The Deep River/ Turkey Creek Watershed Management Plan

June 2002

City of Hobart , Indiana
414 Main Street
Hobart, Indiana 46342
(219) 942-6112

The Deep River/ Turkey Creek Watershed Management Plan

June 30, 2002

Developed for:

The City of Hobart, Indiana
Ms. Linda Buzinec, Mayor

Ms. Denarie A. Kane
Director of Development
414 Main Street
City of Hobart, IN 46342
(219)942-6112

Mr. Steve Truchan
City Engineer
414 Main Street
City of Hobart, IN 46342
(219)942-6112

Prepared by:

Goode & Associates, Inc.
Environmental Consulting
Watershed Coordination
Professional Staffing and Support Services

J.F. New & Associates
Ecological Consultants & Environmental Engineers

Steve Hall
Goode & Associates, Inc
5335 N. Tacoma Ave, Suite 6
Indianapolis, IN 46220
(317) 254-8235

Marianne Giolitto
J.F. New & Associates, Inc
708 Roosevelt Road
Walkerton, Indiana 46574
(219) 586-3400

Acknowledgements

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We would like to offer special thanks to the Mayors and Council Persons from the communities of Hobart, Merrillville, Crown Point, Winfield, Griffith, Schererville, Gary, Portage, New Chicago, and Lake Station for allowing their staff to partcipate in this planning effort. We realize that truly affecting change in the Deep River/ Turkey Creek watershed cannot occur without your willing participation and support.

We would also like to thank the members of the various Lake and Porter County governments who offered their knowledge, expertise, and advice during the development of this plan, especially the Lake County Surveyor's Office, the Lake and Porter County District Conservationist and SWCD representatives, and the Lake County Parks and Recreation Department.

Finally, we would like to thank Mr. Larry Osterholz of the IDNR and Mr. Matt Jarvis of the NRCS for their commitment to supporting the development of this plan, as well as the IDEM for their support and funding of this project.

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Distribution List – Watershed Plan Steering Committee

Salutation	First Name	Last Name	Representing
Mr.	Jeff	Greiner	Greiner Enterprises
Mr.	Greg	Bright	Indiana Lakes Management Society
Mr.	Pete	Julovich	Community Stakeholder
Ms.	Sandy	O'Brien	Community Stakeholder
Mr.	Craig	Zandstra	Lake County Parks Department
Mr.	Matt	Jarvis	IDEM/ NRCS
Mr.	Jeff	Ban	Crown Point City Engineer
Mr.	Stanley	Dobosz	Council Member, Town of Griffith
Mr.	George	Van Til	Lake County Surveyor
Mr.	Kevin	Breitzke	Porter County Surveyor
Mr.	Shawn	Pettit	Director of Operations, Town of Schererville
Mr.	Jerry	Kousen	Science Teacher, Hobart High School
Mr.	Steve	Fralish	Lake Station City Engineer
Mr.	Robert	Ellenberger	Council Member, City of Hobart
Ms.	Denarie	Kane	Director of Development, City of Hobart
Mr.	Taghi	Arshami	Planning Director, City of Gary
Mr.	Tris	Miles	Merrillville Town Engineer
Mr.	Craig	Hendrix	Portage City Engineer
Mr.	Steve	Truchan	Hobart City Engineer
Mr.	Chuck	Walker	Lake Co. District Conservationist
Mr.	Ron	Trigg	Shirley Heinze Environmental Fund

The Deep River/ Turkey Creek Watershed Management Plan

Executive Summary

The Deep River/ Turkey Creek watershed, identified as hydrologic unit coded (HUC) watershed 04040001030, covers a drainage area of approximately 124 square miles in northwestern Indiana, of which 104 square miles are located in Lake County, and 20 square miles are located in Porter County. The Deep River watershed covers a drainage area of 79.4 square miles and the Turkey Creek watershed covers a drainage area of 38.3 square miles. An additional 6.3 square miles drain directly to Lake George (Hoggatt, 1975).

The watershed encompasses areas of diverse land uses including significant agricultural areas in the southern portion of the watershed to predominately urban areas in the northern portion of the watershed. This region includes the communities of Hobart, Merrillville, Crown Point, and Winfield, Indiana, as well as touching upon small portions of other communities in the area, such as Griffith, Schererville, Gary, Portage, New Chicago, and Lake Station.

