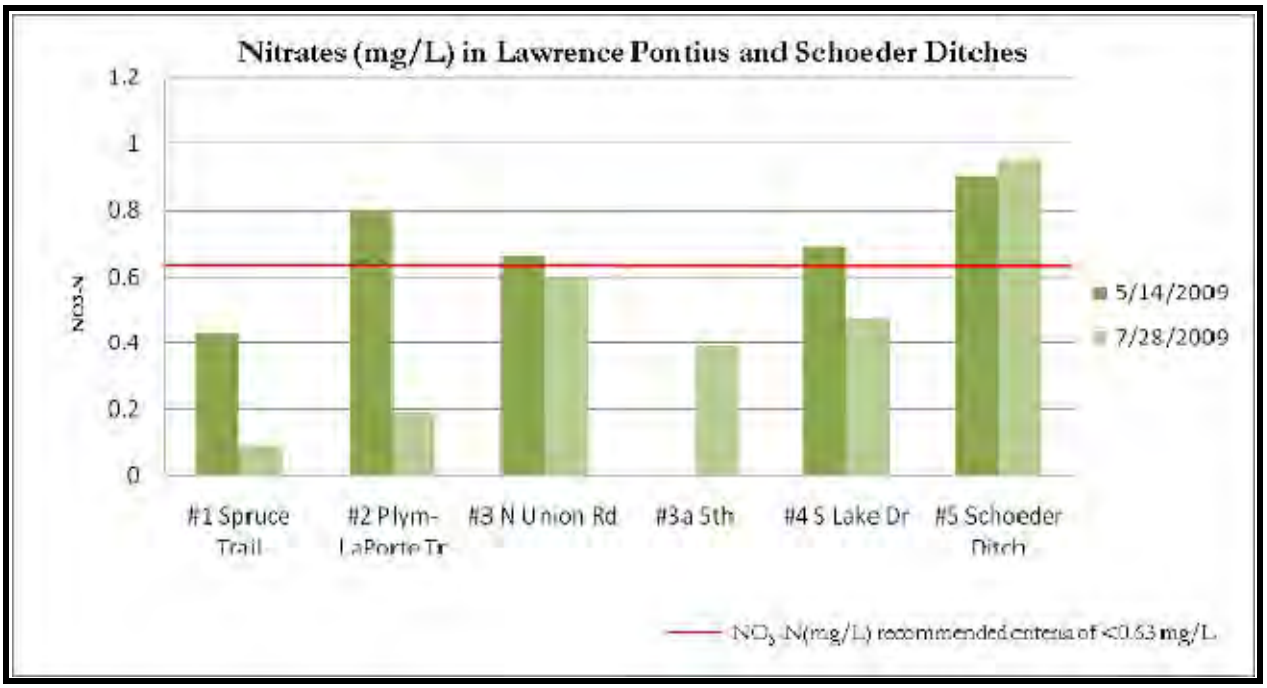


Figure 37. Nitrate levels (mg/L) on Lawrence Pontius and Schoeder Ditches under storm and base flow conditions sampled on 5/14/09 and 7/28/2009, respectively.

Total Kjeldahl Nitrogen (TKN) is a measure of inorganic nitrogen plus ammonia and it provides a fairly good picture of all the nitrogen in the water sample, some of which may not be available for uptake by aquatic plants and algae. TKN concentrations ranged from a low of 0.499 mg/L at Site #2 under base flow conditions to a high of 2.152 mg/L at Site #5 under storm flow conditions. The recommended level for TKN is <0.591 mg/L (EPA, 2000), and several samples contained levels higher than the EPA recommended level (See Table 11). Figure 38 shows that under storm flow conditions, TKN was higher in the upper watershed, diminished in the middle portion of the watershed, but rose after flow through the last reach of the ditch before it enters Koontz Lake. Under storm flow conditions in Lawrence Pontius Ditch, TKN levels generally rose from upstream to downstream.

Total phosphorus is a measure of this particular nutrient in both dissolved and undissolved forms. The dissolved form, known as soluble reactive phosphorus (SRP, aka ortho-phosphate), can serve as a source of nutrients to aquatic plants and algae, while the undissolved form is not readily taken up by plants and algae. Total phosphorus levels ranged from a low of 0.046 mg/L at Site #1 under base flow conditions to a high of 0.245 mg/L at Site #1 under storm flow conditions. Most of the samples contained total phosphorus levels which exceed the EPA (2000) recommended level of 0.08 mg/L and recommended level of 0.075 mg/L thats indicate eutrophic conditions in streams (Dodd et al., 1998). Figure 39 shows, that under storm flow conditions, total phosphorus decreased from upstream to downstream, but rose at Site #4. Under base flow conditions, total phosphorus concentrations remained generally the same until the downstream Site #4 where they rose to 0.170 mg/L. Recall that above Site #4 and below Site #3a, land use activities such as grazing farm animals,

occur. Phosphorus inputs from this reach are probable and likely related to the land use activity.

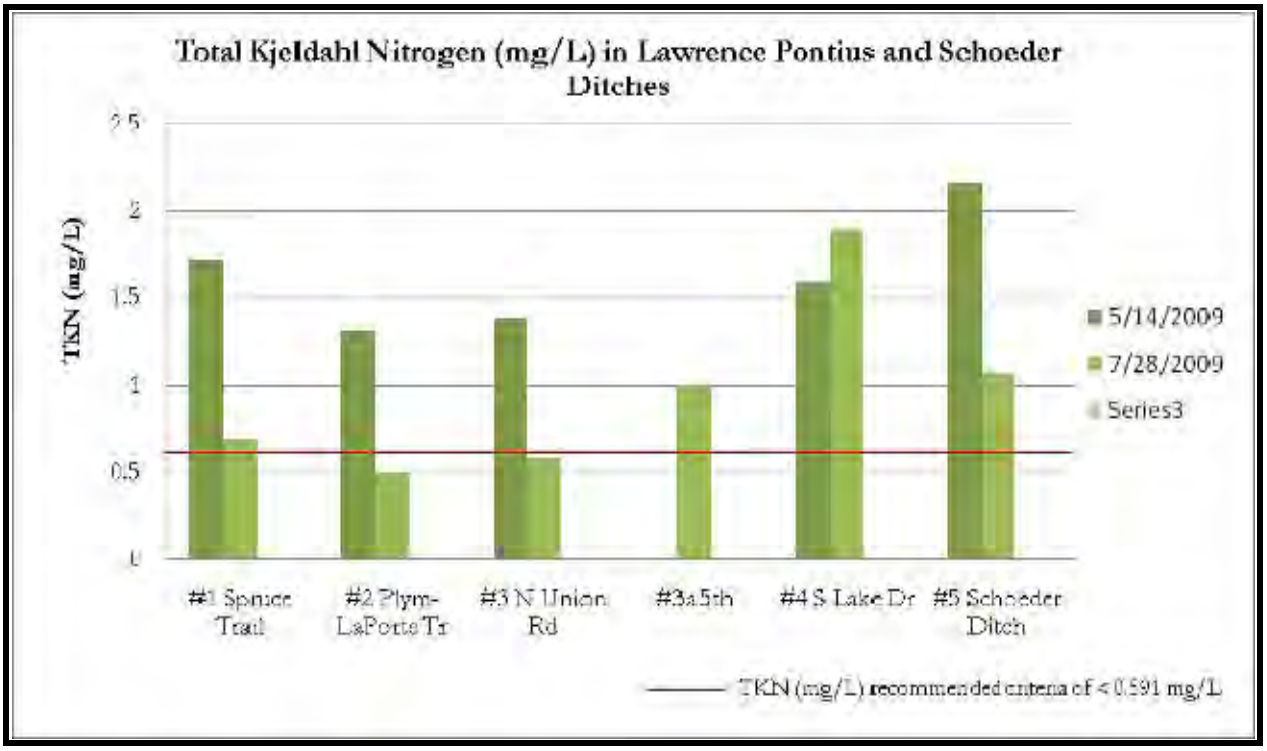


Figure 38. TKN levels (mg/L) on Lawrence Pontius and Schoeder Ditches under storm and base flow conditions sampled on 5/14/09 and 7/28/2009, respectively.

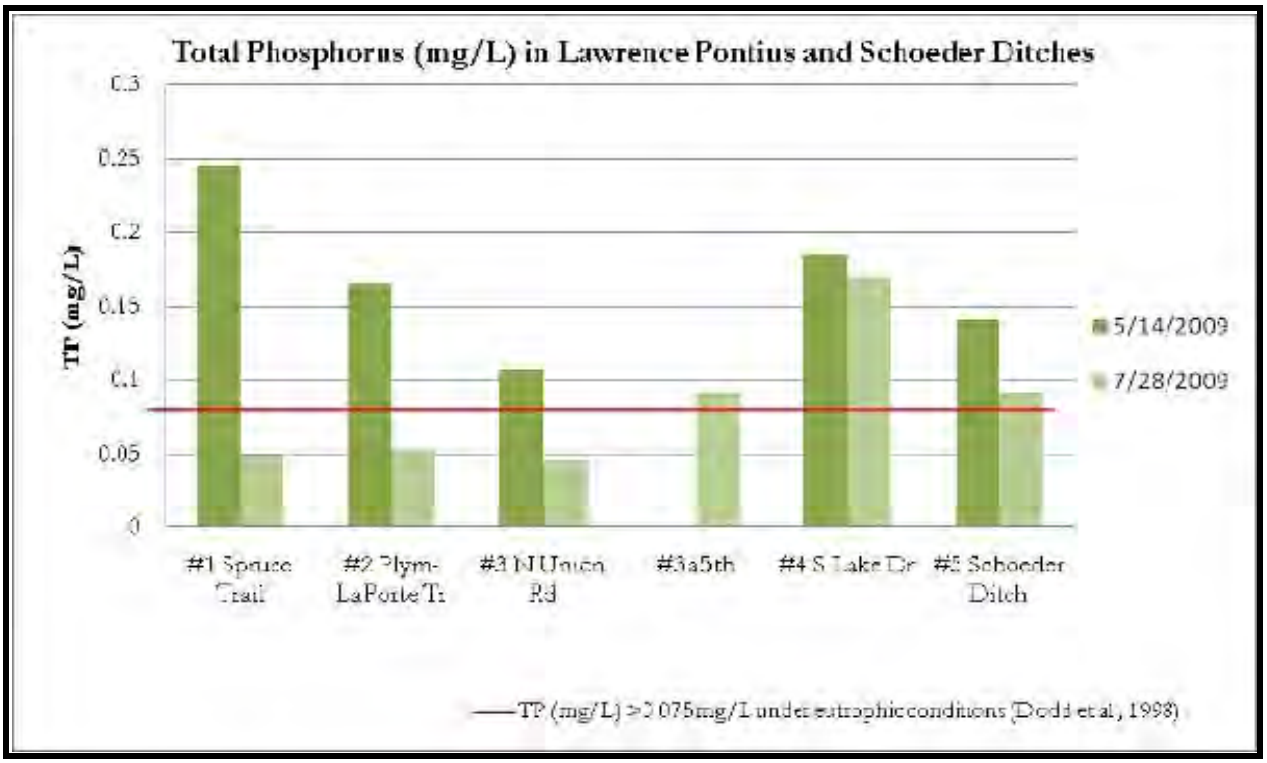


Figure 39. Total Phosphorus levels (mg/L) on Lawrence Pontius and Schoeder Ditches under storm and base flow conditions sampled on 5/14/09 and 7/28/2009, respectively.

Soluble reactive phosphorus (SRP) ranges from a low of 0.011 mg/L at Site #3a under base flow conditions to a high of 0.083 at Site #1 under storm flow conditions. Site #1 is located where Lawrence Pontius Ditch emerges from a tile, where the land is highly eroded due to a broken tile, and where cattle graze. Figure 40 reveals that the Wawasee Area Conservancy Foundation's recommended level of 0.005 mg/L at area lakes is exceeded by all samples. SRP can contribute to aquatic plant and algal growth at the levels found during the 2009 sampling season.

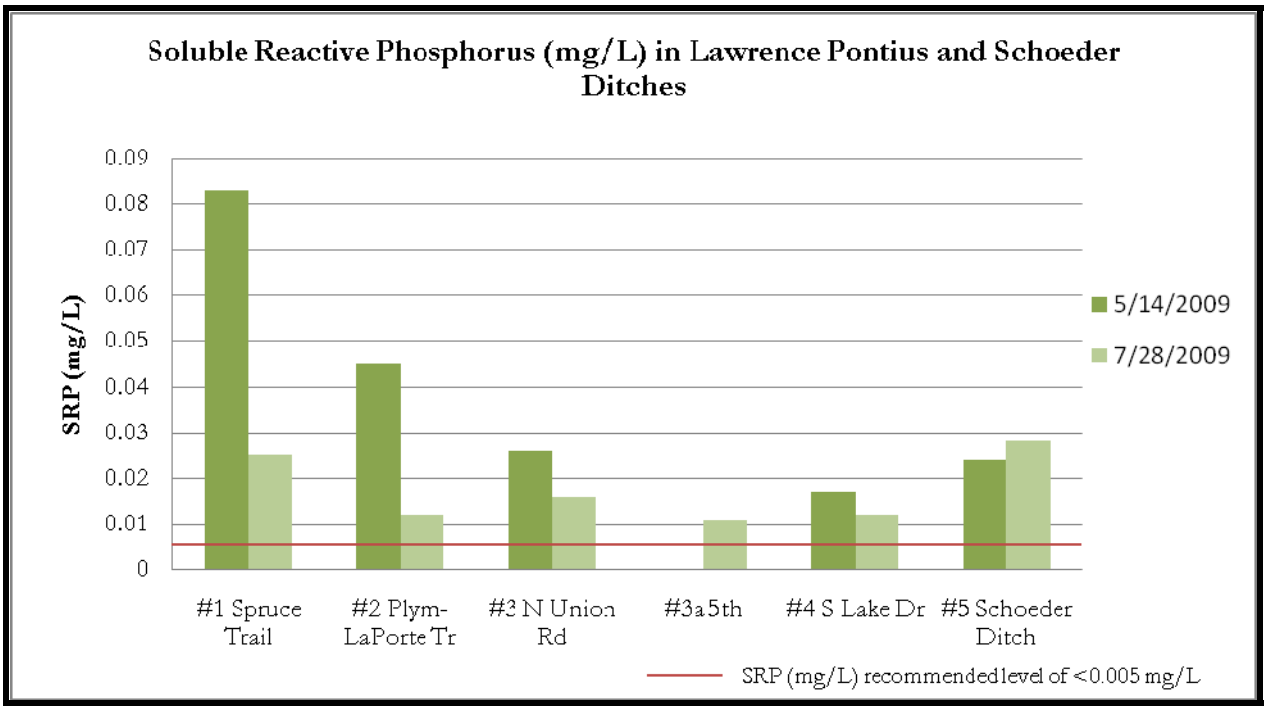


Figure 40. SRP levels (mg/L) on Lawrence Pontius and Schoeder Ditches under storm and base flow conditions sampled on 5/14/09 and 7/28/2009, respectively.

Under storm flow conditions, the concentration of SRP diminished going downstream, as it did under base flow conditions. Concentration of SRP under both flow regimes was above 0.02 mg/L in Schoeder Ditch, well above the recommended level of 0.005 mg/L.

Total suspended solids (TSS) reveals how much sediment is suspended in the water column. TSS ranged from a low of 5.00 mg/L under base flow conditions at Site #1 to a high of 91.43 mg/L under storm flow conditions as Site #4. IDEM has developed draft total maximum daily loads (TMDLs, to be discussed in Section 4.5) of <30 mg/L. This level is exceeded at Sites #2 and #3 under base flow conditions, and at #4 and #5 under both flow conditions. Sediment may have phosphorus adhered to it, which can be released under conditions lacking oxygen such as you would find at the bottom of Koontz Lake. Figure 41 shows that under storm conditions, TSS rose from upstream to downstream, and under base flow conditions, TSS varied from downstream to upstream, but reached its highest level of 38.01 mg/L at Site #4.

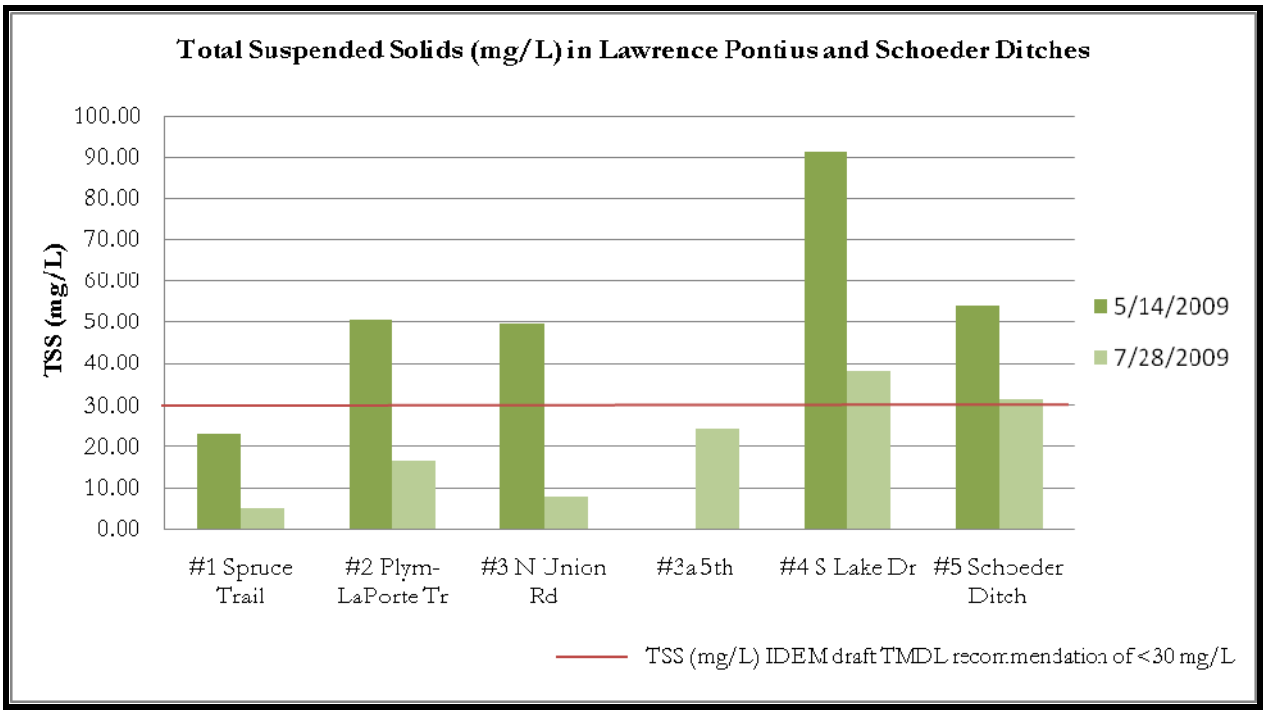


Figure 41. TSS levels (mg/L) on Lawrence Pontius and Schoeder Ditches under storm and base flow conditions sampled on 5/14/09 and 7/28/2009, respectively.

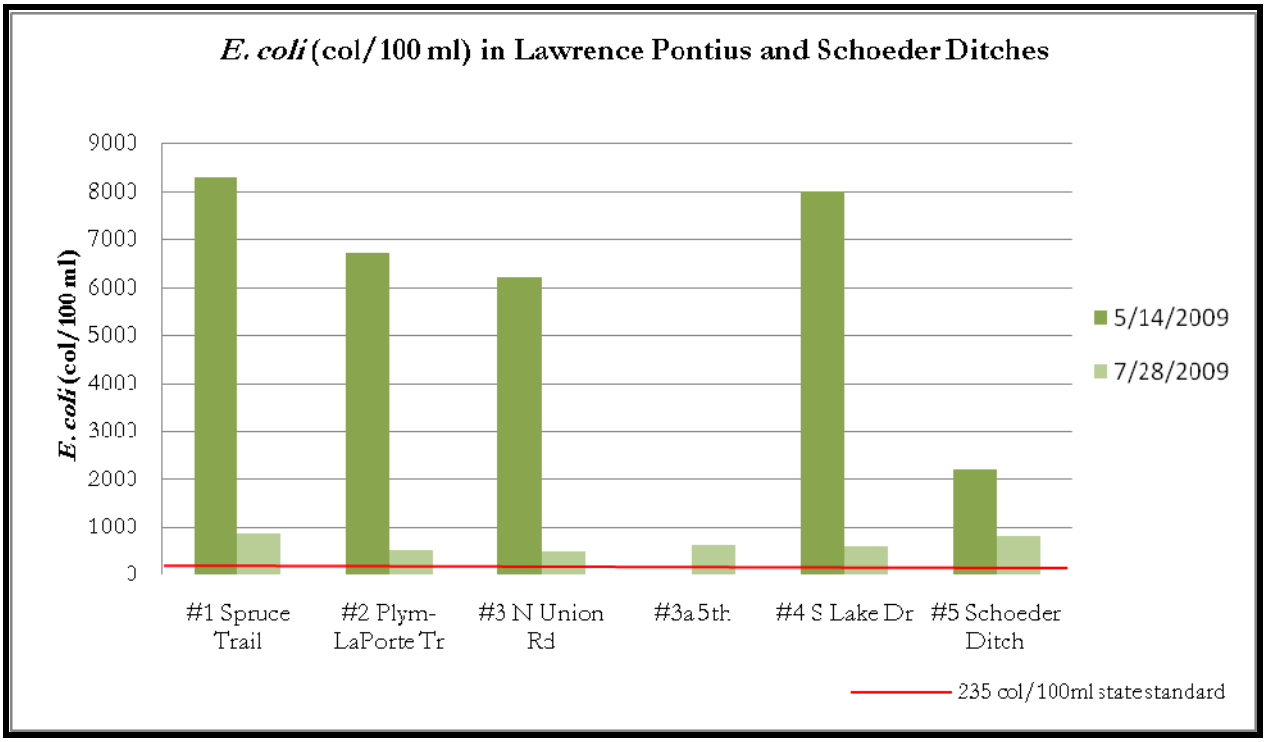


Figure 42. *E. coli* levels (col/100 ml) on Lawrence Pontius and Schoeder Ditches under storm and base flow conditions sampled on 5/14/09 and 7/28/2009, respectively.

E.coli measures the degree to which fecal contamination may occur in water. Its presence generally indicates a source of contamination coming from somewhere such as a septic system, a farm or wildlife entering the stream and defecating. Levels of *E.coli* ranged from a low of 500 col/100 ml at Site #3 under base flow conditions, to a high of 8300 col/100 ml) at Site #1 under storm flow conditions, both of which exceed the state water quality standards of 125 col/100 ml from 5 equally spaced samples over a 30-day period, or 235 col/100 ml in any one sample in a 30-day period (IAC, 2000). It is not unusual for Indiana waters to display high *E.coli* levels, but of interest is the high level found in the upper watershed where Lawrence Pontius Ditch exits the tile at Site #1. At this site, bacterial levels may be high due to cattle grazing, failed septic systems or wildlife use. Figure 42 shows that under storm water conditions the bacterial levels increased 10-fold at most sites. The levels of *E. coli* at the site below Swan Lake Resort (Site #3) were generally lower than those encountered upstream and downstream.

We calculated loading and areal loading of nutrients and sediments to Koontz Lake. These calculations provide information on how much material is moving through the ditches and eventually reaching the lake. Calculating load at various points in a watershed is important for a lake association because it can pinpoint the source of the pollutant and whether the loading exceeds acceptable levels such as those predicted by Vollenweider (1975) (see discussion in Section 4.5). Loading is the concentration of the nutrient or the sediment in the water (see Table 13) multiplied by discharge (e.g. cubic feet or meters per second) resulting in a measurement of weight per time period such as kg/d as presented in Appendix H. Areal loading is also an important calculation and is the load divided by the subwatershed size. It predicts which subwatersheds contribute the greatest loads in comparison to other watersheds based on unit size.

Appendix H provides tables and graphs of the loads and areal loads for nutrients and sediments. Loading of nitrates is highest under storm flow conditions. This is not unusual because under these conditions, more water carries more materials from various sources such as surface runoff, feedlots and hard surfaces. Nitrate loading ranged from a low of essentially 0.0 kg/d under base flow conditions at Site #1 to a high of 28.16 kg/d at Site #4 at the inlet to the lake. (Under base flow conditions no measurable flow occurred at Site #1 thus resulting in no loading of nitrates at this site.) Areal loading of nitrates was the highest (28.53 kg/ha-yr) at Site #5 on Schoeder Ditch. This indicates that Schoeder Ditch per its unit area contributes the highest amount of nitrate to the system compared to other subwatersheds.

Loading of ammonia ranged from a low of 0.0 kg/d at Site #1 under base flow conditions to a high of 2.75 kg/d at Site #3 under storm flow conditions. Site #3 is located below Swan Lake Resort where a wastewater treatment facility can contribute to high ammonia levels if the treated of wastewater does not include adequate aeration. Areal loading of ammonia was calculated to be the highest at 3.49 kg/ha-yr at Site #5 under storm flow conditions.

Loading of Total Kjeldahl Nitrogen was calculated to be the highest at 65.27 kg/d at Site #4 under storm flow conditions. Areal loading of Total Kjeldahl Nitrogen is highest at 67.70 kg/d-yr at Site #5 (Schoeder Ditch) under storm flow conditions.

Site #3 possessed the highest loading of soluble reactive phosphorus (SRP) calculated as 0.722 kg/d under storm flow conditions. Again, Site #5 possessed the highest areal loading of SRP at 0.755 kg/ha-yr under storm flow conditions. Site #4 possessed the highest loading of total phosphorus calculated as 7.61 kg/d under storm flow conditions. Areal loading for total phosphorus was highest at Site #5 at 4.44 kg/ha-yr under storm flow conditions.

Loading for total suspended solids (TSS) was highest at Site #4 under storm flow conditions with a calculated level of 3741.61 kg/d. Areal loading was highest at Site #5 under storm flow conditions with a calculated level of 1704.06 kg/ha-yr.

Under storm flow conditions, loading increased for all parameters from upstream to downstream in Lawrence Pontius Ditch, with two exceptions: ammonia loading was highest at Site #3 located below Swan Lake Resort, and SRP loading revealed similar levels at all sites on Lawrence Pontius Ditch. Calculated loading levels at Site #5 (Schoeder Ditch) were always lower than those calculated for the Lawrence Pontius Ditch sites. Under storm flow conditions, areal loading was consistently higher at Site #5 than at all the other sites on Lawrence Pontius Ditch. The implications are that as one progresses through the watershed the amount of nutrient and sediment loading increases, particularly between sites #3a and 4, and areal loading is highest for nutrients and sediments in Schoeder Ditch compared to Lawrence Pontius Ditch.

3.5.3 Biological Assessment of Ditches - 2009

Biological assessment or biomonitoring is a very important means of determining whether a waterbody is able to support fish and aquatic insects. While taking a water sample provides a one-snap shot of current water quality conditions in a stream, monitoring the biota provides a long-term overview of the stream's water quality because the organisms are exposed to the water chemistry and the site's habitat for a majority of their lifecycle. We used the EPA's Benthic Macroinvertebrate Protocol II (EPA, 1990 and EPA, 1999) to collect and to interpret water quality based on the presence of certain families of macroinvertebrates. The method provides a systematic field collection and analysis method to determine how benthic macroinvertebrate groups reflect habitat and water quality conditions (IDNR website accessed 12/09). High overall biodiversity exemplified by a high number of families indicates that a wide range of habitat and food resources exist with very little water pollution. Because different families of macroinvertebrates have particular needs for feeding, reproduction, and pollution tolerance, they each garner a score for each of these characteristics. The scores are predictive of the quality of the physical habitat or water chemistry.

For the purposes of this study, we selected two sites, one from Lawrence Pontius Ditch and a reference site in Potato Creek. Per LARE and the 319 Non-point Pollution program requirements, a reference site must be assessed and used as a means of

determining how well the study site's condition fares against the reference site. Due to resource limitations, only one site on Lawrence Pontius Ditch was selected. Site #3 (N Union Road) was selected since it was accessible and representative of the majority of the ditch. The reference site, Potato Creek below the Potato Creek Nature Preserve in Potato Creek State Park, was selected for the following reasons: location within the same 8-digit watershed; proximity to the study site; natural setting; and lack of stressors.

We employed the methodology outlined in IDNR's Protocol for Macroinvertebrate Sample Collections and Index Calculation (IDNR website, accessed 12/09). One kick net sample was collected from each of two riffle sections located within a 300-foot reach of Site #3 and the reference site. Samples were collected in a screen-bottomed bucket and all macroinvertebrates were transferred from the bucket and kick net screen to a 1 quart, wide mouth jar. Since there were a total of 114 and 130 organisms collected at Site #3 and Potato Creek, respectively, all individuals were identified to family, and tallied in the electronic bench sheets. The macroinvertebrate index of biotic integrity (mIBI) scores and the metrics for the Rapid Bioassessment Protocol II (RBP II) were calculated and used to assess water quality.

Prior to discussing the results, it is important to understand that the mIBI index score and RBP II metrics signify the quality of the waterbody, and in essence, reflect the ability of the water quality and habitat to support aquatic life. Tables 15 and 16 present the mIBI scores, their associated classifications, and IDEM's criteria for aquatic life use support. Note that in Table 16 the Qualitative Habitat Use Evaluation (QHEI) is a measure of habitat quality for aquatic organisms, whereby the habitat either fully supports, partially supports or does not support aquatic life. This is discussed more fully in Section 3.5.4. The scores and metrics for Site #3 and the reference site are presented in Tables 17 through 20.

Table 15. Macroinvertebrate Index of Biotic Integrity scores and associated classification.

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

Table 16. IDEM's criteria for aquatic life use support.

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

Source: IDEM, 2004.

Samples from Site #3 and Potato Creek were collected on July 24, 2009. The evaluation of the Lawrence Pontius Ditch biological community at Site #3 (N Union Rd) indicates that the ditch partially supports its aquatic life use designation as determined by IDEM. The mIBI score of 2.9 signifies moderately impaired conditions in the ditch (Table 17). With a total of 9 taxa encountered, Lawrence Pontius Ditch appears to support a low variety of macroinvertebrate. The number of individuals collected at the site totaled 114 with the majority consisting of amphipods in the family Gammaridae, and caddisflies (tricopterans) in the family Hydropsychidae. While caddisflies are typically indicators of good water quality, this particular family harbors several taxa that are tolerant of low quality waters. The HBI (modified Hilsenhoff Biotic Index value) of 4.17, another indicator of the biological community's tolerance to levels of water quality, indicates slight organic pollution in the ditch. The EPT acronym stands for ephemeroptera, plecoptera and tricoptera, which are families of macroinvertebrates less tolerant of pollution. When these organisms are lacking in abundance, water pollution is likely present. In Table 17, there are several scores for metrics which use EPT counts. Since Site #3 was not dominated by EPT families, the respective metric scores were low. The data set for collected organisms is presented in Appendix H.

