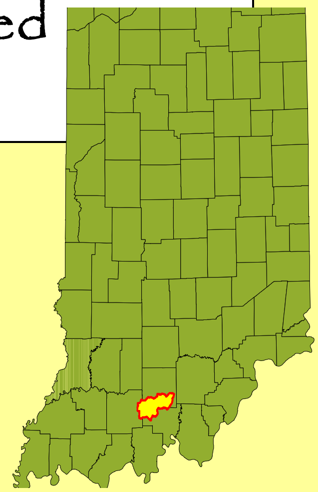
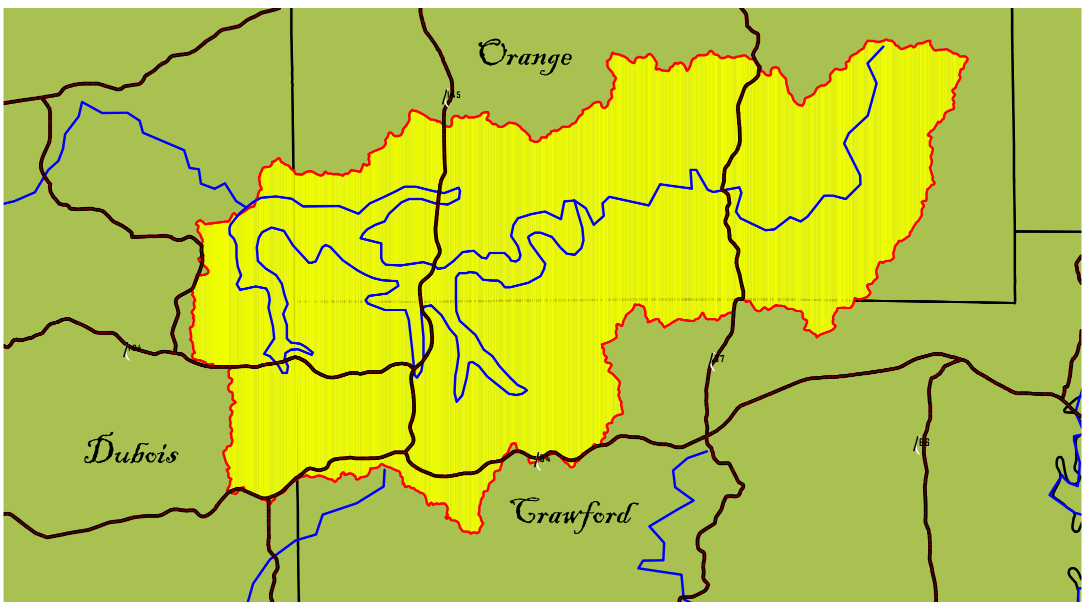
Source Water Protection Plan for the Patoka Lake Watershed

January 2007



Prepared by the Alliance of Indiana Rural Water
in cooperation with the many stakeholders
of the Patoka Lake Watershed (11 Digit HUC_05120209010)



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Executive Summary

Patoka Lake is a significant area of natural beauty within the Patoka Lake Watershed located in southwest Indiana. Patoka Lake also serves as the drinking water source for more than 65,000 residents in 9 counties throughout southwest Indiana. Its confluence with the Patoka River lies in the northeastern corner of Dubois County and is where the City of Jasper draws its drinking water from. A mix of farms and agricultural land, small towns, and magnificent geological features mark this watershed that contributes water to Patoka Lake.

For several years in the EPA Assessment Database, IDEM has listed Patoka Lake as threatened for drinking water use. This assessment was initially based on the predominance of blue-green algae in summer lake samples, despite the low trophic state of the waterbody overall. This assessment remains today because of the presence of the exotic blue-green algae, *Cylindrospermopsis raciborskii*. It is interesting to note that utilities in Indiana, which currently treat their public water supply reservoirs with herbicides to reduce taste and odor causing algae, are listed as partially supporting for drinking water use; an assessment which places them on the 303(d) list of impaired waterbodies for Indiana. The Army Corps. Of Engineers confirmed the presence of *Cylindrospermopsis raciborskii* in 2001.

Efforts to address the pollution problems of Patoka Lake began in December 2004 when representatives from the Patoka Lake Regional Water & Sewer District contacted Toby Days with the Alliance of Indiana Rural Water. The two organizations agreed to voluntarily work within the community to develop a Source Water Protection Plan (SWP) for the Patoka Lake Watershed and support implementation of voluntary best management practices (BMPs) in the watershed. As this progressed through the spring and summer of 2005, a draft SWP plan was developed for the Patoka Lake Watershed and several public meetings were held to gather input from other Patoka Lake Watershed stakeholders regarding perceived problems, goals, and activities that need to be addressed.

Community and State based support for the *Source Water Protection Plan for the Patoka Lake Watershed* led the Alliance of Indiana Rural Water and the Patoka Lake Regional Water & Sewer District to seek out a mechanism to support such a voluntary, community-based, and community-led watershed management plan. In October of 2005, a CWA Section 319 grant application, sponsored by the Patoka Lake Regional Water & Sewer District, was submitted to IDEM to support the implementation of the *Source Water Protection Plan for the Patoka Lake Watershed*.

The *Source Water Protection Plan for the Patoka Lake Watershed* is intended to be a living document designed to assist the watershed stakeholders in their efforts toward the restoration and protection of the Patoka Lake Watershed.

To receive a copy of this SWP plan, please contact the:
Patoka Lake Regional Water & Sewer District
2647 N ST. RD. 545
Dubois, IN 47527
812-678-5781

Water Quality Vision
The overall water quality goal for the Patoka Lake Watershed is to maintain the existing water quality of the watershed and prevent future water quality degradation by establishing programs for water quality monitoring, public education on water quality, and land planning.

Mission Statement
To assess the water quality of the Patoka Lake Watershed and promote watershed health for the benefit of all that depend on it.

1. Introduction

While water supply treatment and disinfection practices reduce the risk associated with water pollutants, experience has shown us that these strategies by themselves are not fail safe-there are limits to how much and what can be removed. Furthermore, treatment and disinfection can be very expensive. The 1996 Safe Drinking Water Act (SDWA) Amendments promote the idea of "source protection"-a new term, but a time-honored concept. Source protection has emerged as a "hybrid" of wellhead and watershed protection, terms and concepts that have an established and fundamental place in our water supply/water quality protection modus operandi. Source protection, simply meaning that drinking water sources must be protected, has become synonymous with water supply protection.

Section1453 of the SDWA Amendments, required states to assess the Source Water (SW) susceptibility of each Public Water System (PWS) to contamination, and provide the public a summary of the findings. Assessments, conducted on all public water supply sources within states, must identify a source protection area around a public water systems' source waters, identify the potential and existing sources of contaminants, and determine the vulnerability of the source waters to those contaminants. As of April 2005, the Drinking Water Branch for the Indiana Department of Environmental Management (IDEM) has not completed the Source Water Assessments for all the PWSs in the State, thus they have not been made available to the public. However, IDEM has agreed to supply the Alliance of Indiana Rural Water with the incomplete SW Assessment data that they have compiled for a specific area in an effort to assist local communities in designing and implementing voluntary Source Water Protection (SWP) programs. (The completed SW assessment for the Patoka Lake Regional Water & Sewer District was added as Appendix X on July 7, 2006).

Partnerships
Toby Days, Source Water Specialist for the Alliance of Indiana Rural Water, was granted funding through EPA appropriations to assist communities throughout Indiana in developing and implementing SWP Programs based on their SW Assessment. The Alliance of Indiana Rural Water works closely with all state agencies to compile the most up-to-date and comprehensive data available to assist proactive communities in completing their SW Assessment and developing a SWP program that best fits the protection needs of that area.

To better address the SWP needs of the State, the Alliance of Indiana Rural Water hosts a SWP Forum before the beginning of every year to receive input from local agency, water suppliers, citizens, etc. on what SWP efforts the Alliance of Indiana Rural Water needs to focus on in 2005. The 2005 SWP Forum was held on December 7, 2004 at the IDEM-Shadeland office and is where Jerry Allstott from the Patoka Lake Regional Water & Sewer District voiced his interested in developing a SWP program for the contributing watersheds of Patoka Lake.

The Patoka Lake Regional Water & Sewer district is a surface water treatment Public Water System (PWSID IN5219012) that obtains its raw water from an intake structure within Patoka Lake and supplies 9 counties in Southwestern Indiana with their drinking water. As part of IDEM's SDWA SW Assessment requirements, the SWP area delineation was completed for the Patoka Lake Regional Water & Sewer District and consists of an 11 digit (05120209010) hydrological unit code (HUC) watershed located in Southwestern Indiana (Figure 2-1). For the remainder of this document this watershed will be referred to as the Patoka Lake Watershed. The Patoka Lake Watershed also serves as a portion of the Japer Municipal Water Utility's SWP Area.

Patoka Lake Watershed Overview

The Patoka Lake Watershed lies within the Southern Bottomlands and Southwestern Lowland Natural Regions and includes rainfall runoff from parts of Dubois, Orange, and Crawford counties. The Patoka Lake Watershed is subdivided into eleven sub-basins represented on the map by 14 digit HUCs (Figure 2-3). Its floodplain contains some of the finest examples of bottomland forested wetlands in the State (Patoka River National Wildlife Refuge, 1998). The landscape provides a variety of scenic areas that range from flat bottomland fields with numerous meandering streams to steeply rolling hills and valleys covered with hardwoods and outcropping limestone ledges.

Located in the center of the watershed is part of the Hoosier National Forest and Patoka Lake. Patoka Lake was designed and built by U.S. Army Corps of Engineers in July 1972. It is the third largest body of water in Indiana, providing an 8,800 acre (surface area) water supply, also used for fish, wildlife, and recreational activities.

1.1 Stakeholder Groups in the Watershed

Mr. Allstott's initial inquiry sparked the interest of many attendees at the Alliance of Indiana Rural Water 2005 annual SWP forum. That interest spread throughout the communities of the 2005 SWP forum attendees and on February 17, 2005 the first stakeholder meeting for the Patoka Lake Watershed was held at the Dubois County SWCD office (see Appendix IV for attendees list). In addition to the initial stakeholders, many more stakeholder groups have came to the table to contribute to the development of a SWP Program for the Patoka Lake Watershed. The following discussion briefly describes some of the stakeholder groups in the watershed (see Appendix V for a list of additional stakeholders):

The Alliance of Indiana Rural Water

The Alliance of Indiana Rural Water (AIRW) is a non-for-profit organization that assists rural communities throughout Indiana with their water and wastewater needs. As the only Indiana affiliate of the National Rural Water Association (NRWA), the AIRW's mission is to provide water and wastewater systems with high quality professional support, services, and solutions. The Alliance provides solutions to the daily water and wastewater challenges of communities through training and continuing education, on-site technical assistance, leak detection, line location, and Wellhead and Source Water Protection. The Alliance also works to lobby at the Statehouse for small water and wastewater utilities. More information about the Alliance is available at www.inh2o.org.

SWCD's & NRCS & ISDA

In Dubois, Gibson, and Pike Counties, the field office personnel of the Natural Resources Conservation Service and ISDA, along with the Soil and Water Conservation Districts have identified that soil erosion and animal waste are concerns in the Patoka River watershed.

In Orange, Crawford, Martin and Warrick Counties, the field office personnel of the Natural Resources Conservation Service and ISDA, along with the Soil and Water Conservation Districts did not identify any major natural resource concerns in the Patoka River watershed areas in their counties.

Within some areas of the Patoka River watershed, a big concern is the large amount of manure being produced by the poultry and turkey industry. Soil phosphorus levels need to be aggressively managed because some of the fields are reaching 1000 parts per million (Pitstick 1999). Some of the livestock operations store the manure on the top or side of a hill until an opportunity to spread it becomes available. A few producers do not maintain a grass filter area below the manure and it washes down to waterbodies. Several of the poultry and turkey operations are located on sites where spreading acreage is limited. Many of the livestock operations in Dubois County need a dry stacking manure system to help manage the manure problem (Pitstick 1999). Dead poultry are presently being buried or stored in holding tanks in the ground. While some of these tanks get cleaned out, others are left in the ground and may leak in time. Livestock operations would benefit from an animal composting system (Pitstick 1999).

Every spring and fall, the Dubois County Purdue Cooperative Extension Service receives numerous complaints of hog manure odor. Many homes are being constructed closer to existing animal feeding operations (Peters, 1999).

Local Board of Health Departments

The County Health Departments within the Patoka Lake watershed are constantly challenged in assisting homeowners with their septic systems. In all of the counties of the Patoka Lake watershed, the two most common septic system related problems are poorly drained soils with fragipans and seasonal high water tables. Also, some home sites have slopes of 15% or greater, which makes percolation very difficult.

Many of the counties are using alternative septic systems or modified techniques. For example, in Dubois County, approximately 45 sand mound systems are typically installed per year because the standard system will not work (Oeding, 1999).

Every county varies in the number of septic system permits issued. In counties like Dubois, urban growth continues with approximately 130 – 150 new permits a year. (Oeding, 1999).

Many septic systems receive too much water at one time, and therefore do not function properly. This happens because 90% of the households in Dubois County are served with public water (Oeding, 1999).

Other possible reasons why septic systems fail are:
- lot sizes are too small
- poor soils
- lack of septic system management (such as emptying tank every 2 to 5 years)
- filter field is too small
- weather (too much rain causing soil saturation)
- poor site selection
- decomposing bacteria die from grease and other harmful items
- laundry (should be done in little amounts and more often)

Overall, there is an undetermined number of failing septic systems within the Patoka Lake watershed. Some of these systems are straight pipe outlets that discharge the septic effluent on the soil surface, in road ditches, in drainage field tile, down hill sides, etc. These systems create a health hazard from the possibility of spreading disease and are illegal. There are two ways these illicit discharges get upgraded to county standards:
1. the owner sells the property and must disclose it
2. a complaint is filed

To help homeowners understand more about their septic systems, the environmental health specialists provide individual assistance and educational material when permits are issued and/or during site visits. Funding from the Build Indiana and the State Revolving Loan Funds, along with local business and industry donations have secured enough money to connect the towns of Celestine, St. Anthony, St. Marks, Schnellville, and Bretzville to the Patoka Regional Sewer & Water District.

Southwest Indiana Brine Coalition
The Southwest Indiana Brine Coalition is presently targeting brine sites located in Posey, Daviess, Dubois, Vanderburg, Warrick, Gibson, and Pike Counties, that do not have an identified oil operator. They provide technical and possibly financial assistance to landowners with land areas that have soils of high saline concentration from old mining operations. These areas are called brine sites and range from ½ to 5 acres.

Oil and gas drilling activities are quite prolific in Pike and Gibson Counties. In the process of extraction, oil related problems such as salt water and oil spills have impaired water and soil quality. Brine sites on hillsides, cause deep gully erosion from the lack of a vegetative cover and the contaminated sediment moves downhill which continues to sterilize more acres (Hazlewood,1999). Sites that are close to watercourses are a high priority. The number of brine sites within the seven counties has yet to be determined.

The next phase of the Brine Coalition is to provide more education and possibly technical cost share assistance toward improving the brine sites. The best solution, thus far, is building up the soil organic content by incorporating animal manure, wood chips, grass clippings, etc. The best vegetation that may somewhat grow on these areas has been Tall wheat (Hazlewood, 1999).

Patoka South Fork Watershed Steering Committee

The South Fork of the Patoka River Watershed is considered the most heavily impacted watershed in the State of Indiana (Patoka South Fork Watershed Steering Committee Brochure, no date). Of the approximately 52,000 acre watershed, between 60 and 75 percent has been impacted or impaired with acid mine drainage. The environmental degradation from acid mine drainage has been well documented by numerous scientific studies. These studies have documented the loss of fish, aquatic insects, and plants due to the inflow of water with low pH, heavy metals, suspended sediments, and precipitates that coat the stream bottoms. (Patoka South Fork Watershed Steering Committee Brochure).

The Committee is mostly working with mined sites that date 1977 and earlier. Located throughout the abandoned mining areas are creeks, streams, pits and ponds. Many of these water sources are very acidic with pH levels of 1 or 2. Heavy iron levels are also present which gives an orange color to the water. The thousands of acres of rolling spoil banks act like sponges during rainfall, and then slowly release the acid water in the form of seeps and streams.

One solution being implemented is the application of calcium hydroxide in the streams, pits and ponds, which raises the pH levels to 7, 8, or 9. The calcium hydroxide is produced in the forms of liquid or solid material. Other solutions are to apply limestone to the site areas, cover with dirt and plant vegetation or create limestone rock filter basins which neutralize the acid (Mosley, 1999).

The Committee uses a geographic information system (GIS) and has completed inventorying the area. Prioritization of sites is done on a continual basis, and implementation as funding becomes available. Financial assistance for the implementation of these solutions comes from the Abandon Mine Lands Fund and/or the Appalachian Clean Streams Initiative. The cost of implementation can range from one thousand to half a million dollars per project area. The Committee also organizes trash pick up and educational activities, such as Adopt-a-River or Adopt-a-Highway events.

Currently, the South Fork tributary has some river segments that support aquatic vegetation and fish (Mosley, 1999).

Hoosier Riverwatch

Hoosier Riverwatch is an organization sponsored by the state Department of Natural Resources (DNR). The organization started in 1994 to increase public awareness of water quality issues and concerns by training volunteers to monitor stream water quality. Hoosier Riverwatch increases public involvement in water quality through hands on training of volunteers in stream monitoring and clean up activities, educates local communities about the relationship between land use and water quality, and provides water quality information through its volunteer monitoring database. Hoosier Riverwatch offers a grant program that provides water quality test kits to organizations and citizen groups that agree to monitor stream segments in their home area for a specific period of time.

Others
Other conservation groups are active in the region, including Ducks Unlimited, Pheasants Forever, and several local conservation clubs located in this watershed. Additionally, several middle and high schools conduct environmental classes (see Appendix V for addition stakeholders).

1.2 Current Status of the Water Quality in the Patoka Lake Watershed

Section 303(d) of the Clean Water Act (CWA) requires states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. The CWA Section 303 (d) list for Indiana provides a basis for understanding the current Status of water quality in the Patoka Lake Watershed. The following waterbodies are on Indiana's 2004 Clean Water Act Section 303(d) list submitted to and approved by EPA:

- **Patoka Reservoir/Lake**-fish consumption advisory for Mercury
- **Patoka Lake Dam-Lick Creek**-fish consumption advisory for Mercury

Eutrophication causing Cyanobacteria (Blue-Green Algae) blooms has resulted in a taste & odor nuisance in the raw water of Patoka Lake (Figure 1.2). Although receiving a low Trophic State Index (TSI) score of 21 for the Eutrophication Survey conducted by IU/SPEA on 8/12/2001 the Lake continues to have a preponderance of blue-green algae species given biologist the idea that Patoka Lake has the potential to go anoxic during the summer months. This is a concern with regard to Patoka Lake's use as a drinking water source. Environmental Health Laboratories conducted an "Odor in Water Analysis" to determine the compounds responsible for the earthy musty odors in the raw water. A total of six compounds were identified by the analysis. The compounds are all produced by Actinomycetes, a bacteria which is commonly found in water and sediments of rivers and lakes and live within or on algae. For several years in the EPA Assessment Database, IDEM has listed Patoka Lake as threatened for drinking water use. This assessment was initially based on the predominance of blue-green algae in summer lake samples, despite the low trophic state of the waterbody overall. This assessment remains today because of the presence of the exotic blue-green algae, *Cylindrospermopsis raciborskii*. It is interesting to note that utilities in Indiana, which currently treat their public water supply reservoirs with herbicides to reduce taste and odor causing algae, are listed as partially supporting for drinking water use; an assessment which places them on the 303(d) list of impaired waterbodies for Indiana. The Army Corps. Of Engineers confirmed the presence of *Cylindrospermopsis raciborskii* in 2001.

Figure 1.2 Algae growth on Patoka Lake

Gizzard shad, *Dorosoma cepedianum,* is an Aquatic Invasive Species (AIS) that was discovered in Patoka Lake by DFW personnel in 1996. A total of four gizzard shad were collected in 1996. Sampling in 1997 indicated the gizzard shad population exploded in one year. With less than half the fish collected in 1997 as in 1996, 3,301 shad were sampled that weighed 358 pounds.

Gizzard shad were the most abundant fish sampled by both number and weight from 1997 through 2001. Since, 2001, shad have ranked second in relative abundance by number (Carnahan, D.P. 2004). Gizzard shad are not native to Indiana and have become a nuisance fish in many of our lakes and rivers. When young, these fish provide some forage for predators. However, when they get older and larger, they compete for food with game fish and other species.

The chemical characteristics of the Lake have also been monitored. The amount of dissolved oxygen (DO) present in a lake is very important. DO indicates the suitability of the water for sustaining life. Fish, and the organisms on which fish feed, require dissolved oxygen. Warmwater fish require about five parts per million (ppm) of dissolved oxygen (Hudson, 1998). Data pulled from IDEMs AIMS database for samples taking in 1996 and 2001 show DO levels that dip well below 5 ppm on numerous occasions, which demonstrates the growth of the anoxic zone within the Lake. The US Army Corps. Of Engineers has comparable DO monitoring numbers (see Appendix III and VIII for IDEMs and the COREs monitoring analysis spreadsheets).

Total alkalinity, a measure of chemical nutrients, particularly calcium carbonate, provides another index of the lake's ability to produce fish. Lakes where total alkalinity measures less than 50 ppm are classified as unproductive, and the pounds of fish produced is normally low. The total alkalinity level of most Indiana lakes is within the range of 50-200 ppm, and these lakes are capable of producing large amounts of fish (Hudson, 1998). The Patoka Lake Regional Water & Sewer District's alkalinity monitoring data for 2004 and 2005 ranges from 54-77 ppm (see Appendix VI for data reports).

The acidity measures, or pH, is another important water quality parameter. It is generally agreed that for good sport fish production and growth of fish food organisms, pH values should be between 6.5 and 8.5 (Hudson, 1998). IDEM, CORE, and the Patoka Lake Regional Water & Sewer District all have acidity measurement data for the lake where pH values range from 7.1 to 8.8 (see Appendix III, VI, and VIII for data reports).

1.3. Structure of the Planning Group

Toby Days, Source Water Specialist for the Alliance of Indiana Rural Water, was granted funding through EPA appropriations to assist communities throughout Indiana develop and implement SWP Programs based on their SW Assessment. The Alliance of Indiana Rural Water works closely with all state agencies to compile the most up-to-date and comprehensive data available to assist proactive communities in completing their SW Assessment and developing a SWP program that best fits the protection needs of that area.

To better address the SWP needs of the State, the Alliance of Indiana Rural Water hosts a SWP Forum before the beginning of every year to receive input from local agency, water suppliers, citizens, etc. on what SWP efforts the Alliance of Indiana Rural Water needs to focus on in 2005. The 2005 SWP Forum was held on December 7, 2004 at the IDEM-Shadeland office and is where Jerry Allstott from the Patoka Lake Regional Water & Sewer District voiced his interested in developing a SWP program for the contributing watersheds of Patoka Lake.

The Patoka Lake Regional Water & Sewer District is a surface water treatment Public Water System (PWSID IN5219012) that obtains its raw water from an intake structure within Patoka Lake and supplies 9 counties in Southwestern Indiana with their drinking water. As part of IDEM's SDWA SW Assessment requirements, the SWP area delineation was completed for the Patoka Lake Regional Water & Sewer District and consists of an 11 digit (05120209010) hydrological unit code (HUC) watershed located in Southwestern Indiana (Figure 2-1).

Throughout the summer months of 2005, the Alliance of Indiana Rural Water in cooperation with the Patoka Lake Regional Water & Sewer District began to organize watershed data and contacting stakeholders interested in addressing the pollution problems in the Patoka Lake Watershed. To receive input on the concerns of the stakeholders a public meeting was held at the Patoka Lake Regional Water & Sewer District's office on August 30, 2005. Twenty one (21) stakeholders attended the public meeting and were given the opportunity to voice there concerns on the issues that felt needed to be addressed and represented in this plan. This meeting produced cooperative agreements with community volunteers, as well as, representatives from several county agencies (SWCDs, NRCSs, Health Departments, ISDA, CORE, US Forest Service, etc.) all interested in participating in the planning group for the "Source Water Protection Plan for the Patoka Lake Watershed" (see Appendix IX for meeting attendees).

At this public meeting it was determined that there are water quality problems in the Patoka Lake watershed that need to be addressed. The group decided to continue to work on the development of this SWP plan and to seek out funding options to implement the plan.

The Patoka Lake Watershed Steering Committee will be responsible for reviewing and revising this Source Water Protection plan to best represent the concerns of the many stakeholders who depend on the water resource of the Patoka Lake Watershed (Appendix XI).