In the late 1980's, the City of Hobart, in partnership with a local private economic development organization, began a program to improve the community's quality of life and retain and expand business within the City that resulted in a multi-phased lakefront development and downtown revitalization plan. In the early 1990's, degrading water quality, recreational uses, and aesthetic issues began to pose a threat to the community's investments in lakefront and downtown revitalization efforts as a growing sedimentation problem in Lake George was becoming obvious. Accumulating sediments were precluding the use of the lake as a recreational resource for boating, degrading habitat for biological communities, and reducing recreational fishing opportunities in the lake. In addition, overgrowing plant life began to cause an aesthetic nuisance to lake residents and recreational enthusiasts.

As the result of community concerns, in 1993 the U.S. Army Corps of Engineers (USACE), Chicago District, initiated an extensive evaluation of Lake George and its major tributaries and later published a 1995 Planning/ Engineering feasibility report for the dredging of Lake George. The USACE report determined that the dredging of Lake George was feasible and economically viable. Consequently, in the spring of 2000 the City of Hobart proceeded with a limited dredging project for the lake. By the fall of 2000 the City had successfully removed more than 590,000 cubic yards of sediment from Lake George; however, the project was completed at a cost of more than two million dollars to the City of Hobart's taxpayers.

Since the success of the Lake George dredging project was achieved at a high cost to the community, officials with the City of Hobart began to evaluate potential options for protecting their public investments in the lake. As the City began to consider these options, it became apparent that in order to address the sediment loads to Lake George from the upstream tributaries of Deep River and Turkey Creek, there would be far reaching implications to achieving the desired reductions in sediment loadings.

In the fall of 2000, the City of Hobart applied to the Indiana Department of Environmental Management (IDEM) for a Section 319 Watershed Management Grant. During the summer of 2001, the City entered in to a contractual agreement with IDEM, and received 319 funding to begin the development of a Watershed Management Plan for Lake George and its watershed. The City of Hobart began formal watershed planning activities by forming a steering committee for the project, composed of a variety of stakeholders from throughout the Deep River/ Turkey Creek watershed. As a result of the concerns discussed by the Steering Committee and other stakeholders in the project, the committee decided on the following mission and goals for the project:

Mission: To minimize the introduction of sediment and other pollutants into Lake George by addressing local NPS issues and developing partnerships with neighboring communities, businesses, agricultural producers, and interested stakeholders.

Goals:

- Protect Lake George from future sediment and water quality impairments
- Improve water quality in Deep River/ Turkey Creek watersheds, upstream of Lake George
- Improve water quality education throughout the watershed
- Eliminate illegal discharges/ failing septic systems
- Promote consistency among communities developing stormwater programs

Watershed Approach

Although the study area for this project was orignially focused on the Deep River-Lake George (HU 04040001030060) watershed in Hobart, Indiana, participants in this planning effort recognized from the beginning that the water quality issues discussed impacting Lake George could not be adequately addressed without significant actions to manage pollutant loads from the larger Deep River/ Turkey Creek watershed. Rather than limiting the focus and scope of this planning effort to developing specific recommendations for water quality improvements within the Deep River-Lake George watershed and the City of Hobart, this plan also provides additional recommendations for improving water quality throughout the larger Deep River/ Turkey Creek watershed and encourages the development of sub-watershed specific planning efforts.

In addition to understanding the fundamentals of watershed based planning, the project's Steering Committee inherently understood the challenges of working across mulitple jurisdictions and the potential "turf" issues. In order to minimize these potential obstacles and build stronger partnerships throughout the watershed, the group recognized that the planning effort would need to establish and maintain a "shared" leadership structure and a unifying approach to tackling watershed wide issues. Consequently, although the grant for this project was applied for and received by the City of Hobart, the Steering Committee decided to title the project "The Deep River/ Turkey Creek Watershed Plan" to embody a truly watershed based perspective and to avoid association with only a single municipality within the watershed.

Summary of Findings

The water quality data evaluated for this project indicate that elevated concentrations/ loadings of nonpoint source pollutants are entering Lake George from both the Deep River and the Turkey subwatersheds as described below.

Deep River

In the Deep River subwatersheds, excessive pollutants, particularly total suspended solids, nutrients, and *E.coli* enter the study watershed from the upper portions of the Deep River subwatersheds. These findings appear to strongly correlate with the potential soil erodiblity (T factor) ratings and the presence of significant highly erodible lands (HEL) in the subwatersheds upstream of the Deep River – Lake George subwatershed.

In addition, when these observations are compared to land uses, there also appears to be a strong correlation between the agricultural land uses that dominate the areas upstream of the study watershed and the elevated concentrations of total suspended solids and nutrients identified through this study. Based upon these observations, management of agricultural and HELs in the upper portions (subwatersheds) of the Deep River watershed should be prioritized for installation of best management practices (BMPs) for controlling erosion/ sedimentation and nutrients.