The Rapid Bioassessment Protocol II (RBP II) (EPA, 1990; EPA, 1999) metric results are presented in Table 18 for Site #3 on Lawrence Pontius Ditch. The ratio of scrapers to filters is zero, which indicates that the waters are not typically muddy and can support taxa that require clear water to filter. The EPT to chironomid ratio is 8 indicating that more individuals in the EPT category, and in this case, tricopterans, were found than chironomids. The percent dominance reveals that there is an over abundance of one taxa (Gammaridae), and thus the site does not possess high diversity. The EPT indices show that few of the more water quality intolerant species are present. In other words the water is not supportive of good water quality taxa. The Community Loss Index of 0.78 compares the Lawrence Pontius Ditch to a nearby reference site, which is discussed next.

Table 17. mIBI Metric Score for Site #3 (N. Union) on Lawrence Pontius Ditch.

mIBI Metric		**Metric Score**
HBI	4.17	6
No. Taxa (family)	9	2
Total Count (# individuals)	114	2
% Dominant Taxa	69.3	0
EPT Index (# families)	1	0
EPT Count (# individuals)	16	0
EPT Count/Total Count	0.14	2
EPT Abun./Chir. Abun.	8.00	6
Chironomid Count	2	8
mIBI Score		**2.9**

Table 18. Metrics for the RBP II Site #3 (N. Union) on Lawrence Pontius Ditch.

Metric Scoring	Metric
No. Taxa (family)	9
HBI	4.17
Scrapers/Filterers	0
EPT Abun./Chir. Abun.	8.00
% Dominant Taxa	69.3
EPT Index (# families)	1
Community Index Loss	0.78
Jaccard Coefficient Community	0.40
% Shredders/Non-shredders	0/0

The reference site is located on Potato Creek above Worster Lake, but below the Nature Preserve, at Potato Creek State Park. The evaluation of the reference site biological community indicates that the creek is fully supporting of its aquatic life use designation as determined by IDEM. The mIBI score of 4.4 signifies slightly impaired conditions in Potato Creek (Table 19). With a total of 13 taxa encountered, Potato Creek appears to support a low variety of macroinvertebrates, though higher than Site #3 on Lawrence Pontius Ditch. Similar to Site # 3, the number of individuals collected at the creek totaled 130 with the majority consisting of amphipods in the family Gammaridae, and caddisflies (tricopterans) in the family Hydropsychidae. The HBI (modified Hilsenhoff Biotic Index value) of 4.05 indicates slight organic pollution in the ditch.

The ratio of scrapers to filters is zero while the EPT to chironomid ratio is 9.20 indicating that more individuals in the EPT category, and in this case, tricopterans, were found than chironomids (Table 19). The percent dominance reveals that there is an over abundance of one taxa (Gammaridae) and thus the site does not possess high diversity; however, its aquatic macroinvertebrate diversity is higher than that at Site # 3. The EPT indices reveals a total of 46 tricopterans out of a total of 130 individuals, and thus an EPT index of 0.35 compared to an index of 0.14 for Site # 3. The Community Loss Index of 0.78 compares the Lawrence Pontius Ditch to the reference reach on Potato Creek. A higher number shows that more species are missing from the collection site than would have been expected under high quality conditions, and in this case the 0.78 metric indicates dissimilarity between Lawrence Pontius Ditch and the reference site. Site #3 possessed a Jaccard Coefficient of Community Similarity (EPA, 1989) metric of 0.40. The coefficient ranges from 0 to 1.0, therefore, the higher the similarity the higher the number. With respect to Site #3 and the reference site, there are some similarities, but they are not overwhelming; Site #3 and the reference site possessed 6 taxa in common, but only 3 species were present at Site #3 that were not present at the reference site, and more importantly, the reference site supported 6 taxa not found at Site #3.

For purposes of comparing the reference site to the collection site, we present Table 19, which assigns a score to the value calculated for a number of metrics, and then through a rating system determines the impairment level of the collection site. Table 19

indicates that Site #3 is slightly impaired compared to the reference site. It underperforms in 4 of the 9 metric categories, including the number of taxa, the percent dominant taxa, the EPT Index, and the Community Loss Index.

Table 19. Metrics for the RBP II for the reference site on Potato Creek in Potato Creek State Park and the collection Site#3 on Lawrence Pontius Ditch. (Source: IDNR website, accessed 12/09).

Metric Scoring	Metric Value		Score	
	Reference Site	Site #3	Reference Site	Site #3
No. Taxa (family)	13	9	6	4
HBI	4.05	4.17	6	6
Scrapers/Filterers	0	0	6	6
EPT Abun./Chir. Abun.	9.20	8.0	6	6
% Dominant Taxa	45.4	69.3	6	4
EPT Index (# families)	1	2	6	2
Community Loss Index	1	0.78	6	4
% Shredders/Non-shredders	0	0	6	6
TOTAL			48	38
% of Reference			100%	79%
Impairment Category				S*

*slightly impaired

The results of the bioassessment at Site #3 corroborate the results of the water quality study. The macroinvertebrates families collected at that site are representative of moderately impaired conditions and are tolerant of poorer water quality conditions.

3.5.4 Qualitative Habitat Evaluation (QHEI) of Ditches - 2009

Lastly, JFNew performed a habitat quality assessment at Site #3 and the reference site using the Qualitative Habitat Evaluation Index (QHEI) (Rankin, 1989) on July 28, 2009. The QHEI measures the quality of habitat suitable for aquatic organisms. The presence of substrate including boulders, cobbles, and sandy and gravelly provide a varied habitat for macroinvertebrates in which to hide and feed. Instream cover such as overhanging vegetation and undercut banks also provide good quality habitat. Channel morphology is an indication of how sinuous the stream is; high sinuosity implies better habitat. Riparian area width is important to a stream since wide riparian areas filter runoff from adjacent agricultural fields. In addition, the vegetation within the riparian area provides a food source for aquatic organisms in the stream. Lack of bank erosion indicates that little sediment is being contributed to the stream. The pool/glide and riffle/run metrics are additional measures of habitat diversity for aquatic biota, particularly fish.

The QHEI value for Site #3 was 19 and for the reference site at Potato Creek 56.5. The ratings indicate that Site #3 which is located on Union Road below Swan Lake Resort is not supporting of aquatic life while the reference site is partially supporting of aquatic life. Table 20 provides the scores that each site received.

Table 20. Qualitative Habitat Evaluation Index for Potato Creek (reference site) and Site #3 on Lawrence Pontius Ditch, 7/28/2009.

Site	Reference Site	Site #3
QHEI Value	56.5	19
Substrate (20 pts max)	14	3
Instream Cover (20 pts max)	8	3
Channel Morphology (20 pts max)	16	7
Riparian Zone & Bank Erosion (10 pts max)	10	4
Pool/Glide Quality (12 pts max)	4	0
Riffle/Run Quality (8 pts max)	2.5	0
Gradient (10 pts max)	2	2

The reference site possessed a substrate value of 14 out of a possible 20 versus 3 for Site #3, indicating that gravel and sand dominates the reference site streambed while silt dominates Site #3's streambed. The reference site scored an 8 for instream cover, while Site #3 scored a 3. The reference site supported undercut banks, overhanging vegetation, boulders, shallows, and logs and woody debris. Though these features were sparse in the reference channel, Site #3 supported only undercut banks and these were nearly absent. The reference site scored a value of 16 for channel morphology, while Site #3 scored a value of 7. The difference between the two is based on the fact that the reference site does not reveal channelization whereas Site #3 is located on a manmade ditch. The reference site scored a value of 10 for the riparian zone category, while Site #3 scored a value of 4. The reference site possesses a wide riparian area greater than 50 meters, which supports a forested canopy, while Site #3 has a narrow riparian area with open pasture on each side of its banks. The reference site scored a value of 4 for the pool/glide quality while Site #3 possessed a value of 0. Potato Creek is a small stream and does not have great depth in its pools, but Site #3 does not possess pools as it is a channelized system. The reference site scored a value of 2.5 while Site #3 possessed a value of 0. These low scores indicate that both systems possess relatively poor riffle/run quality. Both of the reference site and Site #3 are low gradient systems with small watersheds of 1.3 and 3.6 sq. miles, respectively and therefore score low on the gradient parameter.

In summary, the QHEI for Site #3 is indicative of its nature; it is a ditch, and though excavated in the 1930s continues to serve as drainage for the surrounding agricultural and residential lands. Both poor water quality and poor habitat play a large role in limiting the numbers and the types of macroinvertebrates found in the system.

4.0 BASELINE WATERSHED CONDITIONS

Collection and analysis of chemical and biological data from the lake and ditches combined with watershed tours helped establish a better understanding of the Koontz Lake watershed. In this section, we describe the outcomes of the watershed tour and combine that with data analysis of the chemical and biological data. This process leads to selecting sites for future water quality improvement projects. KLACC with JFNew

toured the Koontz Lake watershed on October 13, 2008 and May 8, 2009, and the lake on May 19, 2008. JFNew as part of the aquatic plant survey toured the lake on May 27, 2008 and August 29, 2008.

Figure 43 depicts the areas of concern identified through the watershed tours, stakeholder meetings, and discussions with stakeholders and data collection. Within these areas of concern are multiple examples of bank erosion or non-point source pollution, the solution to which would be a collaborative effort with landowners and public agencies. The following discussion and presentation of photographs highlights the concerns.

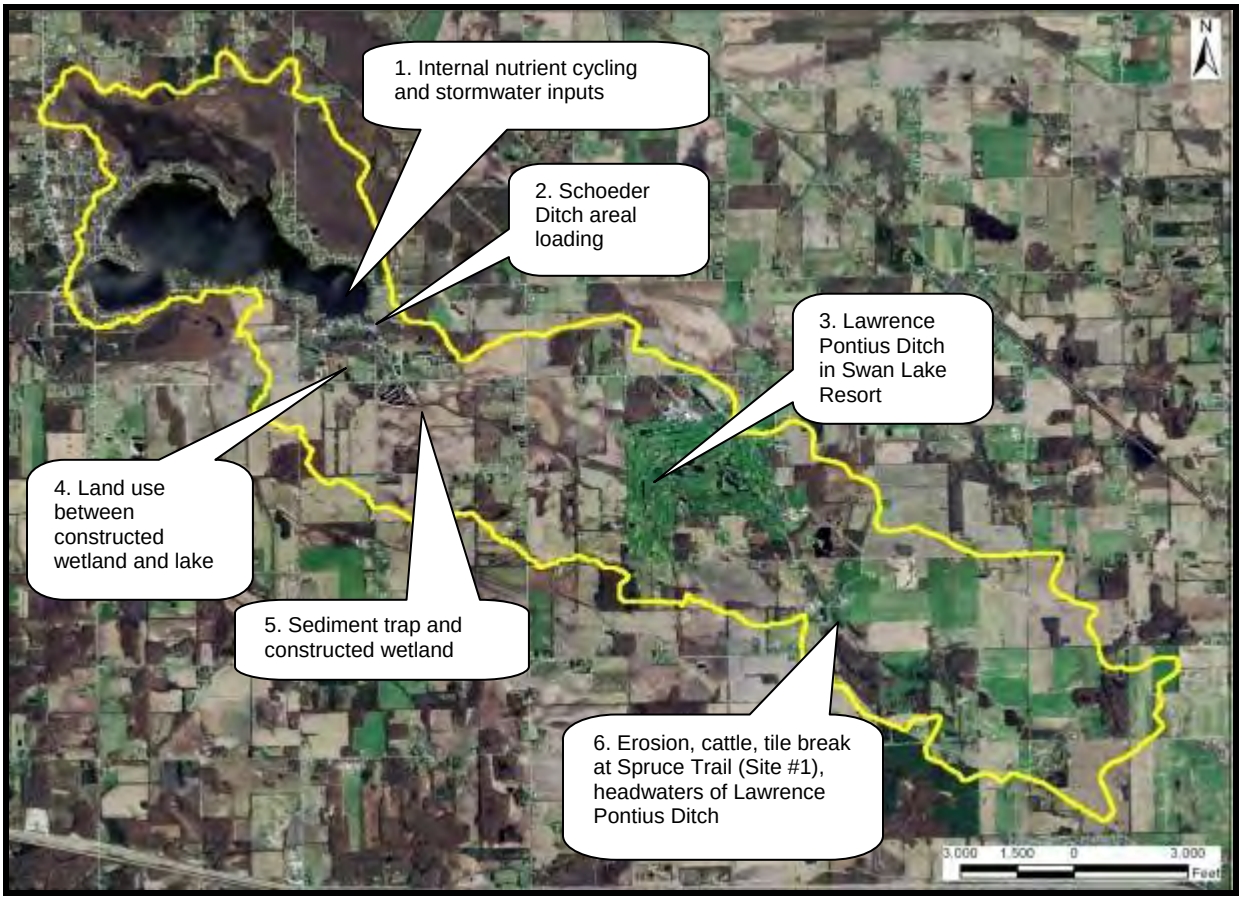


Figure 43. Locations of general areas of concern.

4.1 Lawrence Pontius Ditch

On May 8, 2009 four groups of KLACC members investigated Lawrence Pontius and Schoeder ditches. The watershed was split into 4 areas: above Swan Lake Resort; Swan Lake Resort; below Swan Lake Resort; and the lake. In the upper watershed, a broken tile and eroded area serves as the head of the surface waters for Lawrence Pontius Ditch (Photograph 8). This area drains an agricultural area and where livestock graze and runoff from agricultural land use flows into Lawrence Pontius Ditch.

Photograph 8. Headwaters of Lawrence Pontius Ditch, 5/8/09.

Water then flows through forested and agricultural lands to a point where it enters Swan Lake Resort (SLR) property. The second group reviewed the streambanks and alignment of the ditch within SLR and observed places where bank erosion was occurring (Photograph 9). Some of the control features installed in 1989 and 1990 were also observed (Photograph 10).

Photograph 9. Streambank erosion on Lawrence Pontius Ditch at Swan Lake Resort, 5/8/09.

Photograph 10. Drop structure on Lawrence Pontius Ditch at Swan Lake Resort, 5/8/09.

The third group observed the ditch as it flows through agricultural land below the constructed wetland before its outlet into Koontz Lake. In this area, the ditch flows through agricultural land that supports livestock that have access to the water. The banks of the ditch are eroded within this reach (Photograph 11), though pictured as fenced in the photograph, some sections of the ditch are not fenced and livestock have access to it.

Photograph 11. Bank erosion on Lawrence Pontius Ditch immediately upstream of inlet to Koontz Lake, 5/8/09.

The fourth group toured the lake looking for other inlets such as culverts that may contribute stormwater to the lake (Photograph 12). In addition to outlets coming into the lake, the watershed tour on October 13, 2009 encountered various standpipes and stormwater inlets that likely lead to the lake (Photographs 13-14).

In addition to the tours, JFNew personnel assessed sediment depths in the constructed wetland to determine if sediment was accumulating. Figure 44 reveals that on average about 0.9 feet or about ½ inch per year of sediment has accumulated since they were constructed in 1989-1990,

These examples of broken tiles, stream bank erosion, and stormwater inlets to the lake in addition to the drainage from the ditches themselves contribute nutrients and sediment to the lake. These inputs have been studied and considered in the past, and in 1989-1990, 14 drop structures, a sediment trap and a constructed wetland were placed in the ditch. The sediment trap has been cleaned and will be cleaned by the end of 2009 by the Marshall County Drainage Board. Jones et al., (1997) estimated that the constructed wetland and sediment trap reduce phosphorus loads to the lake by 41%, and their benefit was also documented through the KLA water quality study. Their continued maintenance is paramount to reducing increased nutrient enrichment in the lake.

Photograph 12. Inlet into east basin of Koontz Lake near Underwood Road, 5/8/09.

Photograph 13. Stormwater inlet into east basin of Koontz Lake near Underwood Road, 10/13/09.

Photograph 14. Stormwater inlet into east basin of Koontz Lake at NW corner of Underwood Road and S. Lake, 10/13/09.

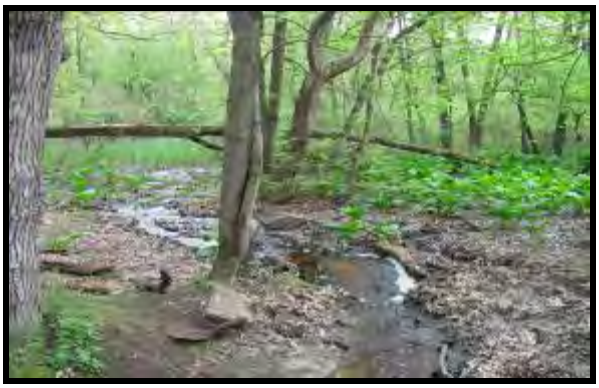
Figure 44. Sediment depth (ft) in constructed wetland downstream of Koontz Lake.

4.2 Schoeder Ditch and the Koontz Lake Nature Preserve Area and Wetland Conservation Area

During the October 13, 2008 and May 8, 2009 KLACC and JFNew toured the Schoeder Ditch and Nature Preserve. No apparent erosion issues or non-point source areas of nutrient inputs were observed on Schoeder Ditch, since the ditch supported forested riparian areas on each of its banks (Photograph 15). However, nearby farms, which are on septic systems, likely contribute surface water runoff to the ditch.

The Koontz Lake Nature Preserve to the north of the lake possesses emergent and forested wetlands and sheds water to the northern side of the lake. Drainages that flow into the Nature Preserve wetlands and on to the Wetland Conservation Area (which is south of the preserve) reveal iron-laden water (Photograph 16).

Photograph 15. Site #5 sampling point looking upstream.



Photograph 16. Iron-laden water in Koontz Lake Nature Preserve.

4.3 Shoreline Development

Since 1950 the shoreline of Koontz Lake has been almost entirely developed with individual residences and some commercial properties (Allen, 2008). A recent aerial photograph (Figure 45) confirms the presence of houses along the entire shoreline of Koontz Lake, with the exceptions being the wetland area on the north side of the lake and the channel near the public access site on the southern side of the lake.

Given the plethora of houses along Koontz Lake's shoreline, it is not surprising that nearly 82% of Koontz Lake's shoreline has been altered in some form. Along part of Koontz Lake's shoreline (29%; 10,566.3 feet or 3,220.5 m), trees and emergent vegetation have been thinned; however, these areas possess at least a narrow band of emergent plants (Figure 45). These areas are mapped as modified natural shoreline because they still possess at least a small portion of all these strata (submerged, emergent, and floating). Other portions of the shoreline that are also mapped as modified natural include those areas where individuals removed only the portion of the shoreline vegetation required to view or access the lake.

Figure 45. Shoreline surface type observed at Koontz Lake, August 29, 2008.
Source: ISDP, 2005 Orthophotography, Starke County, Indiana.

Approximately 53% of Koontz Lake's shoreline has been largely altered from its natural state (Figure 45, Photograph 17). Along these portions of Koontz Lake's shoreline, emergent and floating rooted vegetation has been completely removed from areas adjacent to the shoreline. This leaves bare soils or mowed, residential lawns exposed to wave action. In some areas, wooden railroad timbers, concrete seawalls, glacial stone, or riprap cover the shoreline. This type of shoreline is especially prevalent in the lake's southeastern basin where wind and wave energy is higher than other areas of the lake. This area of the lake is subject to higher wave energy due to prevailing winds and possessing the highest ***fetch*** (longest distance that the wind travels without touching land) of anywhere on the lake. Ice formation can also exacerbate problems with exposed shoreline and cause additional erosion.

Photograph 17. Example of modified lakeshore of Koontz Lake where erosion can occur.

Natural shoreline remains along approximately 18% of Koontz Lake's shoreline where bands of trees, emergent vegetation, floating vegetation, and submerged vegetation are located in distinct zones along the lakeshore (Figure 45). In these areas, the submerged, floating, emergent, and shoreline canopy layers all remain intact.

The shoreline surface becomes especially important in and adjacent to shallow portions of Koontz Lake. In areas where concrete seawalls are present, wave energy from wind and boats strike the flat surface and reflect back into the lake. This creates an almost continuous turbulence in the shallow areas of the lake. Where the waves revert back to the lake and meet incoming waves, wave height increases resulting in additional in-lake turbulence. This turbulence re-suspends bottom sediments thereby increasing the transfer of nutrients from the sediment-water interface to the water column. Continuous disturbance in shallow areas can also encourage the growth of disturbance-oriented plants.

In contrast, shorelines vegetated with emergent or rooted floating vegetation or those areas covered by sand will absorb more of the wave energy created by wind or boats. In these locations, wave energy will dissipate along the shoreline each time a wave meets the shoreline surface. Similarly, stone seawalls or those covered by wood can decrease shallow water turbulence and lakeward wave energy reflection while still providing shoreline stabilization.

4.4 303(d) List of Impaired Waterbodies

The Indiana Department of Environmental Management (IDEM) has placed Koontz Lake on the 2008 303(d) list of impaired water for excessive phosphorus.

4.5 Phosphorus Budget

We have used a phosphorus model to estimate the dynamics of this important nutrient in Koontz Lake. With its role as the limiting nutrient, phosphorus should be the target of management activities to lower the biological productivity of these lakes. In order to

estimate phosphorus loads to the lake, we developed a water budget, which measures the water inputs to and outputs from the lake. The methodology for development of the water budget is explained in Appendix I.

The limited scope of this LARE study did not allow us to determine phosphorus inputs and outputs outright. Therefore, we have used a standard phosphorus model to estimate the phosphorus budget. Reckhow et al. (1980) compiled phosphorus loss rates from various land use activities as determined by a number of different studies, and from this, they calculated phosphorus export coefficients for various land uses. We used mid-range estimates of these phosphorus export coefficient values for all watershed land uses (Table 21). Phosphorus export coefficients are expressed as kilograms of phosphorus lost per hectare of land per year. The export coefficient for a particular land use was multiplied by the area of land in that land use category to derive an estimate of annual phosphorus export (as kg/year) for each land use (Table 22).

Table 21. Phosphorus export coefficients (units are kg/hectare except the Septic Category, which are kg/capita-yr).

Estimate Range	Agriculture	Forest	Precipitation	Urban	Septic
High	3.0	0.45	0.6	5.0	1.8
Mid	0.40-1.70	0.15-0.30	0.20-0.50	0.80-3.0	0.4-0.9
Low	0.10	0.2	0.15	0.50	0.3

Source: Reckhow and Simpson (1980)

We estimated direct phosphorus input via precipitation to the lakes by multiplying mean annual precipitation in Marshall County (36.8 in/yr) times the surface area of the lake times a typical phosphorus concentration in Indiana precipitation (0.03 mg/L). Because homes surrounding Koontz Lake are currently on septic systems, we used a procedure in Reckhow and Simpson (1980) to estimate phosphorus loss from septic systems at homes on the lakeshore. Using information from the Koontz Lake Association, we estimated that 250 homes were occupied by permanent residents and the remaining 250 homes were occupied by seasonal residents.

The constructed wetlands on Lawrence Pontius Ditch upstream from Koontz Lake were designed in 1989 and funded by the IDNR T by 2000 Lake Enhancement Program (the precursor to the LARE). These two wetlands were designed to trap and retain NPS pollutants. A four-year evaluation of these wetlands during 1992-1995 (Jones et al. 1997) showed that 67% of total suspended solids and 41% of total phosphorus were retained by these wetlands at that time. Given this, we reduced the mid-level phosphorus loadings in Table 22 above accordingly.

The results, shown in Table 22, yielded an estimated 594 kg of phosphorus loading to Koontz Lake from its watershed, septic systems, and from precipitation annually. The greatest estimated source of phosphorus loading to the lake is from row crop agriculture – over 66% of total watershed loading.

Table 22. Phosphorus loading model for Koontz Lake.

LAKE:	Koontz		**DATE:**	9/25/2009
COUNTY:	Marshall/Starke			
STATE:	Indiana			
INPUT DATA		**Unit**		
Area, Lake	331	acres		
Volume, Lake	4014	ac-ft		
Mean Depth	12.1	ft		
Hydraulic Residence Time	0.87	yr		
Flushing Rate	1.15	1/yr		
Mean Annual Precipitation	0.93	m		
[P] in precipitation	0.03	mg/l		
[P] in epilimnion	0.018	mg/l		
[P] in hypolimnion	0.077	mg/l		
Volume of epilimnion	3670	ac-ft		
Volume of hypolimnion	344	ac-ft		
Land Use (in watershed)	**Area**		**P-export Coefficient**	
Deciduous Forest	249.20	hectare	0.15	kg/ha-yr
Emergent Herbaceous Wetlands	19.90	hectare	0.1	kg/ha-yr
Evergreen Forest	6.90	hectare	0.15	kg/ha-yr
High Intensity Residential	1.10	hectare	0.5	kg/ha-yr
Commercial/Industrial	1.40	hectare	0.5	kg/ha-yr
Low Intensity Residential	26.9	hectare	0.5	kg/ha-yr
Urban Recreation Grasses	54.1	hectare	0.5	kg/ha-yr
Mixed Forest	0.6	hectare	0.1	kg/ha-yr
Pasture/Hay	274.6	hectare	0.1	kg/ha-yr
Row Crops	826.1	hectare	0.2	kg/ha-yr
Woody Wetlands	83.6	hectare	0.1	kg/ha-yr
Other Data				
Soil Retention coefficient	0.75	-------	0.50	kg/ha-yr
# Permanent Homes	250	homes		
Use of Permanent Homes	1.0	year		
# Seasonal Homes	250	homes		
Use of Seasonal Homes	0.25	year		
Avg. Persons Per Home	3	persons		
OUTPUT				
P load from watershed	283.3	kg/yr		
P load from precipitation	37.41	kg/yr		
P load from septic systems	273.4	kg/yr		
Total External P load	594.1	kg/yr		
Areal P loading	0.444	g/m2-yr		
Predicted P from Vollenweider	0.031	mg/l		
Back Calculated L total	0.329	g/m2-yr		
Estimation of L internal	-0.115	g/m2-yr		
% of External Loading	135.0	%		
% of Internal Loading	-35.0	%		

The 594.1 kg/yr total phosphorus loading predicted by this model is nearly identical to that predicted when we ran the Long-Term Hydrologic Impact Analysis (L_THIA) model of Engel and Harbor (2009). The L-THIA prediction for annual phosphorus loading to Koontz Lake was 596.9 kg/yr. From these two independent sources, we believe that our estimate of phosphorus loading to Koontz Lake is valid. Calculation of total phosphorus loading based on the 2009 diagnostic study measurements are more than twice as high as the modeled estimates (1360 kg/yr; see Appendix H, average TP loads at site #4 in kg/d were multiplied by 356 days); however, the calculation reflect only two sampling events with the storm flow loads weighing heavily in the calculation.

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

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

During our July 20, 2009 sampling of Koontz Lake, the mean volume weighted phosphorus concentration in the lake was 0.023 mg/L. Now it is useful to ask the question, "How much phosphorus loading from all sources is required to yield a mean phosphorus concentration of 0.023 mg/L in Koontz Lake?" By plugging this mean concentration along with the mean depth and flushing rate into Vollenweider's phosphorus loading model and solving for L, we get an estimated areal phosphorus loading rate (mass of phosphorus per unit area of lake) of 0.329 g/m^2-yr. This means that in order to get a mean phosphorus concentration of 0.023 mg/L in Koontz Lake, a total of 0.329 grams of phosphorus must be delivered to each square meter of lake surface area per year.

However, our phosphorus loading model (Reckhow et al. 1980) estimated that 0.444 g/m^2-yr of phosphorus is delivered to the lake from watershed sources. What has happened to this extra phosphorus loading (0.444 g/m^2-yr - 0.329 g/m^2-yr = 0.115 g/m^2-yr). There are several possible explanations:

1. The phosphorus loading model overestimated the watershed phosphorus delivery to the lake.
2. Koontz Lake acts as a phosphorus sink. The excess phosphorus settles down to the sediments or is sequestered in the substantial biomass of aquatic macrophytes in the lake where it doesn't contribute to the in-lake phosphorus concentration.
3. Since both the inlet and the outlet are in the southern part of the lake, inflow during storm events may be short-circuited, which means the inflow moves to the outflow without mixing throughout the lake.
4. The results of the 7/20/09 sampling of Koontz Lake were an anomaly.

Determining which of the above may be important in explaining the phosphorus dynamics in Koontz Lake is difficult. Of the possible explanations listed above, #2 is most likely given that macrophytes cover more than 124 acres (37.5%) of the lake. Aquatic macrophytes can be important phosphorus sinks in lakes. Emergent and floating-leaved macrophytes obtain phosphorus exclusively from the sediments while submergents draw phosphorus both from the water and the sediments. Plant matter buried in the sediments may be a permanent phosphorus sink (Graneli and Solander, 1988).

Results from previous samples we have collected from Koontz Lake have also shown the same or slightly higher concentrations of phosphorus in the hypolimnion sample than in the epilimnion sample, unlike this present year (Table 23). This suggests that Koontz Lake's sediments have not been a significant source of internal loading of phosphorus historically, but rather, are a sink for phosphorus. Experiences with other lakes show that a lake's capacity to assimilate phosphorus in the sediments is limited and eventually, this limit is exceeded and phosphorus is released from the sediments. The consequences of this internal loading are bad for lakes and most expensive to mitigate.

Table 23. Historic sediment phosphorus release from Koontz Lake.

YEAR	Epilimnion (mg/L)	Hypolimnion (mg/L)	Sediment Phosphorus Release Factor[1]
1990	0.010	0.026	2.6
1993	0.010	0.010	1.0
1995	0.010	0.016	1.6
1999	0.010	0.015	1.5
2004	0.010	0.010	1.0
2009	0.010	0.067	6.7

[1]Hypo SRP concentration/Epi SRP concentration. For example, in 2009 hypolimnetic SRP concentration was 6.7 times that in the epilimnion. A large difference is strong evidence of substantial internal loading of phosphorus. The difference for 2009 is likely attributable to sedimentation of particulates and algae and not release of phosphorus from the sediments.