1.4. Concerns of the Stakeholders

To receive input on the concerns of the stakeholders a public meeting was held at the Patoka Lake Regional Water & Sewer District's office on August 30, 2005. Twenty one (21) stakeholders attended the public meeting and were given the opportunity to voice their concerns on the issues that they felt needed to be addressed and represented in this plan. The following list is the concerns voiced by the group (see Appendix IX for a photo copy of written responses & meeting sign-in sheet):

- Runoff from vehicles
- Chemical drainage into the lake
- Small town runoff
- Septics
- Septic Systems
- Nitrogen content in finished tap water, Taste & Odor is a big issue-haven't noticed the problem this year.
- Concerns of runoff from hog farms-large confined feeding operations should not be allowed in watersheds of drinking water lake.
- Ag-nutrient & pesticides
- Stock piling of animal waste

- Nutrient runoff from cattle and turkey
- Farming practices- livestock & row crops
- Recreational uses/over use
- Jet skis
- Maintain water quality in Patoka Lake to insure a good fisheries.
- Improve stream crossing to reduce sediment entering the stream system from this source and to address aquatic organism passage.
- Main concern is oil in water from 2 cycle engines-change to 4 cycle engines could do a lot to clean up the lake
- Fish consumption advisory
- Beach Closing
- Enforcement
- Encourage forest cover would do much to keep source water clean
- Air pollution falling onto lake surface is probably introducing more pollution than you think.

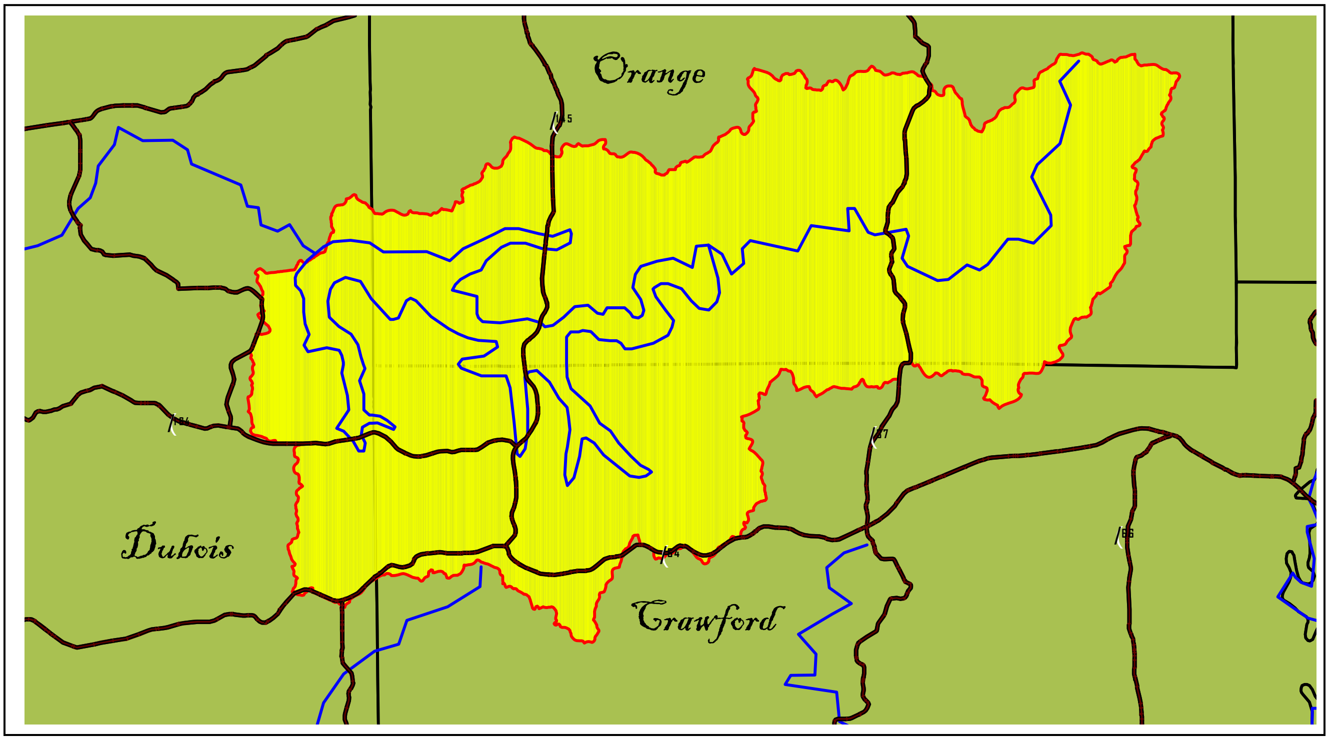
In addition, it was determined that a significant percentage of the residents and stakeholders in the Patoka Lake Watershed do not know the physical boundaries of the watershed or its relationship to the Patoka River and the Wabash River Basin. Further, they do not understand how their actions affect the quality of water in the watershed, and the negative economic impact of polluted water could have on the many towns and Counties in Southwest Indiana, that depend on this water resource.

The perceived watershed problems mentioned by the stakeholders in the above list were centered around two uses of Patoka Lake, which were the use of the Lake for 1). drinking water and 2). recreational opportunities.

2. Description of the Patoka Lake Watershed

The Patoka Lake Watershed is an 11 digit (05120209010) hydrologic unit code (HUC) watershed located in southwest Indiana (Figure 2.1). It lies within the Southern Bottomlands and Southwestern Lowland Natural Regions, and receives rainfall from three different counties (Figure 2.2). The Patoka Lake Watershed is subdivided into 11 sub-basins represented on the map by 14 digit HUCs (Figure2.3).

Figure 2.1- Patoka Lake Watershed Boundaries

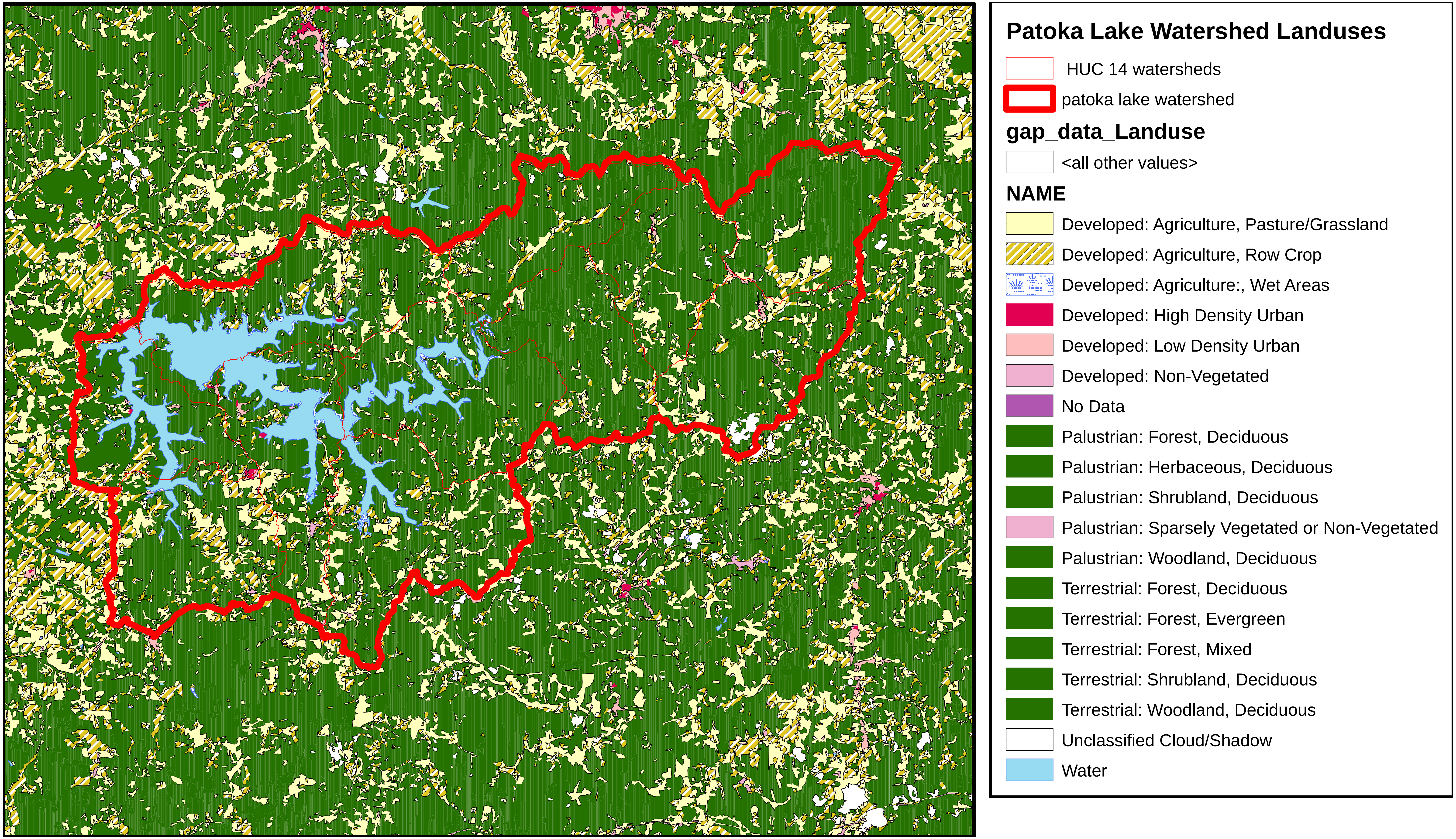


Land use in the watershed is predominately agriculture and forestry, which represents approximately 90 percent of the total land cover. Corn, Soybeans, and hay comprise the majority of crops produced, while various hardwood species comprise the majority of the forest land. Other land uses include urban, wetland vegetation and open water. Table 2 and Figure 2.5 shows the breakdown of the landuses within the Patoka Lake Watershed.

Table 2. Patoka Lake Watershed Landuse

HUC 14	Name	Wetlands/ Water	Ag	Grass/ Pasture	Forest	Commercial	LD Residential	HD Residential	Impervious Surface	Total Acres
05120209010020	Patoka River-Baron Creek	11.3	1487.8	1632.9	6764.8	4.5	7.4		192.1	9908.9
05120209010010	Patoka River-Fudge Creek	5.1	620.7	967	6361.7	0.9	3.9		152	7959.5
05120209010030	Patoka River-Hogs Defeat Creek	2.3	734.6	922.5	5759.5	0.4	4.4		141.7	7423.8
05120209010050	Youngs Creek	16.3	678.7	639.9	5779	0	0.4		130.8	7114.5
05120209010040	Patoka River-Dillard Creek	111.4	1156.8	859.8	6460.1	0.2	1.3		158	8589.2
05120209010060	Patoka River-Dumplin Branch	1151.7	1650.4	648.3	8305.1	0	2.1		202.2	11757.8
05120209010070	Little Patoka River	374.2	2995.3	1676.1	7681.4	3.2	13	1.9	239.5	12745.4
05120209010090	Patoka River-Painter Creek	359.7	2193.5	1131.8	5881.3	2.3	1.1		170	9570.6
05120209010080	Patoka River-Fleming Creek	291.7	1537.9	641.6	3799.8	7.8	1.1	0	106.1	6480.2
05120209010100	Lick Creek-Ritter Creek	200.4	2795.4	1911.1	5274.6	2.9	24.6	1.9	188	10216.6
05120209010110	Patoka Lake Dam-Lick Creek	1226.1	1049.66	846.7	4745.3	3.2	3.7	1	98.2	7922.4
	Totals *doesn't include 8,800 acres of Patoka Lake	3750.2	16900.76	11877.7	66812.6	25.4	63	4.8	1778.6	99688.9
05120209010	Patoka Lake Watershed *does include 8,800 acres of Patoka Lake	4177.2	16936.2	11894.2	67687.1	21.2	71.8	5.4	1861.8 1.84% of watershed is impervious	107140.4

Figure 2.5 Patoka Lake Watershed Landuses



Geology and Soils
The Patoka Lake Watershed area covers a vast landscape of various landforms. The majority of the watershed is underlain with interbedded sandstone, shale and siltstone of Mississippi and Pennsylvanian-age. The dominant soil types are Zanesville, Gilpin, Wellston, Tilsit and Berks. Gilpin and Berks soils are formed in loamy residuum. Zanesville, Wellston and Tilsit soils are formed in thin loess over loamy residuum. These soils are mainly used for pasture and woodland, and to a lesser extent cropland (USDA-NRCS 1999).

Drainage from the Patoka Lake Watershed flows westward towards the Patoka Reservoir dam, which serves as the headwaters for the Patoka River (Figure 2.6). The dam is built from earth and rock fill, with a maximum height of 84 feet and is 1550 feet in length. The watershed drains 168 square miles of land above the dam (Patoka Lake, Indiana-US Army Corps of Engineers Brochure, No date).

Figure 2.6 Patoka Lake dam near CORE Headquarters

Areas of Interest
Patoka Lake was authorized by the Flood Control Act of October 27, 1965. Construction began in July 1972 with the dam completed in January 1979 and initial recreational facilities completed in December 1980.

Patoka Lake, the second largest reservoir in Indiana is operated for flood control, water supply, provides general recreation, and fish and wildlife opportunities. The lake forms an integral unit in the Ohio River Basin comprehensive plan and serves to reduce flood stages downstream from the dam. Patoka Lake was developed in accordance with a long range program and provides for beneficial use of reservoir lands, fish and wildlife resources, and an opportunity for outdoor activities associated with large bodies of water.

Patoka Lake is the third largest body of water in Indiana at 8,800 surface water acres. There are approximately 26,000 acres of federal and state owned properties within the Patoka Lake Watershed. The Indiana Department of Natural Resources (IDNR) operates seven State Recreation Areas at the lake. The Newton-Stewart State Recreation Area is the most developed with campgrounds, swimming beach, visitor center, marina, and other attractions. Eleven boat launching ramps provide anglers and boaters access to the lake. Areas for bank fishing are numerous and are located by any road bordering the lake (Carnahan, 2004).

The Patoka Lake Watershed serves as all of Patoka Lake Regional Water & Sewer District’s and portions of Jasper Water Department’s Source Water Protection Area, delineated by IDEMs Source Water Assessment Program in 2004 to determine the area that recharges each drinking water source. Patoka Lake is the drinking water supply for over 65,000 people in 9 Counties throughout Southwestern Indiana. The wastewater from the homes around Patoka Lake including the community of Dubois is treated by the Patoka lake Regional Water & Sewer District.

The purchase area of the Hoosier National Forest is located adjacent to Patoka Lake. The surrounding area of the lake consists of rolling topography, heavily wooded sections, deep draws and has retained a rustic and rural appearance. During their annual migration, buffalo created well-worn paths that served as the first roads of early settlers.

Numerous caves of significance lie to the east of Patoka Lake. The scenic rock outcroppings, acres of timberland, and rich history of this area provide additional outstanding places for sightseeing and recreation.

Figure 2-2: Indiana's Natural Regions

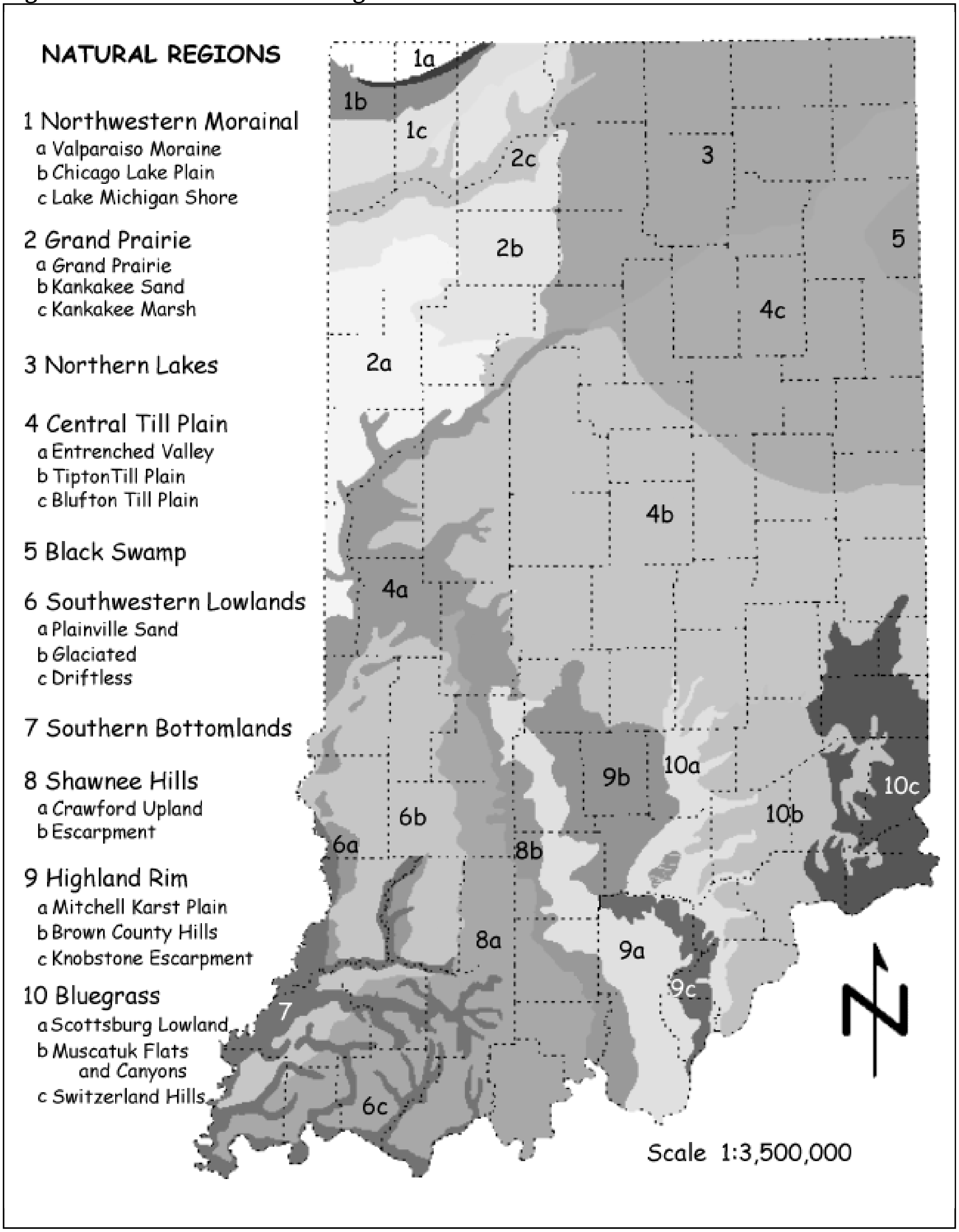
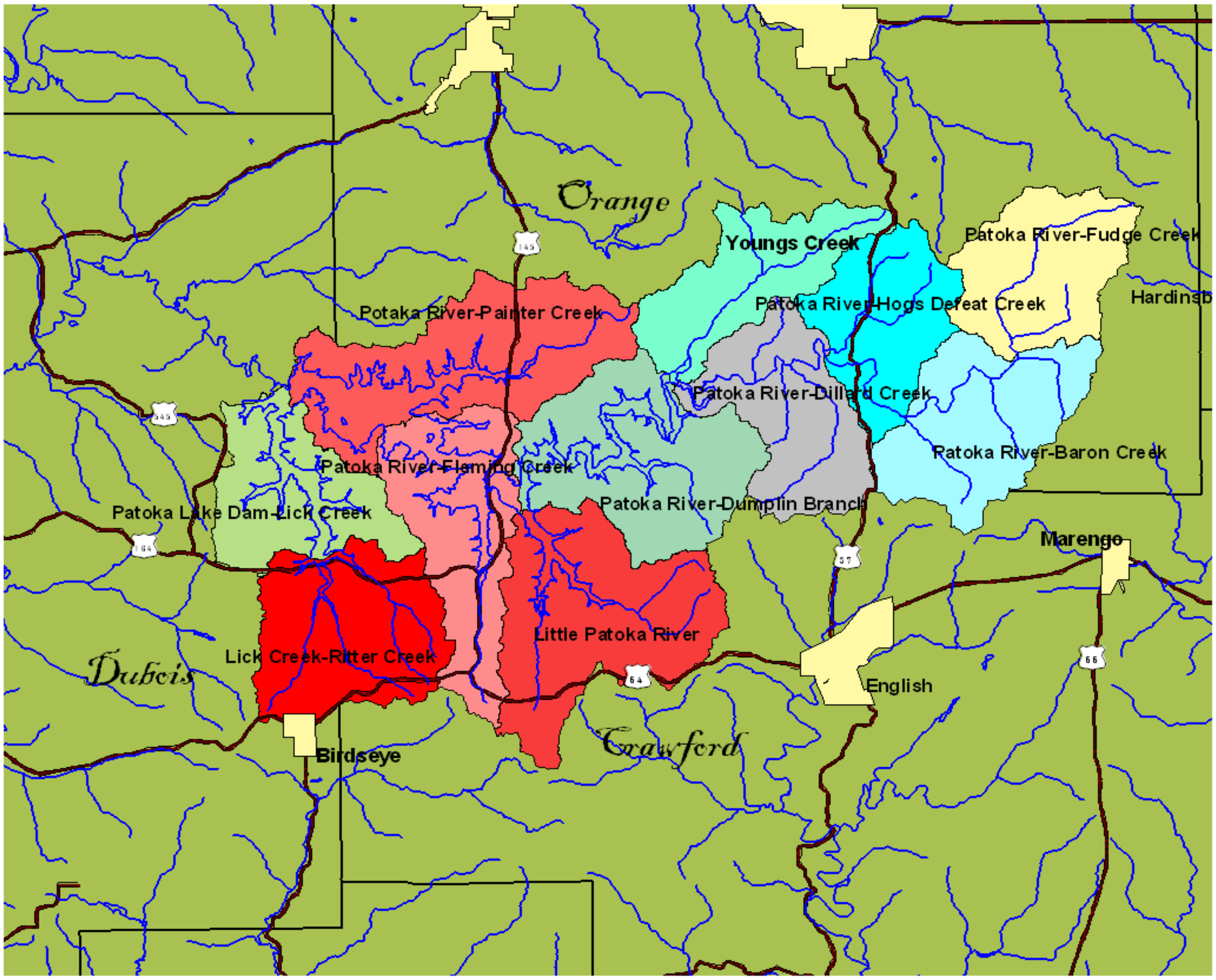


Figure 2.3-Huc 14 digit watersheds within the Patoka Lake Watershed



2.1. Location of the Patoka Lake Watershed

Patoka Lake is located in Dubois, Crawford, and Orange Counties in southern Indiana on the Patoka River. Patoka Lake is accessible from State Road 164 along the southern edge of the property, State Road 145 running north and south along the eastern edge of the lake, or State Road 56 on the northern edge of the lake (Figure 2.3 & 2.4).

Figure 2.4 DNR Managed Property around Patoka Lake

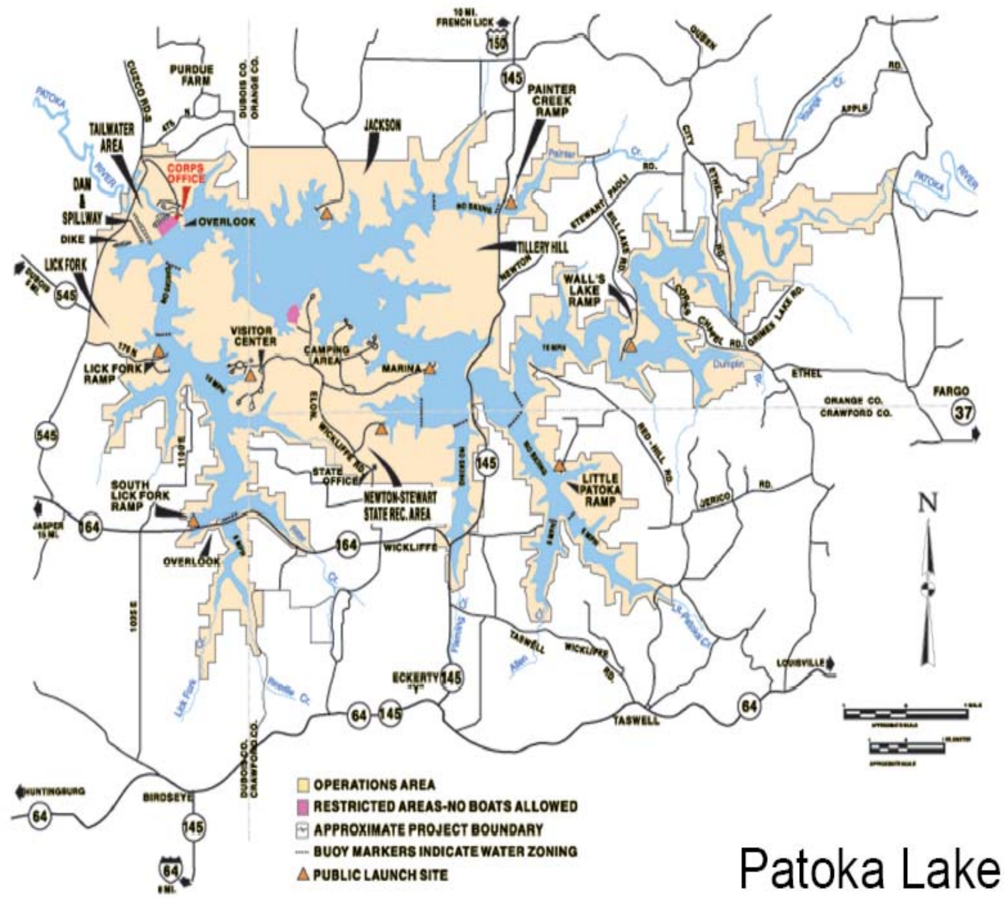


Figure 2.7 left: Patoka Lake Regional Water & Sewer District Intake Structure.
Figure 2.8 below: Rock outcropping along SE lake shore

3. Benchmarks: Current Status

3.1 Fish Consumption Advisories-Patoka Lake on the 303(d) list for Mercury

Section 303(d) of the Clean Water Act (CWA) requires states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. The CWA Section 303 (d) list for Indiana provides a basis for understanding the current Status of water quality in the Patoka Lake Watershed. The following waterbodies are on Indiana's 2004 Clean Water Act Section 303(d) list submitted to and approved by EPA:

- **Patoka Reservoir/Lake**-fish consumption advisory for Mercury
- **Patoka Lake Dam-Lick Creek**-fish consumption advisory for Mercury

Fish Consumption advisories are based on the Indiana Administrative Code 317 IAC 2-1-9(45) defining toxic substances as those substances that are or may become harmful to plant or animal life or to food chains when present in sufficient concentrations or combinations. Toxic substances include, but are not limited to those pollutants identified as toxic under Section 307 (a)(1) of the Clean Water Act.

Toxic substances frequently encountered in Indiana streams include chlorine, ammonia, organics (including hydrocarbons and pesticides), and heavy metals. These materials are toxic to different organisms in varying amounts and the effects may be evident immediately or may only be manifested after long term exposure or accumulation in living tissue. Fish consumption advisories are based on data resulting from bioaccumulation of pollutants in fish tissue (IDEM 2002). See Appendix VII for IDNR/DFW fish tissue sample report.

3.2 Existing Water Quality Data

3.2.1 Local Water Quality Monitoring Efforts

Water quality data in the Patoka Lake Watershed is available from many sources. Since the mid-1990s groups such as the U.S. Army Corps of Engineers and the Indiana Department of Environmental Management have maintained a database on stream water quality for the Patoka Lake Watershed and its tributaries. Indiana University and the Patoka Lake Water & Sewer District have also kept monitoring data for Patoka Lake. This data with several historical data sets were used to assess the water quality conditions in the Patoka Lake sub-watersheds, and to develop Problem Statements and locate Critical Areas of Concern.

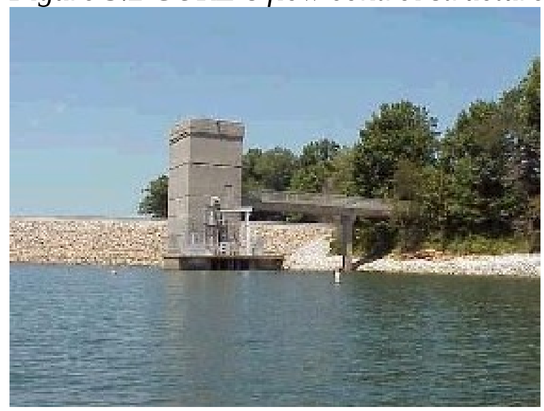
This assessment process takes into account several indicators of water quality, ranging from concentrations of contaminants, to loads of contaminants and remotely sensed land-use/land cover data, to visual assessments. This robust assessment allowed the Patoka Lake Watershed Steering Committee to formulate Problem Statements and Identify Critical Areas of Concern. This approach allowed the Steering Committee to determine the best course of remediation and develop insight into possible outcomes of proposed remediation.

The following sections summarize the water quality information that has been collected or is currently being collected on, about, or regarding the Patoka Lake Watershed and/or Patoka Lake that was used in the Watershed assessment.

3.2.1.1 Water Quality Monitoring by the US Army Corps of Engineers (CORE)

The US Army Corps of Engineers have a log of daily temperature & DO profiles for the Patoka Lake since it has been built. Daily samples are taken at the CORE's flow control structure (Figure 3.2) located near the dam. See the CORE's website for daily profiles http://www.lrl.usace.army.mil/wc/wq/prrtext.html

Figure 3.2 CORE's flow control structure



Macroinvertebrate, physical & chemical characteristics have also been analyzed by the CORE for various locations throughout the Patoka Lake Watershed (Appendix VIII). The CORE maintained a database for monitoring efforts at 11 locations throughout the Patoka Lake Watershed from 1999-2005. At each of the 11 sample locations, sampling involved taking grab samples from the stream, but did not include determination of the stream discharge (see Figure 3.2.1.1). Although multiple samples were taken at each location multiple times throughout a day, samples were not taken at the same time from year to year nor were each location sampled for the same parameters, thus, determining a mean baseline was difficult. Therefore, this data was searched for parameters that did not meet the Indiana Surface Water Quality Standards (IAC 327 2-1).

Over 15,000 samples were searched for chemical and physical parameters that did not meet surface water standards set by the State of Indiana. Only two of the chemical parameters exceeded the state standards: 1. Dissolved Oxygen and 2. Atrazine. Dissolved Oxygen shall never be less then 4.0 mg/L and Atrazine shall never exceed 3.0 µg/L were the water quality standards used to determine target loads.

Dissolved Oxygen was measured at 7 locations throughout the watershed. Five of the seven sample locations had DO levels that fell well below 4.0 mg/L (see Figure 3.2.1.1 for DO sample locations). Sample locations that fell below the 4.0 mg/L DO threshold were in the Lick Creek-Ritter Creek, Patoka Lake Dam-Lick Creek, Patoka River-Fleming Creek, and the Patoka River-Dumplin Branch subwatersheds (figure 2.3).

There was only one sample location that monitored for Atrazine levels. Sample site located at mile 147.8 on Patoka River on a County Road, 3 miles North of Fargo, IN. There was only one sample that exceeded the water quality standard of 3.0 µg/L. A sample taken on 6/1/99 within the Hogs Defeat Creek sub-watershed measured 3.6 µg/L (see Figure 3.2.1.2 & figure 2.3).

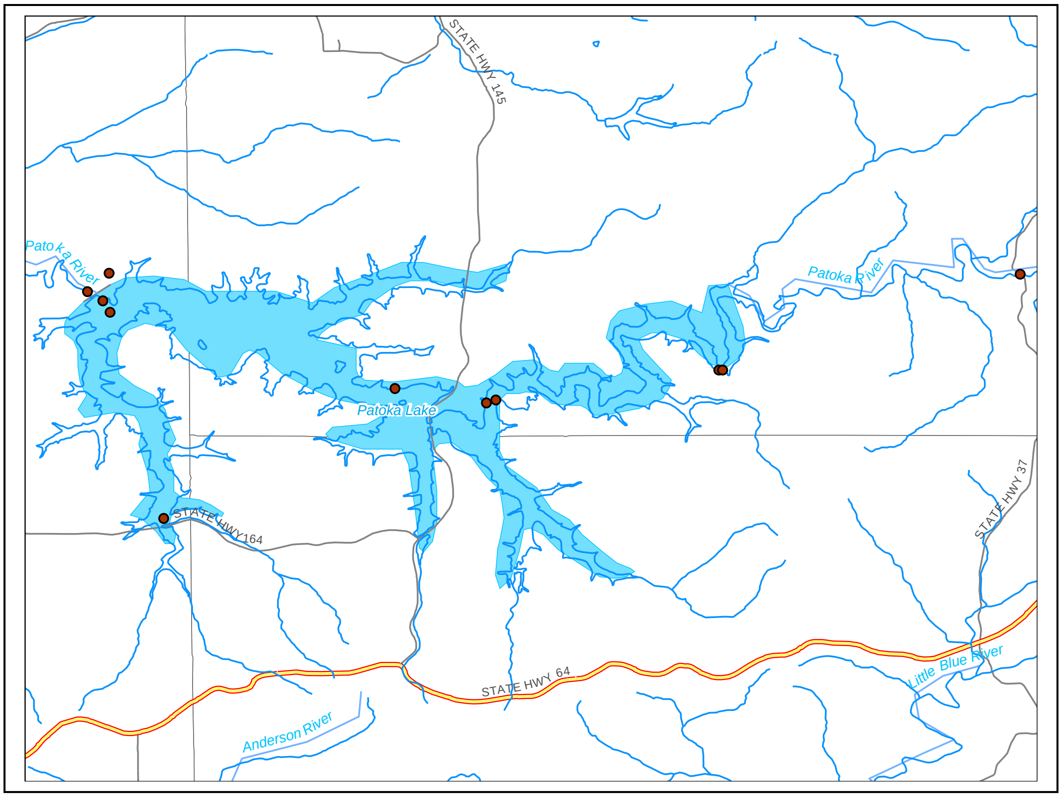


Figure 3.2.1
All of the CORE sample locations.

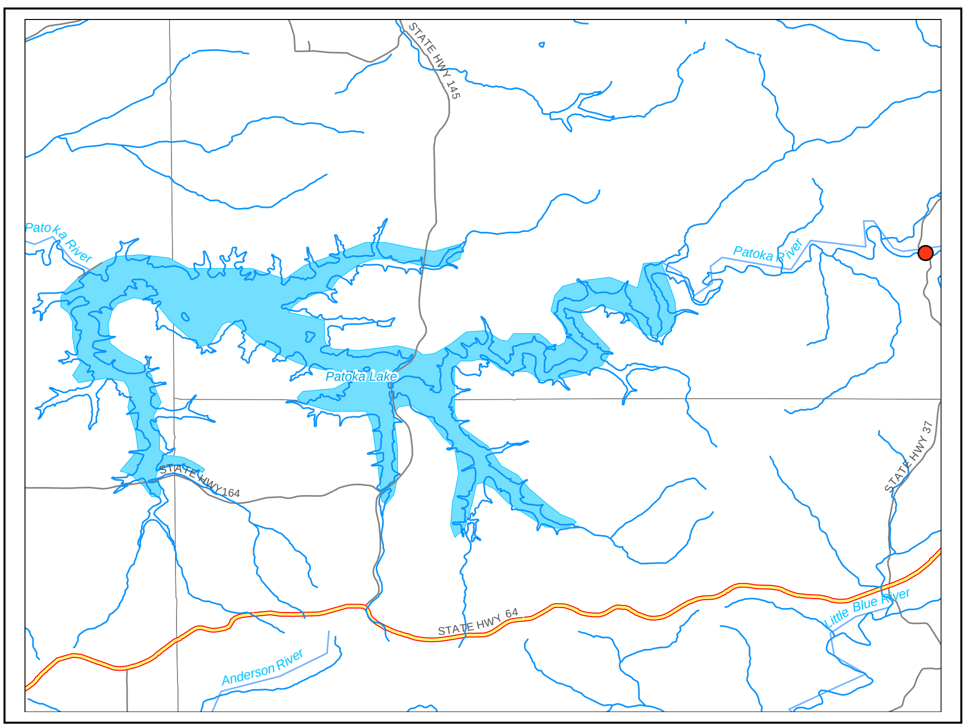


Figure 3.2.1.2-
CORE Atrazine Sample Location. Only one sample taken from this location exceeded the State Surface Water Quality Standard of 3.0 µg/L.

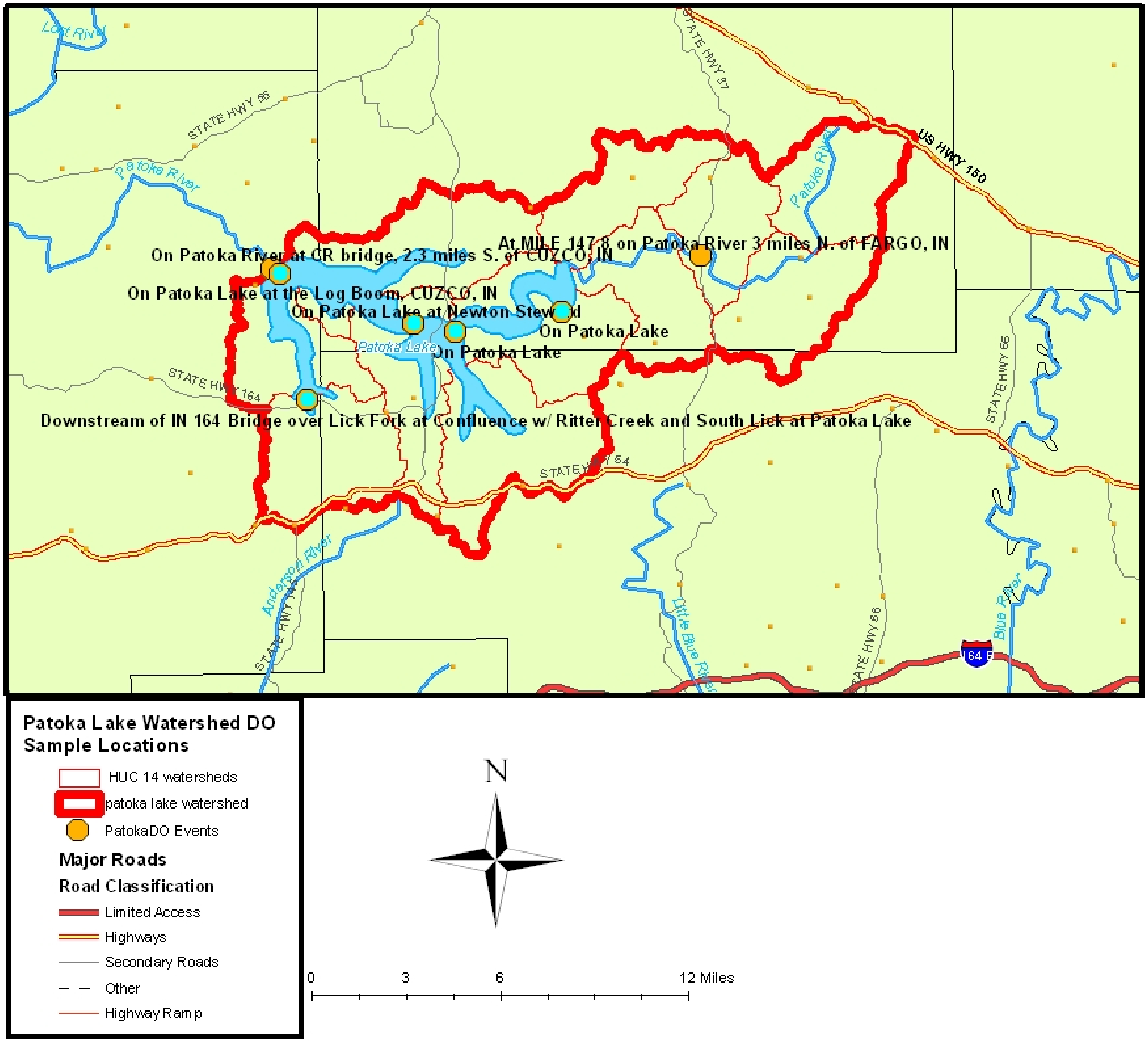


Figure 3.2.1.1-CORE Dissolved Oxygen sampling locations. Sites highlighted in green are location that exceed the water quality standard of 4.0 mg/L for DO.

3.2.1.2 Water Quality Monitoring by Indiana University/School of Public & Environmental Affairs (IU/SPEA)

Eutrophication causing Cyanobacteria (Blue-Green Algae) blooms has resulted in a taste & odor nuisance in the raw water of Patoka Lake. Although receiving a low Trophic State Index (TSI) score of 21 for the Eutrophication Survey (TSI Scores >31 qualify a waterbody as being eutrophic) conducted by IU/SPEA on 8/12/2001 the Lake continues to have a preponderance of blue-green algae species given biologist the idea that Patoka Lake has the potential to go anoxic during the summer months (see Appendix I for TSI scores).

3.2.1.3 Water Quality Monitoring by the Patoka Lake Regional Water & Sewer District

Eutrophication is a concern with regard to Patoka Lake's use as a drinking water source. In 2002 the Patoka Lake Regional Water & Sewer District contracted with the Environmental Health Laboratories to conduct an "Odor in Water Analysis" using the Purge & Trap Capillary Gas Chromatograhy-Mass Spectrometry (P&T-GC/MS) technique to determine the compounds responsible for the earthy musty odors in the raw water of Patoka Lake. A total of six compounds were identified by the analysis. The compounds are all produced by Actinomycetes, a bacteria which is commonly found in water and sediments of rivers and lakes and live within or on algae (see Appendix II for Environmental Health Laboratories final analysis report).

The Patoka Lake Regional Water & Sewer District takes daily samples of raw water at both Treatment Plant #1 and Treatment Plant #2. Raw water samples are taken at the point in which the water first enters the treatment plants, before pre-chlorination and any other treatment processes. Raw water is analyzed for turbidity, alkalinity, pH, hardness, iron, manganese, aluminum, fluoride, temperature, and ammonia.

Total Organic Carbon (TOC) analysis is done once a month on both the raw and finished water. The TOC raw water sample is taken at the intake structure located on the northeast shoreline of Patoka Lake. The TOC finished water sample is taken from both Treatment Plant #1 & #2 after all treatment processes have been completed.

Quarterly samples for Total Trihalomethanes (TTHM) and Haloacetic Acid (HAA5) are taken at four locations throughout the distribution system. The four sample locations are at: 1). Dubois North Meter Pit, 2). Ireland #2, 3). Holland, and 4). Lynville.

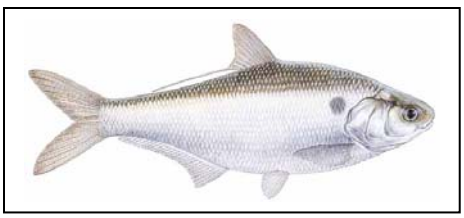
A annual analysis for Synthetic Organic Compounds (SOCs), Volatile Organic Compounds (VOCs), Inorganic Chemicals (IOCs), Nitrate, Sodium, and Methyl Tertiary Butyl Ether (MTBE) is done on finished water samples taken at both Treatment Plant #1 and #2 (see Appendix VI for Patoka Lake Regional Water & Sewer District's monitoring data).

Analysis of the Patoka lake Regional Water & Sewer District's raw water data showed that all samples taken at both treatment plant #1 and #2 meet EPA's Ambient Water Quality Recommendations.

3.2.1.4 Fish Management Reports by the Indiana Department of Natural Resources-Division of Fish and Wildlife

The 2003 fish management survey, angler creel survey, bass tournament monitoring, striped bass survey, and spring crappie survey were conducted under Division of Fish and Wildlife (DFW) work plan 200739 and was the most update fish management reports available at the time this plan was put together for Patoka Lake.

Patoka Lake standard fish management surveys were conducted in 1981, 1983, 1984, 1987, 1989, 1991, 1994,1996, 2000, and 2002 (Ball and Glander 1985, Stefanavage 1991 and 1993a, Stefanavage and Carnahan 1995, Stefanavage 1997, Carnahan 1999, 2001, 2004). Spot check fish management surveys were conducted in 1995, 1997, 1999, and 2001 (Stenfanavage 1996, Carnhan 1998, 2000, and 2002a). A largemouth bass research study was conducted during 1985 and 1986 (Ball 1988). Angler creel surveys were conducted in 1981, 1982, 1985, 1986, 1989, 1991, 1994, 1996, and 2000 (Glander 1983 and 1984, Brown 1987a and 1987b, Stenfanavage 1991 and 1993b, Stefanavage and Carnahan 1995, Stefanavage 1997, Carnahan 2001). Largemouth tournament monitoring surveys were conducted in 1985, 1986, and 1990 through 2002 (Blackwell 1993 and 1994, Carnahan 1993, 1998, 1999, 2000, 2001, 2002a and 2004, Stefanavage and Carnahan 1995, Stefanavage 1995, 1996, and 1997).



Gizzard shad, *Dorosoma cepedianum,* is an Aquatic Invasive Species (AIS) that was discovered in Patoka Lake by DFW personnel in 1996. A total of four gizzard shad were collected in 1996. Sampling in 1997 indicated the gizzard shad population exploded in one year. With less than half the fish collected in 1997 as in 1996, 3,301 shad were sampled that weighed 358 pounds. Gizzard shad were the most abundant fish sampled by both number and weight from 1997 through 2001. Since, 2001, shad have ranked second in relative abundance by number (Carnahan, D.P. 2004). Gizzard shad are not native to Indiana and have become a nuisance fish in many of our lakes and rivers. When young, these fish provide some forage for predators. However, when they get older and larger, they compete for food with game fish and other species.

Some of the concerns brought forth by stakeholders indicated a decline in the quantity and quality of recreational game fishing in Patoka Lake. The predominance of the exotic gizzard shad may account for some of the stakeholder concerns. The Gizzard Shad often out compete native game fish, thus the possible decline.

3.2.1.5 Water Quality Monitoring Done by Indiana Department of Environmental Management (IDEM)

For several years in the EPA Assessment Database, IDEM has listed Patoka Lake as threatened for drinking water use. This assessment was initially based on the predominance of blue-green algae in summer lake samples, despite the low trophic state of the waterbody overall. This assessment remains today because of the presence of the exotic blue-green algae, *Cylindrospermopsis raciborskii*. It is interesting to note that utilities in Indiana, which currently treat their public water supply reservoirs with herbicides to reduce taste and odor causing algae, are listed as partially supporting for drinking water use; an assessment which places them on the

303(d) list of impaired waterbodies for Indiana. The Army Corps. Of Engineers confirmed the presence of *Cylindrospermopsis raciborskii* in 2001.

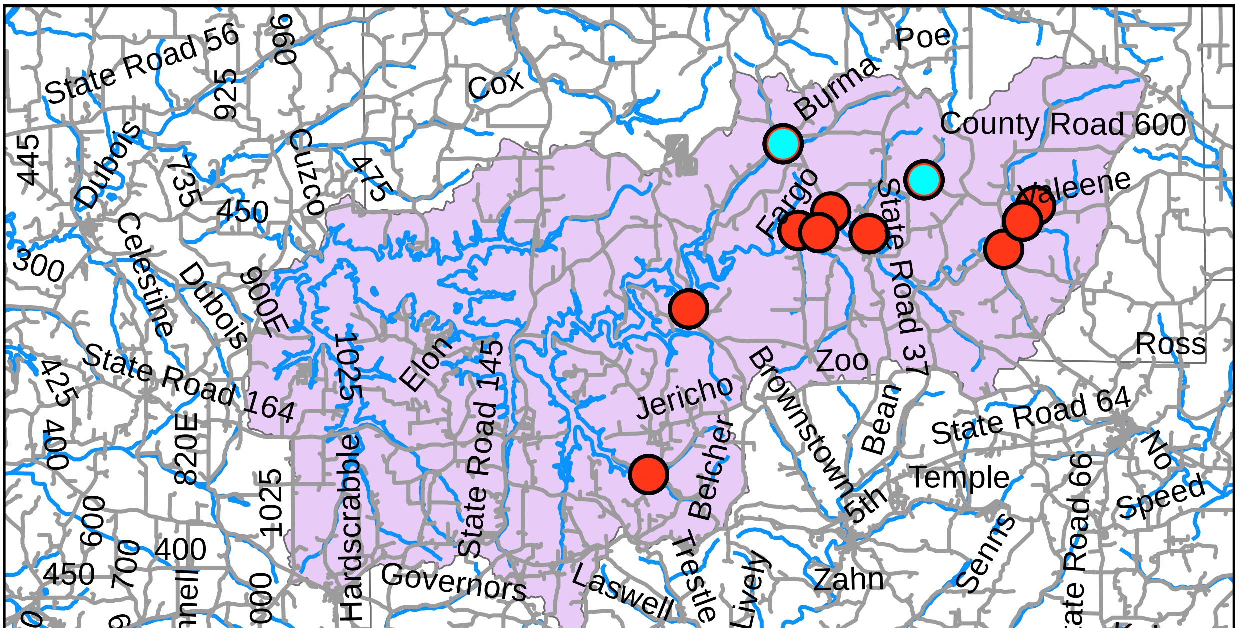
Patoka Lake and tributary data files from IDEM's AIMS database show numerous parameters analyzed by IDEM throughout the Patoka Lake Watershed. IDEM took samples from the watershed in July 1991, July 1996, and August 2001. Samples were analyzed for DO, Temperature, pH, Specific Conductance, % Saturation, % Oxic Water Column, % Light Level, Turbidity, Blue-Green Algae, Green Algae, Ammonia, Nitrate+Nitrite, Chloride, COD, Coliforms, Cyanide, E.Coli, Fluoride, Hardness, Oil & Grease, Sulfate, TDS, TOC, TPH-IR, Alkalinity, MicroCrustacea, Rotifers, Chlorophyll, Phosphorus, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Magnesium, Mercury, Nickel, Selenium, Zinc and TKN. In addition, 40 other organic compounds and 110 pesticides were monitored for (see Appendix III).

Although multiple samples were taken at each location multiple times throughout the day, samples were not taken at the same time from year to year nor was each location sampled for the same parameters, thus, determining a mean baseline was difficult. Therefore, this data was searched for parameters that did not meet the Indiana Surface Water Quality Standards (IAC 327 2-1).

Over 150 samples were searched for chemical and physical parameters that did not meet surface water standards set by the State of Indiana. Only one of the chemical parameters exceeded the state standards: 1. Dissolved Oxygen. Dissolved Oxygen shall never be less then 4.0 mg/L was the water quality standards used to determine target loads.

Dissolved Oxygen was measured at 11 locations throughout the watershed. Two of the sample locations had DO levels that fall well below 4.0 mg/L (see Figure 3.2.5 for DO sample locations) in 2001. The two sample locations were in the NE portions of the watershed in the Hogs Defeat Creek and Young Creek sub-watersheds (see Figure 2.3 for sub-watershed locations)..

Figure 3.2.5-Shows all IDEM sample locations taken within the Patoka Lake Watershed. Locations highlighted in green indicate locations that did not meet the state water quality standards of 4.0 mg/L for Dissolved Oxygen.