Our experience on other lakes has shown that the runoff coefficient model of Reckhow et al. (1980) gives fairly accurate estimate of watershed loadings. The significance of areal phosphorus loading rates is better illustrated in Figure 46 in which areal phosphorus loading to Koontz Lake is plotted against the product of Koontz Lake's mean depth times flushing rate. Overlain on this graph is a curve, based on Vollenweider's model, which represent an acceptable loading rate that yields a phosphorus concentration in lake water of 30 µg/L (0.03 mg/L). The areal phosphorus loading rate for Koontz Lake lies slightly above the acceptable line.

This figure can also be used to evaluate management needs. For example, areal phosphorus loading to Koontz Lake would have to be reduced from 0.444 g/m^2-yr to 0.427 g/m^2-yr (the downward vertical intercept with the line) to yield a mean lake water concentration of 0.030 mg/L. This represents a reduction in areal phosphorus loading of 0.0.016 g/m^2-yr to the lake, which is equivalent to a total phosphorus mass loading

reduction of 21.5 kg P/yr or 3.6% of current estimated total phosphorus loading to the lake (Table 24).

This now can be a target for management – finding a way to reduce external phosphorus loading to Koontz Lake by 21.5 kg per year. Admittedly, this is a rather small quantity of phosphorus to manage, and it depends upon the constructed wetlands continuing to trap NPA pollutants. Therefore, long-term nutrient management, particularly phosphorus, will depend upon the regular monitoring and maintenance of the constructed wetlands to insure that they operate effectively. Efforts to reduce losses of phosphorus from watershed land uses (agriculture, residential lawns, etc.) should continue as these efforts have been shown to be very cost-effective.

Table 24. Phosphorus reduction required to achieve an acceptable phosphorus loading rate and a mean lake concentration of 0.03 mg/L under typical conditions and assuming phosphorus retention in the constructed wetlands and sediment trap.

Condition	Current External Total Areal P Loading (g/m^2-yr)	Acceptable Areal P Loading (g/m^2-yr)	Reduction Needed (kg P/yr and %)
Without Constructed Wetlands	0.901	0.427	646.6 kg (53%)
With Wetland Retention	0.444	0.427	21.5 kg (3.6%)

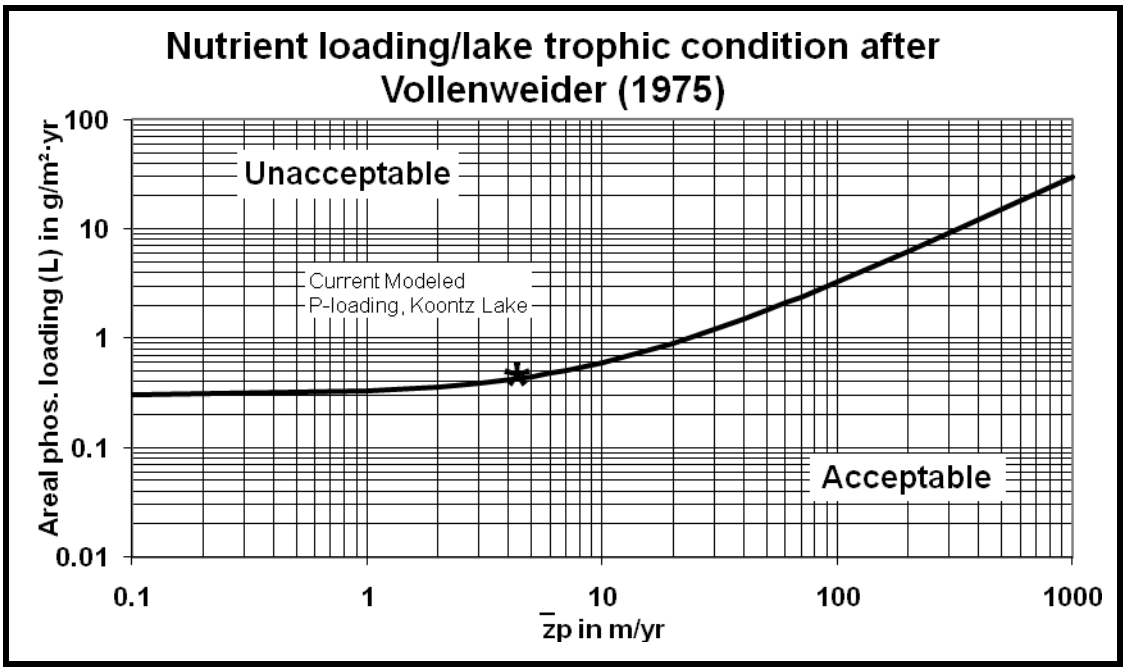


Figure 46. Estimated external phosphorus loadings from Reckhow and Simpson's runoff coefficients to Koontz Lake compared to acceptable loadings determined from Vollenweider's model. The dark line represents the upper limit for acceptable loading.

4.6 Other Pollutants

The Long-Term Hydrologic Impact Analysis (L_THIA) model of Engel and Harbor (2009) provides estimates for a large number of non-point source (NPS) pollutants carried by runoff. Table 25 below shows results for several of these pollutants.

Table 25. Non-point source loading to Koontz Lake estimated by L-THIA.

PARAMETER	CONCENTRATION	% FROM AGRICULTURE
Total Suspended Solids	50,574 lbs/yr	74
Total Nitrogen	4,509 lbs/yr	89
BOD	9,659 lbs/yr	38
Fecal Coliform	50,733/100ml mean	84

The L-THIA model identified agriculture as the source of the majority of nitrogen, fecal coliform bacteria, and soil and other solids entering the lake annually. Our phosphorus budget identified agricultural practices as the primary source of phosphorus entering Koontz Lake. Residential areas are the second leading source of NPS pollutants entering the lake according to L-THIA. Jones et al. (1997) showed that 67% of total suspended solids (TSS) were retained by the constructed wetland and sediment trap at that time of the study. TSS and its contribution to problems within the watershed are discussed in Section 5 as are issues related to bacteria and nutrients in general.

5.0 CLARIFYING OUR PROBLEMS

5.1 Linking Concerns to Existing Data

Section 3 presented existing data from lake and stream studies, which explain that several water quality parameters either violate state standards or exceed accepted benchmark levels for maintenance of a healthy aquatic biota. This section expands the discussion in Section 4 and details the potential sources of pollutants relative to achieving water quality. These sources were identified through watershed tours, and could certainly contribute to the high levels of nutrients, sediment, and bacteria found during the diagnostic study, though they may not be the sole causative agent.

Table 26 identifies the concerns noted during the watershed and lake tours and the supporting evidence for those concerns. The table also identifies management practices that could alleviate the concern or source and provides the locations where practices may be installed.

Table 26. Concerns and sources of pollutants, the existing data for the location of concern and suggested management practices (Refer to Figure 43).

Location	Concern/Source	Existing Data	Suggested Management Practices
1	Internal nutrient loading; external nutrient loading from ditches; stormwater inputs	**Nutrients:** Hypolimnetic SRP level and TP exceeded recommended levels; Site #1-4 SRP and TP concentrations exceed recommended levels. **Transparency:** Secchi depth decreased from 5 feet in previous	Alum application to lake bed; dredge 3-7' zone around lake; streambank restoration at Swan Lake resort; erosion control at headwaters; clean sediment trap and constructed wetland of accumulated sediment; fence livestock from ditch, or

Location	Concern/Source	Existing Data	Suggested Management Practices
		years to 3.6 feet in 2009. **E.coli:** Site #1-5 exceeds state standards; low levels in lake based on 2005 study. **Watershed tour observations:** Photos 8, 9, 11.	construct a berm at ditch edge to reduce direct runoff to ditch; use phosphate free fertilizers on lawns; install sewage system; reroute Lawrence Pontius Ditch to Robbins Ditch.
2	High areal loading from Schoeder Ditch	**Nutrients and Sediments:** NO_3, TKN, SRP, TP, TSS exceed recommended levels; areal loads of these constituents exceed areal loads from other sites in watershed; ammonia storm levels exceeded state standards. **E. coli:** exceeds state standards.	Construct wetland at headwater of Schoeder Ditch; filter strip and fencing at headwater; install sewage system.
3	Lawrence Pontius Ditch in Swan Lake Resort	**Nutrients:** NO_3, TKN, TP, TSS storm levels exceed recommendations; ammonia loading exceeds loading from all other sites. **Erosion:** Storm TSS levels exceed recommendations. **E. coli:** exceeds state standards. **Watershed tour observations:** Photo 9.	Filter strip along ditch in SLR; restore and vegetate streambanks; ensure sewage system is functioning properly.
4	Land use (agricultural based) between constructed wetland and lake.	**Nutrients:** Site #4 NO_3 storm concentration exceeds recommendation; ammonia base concentration exceeds state standards; TKN, SRP, TP base and storm concentrations exceed recommended levels. **Erosion:** TSS base and storm concentrations exceed recommended levels. **E. coli:** exceeds state standards. **Watershed tour observations:** Photo11.	Restore and vegetate streambanks; fence out livestock, or construct berm at edge of ditch; install filter strips. Consider linkage with proposed installation of Koontz Lake sewage system. Reroute Lawrence Pontius Ditch to Robbins Ditch.
5	Sediment trap and constructed wetland	**Nutrients** Jones et al. (1997) indicates 41% reduction in phosphorus load; KLA 2002-2004 study indicates that trap and wetland reduce nutrients seasonally; 2009 diagnostic study: lower NO_3 concentration below trap at site #3a than upstream or downstream; NO_3, TKN, SRP, TP exceed recommended levels; higher ammonia and TKN than upstream levels. **Sediment:** JFNew study indicates sediment accumulation in constructed wetland. **E.coli:** exceeds state standards.	Marshall County Drainage Board to dredge sediment trap winter 2010; remove sediment from constructed wetland; plant additional wetland species in constructed wetland; investigate connection of LPD to Robbins Ditch; document and locate springs and measure flow; ensure ongoing maintenance of sediment trap and constructed wetland.

Location	Concern/Source	Existing Data	Suggested Management Practices
6	Erosion, cattle, tile break at headwaters of Lawrence Pontius Ditch	**Nutrients:** base ammonia levels exceed state standard; base TP exceeds recommended levels; storm and base SRP exceeds recommended levels. **E. coli:** exceeds state standards. **Watershed tour observations:** Photo 8.	Restore tile area; fence out livestock; install fence;

Aside from the actual water quality monitoring and the watershed tours, the public was invited to voice their concerns about their watershed at the beginning of the planning process. Their concerns were presented in Section 1.2 of the Introduction. They are again discussed in this section through development of problem statements. The problem statements reflect the information gathered throughout the entire planning process. Stressors, possible pollutant sources, and identified critical areas are listed for each problem statement. Table 27 reflects 1) the stakeholders concerns, 2) existing data identified that supports or refutes those concerns, and 3) the problem statement number for that particular concern. For three of the categories, no problem statement is presented because the watershed management process addresses those concerns.

Table 27. Linking watershed stakeholders' concerns with existing data to develop problem statements.

Concern	Existing Data	Problem Statement
Process		
Ensure that stakeholders in watershed are not just lake residents are part of the process.	Flyers, invitations, advertisements were sent to area residents.	-
Make sure that the whole picture is investigated including the lake and the watershed.	The watershed management plan is a comprehensive document which includes historical information and current information to describe and discuss issues in the watershed.	-
Determine if there are issues in the watershed that need to be addressed.	The watershed management plan is developed to do that.	-
Provide opportunity for a watershed tour.	Watershed tours occurred on October 13, 2008 and May 8, 2009, and the lake on May 19, 2008.	-
Develop viable relationship between watershed and lake residents.	Contact was made with upstream landowners.	-
Fix of problems is not occurring.	The WMP outlines how to proceed with fixes. Sediment trap will be cleaned in winter 2010.	-
Send KLA representatives to SWCD meetings to provide updates. SWCD can assist with watershed projects.	KLACC representative has been attending SWCD meetings.	-
Implementation		
How could boat wash stations be funded?	Discuss with LARE	5
What if whole-lake treatment is not funded by LARE, but instead spot treatment?	Dealt with through Aquatic Plant Management Plan process. Continue to submit applications. No funding for 2009, resubmit 2010.	5

Nutrient (Phosphorus and Nitrogen) Introduction		
Over-application of fertilizer. Phosphorus load in water is creating a problem. Koontz Lake on 303(d) list for phosphorus.	No cause and effect data; historical water and the JFNew 2009 diagnostic study indicate elevated levels of total phosphorus, soluble reactive phosphorus, and nitrates in streams and some lakes. Chlorophyll *a* levels indicate mesotrophic conditions.	1
Fertilizer should be phosphorus-free.	No cause and effect data; use of phosphate free fertilizer will not introduce phosphorus to lake.	1
No dumping of lawn cuttings and leaves in lake and Lawrence Pontius Ditch.	No direct cause and effect determined; lawn cuttings contain phosphorus; addition of clippings to lake and ditch could release nutrients to lake and ditch.	1
Algal blooms are a problem.	No direct data; photographs of algal scum document problem at shoreline; historical data and JFNew study indicate mesotrophic conditions and moderate levels of chlorophyll *a* and plankton densities. Algal blooms blown to shore. Refer to historical data and JFNew 2004 study for water quality information. Plankton population dominated by blue-green algae (99.7%)	1
Dumping in lake occurs and this should be stopped unless permits are obtained.	No data to corroborate statement. Stakeholder observation. Dumping soils, grass clippings and other materials can introduce nutrients into the lake.	1
Internal cycling of nutrients is the problem.	Elevated TP and SRP levels in hypolimnion of lake (sampled 7/20/09). Phosphorus model indicates external loading dominates the system.	1
Problems with Koontz Lake are caused either internally or by upstream lake and constructed wetland.	Elevated TP and SRP levels in hypolimnion of lake (sampled 7/20/09). Historical data and JFNew 2009 diagnostic study indicate elevated levels of total phosphorus, soluble reactive phosphorus, and nitrates in ditches and lake. Chlorophyll *a* levels indicate mesotrophic conditions.	1
Application of alum to control internal phosphorus cycling is a promising technique for Koontz Lake. Apply below 10'.	No data to corroborate statement. Carpenter (2005) and Steinmand and Ogdahl (2007) discuss benefits of whole-lake treatments with alum	1
Erosion/Sedimentation		
Lake shore erosion issues in general and at hotel.	Stakeholder observation. Earth Source (1988) documents near shore erosion from speed boats. Figure 45 documents location of lake shore erosion.	2
Seawall restoration needed.	Stakeholder observation. Earth Source (1988) documents near shore erosion from speed boats. Figure 45 documents location of lake seawalls.	2
Repair-restore vegetation around lake- aquatic plant installation where they will do well.	Stakeholder observation (Photo. Earth Source (1988) documents near shore erosion from speed boats. Figure 45 documents location of lake's modified and modified natural shoreline.	2
Wind driven wave action causes lake shore erosion	Stakeholder observation. Earth Source (1988) documents near shore erosion from speed boats. Figure 45 documents location of lake's modified and modified natural shoreline.	2
Carp cause re-suspension of sediment.	Stakeholder observation. IDNR observation at 2008 AVMP meeting. IDNR (2000) document gizzard shad most abundant species collected by weight (32.0%), followed by carp (19.4%), bluegill (16.1%), and northern pike (7.4%).	2
Wave runners and need for boats that cause large waves causing re-suspension of sediments.	Stakeholder observation. Earth Source (1988) documents near shore erosion from speed boats.	2

Boaters inside buoys.	Stakeholder observation. Earth Source (1988) documents near shore erosion from speed boats. Per recommendations of 1988 study buoys established at 200 foot distance from shore line.	5
Point Source		
Swan Lake Resort (SLR) STP effluent goes into Lawrence Pontius Ditch. Locate public records.	Watershed tour located pipeline from treatment facility heading south to Lawrence Pontius Ditch. Data indicate that *E. coli* levels surpass standards of 235 cfu/100 ml in streams throughout the watershed and below SLR. Ammonia load from site below SLR highest (2.75 kg/d) than all other sites. NO_3, TKN, TP, TSS storm levels exceed recommended levels; ammonia loading exceeds loading from all other sites.	1
Identify point sources, especially culverts, and other storm water point sources to lakes.	Three culverts located during watershed tour	1
Pollutants		
Oil and grease inputs are a concern.	Stakeholder observation. No data to corroborate statement.	1
Scum is present on lake.	No direct data; photographs of algal scum document problem at shoreline (Photograph 1); historical data and JFNew study indicate mesotrophic conditions and moderate levels of chlorophyll *a* and plankton densities. Algal blooms blown to shore. Refer to historical data and JFNew 2009 study for water quality information. Plankton population dominated by blue-green algae (99.7%).	1
Foam and detergent identified in lake and at constructed wetland dam on 5th road.	Stakeholder observation. No data to corroborate statement. Foam may be a result of humic acid production, which is a component of degraded organic matter such as algae and plant material.	1
Sampling		
Sampling should occur on all ditches and tributaries to Koontz Lake.	Funding limited sampling to 5 stream sites, and one lake sampling.	-
Sampling should occur at the highest point in the watershed.	Site #1 is the highest point where surface flow in Lawrence Pontius Ditch is present.	-
Values		
Aesthetic problems with algal blooms.	No direct data; photographs of algal scum document problem at shoreline (Photograph 1); historical data and JFNew study indicate mesotrophic conditions and moderate levels of chlorophyll *a* and plankton densities. Algal blooms blown to shore. Refer to historical data and JFNew 2004 study for water quality information. Plankton population dominated by blue-green algae (99.7%)	1
Turbidity is a problem for fishing, aesthetics.	Stakeholder observation. JFNew (2009) data indicate that lake turbidity levels are moderate and range from 6 to 22.	1,2
Education and Information		
Need to exchange ideas and have an understanding of the water quality and watershed.	Stakeholder observation.	4

We need to have more education for the lake residents especially on the over-application of lawn fertilizer.	Stakeholder observation.	4
Restrictions placed on private property if federal or state monies provided for conservation projects.	Stakeholder observation.	4
Recreation		
Algal blooms and aquatic vegetation make it difficult to swim at the beach.	No direct data; photographs of algal scum document problem at shoreline; historical data and JFNew study indicate mesotrophic conditions and moderate levels of chlorophyll *a* and plankton densities. Algal blooms blown to shore. Refer to historical data and JFNew 2004 study for water quality information. Plankton population dominated by blue-green algae (99.7%)	5
Wake boarding is a problem and contributes to sediment re-suspension.	Stakeholder observation. Earth Source (1988) documents near shore erosion from speed boats.	5
There are no cleaning facilities available for boaters as they come off of lake.	Stakeholder observation.	5
Many people access the lake and it is important to have boat wash stations. Locate them at the marina and public access and make sure it doesn't drain into the lake.	Stakeholder observation.	5
Oil and grease film apparent in eastern basin during high motorboat use times.	Stakeholder observation. No data to corroborate statement.	5
Bass tournament open to public making lake too busy.	Stakeholder observation. No data to support or refute.	5
Carp are present in lake.	Stakeholder observation. IDNR observation at 2008 AVMP meeting. IDNR (2000) document gizzard shad most abundant species collected by weight (32.0%), followed by carp (19.4%), bluegill (16.1%), and northern pike (7.4%).	5
Health		
Check with Health Board for bacteriological testing in lake.	2005 data retrieved from Starke County Health Dept. Data indicate low levels of *E. coli*. Numbers range from 1-66 MPN at sites around the lake.	3
Ensure safe swimming at beach.	Stakeholder observation. Aquatic vegetation so thick, swimmers get stranded.	5
Wildlife		
Control geese population in lake and at Swan Lake Resort.	Studies show that geese increase nutrient loading up to 40% for total nitrogen and 75% for total phosphorus (Kitchell et al., 1999). Utilize nest disruption.	1

Problem Statement 1. Phosphorus loadings to the lake and streams, and levels of phosphorus in the lake and potentially in the hypolimnion, or bottom waters are creating problems that compromise the health, aesthetics and recreational value of Koontz Lake, and Lawrence Pontius and Schoeder ditches. During the 2009JFNew diagnostic survey of the ditches, phosphorus concentrations exceeded levels in streams considered

eutrophic by Dodd et al. (1998). These same concentrations equal levels at which the Ohio EPA (1999) observe impairment to the aquatic biota. Of particular interest, was the elevation of phosphorus levels at Site #4 from those at Site #3a, which is located downstream of the constructed wetland. This indicates that though the sediment trap and constructed wetland may be trapping sediment and phosphorus, land use activities between these two sites is elevating the phosphorus concentrations. The land use activities between these sites are agricultural based. Livestock graze are able to graze to the ditch edge. Surface runoff can carry fecal material into to the ditch which then flows in Koontz Lake.

Review of historical lake water quality data reveal that Koontz Lake is mesotrophic, yet the loading of phosphorus from the ditches to the lake without the presence of the sediment trap and constructed wetland is very high and exceeds recommended loading levels by approximately 53% (see Section 4.5). Excess loading leads to increased algal growth and aquatic plant growth, continued storage of phosphorus in the lake sediment. The phosphorus budget section of the report (Section 4.5) indicates that continued loading without trapping of phosphorus is dangerous for the lake.

The stakeholders expressed their opinions about the likely sources of phosphorus. They surmised that over-application of fertilizer, runoff from livestock areas, erosion from animals entering the Lawrence Pontius Ditch, and animals and waterfowl defecating in lake and ditches were a few of the sources of phosphorus to the lake and ditches. The watershed tours on October 13, 2008 and May 8, 2009 corroborated these apparent sources and the sources and critical areas that were observed are listed below. Additional identified sources that lead to phosphorus contributions to the watershed's lake and ditches include erosion along streambanks, actively farmed land from which overland runoff flows to streams and lakes, ditches that flow through barnyards, lack of filter strips between the lake and lawns, and inadequate sewer and septic systems, the latter of which will be partially corrected with the installation of a sewage treatment system for the lake residents.

Regarded as point sources, stormwater that enters the lake through culverts can also contribute to increased phosphorus loading to the lake. These point sources were not assessed for their contributions to the watershed or lake; however, they contain accumulated runoff from roads, residential properties, and old field and agricultural properties. Sediment in the runoff may have adhered phosphorus and dissolved phosphorus may also be present in the stormwater.

General locations of sources identified within the Koontz Lake watershed are listed below and displayed in Figure 43. Management efforts to reduce phosphorus input from the Koontz Lake watershed should focus on the critical areas identified during the watershed tours.

Stressor: Phosphorus - phosphorus (total and soluble)

Source: Streambank erosion

Overland flow from agricultural fields
Fertilizer application from golf course
Phosphorus loads from golf course sewage treatment system
Residential lawn fertilizer
Lack of filter strips along lakes
Inadequate installation of tile risers in agricultural fields
Livestock in ditches
Inadequate sewer and septic systems
Point sources from storm pipes and sewage treatment systems
High goose population

Critical Areas:
Lawrence Pontius Ditch at Spruce Trail (Site #1)
Lawrence Pontius Ditch streambanks at golf course at Swan Lake Resort
Lawrence Pontius Ditch below constructed wetland and lake
Lawns around Koontz Lake
Septic systems around lake and immediately upstream of lake adjacent to Lawrence Pontius and Schoeder ditches.

Problem Statement 2. Erosion and sedimentation in the watershed and in the lake contribute to poor water quality in the ditches and the lake. In the ditches, total suspended solids (TSS) reduce the ability for fish to see their food source. The solids held in suspension in the water column eventually settle to the streambed and can cover habitat used by aquatic organisms. This process, referred to as sedimentation, is not untypical for Indiana streams. Accepted thresholds for turbidity (10.4 NTU recommended by EPA, 2000) were exceeded under storm flow conditions at sites on Lawrence Pontius Ditch during the completion of the JFNew 2009 diagnostic study (Table 13). Concentrations of total suspended solids exceeded recommended levels of 30 mg/L per IDEM draft total maximum daily load at Site #4 on Lawrence Pontius Ditch and Schoeder Ditch (Site #5) under both storm and base flow conditions. By far the greatest load of total suspended solids is from Site # 4 under storm flow conditions: based on our load estimate of 3741.61 kg/d of TSS with flows of 16.73 cfs (0.47 cms) could be contributed under storm flow conditions to the lake.

In Koontz Lake, water clarity is a measure of how much material is suspended in the water quality. This material may be comprised of algal cells, suspended soils, and some dissolved materials that refract light. Koontz Lake's water clarity, measured using a Secchi disk, is no worse than the majority of Indiana's lake water clarity levels, but this year's sampling indicated that the clarity has decreased from the previous last five years of sampling (see Table 9 in Section 3.2.1).

In general, erosion and sedimentation in streams or ditches result from overland runoff from agricultural fields, stream bed scouring, road stream crossings, de-vegetated recreational or urban areas, and surface runoff from residential areas. More specifically, the stakeholders voiced concerns that streambank erosion and livestock near the streambanks or in the ditches were problems. They also indicated that wave action,

watercraft within 200 feet of the shoreline, carp re-suspending vegetation and lack of adequate vegetation around the lake caused the turbid nature of the lake. The watershed tours on October 13, 2008 and May 8, 2009 corroborated some of these apparent sources of total suspended solids in the ditches and the erosion of the lakeshore. Additional areas of erosion which lead to high total suspended solid levels and turbidity in the ditches include eroded streambanks of Lawrence Pontius Ditch at the golf course, at the tile outlet at Spruce Trail (Site #1), and at eroded and unfenced streambanks between the constructed wetland and Koontz Lake. These sites are located in Figure 43.

At lakes, erosion of the shoreline may occur as a result of wave action, removal of shoreline vegetation, poor seawall management, and high speed watercraft. At Koontz Lake, more than 53% of the shoreline is altered through the installation of some type of seawall; therefore, direct erosion from this the actual lakeshore is low except at the old hotel site in the western basin on the southern shore. However, where seawalls have been constructed all the native aquatic vegetation has been removed resulting in exposure of bare sediments. Wave action wind energy and water craft in shallow waters can easily re-suspend any exposed bottom sediments.

Stressor: Sediment

Source: Streambank erosion
Overland flow from agricultural fields
Wildlife and livestock crossing streams
Livestock wading in ditches
Lack of filter strips along lakes
Streambed scouring
Wave action
High speed watercraft

Hotspots/Critical Areas:
Lawrence Pontius Ditch at Spruce Trail (Site #1) – broken tile and eroded area
Lawrence Pontius Ditch at golf course – eroded streambanks
Lawrence Pontius Ditch between constructed wetland and lake – no fence and eroded banks
Standpipes for stormwater leading to lake
Shoreline of lake at old hotel site
Wave action around lake

Problem Statement 3. Elevated pathogen levels are a human health concern in the Koontz Lake watershed. *E. coli* indicates the presence of pathogenic organisms, and *E. coli* measured in the Koontz Lake watershed exceeded state standards (235 cfu/100 ml) at all of the sites sampled under the storm and base flow conditions in 2009. Bacteriological sampling by the Starke County Health Department at sites around the lake in 2005 indicated that *E.coli* levels were low, but the highest level detected was 66

MPN (most probable number) on the southern shore of the western basin just east of the outlet.

Lake property owners expressed concerns about the presence of any *E. coli* in the lake, but had not initially raised concerns about *E.coli* that might be in the ditches until the 2009 storm flow results were presented to them. The watershed tour corroborates the potential for high levels of *E.coli* in the ditches. Presence of livestock near the ditch and in the broken tile area at the Lawrence Pontius Ditch headwaters, the potential for failing septic systems, effluent from Swan Lake Resort (though levels of *E. coli* were lowest compared to other sampled sites in 2009), and the presence of geese and other wildlife were encountered during the tours. These sources can contribute to high levels of pathogens in the water.

While bacteria levels in the lake are of great concern to the lake residents and the other users, the levels measured in 2005 indicate that state standards are being met. However, the KLA can request to have samples taken again at areas around the lake.

Stressor: *E. coli*/Pathogens

Sources: Septic systems failure to function properly
Livestock grazing adjacent to ditches
Geese on lawns and in the lake
Wildlife adjacent or in streams and lakes

Critical Areas:
Geese on the lake
Lawrence Pontius Ditch at Spruce Trail (Site #1) – cattle at headwaters
Lawrence Pontius Ditch between constructed wetland and lake – little fencing and eroded banks
Lawrence Pontius Ditch below Swan Lake Resort effluent

Problem Statement 4. Stakeholders voiced concerns about the lack of education and information available to the general public. They want to exchange ideas and have an understanding of the water quality and watershed. According to stakeholders more education for the lake residents especially on the over-application of lawn fertilizer would be beneficial. Some stakeholders thought there might be restrictions placed on private property if federal or state monies provided for conservation projects, yet the stakeholders voiced that they want results in the form of dredging and aquatic plant control.

Stressor: Lack of knowledge

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

Critical Areas:
Residential and farm property owners, agency personnel, town officials

Problem Statement 5. Indiana lakes are a major source of recreation. The inhabitants of the Koontz Lake watershed differ little from other Indiana lake inhabitants in their desire to recreate on their lakes and to enjoy the aesthetic setting while accruing value in their land. The stakeholders desire good water quality with enough open surface water in the lakes for boating, fishing, swimming and waterskiing.

Lake residents identified a number of issues that lead to recreational impairment. Through a survey and in order of importance, lake residents indicated, that sediment accumulation, abundance of aquatic plants, poor water quality and use of jet skis prevented their enjoyment of Koontz Lake.

Stressor: Pathogens, Nutrients, Sediments, Recreational Users

Sources: See Problem Statements 1-3, boat and personal watercraft users

Critical Areas: See Problem Statements 1-3; lake perimeter

6.0 GOALS AND DECISIONS

During the KLACC steering committee meetings time was spent defining goals and determining conservation actions needed to improve and maintain water quality. Goals were identified based on major water quality parameters measured during this project, observations made during the watershed tours and stakeholder concerns. The committee decided that six focus areas as shown in Figure 43 warranted development of goals to achieve water quality. The final goals for the Koontz Lake watershed are:

Goal 1. Reduce phosphorus loads to the lake from 2009 levels by 3.6% to reach recommended phosphorus loadings to the lake of <0.427 g/m^2-yr by 2020.

Goal 2. Reduce total suspended solid loads to streams from 2009 levels to recommended concentrations of 30 mg/L (IDEM draft TMDL target) by 2020.

Goal 3. Reduce E. coli concentrations in waterbodies in the Koontz Lake watershed so that water within the streams and lakes meets the Indiana state standards of 235 colonies/100 ml by 2020.

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

Goal 5. Maintain and improve the recreational setting of the Koontz Lake watershed within five years through education and in-lake actions.

To implement these goals, KLACC will continue to rely on individuals who have shown sincere interest in achieving water quality in their watershed. More than five individuals attended each one of the stakeholder meetings; their commitment is documented by their attendance and their review of the plan. In addition, during the watershed tour residents within the watershed were contacted and asked to participate in achieving water quality in their watershed. Their initial positive response warrants reconnecting with them and getting them involved with efforts on streambank stabilization and tile management.

With support of the Koontz Lake Association, the continued leadership of KLACC, it is highly likely that many of the following objectives can be carried out. With a final watershed management plan is accepted that the group meet again to pick their top priorities, develop a feasibility study which provides conceptual design, cost estimates, funding source and permitting requirements. The following priority list provides a basis for selecting projects to be considered in the feasibility planning stage. However, not all objectives require a feasibility study and these objectives may be initiated as soon as possible, but the watershed team needs to ensure that all regulations and permit requirements are considered.

6.1 Prioritization of Water Quality Goals and Objectives

The KLACC steering committee prioritized their goals as well as the specific objectives to meet those goals. The goals, objectives, action items to achieve the goals and potential goals are provided below. While KLACC placed at the top of their list of objectives remedial actions such as lake dredging and sediment trap maintenance, it is understood that objectives which reduce nutrient and sediment loads through establishing best management practices should be given greatest consideration. Some examples of best management practices include exclusion of livestock from ditches, stabilization off streambanks, promotion of wetland construction, enrollment of landowners in CRP, promotion of phosphate-free fertilizer, installation of filter strips, and reduction of geese populations. Requests for funding of the load reduction objectives are more likely to receive a positive response since they are preventative measures.

Goal 1: Reduce phosphorus loads to the lake from 2009 levels by 3.6% to reach recommended phosphorus loadings to the lake of <0.427 g/m^2-yr (after Vollenweider, 1975) by 2020.

Goal time frame: Except for annual or continuous tasks, the goal would be reached by 2020.

Associated costs: Evaluated by objective.

Estimated load reduction: Based on the discussion in Section 4.5, phosphorus loading reductions of 3.6% will place Koontz Lake in the area of acceptable Areal P loading (g/m^2-yr) per Vollenweider 1975. Loadings above this level will expose the lake to increased algal growth, increased aquatic plant growth, the potential for internal cycling of nutrients and poor water clarity. The reason so little reduction is needed is based on

the results of Jones et al. (1997) which indicates that the constructed wetland and sediment trap upstream of Koontz Lake is effective in removing 41% of the areal load. This study was completed 12 years ago and since then, the trap and the wetlands have accumulated sediments. Therefore, these features must be maintained to ensure that the phosphorus loadings remain low. More importantly, a sewage treatment facility is going to be constructed with the next 5 years for residents of Koontz Lake.

Potential targets: There are several target areas or methods to reduce phosphorus loading to the lake. One target area is the lake resident properties where septic systems will be replaced by connection to a central system. Another targeted area is the sediment trap which should be regularly dredged. In addition, the constructed wetland should be maintained such that wetland vegetation continues to grow and sediment removed where access to open water areas are present. This later target area will require pursuing the appropriate permits. Areas of erosion along the Lawrence Pontius Ditch are also target sites. Another target area is the stretch of Lawrence Pontius Ditch immediately upstream of the lake where livestock can access the ditch. Control of geese on Koontz Lake presents a target method that will reduce phosphorus loading. The edge of the lake on resident's property is a target for the introduction of filter strips. Also, switching from conventional lawn fertilizer to a phosphate-free fertilizer is another target method. Lastly, application of alum to the lake bed below 10 feet may effectively bind available phosphorus and prevent its use by algae and aquatic plants.

Estimated load reduction: The following information provide a range of pollutant load reduction values based on the type of water quality improvement project implemented. First, approximately 500 residents will be placed on a centralized sewer system. Treatment by a central sewer system could reduce areal loading by 273 g/m^2-yr, which equates to a 23% reduction and readily meets the goal of the 3.6% targeted reduction.

Continued maintenance of the sediment trap will ensure that loads from the Koontz Lake watershed will be reduced by approximately 41%. Without the trap, phosphorus loading to the lake is approximately 910 g/m^2-yr which would require a 53% reduction in phosphorus loads to the lake.

Where streambank erosion is a concern, stabilization features can reduce introduction of sediment and phosphorus that may be adhered to the soil particles. Where livestock and their wastes may enter Lawrence Pontius Ditch or Schoeder Ditch, fencing or berm construction may be used to prevent livestock from entering the water and to control surface runoff of wastes into the water. 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).

Filter strips of native vegetation between the lake edge and managed turf reduces the introduction of phosphorus to the lake. Buffer strips can reduce up to 50% of the

phosphorus in runoff according to the Conservation Technology Information Center (2000).

Several stakeholders requested that rerouting of Lawrence Pontius Ditch to Robbins Ditch be considered. While this would reduce phosphorus and sediment loading to the lake, it would also reduce a major source of water to the lake. Brief discussions with an engineer at Lawson-Fisher (personal communication, Dennis Zebell, summer 2009) indicates that removing the Lawrence Pontius Ditch flow from the lake, could result in lowering the lake level. Koontz Lake is a public lake and with a legal lake level which cannot be changed. In addition, rerouting of Lawrence Pontius Ditch to Robbins Ditch requires that Robbins Ditch be at the least cleaned if not increased in size. Regardless of the issues associated with a reroute, the feasibility of doing so should be explored more thoroughly as this would result in a reduction near to 283 kg/yr of phosphorus to the lake.

Lastly, application of alum in lakes proves an effective but expensive means of preventing internal cycling of phosphorus (Steinman and Ogdahl, 2008).

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

Objective 1: Install centralized sewage system for lake residents.

Objective notes: Including residents immediately upstream on Lawrence Pontius Ditch and on Schoeder Ditch on a centralized system would also ensure a reduction in phosphorus loading to the lake.

Estimated load reduction: If the lake residents are placed on centralized sewage system, the expected load reduction is 23% based on the phosphorus budget presented in Section 4.5. Construction of the system is anticipated to begin in 2010.

Estimated Cost: A central sewer will be funded by federal, state and local funds. KLACC is not responsible for implementing this project and will not be requesting funding for its construction.

Actions:

- Encourage sewer treatment board to consider inclusion of residents immediately upstream of Koontz Lake on Lawrence Pontius and Schoeder ditches.

Objective 2: Maintain sediment trap and control structures on Lawrence Pontius Ditch

Estimated load reduction: Based on a study by Jones et al., (1997), the sediment trap on Lawrence Pontius Ditch reduces the phosphorus loads to the lake by 41%. Maintenance of the sediment trap will ensure the continued reduction of phosphorus loading to the lake, but it must be coupled with control of livestock access to the ditch and streambank stabilization in the reach of Lawrence Pontius Ditch between the constructed wetland and the lake inlet.

Estimated Cost: Dredging of the sediment trap is performed by the Marshall County Drainage Board at no cost to KLA or KLACC. Maintenance of the control structures depends on their embeddness. Costs may range from $500 for removing sediment that has accumulated behind the feature to more than $5000 if the structure must be replaced and permits obtained.

Actions:

- Request that Marshall County dredge sediment from sediment trap on a 5-year cycle.
- Assess the constructed wetland for plant coverage. If less than 50% consider planting additional species to increase coverage.
- Dredge open areas of constructed wetland to remove the approximate 0.8 feet of sediment that has accumulated since its construction.
- Locate all control structures and assess whether they continue to function.
- For those control structures that are submerged or deeply embedded, consider dredging upstream of or removing and replacing.

Objective 3: Dredge Koontz Lake from a depth between 3 to 7 feet.

Estimated load reduction: No model is available to predict a reduction in phosphorus loading by dredging the lake. However, sediment accumulation documented by Earth Source (1988) indicates a 30% reduction in the volume of the eastern basin, an 18% reduction in the central basin and a 39% reduction in volume in the western basin between 1955 and 1988. Removal of sediments between the 3 to 7-foot depth contour will reduce the re-suspension of lake sediments. These sediments likely have adhered phosphorus which can contribute to increased algal growth.

Estimated Cost: Dredging costs have been estimated at $1.3 to $3 million.

Actions:

- Continue with permitting process and appropriation of monies for project.

Objective 4: Exclude livestock from Lawrence Pontius and Schoeder ditch banks.

Estimated load reduction: It is difficult to estimate a reduction in sediment and phosphorus loading that will result from restricting livestock access to waterbodies within the watershed. However, 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), we estimated that livestock access to two areas identified within the Koontz Lake watershed results in an annual loading of 94 pounds of phosphorus to the watershed. (These areas include one area with approximately 20 head of livestock adjacent to a stream reach of approximately 160 feet and an area with several head of livestock adjacent to a stream reach measuring approximately 690 feet.) By fencing out livestock, placing filter strips, or installing a berm to restrict surface runoff to the ditch, the load reduction worksheet estimates that phosphorus loading would decrease to 14 lbs/yr. This would result in approximately 85% lower phosphorus loading from this source to the Koontz Lake watershed.

Estimated Costs: Costs include design of fencing, materials and labor. Costs for materials associated with fencing may be $2/ft. 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. Costs for stabilizing streambanks are discussed in Objective 5.

Actions:

- Identify properties where livestock fencing, filter strip establishment or berm construction should occur. Spruce Trail (Site #1) and Lawrence Pontius Ditch and the area immediately upstream of the lake are two of the target areas.
- Work with the NRCS and the associated landowners to identify a feasible solution to restrict livestock access to the associated waterbody.
- Identify an alternate watering source for the livestock.
- Estimate fencing, filter strip establishment, or berm construction needs for willing landowners.
- Pursue grant money for fencing or berm construction.
- Hire a contractor to install fencing, filter strip or berm along specified drainages.

Objective 5: Implement stream bank stabilization.

Estimated load reductions: The current phosphorus contribution from eroding banks at sites identified in Figure 43 has not been calculated; therefore, actual load reductions cannot be determined. However, Steffen (1982) calculated phosphorus loads to streams from streambank erosion, and subsequent reduction of loads from stabilizing streambanks. Under conditions of moderate erosion with soil containing about 0.0005 lb of phosphorus per lb soil, stabilizing 100 feet of streambank reduced phosphorus loading from 1.6 lbs/yr to 0.5 lbs/yr. This results in a 68% reduction in phosphorus

loading from this source. Stabilizing streambanks includes developing an adequate vegetative buffer.

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

Actions:

- Identify landowners that are willing to have streambank erosion stabilized. Spruce Trail (Site #1) and Lawrence Pontius Ditch and the reach of Lawrence Pontius Ditch within Swan Lake Resource are target areas.
- Pursue grant money for buffer or filter strip installation, or streambank stabilization.
- Install filter strips, buffers or stabilize streambanks along identified sections.

Objective 6: Reduce geese populations on lakeshore properties.

Objective Note: Two approaches to reducing impacts from geese are presented. The first approach is removal of geese through egg treatment; this approach removes the source and the associated fecal matter that contributes to increased phosphorus loading in the lake. The other approach involves establishment of a native plant buffer at the lake edge; this approach prevents geese easy migration from lawns to the lake and prevents runoff laden with fecal material from entering the lake.

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 Koontz Lake, 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.

Cost estimate: 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). Residents around Koontz Lake already participate in

the permitted goose egg treatment. 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.

Actions:

- Identify properties in need of buffers.
- Identify funding sources for buffer design and installation.
- Coordinate with property owners for buffer installation.
- Install natural vegetation which inhibits geese from entering the lake easily. Install along 35% of lakeshore properties that do not have buffers.
- Relocate geese and/or continue egg and test treatment based on available permitting from US Fish and Wildlife Service.
- Coordination with Ducks Unlimited and the local IDNR biologist to remove geese.
- Develop a plan of action and consult with the DNR biologist often about new methods of control.

Objective 7: Implement wetland construction, if feasible, on Schoeder Ditch and in the remainder of the watershed.

Objective notes: In general, restoring or constructing wetlands, where feasible, will increase the water, sediment and nutrient storage capacity of the watershed. Phosphorus can be retained in wetlands through its uptake by wetland vegetation. Sediments will be held as a result of the slowing of stream flows as they enter the wetland; hence, the sediment settles out from the water column. In addition to storing sediment and nutrients, wetlands serve as ground-water recharge sites and allow the watershed to regain its natural hydrological regime. This helps prevent bed and bank erosion in adjacent streams, since water is stored in wetlands during high flows, thereby protecting the streams from the energy associated with high flows. A site at the headwaters of Schoeder Ditch would reduce the loading of nutrients to Koontz Lake. Additional wetland restoration opportunities mentioned above are not being ruled out for restoration opportunities.

Estimated load reduction: No model is available to predict a reduction in sediment loading by restoring wetlands in the watershed. Based on the measured effects of the sediment trap and constructed wetland built on Lawrence Pontius Ditch, phosphorus loading reductions of up to 41% may be garnered if a similar feature is built on Schoeder Ditch.

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 $135,000/acre depending if the cost of land is included.

Actions:

- Identify location of potential constructed wetland and sediment trap on Schoeder Ditch.
- Identify location of other wetland restoration, construction and creation sites in the watershed.
- Identify funding for wetland preservation, restoration, and creation.
- 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, etc.).
- 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 8: Promote the usage of alternative fertilizers and/or the reduction in use of fertilizer.

Objective note: Koontz Lake stakeholders have already located a source of phosphorus-free fertilizer and it is currently available. Education and promotion of phosphorus-free fertilizer is integral to achieving this objective.

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

Actions:

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

Objective 9: Apply alum to lake below the 10-foot depth contour.

Objective note: Alum application to water forms aluminum hydroxide which binds with phosphorus to form an aluminum phosphate compound; the compound, which is insoluble, combines with sediment and settles to the lake bottom. Once on the bottom the floc forms a barrier further retarding the release of phosphorus to the water column.

Toxicity to lake organisms including fish is minimal. Lakes with alkalinities above 75 mg/L as $CaCO_3$ are not expected to have chronic or acute effects to biota (Naarf, 1990). (The alkalinity concentration of the bottom waters measured during the 2009 diagnostic study was approximately 155 mg/L $CaCO_3$.) According to Welch and Cook (1995), control of internal phosphorus cycling with alum lasts for approximately 8 years.

Application of alum requires consideration of disturbances by fish such as carp that may disturb bottom sediments. If dredging is funded and occurs, it should precede alum application, since dredging will suspend sediments, some of which could settle below the 10-foot contour where alum is proposed for application. Also, application of alum will required from IDNR and IDEM.

Estimated load reduction: Based on a study completed by Welch and Cook (1995), internal phosphorus loading is typically reduced by 80%.

Cost estimates: Alum application ranges from $280/acre to $700/acre depending on the dosage requirements and the costs to mobilize equipment (Wisconsin Dept. of Natural Resources, 2003).

Objective 10: Enroll willing landowners in the CRP program, review farmland in CRP program, and promote other practices to reduce phosphorus loads to streams.

Estimated load reduction: Exact load reductions will depend upon the BMP utilized and acreage to which the BMP is applied. An example load reduction calculation for converting a portion of a row cropped field to pasture (CRP) was completed for the Koontz Lake 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. 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.

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

Actions:

- Attend local SWCD meetings.
- Identify and enroll 5 new landowners in CRP by 2015 with at least 15 establishing forested riparian buffer strips.

- Review existing CRP enrolled filter strips to evaluate maintenance and condition.
- Identify and replace 10 tile risers with gravel tile inlets.

Objective 11: Identify and map all surface and subsurface drains that discharge to Koontz Lake.

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

Actions:

- Work cooperatively with the county drainage boards to identify locations of known surface and subsurface drains based on county drainage board maps and personnel's field knowledge of the watershed.
- Identify funding sources to map surface and subsurface drainages.
- Obtain permission to survey the entire length of the open streams and tributaries to document drains.
- Survey perimeter the lake and the entire length of Lawrence Pontius Ditch and its tributaries. Surveys should be conducted from within the lake and ditches where possible.
- Enter data/map locations of all surface and subsurface drains in a GIS or similar system. Attributes such as size of pipe/ditch, whether it is a surface or subsurface drain, whether it carries water continuously or is simply a wet-weather conduit, and potential pollutants associated with it should be attached to the location information for each drain. Use plan drawings of control structure installation to located Lawrence Pontius Ditch features.

Objective 12: Quantify pollutant (sediment, nutrients, and bacteria) loads from all storm drains that discharge to Koontz Lake.

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

Actions:

- Identify all storm drains entering Koontz Lake.
- Develop a spreadsheet/database containing the location of all storm drains.
- Enter data/map or update maps of the storm drains. Attributes such as size of pipe, area of drainage, whether it carries water continuously or only during wet weather, and potential pollutants associated with it should be attached to the location information for each drain.
- Identify funding sources to support sampling efforts.

- Develop a plan to measure pollutant loads. Sampling protocol will have to be developed once the nature and location of storm drains is known (i.e. some drains may not be accessible to sampling while others may only carry water during storm events). Sampling protocol will depend upon the funding available to sample identified storm drains.
- Develop spreadsheet/database to hold sampling results.
- Disseminate results of this sampling to watershed stakeholders in a watershed stakeholder meeting. Future versions of the watershed management plan should include methods for addressing storm drain pollutant loads, if necessary, and a prioritization of which drains should be addressed first.

Objective 13: Monitor the phosphorus load of at the 6 sampling sites used during the development of this plan and total phosphorus concentration in Koontz Lake.

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

Actions:

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

Objective 14: Conduct feasibility study of rerouting Lawrence Pontius Ditch to Robbins Ditch.

Actions:

- Hire engineering firm to explore reroute.
- Model reduction in phosphorus loading reduction.
- Model change in lake level.

Goal 2. Reduce total suspended solid concentrations to streams from 2009 levels to recommended concentrations of 30 mg/L (IDEM draft TMDL target) by 2020.

Goal time frame: Except for annual and continuous tasks, the goal should be reached by 2020.

Associated cost: Evaluated by objective.

Estimated load reduction: The entire watershed is targeted for sediment load reductions, but we focus particular emphasis on Lawrence Pontius Ditch as it 1) surfaces near Spruce Trail (Site #1), 2) flows through Swan Lake Resort, and 3) flows

through property immediately upstream of the lake. A review of the watershed tour information and analysis of water quality data collected during the water quality sampling portion of this project shows that contribution of sediments during storm flows is substantial. Table 28 presents the sediment load measured as total suspended solids (TSS) during the two sampling events and the ideal average loads to meet a reduction to stream TSS concentration of 30 mg/L. To calculate the ideal loads, flows in liters/second at each sampling site were averaged over all the sampling events. The average flow for each site was multiplied by 30 mg/L and a conversion factor (0.0864) to adjust for mg/second to kilograms/day.

Table 28. Ideal TSS load and percent reduction required to meet 30 mg/L concentration in streams.

Site	TSS load (kg/d)	Ideal TSS load (kg/d)	% Reduction to meet 30 mg/L target TSS level
1 LPD – Spruce Trail			
Storm flow	174.77	228.29	No reduction
Base flow	no flow	2.59	No reduction
2 LPD - Plymouth LaPorte Trail			
Storm flow	624.46	367.76	41%
Base flow	23.21	42.43	No reduction
3 LPD – N. Union			
Storm flow	1381.64	833.15	40%
Base flow	22.44	86.32	No reduction
4 LPD – S. Lake Drive			
Storm flow	3742.76	1228.07	67%
Base flow	5.67	4.48	No reduction
5 Schoeder Ditch			
Storm flow	107.36	59.46	44%
Base flow	6.94	6.61	4%
3a LDP – 5th			
Base flow	39.20496	48.521	No reduction

Concentrations of total suspended solids greater than 80 mg/L reduce the biotic integrity of water (Waters, 1995; Dodd and Whiles, 2004). Since TSS can interfere with the growth and reproduction of fish, stress threatened and endangered species, and kill sensitive invertebrate species, focusing on a reduction can improve the ditch water quality and prevent sediment from reaching the lake. Excessive turbidity and total suspended solids in the lakes reduce algal production which serves as a food source for fish and zooplankton. Aesthetically, muddy water is less attractive and dampens interest in lake recreation.

Although water quality is often impaired above 80 mg/L, we chose to use a target level of 30 mg/L for several reasons. This is the target value presented in the draft IDEM total maximum daily load (TMDL) calculations and is presented as one of the benchmark levels on the LARE website. The stakeholders identified reduction of sediment as it relates to sedimentation and turbidity problems in the lake as one of their original goals. They recognized that the presence of turbid waters indicates that something is wrong with the watershed. (There is a relationship between turbidity and TSS within an order

of magnitude (Dodd and Whiles, 2004.)) Because phosphorus adheres to sediment, reducing sediment loads to a stream will result in reduced phosphorus loads as well. Also, other states have as their standards for stream water quality TSS levels that are substantially less than 80 mg/L. Some of these standards are as low as 10 mg/L. Furthermore, drinking water regulations in the United States require that water not exceed 5 NTU (which is a measurement of turbidity). Based on work completed by Dodd and Whiles (2004), approximately 19 mg/L of TSS is equivalent to 5 NTU. Though no one should be drinking water directly from the streams and lakes in the Koontz Lake watershed, having water with low TSS, and therefore low turbidity, is a goal that can ensure human safety, aquatic life sustainability, and recreational satisfaction. Therefore, we have stated that target total suspended sediment concentrations of < 30 mg/L will improve water quality within the ditches that flow into Koontz Lake.

Based on the calculations (Table 28), total suspended solid loads during base flows require only slight reductions, however, storm flows increase TSS loading beyond state benchmark levels. Reducing sediment loads should focus on the upper watershed at Spruce Trail (Site #1), at Swan Lake Resort and below the constructed wetland on Lawrence Pontius Ditch. While the load reduction table indicates that no reduction is needed at Spruce Trail, this site is the headwaters of surface flow for Lawrence Pontius Ditch. Severe erosion, which is migrating up gradient at this site, will continue, and at some point, the 30 mg/L of TSS recommendation will be exceeded. It is very important to prevent further degradation at this site.

Potential load targets: Emphasis will be placed on the highly eroded area at Spruce Trail (Site #1) and Lawrence Pontius Ditch, at Swan Lake Resort and immediately upstream of Koontz Lake on Lawrence Pontius Ditch. Streambank erosion, wetland restoration, filter strips and buffers, and grazing management efforts will be the focus. We also recommend targeting the sediment trap above the constructed wetland on 5th Road for maintenance since this feature's purpose is to reduce sediment entering the lake.

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

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

Objective 1: Maintain sediment trap and control structures on Lawrence Pontius Ditch.

Estimated load reduction: Based on a study by Jones et al., (1997), the sediment trap reduces the phosphorus loads to Koontz Lake by 41%. The very name – sediment trap – implies that sediment settles from the water column into the trap and that they must be removed on occasion. The Long-Term Hydrologic Impact Analysis (L_THIA) model of Engel and Harbor (2009) indicates that with the sediment trap in place approximately 63 kg/day of total suspended solids reaches Koontz Lake. To the contrary, sampling during 2009 at site # 4 indicates that an average of 1874 kg/day can reach the lake. We determined that a 67% reduction in the sediment load of Lawrence Pontius Ditch was

required to achieve a concentration of 30 mg/L, which is the benchmark level in the draft Indiana total maximum daily load calculation. Maintenance of the sediment trap will ensure the continued reduction of sediment loading, but it must be coupled with streambank stabilization in the reach of Lawrence Pontius Ditch between the constructed wetland on 5th Road and the lake inlet.

Estimated Cost: Dredging of the sediment trap is performed by the Marshall County Drainage Board at no cost to KLA or KLACC. Maintenance of the control structures depends on their embeddness. Costs may range from $500 for removing sediment that has accumulated behind the feature to more than $5000 if the structure must be replaced and permits obtained.

Actions:

- Request that Marshall County dredge sediment from sediment trap on a 5-year cycle.
- Consider dredging the approximate 0.9 feet of sediment that has accumulated in the constructed wetland.
- Using plan drawings and field studies, locate all control structures and assess whether they continue to function.
- For those control structures that are submerged or deeply embedded, consider dredging upstream of or removing and replacing.

Objective 2: Exclude livestock from stream bank access.

See Goal 1, Objective 4 for information and action items relative to this objective.

Objective 3: Implement stream bank stabilization.

See Goal 1, Objective 5 for information and action items relative to this objective.

Objective 4: Implement wetland restoration.

See Goal 1, Objective 7 for information and action items relative to this objective.

Objective 5: Enroll willing landowner in the CRP program, review farmland in CRP program, and promote other practices to reduce sediment loads to streams.

See Goal 1, Objective 10 for information and action items relative to this objective.

Objective 6: Reduce contamination from stormwater system infrastructure.

See Goal 1, Objectives 11 and 12 for information and action items relative to this objective.

Objective 7: Reduce erosion from active construction sites.

Objective notes: As a result of the sewer system coming on line, the potential for more building construction around the lake is possible. Construction leads to soil erosion if best management practices are not employed during site clearing and building. This objective deals with the both the education of the watershed group and of developers in the area. As such, specific on-the-ground implementation tasks are not a part of this objective. Future iterations of the Koontz Lake Watershed Management Plan should account for any potential implementation practices and associated costs and sediment load reduction as information becomes available.

Actions:

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

Objective 8: Encourage county officials to maintain vegetated riparian buffer along legal drains.

Actions:

- Meet with the Marshall County Surveyors to determine the maintenance schedule for legal drains within the Koontz watershed.
- Attend one Marshall County Drainage Board meeting and one Starke County Drainage Board meeting annually.

Objective 9: Monitor the sediment load of each of the six ditch sampling sites and water clarity (Secchi disk transparency) in Koontz Lake used during the development of this plan.

Objective 10: Conduct feasibility study of rerouting Lawrence Pontius Ditch to Robbins Ditch.

Actions:

- Hire engineering firm to explore reroute.
- Model reduction in sediment loading reduction.
- Model change in lake level.

Goal 3. Reduce *E. coli* concentrations in Lawrence Pontius Ditch, Schoeder Ditch, and in Koontz Lake so that the water meets the Indiana state standards of 235 colonies/100 ml by 2020.

Goal time frame: This is a long-term goal. The goal should be reached by 2020.

Goal notes: Many of the objectives included for Goals 1 and 2 will also help to reduce the concentration of *E. coli* within the waterbodies of the Koontz Lake watershed. Completing specific tasks including excluding livestock from waterbodies within the watershed; reducing lakeshore geese populations; installation of a sewage system around the lake; stabilizing eroding streambanks; and establishing buffers adjacent to lakes and streams within the watershed will increase the likelihood of meeting this goal as well. Other potential tasks should target education of watershed residents.

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

Estimated load reduction: As this is an educational goal and all implementation projects are included as part of Goals 1 and 2. Additionally, this goal deals with a reduction in concentration not load. As such, a reduction in load cannot be calculated for this goal.

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

With no action: If water quality improvement projects are not implemented it is anticipated that *E. coli* concentrations will likely remain at their current levels or increase as erosion continues and population levels increase throughout the watershed.

Objective 1: Install centralized sewage system for lake residents.

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

Objective 2: Learn more about identifying the sources of *E. coli*.

Actions:

- Identify septic systems outside of those around the lake that could contribute to *E. coli*.
- Ensure that Swan Lake Resort sewage treatment facility is working properly by reviewing state NPDES records.

Objective 3: Publicize Best Management Practices available to reduce pathogenic contamination of the Koontz Lake watershed waterbodies.

Actions:

- Meet with the Marshall and Starke County Health Departments to discuss Best Management Practices available to maintain properly functioning septic systems.
- Develop a list or summary of Best management Practices available to reduce the risk of pathogenic contamination of watershed waterbodies. The list should include management techniques that address contamination from all sources, including domestic and wild animals in the watershed.
- Publish a newspaper particle targeting the list or summary of Best Management Practices available to reduce the risk of pathogenic contamination of watershed waterbodies.
- Develop a website or electronic email that gets the attention of all watershed residents. See http://www.busseron.org/BCWP_Septic.htm for an example.

Objective 4: Monitor the *E. coli* concentration of each of the watershed stream sites that were sampled for development of this plan.

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

Actions:

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

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

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

Goal notes: This goal is ultimately targeted at educating individual stakeholders within the Koontz watershed. The actual implementation of the practice or technique will be handled by the landowner themselves. Specific grants or cost-share programs may be available for the implementation of these practices or techniques.

In order for educational efforts to be developed and practices to be implemented, a watershed group representing the interested groups and individuals, and local and state governmental entities should form a stable watershed group. As a small group of individuals have attended all of the watershed planning meetings to date, these

individuals will likely be charged with maintaining the current attendance standard and will need to work with other community members to boost interest and participation in project implementation phase of this project. The core group of individuals working on planning in the Koontz Lake watershed should always contain a representative from the Koontz Lake Conservation Association, the Koontz Lake Aquatic Control Committee and the Marshall and Starke County SWCDs. Meeting this goal requires that a core group of individuals begin implementation of this plan and that these individuals meet at least on a quarterly basis.

Associated cost: This goal is targeted at educating individuals within the Koontz Lake watershed. As such, educational efforts will be targeted at items that will result in reduced nutrient, sediment, and pathogen loads and concentrations as described in Goals 1 through 3. Specific grants or cost-share programs may be available for the implementation of these practices or techniques. However, as all of the objectives and action items target education, associated costs for this goal also target education not implementation. In regards to sampling equipment, the KLA will want to participate in the Hoosier Riverwatch program or obtain the sampling equipment from Marshall or Starke counties if either of them have the equipment. Koontz Lake will need to continue its participation in the Indiana Clean Lakes Program which they have been doing for 15 years.

Estimated load reduction: A load reduction cannot be attributed to this goal or any of its objectives or action items. As this goal deals specifically with education, pollutant load reduction is not the ultimate goal. For specific load reductions based on the type of practice implemented, see Goals 1 through 3.

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

With no action: With no additional education, watershed landowners will continue to be informed by the KLA, the KLACC, and by the Marshall and Starke County SWCD and NRCS offices. However, it is unlikely that each and every landowner within the watershed will learn and/or implement a water quality improvement project as they will not all be exposed to the educational materials. Without the installation of water quality improvement projects, it is unlikely that water quality within the Koontz watershed will improve.