<u>3.2.1.6 Beach Monitoring Data Processed by the Indiana State Department of Health (ISDH)</u>
All public swimming beaches on Patoka Lake have water samples collected by the IDNR. Samples are sent to ISDH to be analyzed for *E. Coli*. This information is available for public viewing and a request for this data was submitted to ISDH in the spring of 2005. However, this information was unable to be found by the time this SWP was completed. Additional request for this information should be made and included in this plan.

Pools, beaches, and spas that serve the public are regulated by the ISDH Sanitary Engineering programs and all monitoring inquires should be directed to the staff in this program area (317) 233-7183.

4. Identifying Problem Causes & Stressors of the Patoka Lake Watershed

<u>Disclaimer</u>

The information contained in this "Plan" is limited to that available from public records and the water supplier. Other "potential contamination source" or threats to the water supply may exist in the Source Water Protection Area that are not identified in this "Plan". Identification of a site as a "potential contamination source" should not be interpreted that this site has or will cause contamination of the water supply.

Patoka Lake and its tributaries, as envisioned by the stakeholders, is a watershed that provides diverse use, function and habitat for all that rely on it. Stakeholders understand that problems with water pollution can make the watershed fall short of that vision. In examining the perceived problems in the watershed, as well as the information that has been gathered over the course of compiling this Source Water Protection plan, the Patoka Lake Steering Committee identified the following problems that can or do impair this vision.

A computerized search of the Envirofact and IDEM potential contamination databases were completed in June of 2005 by Toby Days, Source Water Specialist for the Alliance of Indiana Rural Water, Inc. A windshield survey was also completed in June of 2005. Potential Contamination Sources (PCSs) in the Source Water Protection Area (SWPA), Patoka Lake Watershed, were identified and the locations of the sites were field verified from the database search. Figure 5.1.4, Figure 5.4 and Table 5.1 display the PCSs for the SWPA.

<u>4.1 Industrial Activities</u>

Industrial operations commonly use toxic substances as part of manufacturing, warehousing, and/or distribution. Materials such as chemicals, petroleum, cleaning supplies, machinery, metals, electronic products, asphalt, and others pose a potential threat to the water supply if not managed properly.

Other possible sources of contamination associated with industrial land uses include:

- Pipelines
- Above and Underground Storage Tanks (AST/UST)
- Operating and abandoned wells (e.g., gas, oil, water supply, injection, monitoring, and exploration)
- Wastewater Lagoons
- Manufacturing plants

The PCS inventory of IDEM and EPA's databases only identified one industrial site in the Source Water Protection Area (SWPA). However, the windshield survey identified several more industrial sites throughout the watershed, but no specific information could be found on these locations, therefore these sites are not included in the PCS inventory (Table 5.1).

<u>4.2 Commercial Activities</u>

Many commercial operations use toxic and hazardous materials in their processes.

Examples include:

- Auto repair shops, gas stations, car washes, paint shops

- Road maintenance depots, de-icing operations
- Boat yards, railroad tracks and yards, airports
- Construction areas
- Dry cleaners, Laundromats
- Medical institutions, research laboratories, photography establishments, printing facilities
- Restaurants, bakeries
- Woodworking and finishing facilities

The storage, use, and disposal of chemicals required by these operations can pose a potential threat to water since even small amounts of the hazardous materials can contaminate large amounts of surface or ground water. Storing quantities of the material can also create a serious problem if they are not contained and stored properly. Leaks and spills from storage tanks and pipes can contaminate water, rendering the water unfit for consumption.

Fuel oil tanks represent a potential source of petroleum compound, which includes volatile and semi-volatile compounds, as well as chemical additives that may be present in the fuel. The potential threat of contamination from this source would be from a leak, overfill, or spill. Patoka Lake SWPA contains known Underground Storage Tanks (UST), which are potential sources of petroleum contamination (MTBE).

The Steering Committee identified 9 commercial establishments during the inventory of the SWP area. Included in the inventory are 7 facilities that have at least 1 Underground Storage Tank (UST). A search of IDEM's Leaking Underground Storage Tanks (LUSTs) database, conducted by the Alliance of Indiana Rural Water, Inc in June 2005, identified no Leaking Underground Storage Tanks in the Patoka Lake SWPA. In addition, it is anticipated that the area surrounding Patoka Lake has a high potential for commercial growth. Primarily, the handling of engine fluids (oil, antifreeze, etc.), restaurant waste (oil), and the private wells and on-lot septic systems at these facilities are the highest concern (Figure 5.4 & Table 5.1).

Construction Activity

In addition to the established commercial facilities, there are numerous commercial construction activities occurring throughout the Patoka Lake Watershed that are clearing the land of vegetative and riparian buffers potentially causing an increase in erosion. Erosion occurs when land is disturbed and vegetation removed, allowing wind and rain to wash soil particles into the streams and rivers. Some erosion is natural. However, human activities such as agriculture and construction generally increase erosion, affecting the streams, rivers and lakes.

Sheet and rill erosion is the annual removal of a thin layer of soil. It accounts for the largest amount of soil eroded from land. Gully erosion happens where concentrated water flows over unprotected soils, such as where failing drainage systems cause all the water to flow over the top of the ground, and may deposit the eroded soil in depression areas or directly into drainage ditches. Wind erosion is generally confined to fine sandy soils or muck soils that are clean tilled. Erosion can be controlled by using soil stabilizers and silt fences.

Soil particles that build up in slowly moving streams and tributaries can cause reduced stream capacity and flow. Excessive sediment can fill wetlands, reducing their capacity to hold water during flood events and diminishing their ability to filter out contaminants. Sediment will fill spaces between the rocks and gravel in streambeds, smothering fish eggs and bottom-dwelling animals. Nutrients such as phosphorus from fertilizers entering waterways with sediment increase cloudiness (turbidity) in the water and support an overabundance of algae and weed growth. As these plants die and decay, they use oxygen from the stream, reducing oxygen levels available for fish and other aquatic animals and plants.

Figure4.2: *Erosion on a construction site along S.R. 64 & Fleming Creek. Top three pictures taken 3/26/06 looking east down S.R. 64 from the S.R. 145 junction. Below picture taken 8/16/05 looking southward off of S.R. 64, 2 miles east of the S.R.145 junction.*

A considerable amount of commercial construction activity within the Patoka Lake Watershed is occurring along the State Road 64 corridor, between Birdseye and English. A working meeting with several local agencies on December 6, 2006 produced watershed concerns about the new housing developments, subdivisions, and private residence being built in the Lick Creek-Ritter Creek and the Patoka River-Fleming Creek subwatersheds. Windshield surveys confirmed a significant amount of construction activity occurring in the Patoka River-Fleming Creek and Little Patoka River Huc-14 sub-watersheds (Figure 2.3 & 4.2).

Ditch Maintenance Activities

Many streams and ditches are "legal drains" that serve the function of relieving the excess water from saturated soils of farmland and cities. In order to preserve the functionality of ditches that fill with sediment, a cleaning process is undertaken to remove sediment that has built up over a period of years. This process generally includes debrushing or removal of vegetation and mechanical dredging for removal of the sediment from the bed and sides of the channel.

Figure 4.2.1a: Ditch Maintenance on Fleming Creek along SR 145, near Allen Creek Road 3/23/05.

Lakes and streams in the Patoka Lake watershed are significant tributary sources to the Wabash River Basin. Drainage maintenance and other types of construction along ditches and streams make the waterway and surrounding area susceptible to increased erosion during construction activity until the banks are stabilized and vegetation is reestablished. Removal of the meandering of the stream through engineered straightening and deepening of the channels for the purpose of improving drainage, often increases the velocity of the flow. Increased flow velocity may result in bank erosion, undercutting and downstream flooding, all of which add sediment and associated pollutants to the stream.

Figure 4.2.2a: Cuzco Rd. Bridge over Patoka River 3/23/2005

Removal of riparian cover can increase temperature of the stream (thermal pollution) and disturbance of the bank and stream bottom removes or interrupts the lifecycle of aquatic life (Figure 4.2.1ab). While the ditch supports the goal of aiding drainage and quickly removing water from fields, it can result in damage to habitat through scouring of the stream bed, increasing velocity of the moving water, undercutting of the banks, downstream flooding, and movement and deposition of sediment further downstream.

Figure 4.2.1(b):*Ditch Maintenance along S.R.145 (8/16/2005)*

Suspended sediment causes turbidity (cloudiness) in the water. When the water is slow-moving, the suspended sediment settles on the bottom of streams and lakes and clogs the streambed, affecting aquatic life. As the stream flow increases or is disturbed, such as during storms and high water events, sediment is re-suspended and sent downstream to the river, often settling in reservoirs.

Turbidity becomes a water quality problem when suspended soil sediment in the water increases the water temperature by absorbing heat, decrease light penetration, and increase treatment costs. Poor water clarity also interferes with feeding in predators that hunt by sight and clogs gills of fish and other aquatic animals during breathing and feeding. As sediment settles out of the stream during low flow or otherwise quiet water times, it smothers nests and eggs and fills crevices in gravel beds required for bottom dwelling species. Eroded soils can also carry attached toxic chemicals and phosphorus into the water (figure 4.2.2ab).

Figure 4.2.2b: Cuzco Rd. Bridge over Patoka River 3/23/2005

4.3 Residential Activities

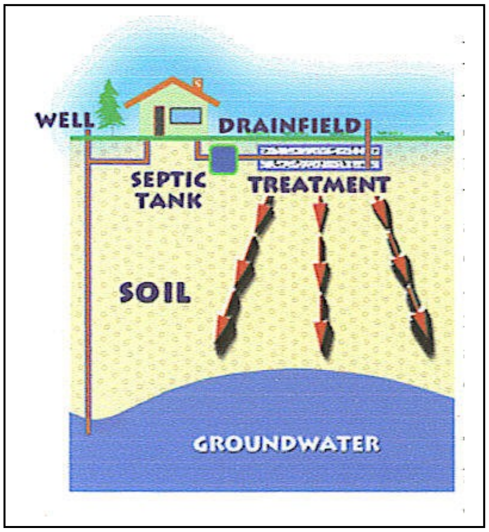
Residential contamination threats to surface or groundwater, if taken on a case-by-case basis, are normally less than other land use contamination. However, most citizens are unaware of the effects of numerous potential contaminants stored, used, and disposed of from residential homes. The potential contaminants include:

- Household chemicals
- Automotive products
- Paint/solvents
- Fuel storage systems
- On-site septic/sand mound systems
- Lawn/garden chemicals
- Abandoned wells

Abandoned natural gas wells, water wells, and cisterns are a potential conduit for surface or near surface contamination to reach the underlying bedrock and aquifers. Inactive or abandoned wells and cisterns are typically found in rural residential and agricultural areas throughout the State. All abandoned wells whether drilled, driven, or dug should be considered sources of concern. Potential ground and surface water contaminants which may enter through abandoned wells or cisterns include contaminated stormwater runoff, spilled or over applied fertilizers and pesticides, used oil, antifreeze, gasoline, road salt, septic system waste and a variety of other substances. Although many abandoned wells are likely within the SWPA, there were none identified during the windshield survey of the SWPA. There were numerous residential properties throughout the watershed's roadsides that have discarded barrels, abandoned vehicles and automotive parts scattered about that maybe a potential sources of contamination (Figure 4.3).

Figure 4.3: Abandoned cars and rusted barrels sit along a streambank behind a residential property off of Highfill Chapel Road 3/25/06.

On-Site Septic Systems (OSSs)



The high prevalence of karsts areas, poor soils and steep slopes in the Patoka Lake Watershed poses significant problems to the sighting of conventional onsite sewage treatment systems (OSS). Septic systems located on lands that either do not have the soil capacity or the space to provide proper functionality will generally fail and leak sewage into the surrounding land and waterways. Groundwater and surface water contamination is also a threat if the OSS is positioned close to a residential well or area with groundwater/surface water interchange, such as a wetland. Although no failed septic systems were identified within the Patoka Lake Watershed potential surface water and groundwater contamination associated with improperly maintained or failed septic systems could occur. In addition, if improperly used, such as for disposal of paints, solvents, petroleum products and other hazardous waste, they could be a source of organic compounds. A working meeting held at the Patoka Lake Regional Water & Sewer District on December 6, 2006 with local agencies estimated that 95% of residences do not properly maintain their OSS.

The Dubois County Health Department alone approves approximately 100 new OSSs permits each year. Of which the Health Department estimates 10% of the approved permits go to residential homeowners that are replacing a failing septic system.

On-site septic systems and sewer lines represent potential sources of nitrates, chlorides, bacteria and viruses if onsite septic system's absorption fields are not properly located. The Natural Resources Conservation Services' Web Soil Survey 1.1 was used to evaluate the soils in and surrounding the Patoka Lake Watershed. The ratings are based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. The rating class terms of the NRCS Web Soil Survey indicate the extent to which the soils are limited by all of the soil features that affect these uses.

"Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected.
"Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected.
"Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

The NRCS Web Soil Survey 1.1 classified the majority of the soils in Crawford, Dubois, and Orange Counties as "Very Limited", which makes these three counties and the Patoka Lake

Watershed highly vulnerable to onsite septic system failure, a concern expressed by many stakeholders within the watershed (Table 4.3 and Appendix XII).

There is a high potential for more development around Patoka Lake making residential activities a PCS within the watershed.

Table 4.3-NRCS Web Soil Survey
Septic Tank Absorption Fields Rating

Crawford County		
Rating	**Total Acres in AOI**	**Percent of AOI**
Very Limited	179,327	90.7
Somewhat Limited	13,526	6.8
Not rated	4,902	2.5
Dubois County		
Rating	**Total Acres in AOI**	**Percent of AOI**
Very Limited	263,142	94.5
Somewhat Limited	11,013	4
Not rated	4,419	1.6
Orange County		
Rating	**Total Acres in AOI**	**Percent of AOI**
Very Limited	176,864	67.7
Somewhat Limited	78,527	30
Not rated	5,947	2.3

AOI-Area of Interest
Source: http://websoilsurvey.nrcs.usda.gov/app/

4.4 NDES Point Sources Data

The National Pollutant Discharge Elimination System (NPDES) Program was established by the Federal Water Pollution Control Act Amendments of 1972. Under this program, all facilities that discharge pollutants from a point source into any US waterway must obtain a permit. The permit regulates the amount of allowable pollutants discharged from a point source. Point sources are specific locations of discharge such as a pipe or manmade ditches and include "discharges from publicly owned treatment works (POTWs), discharges from industrial facilities, and discharges associated with urban runoff" (USEPA, www.epa.gov/npdes/pubs/101pape.pdf).

Stormwater point source discharges include stormwater collection systems for medium and large municipalities and stormwater discharges associated with industrial activity as defined in the Code of Federal Regulations (40 CFR 122.26(a)(14)). The primary pollutants associated with point source discharges are oxygen-demanding waste, nutrients, sediment, color and toxic substances including chlorine, ammonia, and metals.

As of June 2005, there were 2 active NPDES permits within the Patoka Lake SWPA (Table 4 & Figure 5.1.4).

In addition to the NPDES permitted dischargers in the SWP area, there may be many unpermitted, illegal dischargers.

Animal Production

Concentrated Animal Feeding Operations (CAFOs) are also considered a point source and require NPDES permits, although most other agricultural activities are non-point sources.

In 2003, IDEM began rule development to provide a general National Pollutant Discharge Elimination System (NPDES) permit program for Concentrated Animal Feeding Operations (CAFOs). CAFOs are the larger Confined Feeding Operations (CFOs) that meet certain criteria based on size and compliance history as listed in the Clean Water Act. In 2003, IDEM began issuing NPDES permits for CAFOs. Twenty percent of the regulated animal feeding operations in Indiana are CAFOs, numbering 474, and those facilities raise 80% of the livestock in Indiana (Figure 4.4.1)(IDEM, www.in.gov/idem/soe2004/land/chart.html#cafo).

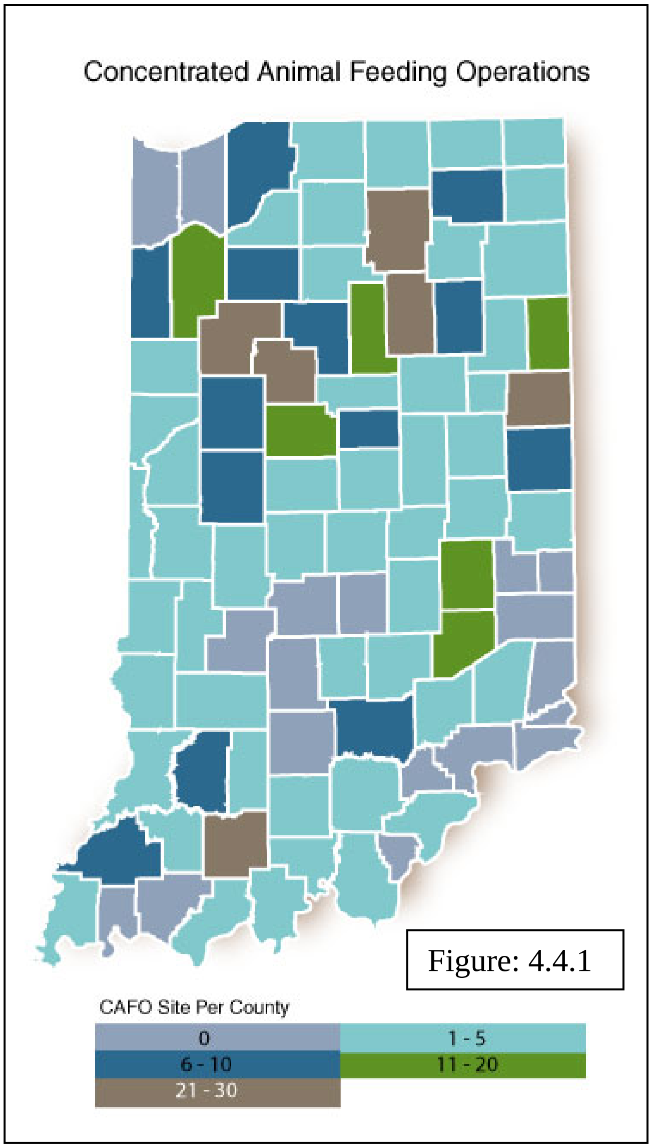
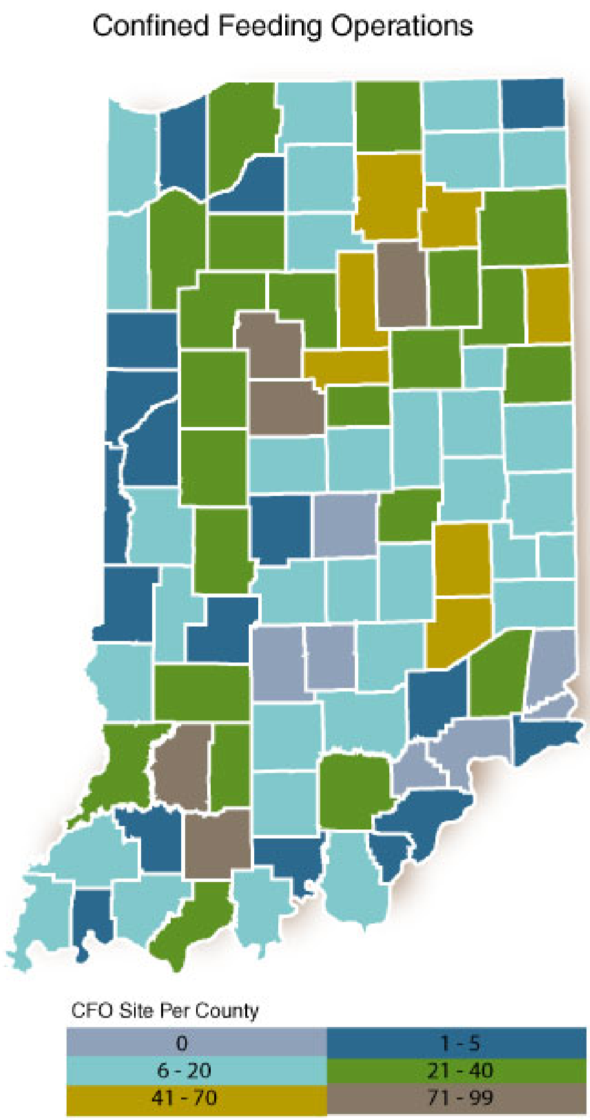


Figure: 4.4.1

Although there are no CAFOs within the Patoka Lake Watershed that have been issued NPDES permits, Dubois County has one of the highest concentrations of CAFOs in Indiana.

Figure: 4.4.2



An animal feeding operation where at least 300 cattle, 30 thousand fowl, or 600 sheep or swine are confined for at least 45 days during any 12-month period and ground cover or vegetation is not sustained over at least 50% of the animal confinement area is a Confined Feeding Operation (CFO). In 2002, IDEM adopted a new Water Pollution Control Board rule to supplement the original 1971 Confined Feeding Control Law. Currently, there are 2,362 regulated animal feeding operations in Indiana; 1,888 of these are CFOs (figure 4.4.2). There were 3 CFOs active in the Patoka Lake Watershed as of April 2005 (Table 5.1 and Figure 5.1.4). These operations are regulated by IDEM and are required to have manure management plans in place in order to be eligible for federal funding. Although there are only 3 CFOs within the Patoka Lake Watershed, there are more than 80 CFOs within the 3 Counties that the watershed spans, with Dubois County having the highest concentration. It is important to note the location of these CFOs with respect to Patoka Lake Watershed boundary because of their close proximity to the watershed and the possibility of the tile drainage system transporting water across watershed boundaries (Figure 4.4.4 & 5.1.4, and Table 5.1).

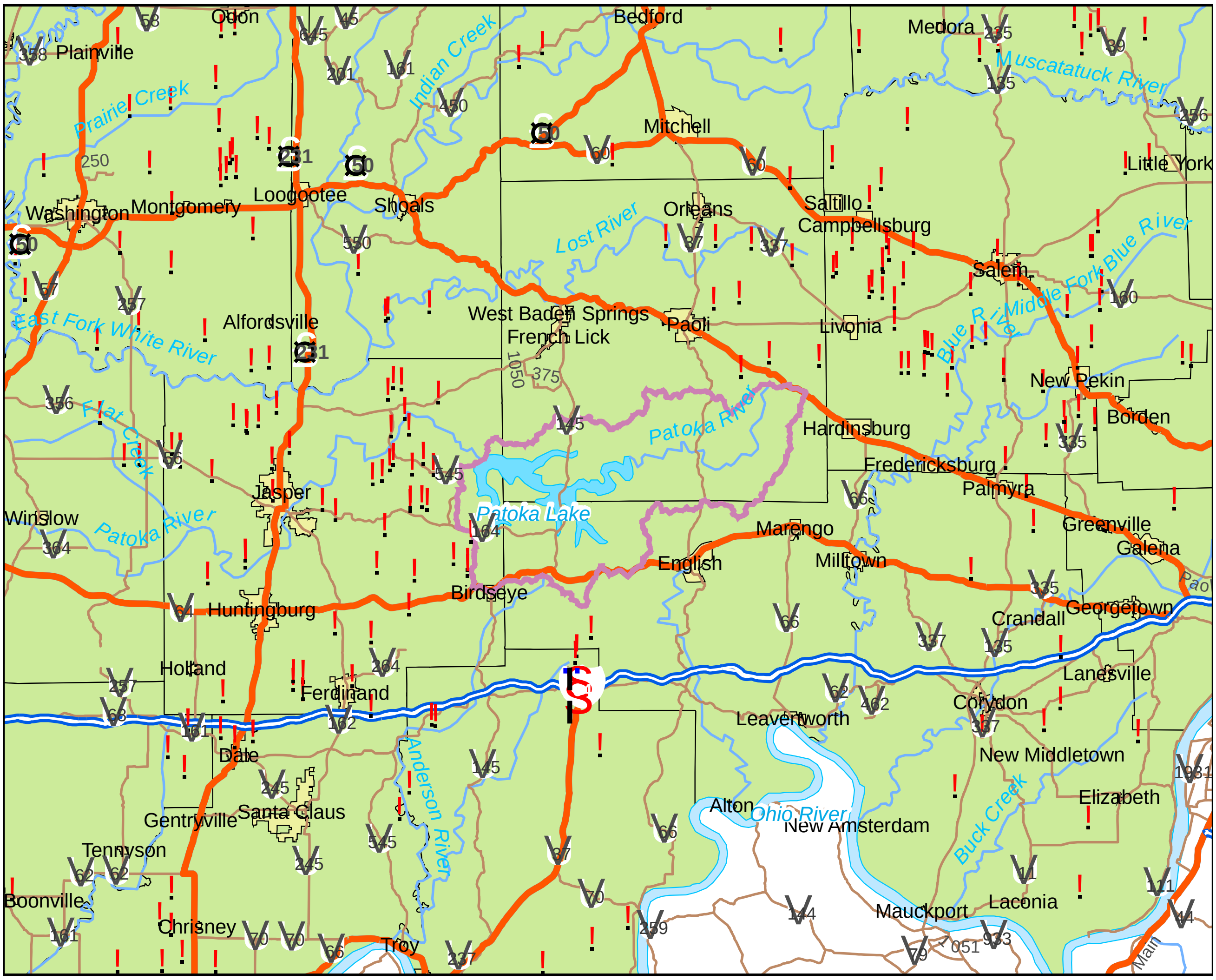
In addition, many small operations that are below the level of regulation by IDEM exist throughout the watershed. The number of resident animals on these small operations can fluctuate easily and often from year to year (Figure 4.4.5 shows a small turkey operation along SR 164).