If the Koontz Lake Aquatic Control Committee does not continue to meet, then there will be no checks or balances on any of the activities identified as part of this plan. Likewise, individual's completing work items through this plan will not have a forum to discuss successes or failures. Additionally without an established watershed group, a

mechanism to implement projects related to this plan or to review and update the plan will not be in place.

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

Actions:

- Contact potential core group members including the local IDNR conservation officer, high school biology teacher, County SWCD, or other community and conservation groups active in the watershed.
- Advertise the formation of the group in local newspapers and mailing to stakeholders.
- Host regular water quality meetings at the Koontz Lake Clubhouse.
- Biannually, invite local, regional, and state natural resources professionals to attend watershed group meetings. Hold discussions dealing with local and state efforts/events highlighting water quality (including regulatory efforts) and resources available to assist watershed groups.
- Publish meeting minutes via an email list, newsletter, and/or website. These publications should include information detailing current and future efforts at improving water quality, the aesthetic value of a healthy watershed, and information on how stakeholders may get involved in these efforts.

Objective 2: Organize and hold one annual field day highlighting the value of the Koontz Lake, Lawrence Pontius Ditch, Schoeder Ditch, the Koontz Lake Nature Preserve, the Koontz Lake Wetland Conservation Area, and Swan Lake Resort in the Koontz Lake 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 Koontz Lake watershed.
- Advertise the field days via press releases to the local media, an annual newsletter, and/or mailings to stakeholders using the existing stakeholder database and SWCD contacts.

Objective 3: Publicize the value of the Koontz Lake 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 Koontz Lake watershed and the Koontz Lake watershed group in language understood by a non-technical audience.
- Develop a system of mailing information to residents on the water quality of the Koontz Lake watershed and information on how individuals can help to improve water quality.
- Publish an annual newsletter containing information outlined in the first three action items of this objective.
- Develop a web site containing information outlined in the first three action items of this objective.
- Develop a brochure which summarizes the value of the Koontz Lake watershed and provides a list objectives and actions. Distribute widely.

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

Actions:

- Work with the NRCS and SWCD to identify which property owners in the Koontz Lake watershed are using conservation tillage methods and/or land conservation programs. Where possible or appropriate, assist the NRCS and SWCD in encouraging agricultural property owner's not using conservation tillage or not participating in conservation programs to utilize these programs.
- Work with SWCD to apply for LARE Watershed Land Treatment funding to assist landowners with fencing or berm construction to prevent livestock and fecal matter from entering the ditches, and to assist with headwater and streambank stabilization.
- Work with NRCS and SWCD representatives to hold one demonstration day annually on properties where landowners are implementing conservation tillage methods and/or land conservation programs. This effort will help advertise available methods to reduce soil loss from land and pollutant loading to local streams.
- Attend local SWCD meetings.

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

Actions:

- Work with the NRCS and SWCD to develop a list of potential activities that residential property owners can do to improve water quality within the Koontz Lake watershed.

- Work with NRCS and SWCD representatives to hold one demonstration day annually on residential properties where landowners are implementing water quality improvement projects. This effort will help advertise available methods to reduce soil loss from land and pollutant loading to local streams.
- Locate and develop a list of potential grant monies for residential water quality improvement project implementation.

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

Actions:

- Talk with fair representatives to determine the feasibility of establishing a table or booth at the Marshall County and Starke County Fairs to target watershed and water quality education.
- Work with the NRCS, SWCD, and 319 and IDEM Project Manager to develop program materials and handouts for the table or booth.
- Establish a core group of individuals to manage the table or booth during the fair and provide educational information to attendees on the watershed, water quality, and the watershed management planning process.

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

Actions:

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

Goal 5. Maintain and improve the recreational setting of the Koontz Lake watershed within five years through education and in-lake actions.

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

Goal notes: This goal is targeted at addressing all recreational issues identified by watershed stakeholders. The goal will be met when a recreational plan for Koontz Lake has been developed and implemented or when the KLA or KLACC has addressed each of the items listed below. Specific objectives and action items which target water quality improvements to generate improved recreation are found under Goals 1 through 3. Improvements to lake water quality will be achieved by achieving water quality in the

watershed. In turn, algal blooms and excessive aquatic plant growth, particularly the growth of exotic aquatic plants will diminish.

Koontz Lake has already developed an aquatic management plan that identified whole lake treatment for exotic invasive plant species as a viable goal for achieving an improved aquatic plant community in the lake. The plan also provides educational information on the benefits of native aquatic plants and their control in light of recreational activities such as fishing, swimming and boating. Development and implementation of a recreational plan can address the issues brought up in Problem Statement 5.

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

Estimated load reduction: There is no exact load reduction that can be calculated for this goal. As this goal deals specifically with recreation and in-lake issues, pollutant load reduction is not the ultimate goal. The volume of pollutant loading reduction that will occur will depend upon the type of water quality improvement project implemented.

Potential targets: This goal targets Koontz Lake.

With no action: With no additional recreational planning, recreational issues within Koontz Lake will not be addressed and will become unmanageable. Ultimately, it is unlikely that water quality within the Koontz Lake will improve without the implementation of some of these recreational planning items.

Objective 1: 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 LARE funds available to the County Sheriff to train deputy law enforcement officers specifically for patrolling the lakes.
- Obtain funding to employ a law enforcement person.

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

Actions:

- Ensure that deployment of buoys at a distance of 200 feet from the shoreline around the perimeter of the lake is maintained.
- Encourage boaters to reduce speeds over shallow water through education and use of local law enforcement.
- Explore establishment of ecological protection zones to protect areas of native aquatic vegetated habitat in shallow waters around selected areas of the lake.
- Dredge areas of accumulated sediment that are not identified as ecological protection zones.

Objective 3: Reduce the possibility of introducing exotic plant and animal species to Koontz Lake.

Actions:

- Establish boat wash stations at the public access point and the marina.
- Post signs indicating that the importance of cleaning your boat before accessing lake.
- Use information from www.protectyourwaters.net/resources/ and distribute widely for education about aquatic invasive species.
- Provide brochure (outlined in Goal 4) at a lake event to educate boat owners about exotic invasive plants and animals and the importance of boat cleaning.
- Tally number of brochures distributed at educational lake event. Target at least 65% of attendees for educational material.

Objective 4: Address fuel contamination issues, which result from boats with poorly maintained or older engines and also occur during refueling.

Actions:

- Place warning and informational signs at public access and marina encouraging boaters to take care when refueling.
- Encourage watercraft owners to maintain or replace older engines.
- Locate funding for and initiate cash-for-clunker engines program.
- Work with the public or commercial facilities to minimize fuel spills during in-lake refueling.
- Support restrictions on group piers to limit fuel spills.
- Submit proposal that fuel contamination be added to county ordinances regarding group pier issues.

Objective 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 county and state.

Actions:

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

Objective 6: Monitor and improve the fish community within the Koontz and other lakes within the Koontz 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 Koontz.
- Implement water quality improvement projects as discussed in Goals 1 through 3 to assist with improving water quality within the lakes.

7.0 MEASURING SUCCESS

Measuring stakeholders' success at achieving their goals and assessing progress toward realizing their vision for the Koontz Lake watershed is a vital component of the plan. The following describes concrete milestones for stakeholders to reach and 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 listed as milestones in this section. 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 J.

Goal 1: Reduce phosphorus loads to the lake from 2009 levels by 3.6% to reach recommended phosphorus loadings to the lake of <0.427 g/m^2-yr (after Vollenweider, 1975) by 2020.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2020.)

- Landowners contacted regarding potential livestock exclusion
- Follow-up on sewage system installation for lake residents.
- Maintenance of sediment trap and constructed wetland completed.
- .
- Plans developed for livestock exclusion.
- Funding obtained for livestock exclusion.
- Contractor for livestock exclusion installation hired.
- Landowners contacted regarding streambank stabilization/buffer installation.

- Grant monies applied for and obtained for streambank stabilization.
- Filter strips, buffer strips, and streambank stabilization implemented.
- Properties in need of buffer installation adjacent to the lakeshore identified.
- Landowners contacted regarding shoreline buffer installation.
- Planting plan for the Koontz Lake's shoreline developed.
- Goose egg treatment completed.
- Potential wetland restoration sites identified.
- Landowners contacted regarding potential wetland restoration.
- Wetland restoration designed.
- Funding for wetland restoration applied for and obtained.
- Information regarding phosphorus-free fertilizer disseminated.
- Marketing methods for phosphorus-free fertilizer determined/developed.
- Meeting regarding failing septic systems held with the two county health departments.
- Failing septic systems identified.
- 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.
- Total Maximum Daily Load development meetings attended.
- Meeting minutes distributed.
- Meeting with health department held.
- Lake dredged.
- Alum applied to lake bottom.
- Feasibility study of rerouting Lawrence Pontius Ditch to Robbins Ditch.

The goal is attained when the phosphorus load to the Koontz Lake is reduced by 3.6% or more to meet the 0.427 g/m^2-yr.

Indicator to be monitored: Reduction of phosphorus loading by 21.5 kg/yr.

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 2.

Length of monitoring: The monitoring will occur for five years.

Protocol: Monitoring will be conducted according the Hoosier Riverwatch protocol for measuring total phosphorus (http://www.state.in.us/dnr/nrec/3013.htm).

Monitoring equipment: For equipment requirements for total phosphorus using the Hoosier Riverwatch method, see the Hoosier Riverwatch Training Manual (http://www.state.in.us/dnr/nrec/3013.htm).

Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter total phosphorus and flow measurements in an electronic database.

Data evaluation: The local SWCD or NRCS staff can provide assistance in interpreting the data as needed. Additionally, Hoosier Riverwatch staff or local instructors may also be available to provide assistance with data analysis.

Goal 2. Reduce total suspended solid loads to streams from 2009 levels to recommended concentrations of 30 mg/L (IDEM draft TMDL target) by 2020.

Milestones: (Except for annual or continuous tasks, this goal should be reached by 2020.)

- Implementation of Goal 1 milestones.
- 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.
- Drainage board meeting attended.
- Feasibility study of reroute of Lawrence Pontius Ditch to Robbins Ditch.

Goal Attainment: The goal is attained when the sediment load at Site #4 in the Koontz Lake watershed has been reduced by 67% and 44% at Site #5.

Indicator to be monitored: Sediment loading measuring more than half of current sediment loads within Lawrence Pontius Ditch and slightly less than half in Schoeder Ditch.

Parameter assessed: Total suspended solids (streams)

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 2.

Length of monitoring: The monitoring will be conducted for five years.

Protocol: Monitoring will be conducted through collection of water s ample and measurement of flow and transfer of sample to appropriate lab using acceptable standard operating procedures and utilizing Standard Method 2540 D 20th Edition (1997) for analysis.

Monitoring equipment: Equipment required for TSS includes a clean sampling bottle and discharge analysis measurements using the Hoosier Riverwatch method. See the Hoosier Riverwatch Training Manual (http://www.state.in.us/dnr/nrec/3013.htm).

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 and flow measurements in an electronic database.

Data evaluation: The local SWCD or NRCS staff can provide assistance in interpreting the data as needed. Additionally, Hoosier Riverwatch staff or local instructors may also be available to provide assistance with data analysis.

Goal 3. Reduce *E. coli* concentrations in Lawrence Pontius Ditch, Schoeder Ditch, and in Koontz Lake so that the water meets the Indiana state standards of 235 colonies/100 ml by 2020.

Milestones: (Except for continuous or annual tasks, this is a long-term goal. The goal should be reached by 2020.)

- Implementation of Goal 1 milestones.
- Identify septic systems on ditches immediately upstream of lake
- Meet with Swan Lake Resort to learn about their sewage system
- Meet with Marshall and Starke County Health Dept. to discuss Best Management Practices for septic systems.
- Develop list of Best Management Practices for septic systems.
- Publish newspaper article.
- Develop website about septic system management or guide watershed residents to other sites that already provide information.

Goal Attainment: This goal is attained when *E. coli* concentrations in Lawrence Pontius Ditch, Schoeder Ditch, and in Koontz Lake meet the Indiana state standards of 235 colonies/100 ml by 2020.

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 2.

Length of monitoring: The monitoring will occur for five years.

Protocol: Monitoring will be conducted according to the protocol utilizing the Hoosier Riverwatch protocol for measuring *E. coli* (http://www.state.in.us/dnr/nrec/3013.htm).

Monitoring equipment: Equipment for *E. coli* analysis is based on certified laboratory requirements. For equipment requirements for *E. coli* measurement using the Hoosier Riverwatch method, see the Hoosier Riverwatch Training Manual (http://www.state.in.us/dnr/nrec/3013.htm).

Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter *E. coli* concentrations in an electronic database.

Data evaluation: The local SWCD or NRCS staff can provide assistance in interpreting the data as needed. Additionally, Hoosier Riverwatch staff or local instructors may also be available to provide assistance with data analysis.

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

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

- Identification of a point person to lead the implementation of the plan.
- Koontz Lake watershed group formed.
- Watershed group meetings held.
- Watershed group meeting minutes published.
- Watershed group newsletter published.
- Watershed group website developed.
- Website updates noting new members and participants.
- Value of the watershed and watershed group summarized and promoted.
- Property owners implementing conservation projects identified.
- Local experts invited to speak at field days.
- Field days advertised and held.
- List of agricultural Best Management Practices developed.
- Agricultural demonstration day held.
- List of residential Best Management Practices developed.
- Annual newsletter published.

- Property owners using conservation land programs identified.
- Local SWCD meeting attended.
- Residential demonstration day held.
- List of grants for residential water quality projects developed.
- Program materials and handouts regarding the watershed group and water quality developed.
- Table or booth established at the Starke and Marshall County Fairs.
- Conservation practices implemented.
- Hoosier Riverwatch volunteer training attended.
- Hoosier Riverwatch data collected and submitted.

Goal Attainment: The goal is attained when each landowner learns about and/or implements one water quality improvement project or technique on his or 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 Koontz Lake watershed within five years through education and in-lake actions.

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

- Funding for exotic aquatic plant control received.
- Funding for future plant surveys identified and obtained.
- Boater's education course held.
- Law enforcement contacted in regards to lake patrols.
- Educational materials regarding boating in shallow water distributed.
- Locate funding for boat wash stations
- Install boat wash stations at public access and marina.
- Install signs regarding boat speed and exotic aquatic plants.
- Dredging addressed.
- Information regarding the impacts of boat fuel distributed.
- Funneling, group piers, and boat speed issues information distributed.
- ILMS meetings/workshops attended.

Goal Attainment: The goal is attained when funding is received for exotic aquatic plant control and a recreational plan is developed. This does not involve a specific water quality target. This goal will be a continual effort by watershed stakeholders.

8.0 FUTURE CONSIDERATIONS

There are several considerations stakeholders should keep in mind as they implement the Koontz Lake Watershed Management Plan.

Permits, Easements, and Agreements

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

Operation and Maintenance

Wetland Restoration: Wetland restoration projects were identified in the watershed. In the long term, these areas will provide water quality benefits while requiring little maintenance. In the short term, certain management activities may be employed to help these areas recover faster than they would if left alone. Such activities include 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 KLA or KLACC will be responsible for holding and revising the Koontz Lake 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 K. This form should be returned to the KLACC. The KLACC will keep completed action registers in three ring binder and review action registers to ensure tasks are being completed. The forms will also help document the success of actions taken in the watershed.

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APPENDIX A

LIST OF INVITED STOCKHOLDERS

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

List of Invited Stakeholders

Jim Berger – Chair, KLACC
Joan Darflinger – resident
Janet Davison – resident, KLA member
Loretta Dobuck – Co-chair, KLACC
Tim Dyczko – Swan Lake Resort
Karen Jaros Doria – resident
Charles Ens – resident
Joel Fisher – Marshall County SWCD
Gene Fleming – resident
Audrey Gorka – resident
John & Barb Hnatovic – Publicity, KLACC
Jim Jackson- Secretary, KLACC
John Kohles - resident
Nathan Long – Aquatic Control
Mike McKenna – resident, KLECC member
Paul Miles – resident
Kathy Norem – Starke County Commissioner
Don O'Barski – resident
George & Susan Ruiter – residents
Mario and Sandy Santacaterina - residents
Linda Schmidt – IDEM, 319 Program
Bob & Alice Thomas – residents
Flora Tibbetts – resident
John Ullrich –resident
Paul Warnke – resident
Gwen White – IDNR, LARE program
Dennis Zebell – Lawson Fisher

APPENDIX B

ENDANGERED, THREATENED AND RARE SPECIES, AND HIGH QUALITY NATURAL COMMUNITIES DOCUMENTED FROM THE KOONTZ LAKE WATERSHED AREA, MARSHALL AND STARKE COUNTIES, INDIANA

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

February 23, 2009

Endangered, Threatened and Rare Species, and High Quality Natural Communities Documented
From the Koontz Lake Watershed Area, Marshall and Starke Counties, Indiana

TYPE	Species Name	Common Name	Fed	State	Town Range	Date	Comments
Vascular Plant	Arabis glabra	Tower-mustard		WL	034N001W 02 NWQ NEQ SEQ	1997-06-06	
Mammal	Taxidea taxus	American Badger		SSC	034N001E 33	1987-11-01	
Vascular Plant	Carex atlantica ssp. atlantica	Atlantic Sedge		ST	034N001W 12	1934-06	
Vascular Plant	Coeloglossum viride var. virescens	Long-bract Green Orchis		ST	034N001E 06	1921-05	
Vascular Plant	Arabis missouriensis var. deamii	Missouri Rockcress		SE	034N001W 02 NWQ NEQ SEQ	1997-06-06	
Vascular Plant	Lycopodium obscurum	Tree Clubmoss		SR	034N001W 13 NWQ NWQ SWQ	1997-12 23	
Mammal	Spermophilus franklinii	Franklin's Ground Squirrel		SE	034N001E TYNER	1961-08-14	
KOONTZ LAKE NATURE PRESERVE							
Amphibian	Ambystoma laterale	Blue-spotted Salamander		SSC	034N001W 01	2001-06-19	
Amphibian	Hemidactylium scutatum	Four-toed Salamander		SE	034N001W 01	2001-06-19	
Amphibian	Rana pipiens	Northern Leopard Frog		SSC	034N001W 01	2001-06-19	
Insect Lepidoptera	Grammia figurata	The Figured Grammia		SR	034N001W 01 SEQ SWQ	2001	
Vascular Plant	Botrychium matricariifolium	Chamomile Grape-fern		SR	034N001W 01 SWQ NWQ SWQ	1988-06-01	
Insect Lepidoptera	Macrochilo absorptalis	A Moth		SR	034N001W 01 SEQ SWQ	2001	
Insect Lepidoptera	Lesmone detrahens	A Moth		SR	034N001W 01 SEQ SWQ	2001	
Insect Lepidoptera	Euxoa albipennis	White-striped Dart		SR	034N001W 01 SEQ SWQ	2001	
Insect Lepidoptera	Macrochilo hypocritalis	A Noctuid Moth		SR	034N001W 01 SEQ SWQ	2001	
Insect Lepidoptera	Papaipema speciosissima	The Royal Fern Borer Moth		ST	034N001W 01 EH SWQ	2001-03-05	
High Quality Natural Community	Savanna - sand dry-mesic	Dry-mesic Sand Savanna		SG	034N001W 01 SEQ	1985-08-14	
Reptile	Clemmys guttata	Spotted Turtle		SE	034N001W 01 NWQ NWQ SWQ	1988-04-26	
Vascular Plant	Carex atlantica ssp. atlantica	Atlantic Sedge		ST	034N001W 01 SEQ NWQ SEQ	1988-06-03	
Insect Lepidoptera	Eucoptocnemis tripars	Pearly Dune Moth		ST	034N001W 01 SEQ SWQ	2001	
Insect Lepidoptera	Melanomma auricinctaria	Huckleberry Eye-spot Moth		SR	034N001W 01 SEQ SWQ	2001	
Insect Lepidoptera	Leucania inermis	A Moth		SR	034N001W 01 SEQ SWQ	2001	
Vascular Plant	Carex echinata	Little Prickly Sedge		SE	034N001W 01 NWQ SWQ	1990-07-16	
Insect Lepidoptera	Grammia phyllira	The Sand Barrens Grammia		SR	034N001W 01 SEQ SWQ	2001	
Insect Lepidoptera	Catocala praeclara	Praeclara Underwing		SR	034N001W 01 SEQ SWQ	2001	

Fed: LE = listed federal endangered; C = federal candidate species

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SG = state significant; WL = watch list; no rank = not ranked but tracked to monitor status

Endangered, Threatened and Rare Species, and High Quality Natural Communities Documented
From the Koontz Lake Watershed Area, Marshall and Starke Counties, Indiana

TYPE	Species Name	Common Name	Fed	State	Town Range	Date	Comments
High Quality Natural Community	Wetland - marsh	Marsh		SG	034N001W 01 SH	1985-08-14	
Reptile	Emydoidea blandingii	Blanding's Turtle		SE	034N001W 01 NH SWQ	2001-06-19	

Fed: LE = listed federal endangered; C = federal candidate species

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SG = state significant; WL = watch list; no rank = not ranked but tracked to monitor status

Indiana County Endangered, Threatened and Rare Species List

County: Marshall

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Alasmidonta viridis	Slippershell Mussel			G4G5	S2
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G4	S2
Ligumia recta	Black Sandshell			G5	S2
Obovaria subrotunda	Round Hickorynut		SSC	G4	S2
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Mollusk: Gastropoda					
Campeloma decisum	Pointed Campeloma		SSC	G5	S2
Lymnaea stagnalis	Swamp Lymnaea		SSC	G5	S2
Fish					
Ammocrypta pellucida	Eastern Sand Darter			G3	S2
Coregonus artedi	Cisco		SSC	G5	S2
Ichthyomyzon bdellium	Ohio Lamprey			G3G4	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
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Terrapene ornata	Ornate Box Turtle		SE	G5	S2
Thamnophis butleri	Butler's Garter Snake		SE	G4	S1
Bird					
Accipiter striatus	Sharp-shinned Hawk	No Status	SSC	G5	S2B
Ardea herodias	Great Blue Heron			G5	S4B
Botaurus lentiginosus	American Bittern		SE	G4	S2B
Certhia americana	Brown Creeper			G5	S2B
Cistothorus palustris	Marsh Wren		SE	G5	S3B
Dendroica cerulea	Cerulean Warbler		SSC	G4	S3B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Rallus elegans	King Rail		SE	G4	S1B
Rallus limicola	Virginia Rail		SE	G5	S3B
Wilsonia citrina	Hooded Warbler		SSC	G5	S3B
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		SE	G5	S1B
Mammal					
Spermophilus franklinii	Franklin's Ground Squirrel		SE	G5	S2
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Armoracia aquatica	Lake Cress		SE	G4?	S1
Aster borealis	Rushlike Aster		SR	G5	S2
Coeloglossum viride var. virescens	Long-bract Green Orchis		ST	G5T5	S2
Cypripedium candidum	Small White Lady's-slipper		WL	G4	S2
Eleocharis equisetoides	Horse-tail Spikerush		SE	G4	S1
Glyceria grandis	American Manna-grass		SX	G5	SH
Hypericum pyramidatum	Great St. John's-wort		ST	G4	S1
Platanthera orbiculata	Large Roundleaf Orchid		SX	G5	SX
Poa alsodes	Grove Meadow Grass		SR	G4G5	S2
Potamogeton friesii	Fries' Pondweed		ST	G4	S1
Potamogeton pusillus	Slender Pondweed		WL	G5	S2
Potamogeton strictifolius	Straight-leaf Pondweed		ST	G5	S1
Valeriana edulis	Hairy Valerian		SE	G5	S1
Zannichellia palustris	Horned Pondweed		SR	G5	S2
High Quality Natural Community					
Prairie - mesic	Mesic Prairie		SG	G2	S2

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list

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

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: Marshall

Species Name	Common Name	FED	STATE	GRANK	SRANK
Wetland - beach marl	Marl Beach		SG	G3	S2
Wetland - bog acid	Acid Bog		SG	G3	S2
Wetland - fen	Fen		SG	G3	S3
Wetland - flat muck	Muck Flat		SG	G2	S2

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
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Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

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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

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: Starke

Species Name	Common Name	FED	STATE	GRANK	SRANK
Insect: Coleoptera (Beetles)					
Nicrophorus americanus	American Burying Beetle	LE	SX	G2G3	SH
Insect: Lepidoptera (Butterflies & Moths)					
Atrytonopsis hianna	Dusted Skipper		ST	G4G5	S1S2
Catocala praeclara	Praeclara Underwing		SR	G5	S2S3
Chortodes enervata	The Many-lined Cordgrass Moth		ST	G4	S1
Dasychira cinnamomea	A Moth		SR	G4	S1
Eucoptocnemis tripars	Pearly Dune Moth		ST	GNR	S2
Euxoa albipennis	White-striped Dart		SR	G4G5	S1S3
Grammia figurata	The Figured Grammia		SR	G5	S2S3
Grammia oithona	Oithona's Grammia		SR	G4Q	S2S3
Grammia phyllira	The Sand Barrens Grammia		SR	G4	S2S3
Iodopepla u-album	A Noctuid Moth		SR	G5	S2
Lesmone detrahens	A Moth		SR	G5	S2
Leucania inermis	A Moth		SR	G4	S2S3
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 beeriana	Beer's Blazing Star Borer Moth		ST	G2G3	S1S3
Papaipema limpida	The Ironweed Borer Moth		SR	G4	S1S2
Papaipema speciosissima	The Royal Fern Borer Moth		ST	G4	S2S3
Fish					
Moxostoma valenciennesi	Greater Redhorse		SE	G4	S2
Amphibian					
Ambystoma laterale	Blue-spotted Salamander		SSC	G5	S2
Hemidactylium scutatum	Four-toed Salamander		SE	G5	S2
Rana pipiens	Northern Leopard Frog		SSC	G5	S2
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Kinosternon subrubrum	Eastern Mud Turtle		SE	G5	S2
Ophisaurus attenuatus	Slender Glass Lizard			G5	S2
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Terrapene ornata	Ornate Box Turtle		SE	G5	S2
Bird					
Ardea alba	Great Egret		SSC	G5	S1B
Ardea herodias	Great Blue Heron			G5	S4B
Botaurus lentiginosus	American Bittern		SE	G4	S2B
Buteo lineatus	Red-shouldered Hawk		SSC	G5	S3
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
Dendroica cerulea	Cerulean Warbler		SSC	G4	S3B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Lophodytes cucullatus	Hooded Merganser			G5	S2S3B
Rallus elegans	King Rail		SE	G4	S1B
Rallus limicola	Virginia Rail		SE	G5	S3B
Sturnella neglecta	Western Meadowlark		SSC	G5	S2B
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		SE	G5	S1B
Mammal					
Lynx rufus	Bobcat	No Status		G5	S1
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Spermophilus franklinii	Franklin's Ground Squirrel		SE	G5	S2
Taxidea taxus	American Badger			G5	S2

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Indiana County Endangered, Threatened and Rare Species List

County: Starke

Species Name	Common Name	FED	STATE	GRANK	SRANK
Vascular Plant					
Androsace occidentalis	Western Rockjasmine		ST	G5	S2
Arabis glabra	Tower-mustard		WL	G5	S2
Arabis missouriensis var. deamii	Missouri Rockcress		SE	G4G5QT3?Q	S1
Aralia hispida	Bristly Sarsaparilla		SE	G5	S1
Aristida intermedia	Slim-spike Three-awn Grass		SR	GNR	S2
Armoracia aquatica	Lake Cress		SE	G4?	S1
Aster sericeus	Western Silvery Aster		SR	G5	S2
Azolla caroliniana	Carolina Mosquito-fern		ST	G5	S2
Botrychium matricariifolium	Chamomile Grape-fern		SR	G5	S2
Carex atlantica ssp. atlantica	Atlantic Sedge		ST	G5T4	S2
Carex conoidea	Prairie Gray Sedge		ST	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
Carex straminea	Straw Sedge		ST	G5	S2
Corydalis sempervirens	Pale Corydalis		ST	G4G5	S1
Cyperus dentatus	Toothed Sedge		SE	G4	S1
Diervilla lonicera	Northern Bush-honeysuckle		SR	G5	S2
Drosera intermedia	Spoon-leaved Sundew		SR	G5	S2
Epigaea repens	Trailing Arbutus		WL	G5	S3
Eriocaulon aquaticum	Pipewort		SE	G5	S1
Geranium bicknellii	Bicknell Northern Crane's-bill		SE	G5	S1
Hymenopappus scabiosaeus	Carolina Woollywhite		SE	G4G5	S1
Juncus articulatus	Jointed Rush		SE	G5	S1
Linum intercursum	Sandplain Flax		SE	G4	S1
Ludwigia sphaerocarpa	Globe-fruited False-loosestrife		SE	G5	S1
Lycopodium obscurum	Tree Clubmoss		SR	G5	S2
Lycopus amplectens	Sessile-leaved Bugleweed		SE	G5	S1
Panicum boreale	Northern Witchgrass		SR	G5	S2
Panicum columbianum	Hemlock Panic-grass		SR	G5	S2
Panicum leibergii	Leiberg's Witchgrass		ST	G5	S2
Panicum longifolium	Long-leaved Panic-grass		SX	G4	SX
Panicum subvillosum	A Panic-grass		SE	GNRQ	S1
Platanthera ciliaris	Yellow-fringe Orchis		SE	G5	S1
Platanthera leucophaea	Prairie White-fringed Orchid	LT	SE	G3	S1
Polygonum careyi	Carey's Smartweed		ST	G4	S2
Polytaenia nuttallii	Prairie Parsley		SE	G5	S1
Potamogeton strictifolius	Straight-leaf Pondweed		ST	G5	S1
Psilocarya nitens	Short-beaked Bald-rush		SX	G4?	SX
Psilocarya scirpoides	Long-beaked Baldrush		ST	G4	S2
Rubus deamii	Deam Dewberry		SX	G4?	SX
Scirpus purshianus	Weakstalk Bulrush		SR	G4G5	S1
Scirpus torreyi	Torrey's Bulrush		SE	G5?	S1
Scleria reticularis	Reticulated Nutrush		ST	G4	S2
Spiranthes lucida	Shining Ladies'-tresses		SR	G5	S2
Spiranthes magnicamporum	Great Plains Ladies'-tresses		SE	G4	S1
Trichostema dichotomum	Forked Bluecurl		SR	G5	S2
Utricularia geminiscapa	Hidden-fruited Bladderwort		SE	G4G5	S1
Utricularia resupinata	Northeastern Bladderwort		SX	G4	SX
Viola primulifolia	Primrose-leaf Violet		ST	G5	S2
High Quality Natural Community					
Forest - flatwoods sand	Sand Flatwoods		SG	G2?	S1
Forest - upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3

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Indiana County Endangered, Threatened and Rare Species List

County: Starke

Species Name	Common Name	FED	STATE	GRANK	SRANK
Lake - lake	Lake		SG	GNR	S2
Prairie - mesic	Mesic Prairie		SG	G2	S2
Prairie - sand dry	Dry Sand Prairie		SG	G3	S2
Prairie - sand dry-mesic	Dry-mesic Sand Prairie		SG	G3	S3
Prairie - sand wet-mesic	Wet-mesic Sand Prairie		SG	G1?	S2
Prairie - wet	Wet Prairie		SG	G3	S1
Savanna - sand dry	Dry Sand Savanna		SG	G2?	S2
Savanna - sand dry-mesic	Dry-mesic Sand Savanna		SG	G2?	S2S3
Wetland - fen	Fen		SG	G3	S3
Wetland - marsh	Marsh		SG	GU	S4
Wetland - meadow sedge	Sedge Meadow		SG	G3?	S1
Wetland - swamp forest	Forested Swamp		SG	G2?	S2
Other					
Migratory Bird Concentration Area	Migratory Bird Concentration Site		SG	GNR	SNR

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APPENDIX C

CLEAN LAKES PROGRAM SAMPLING DATA

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

Koontz Lake Water Quality Data from Clean Lakes Program Sampling, 1990-2004

Year	1990	1993	1995	1999	2004
Date Sampled	07-Aug-90	28-Jul-93	25-Jul-95	12-Jul-99	17-Aug-04
Max Depth (m)	9.4	9.4	9.4	9.45	8.8
ITSI Total	16	24	34	20	26
TSI (SD)	53	57	65	54	59
TSI (Chl)			60	50	55
TSI (TP_EP)	55	37	58	64	58
Secchi (m))	1.6	1.2	0.7	1.5	1.1
Light trans @ 3' (%)	38	26	20	46	37
1% Light Level (ft)	16.5	13	9	12.5	17.4
DO Saturation @ 5' (%)	97	111	123.8	100	101
% Water Column Oxic	63	65.8	85.7	59	88
pH - epi	8	8.5	8.55	7.9	8.5
pH - hypo	6.9	7.5	7.04	6.7	7.7
Conductivity - epi (umhos)	343	403	390	393	395
Cond - Hypo	370	383	385	349	392
Alk - epi (mg/L)	110.2	138	133.5	129	137
Alk - hypo	190	139	182.5	174.5	140
NO3 - epi (mg/L)	0.427	0.022	0.022	0.022	0.013
NO3 - hypo	1.012	0.022	0.022	0.022	0.013
NH3 - epi (mg/L)	0.018	0.025	0.018	0.018	0.018
NH3 - hypo	2.598	0.025	1.551	1.084	0.306
TKN - epi (mg/L)	1.391	0.454	0.973	0.952	0.857
TKN - hypo	1.63	0.493	2.184	2.022	0.933
SRP - epi (mg/L)	0.01	0.01	0.01	0.01	0.01
SRP - hypo	0.026	0.01	0.016	0.015	0.01
Total Phosphorus - epi (mg/L)	0.033	0.01	0.043	0.065	0.041
Total Phosphorus - hypo (mg/L)	0.059	0.025	0.046	0.063	0.048
Chlorophyll a (mg/m3)		11.48	20.07	7.01	12.66
Plankton (#/L)	2380	20901	106356	3289	22116
Blue-green dominance (%)	25	68	48	6	53.5
Blue-greens (#/L)	594	14252	51370	193	11839
Green algae (#/L)	396	4561	5144	1633	3438
Diatoms (#/L)	780	1140	44464	1170	5366
Other algae (#/L)	594	815	5074	180	1358
Rotifers (#/L)	16	133	282	103	84
Zooplankton (#/L)	0	0	22.5	11.1	31.2
Temperture-1foot	22	27.2	28.8	24	22.2
Dissolved Oxygen -1foot	8.5	9.1	9.9	8.6	8.8

Koontz Lake Clean Lakes Volunteer Monitoring Data

Sample_Date	Transparency (ft)	TP (mg/L)	Chl *a* (µg/L)
19-Aug-90	5.5.		
26-Aug-90	6.5.		
11-May-91	9.0.		
20-May-91	6.0.		
27-May-91	5.0.		
02-Jun-91	5.0.		
08-Jun-91	4.0.		
15-Jun-91	3.5.		
23-Jun-91	3.5.		
30-Jun-91	2.5.		
07-Jul-91	2.0.		
14-Jul-91	2.5.		
21-Jul-91	2.0.		
28-Jul-91	2.5.		
03-Aug-91	3.0.		
10-Aug-91	3.0.		
24-Aug-91	3.0.		
07-Sep-91	4.5.		
14-Sep-91	4.0.		
26-Sep-91	4.0.		
02-May-92	6.0.		
10-May-92	6.0.		
17-May-92	6.0.		
31-May-92	5.5.		
02-Jun-92			1.3
13-Jun-92	8.0.		
21-Jun-92	6.8.		
28-Jun-92	6.0.		3.01
05-Jul-92	6.0.		
12-Jul-92	5.5.		
19-Jul-92	5.3.	37.5	2.41
01-Aug-92	4.5.		
08-Aug-92	3.8.		
16-Aug-92	3.5.		
23-Aug-92	2.8.		
30-Aug-92	4.0.		
07-Sep-92	4.8.	30	0.02
20-Sep-92	6.0.		
03-Oct-92		30	3.34
28-Mar-93	6.0.		
02-May-93	14.0.		
09-May-93	14.0.		
16-May-93	10.0.		
23-May-93	10.0.		
29-May-93	8.0.		

Sample_Date	Transparency (ft)	TP (mg/L)	Chl *a* (µg/L)
06-Jun-93	6.5.	27	9.16
12-Jun-93	5.0.		
20-Jun-93	5.0.		
27-Jun-93	4.0.		
03-Jul-93	4.0.		
11-Jul-93	4.0.	21	13.88
18-Jul-93	5.0.		
25-Jul-93	5.0.		
01-Aug-93	5.0.		
07-Aug-93	4.0.		
13-Aug-93	3.0.	37	
04-Sep-93	3.5.		
11-Sep-93	3.5.		
18-Sep-93	4.0.	30	
16-Oct-93	5.0.	25	
31-Mar-94	8.0.		
10-Apr-94	6.0.		
01-May-94	5.5.		
08-May-94	7.0.		
15-May-94	7.5.		
21-May-94	7.5.	51	2.77
29-May-94	7.5.		
04-Jun-94	7.0.		
05-Jun-94	7.0.		
12-Jun-94	6.0.		
15-Jun-94	5.0.		
18-Jun-94	6.0.		
19-Jun-94		36	6.73
26-Jun-94	4.5.		
04-Jul-94	4.5.		
10-Jul-94	3.5.		
17-Jul-94	3.0.	52.3	7.015
24-Jul-94	3.3.		
31-Jul-94	3.0.		
14-Aug-94	4.5.		
21-Aug-94	4.3.	83	7.33
28-Aug-94	3.5.		
04-Sep-94	3.5.		
11-Sep-94	5.0.		
17-Sep-94	5.0.	17	3.03
24-Sep-94	5.5.		
01-Oct-94	4.0.		
16-Oct-94	4.5.		
23-Oct-94	4.5.		
06-Nov-94	5.0.		
13-Nov-94	5.0.		

Sample_Date	Transparency (ft)	TP (mg/L)	Chl *a* (µg/L)
20-Nov-94	5.0.		
25-Mar-95	7.0.		
15-Apr-95	5.0.		
07-May-95	6.5.		
28-May-95	6.0.	43	4.3
03-Jun-95	5.0.		
17-Jun-95	5.0.	44	8.27
25-Jun-95	5.3.		
03-Jul-95	4.0.		
14-Jul-95	3.0.		
22-Jul-95		57	16.545
30-Jul-95	2.8.		
13-Aug-95	3.0.	29	3.67
04-Sep-95	3.0.		
10-Sep-95	3.0.		
16-Sep-95		35	2.78
24-Sep-95	5.0.		
08-Oct-95	6.0.		
14-Apr-96	9.0.		
21-Apr-96	8.5.		
29-Apr-96	6.5.		
04-May-96	6.0.		
18-May-96	5.5.		
01-Jun-96	4.5.		
15-Jun-96	8.0.		
22-Jun-96	7.0.		
29-Jun-96	4.0.	59	9.53
06-Jul-96	4.5.		
14-Jul-96	3.0.		
20-Jul-96	3.0.		
26-Jul-96		60	30.42
04-Aug-96	2.5.		
11-Aug-96	2.0.		
25-Aug-96		52	5.28
02-Sep-96	4.0.		
29-Sep-96	4.5.	43	11.71
12-Oct-96	5.0.		
06-Apr-97	7.5.		
14-Apr-97	5.5.		
28-Apr-97	5.0.		
11-May-97	5.0.		8.89
18-May-97	4.3.		
26-May-97	4.5.		
08-Jun-97	4.5.		
22-Jun-97	3.8.		15.43
05-Jul-97	3.8.		

Sample_Date	Transparency (ft)	TP (mg/L)	Chl *a* (µg/L)
14-Jul-97	3.0.		
20-Jul-97		40	15.55
26-Jul-97	3.3.		
10-Aug-97	4.0.		
16-Aug-97	5.0.	100	11.97
31-Aug-97	4.0.		
07-Sep-97	5.0.		
15-Sep-97	4.3.		
26-Sep-97	4.5.		
01-Nov-97	4.5.		
16-Mar-98	6.0.		
12-Apr-98	5.3.		
21-Apr-98	4.0.		
05-May-98	3.8.		
25-May-98	4.0.	40	15.79
31-May-98	6.0.		
13-Jun-98	6.3.	29	6.2
27-Jun-98	4.8.		
28-Jul-98	5.3.	22	2.74
10-Aug-98	4.0.		
16-Aug-98		19	4.88
23-Aug-98	5.0.		
15-May-99	5.2.	67	10.57
06-Jun-99	5.0.		
20-Jun-99	5.5.	70	10.54
17-Jul-99	4.6.	49	7.11
07-Aug-99	3.9.	59	8.16
28-Aug-99	5.0.		
05-Sep-99	4.3.		
19-Sep-99	5.2.		
02-Oct-99	5.4.		
31-Oct-99	6.0.		
21-May-00	5.6.	50	6.46
01-Jun-00	6.0.		
25-Jun-00	5.1.	54	9.2
11-Jul-00	3.6.		
15-Jul-00	3.0.	46	9.48
22-Jul-00	3.0.		
07-Aug-00	3.4.		
30-Aug-00	4.6.	56	5.13
22-Oct-00	5.2.		
04-May-01	5.8.	77	5.25
30-May-01	4.0.		
06-Jun-01	4.2.		
17-Jun-01	3.4.	132	9.17
01-Jul-01	3.0.		

Sample_Date	Transparency (ft)	TP (mg/L)	Chl *a* (µg/L)
21-Jul-01	3.6.	86.5	7.3
18-Aug-01	3.5.	63	9.29
26-Aug-01	4.2.		
03-Sep-01	4.2.		
30-Sep-01	6.0.		
21-May-02	6.0.	57	0.25
30-May-02	6.6.		
11-Jun-02	5.6.		
19-Jun-02	4.0.	69	1.32
26-Jun-02	5.0.		
04-Jul-02	4.0.		
14-Jul-02	4.0.		
21-Jul-02	3.6.	38	8.2
17-Aug-02	4.0.	29	11.92
04-Sep-02	4.6.		
08-Sep-02	4.6.		
29-Sep-02	4.6.		
25-May-03	8.0.	7	
01-Jun-03	7.6.		
08-Jun-03	5.0.		
15-Jun-03	5.8.		
21-Jun-03	4.5.		
29-Jun-03	4.2.	45	5.12
05-Jul-03	4.0.		
13-Jul-03	4.2.	63	9.56
20-Jul-03	4.6.		
03-Aug-03	4.0.	52	
10-Aug-03	4.0.		
17-Aug-03	4.0.		
24-Aug-03	4.0.		
31-Aug-03	3.6.		
06-Sep-03	3.6.		
02-May-04	6.5.		
30-May-04	6.0.	79	5.13
02-Jun-04	6.0.		
06-Jun-04	6.0.		
19-Jun-04	5.0.	33	6.92
27-Jun-04	5.2.		
05-Jul-04	4.2.	28	14.1
18-Jul-04	3.0.		
01-Aug-04		31	8.97
14-Aug-04	4.2.		
29-Aug-04	4.4.		
06-Sep-04	3.5.		
19-Sep-04	4.5.		
02-Oct-04	5.0.		

Sample_Date	Transparency (ft)	TP (mg/L)	Chl *a* (µg/L)
24-Oct-04	6.0.		
17-Apr-05	3.0.		
01-May-05	3.6.		
22-May-05	6.5.	84	5.61
30-May-05	5.5.		
12-Jun-05	4.0.		
19-Jun-05	3.5.	70	12.95
24-Jun-05	3.5.		
03-Jul-05	3.5.		
09-Jul-05	5.0.	30	6.81
15-Jul-05	5.0.		
24-Jul-05	5.0.		
13-Aug-05	4.0.	33	11.08
03-Sep-05	5.0.		
18-Sep-05	5.4.		
25-Sep-05	5.0.		
08-Apr-06	5.5.		
22-Apr-06	4.5.		
04-May-06	6.5.		
14-May-06	6.5.	59	6.14
20-May-06	7.5.		
30-May-06	6.5.		
17-Jun-06	6.3.	42	2.67
01-Jul-06	3.3.		
07-Jul-06	4.3.		
15-Jul-06	4.8.		
17-Jul-06		58	1.28
28-Jul-06	4.0.		
08-Aug-06	3.8.	45	0.11
08-Aug-06	3.8.		
31-Aug-06	4.3.		
10-Sep-06	4.5.		
08-Oct-06	5.0.		
26-Oct-06	5.0.		
16-Apr-07	5.0.		
05-May-07	7.0.		
12-May-07	7.0.		
18-May-07	8.0.	64	3.46
01-Jun-07	6.8.		
16-Jun-07	5.6.		
19-Jun-07	5.6.	35	9.4
12-Jul-07	3.6.	46	6.3
18-Jul-07	4.3.		
26-Jul-07	4.5.		
04-Aug-07	5.5.		
06-Aug-07	4.0.		

Sample_Date	Transparency (ft)	TP (mg/L)	Chl *a* (µg/L)
13-Aug-07	3.3.	0	0
13-Aug-07	3.3.	0	0
13-Aug-07	4.0.	33	11.92
21-Aug-07	4.0.		
18-Sep-07	4.6.		
08-Apr-08	3.2.		
22-May-08	8.0.		
28-May-08	8.2.		
09-Jun-08	7.7.		
23-Aug-08	4.1.	0	0
23-Aug-08	4.1.	0	0

APPENDIX D

WATER QUALITY METHODS AND DISCUSSION OF WATER QUALITY PARAMETERS

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

Methods – Water Quality

The water sampling and analytical methods used for Koontz Lake were consistent with those used in IDEM's Indiana Clean Lakes Program and IDNR's Lake and River Enhancement Program. We collected water samples from Koontz Lake on July 20, 2009 from one meter below the water surface (***epilimnion***) and from two meters above the lake bottom (***hypolimnion***) at a location over the deepest water. Chlorophyll was determined only for the epilimnetic sample. Other parameters such as Secchi disk transparency, light transmission, and oxygen saturation are single measurements made in the epilimnion. In addition, 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 to the water surface.

Conductivity, turbidity, temperature, and dissolved oxygen were measured *in situ* at the lake sampling site with a HydroLab Model QD 0337 meter.

In addition, water samples were collected for the following parameters:

- pH
- alkalinity
- total phosphorus (TP)
- soluble reactive phosphorus (SRP)
- nitrate-nitrogen (NO_3^-)
- ammonia-nitrogen (NH_4^+)
- total Kjeldahl nitrogen (TKN)
- turbidity
- plankton
- chlorophyll *a*

These samples were placed in the appropriate bottle (with preservative if needed) and stored in an ice chest until analysis at SPEA's laboratory in Bloomington. SRP samples were filtered in the field through a Whatman GF-C filter.

All sampling techniques and laboratory analytical methods were performed in accordance with procedures in *Standard Methods for the Examination of Water and* Wastewater, 21th Edition (APHA, 2005). Plankton counts were made using a standard Sedgewick-Rafter counting cell. Fifteen fields per cell were counted. Plankton identifications were made according to: Wehr and Sheath (2003), Prescott (1982), Ward and Whipple (1959) and Whitford and Schumacher (1984).

The comprehensive evaluation of lakes and streams require collecting data on a number of different, and sometimes hard-to-understand, water quality parameters. Some of the more important parameters that we analyze include:

Temperature. Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. 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 (EPA, 1976).

The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits to protect aquatic life for Indiana streams. For example, temperatures during the month of May should not exceed 80 ^{o}F (23.7 ^{o}C) by more than 3 ^{o}F (1.7 ^{o}C). June temperatures should not exceed 90 ^{o}F (32.2 ^{o}C).

Dissolved Oxygen (D.O). D.O. is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least 3-5 mg/L of D.O. Cold-water fish such as trout generally require higher concentrations of D.O. than warm water fish such as bass or Bluegill. The IAC sets minimum D.O. concentrations at 6 mg/L for cold-water fish. D.O. 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 D.O. 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, 2005). During low discharge, conductivity is higher than during storm water runoff 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.

pH. The pH of water is a measure of the concentration of acidic ions (specifically H^+) present in the water. The pH also determines the form, solubility, and toxicity of a wide range of other aqueous compounds. The IAC establishes a range of 6-9 pH units for the protection of aquatic life.

Alkalinity. Alkalinity is a measure of the acid-neutralizing (or buffering) capacity of water. Certain substances, if present in water, like carbonates, bicarbonates, and sulfates can cause the water to resist changes in pH. A lower alkalinity indicates a lower buffering capacity or a decreased ability to resist changes in pH. During base flow conditions, alkalinity is usually high because the water picks up carbonates from the bedrock. Alkalinity measurements are usually lower during storm flow conditions because buffering compounds are diluted by rainwater and the runoff water moves across carbonate-containing bedrock materials so quickly that little carbonate is dissolved to add additional buffering capacity.

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 4.5-17.5 NTU (White, unpublished data). Turbidity measurements >20 NTU have been found to cause undesirable changes in aquatic life (Walker, 1978).

Nitrogen. Nitrogen is an essential plant nutrient found in fertilizers, human and animal wastes, yard waste, and the air. About 80% of the air we breathe is nitrogen gas. Nitrogen gas diffuses into water where it can be “fixed”, or converted, by Blue-green

algae to ammonia for their use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia. Because of this, there is an abundant supply of available nitrogen to aquatic systems. The three common forms of nitrogen are:

> ***Nitrate (NO_3^-)*** – Nitrate is an oxidized form of dissolved nitrogen that is converted to ammonia by algae. It is found in streams and runoff when dissolved oxygen is present, usually in the surface waters. Ammonia applied to farmland is rapidly oxidized or converted to nitrate and usually enters surface and groundwater as nitrate. The Ohio EPA (1999) found that the median nitrate-nitrogen concentration in wadeable streams that support modified warmwater habitat (MWH) was 1.6 mg/L. Modified warmwater habitat was defined as: aquatic life use assigned to streams that have irretrievable, extensive, man-induced modification that preclude attainment of the warmwater habitat use (WWH) designation; such streams are characterized by species that are tolerant of poor chemical quality (fluctuating dissolved oxygen) and habitat conditions (siltation, habitat amplification) that often occur in modified streams (Ohio EPA, 1999). Nitrate concentrations exceeding 10 mg/1 in drinking water are considered hazardous to human health (Indiana Administrative Code IAC 2-1-6).
>
> ***Ammonia (NH_4^+)*** – Ammonia is a form of dissolved nitrogen that is the preferred form for algae use. It is the reduced form of nitrogen and is found in water where dissolved oxygen is lacking. Important sources of ammonia include fertilizers and animal manure. In addition, bacteria produce ammonia as a by-product as they decompose dead plant and animal matter. Both temperature and pH govern the toxicity of ammonia for aquatic life.
>
> ***Organic Nitrogen (Org N)*** – Organic nitrogen includes nitrogen found in plant and animal materials. It may be in dissolved or particulate form. In the analytical procedures, total Kjeldahl nitrogen (TKN) was analyzed. Organic nitrogen is TKN minus ammonia.

Phosphorus. Phosphorus is an essential plant nutrient, and the one that most often controls aquatic plant (algae and macrophyte) growth in freshwater. It is found in fertilizers, human and animal wastes, and yard waste. There are few natural sources of phosphorus to streams other than what is attached to soil particles, and there is no atmospheric (vapor) form of phosphorus. For this reason, phosphorus is often a ***limiting nutrient*** in aquatic systems. This means that the relative scarcity of phosphorus may limit the ultimate growth and production of algae and rooted aquatic plants. Therefore, management efforts often focus on reducing phosphorus inputs to receiving waterways because: (a) it can be managed and (b) reducing phosphorus can reduce algae production. Two common forms of phosphorus are:

> ***Soluble reactive phosphorus (SRP)*** – SRP is dissolved phosphorus readily usable by algae. SRP is often found in very low concentrations in phosphorus-limited systems where the phosphorus is tied up in the algae themselves. Because phosphorus is cycled so rapidly through biota, SRP concentrations as low as 0.005 mg/L are enough to maintain eutrophic or highly productive conditions in lake systems (Correll, 1998). Sources of SRP include fertilizers, animal wastes, and septic systems.

Total phosphorus (TP) – TP includes dissolved and particulate phosphorus. TP concentrations greater than 0.03 mg/L (or 30μg/L) can cause algal blooms in lakes and reservoirs. The Ohio EPA (1999) found that the median TP in wadeable streams that support MWH for fish was 0.28 mg/L.

Secchi Disk Transparency. This refers to the depth to which the black & 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 lands, and riverbanks. Bottom sediments may be resuspended by bottom feeding fish such as carp, or in shallow lakes, by motorboats or strong winds.

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 and is referred to as the *photic zone*.

Plankton. Plankton are important members of the aquatic food web. The plankton include the algae (microscopic plants) and the zooplankton (tiny shrimp-like animals that eat algae). Determined by filtering water through a net having a very fine mesh (63-micron openings = 63/1000 millimeter). The plankton net is towed up through the lake's water column from the one percent light level to the surface. Algae are reported as *natural units*, which records one colonial filament of multiple cells as one natural unit and one cell of a singular alga also as one natural unit. Of the many different algal species present in the water, we are particularly interested in the Blue-green algae. 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 of 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.

APPENDIX E

ANNOTATED BIBLIOGRAPHY FOR KOONTZ LAKE WATER QUALITY STUDIES

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

Annotated Bibliography of Water Quality and Related Studies in Koontz Lake

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APPENDIX F

TROPHIC INDICES

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE 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% 50 119%	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% 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

Carlson's Trophic State Index with Koontz Lake scores indicated with arrows.

	Oligotrophic				Mesotrophic			Eutrophic			Hypereutrophic			
Trophic State Index	20	25	30	35	40	45	50	55	60	65	70	75	80	
Secchi Disk (feet)	50	33	26	20	16	13	10	7	5	3	1.5			
Chlorophyll-*a* (µg/L or PPB)	0.5	1	2	3	4	5	7	10	15	20	30	40	60	80 100 150
Total Phosphorus (µg/L or PPB)	3	5	7	10	15	20	25	30	40	50	60	80	100	150

APPENDIX G

KOONTZ LAKE ASSOCIATION STREAM DATA, 2001-2005

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

Data from Koontz Lake Association 2001 to 2005 study.

Nitrate-Nitrite (mg/L)				
Date/Site	**Lake Entrance**	**Dam&5th**	**Union below SLR**	**6th above SLR**
1/7/2001		1.3		
1/17/2001				
2/22/2001		4		
3/20/2001		3		
6/5/2001		1.8		
7/2/2001		1		
8/1/2001		0.49		
9/18/2001		0.7		
10/2/2001		0.6		
11/7/2001		2.1		
12/11/2001		1.9		
3/12/2002		3		
5/22/2002		1.5		
6/4/2002		0.7		
7/3/2002		0.8		
8/19/2002			1.2	0.5
9/10/2002		0.6		
9/23/2002	0.06	0.9	0.7	0.5
10/21/2002	0.05	0.9	0.6	0.5
11/26/2002	0.05	1	0.7	0.6
12/16/2002	0.05	1	0.6	0.6
1/20/2003	0.05	1.1	1.1	0.7
2/28/2003	1.3	1.1	1.2	0.9
3/24/2003	0.06	1.4	1.5	1.6
4/8/2003	3.2	3.2	3.2	3.3
4/21/2003	1	0.8	1.1	1.4
5/20/2003	2	1.6	2	2.2
6/16/2003	1.3	0.9	0.9	0.1
7/21/2003	0.6	1.1	1	0.7
8/18/2003	0.1	0.4	1.1	0.4
9/22/2003	0.4	0.6	0.8	0.5
10/27/2003	1.6	1.2	1.3	0.9
12/18/2003	3.5	2.8	2.7	3.6
3/12/2004	2.7	2.6	2.6	3
4/20/2004	1.4	1.2	1.6	1.5
5/24/2004	1.2	1.3	1.4	1.1
6/22/2004	1.3	1.6	1.9	1.8

Nitrate-Nitrite (mg/L)				
Date/Site	**Lake Entrance**	**Dam&5th**	**Union below SLR**	**6th above SLR**
7/20/2004	0.2	1	1.6	0.8
8/24/2004	0.3	0.7	1	0.4
10/26/2004	1.1	0.8	0.98	0.43
12/8/2004	2.6	2.2	2.1	2.4
4/19/2005	1.3	1.1	1.5	1.3

Total Phosphorus (mg/L)				
Date/Site	**Lake Entrance**	**Dam&5th**	**Union below SLR**	**6th above SLR**
1/7/2001				
1/17/2001				
2/22/2001		0.049		
3/20/2001		0.049		
6/5/2001		0.050		
7/2/2001		0.080		
8/1/2001		0.170		
9/18/2001		0.049		
10/2/2001		0.080		
11/7/2001		0.050		
12/11/2001		0.170		
3/12/2002		0.050		
5/22/2002		0.070		
6/4/2002		0.070		
7/3/2002		0.080		
8/19/2002			0.1	0.08
9/10/2002		0.05		
9/23/2002	0.06	0.18	0.06	0.05
10/21/2002	0.05	0.06	0.06	0.05
11/26/2002	0.05	0.05	0.05	0.05
12/16/2002	0.05	0.06	0.05	0.05
1/20/2003	0.05	0.05	0.05	0.05
2/28/2003	0.049	0.05	0.06	0.05
3/24/2003	0.06	0.05	0.08	0.05
4/8/2003	0.1	0.11	0.09	0.07
4/21/2003	0.08	0.13	0.11	0.06
5/20/2003	0.06	0.06	0.19	0.14
6/16/2003	0.13	0.09	0.1	0.05

Total Phosphorus (mg/L)				
Date/Site	**Lake Entrance**	**Dam&5th**	**Union below SLR**	**6th above SLR**
7/21/2003	0.12	0.21	0.15	0.11
8/18/2003	0.13	0.13	0.11	0.15
9/22/2003	0.07	0.06	0.29	0.18
10/27/2003	0.08	0.08	0.07	0.06
12/18/2003	0.05	0.05	0.05	0.05
3/12/2004	0.08	0.1	0.08	0.1
4/20/2004	0.04	0.05	0.06	0.08
5/24/2004	0.14	0.15	0.12	0.12
6/22/2004	0.08	0.06	0.09	0.1
7/20/2004	0.05	0.05	0.1	0.05
8/24/2004	0.05	0.05	0.05	0.05
10/26/2004	0.05	0.05	0.1	0.05
12/8/2004	0.05	0.05	0.05	0.05
4/19/2005	0.05	0.05	0.05	0.05

Fecal Coliform (MPN)				
Date/Site	**Lake Entrance**	**Dam&5th**	**Union below SLR**	**6th above SLR**
1/7/2001				
1/17/2001		20		
2/22/2001		27		
3/20/2001		5		
6/5/2001		130		
7/2/2001		140		
8/1/2001		200		
9/1/2001		580		
10/2/2001		220		
11/7/2001		240		
12/11/2001		280		
3/12/2002		130		
5/22/2002		170		
6/4/2002		220		
7/3/2002		520		
8/2/2002		6200		
8/19/2002		1000	7500	640
9/10/2002		390		
9/23/2002	210	300	880	340
10/21/2002	50	310	730	270
11/26/2002	32	300	870	250

Fecal Coliform (MPN)				
Date/Site	**Lake Entrance**	**Dam&5th**	**Union below SLR**	**6th above SLR**
12/16/2002	4	73	980	230
1/20/2003	1	76	140	14
2/28/2003	290	190	6	160
3/24/2003	13	29	53	43
4/8/2003	370	260	170	170
4/21/2003	86	300	210	110
5/20/2003	590	2300	18000	13000
6/16/2003	490	300	2000	530
7/21/2003	750	3100	2100	10000
8/18/2003	110	370	1600	480
9/22/2003	480	1200	12000	7300
10/27/2003	150	340	510	140
12/18/2003	180	200	180	45
3/12/2004	32	92	98	49
4/20/2004	35	240	340	83
5/24/2004	340	680	1500	710
6/22/2004	320	720	460	450
7/20/2004	56	480	2100	260
8/24/2004	52	500	550	420
10/26/2004	86	210	350	950
12/8/2004	35	200	62	28
4/19/2005	320	390	340	190