Figure 4.4.5:*Turkey Barns near SR 164 & 1025E.*

Figure 4.4.3 (a): Cattle in Highfill Creek near White Oak Cabins off of Alstott Rd 3/25/06.

The manure produced by livestock operations is a source of potentially dangerous bacteria and excessive nutrients that has been recognized in the watershed. Animals should be fenced out of the streams and ditches, and fields where livestock graze should be protected by buffers wide enough to filter out waste runoff. These management practices protect ground and surface water used as sources of drinking water and recreational activity from pathogens that can cause diseases in humans and other animals.

Figure 4.4.4: Red dots indicate the proximity of CFOs to the Patoka Lake Watershed. Note the density of CFOs in Dubois County.



Winter manure application onto frozen fields, excess rain or saturated soil conditions in warm weather, and subsurface tile drainage can cause manure to enter streams and waterways, and to leach into old and/or shallow domestic wells. The Alliance of Indiana Rural Water has verified anecdotal reports that livestock have access to streams in some areas and that buffers are absent on many ditches, a condition that allows bacteria-laden waters to enter the stream unimpeded (Figure 4.4.3 a,b,c). For example, influxes of nitrogen and phosphorous rich animal waste can contribute to excess algae and plant growth,; fecal material can introduce human pathogens (such as *E. coli, cryptosporidium,* and *giardia*) to the water source, turning the stream into a mechanical vector of disease; and livestock trampling of streambanks and beds can increase rates of erosion, resulting in elevated levels of suspended sediments in the stream.

Figure 4.4.3 (b): Cattle pasture with stream access in the Little Patoka River HUC_14 sub-watershed 3/25/06.

A December 6, 2006 meeting held by the Patoka Lake Regional Water & Sewer District with local County Agencies estimated that 65-70% of all animals pastured in areas adjacent to streams have direct access. Areas where livestock had direct access to waterways were observed during the windshield survey. Lick Creek-Ritter Creek, Little Patoka River, Patoka River-Dumplin Branch, and Patoka River-Dillard Creek Huc_14 sub-watersheds had multiple sites each where animals were observed with stream access. Animal access to streams was not observed in the other sub-watersheds, but is likely to exist in all of the sub-watersheds. Cattle, horses, and goats were the most common animals observed with stream access.

Figure 4.4.3 (c): Cattle with access to stream in the Patoka River-Dillard Branch sub-watershed 3/25/06.

Generally, the overall numbers of livestock have decreased in the watershed, based on USDA farm census reports by county. Note that only a small portion of Dubois County actually falls within the Patoka Lake Watershed. The numbers in Table 5.1.4b below do not include horses and sheep, for which we have no comparison numbers. In specific areas in the Patoka Lake Watershed, visual reports confirm a substantial number of horses, although they are generally present in small numbers on any given farm or rural residential location.

Table 5.1.4b

COUNTY/YEAR	CATTLE	HOGS	POULTARY
Crawford 2002	7,801	110,421	830
Crawford 1997	9,551	950	516
Dubois 2002	26,481	84,659	3,610,011
Dubois 1997	28,144	110,421	4,529,388
Orange 2002	10,327	8,916	418
Orange 1997	13,232	15,545	99
Source: USDA/NASS 2002 Census of Agriculture-County Data			

Livestock production is of great economic importance to residents and businesses in and surrounding the Patoka Lake Watershed. With an extensive Outreach & Educational program to teach local stakeholders of the importance of Pasture Management Best Management Practices (e.g. re-seeding, rotational grazing, watering systems, fencing,...), livestock production can have minimal water quality impacts.

4.5 Lack of Vegetative & Riparian Buffers Threaten Water Quality

Vegetated and riparian stream buffers are natural boundaries between the waterway and the land surrounding it. Stream buffers are important in protecting our water resources by filtering pollutants, providing flood control, reducing streambank erosion, and maintaining aquatic habitat. Woody riparian buffers can also provide shade that is important for stream quality by reducing the surface water temperature. Lack of adequate stream buffers can result in increased runoff of nutrients and pollutants and increased bank erosion.

Riparian buffers and filtering areas between cropland and perennial streams, seasonal streams, sinkholes, lakes and ponds help to protect both surface and groundwater from the pesticides and nutrients that are present on the surface soils. Strips of grass, trees or shrubs, or a combination of them that provide a cushion, or buffer, between intensive farming operations and other lands and waterways are generally called "conservation buffers" and are considered as Best Management Practices (BMPs).

Above: Figure 4.5: example of a vegetative buffer strip.
Left: Figure 4.5.1: Lack of vegetative buffer between cropped field and Sycamore Creek off of Alstott Rd 3/25/06.

The most common buffers are filter strips of grass, shrub and tree (riparian) plantings along a stream or river (figure 4.5). Contour grass strips in a crop field or surrounding a crop field, and farmstead windbreaks are also considered buffers.

Filter strips are typically 20 to 120 feet wide, and riparian buffers are greater than 35 feet wide. A 66-foot wide grass buffer along ditches, rivers and streams creates the label-required 66-foot setback for Atrazine applications near moving water. (*Atrazine and Drinking Water: Understanding the Needs of Farmers and Citizens.* Purdue Extension, 2004).

The windshield survey provided information on which areas in the watershed were lacking adequate buffers (figure 4.5.1). Grassy buffers as well as woody riparian buffers were noted and taken into consideration when determining whether an adequate amount of buffers was present to prevent stormwater runoff. A width of 25' was used to measure adequate buffer width, although ideally more than 25' buffer should be present, especially if it is grassy buffer without woody species. Results from the windshield survey show that adequate buffering in the upper Patoka Lake Watershed exists where landuse is predominantly forested, however downstream in the watershed there is a significant lack of adequate buffers along stream banks. The lack of adequate buffers seems to be more prevalent in the southwest portions of the Patoka Lake Watershed where there is more agricultural and urban landuse, particularly in the Lick Creek-Ritter Creek and Little Patoka River sub-watersheds (Figure 2.3 & 2.5, Table 2).

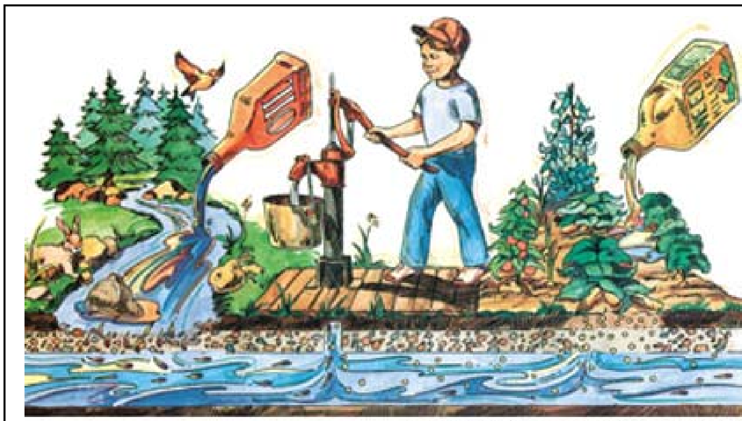
Conservation buffers improve water quality. The vegetation slows runoff water, allowing sediment, nutrients and pesticides to settle out in the buffer instead of rushing quickly into streams, carrying the pollutants into the waterways. The combination of plant types, such as variation in grasses and inclusion of trees (riparian buffers) affect the removal rate of pollutants. Vegetation in buffers is also a source of food and cover for wildlife. However, both habitat for wildlife and water filtering effects are enhanced in wider buffers as opposed to more narrow strips. Generally, the wider the plant diversity in the buffer, the wider the wildlife diversity. Best management practices (BMPs) for shorelines and stream banks include observing appropriate setbacks for homes and leaving adequate vegetative cover to anchor stream banks during storm events.

Discussion with local county agricultural agencies indicated that crop production on land adjacent to streams within the Patoka Lake watershed are tilled in valleys and river bottoms where fields are bordered by land with steep slopes. These fields are usually long and narrow, which make buffers an undesirable BMP for landowners in these areas. Therefore, use of other conservation practices such as, Water & Sediment Control Basins (WASCOBs) or rock chutes could be used to increase infiltration and control runoff.

The Purdue University 2002 Tillage Transect Data obtained from the Indiana Conservation Tillage Initiative website (http://www.agry.purdue.edu/cti/index.html) showed that conservation tillage is already used in most areas of Crawford, Dubois and Orange Counties, however small opportunities may still exist (Appendix XIII-2002 IN Cropland Tillage Maps). Therefore, promotion of no-till and other conservation tillage practices should still be exhibited throughout the Patoka Lake Watershed.

4.6 Lack of knowledge among the Patoka Lake Watershed Stakeholders

Although no one expects all stakeholders to be experts on watershed issues, however there is generally a lack of working knowledge among a great majority of stakeholders of the Patoka Lake Watershed and its downstream neighbors. Knowledge about the physical history that has shaped the environment of the



watershed and its relationship to the health and welfare of residents of the region is not understood by many.

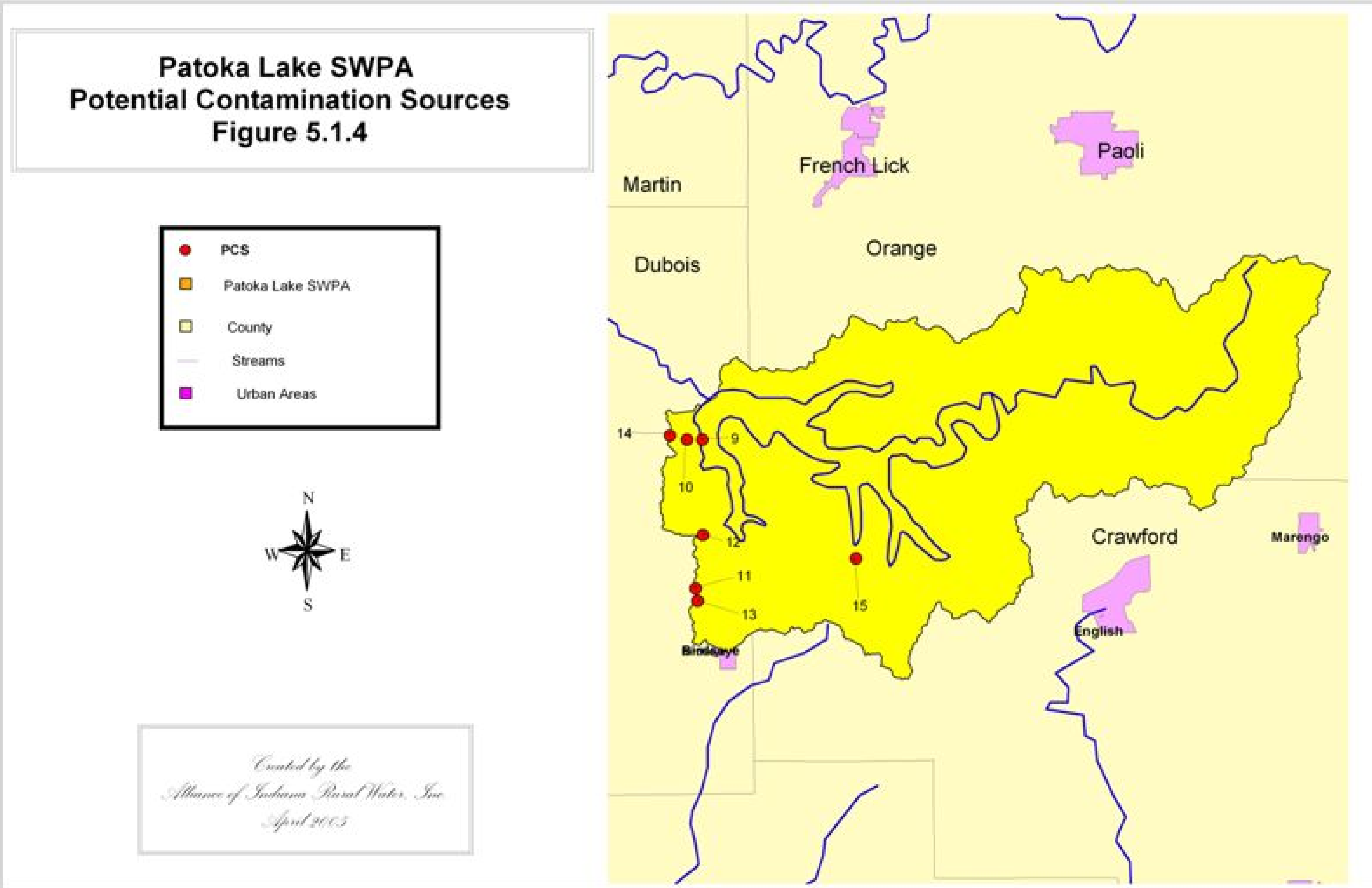
Because of this, the protection of water quality, water quantity, wetlands, soil fertility, recreational opportunities, aquatic and wildlife habitat, and aesthetic beauty is often economically and socially undervalued. Addressing the problems of the watershed must include a directed educational effort. Appreciation for the environment of the Patoka Lake Watershed and efforts for its protection start with knowledge and appreciation of the watershed's value to the community, and this educational effort must focus on the entire community, from children to retired adults. Figure 4.6 shows some signage placed along the roadsides of Crawford County intended to educate those that pass by.

Figure 4.6:*Educational Signs along Roadways in Crawford County (8/16/2005).*

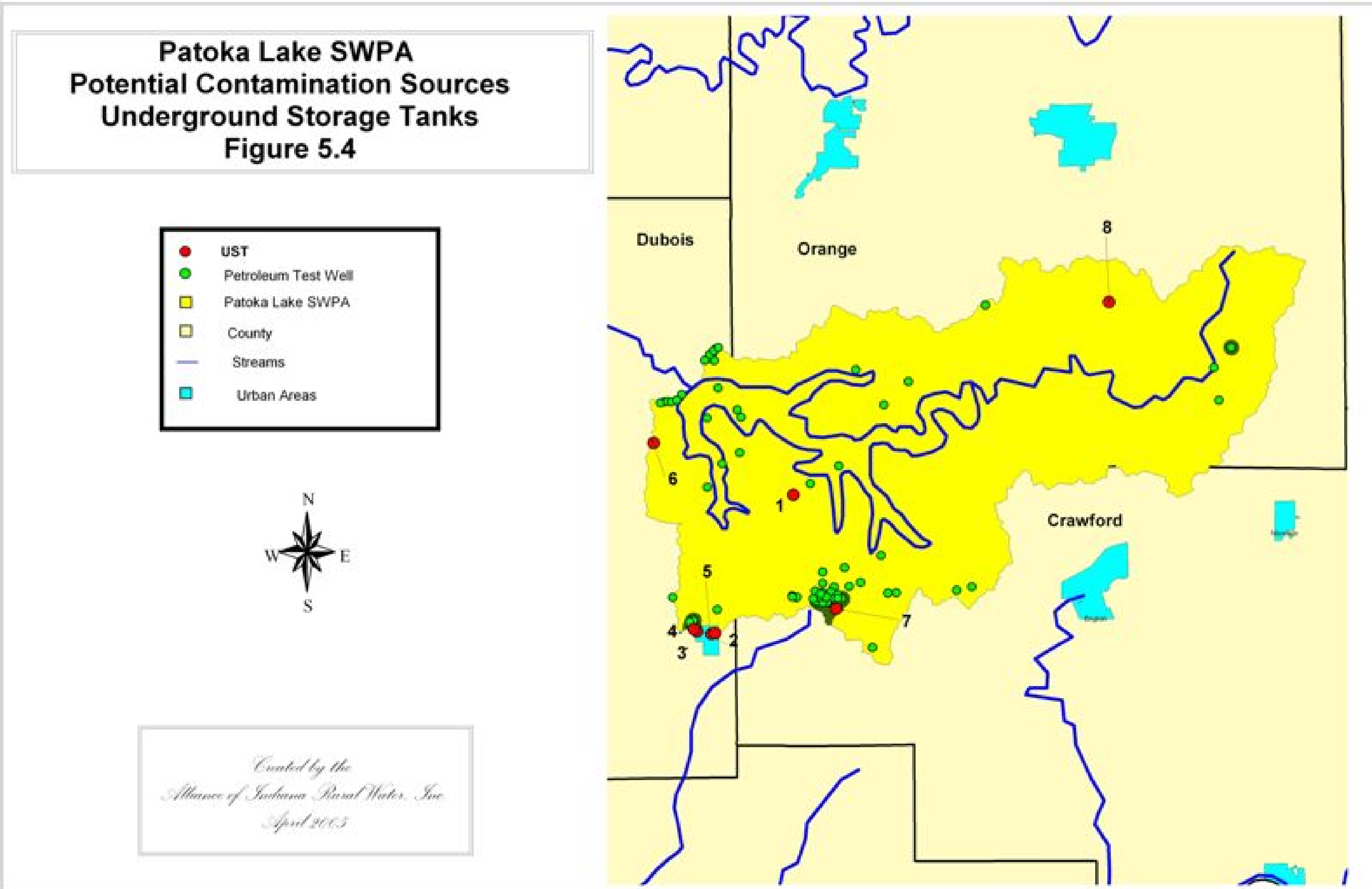
Table 5.1: Potential Contamination Sources

ID #	Facility Name and/or Owner	Address	Site Type	Contaminant Type	Permits	Operating Status
1	Patoka Station	2991 N Dillard Rd., Birdseye, IN 47513	Gas Station & Laundromat	Petroleum & Phosphates 6-2000 gal 12-6000 gal	UST4919	All 2000 gal USTs Permanently out of service All 6000 gal USTs currently in use
2	Birdseye Sunoco & Laundromat	1 SR 145, Birdseye, IN 47513	Gas Station & Laundromat	Petroleum & phosphates		Active
3	Debs Truck Stop	502 W. SR 64, Birdseye, IN 47513	Gas Station	Petroleum		Active
4	One Stop Convenience Store	500 W. SR 64, Birdseye, IN 47513	Gas Station	Petroleum 1-1000 gal 2-575 gal	UST8235	Currently in use
5	Circle A Food Mart #106	SR 64 & SR 145, Birdseye, IN 47513	Gas Station	Petroleum 2-6000 gal 1-8000 gal 7-2000 gal	UST1184	All permanently out of service
Location unknown	IDNR/Patoka Reservoir	RR 1	SRA	Petroleum 1-8000 gal 2-550 gal 3-4000gal	UST10158	All USTs currently in use
6	Hoosier Hills Marina	10306 E. Lick Fork Marina, Celestine, IN 47521	Marina	Petroleum 3-9000 gal	UST5227	All Currently in use
7	Pappy's Convenient Store	HWY 64, Eckerty, IN 47116	Gas Station	Petroleum 6-2000 7-4000 3-8000	UST17408	All Currently in use
8	Pine Valley Store	5579 S. SR 37, Paoli, IN 47454	Gas Station	Petroleum 3-1000 gal 4-4000 gal 3-6000 gal	UST12194	All Currently in use

9		N/A	Sewer Line	Bacteria/Nitrates		Active
10		N/A	Agricultural Area	Fertilizers/Pesticides Bacteria/Nitrates		Active
11	Foltz		CFO	Fertilizers/Pesticides Bacteria/Nitrates	CFO_4053	Active
12	Foltz		CFO	Fertilizers/Pesticides Bacteria/Nitrates	CFO_3431	Active
13	Knies		CFO	Fertilizers/Pesticides Bacteria/Nitrates	CFO_4717	Active
14	Patoka Lake Regional Water & Sewer District	2647 N. SR 545, Dubois, IN 47527	Water Treatment		NPDES_IN0052698	Active Discharge to Patoka River
15	Mulzer Crushed Stone	SR 145 & SR 64, Eckerty, IN 47116	Cut Stone	Sediment Petroleum Air Pollution Septic System/Sewer lines	NPDES_IN0029661 UST_5859 AIRS/AFS-IN0087632	Active Active Active
16						



Patoka Lake SWPA
Potential Contamination Sources
Figure 5.1.4


Patoka Lake SWPA
Potential Contamination Sources
Underground Storage Tanks
Figure 5.4
UST
Petroleum Test Well
Patoka Lake SWPA
County
Streams
Urban Areas
N
W
E
S
Created by the
Alliance of Indiana Rural Water, Inc
April 2005
Dubois
Orange
Crawford
1
2
3
4
5
6
7
8

5. Subwatershed Assessment

In an effort to characterize water quality throughout the Patoka Lake Watershed using multiple data sets collected over several years, a comprehensive Subwatershed Assessment was conducted utilizing several layers of information ranging from water quality data to land cover analysis.

5.1 Pollutant Loading Calculations

The output from the L-THIA (Long-Term Hydrologic Impact Assessment) and U.S. EPAs Spreadsheet Tool for Estimation of Pollutant Load (STEPL) model provided estimations on current pollution loads, as well as, targets for nutrient and sediment reductions. The LTHIA and the STEPL models do have limitation, however the calculations have given baseline numbers for the current pollutant loads and load reduction rates for the Patoka Lake Watershed.

L-THIA (Long-Term Hydrologic Impact Assessment) Calculations

L-THIA (Long-Term Hydrologic Impact Assessment) has been developed as a straight forward analysis tool that provides estimates of change in runoff, recharge and nonpoint source pollution resulting from past or proposed land use changes. It gives long-term average annual runoff for a land use configuration, based on actual long-term climate data for that area. By using many years of climate data in the analysis, L-THIA focuses on the average impact, rather than an extreme year or storm. L-THIA results do not predict what will happen in a specific year. Table 6.1 show the current pollutant loads and estimated load reductions for each of the eleven HUC 14 digit watersheds in the Patoka Lake Watershed.

Target Pollutant Load

In EPA's "2000 Ambient Water Quality Criteria Recommendations," recommended nutrient ranges for Ecoregion IX, which is the Ecoregion that the Patoka Lake Watershed is located in. Target loads were based on the mid range nutrient concentration values and are to be used as recommended baseline nutrient concentrations for the Patoka Lake watershed. The following targeted nutrient loads are suggested for the Patoka Lake Watershed:

- 1.0 mg/L Total Nitrogen
- 0.3 mg/L Total Phosphorus

(http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/rivers_9.pdf).

The American Fisheries Society has determined that aquatic life can be negatively impacted if Total Suspended Solids (TSS) levels are greater than:

- 80 mg/L TSS

Therefore, to maintain turbidity levels that will support a healthy aquatic ecosystem within the Patoka Lake Watershed, a TSS water quality standard of 80 mg/L will be used as a targeted Total Suspended Solids load.

These suggested water quality standards are to serve as a critical basis for assessing attainment of designated uses and measuring progress toward meeting the water quality goals of the Clean Water Act. The intent of developing watershed nutrient criteria is to represent conditions of surface waters that are minimally impacted by human activities and thus protect against the adverse effects of nutrient over enrichment from cultural eutrophication.

Based on the LTHIA load calculations, the four subwatersheds contributing the greatest amounts of nutrient & sediment runoff to the Patoka Lake Watershed are (Table 6.1):

- Little Patoka River
- Lick Creek Ritter Creek
- Patoka River-Painter Creek
- Patoka River-Fleming Creek

These 4 subwatersheds have been identified as critical areas in greatest need of conservation management. The following discussion will look at each of these 4 subwatersheds and provide possible sources for the current high nutrient & sediment loading.

<u>Little Patoka River</u>

The Little Patoka River subwatershed was estimated as contributing the largest amount of Total N, at 27,143 lbs/yr; Total P, at 6,711 lbs/yr; and Total Suspended Solids, at 554,091 lbs/yr. There are several contributing factors that may suggest the reasoning for these high nutrient and sediment loads in this particular subwatershed.

The Little Patoka River has the highest amount of Agriculture land being cropped within the entire Patoka Lake Watershed. More than 2995 acres of this subwatershed is dedicated to crop production, subjecting this land to tilling that bares soil and increases runoff potential. Fertilizers and pesticides are also applied to the crops, which have the potential to runoff during rain events or infiltrate into groundwater supplies. There is also 1,676 acres of this subwatershed that is used as pasture land. Discussion with local stakeholders also note that a large portion of the pasture land (65-70%) allow livestock to have direct access to adjacent streams, which can be another source of nutrient and sediment loading (Figure 4.4.3 (b)). A Spring 2006 windshield survey confirmed numerous pastures provided direct stream access for livestock watering.

The rapid development of new housing subdivisions occurring along S.R. 64 (Figure 4.2) was a concern expressed by several local County Agencies during a stakeholder meeting on December 6, 2006 at the Patoka Lake Regional Water & Sewer District. State Road 64 runs along the southern border of the Little Patoka River subwatershed. Large parcels of land have been cleared and graded, but little vegetation has been reseeded to help stabilize the disturbed soil (Figure 4.2). This is a concern considering the steep slope grades of most of the land in this area, which are already subjected to high runoff rates.

It is estimated that 15,433 lbs/yr of Total N and 3,198 lbs/yr of Total P will need to be reduced from the Little Patoka River subwatershed in order to meet the targeted nutrient loads needed to maintain healthy aquatic life in the Patoka Lake Watershed (Table 6.1). Sediment loads currently meet targeted concentrations.