APPENDIX H

2009 STREAM WATER QUALITY, BIOTIC AND HABITAT DATA

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

Koontz Lake Watershed Stream Water Quality Data 2009

Storm Sampling

ID	1	2	3	4	dup 4	5	5 split
Stream	**LPD**	**LPD**	**LPD**	**LPD**	**LPD**	**Schoeder D**	**Schoeder D**
Location	**Spruce Trail**	**Plymouth-LaPorte Trail**	**N Union Road**	**S Lake Drive**	**S Lake Drive**	**N Underwood Road**	**N Underwood Road**
Date	**5/14/2009**	**5/14/2009**	**5/14/2009**	**5/14/2009**	**5/14/2009**	**5/14/2009**	**5/14/2009**
Timing	**storm**	**storm**	**storm**	**storm**	**storm**	**storm**	**storm**
Watershed (ac)	1022	1230	2170	3006	3006	57	57
Flow (cfs)		5.01	11.35	16.73	16.73	0.81	0.81
Flow (l/s)	88.18	141.81	321.48	473.66	473.66	23.02	23.02
Temp(°C)	17.2	16.6	15.2	15.3	15	14.2	14.2
DO(mg/l)	5.9	7.6	8.6	7.6	7.6	5.9	5.9
%Sat	61.3	78.4	86.1	76.1	74.9	57.0	57.0
pH	7.12	7.5	7.66	7.45	7.48	7.4	7.4
Cond (mmhos/cm)	220	324	375	350	347	377	377
Alk(mg/l)	99.1	139.6	142.6	138.2	137.0	159.7	158.3
pH[a]	7.39	7.6	7.8	7.7	7.63	7.7	7.65
NO3-N (mg/l)	0.431	0.792	0.661	0.688	0.696	0.907	0.926
NH3-N (mg/l)	0.050	0.052	0.099	0.011	0.104	0.111	0.126
TKN(mg/l)	1.716	1.317	1.384	1.595	1.130	2.152	2.119
TP(mg/l)	0.245	0.165	0.107	0.186	0.176	0.141	0.145
SRP(mg/l)	0.083	0.045	0.026	0.017	0.012	0.024	0.022
TSS(mg/l)	22.9391	50.9434	49.7462	91.4286	82.4859	54.1667	53.886
E. coli (col/100ml)	8300	6700	6200	8000		2200	
Turbidity(NTU)	15.5	16	13.5	22	22	6	6

[a] - lab measurement

LPD – Lawrence Pontius Ditch

Koontz Lake Watershed Stream Water Quality Data 2009

Base Flow Sampling

ID	1	2	3	3 Dup	4	5	3a
Stream	**LPD**	**LPD**	**LPD**	**LPD**	**LPD**	**Schoeder D**	**LPD**
Location	**Spruce Trail**	**Plymouth-LaPorte Trail**	**N Union Road**	**N Union Road**	**S Lake Drive**	**N Underwood Road**	**Wetland Outlet**
Date	**7/28/2009**	**7/28/2009**	**7/28/2009**	**7/28/2009**	**7/28/2009**	**7/28/2009**	**7/28/2009**
Timing	**base**	**base**	**base**	**base**	**base**	**base**	**base**
Watershed Size (ac)	1022	1230	2170	2170	3006	57	2595
Flow (cfs)	minimal flow	0.578	1.176		0.061	0.09	0.661
Flow (l/s)		16.367	33.3		1.727	2.549	18.717
Temp(°C)	15.5	19.7	19.1	19	20.3	17.3	21.3
DO(mg/l)	6.37	7.81	7.14	7.07	5.33	7.12	6.18
%Sat	64.1	85.6	77	76.7	59	74	69.8
pH	7.5	8.08	7.94	7.94	7.6	7.93	7.76
Cond (mmhos/cm)	511	500	515	516	485	516	499
Alk(mg/l)	225	219.6	214	218	190.4	227.5	200.25
pH	8.1	8.3	8.3	8.1	7.95	8.3	7.92
NO3-N (mg/l)	0.092	0.191	0.601	0.582	0.474	0.954	0.390
NH3-N (mg/l)	0.145	0.068	0.093	0.085	0.272	0.086	0.171
TKN(mg/l)	0.692	0.499	0.581	0.597	1.898	1.064	1.000
TP(mg/l)	0.049	0.053	0.046	0.042	0.170	0.091	0.091
SRP(mg/l)	0.025	0.0115	0.016	0.014	0.012	0.028	0.011
TSS(mg/l)	5.0000	16.4080	7.7951	7.4000	38.0079	31.5000	24.2857
E. coli (col/100ml)	855	509	500	836	600	800	609
Turbidity(NTU)	4.4	5.3	4.5	5	9	4.55	9.2

LPD – Lawrence Pontius Ditch

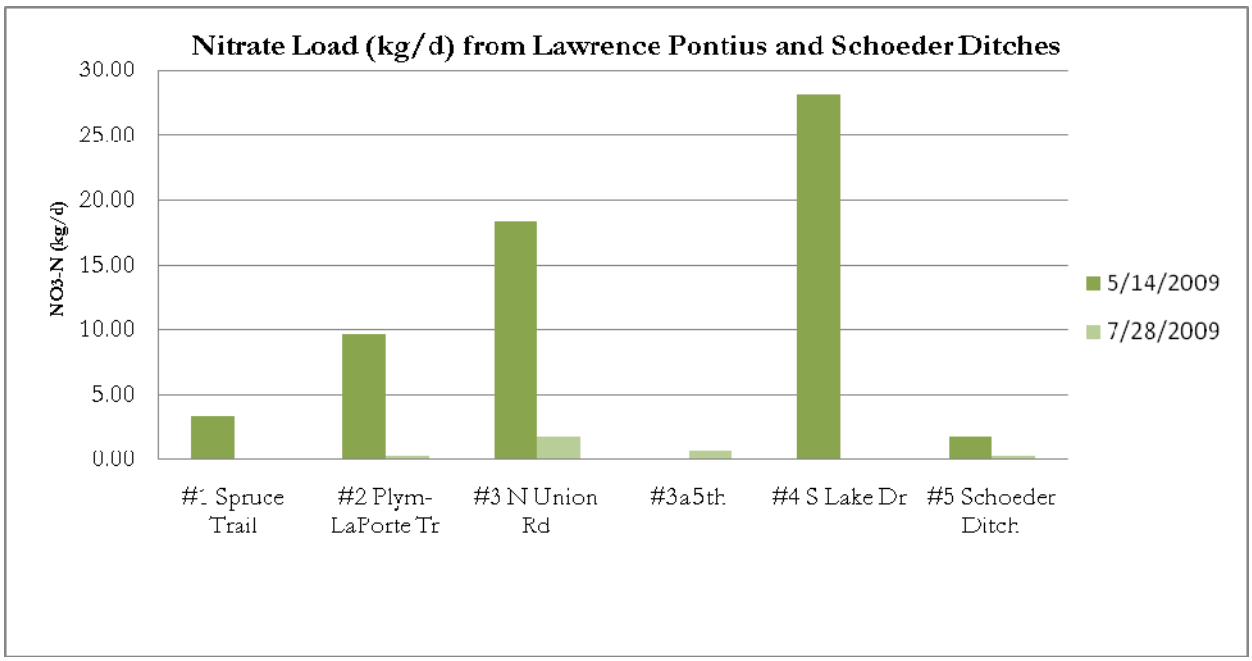
2009 Nutrient and Sediments Loads, Biotic and Habitat Stream Data

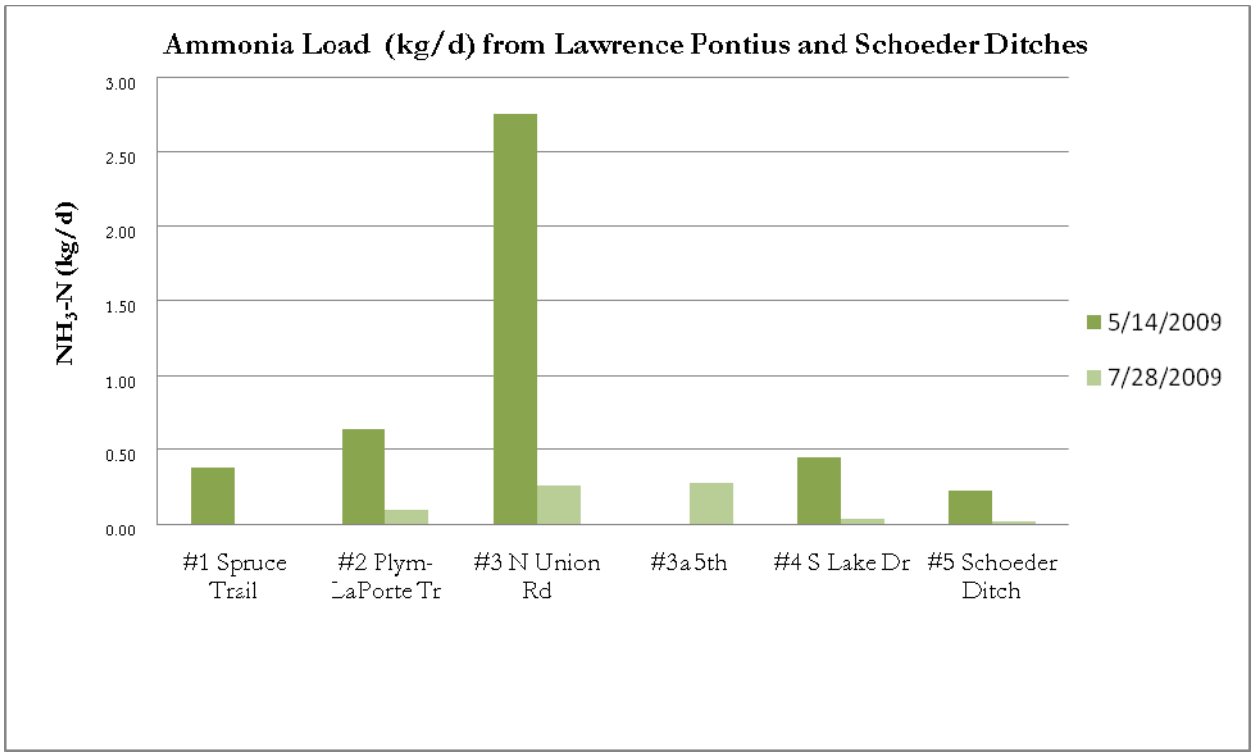
Calculated nutrient and sediment loads for sampled ditch sites.

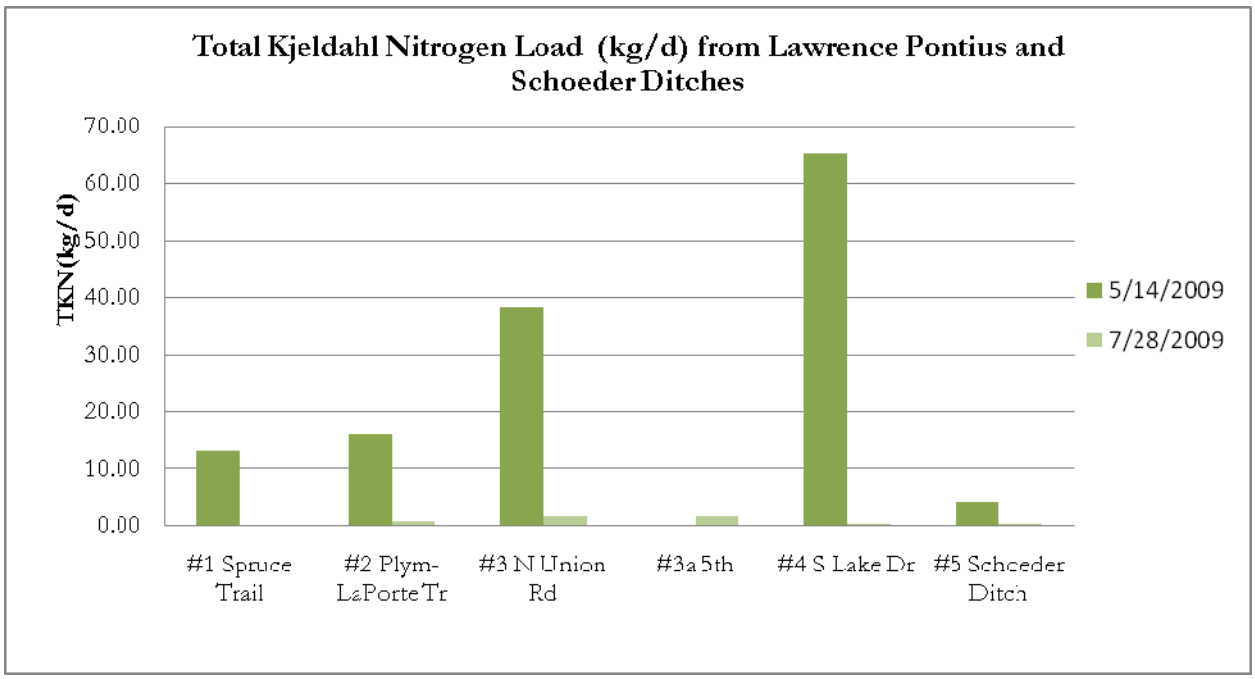
Stream Name	Date	Event	NH3-N (kg/d)	NO3-N (kg/d)	TKN (kg/d)	SRP (kg/d)	TP (kg/d)	TSS (kg/d)
#1 Spruce Trail	5/14/2009	storm	0.38	3.28	13.07	0.632	1.87	174.77
	7/28/2009	base	0.00	0.00	0.00	0.000	0.00	0.00
#2 Plym-LaPorte Tr	5/14/2009	storm	0.64	9.70	16.14	0.551	2.02	624.18
	7/28/2009	base	0.10	0.27	0.71	0.016	0.07	23.20
#3 N Union Rd	5/14/2009	storm	2.75	18.36	38.44	0.722	2.97	1381.75
	7/28/2009	base	0.27	1.73	1.67	0.046	0.13	22.43
#3a 5th	7/28/2009	base	0.28	0.63	1.62	0.02	0.15	39.27
#4 S Lake Dr	5/14/2009	storm	0.45	28.16	65.27	0.696	7.61	3741.61
	7/28/2009	base	0.04	0.07	0.16	0.000	0.03	5.67
#5 Schoeder Ditch	5/14/2009	storm	0.22	1.80	4.28	0.048	0.28	107.74
	7/28/2009	base	0.02	0.21	0.23	0.006	0.02	6.94

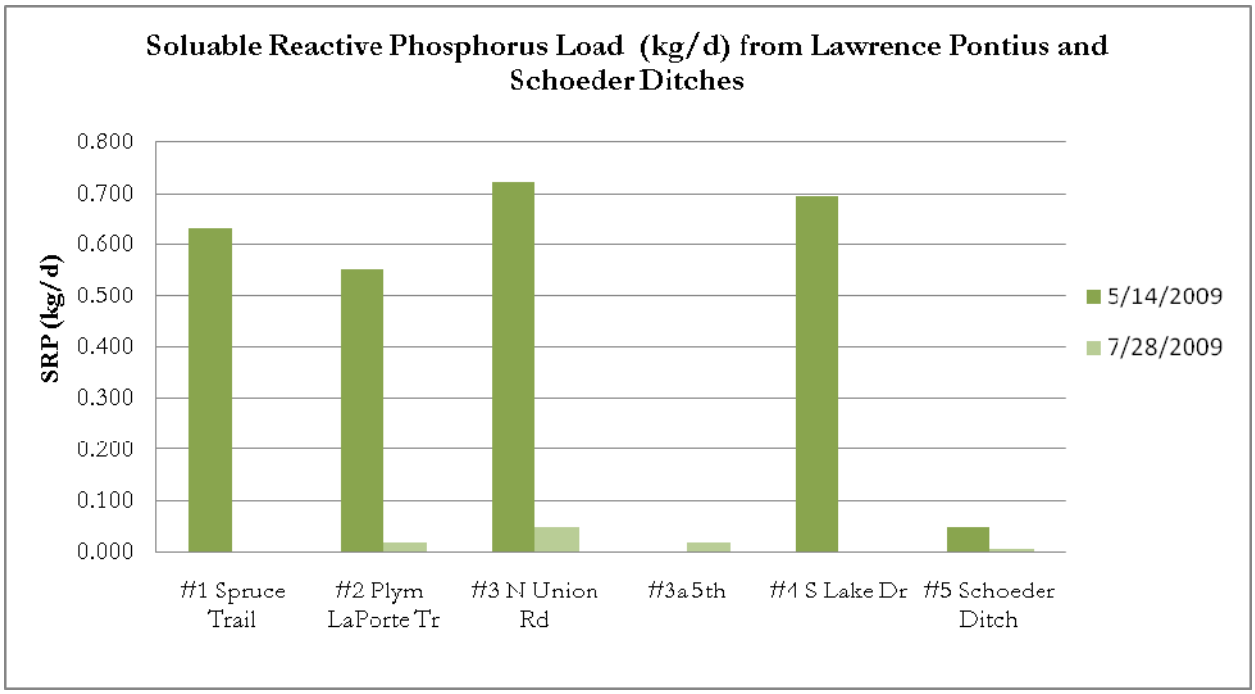
Calculated nutrient and sediment areal loads for sampled ditch sites.

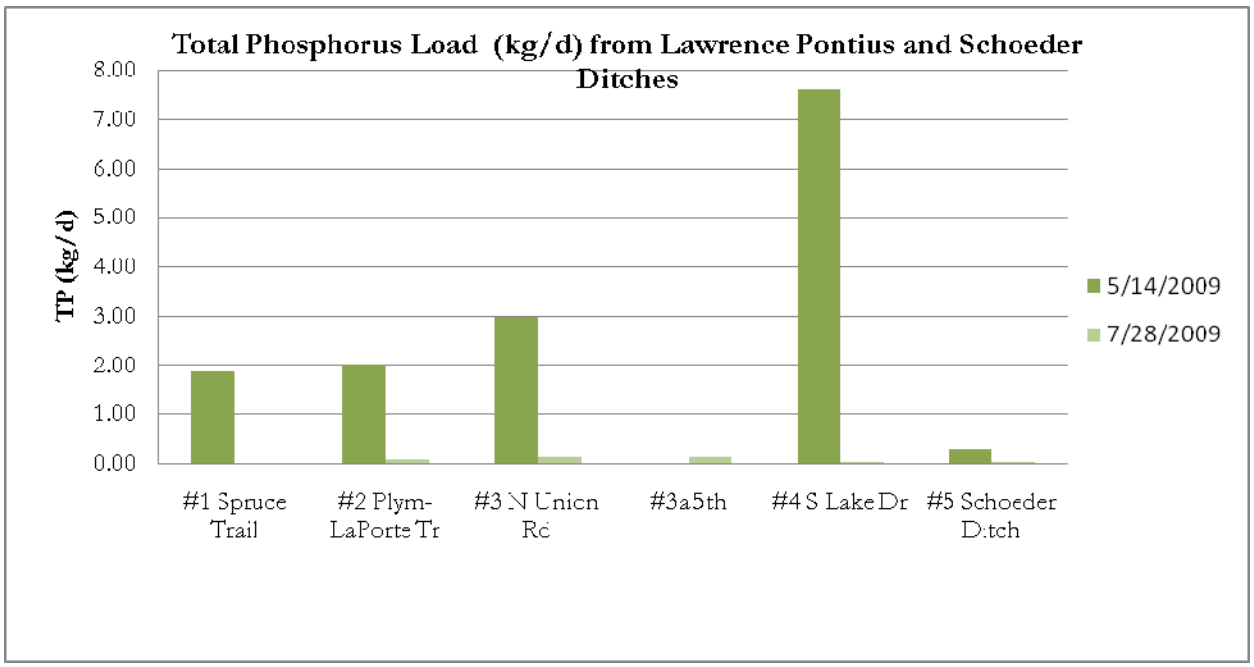
Stream Name	Date	Event	NH3-N (kg/ha-yr)	NO3-N (kg/ha-yr)	TKN (kg/ha-yr)	SRP (kg/ha-yr)	TP (kg/ha-yr)	TSS (kg/ha-yr)
#1 Spruce Trail	5/14/2009	storm	0.34	2.90	11.53	0.558	1.65	154.17
	7/28/2009	base	0.00	0.00	0.00	0.000	0.00	0.00
#2 Plym-LaPorte Tr	5/14/2009	storm	0.47	7.11	11.83	0.404	1.48	457.50
	7/28/2009	base	0.07	0.20	0.52	0.012	0.05	17.01
#3 N Union Rd	5/14/2009	storm	1.14	7.63	15.97	0.300	1.23	574.06
	7/28/2009	base	0.11	0.72	0.69	0.019	0.05	9.32
#3a 5th	7/28/2009	base	0.10	0.22	0.56	0.006	0.05	13.64
#4 S Lake Dr	5/14/2009	storm	0.14	8.44	19.58	0.209	2.28	1122.17
	7/28/2009	base	0.01	0.02	0.05	0.000	0.01	1.70
#5 Schoeder Ditch	5/14/2009	storm	3.49	28.53	67.70	0.755	4.44	1704.06
	7/28/2009	base	0.30	3.32	3.71	0.098	0.32	109.73

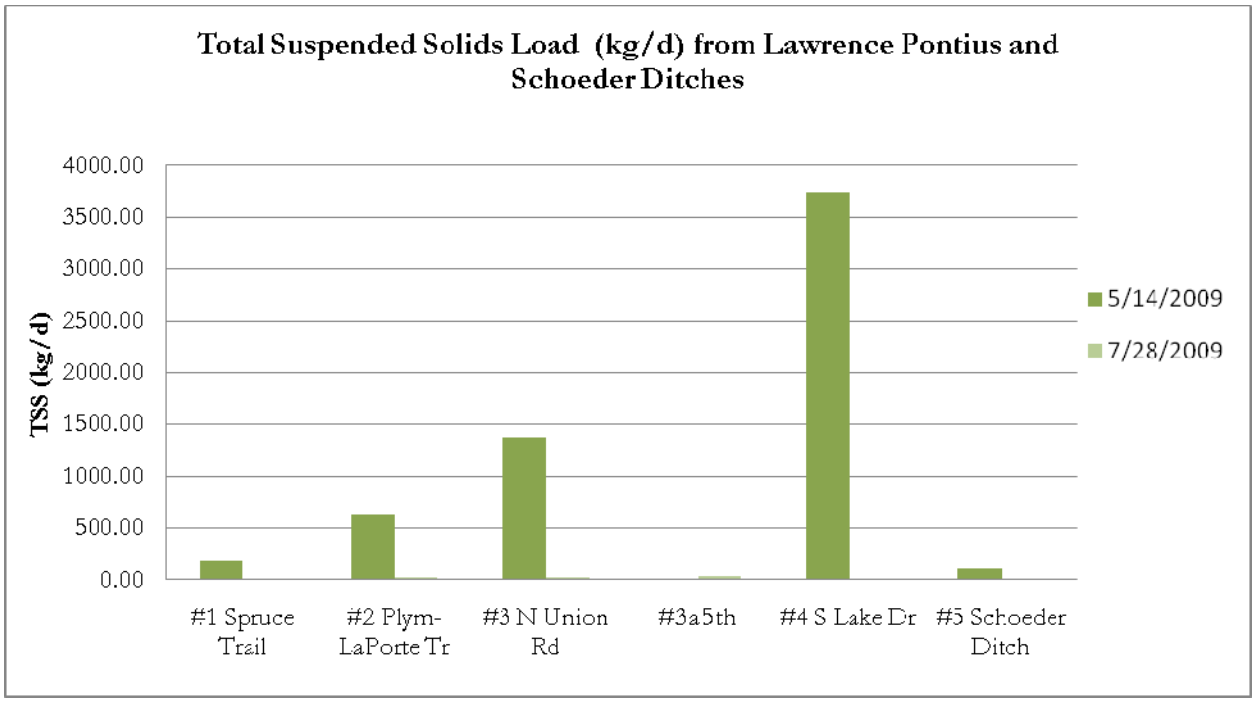

Nitrate Load (kg/d) from Lawrence Pontius and Schoeder Ditches
NO3-N (kg/d)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a 5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009

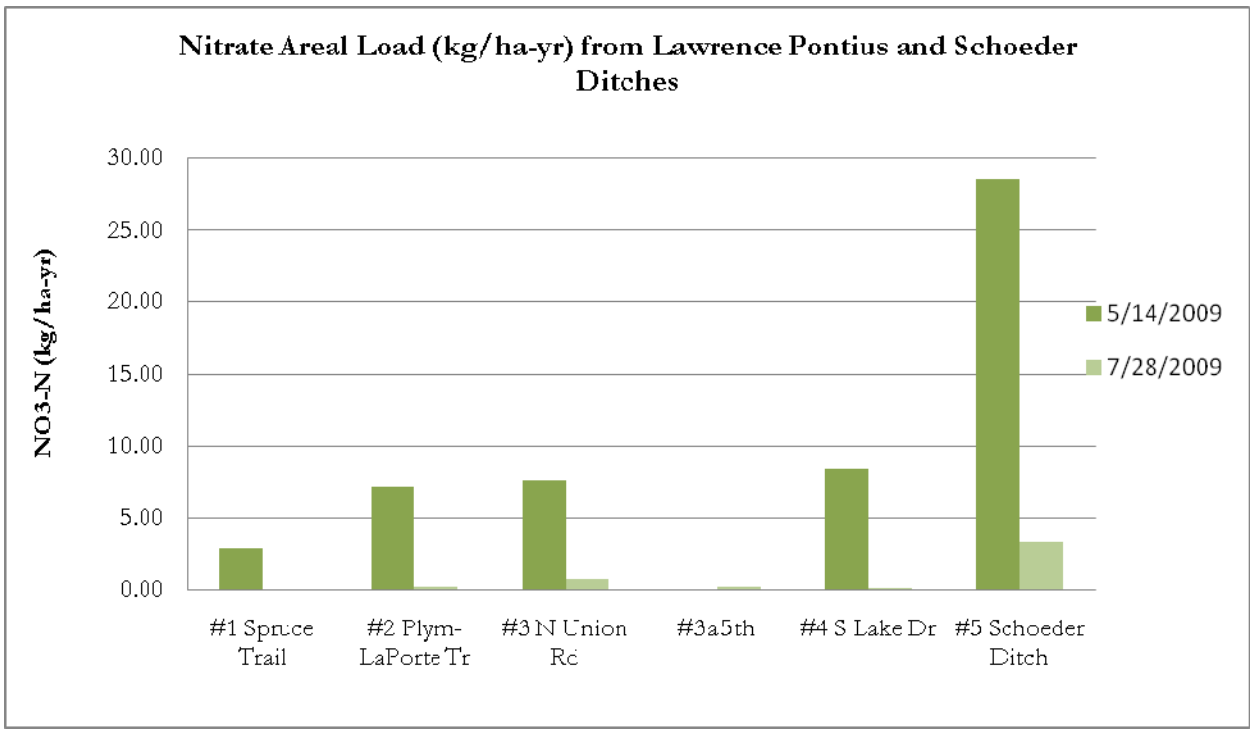

Ammonia Load (kg/d) from Lawrence Pontius and Schoeder Ditches
NH3-N (kg/d)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a 5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009

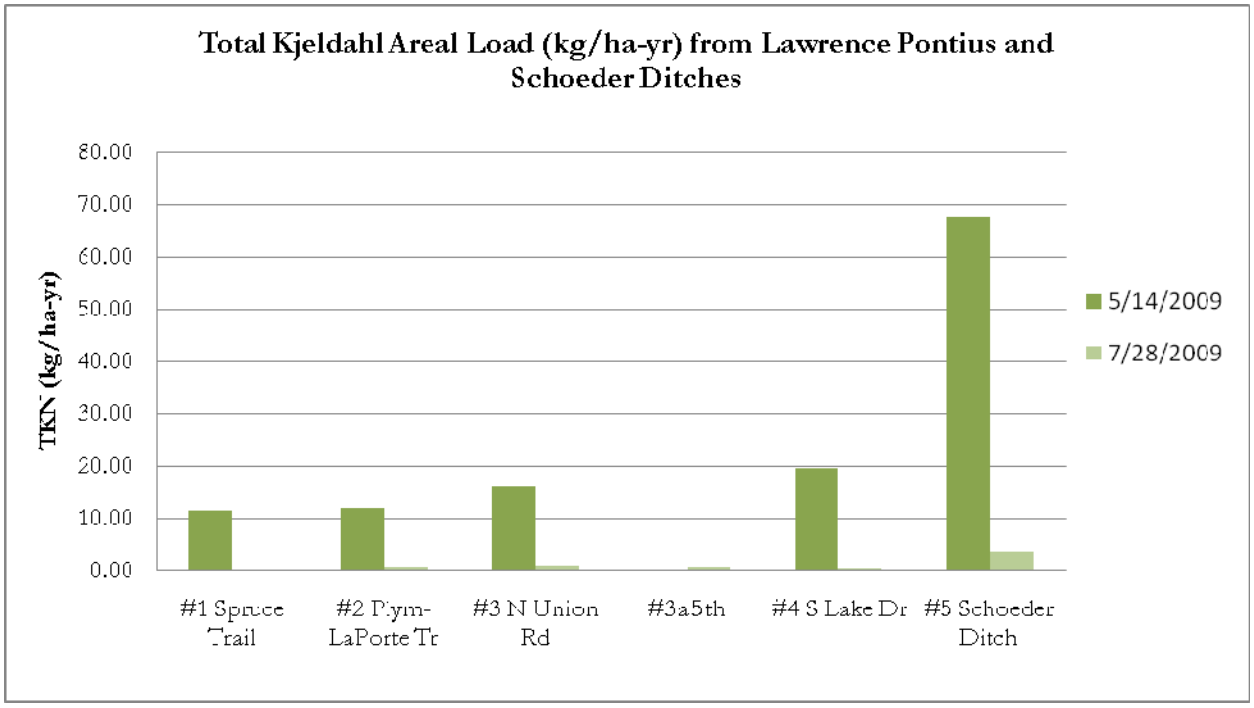

Total Kjeldahl Nitrogen Load (kg/d) from Lawrence Pontius and Schoeder Ditches
TKN(kg/d)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a 5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009