<u>Lick Creek-Ritter Creek</u>

Lick Creek-Ritter Creek subwatershed was estimated at contributing the second highest amounts of nutrients and sediment to the Patoka Lake Watershed. This subwatershed has the highest amount of residential landuse in the entire Patoka Lake Watershed. In addition, the rapid development of new housing subdivisions occurring along S.R. 64 (Figure 4.2) was a concern expressed by several local County Agencies during a stakeholder meeting on December 6, 2006 at the Patoka Lake Regional Water & Sewer District, which is along the southern border of the Lick Creek-Ritter Creek subwatershed and extends into the Little Patoka River Subwatershed. Large parcels of land have been cleared and graded, but little vegetation has been reseeded to help stabilize the disturbed soil. This is a concern considering the steep slope grades of most of the land in this area, which are already subjected to high runoff rates.

Lick Creek-Ritter Creek sub-watershed also has the highest concentration of confined feeding operations (CFOs) and the highest concentration of underground storage tanks (USTs) of the entire Patoka Lake Watershed (see table 5.1 and Figure 5.4 & 5.1.4). In addition, the town of Birdseye is the only metropolitan area in the Patoka Lake Watershed and happens to be located in the southern edge of the Lick Creek-Ritter Creek sub-watershed, thus we can assume pollutants associated with urbanization (household hazardous waste, parking lot runoff, etc.) are also contributing to the pollutant loading in this subwatershed. This area is of concern due to the Lick Creek-Ritter Creek subwatershed being the main tributary feeding the Patoka Lake southwest basin, which is the lake basin where the Patoka Lake Regional Water & Sewer District's water intake structure pulls their drinking water from.

Some of the concerns brought forth by stakeholders indicated a decline in the quantity and quality of recreational game fishing in Patoka Lake. Fish, and the organisms on which they feed on, require dissolved oxygen (DO). Warmwater fish require about five parts per million (ppm) of dissolved oxygen (Hudson, 1998). Data pulled from IDEMs AIMS database for samples taking in 1996 and 2001 show DO levels that dip well below 5 ppm on numerous occasions within the Lick Creek-Ritter Creek subwatershed. These low DO trends may demonstrate the Lakes continuing preponderance of blue-green algae species that supports the growth of the anoxic zone within the Lake producing poor fish habitat . The US Army Corps. Of Engineers has comparable DO monitoring numbers (see Appendix III and VIII for IDEMs and the COREs monitoring analysis spreadsheets).

It is estimated that 14,055 lbs/yr of Total N and 3,107 lbs/yr of Total P will need to be reduced from the Lick Creek-Ritter Creek subwatershed in order to meet the targeted nutrient and sediment loads need to maintain healthy aquatic life in the Patoka Lake Watershed. Total Suspended Solid loads are currently meeting the targeted water quality standards set for the Patoka lake Watershed (Table 6.1). However, nutrients bind to soil particles, thus, reducing erosion may help control nutrient loads within the watershed.

<u>Patoka River-Painter Creek</u>

The Patoka River-Painter Creek subwatershed is estimated at contributing the 3rd highest amount of nutrients and sediment of all the subwatersheds in the Patoka Lake Watershed. This is the most northern of the 4 critical subwatersheds, with the confluence of the 3 largest basins of the Patoka Lake occurring in the middle of the Lick Creek-Ritter subwatershed before spilling over the dam into Patoka River. Therefore, accumulation of pollutants that have washed down from the outer reaches of the watershed may increase the high nutrient & sediment loads in the Patoka River-Painter Creek subwatershed.

It is estimated that 11,345 lbs/yr of Total N and 2,328 lbs/yr of Total P will need to be reduced from the Patoka River-Painter Creek subwatershed in order to meet the targeted nutrient loads need to maintain healthy aquatic life in the Patoka Lake Watershed. Total Suspended Solid loads are currently meeting the targeted water quality standards set for the Patoka lake Watershed (Table 6.1). However, nutrients bind to soil particles, thus, reducing sedimentation may help control nutrient loads within the watershed.

Patoka River-Fleming Creek

The Patoka River-Fleming Creek Subwatershed contributes the 4th highest nutrient and sediment load to the Patoka Lake Watershed. This subwatershed has S.R. 145 running north to south with the junctions of S.R. 164 occurring in the middle of the subwatershed and S.R. 64 occurring in the south end. Concerns about the rapid development of new housing subdivisions along S.R. 64 (Figure 4.2) was expressed by several local County Agencies during a stakeholder meeting on December 6, 2006 at the Patoka Lake Regional Water & Sewer District, which is along the southern border of the Patoka River-Fleming Creek Subwatershed. Large parcels of land have been cleared and graded, but little vegetation has been reseeded to help stabilize the disturbed soil. This is a concern considering the steep slope grades of most of the land in this area, which are already subjected to high runoff rates.

To accommodate for the growing congestion at the S.R. 64 and S.R. 145 intersection, the Department of Transportation has widen and repaved this intersection. Part of this construction activity, new bridges were built and drainage work was done throughout the entire southern half of the Patoka River-Fleming Creek Subwatershed. This construction activity along with the large number of heavily traveled transportation routes may be contributing large pulses of nutrient and sediment loads to the Patoka Lake Watershed (Figure 4.2.1). Several known underground storage tanks are also located near the 64 & 145 intersections that have the potential to leak contaminants into the nearby Fleming Creek.

In addition to the above Potential Contamination Sources, there is a NPDES permit located within this subwatershed that may be contributing to the nutrient and sediment loads within the Patoka River-Fleming.

It is estimated that 7,846 lbs/yr of Total N and 1,668 lbs/yr of Total P will need to be reduced from the Patoka River-Fleming Creek subwatershed in order to meet the targeted nutrient and sediment loads need to maintain healthy aquatic life in the Patoka Lake Watershed. Total Suspended Solid loads are currently meeting the targeted water quality standards set for the Patoka lake Watershed (Table 6.1). However, nutrients bind to soil particles, thus, reducing sedimentation may help control nutrient loads within the watershed.

Eutrophication of the waters in the Patoka Lake Watershed have resulted in several nuisances to the stakeholders. Nutrification of the water spurs the rapid growth of algae blooms resulting in a musty taste & odor of the waters of Patoka Lake. As algae grows it consumes the oxygen bound to the water particles, greatly decreasing the amount of DO that is available to aquatic animals. Data pulled from IDEMs AIMS database for samples taking in 1996 and 2001 show DO levels that dip well below 5 ppm on numerous occasions within the Patoka River-Fleming Creek subwatershed. These low DO trends may demonstrate the Lakes continuing preponderance of blue-green algae species that supports the growth of the anoxic zone within the Lake producing poor fish habitat.

Spreadsheet Tool for the Estimation of Pollutant Load (STEPL)

The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL, Version 3.1) provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs), including Low Impact Development practices (LIDs) for urban areas. It computes surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD_5); and sediment delivery based on various land uses and management practices.

For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (from sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

The STEPL model enables the user to input a desired BMP and calculate the estimated nutrient and sediment load reduction that the BMP would have on the watershed if installed. For the purpose of this SWP plan the STEPL model was ran to determine the impact that a suggested combination of BMPs would have on the 4 critically identified subwatersheds. Possible BMPs were discussed with local agencies at a December 6, 2006 Patoka Lake Regional Water & Sewer District meeting to determine suitable BMPs that would assist in the control of the nutrient and sediment loading problems in these 4 subwatersheds. These local agencies suggested that the following BMPs would have the greatest management outcomes on the identified landuse.

- Ag/cropland-Infiltration Basins
- Ag/cropland-Filter Strips
- Pasture-Streambank Stabilization and Livestock Fencing
- Forest-Seed/Mulch/Transplant Vegetative Cover on Disturbed Land
- Urban-Infiltration Devices and Grass Swales

The STEPL model and suggested BMPs were used to determine the approximate nutrient and sediment load reduction that the installation of the above BMPS would have on the four critically identified subwatersheds. Three simulations were ran using the same combination of BMPs, however different percentages of the land dedicated to BMP installation were used to determine what effect the installation of more BMPS would have on the overall load reduction rates. STEPL Simulations for the installation of BMPs on 25%, 50%, and 75% of the total landuse acreages for the four subwatersheds identified as contributing the most nutrient and sediment loads were ran. It is important to note that even though the STEPL simulations do not reduce nutrient and sediment loads to meet targeted rates, these simulations give the steering committee estimates for the amount of work needed to meet the targeted loads mentioned earlier in Section 5 and displayed in Table 6.1. Table 5.3 displays the outcomes of the 3 STEPL model simulations.

Table 5.3 STEPL Load Table
Baseline and BMP Scenario Simulation Results

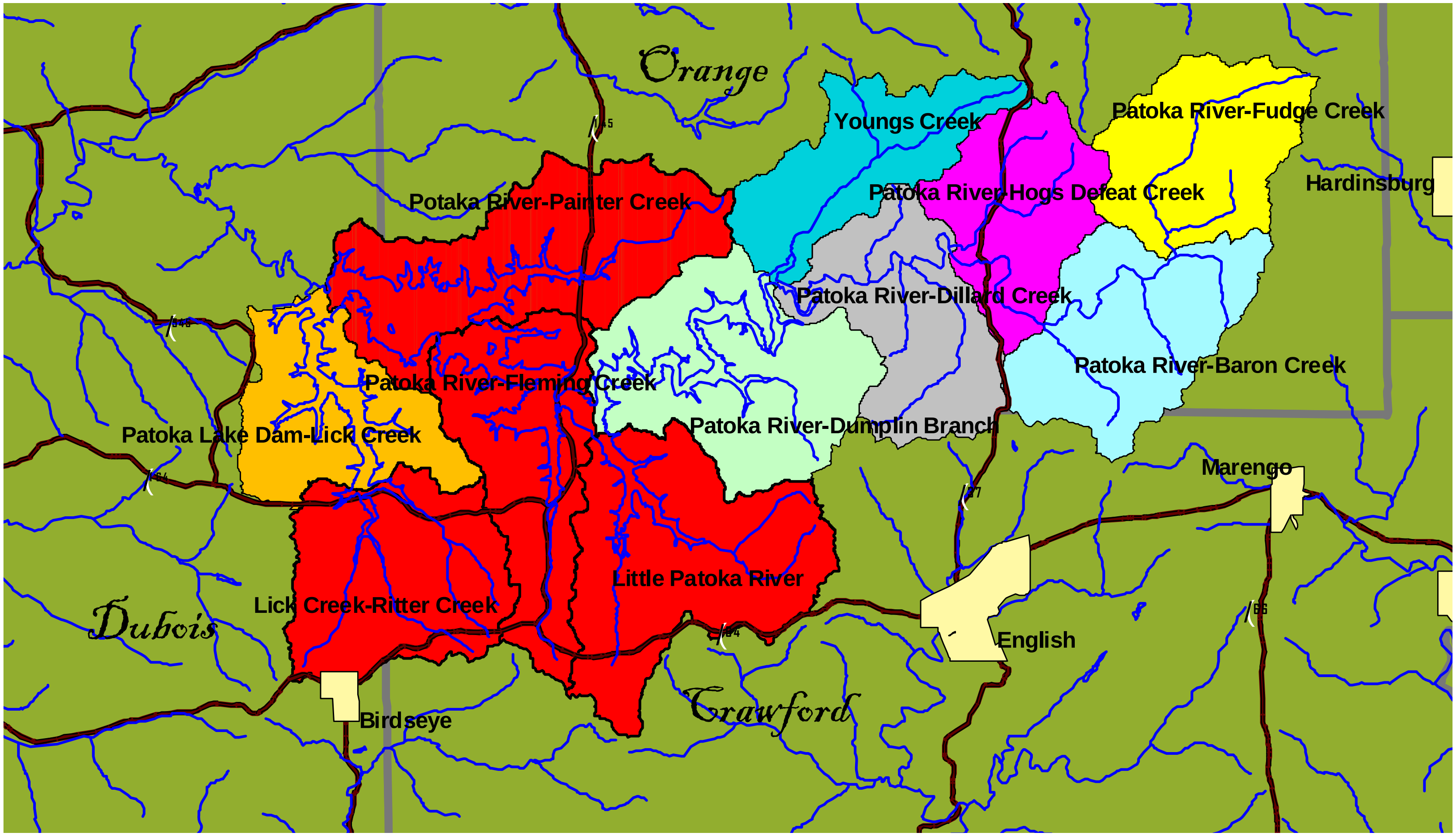
Best Management Practice	Scenario	Subwatershed	Total N			Total P			Sediment**	
	% of Landuse BMP Applied		Total N Reduction lbs/yr	%N Reduction	% N Reduction to meet Targeted N Loads	Total P Reduction lbs/yr	%P Reduction	% P Reduction to meet Targeted P Loads	Sediment Reduction lbs/yr	% Sed. Reduction
Cropland-Iinfiltration Basins and Filter Strips Pasture-Streambank Stabilization and Livestock Fencing Forest- Seed/Transplant Vegitation on Disturbed Land Urban-Infiltration Devices and Grass Swales	25% of 37579 acres= 9395 Acres	Little Patoka	4912	18.1	31.8	1134	16.9	35.5	106385	19.2
		Lick Creek	4400	18.3	31.3	1092	17.9	35.1	97767	19.4
		Painter Creek	3618	18.1	31.9	837	16.6	36	77700	19.1
		Fleming Creek	2458	18.1	31.3	576	17	34.5	52478	19.2
		Total	15389	18.2	31.6	3639	17.1	35.3	334330	19.2
	50% of 37579 acres= 18790 Acres	Little Patoka	9825	36.2	63.7	2242	33.4	70.1	211663	38.2
		Lick Creek	8800	36.6	62.6	2149	35.2	69.1	194023	38.5
		Painter Creek	7216	36.1	63.6	1629	33.1	70	154995	38.1
		Fleming Creek	4903	36.1	62.5	1143	33.7	68.5	104409	38.2
		Total	30744	36.3	63.2	7163	33.9	69.5	665090	38.2
	75% of 37579 acres= 28184 Acres	Little Patoka	14712	54.2	95.3	3349	49.9	105	316940	57.2
		Lick Creek	13224	55	94.1	3205	52.5	103	289775	57.5
		Painter Creek	10834	54.2	95.5	2441	49.6	105	232288	57.1
		Fleming Creek	7363	54.2	93.8	1709	50.4	102	156341	57.2
		Total	46133	54.4	94.8	10704	50.7	104	995344	57.3

**The total landuse acreage for all four critical subwatersheds =37,579 acres*
***Current Sediment loads meet targeted TSS loads (80 mg/L)*

Table 6.1 Annual Nutrient & Sediment Loading Estimates

Watershed Name	Total N Runoff/ yr (lbs)	Total N Target (1.0 mg/l)	N reduction needed lb/yr	Total P Runoff/yr (lbs)	Total P Target (0.3 mg/l)	P reduction needed lb/yr	Total Suspended Solids Runoff/yr (lbs)	TSS Target (80 mg/l)	TSS reduction needed lb/yr
Little Patoka River	27,143	11,710	15,433	6,711	3,513	3,198	554,091	936,773	-382,682
Lick Creek-Ritter Creek	24,045	9,990	14,055	6,104	2,997	3,107	503,956	799,179	-295,223
Patoka River-Painter Creek	19,989	8,644	11,345	4,922	2,593	2,328	406,810	691,544	-284,734
Patoka River-Fleming Creek	13,584	5,739	7,846	3,390	1,722	1,668	273,324	459,094	-185,769
Patoka River-Baron Creek	15,360	8,511	6,849	3,342	2,553	789	276,898	680,898	-404,000
Patoka River-Dumplin Branch	15,537	8,909	6,628	3,400	2,673	727	280,817	712,691	-431,874
Patoka River-Dillard Creek	12,371	7,031	5,340	2,638	2,109	529	218,010	562,494	-344,484
Patoka Lake Dam-Lick Creek	10,734	5,715	5,018	2,427	1,715	712	200,543	457,210	-256,667
Patoka River-Hogs Defeat Creek	8,924	5,914	3,010	1,710	1,774	-64	141,419	473,092	-331,673
Youngs Creek	8,253	5,574	2,679	1,552	1,672	-120	128,712	445,896	-317,184
Patoka River-Fudge Creek	8,312	6,165	2,147	1,434	1,850	-416	119,234	493,204	-373,970

Figure 5.2-Subwatersheds Contributing the Greatest Amount of Runoff
The subwatersheds in red indicate the four subwatersheds that contribute the greatest load per acre of Total N, Total P and TSS. Subsequently, these 4 subwatersheds will require the greatest amount of load reductions to meet targeted load rates.



6. Results of Assessment & Load Calculations

This overall analysis demonstrates the importance of an integrated approach to improving water quality in Patoka Lake Watershed: All subwatersheds pose serious challenges for remediation as there are multiple contaminants of concern and multiple land-use/land cover stressors that may be contributing to the subwatersheds degraded water quality.

Summary of Findings:

- Sample data for Patoka Lake and its tributaries collected from IDEM, CORE, and the Patoka Lake Regional Water & Sewer District were analyzed to determine areas that exceeded the threshold of 3 ppb of Atrazine. There was only one sample location that exceeded the 3 ppb threshold for Atrazine. Sample site, monitored by the CORE, was located at mile 147.8 on Patoka River on a County Road, 3 miles North of Fargo, IN. There was only one sample that exceeded the water quality standard of 3.0 µg/L (ppb = µg/L). A sample taken on 6/1/99 within the Hogs Defeat Creek sub-watershed measured 3.6 µg/L (see Figure 3.2.1.2 & figure 2.3). As Patoka Lake has a designated use as a drinking water resource, any subwatershed that exceeds IAC 327 and US EPA Primary Drinking Water Regulations of 3 ppb of Atrazine is a concern.

  There was a very limited amount of Atrazine monitoring data that currently is available for the Patoka Lake Watershed. Therefore, these Atrazine findings in the Patoka River-Hogs Defeat Creek subwatershed may or may not represent high levels of Atrazine in other parts of the Patoka Lake Watershed. However, corn production continues to be a major crop produced throughout the Patoka Lake Watershed, making Atrazine a pollutant that should continue to be monitored for.

- Sample data for Patoka Lake and its tributaries collected from IDEM, CORE, and the Patoka Lake Regional Water & Sewer District were analyzed to determine areas that fell below the 4.0 mg/L Dissolved Oxygen (DO) threshold. Both the CORE and IDEM had sample locations that fell below the DO threshold, all of the Patoka Lake Regional Water & Sewer District met Ambient Water Quality Standards.

  Dissolved Oxygen was measured by IDEM at 11 locations throughout the watershed. Two of the sample locations had DO levels that fall well below 4.0 mg/L (see Figure 3.2.5 for DO sample locations) in 2001. The two sample locations were in the NE portions of the watershed in the Hogs Defeat Creek and Young Creek sub-watersheds (see Figure 2.3 for sub-watershed locations).

  Dissolved Oxygen was measured at 7 locations throughout the watershed by the CORE. Five of the sample locations had DO levels that fell well below 4.0 mg/L (see Figure 3.2.1.1 for DO sample locations). Sample locations that fell below the 4.0 mg/L DO threshold were in the Lick Creek-Ritter Creek, Patoka Lake Dam-Lick Creek, Patoka River-Fleming Creek, and the Patoka River-Dumplin Branch subwatersheds (figure 2.3).

Eutrophication causing Cyanobacteria (Blue-Green Algae) blooms has been a trend in the raw water of Patoka Lake (Figure 1.2). The Lake continues to have a preponderance of blue-green algae species giving IDEM biologist the idea that Patoka Lake has the potential to go anoxic during the summer months. The amount of dissolved oxygen (DO) present in a lake is very important. DO indicates the suitability of the water for sustaining life. As the algae grows it consume DO, which limits the DO for other aquatic life. Data pulled from IDEMs AIMS database for samples taking in 1996 and 2001 show DO levels that dip well below 5 ppm on numerous occasions, which demonstrates the growth of the anoxic zone within the Lake.

Nutrient loading aids in eutrophication causing algae blooms. The increased construction and agricultural activities occurring within the Patoka Lake Watershed will continue to contribute nutrient loading in Patoka Lake. Therefore, eutrophication causing Oxygen consuming blue-green algae is currently and will continue to be the biggest threat to the Patoka Lake Watershed.

- A Benchmark Analysis of Total N and Total P showed the nutrient load that each subwatershed was contributing to Patoka Lake. Load analysis shows that over 164,250 lbs of Total N and 37,624 lbs of Total P are transported in Patoka Lake Watershed streams annually.

  Little Patoka River HUC 14 Digit watershed (05120209010070) has the highest amount of Total Nitrogen runoff at 27,143 lbs/yr and Total Phosphorus at 6,711 lbs/yr.

  These nutrients are most likely sourced from agricultural production, inadequate septic systems, animal waste and residential runoff, NPDES point source discharges and uncontrolled stormwater in tributary streams and Patoka Lake. Additionally, pressures from agriculture, urban development, and increasing population demands threaten the sustainability of the watershed’s designated uses.

- Total suspended sediment loading estimates indicate that all subwatersheds within the Patoka Lake Watershed meet the TSS targeted water quality standard. However, the Adequate Buffer Assessments completed from the windshield survey show that the watershed is susceptible to suspended sediment contamination from streambanks, cropland, construction sites and ditch maintenance.

  Total suspended solids load analysis showed that the entire Patoka Lake Watershed contributes over 1,551 tons of Suspended Sediment each year Patoka Lake.

7. Development of Problem Statements and Threat Identification

The Subwatershed Assessment, along with the ongoing watershed research and monitoring has allowed the Patoka Lake Watershed Steering Committee to determine the scope of each water quality concern and from those concerns develop problem statements to summarize the primary watershed concerns.

Concerns Based on the results of the Subwatershed Assessment, four areas of primary concern have been identified. They are (in no particular order):

1. Nutrient (nitrogen and phosphorous) loading within the watershed is frequently at or above levels that promote algal blooms in Patoka Lake. Taste and odor problems in finished drinking water, potential health risks associated with elevated nitrates in source waters, and the toxins from algal blooms in both Patoka Lake Reservoir are concerns considering the Lake's designation as a drinking water supply.

2. Sedimentation/Turbidity, low dissolved oxygen, and elevated nutrients may be causing degradation of aquatic habitats. Riparian habitats in many portions of the watershed have been degraded by stream erosion and/or loss of riparian buffer. These combinations of factors are resulting in poor habitat quality in some portions of the watershed.

3. Residents, non-residents and governing bodies do not fully understand how their actions can impact water quality. There is no educational program available to teach individuals how to be better stewards of the land.

4. Atrazine loading (measured as triazine) within the watershed has been shown to exceed USEPA and IAC drinking water standards within the watershed. Although drinking water standards are based on an annual average of atrazine in treated water, high atrazine loads in the watershed can pose a problem and are a concern. Given the source of triazines is agricultural applications, other herbicides, pesticides and metals may also exceed acceptable standards.

Problem Statements

1. Problem:

Nutrient loading in all streams in Patoka Lake Watershed have the potential to threaten the designated use of Patoka lake, being Recreation and Drinking Water.

Discussion:

Despite Patoka Lake Watershed's low agricultural landuse compared to other Indiana watersheds, Patoka Lake Watershed streams have the potential to have high nutrient loading events. Although the overall nutrient loads for the Patoka Lake Watershed are in the mid-to-low range compared to other watersheds in Indiana, the nutrient loads still exceed the target Total N load of 1.0 mg/L and 0.3 mg/L for Total P. Fertilizer and Manure application on crop land and livestock with direct stream access are potential sources of nutrients in the Patoka Lake Watershed. The Little Patoka River and Lick Creek-Ritter Creek subwatersheds being of highest concern for Total N and Total P (Table 6.1).

Discussion with local stakeholders also note that a large portion of the pasture land (60-70%) allow livestock to have direct access to adjacent streams, which can be another source of nutrient and sediment loading (Figure 4.4.3 (b)).

Onsite Septic Systems are a potential source of human waste contamination. Contaminates such as *E. Coli* , ammonia, and phosphorous are associated with human waste. While well-maintained septic systems can remove most contaminates before waste enters the stream, septic system failure can release excess *E. Coli* and nutrients, especially ammonia and phosphorous compounds into surface water. However, septic system location and function information is difficult to obtain.

The Dubois County Health Department alone approves approximately 100 new OSSs permits each year. Of which the Health Department estimates 10% of the approved permits go to residential homeowners that are replacing a failing septic system. Discussions with the Patoka Lake Regional Water & Sewer District and the local County Health Departments estimated that 80-90% of residents rely on septic systems for waste disposal, of which 95% of homeowners do not properly maintain their on-site septic systems. The Indiana State Department of Health estimates that 25% of the septic systems in Indiana are inadequate or failing, and that for every failing septic system over 82,000 gallons of untreated wastewater is released into the environment annually (Lee *et al.*, 2004).

A common cause of septic system failure stems from the placement of septic systems in improper soils: soils that do not allow for proper drainage. The NRCS Web Soil Survey estimated that greater than 90% of the soils within the Patoka Lake Watershed are rate as "very limited" for construction of septic system absorption fields. Therefore, the stakeholders concerns about waste disposal system for the new subdivisions and residential homes being constructed in the Little Patoka River and Patoka River-Fleming Creek Subwatersheds are valid and maybe contributing to the high nutrient loads.

Excess amounts of phosphorous and nitrogen, can have detrimental affects down stream in Patoka Reservoir and Patoka River. These high nutrient loads spur algal blooms that adversely affect the water quality of the reservoir, a designated public water supply for over 65,000 residents in southwest Indiana. Excessive algae growth consumes dissolved oxygen, limiting the DO availability to other aquatic species and is a potential source for the low DO levels through the Patoka Lake Watershed. Algae blooms are also a recreational nuisance to the thousands of people that travel to Patoka Lake for its numerous water related activities.

Nutrient concentrations in water are generally related to landuse in the upstream watershed or the area overlying an aquifer (USGS, 1996). Therefore, conservation efforts that manage nutrient loading are need throughout the Patoka Lake Watershed.

2. Problem:

Sediment loads in the subwatersheds of the Patoka Lake Watershed are high during event flows, eventually transporting large pulses of sediment to the reservoir and potentially degrading aquatic health.

Discussion:

Estimated Total Suspended Solid (TSS) loads for all subwatersheds in the entire Patoka Lake Watershed currently meet the targeted TSS load of 80 mg/L. Although base flow does not contribute excessive amounts of suspended sediment in the watershed, storm events have high suspended sediment loads, particularly in the spring. The Little Patoka River subwatershed was estimated as contributing the greatest TSS load of all subwatersheds at 554,091 lbs/yr. The Little Patoka River subwatershed has the largest amount of agricultural and residential land-uses that may be contributing to the large TSS loads within this subwatershed.

Many areas of moderate stream bank erosion in Patoka Lake Watershed were also noted during the windshield survey, an indicator that these areas are sensitive to high flowing water removing the stream's bank. Lack of adequate buffer was observed and can also influence stream bank erosion, making the banks less stable and more vulnerable. Steep slopes are another stressor and lead to higher rates of sedimentation, as well as, runoff. Although some of Patoka Lake Watershed has a low percent slope, the majority of the areas have a high slope grade. Discussion with local county agricultural agencies indicated that crop production on land adjacent to streams within the Patoka Lake watershed are tilled in valleys and river bottoms where fields are border by land with steep slopes. These fields are usually long and narrow, making buffers an undesirable BMP for landowners in these areas, which increase the potential to runoff into adjacent streams.

Additionally, rapid development is occurring along the S.R. 64 corridor in the Little Patoka River, Lick Creek-Ritter Creek, and the Patoka River-Fleming Creek subwatersheds. More impervious surfaces are associated with development, increasing runoff and therefore, increasing discharge to the streams. Much of the suspended sediment transport occurs during pulses of higher discharge in Patoka Lake and its tributaries.

Chemicals, nutrients and other pollutants are carried with the sediment during these pulses which also threaten the stream's health. Studies have shown phosphorus may be bound to the suspended sediment particles. These phosphorous-laden particles are transported to the reservoir where anoxic conditions can release the bound phosphorus and become a phosphorous source for reservoir algal blooms (Pascual *et al*., 2004; Raftis *et al*., 2004).

Turbidity becomes a water quality problem when suspended soil sediment in the water increases the water temperature by absorbing heat, decrease light penetration, and increase treatment costs. Poor water clarity also interferes with feeding in predators that hunt by sight and clogs gills of fish and other aquatic animals during breathing and feeding. As sediment settles out of the stream during low flow or otherwise quiet water times, it smothers nests and eggs and fills crevices in gravel beds required for bottom dwelling species. Although current Total Suspended Solids loads meet water quality standards, the increased development and agricultural pressures within the Patoka Lake Watershed have the potential to dramatically increase sedimentation, which may negatively impact recreational opportunities and increase drinking water treatment costs.

3. Problem:
An adequate educational outreach program is not in place to inform the residents in the Patoka Lake Watershed about their role in maintaining the overall quality of the watershed.

Discussion:
While difficult to quantify, many of the observed water quality problems in the Patoka Lake Watershed suggest that the residents do not fully understand how their actions can impact water quality. Personal contact with Dubois County Health Department and the County SWCD confirm that no formal educational outreach programs are currently in place for the Patoka Lake Watershed community. Residents encountered during the 2005-2006 stakeholder meetings, often expressed interest in knowing more about the overall state of their watershed. As development continues in the watershed, a considerable outreach effort will be required to integrate newer watershed scale practices into these areas.

4. Problem:
Atrazine levels in Patoka Lake Watershed have exceeded the USEPA standard of 3.0 ug/L (.003 mg/L) for drinking water supplies.

Discussion:
Atrazine was monitored for on a very minimal basis within the Patoka Lake Watershed. Therefore, enough data is not available at this time to determine if Atrazine is viable concern within the watershed. However, samples taken from a stream within the Patoka River-Hogs Defeat Creek subwatershed did exceed the Atrazine maximum contaminant level of 3.0 ug/L for a drinking water supply (USEPA, National Primary Drinking Water Regulations; http://www.epa.gov/safewater/mcl.html#2).

Atrazine continues to be the most widely used herbicide for corn produced within the Patoka Lake Watershed. 2002 Purdue University Tillage Transect Data indicates that a large percent of the crop land is no-tilled, which slows surface runoff. Adequate vegetative/riparian buffer were noted to be missing in the subwatersheds, which is crucial to prevent runoff of agricultural and lawn chemicals applied to the adjacent lands from entering the streams. Discussion with local county agricultural agencies indicated that crop production on land adjacent to streams within the

Patoka Lake watershed are tilled in valleys and river bottoms where fields are border by land with steep slopes. These fields are usually long and narrow, making buffers an undesirable BMP for landowners in these areas, which increase the potential to runoff into adjacent streams.

The extent of the tile system throughout the Patoka Lake Watershed is unknown. However, the windshield survey in the Fall of 2005 revealed that there are numerous agricultural drainage pipes discharging into the watershed streams and ditches. A tile can act as an avenue for pesticides to move quickly agriculture fields to streams, making tile drainage systems a potential source of Atrazine.

The Patoka Lake Water & Sewer District voluntarily samples for Atrazine at their treatment plant and never had a sample that exceeded the Atrazine MCL. Although the maximum contaminant level (MCL) of 3.0 µg/L for atrazine is based on an annual average of atrazine in treated water, the importance of keeping atrazine levels low in the watershed and reservoir is recognized.

8. Critical Areas Identification & Remediation Strategies

Based on the concerns and problem statements elucidated in the previous sections, the Patoka Lake Watershed Steering Committee was able to identify Critical Areas and create a list of possible remediation strategies for each subwatershed based on its water quality and vulnerable land-use activities (Table 8.1).

Critical Areas Identification

Through literature reviews of best management practices, the Steering Committee will determined what type of remediation (e.g., fencing, increased stream buffer, created wetland, and/or education and outreach) is necessary to reduce or control the contaminant from its respective source. Once a type of remediation is selected, visual assessments will be used to determine the best possible stream reach locations for the proposed remediation. Once these areas have been mapped, discussions with landowners or stakeholders will be held to determine which landowners and stakeholders will be most amenable to work with the Patoka Lake Watershed Steering Committee to implement best management practices on their land.

Critical Areas will be evaluation based on:
(1) the level of water quality degradation based on benchmark assessment of water quality; *and/or*
(2) the identification of land-use/land cover assessments that showed specific areas particularly vulnerable to on-going and future degradation (vulnerability); and
(3) the feasibility of remediation.

The following sections discuss the four subwatersheds that have been identified as contributing the largest pollutant loads in the Patoka Lake Watershed. Therefore, these four subwatersheds are considered as the most critical areas in need of watershed management practices.

Table 8.1: Identifying Critical Areas

Watershed Name	Water Quality Degradation Contributions	Vulnerable Land-use Activity	Possible Remediation Type(s)
Little Patoka River	Total N-27,143 lbs/yr Total P-6,711 lbs/yr TSS-554,091 lbs/yr	Residential & Commercial Construction Activity along SR 64 Largest amount of residential landuse Largest amount of impervious surface (239.5 acres) 70% of Livestock have access to streams Transportation corridors (SR 64) Largest acreage dedicated to crop production Tile and /or pipes into stream "Very limited" soil types for OSSs	Replace failing OSSs Trash pickup Whole community Planning (e.g., low impact development practices and stormwater management) Stream Protection (silt/livestock fences) Reseed disturbed land Education/Outreach Grass and Tree Buffers Constructed Water/Sediment Control Basins

Lick Creek-Ritter Creek	Total N-24,045 lbs/yrTotal P-6,104 lbs/yrTSS-503,956 lbs/yrLow DO Levels	Largest number CAFOs Largest amount a pasture acreage Residential &Commercial development along SR 64 Road/Ditch Maintenance 70% of Livestock have Access to streams Agricultural Run-off Tile and /or pipes into stream "Very limited" soil types for OSSs	Replace failing OSSsWhole community Planning (e.g., low impact development practices and stormwater management)Whole Farm PlanningPasture rotation planningTrash pickupStream Protection (silt/livestock fences)Education/OutreachGrass and Tree BuffersConstructed Water/Sediment Control Basins

Patoka River-Painter Creek	Total N-19,989 lbs/yr Total P-4,922 lbs/yr TSS-406,810 lbs/yr Low DO Levels	Livestock Access to streams Agricultural Run-off Tile and /or pipes into stream "Very limited" soil types for OSSs Lake recreation (trash, engine fluids, waste disposal)	Replace failing OSSs Pickup Trash Whole community Planning (e.g., low impact development practices and stormwater management) Stream Protection (fences) Education/Outreach Grass and Tree Buffers Constructed Water/Sediment Control Basins

Patoka River-Fleming Creek	Total N-13,584 lbs/yr Total P- 3,390 lbs/yr TSS-273,324 lbs/yr Low DO Levels	NPDESs Most USTs Residential & Commercial construction activity along SR64 Largest amount of interstates Road/Ditch Maintenance (SR 64 & SR145) 70% of Livestock have Access to streams Agricultural Run-off Tile and /or pipes into stream	Replace failing OSSs Trash pickup Whole community Planning (e.g., low impact development practices and stormwater management) Point Source Reduction Stream Protection (silt/livestock fences) Education/Outreach Grass and Tree BuffersConstructed Water/Sediment Control Basins

9. Watershed Management Goals

Based on the concerns and problem statements elucidated in the previous sections, a set of goals were developed. Goal achievement was based on targeted outcomes with each having an associated objective, action, and indicator(s) of success listed.

These goals are:

(1) Reduce nutrient loads throughout Patoka Lake Watershed, particularly nutrient runoff from agriculture and pasture lands within the four subwatersheds that were identified as contributing the largest nutrient loads (Little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek, Patoka River-Fleming Creek).
Problem: Nutrient loads in all streams in Patoka Lake Watershed are contributing to the algae blooms and low Dissolved Oxygen levels in the waters of Patoka Lake Watershed, threatening the use of Patoka Lake as a drinking water and recreational resource.
Management Goal: Develop a cost-share program and educational programs that promote the installation of a combination of BMPs throughout the Patoka Lake Watershed in an effort to reduce current nutrient loads to targeted loads. Efforts should be focused on the four subwatersheds that were identified as contributing the largest nutrient loads, however, other subwatersheds should not be excluded from such practices. Agriculture and pasture lands were identified as landuse that have the potential to contribute large pulses of nutrients. Therefore, landowners that use there properties for crop and livestock production shall be identified and targeted for BMP work.

Soils within Dubois, Crawford and Orange County have been rated as “Very Limited” for supporting properly functioning on-site septic systems. Therefore, its been determined that there is potentially a high number of failing septic systems throughout the Patoka Lake Watershed. Efforts to educate homeowners on the proper maintenance of their septic systems will be made to assist in the nutrient reductions.
Target Outcome: Increase the number of functional BMPs in the Patoka Lake Watershed to aid in the reduction of Total Nitrogen loading by 37,908 lbs/yr and Total Phosphorus loading by 10,435 lbs/yr to Patoka Lake so that the reservoir eutrophic state is reduced, leading to a reduction in algae blooms and the musty odor & taste of the raw water of Patoka Lake.

(2) Reduce sediment loads in Patoka Lake Watershed.
Problem: Although sediment loads currently meet target loads, sediment loads in the subwatersheds of Patoka Lake Watershed have the potential to be high during event flows, eventually transporting large pulses of sediment to the reservoir and potentially degrading aquatic habitat. Nutrient clad soil particles that runoff the land also have the potential to contribute to the high nutrient loads of the Patoka Lake Watershed. Sedimentation also increases turbidity in the water that decreases the quality of fishing and other recreation opportunities throughout the watershed, a major concern of stakeholders.
Management Goal: Develop education and cost-share programs that promote the installation of a combination of BMPs on crop, pasture and forested land within the Patoka Lake Watershed. Several residential construction projects are ongoing and planned along S.R. 64. Efforts to work

with these projects to reduce erosion and runoff will contribute to the reduction of sediment and nutrient loads.
Target Outcome: Increase the number of functional BMP combinations in the Patoka Lake Watershed to aid in the reduction of sediment loading in the Patoka Lake Watershed from 3,103,814 lbs/yr to 2,222,477 lbs/yr, which will enhance aquatic habitats and reduce drinking water treatment costs.

(3) Increase watershed education and outreach in Patoka Lake Watershed.
Problem: An adequate educational outreach program is not in place to inform the residents in the Patoka Lake Watershed about their role in maintaining the overall quality of the watershed.
Management Goal: Develop a watershed curriculum that will educate stakeholders on the many aspects a watershed and the programs that are available to help them protect the water resource of the Patoka Lake Watershed
Target Outcome: Raise awareness of watershed and water quality issues in an effort to change attitudes and behaviors to foster environmental stewardship by sponsoring educational workshops, demonstration sites, and a monitoring network.

(4) Reduce Atrazine loads in Patoka Lake Watershed.
Problem: Although monitored on a very limited basis, concentrations of Atrazine in a Patoka Lake Watershed stream has exceeded the USEPA standard of 0.003 mg/L, which threatens Patoka Lake's use as a drinking water source.
Management Goal: Additional monitoring shall be done throughout the Patoka Lake Watershed to determine if Atrazine pollution is a valid concern. However, we know that Atrazine is the most widely used pesticide for corn production within the Patoka Lake Watershed. Therefore, an effort to work with corn producers to educate them on the negative effects of Atrazine and the importance of installing runoff reducing BMPs on their crop land will be made.
Target Outcome: Increase the amount of Atrazine sampling data. Increase the number of functional BMPS throughout the watershed to reduce Atrazine runoff such that concentrations of Atrazine in Patoka Lake never exceed 0.0003 mg/L.

Table 9 Priority Ranking of Goals & Objectives

Goals	Objective	Priority Ranking
Reduce Nutrient Loading		
	Promote whole farm planning by helping farm owners and operators achieve their production and natural resource conservation goals through the development and implementation of a comprehensive nutrient management plan. Plans are site specific and will outline management strategies for the proper operation of storage facilities, waste treatment and land applications processes. Identification of topography features, soil types, drainage courses, and nearest water sources will be mapped to reveal environmentally sensitive areas.	1
	Work w/ landowners to minimize livestock access to streams within the watershed.	2
	Identify and educate unregulated point & non-point source polluters, such as field tiles, stormwater runoff, small farms, manure stockpiles and feedlot runoff.	3
	Develop an educational program to educate homeowners on the proper maintenance of their on-site septic systems. Demonstrations sites and field tours of working, non-working and alternative on-site septic systems will aid in stakeholder education.	4
Reduce Sediment Loading		
	Promote soil stabilizing practices on disturbed land (e.g. silt fences, straw dressing, plant vegetation, No-till farming, compliance of Stormwater Rule 13 & 5 (327 IAC 15-13 & 327 IAC 15-5).	1
	Promote currently available cost-share programs, as well as, develop and implement watershed specific cost-share programs for the installation of BMPs.	2
	Promote forest logging BMPs on private land	3
	Promote whole farm planning by helping farm owners and operators achieve their production and natural resource conservation goals through the development and implementation of a comprehensive nutrient management plan. Plans are site specific and will outline management strategies for the proper operation of storage facilities, waste treatment and land applications processes. Identification of topography features, soil types, drainage courses, and nearest water sources will be mapped to reveal environmentally sensitive areas.	4

Increase Watershed Education & Outreach		
	Develop a voluntary monitoring network of local stakeholders. Increase volunteer data collection/monitoring and make info available to public.	1
	Develop watershed education plan that reaches out to all watershed users(e.g., website, newsletter, paper articles, activities, Water Awareness Day program, sustainable recreational practices, etc.)	2
	Develop BMP Demo sites (e.g.,stream protection-silt/livestock fences, buffers, WASCOBS, wetlands, ration ponds, water gardens, 2-cycle engine demo, etc.)	3
	Develop an educational program to educate homeowners on the proper maintenance of their on-site septic systems. Demonstrations sites and field tours of working, non-working and alternative on-site septic systems will aid in stakeholder education.	4
Reduce Atrazine Loading		
	Develop Educational Program for pesticide applicators on the many incentives (e.g. cost-share programs, land stewards, liability, etc. for proper application practices. Applicators and Stakeholders alike need to know the negative and positive effects pesticide applications have on the environment and human health.	1
	Promote whole farm planning by helping farm owners and operators achieve their production and natural resource conservation goals through the development and implementation of a comprehensive nutrient management plan. Plans are site specific and will outline management strategies for the proper operation of storage facilities, waste treatment and land applications processes. Identification of topography features, soil types, drainage courses, and nearest water sources will be mapped to reveal environmentally sensitive areas.	2
	Promote currently available cost-share programs, as well as, develop and implement watershed specific cost-share programs for the installation of BMPs.	3
	Promote use of alternative and/or environmental friendly pesticides	4

(1) Reduce nutrient loads throughout Patoka Lake Watershed, particularly nutrient runoff from agriculture and pasture lands within the four subwatersheds that were identified as contributing the largest nutrient loads (Little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek, Patoka River-Fleming Creek).

Problem: Nutrient loads in all streams in Patoka Lake Watershed are contributing to the algae blooms and low Dissolved Oxygen levels in the waters of Patoka Lake Watershed, threatening the use of Patoka Lake as a drinking water and recreational resource.

Objective (in order of importance)	Action Item	Stakeholders	Responsible Party	Schedule	Indicators	Estimated Cost
1. Promote whole farm planning by helping farm owners and operators achieve their production and natural resource conservation goals through the development and implementation of a comprehensive nutrient management plan. Plans are site specific and will outline management strategies for the proper operation of storage facilities, waste treatment and land applications processes. Identification of topography features, soil types, drainage courses, and nearest water sources will be mapped to reveal environmentally sensitive areas.	Work w/ IDEM, ISDA, NRCS, and SWCDs to increase whole farm planning practices.	Ag landowners	PLW Steering Committee & volunteers, IDEM, SWCDs	Year1-Year5	Document the number of farmers who have adopted whole farm planning practices	50k
	Work w/ SWCDs and NRCS to identify partners in need of farm planning assistance	Landowners throughout the watershed	PLW Steering Committee & Volunteers, ISDA, SWCDs, NRCS	Years1-Years5	ID of landowners amenable to BMP Installation.Create list of landowners whose land overlaps a critical area and maintain list of partners and possible partners.	5k
	Work with NRCS and SWCDs to increase conservation tillage practices	Ag landowners	PLW Steering Committee & Volunteers, ISDA, SWCDs, NRCS	Years1-Years3	Increase in the amount of ag fields using conservation tillage practices.	10k
	Provide cost-share funding for BMP installation, focusing efforts in the 4 critical subwatersheds (little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek,Patoka River-Fleming Creek).	Ag and residential landowners	PLW Steering Committee & Volunteers	Years1-Years15	Document the number of BMPs installed and projects implemented. Map completed projects. Reduction in the number of event flow water quality samples that exceed the targeted nutrient loads of 1.0 mg/L TN and 0.3 mg/L TP. Installation of BMPs on 75 % of the 4 subwatersheds total land acreage is estimated to reduce TN by 54% an TP by 50%.	300k
2. Work w/ landowners to minimize livestock access to streams within the watershed.	Work w/ NRCS and SWCDs to identify partners that own livestock with direct access to streams.	landowners w/ livestock	PLW Steering Committee & Volunteers, local SWCDs	Years1-Years5	ID of landowners w/ livestock amenable to fence installation. Create list of landowners whose land overlaps a critical area and maintain list of partners and possible partners.	5k

	Provide cost-share funding to install BMPs (e.g. fencing & buffers), focusing efforts in the 4 critical subwatersheds (little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek,Patoka River-Fleming Creek)	landowners w/ livestock	PLW Steering Committee & Volunteers	Years1-Years15	Number of BMPs installed & miles of Fence installed and a decrease in the amount of stream bank with inadequate riparian buffers. Installation of BMPs on 75 % of the 4 subwatersheds total land acreage is estimated to reduce TN by 54% an TP by 50%.	300k
	Monitor BMP effectiveness at keeping livestock out of streams and reducing nutrient loads. Water quality sampling will occur throughout the Patoka Lake Watershed, however monitoring efforts will focus on the 4 critical subwatersheds (little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek,Patoka River-Fleming Creek) downstream of installed BMPs.	landowner w/ livestock	PLW Steering Committee, Coordinator & Volunteers, land owners	Years1-Years15	Compare before and after visual assessments of sites with animal access to streams Reduction in the number of event flow water quality samples that exceed the targeted nutrient loads of 1.0 mg/L TN and 0.3 mg/L TP.	50k
3. Identify and educate unregulated point & non-point source polluters, such as field tiles, small farms, stormwater runoff, manure stockpiles and feedlot runoff.	Work w/ SWCDs and NRCS to identify partners throughout the Patoka Lake Watershed.	Landowners throughout the watershed	PLW Steering Committee & Volunteers	Years1-Years3	ID of landowners amenable to BMP Installation. Create list of landowners whose land overlaps a critical area and maintain list of partners and possible partners.	5k
	Work with NRCS, SWCDs, and local drainage board to reduce nutrient load from tile drainage by increasing controlled drainage practices	Ag landowners	PLW Steering Committee & Volunteers	Years 1-Years 10	increase in the amount of fields using controlled drainage practices. Map tile outlets.	25k
	Work w/ point source dischargers to determine feasibility of load reductions.	Point Source dischargers	PLW Steering Committee & Volunteers	Year3+	Number of meetings w/ Point Source dischargers and CAFOs. Determination of feasible goals. Implementation of possible reductions practices.	25k
	Identify and work with non-point sources to reduce nutrient runoff, focusing efforts in the 4 critical subwatersheds (little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek,Patoka River-Fleming Creek)	Landowners throughout the watershed	PLW Steering Committee & Volunteers	Years1-Years5	ID of landowners amenable to BMP Installation. Create list of landowners whose land overlaps a critical area and maintain list of partners and possible partners.	5k
	Develop educational demonstration sites.	Landowners throughout the watershed	PLW Steering Committee & Volunteers	Years2-3	Number of installed or enhanced BMPs used as demo sites.	30k
	Begin education and outreach program regarding sustainable fertilizer use on lawn and turfgrass.	Landowners throughout the watershed	PLW Steering Committee & Volunteers	Years1-Years2	Increase in landowners and homeowners using non-phosphorous and low-phosphorous fertilizers.	5k
	Work with urbanized areas to reduce nutrient loads from stormwater runoff from impervious surfaces.	Residential, commercial, and industrial landowners	PLW Steering Committee & Volunteers, Local health depts.	Years1-Years3	Number of marked storm drains.	5k

4. Develop an educational program to educate homeowners on the proper maintenance of their on-site septic systems. Demonstrations sites and field tours of working, non-working and alternative on-site septic systems will aid in stakeholder education.	Determine the number of unsewered areas near streams.	Landowners w/ septic or no waste disposal system	PLW Steering Committee & Volunteers	Years1-Years5	Creation of a map showing the location of unsewered areas in the watershed. Development of a mailing list of landowners w/ septic systems.	50k
	Develop educational materials and distribute throughout the watershed.	Landowners throughout the watershed and septic maintenance businesses	PLW Steering Committee & Volunteers	Years1-Years5	Number of educational packets distributed.	30k
	Develop educational demonstration sites.	Landowners throughout the watershed	PLW Steering Committee & Volunteers and local Health depts.	Years2-5	Number of installed, replaced or maintained septic systems	25k

(2) Reduce sediment loads in Patoka Lake Watershed.

Problem: Although sediment loads currently meet target loads, sediment loads in the subwatersheds of Patoka Lake Watershed have the potential to be high during event flows, eventually transporting large pulses of sediment to the reservoir and potentially degrading aquatic habitat. Nutrient clad soil particles that runoff the land also have the potential to contribute to the high nutrient loads of the Patoka Lake Watershed. Sedimentation also increases turbidity in the water that increases drinking water treatment costs and decreases the quality of fishing and other recreation opportunities throughout the watershed, a major concern of stakeholders.