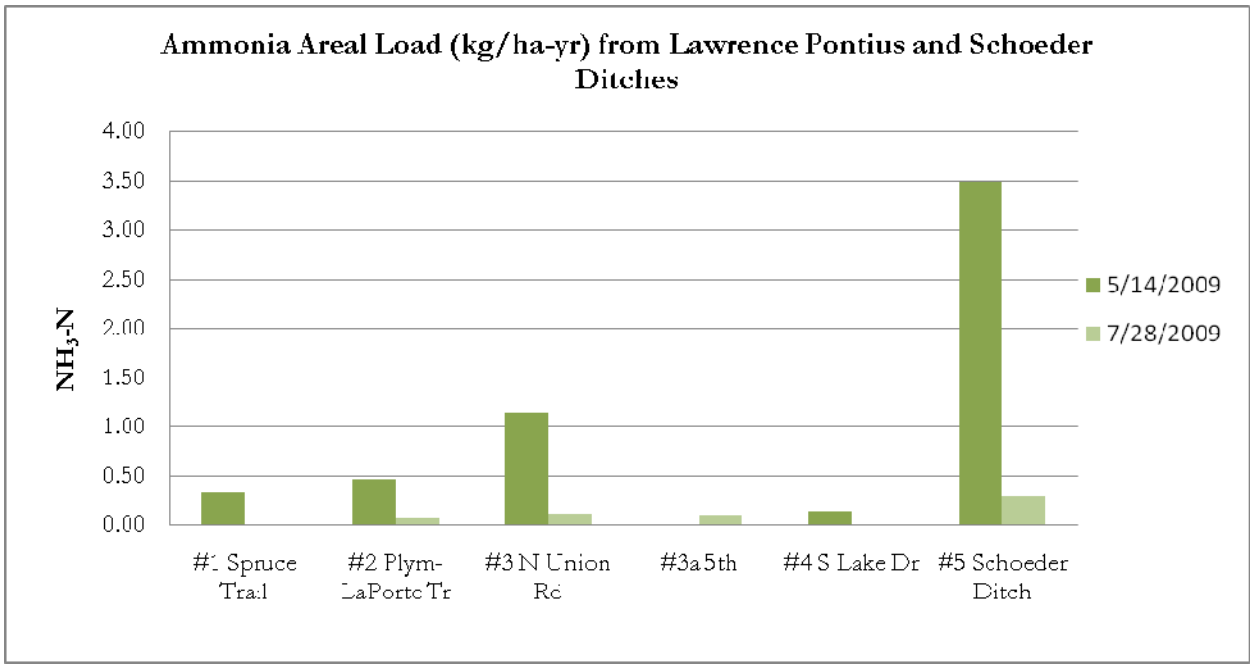

Soluable Reactive Phosphorus Load (kg/d) from Lawrence Pontius and Schoeder Ditches
SRP (kg/d)
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
#1 Spruce Trail
#2 Plym LaPorte Tr
#3 N Union Rd
#3a 5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009

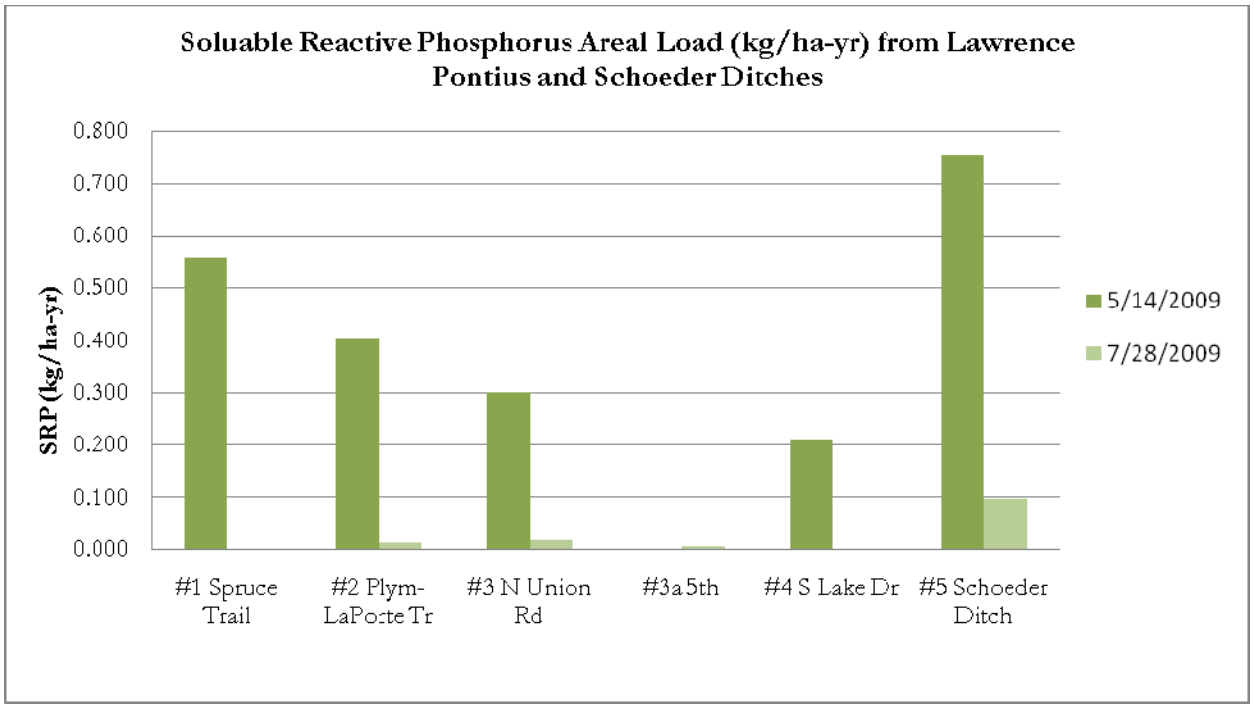

Total Phosphorus Load (kg/d) from Lawrence Pontius and Schoeder Ditches
TP (kg/d)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a 5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009

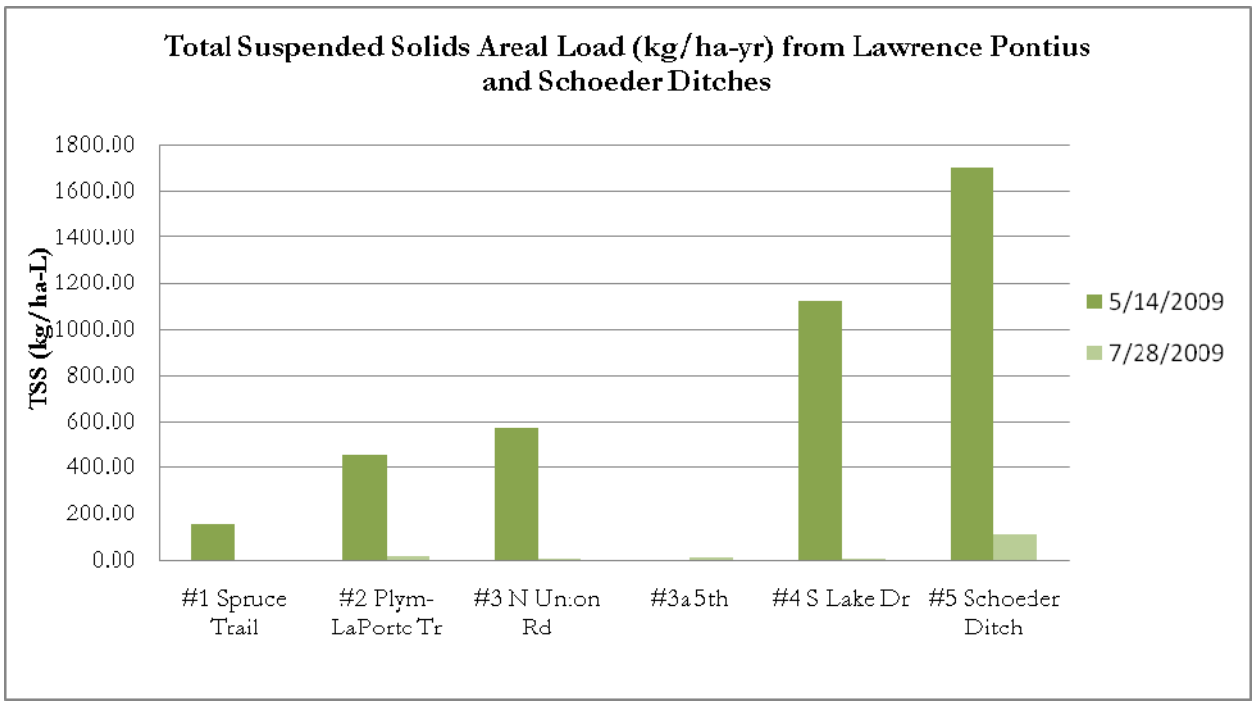

Total Suspended Solids Load (kg/d) from Lawrence Pontius and Schoeder Ditches
TSS (kg/d)
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a 5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009


Nitrate Areal Load (kg/ha-yr) from Lawrence Pontius and Schoeder Ditches
NO3-N (kg/ha-yr)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009


Total Kjeldahl Areal Load (kg/ha-yr) from Lawrence Pontius and Schoeder Ditches
TKN (kg/ha-yr)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009


Ammonia Areal Load (kg/ha-yr) from Lawrence Pontius and Schoeder Ditches
NH3-N
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a 5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009


Soluable Reactive Phosphorus Areal Load (kg/ha-yr) from Lawrence Pontius and Schoeder Ditches
SRP (kg/ha-yr)
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a 5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009


Total Suspended Solids Areal Load (kg/ha-yr) from Lawrence Pontius and Schoeder Ditches
TSS (kg/ha-L)
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
#1 Spruce Trail
#2 Plym-LaPorte Tr
#3 N Union Rd
#3a 5th
#4 S Lake Dr
#5 Schoeder Ditch
5/14/2009
7/28/2009

Macroinvertebrate Data – Site #3 Lawrence Pontius Ditch and Potato Creek

Site # 3 – Sampled 7/24/09

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	79		79	4	316	69.30
Coleoptera	Elmidae	1		1	4	4	0.88
Decopoda	Cambaridae	1		1	8	8	0.88
Diptera	Chironomidae	2		2	6	12	1.75
Diptera	Simuliidae	6		6	6	36	5.26
Hemiptera	Gerridae	2		2	5	10	1.75
Odonata	Aeshnidae	5		5	3	15	4.39
Odonata	Calopterygidae	2		2	5	10	1.75
Trichoptera	Hydropsychidae	16	16	16	4	64	14.04
TOTALS		**114**	**16**	**114**		**475.0**	**100.00**

Site # 3 – Sampled 7/24/09

mIBI Metric		Metric Score
HBI	4.17	6
No. Taxa (family)	9	2
Total Count (# individuals)	114	2
% Dominant Taxa	69.3	0
EPT Index (# families)	1	0
EPT Count (# individuals)	16	0
EPT Count/Total Count	0.14	2
EPT Abun./Chir. Abun.	8.00	6
Chironomid Count	2	8
mIBI Score		**2.9**

Potato Creek – Reference Site – Sampled 7/24/09

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	59		59	4	236	45.38
Coleoptera	Elmidae	3		3	4	12	2.31
Diptera	Chironomidae	5		5	6	30	3.85
Diptera	Empididae	1		1	6	6	0.77
Diptera	Ephydridae	1		1	6	6	0.77
Diptera	Simuliidae	8		8	6	48	6.15
Diptera	Tipulidae	2		2	3	6	1.54
Ephemeroptera	Ephemerellidae	1		1	1	1	0.77
Hemiptera	Gerridae	2		2	5	10	1.54
Hemiptera	Notonectidae	1		1		0	0.77
Odonata	Cordulegastridae	1		1	3	3	0.77
Trichoptera	Glossosomatidae	4	4	4	0	0	3.08
Trichoptera	Helicopsychidae				3	0	0.00
Trichoptera	Hydropsychidae	42	42	42	4	168	32.31
TOTALS		**130**	**46**	**130**		**526.0**	**100.00**

Potato Creek – Reference Site – Sampled 7/24/09

mIBI Metric		Metric Score
HBI	4.05	8
No. Taxa (family)	13	4
Total Count (# individuals)	130	4
% Dominant Taxa	45.4	2
EPT Index (# families)	2	0
EPT Count (# individuals)	46	4
EPT Count/Total Count	0.35	4
EPT Abun./Chir. Abun.	9.20	6
Chironomid Count	5	8
mIBI Score		**4.4**

IDEM — OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #: #3 | bioSample #: | Stream Name: Lawrence Pontius Ditch | Location: Union Rd

Surveyor: TLE | Sample Date: 7/28/09 | County: Marshall | Macro SampleType: | Habitat Complete: | **QHEI Score: 19**

1-Substrate (20 points maximum)

Substrate Score: 3

Check 1 Predominant Pool & 1 Predominant Riffle

Check all that are present — P=Pool, R=Riffle

Predominant P	Predominant R	Present P	Present R		Predominant P	Predominant R	Present P	Present R	
				Bldrs/Slabs(10)					Hardpan(4)
				Boulders(9)					Detritus(3)
				Cobble(8)					Muck(2)
				Gravel(7)	X	X			Silt(2)
		X		Sand(6)					Sludge(1)
				Bedrock(5)					Artificial(0)

Substrate Quality (check only 1, or check 2 and AVERAGE)

Substrate Origin: Limestone(1) | Hardpan(0) | Lacustrine(0) | X Tills(1) | Sandstone(0) | Shale(-1) | Wetlands(0) | Rip/Rap(0) | Coal fines(-2)

Silt Cover: X Silt heavy(-2) | Silt moderate(-1) | Silt normal(0) | Silt free(1)

Embeddedness: Extensive(-2) | Moderate(-1) | Low/Normal(0) | None(1)

NOTE: ignore sludge originating from point sources; score based on natural substrates

>4 substrates present(2)

Comments:

2-Instream Cover (20 points maximum

Instream Cover Score: 3

Type (check ALL that apply): X Undercut banks(1) | Deep pools(2) | Oxbows(1) | X Overhanging vegetation(1) | Rootwads(1) | Aquatic macrophytes(1) | Shallows(in slow water)(1) | Boulders(1) | Logs and woody debris(1) | Rootmats(1)

Comments:

Amount (check only 1, or 2 and AVERAGE): Extensive >75% (11) | Moderate 25-75% (7) | Sparse 5-25% (3) | X Nearly absent <5% (1)

3-Channel Morphology (20) (check only one per category, OR two and AVERAGE)

Channel Score: 7

Sinuosity	Development	Channelization	Stability	Modifications/Other	
High (4)	Excellent (7)	None (6)	High (3)	Snagging	Impound
Moderate (3)	Good (5)	Recovered (4)	X Moderate (2)	Relocation	Islands
Low (2)	Fair (3)	X Recovering (3)	Low (1)	Canopy Removal	Leveed
X None (1)	X Poor (1)	Recent or no recovery (1)		Dredging	Bank shaping
				One side channel modifications	

Comments:

4-Riparian Zone & Bank Erosion (10 points maximum)

Riparian Score: 4

Left/Right banks looking downstream (For each category, check only one per bank, OR two per bank and AVERAGE).

Riparian width L	Riparian width R	(per bank)	Erosion/Runoff-Floodplain quality (past 100 ft Riparian) L	R	(most predominant per bank)	L	R		Bank Erosion L	R	(per bank)
		Wide >50m (4)			Forest, Swamp (3)			Conservation Tillage (1)			None or little (3)
		Moderate 10-50m (3)			Shrub or Old field (2)			Urban or Industrial (0)	X	X	Moderate (2)
X	X	Narrow 5-10m (2)			Residential, Park, New field (1)			Mining, Construction (0)			Heavy/Severe (1)
		Very narrow <5m (1)			Fenced pasture (1)	X	X	Open Pasture/Rowcrop (0)			
		None (0)									

Comments:

5a-Pool/Glide Quality (12 points maximum

Pool/Glide Score: 0

Max pool depth (check one): >1m (6) | 0.7-1m (4) | 0.4-0.7m (2) | 0.2-0.4m (1) | X <0.2m (pool=0)

Morphology (check only one, OR check two and AVERAGE): 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): Eddies (1) | Fast (1) | Moderate (1) | Slow (1) | Torrential (-1) | Interstitial (-1) | Intermittent (-2) | X No pool (0)

Comments:

5b-Riffle/Run Quality (8) (check only one per category, OR two and AVERAGE)

Riffle/Run Score: 0

Riffle/run depth (check one): Generally>10cm, Max>50cm (4) | Generally>10cm, Max<50cm(3) | Generally 5-10cm (1) | X Generally<5cm (riffle=0)

Riffle/run substrate: Stable-e.g. cobble, boulder (2) | Mod. stable-e.g. pea gravel (1) | X Unstable-e.g. sand, gravel (0)

Riffle/run embeddedness: Extensive (-1) | Moderate (0) | Normal/Low (1) | None (2) | X No riffle (0)

Comments:

6-Gradient (10 points maximum)

Gradient Score: 2

Average width: 9' | Gradient: 0.56 (ft/mile) | Drainage Area: 3.561 (square miles)

Comments:

IDEM — OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
#3		Lawrence Pontius Ditch	Union Rd.

Surveyor	Sample Date	County	Macro SampleType	Habitat Complete	QHEI Score:
TLE	7/28/09	Marshall			19

Impacts/Miscellaneous

Major Suspected Impacts (Check all that apply)

- [ ] None
- [ ] Industrial
- [ ] WWTP
- [ ] Agricultural
- [X] Livestock
- [ ] Silviculture
- [ ] Construction
- [ ] Urban Runoff
- [ ] Suburban
- [X] Channelization
- [X] Riparian Removal
- [ ] Flow Alteration
- [ ] CSOs
- [ ] Mining
- [ ] Landfills
- [ ] Natural

Pollution Impact Comments:

Miscellaneous QHEI Information

Subjective rating (1-10):
Aesthetic rating (1-10): 3
Canopy Cover (% Open): 5

% Riffle: —
% Run: 100
% Glide: —
% Pool: —

Is reach representative of stream? Yes

General QHEI Notes:

IDEM — OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample # | bioSample # | Stream Name: Potato Creek | Location: Potato Creek State Park

Surveyor: TLE | Sample Date: 7/28/09 | County: St. Joseph | Macro SampleType | ☐ Habitat Complete

QHEI Score: 56.5

1-Substrate (20 points maximum)

Substrate Score: 14

Check 1 Predominant Pool & 1 Predominant Riffle

Check all that are present — P=Pool, R=Riffle

Predominant P	Predominant R	Present P	Present R	
☐	☐	☐	☐	Bldrs/Slabs(10)
☐	☐	☐	☐	Boulders(9)
☐	☐	☐	X	Cobble(8)
☐	X	X	☐	Gravel(7)
X	☐	☐	☐	Sand(6)
☐	☐	☐	☐	Bedrock(5)
☐	☐	☐	☐	Hardpan(4)
☐	☐	☐	☐	Detritus(3)
☐	☐	☐	☐	Muck(2)
☐	☐	X	☐	Silt(2)
☐	☐	☐	☐	Sludge(1)
☐	☐	☐	☐	Artificial(0)

Substrate Quality (check only 1, or check 2 and AVERAGE)

Substrate Origin: ☐ Limestone(1) ☐ Hardpan(0) ☐ Lacustrine(0) X Tills(1) ☐ Sandstone(0) ☐ Shale(-1) ☐ Wetlands(0) ☐ Rip/Rap(0) ☐ Coal fines(-2)

Silt Cover: ☐ Silt heavy(-2) ☐ Silt moderate(-1) X Silt normal(0) ☐ Silt free(1)

Embeddedness: ☐ Extensive(-2) ☐ Moderate(-1) X Low/Normal(0) ☐ None(1)

NOTE: ignore sludge originating from point sources; score based on natural substrates

☐ >4 substrates present(2)

Comments:

2-Instream Cover (20 points maximum

Instream Cover Score: 8

Type (check ALL that apply): X Undercut banks(1) ☐ Deep pools(2) ☐ Oxbows(1) X Overhanging vegetation(1) ☐ Rootwads(1) ☐ Aquatic macrophytes(1) X Shallows(in slow water)(1) X Boulders(1) X Logs and woody debris(1) ☐ Rootmats(1)

Comments:

Amount (check only 1, or 2 and AVERAGE): ☐ Extensive >75% (11) ☐ Moderate 25-75% (7) X Sparse 5-25% (3) ☐ Nearly absent <5% (1)

3-Channel Morphology (20) (check only one per category, OR two and AVERAGE)

Channel Score: 16

Sinuosity	Development	Channelization	Stability	Modifications/Other	
☐ High (4)	☐ Excellent (7)	X None (6)	☐ High (3)	☐ Snagging	☐ Impound
X Moderate (3)	X Good (5)	☐ Recovered (4)	X Moderate (2)	☐ Relocation	☐ Islands
☐ Low (2)	☐ Fair (3)	☐ Recovering (3)	☐ Low (1)	☐ Canopy Removal	☐ Leveed
☐ None (1)	☐ Poor (1)	☐ Recent or no recovery (1)		☐ Dredging	☐ Bank shaping
				☐ One side channel modifications	

Comments:

4-Riparian Zone & Bank Erosion (10 points maximum)

Riparian Score: 10

Left/Right banks looking downstream (For each category, check only one per bank, OR two per bank and AVERAGE).

Riparian width L	Riparian width R	(per bank)	Erosion/Runoff-Floodplain quality L	Erosion/Runoff-Floodplain quality R	(most predominant per bank)	L	R		Bank Erosion L	Bank Erosion R	(per bank)
X	X	Wide >50m (4)	X	X	Forest, Swamp (3)	☐	☐	Conservation Tillage (1)	X	X	None or little (3)
☐	☐	Moderate 10-50m (3)	☐	☐	Shrub or Old field (2)	☐	☐	Urban or Industrial (0)	☐	☐	Moderate (2)
☐	☐	Narrow 5-10m (2)	☐	☐	Residential, Park, New field (1)	☐	☐	Mining, Construction (0)	☐	☐	Heavy/Severe (1)
☐	☐	Very narrow <5m (1)	☐	☐	Fenced pasture (1)	☐	☐	Open Pasture/Rowcrop (0)			
☐	☐	None (0)									

Comments:

5a-Pool/Glide Quality (12 points maximum

Pool/Glide Score: 4

Max pool depth (check one): ☐ >1m (6) ☐ 0.7-1m (4) ☐ 0.4-0.7m (2) X 0.2-0.4m (1) ☐ <0.2m (pool=0)

Morphology (check only one, OR check two and AVERAGE): ☐ 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): ☐ Eddies (1) X Fast (1) X Moderate (1) X Slow (1) ☐ Torrential (-1) ☐ Interstitial (-1) ☐ Intermittent (-2) ☐ No pool (0)

Comments:

5b-Riffle/Run Quality (8) (check only one per category, OR two and AVERAGE)

Riffle/Run Score: 2.5

Riffle/run depth (check one): ☐ Generally>10cm, Max>50cm (4) ☐ Generally>10cm, Max<50cm(3) X Generally 5-10cm (1) ☐ Generally<5cm (riffle=0)

Riffle/run substrate: ☐ Stable-e.g. cobble, boulder (2) X Mod. stable-e.g. pea gravel (1) X Unstable-e.g. sand, gravel (0)

Riffle/run embeddedness: ☐ Extensive (-1) ☐ Moderate (0) X Normal/Low (1) ☐ None (2) ☐ No riffle (0)

Comments:

6-Gradient (10 points maximum)

Gradient Score: 2

Average width: 7 | Gradient: 1 (ft/mile) | Drainage Area: 1.304 (square miles)

Comments:

IDEM — OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Potato Creek	Potato Creek State Park Potato Creek State Park

Surveyor	Sample Date	County	Macro SampleType	Habitat Complete	QHEI Score
TLE	7/28/09	St Joseph			56.5

Impacts/Miscellaneous

Major Suspected Impacts (Check all that apply)

- [ ] None
- [ ] Industrial
- [ ] WWTP
- [ ] Agricultural
- [ ] Livestock
- [ ] Silviculture
- [ ] Construction
- [ ] Urban Runoff
- [ ] Suburban
- [ ] Channelization
- [ ] Riparian Removal
- [ ] Flow Alteration
- [ ] CSOs
- [ ] Mining
- [ ] Landfills
- [ ] Natural

Pollution Impact Comments:

Miscellaneous QHEI Information

Subjective rating (1-10):
Aesthetic rating (1-10): 8
Canopy Cover (% Open): 5

% Riffle:
% Run:
% Glide:
% Pool:

Is reach representative of stream? Yes

General QHEI Notes:

APPENDIX I

WATER BUDGET

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE COUNTIES, INDIANA

Water Budget

Inputs of water to Koontz Lake are limited to:

1. direct precipitation to the lake
2. discharge from the inlet streams
3. sheet runoff from land immediately adjacent to the lake
4. groundwater

Water leaves the lake system from:

1. discharge from the lakes' outlet channel
2. evaporation
3. groundwater

There are no discharge gages in the watershed to measure water inputs and the limited scope of this study did not allow us to determine quantitatively annual water inputs or outputs. Therefore we must estimate the water budget for lakes from other records.

- Direct precipitation to the lakes can be calculated from mean annual precipitation falling directly on the lakes' surface.
- Runoff from the lakes' watershed can be estimated by applying runoff coefficients. A runoff coefficient refers to the percentage of precipitation that occurs as surface runoff, as opposed to that which soaks into the ground. Runoff coefficients may be estimated by comparing discharge from a nearby gaged watershed of similar land and topographic features, to the total amount of precipitation falling on that watershed. The nearest gaged watershed is a U.S.G.S. gaging station on the Yellow River at Plymouth, Indiana (Morlock et al., 2004). The 58-year (1949–2006) mean annual discharge from this watershed is 268 cfs (cubic feet per second). With a mean annual precipitation for Marshall County of 36.78 inches (Smallwood, 1980), this means that on average, 33.6 % of the rainfall falling on this watershed runs off on the land surface.
- There exist no groundwater records for the lake so we have assumed that groundwater inputs equal outputs. Although local residents and older reports have said that Koontz Lake is spring fed, hydrogeologic reports (Fenelon and Bobay, 1994) state that the sand and gravel aquifer beneath Koontz Lake is unconfined and is recharged by precipitation falling on higher ground. Good wells can produce 200-600 gallons per minute. Hartke (1986) reports that the depth to the potentiometric surface of the unconsolidated aquifer is 0 feet upstream of the lake and about 10 feet below the ground at the lake. Without specific testing, we can't confirm the presence of substantial springs feeding the lake.
- We can estimate evaporation losses by applying evaporation rate data to the lakes. Evaporation rates are determined at six sites around Indiana by the National Oceanic and Atmospheric Administration (NOAA). The nearest site

to the study lakes is located in Valparaiso, Indiana. Annual evaporation from a ‘standard pan’ at the Valparaiso site averages 28.05 inches per year. Because evaporation from the standard pan overestimates evaporation from a lake by about 30%, we correct the evaporation rate by this percentage, which yields an estimated evaporation rate from the lake surface of 19.95 inches per year. Multiplying this rate times the surface area of each lake yields an estimated volume of evaporative water loss from the study lakes.

The water budget for Koontz Lake, based on the assumptions discussed above, is shown in the table following this summary. When the volume of water flowing out of Koontz Lake is divided by the lake’s volume, a *hydraulic residence time* of 0.9 years results. This means that on average, water entering the lake stays in the lake for nearly one year before it flows out. This hydraulic residence time is shorter than other glacial lakes in this part of the country. In a study of 95 north temperate lakes in the U.S., the mean hydraulic residence time for the lakes was 2.12 years (Reckhow and Simpson, 1980). Most glacial lakes have a watershed area to lake surface area ratio of around 10:1 (Vant, 1987). Koontz Lake, with a watershed area to lake surface area ratio of 12:1, has a larger watershed than the average cited in Vant, and because of its mean depth of only 12.1 feet, the relatively small volume of Koontz Lake contributes to its shorter hydraulic residence time.

Water Budget Calculations for Koontz Lake.

Watershed	Koontz Lake - Marshall Co.
Watershed size (ac)	4019
Mean watershed runoff (ac-ft/yr)	4144
Lake volume (ac-ft)	4014
Closest gaged stream	Yellow River, Plymouth
Stream watershed (mi^2)	294
Stream watershed (acres)	188160
Mean annual daily Q (cfs)	268
Mean annual total Q (ac-ft/yr)	194023
Mean ppt (in/yr)	36.78
Mean watershed ppt (ac-ft/yr)	576710
Watershed C	0.336
Pan evaporation (in/yr)	28.05
Pan evaporation coefficient	0.70
Lake surface area (acres)	331
Estimated lake evaporation (ac-ft)	542
Direct precipitation to lake (ac-ft)	1015
	= input data
	= output data
Water Budget Summary	
Direct precipitation to lake (ac-ft)	1015
Runoff from watershed (ac-ft)	4144
Evaporation (ac-ft)	542
TOTAL LAKE OUTPUT (ac-ft)	4617
Hydraulic residence time (yr)	0.87

APPENDIX J

FUNDING SOURCES

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE 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 Koontz Lake watershed. More information about the LARE program can be found at http://www.in.gov/dnr/fishwild/2364.htm

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. A letter from IDEM regarding eligibility will be sent separately to the lake association. See http://www.in.gov/idem/5282.htm for more information.

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.

Indiana Pollution Prevention (P2) Grant Program

The Indiana Pollution Prevention (P2) Grant Program is administered by the Office of Pollution Prevention and Technical Assistance (OPPTA) at IDEM. The purpose of the P2 Grant Program is to increase measurable results from pollution prevention, water and energy conservation, and source reduction activities. P2 Grants will help Indiana entities implement pollution prevention and source reduction activities and continue to promote environmental stewardship throughout Indiana. P2 grants are intended to fund the startup or expansion of programs. See http://www.in.gov/idem/4103.htm#p2grant for more information.

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/4103.htm#205j

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/AM/Template.cfm?Section=GrantPrograms

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/AM/Template.cfm?Section=Charter_Programs_List&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=13423

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

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/business/index.htm#financial

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/

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 K

ACTION TRACKER

KOONTZ LAKE WATERSHED MANAGEMENT PLAN
MARSHALL AND STARKE 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:_____

Return form to: Koontz Lake Association
P.O. Box 25
Walkerton, Indiana 46574

Goal 1. Reduce phosphorus loads to the lake from 2009 levels by 3.6% to reach recommended phosphorus loadings to the lake of <0.427 g/m^2-yr in the lake.

Goal 2. Reduce total suspended solid loads to streams from 2009 levels to recommended concentrations of 30 mg/L (IDEM draft TMDL target) by 2015.

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

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

Goal 5. Maintain and improve the recreational setting of the Koontz Lake watershed by implementing at least 3 of the 5 objectives within five years.