Objective (in order of importance)	Action Item	Stakeholders	Responsible Party	Schedule	Indicators	Estimated Cost
1. Promote soil stabilizing practices on disturbed land (e.g. silt fences, straw dressing, plant vegetation, grass swales, compliance of Stormwater Rule 13 & 5 (327 IAC 15-13 & 327 IAC 15-5).	Work with NRCS, SWCDs, CORE, and County Drainage Boards to identify partnerships.	Ag landowners, NRCS, SWCDs,CORE, County Drainage Boards	PLW Steering Committee & Volunteers	Years1-Years10	Development of common goals between NRCS, CORE, County Drainage Boards, and the PLW Steering Committee. ID of landowners amenable to BMP Installation.	5k
	Work with any "project site owner" engaged in construction-related activities (meaning any manmade change of the land surface, including removing vegetative cover that exposes the underlying soil, excavating, filling, transporting, and grading) within the watershed, particularly along S.R. 64, to install BMPs that would re-vegetate and control erosion.	project site owners	PLW Steering Committee & Volunteers	Years1-Years15	Number of submitted & approved Construction plans and Notices of Intent to IDEM. New STEPL & LTHIA models.	150k
	Quantify extent of headwater erosion through monitoring and load analysis	landowners throughout the watershed	PLW Steering Committee & Volunteers	Years1-Years3	Development of a detailed monitoring database and baseline map showing headwater erosion. New STEPL simulations.	25k
	Promote whole community planning and begin storm drain marking program, focusing efforts in more urban subwatersheds (Lick Creek-Ritter Creek, Patoka River-Fleming, Little Patoka River).	Homeowners	PLW Steering Committee & Volunteers	Years1-Years3	Number of marked storm drains and communities/areas with strormwater management plans.	20k
2. Promote currently available cost-share programs, as well as, develop and implement watershed specific cost-share programs for the installation of BMPs.	Provide cost-share funding, education, and demonstration projects (e.g. buffers and infiltration basins), focusing efforts in the 4 critical subwatersheds (little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek,Patoka River-Fleming Creek).	landowners throughout the watershed	PLW Steering Committee & Volunteers	Years1-Years15	Number of installed BMPs. Visual confirmation of fewer animals in the streams. Map completed projects. Reduction in the number of event flows that contribute large pulse of sediment loading. Installation of BMPs on 75 % of the 4 subwatersheds total land acreage is estimated to reduce TSS by 57%. Input new landuse data in STEPL model.	300k
	Monitor the effectiveness of the demonstration projects through a volunteer monitoring network.	landowners throughout the watershed, Volunteer monitors, Hoosier Riverwatch	PLW Steering Committee & Volunteers	Years1-Years3+	Reduction in total suspended sediment loads. Creation of a BMP effectiveness database and maps. Number of volunteers within the monitoring network.	40k
	Develop relationships that foster corporate and group stewardship by offering and promoting educational workshops to developers, planners and homeowners associations focused on the economic value of the Patoka Lake Watershed and its many uses.	Ag landowners, Schools, Homeowners, Park Patrons, and developers	PLW Steering Committee & Volunteers	Years1-Years10	Number of educational events held. Attendance at educational events.	35k

3. Promote forest logging BMPs on private land	Work w/ the US forest service to identify partners, focusing on newly developed properties along S.R 64 & SR145.	Landowners throughout the watershed	PLW Steering Committee & Volunteers	Years1-Years3	ID of landowners amenable to BMP Installation.Create list of landowners whose land overlaps a critical area and maintain list of partners and possible partners.	5k
	Provide cost-share funding for BMP installation, focusing efforts in the 4 critical subwatersheds (little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek,Patoka River-Fleming Creek).	Ag and forest landowners, home owners, developers	PLW Steering Committee & Volunteers	Years1-Years15	Number of BMPs installed.Map completed projects. Reduction in the number of event flows that contribute large pulse of sediment loading. Installation of BMPs on 75 % of the 4 subwatersheds total land acreage is estimated to reduce TSS by 57%. Input new landuse data in STEPL model.	300k
	Create and deliver watershed education programs, focusing on privately owned forest land, that promotes re-vegetating disturbed land.	Ag landowners, forest landowners, Hoosier National Forest, Homeowners, Park Patrons, and developers	PLW Steering Committee & Volunteers, US Forest Service	Years1-Years3	Number of educational events held. Attendance at educational events.	35k
4. Promote whole farm planning by helping farm owners and operators achieve their production and natural resource conservation goals through the development and implementation of a comprehensive nutrient management plan. Plans are site specific and will outline management strategies for the proper operation of storage facilities, waste treatment and land applications processes. Identification of topography features, soil types, drainage courses, and nearest water sources will be mapped to reveal environmentally sensitive areas.	Work w/ SWCDs and NRCS to identify partners in need of farm planning.	Landowners throughout the watershed	PLW Steering Committee & Volunteers	Years1-Years3	ID of landowners amenable to BMP Installation. Create list of landowners whose land overlaps a critical area and maintain list of partners and possible partners.	5k
	Work with NRCS and SWCDs to increase conservation tillage practices throughout the Patoka Lake Watershed.	Ag landowners	PLW Steering Committee & Volunteers	Years1-Years3	Increase in the amount of ag fields using conservation tillage practices. IN Conservation tillage transact data. Visual assessment of increased no-till acreage.	10k
	Provide cost-share funding for BMP installation, focusing efforts in the 4 critical subwatersheds (little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek,Patoka River-Fleming Creek) where the most crop and livestock production occurs.	Ag and residential landowners, CAFOs	PLW Steering Committee & Volunteers	Years1-Years3	Number of BMPs installed. Reduction in the number of event flows that contribute large pulse of sediment loading. visual assessment of the reduction in livestock access to streams. Installation of BMPs on 75 % of the 4 subwatersheds total land acreage is estimated to reduce TSS by 57%. Input new landuse data in STEPL model.	300k

(3) Increase watershed education and outreach in Patoka Lake Watershed.

Problem: An adequate educational outreach program is not in place to inform the residents in the Patoka Lake Watershed about their role in maintaining the overall quality of the watershed.
Management Goal: Develop a watershed curriculum that will educate stakeholders on the many aspects a watershed and the programs that are available to help them protect the water resource of the Patoka Lake Watershed.

Objective (in order of importance)	Action Item	Stakeholders	Responsible Party	Schedule	Indicators	Estimated Cost
1. Develop a voluntary monitoring network of local stakeholders. Increase volunteer data collection/monitoring and make info available to public.	Promote & host Hoosier riverwatch training programs for the development of the volunteer monitoring network, including the purchase and storage of sampling and training equipment/supplies.	All residents in the watershed	PLW Steering Committee & Volunteers, Hoosier Riverwatch, Patoka Lake Regional Water District	Years1-Years3	Creation of a water quality database. Number of attendees at training events. Number of sample sites. Number of volunteer monitors.	40k
	Host watershed and water quality awareness day programs that educate stakeholders on water quality problems and trends within the Patoka Lake Watershed.	All residents in & Surrounding the watershed	PLW Steering Committee & Volunteers, Hoosier Riverwatch, Patoka Lake Regional Water District, local schools, IDNR	Years1-Years3	Number of attendees.	50k
	Develop, maintain and update a Patoka Lake Watershed water quality database.	All residents in the watershed	PLW Steering Committee, Coordinator, Hoosier Riverwatch & Volunteers	Years1-Years3	Creation of a water quality database. Number of attendees at events. Number of Hoosier Riverwatch training events.	40k
2. Develop watershed education plan that reaches out to all watershed users(e.g., website, newsletter, paper articles, activities, Water Awareness Day program, sustainable recreational practices, etc.)exposing them to the geography, geology and ecology of the Patoka Lake Watershed.	Install watershed identification signs and storm drain markers for watershed education.	All residents and visitors to the watershed	PLW Steering Committee & Volunteers, DOT,	Years1-Years3	Number of signs installed. Number of marked storm drains.	75k
	Establish a semi-annual paper and electronic newsletter that promotes the Patoka Lake Watershed and ongoing protection activities and accomplishments.	All residents in the watershed	PLW Steering Committee, Coordinator & Volunteers	Years1-Years3	Number of residents receiving newsletter and paper.	50k
	Promote watershed stewardship by creating ad distributing a set of watershed, NPS pollution, and septic informational brochures for the general public that address the scope of the problem and the role of the individual in reducing water quality impacts	All residents in the watershed, County Agencies, IDNR, CORE	PLW Steering Committee, county agencies, local schools, Volunteers, IDNR, CORE	Years1-Years5	Number of educational material distributed. Number of outreach events hosted.	100k
	Develop survey to track behavior changes that come w/ education, focusing efforts in the 4 critical subwatersheds (little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek,Patoka River-Fleming Creek).	All residents in the watershed	PLW Steering Committee, Coordinator & Volunteers	Years1-Years3	Number of completed surveys.	25k

3. Develop BMP Demo sites (e.g.,stream protection-silt/livestock fences, buffers, WASCOBS, wetlands, retention ponds, water gardens, and 2-cycle engine demo etc.)	Create and install exhibits, demonstration projects, and educational programs at public parks, forests, schools and other willing landowners throughout the watershed	All residents in the watershed, homeowner associations	PLW Steering Committee & Volunteers, IDNR, CORE, local school boards, US FS.	Years1-Years3	Number of educational exhibit sites. Number of outreach events hosted. Increase in environmental stewardship. Number of visitors.	200k
	Increase watershed residents' knowledge and understanding of their watershed and its resources in order to induce behavioral change by advertising and promoting demonstration site location and activities.	All residents in the watershed, local newspapers, TV & Radio stations, local businesses	PLW Steering Committee, Coordinator & Volunteers	Years1-Years3	Distributed pre & Post-Community surveys. Development of education material. Increase in watershed stewardship. Number of site activity days.	35k
4. Develop an educational program to educate homeowners on the proper maintenance of their on-site septic systems. Demonstrations sites and field tours of working, non-working and alternative on-site septic systems will aid in stakeholder education.	Determine & map the number of unsewered areas near streams and sewer problem areas.	Landowners w/ septic or no waste disposal systems	PLW Steering Committee & Volunteers, County Health Departments	Years1-Years5	Creation of a map showing the location of unsewered areas in the watershed. Development of a mailing list of landowners w/ septic systems.	50k
	Develop educational materials on the proper maintenance of septics and distribute throughout the watershed.	Homeowners throughout the watershed and septic maintenance businesses	PLW Steering Committee & Volunteers	Years1-Years3	Number of educational packets distributed.	50k
	Develop alternative waste management educational demonstration sites that promote alternatives to conventional on-site waste disposal.	Landowners throughout the watershed, Septic businesses	PLW Steering Committee & Volunteers and local Health depts.	Years1-10	Number of installed, replaced or maintained septic systems. Number of alternative systems installed.	100k
	Work w/ local gov't to encourage policies of hook up to local central sewage systems where available.	Landowners throughout the watershed, County planning Commissions, County Health Departments, PL W&SD	PLW Steering Committee & Volunteers, County Planning Commissions, Patoka Lake Regional W&S Dist., and local Health depts.	Years1-5	Number of new hook ups to the Patoka Lake Regional Water & Sewer Dist.	25k

(4) Reduce Atrazine loads in Patoka Lake Watershed.

Problem: Although monitored on a very limited basis, concentrations of Atrazine in a Patoka Lake Watershed stream has exceeded the USEPA standard of 0.003 mg/L, which threatens Patoka Lake's use as a drinking water source.
Management Goal: Additional monitoring shall be done throughout the Patoka Lake Watershed to determine if Atrazine pollution is a valid concern. However, we know that Atrazine is the most widely used pesticide for corn production within the Patoka Lake Watershed. Therefore, an effort to work with corn producers to educate them on the negative effects of Atrazine and the importance of installing runoff reducing BMPs on their crop land will be made.

Objective (in order of importance)	Action Item	Stakeholders	Responsible Party	Schedule	Indicators	Estimated Cost
1. Develop Educational Programs for corn producers and pesticide applicators on the many incentives (e.g. cost-share programs, land stewards, liability, etc. for proper application practices. Applicators and Stakeholders alike need to know the negative and positive effects pesticide applications have on the environment and human health.	Work w/ Dubois, Crawford and Orange Counties SWCDs, Health Departments, ISDA, and IDNR to identify partners.	Agricultural landowners, Applicators, Agencies, and Ag equipment suppliers, Pesticide companies	PLW Steering Committee & Volunteers, ISDA, NRCS, SWCDs, PU Ext.	Year1-Year 5	Identification of educational providers and tools. ID of landowners amenable to BMP Installation. Create list of landowners whose land overlaps a critical area and maintain list of partners and possible partners.	5k
	Develop educational materials (e.g. brochures& fact sheets) on Atrazine application and alternative pesticides.	Agricultural landowners, Applicators, Agencies, and Ag equipment suppliers, Pesticide companies	PLW Steering Committee & Volunteers, ISDA, NRCS, SWCDs, PU Ext.	Year1-Year 3	Number of educational material distributed. Number of meetings w/ Ag landowners. Reduction in Atrazine application.	10k
	Develop relationships that foster corporate and group stewardship by offering and promoting educational workshops and demonstration sites to corn producers that promote the economic value of installing BMPs that reduce pesticide runoff and the overall effect BMPs could have on the Patoka Lake Watershed.	Ag landowners, Schools, Homeowners, Park Patrons, and developers	PLW Steering Committee & Volunteers, ISDA, NRCS, SWCDs, PU Ext.	Years1-Years10	Number of educational events held. Attendance at educational events.	35k

	Promote & host Hoosier riverwatch training programs for the development of the volunteer monitoring network, including the purchase and storage of sampling and training equipment/supplies.	All residents in the watershed	PLW Steering Committee & Volunteers, Hoosier Riverwatch, Patoka Lake Regional Water District	Years1-Years3	Creation of a water quality database. Number of attendees at training events. Number of sample sites. Number of volunteer monitors.	40k
2. Promote whole farm planning by helping farm owners and operators achieve their production and natural resource conservation goals through the development and implementation of a comprehensive nutrient management plan. Plans are site specific and will outline management strategies for the proper operation of storage facilities, waste treatment and land applications processes. Identification of topography features, soil types, drainage courses, and nearest water sources will be mapped to reveal environmentally sensitive areas.	Work w/ IDEM, ISDA, NRCS, and SWCDs to increase whole farm planning practices in an effort to reduce Atrazine loading from ag stormwater run-off.	Ag landowners	PLW Steering Committee & volunteers, IDEM, SWCDs	Year1-Year5	Document the number of farmers who have adopted whole farm planning practices. Create a list of specific ag landowners using atrazine and the quantities they use.	50k
	Identify specific ag landowners using Atrazine and the quantities they use.	Ag landowners	ISOC, SWCDs, Ag suppliers	Year 3+	Identification of landowners amenable to accommodating BMP Implementation.Create a list of specific ag landowners using atrazine and the quantities they use.	50k
	Work with NRCS, ISDA, and SWCDs to educate ag landowners to reduce fertilizer/pesticide application and/or change application practices by creating demonstration workshops that show the benefits of installing a combination of BMPs (e.g. buffers, filter strips, and alternative pesticides) and adjusting application rates.	Ag landowners	PLW Steering Committee & Volunteers, pesticide dealers, SWCD, ISDA, NRCS, IDNR	Year 1-Year 5	Decrease in the amount of ag fertilizers/pesticides applied in Patoka Lake Watershed and/or improved fertilizer/pesticide retention on farms. Increase in the amount of farms w/ developed and implemented Whole Farm Management.	75k

3. Promote currently available cost-share programs, as well as, develop and implement watershed specific cost-share programs for the installation of BMPs.	Provide cost-share funding for BMP installation, focusing efforts in the 4 critical subwatersheds (little Patoka River, Lick Creek-Ritter Creek, Patoka River-Painter Creek,Patoka River-Fleming Creek).	Corn producers	PLW Steering Committee, Coordinator & Volunteers, SWCD, ISDA, NRCS	Years1-Years15	Document the number of BMPs installed and projects implemented. Map completed projects. Reduction in the number of event flow water quality samples that exceed the targeted nutrient loads of 1.0 mg/L TN and 0.3 mg/L TP. Installation of BMPs on 75 % of the 4 subwatersheds total land acreage is estimated to reduce TN by 54% an TP by 50%.	300k
	BMP Installation that will reduce stormwater runoff from corn fields (e.g. filter strips, infiltration Basins, controlled drainage).	Ag and Residential Landowners	PLW Steering Committee & Volunteers, SWCDs	Years1-Years 15	Number of BMPs installed. Miles of installed or enhanced buffers and acres of infiltration basins.	300k
	Promoting watershed stewardship by creating and distributing informational brochures for corn producers that address the scope of the Atrazine problems and the role of the individual in reducing water quality impacts.	Corn producers throughout the Patoka Lake Watershed, SWCDs, NRCS, ISDA	PLW Steering Committee & Volunteers, NRCS, ISDA, SWCD, PU Ext., pesticide dealers, ISOC	Years1-Years5	Number of educational material created and distributed.	50k
	Work w/ SWCDs and NRCS to identify partners throughout the Patoka Lake Watershed that own land amenable to BMP installation that will control atrazine runoff.	CORN producers throughout the watershed	PLW Steering Committee & Volunteers	Years1-Years3	ID of landowners amenable to BMP Installation. Create list of landowners whose land overlaps a critical area and maintain list of partners and possible partners.	5k

4. Promote use of alternative and/or environmental friendly pesticides	Work w/ NRCS, ISDA and SWCDs to determine feasible alternatives to Atrazine.	Ag landowners	PLW Steering Committee & Volunteers, ISOC, SWCDs, Ag suppliers	Year 1- year 5	Inclusion of information into educational material and programs. Increase the amount of ag fields using whole farm practices and alternative pesticides.	5k
	Work with NRCS, ISDA, and SWCDs to educate ag landowners to reduce fertilizer/pesticide application and/or change application practices by creating demonstration workshops that show the benefits of using alternative pesticides and adjusting application rates.	Corn producers	PLW Steering Committee & Volunteers, pesticide dealers, SWCD, ISDA, NRCS, IDNR	Year 1-Year 5	Decrease in the amount of ag fertilizers/pesticides applied in Patoka Lake Watershed and/or improved fertilizer/pesticide retention on farms. Increase in the amount of farms w/ developed and implemented Whole Farm Management.	75k

10. Source Water Protection Plan Implementation

The overall goal of the Patoka Lake Watershed stakeholders is to improve water quality in the Patoka Lake Watershed. Given the rapid rate of growth in the watershed, without significant investment in watershed Best Management Practices (BMPs) and education and outreach programs, it is likely that water quality will continue to degrade. Our ultimate goal is to have Patoka Lake Watershed meet all state water quality standards, reduce nutrient loads to the point that Patoka Reservoir's trophic status can be improved to Oligotrophic with an associated decrease in algal blooms, and improve both riparian and aquatic habitat so that macroinvertebrates and fish population native to the watershed can thrive.

To achieve these water quality goals and maintain them in a sustainable fashion, the Patoka Lake Watershed Stakeholders envisions a multi-pronged approach to water resource sustainability. The first is through a series of watershed BMPs and associated demonstration projects. BMP installation projects will be implemented throughout the watershed, with concentrated efforts focused in Lick Creek-Ritter Creek, Little Patoka River, Patoka River-Painter Creek, and Patoka River-Fleming Creek sub-watersheds.

Load Reductions

Water quality improvements will focus on load reductions (Goals 1, 2 &4). As the majority of loading for most contaminants in most subwatersheds occurred during event flows, a reduction in the number of times event flow contaminant concentration exceeds water quality indicator thresholds should result in a decrease in the contaminant load and an improvement in watershed quality. Therefore, water quality improvement in the Patoka Lake Watershed focuses on restoring natural stream filters, such as vegetative and riparian buffers. These remediations should slow and/or reduce water run-off to streams and remove pesticides, herbicides, nutrients, and sediment from the water before entering the stream. Water quality improvements will also be achieved through source reductions: reducing sediment load from livestock facilitated bank erosion through the installation of fencing along stream corridors, reducing agricultural chemical usage and run-off through the promotion of Whole Farm Planning, and reducing nutrient load from point sources through cooperative initiatives and improved technology.

Education and Outreach

Concomitant with the *in-situ* remediation projects, several complimentary watershed education projects will be initiated (Goal 3). These will include, but not limited to:

1. Establishing a volunteer monitoring network will be coordinated through the DNR's Hoosier Riverwatch program. This program will encourage individuals to participate in a watershed-wide water quality testing program.
2. Creating and delivering watershed education programs throughout the Patoka Lake Watershed. Education and outreach specialist from county SWCDs, the watershed coordinator, and the Patoka Lake Regional Water & Sewer District will create program materials and partner in program delivery. This program will target schools, homeowner groups, ag producers, park patrons, and developers in an effort to prevent further degradation of resources.

3. Encouraging septic system maintenance through the creation of a septic system information campaign. This program will disseminate information in the form of brochures to homeowners and businesses that service septic systems. The Watershed Coordinator and County Health Departments will work together to educate septic owners on problems with malfunctioning septic systems and maintenance requirements, ensuring that homeowners are informed and in compliance with septic system regulations adopted by Indiana in 1990 (Rule 410 IAC 6-8.1).
4. Promoting watershed stewardship by creating and distributing a set of watershed and NPS pollution informational brochures for the general public that address the scope of the problem and the role of the individual in reducing water quality impacts. Distribution will be via mailings, education programs, county park entrances, libraries, SWCD offices and businesses catering to recreational users.
5. Increase the availability of watershed water quality data, issues and events by establishing a newsletter.
6. Developing relationships that foster corporate and group stewardship by offering and promoting workshops to developers, planners and homeowners associations focused on the economic value of infiltration basins and the use of rain-gardens, WASCOBs and wetlands for watershed management.

11. Monitoring Indicators

Success in Watershed Planning requires a long-term, multi-faceted, and integrated approach, involving the dedicated involvement of all stakeholders: citizens, landowners, managers, researchers, schools, community groups and businesses that depend on a healthy watershed. Measuring success, therefore, involves tracking several indicators which have been divided into two major categories: Water Quality Improvements (Goals 1,2 & 4) and Education and Outreach Achievements (Goal 3). While these two categories are not exclusive-benefits from one will affect the other, they are separated for clarity.

Measuring Water Quality Improvements (Goals 1, 2 & 4)

Water quality improvements will be measured using two categories of indicators: Administrative and Ground Truth Indicators.

Administrative Indicators of Success

Administrative Indicators of success track the successful development of an infrastructure for improving water quality in the Watershed. This includes locating areas for best management practice (BMP) implementation, contacting landowners amenable to BMP implementation, and installing BMPs.

Ground Truth Indicators of Success

Ground Truth Indicators of success track the successful improvement of water quality in the Watershed. The success of implemented BMPs will be measured mainly by monitoring water quality and documenting changes in land-use/land cover in the subwatersheds. Changes in land-use/land cover will be loaded into the STEPL model to estimate nutrient and sediment load reductions. Water quality monitoring will begin in the four subwatersheds that were identified as contributing the most nutrient loads and will expand to other subwatersheds as additional vulnerable areas are identified and volunteer monitors become available. This will give the

Patoka Lake Steering Committee baseline (or before remediation) data. Monitoring will continue after installation of the recommended BMPs. While monitoring efforts will focus on contaminants of concern, namely nutrients (Total N & Total P) and Sediment (TSS), several other water quality parameters will be measured in the streams and Lake. These include Coliform bacteria, DO, Macro invertebrates, turbidity, total solids, temperature change, total phosphates, orthophosphate, pH, and nitrates. *In-situ* water quality parameters will be measured utilizing Hoosier Riverwatch trained monitoring volunteers and the HACH sampling kits. This data will allow for the calculation of contaminant loads in the stream and determination of longitudinal changes in water quality before and after BMP implementation.

The Army Corps of Engineers, Fish & Wildlife Service, IDEM and the Patoka Lake Regional Water & Sewer District also collect water quality parameters from Patoka Lake and its tributaries. This data will also be analyzed to give a better understanding of water quality trends within the Patoka Lake Watershed.

Measuring Education and Outreach Achievements
Education and outreach indicators of success track the successful development of an infrastructure for improving public awareness and education about water quality and water quality issues in the Watershed. This includes placing signs in the watershed, creating educational programs and workshops, creation of demonstration sites, treatment plant tours, clean-up days, public meetings, producing educational materials such as brochures & newsletters, and training of volunteer monitors.

12. Adapting and Evaluating the Plan

The Alliance of Indiana Rural Water in partnership with the Patoka Lake Regional Water & Sewer District and the many stakeholders of the Patoka Lake Watershed applied for a Section 319 grant for Phase I implementation, education and public outreach in the Patoka Lake Watershed to begin in the Spring of 2007. With this implementation grant, the group's purpose is to accomplish a series of initiatives including BMP implementation, demonstrations, monitoring, watershed education, and public information and outreach. A Watershed Coordinator position will be funded through the implementation grant. The position will ensure the coordination of stakeholder meetings, assistance to land owners, and the overall progress of implementation.

The Patoka Lake Watershed group will hold quarterly meetings to evaluate the plan implementation progress and assess success of the BMP installation, monitoring, and demonstration program, and outreach and education campaign. The SWP Plan will continue to be re-evaluated during the quarterly meetings and revisions/updates will be made by the watershed coordinator when appropriate.

The Alliance of Indiana Rural Water and the Patoka Lake Regional Water & Sewer District believes that the *SWP Plan for the Patoka Lake Watershed* will provide a good foundation from which more ambitious and holistic management initiatives can be developed. The Patoka Lake Watershed stakeholders should understand that while the proposed remediations detailed in this document may improve some water quality degradation, they fall short of re-creating a true sustainable aquatic ecosystem. As population demands for drinking water and land continue to stress these ecosystems, a balance must be struck, a common ground between resource use and resource conservation. Creating a sustainable aquatic ecosystem cannot happen unless there is a concerted effort by all stakeholders to change.