BMPs planned for this region should be coordinated with the strategies currently under development by the Lake County Surveyor's Office for stormwater management and regional detention in the Deep River/ Turkey Creek watershed. By coordinating these efforts for reducing the volume of water entering the creek and reducing pollutant concentrations, the overall goal of improving and protecting water quality in the Deep River/ Turkey Creek watershed should become more realistically attainable.

Based on the water quality data collected for this project, management of the Deep River watershed should be prioritized due to the greater pollutant loadings being contributed to Lake George by this watershed.

Turkey Creek

In the Turkey Creek subwatersheds, *E.coli* concentrations appear to be the pollutant of most concern, as monitoring indicates both dry and wet weather violations, as well as the highest overall concentrations of *E.coli* (highest geometric mean) per IDEM's monitoring. Since both IDEM's monitoring and the monitoring completed from this project showed the highest concentrations of *E.coli* to be from upstream of State Road 53, an evaluation of land uses in this area seems to indicate that the E.coli measured at this site were generated from primarily urban or residential land uses.

Instream habitat ratings for the Turkey Creek subwatersheds suggest that channel modifications have diminished the ability of Turkey Creek to support viable biological communities. Habitat improvements within the subwatershed of Turkey Creek should result in measured improvements in fish and macroinvertebrate community scores.

Lake George

Although multiple lakefront redevelopment projects have transformed Lake George into a significant natural resource in downtown Hobart, Indiana, the lake is still plagued with poor water quality due to the NPS pollutant loads that the lake receives from Deep River and Turkey Creek. In addition to poor incoming water quality, the lake harbors a tremendous volume of historically deposited sediments in its upstream wetland areas. These sediments appear to become resuspended in the lake during significant rainfall events, further prolonging recovery of Lake George.

In 2000, dredging efforts removed nearly 600,000 cubic yards of sediment from the lake in a successful effort to improve the usability of the lake; however, additional shoreline stabilization efforts are a necessity for maintaining the depth of the lake, as well as the integrity of the City's public parklands. In addition, posted speed limits on the lake need to be more stringently enforced to minimize the affects of wave erosion on the lake's shoreline.

Streambank Erosion

Residential lawns line the banks of Deep River, Turkey Creek, and Duck Creek. Consequently, bank erosion exists at many of sites along these streams due to manicured turf grasses that lack the ability to stabilize the streambank due to their shallow root structures. In streamside areas, turf grasses should be replaced with deeper rooted herbaceous and shrub species. In open canopy areas there are a variety of low profile prairie species that will provide better bank stabilization while still allowing residents to view the river. In shadier areas, savanna species or native shrubs may be more appropriate. In addition to stabilizing banks, buffers around the creeks would filter overland pollutant runoff. Additional bank stabilization should be also considered for channelized areas of the creeks where the banks are unstable.

Floodplain Protection
The reduction in storm total suspended solid loads and many of the nutrient loads between sites 6 and 8 of the monitoring completed for the project suggests that the Deep River is depositing some of its pollutant loads in the floodplain during storm events. As a result, the riparian zone and floodplain areas between these sites are functioning and should be protected. Other areas in the creek's corridor should be examined to identify additional functioning riparian zones for potential protection or riparian zone restoration. In some cases, grade controls and bank reshaping may be necessary to reconnect the creek with its floodplain.

A functioning riparian zone will, in many cases, sequester nutrients and sediment better than on-line wetlands such as the one upstream of Lake George. Many of the same management techniques listed as applicable for the upper Deep River watershed can be applied to areas upstream of State Road 53 in the Turkey Creek subwatersheds and within the Deep River/ Turkey Creek watershed itself.

Stormwater Management
The magnitude of construction and development within the watershed has exacerbated historical problems associated with erosion and sedimentation in Lake George. Consequently, implementation of stormwater management programs by municipalities, especially local erosion and sediment controls, is seen as a necessity for addressing a portion of the significant NPS pollutant load reductions for sediment within the urbanized portions of the Deep River/ Turkey Creek watershed.

Principles of Watershed Management
Although the watershed planning efforts in the Deep River/ Turkey Creek Watershed grew out of community concerns for Lake George, stakeholders involved in the development of this watershed plan realize that initiating water quality improvements in Lake George will require a significant investment of time and resources throughout the larger Deep River/ Turkey Creek watershed.

Generally speaking, watershed management approaches can be divided into two categories: the "quick-fix" approach or "long-term management". Long-term watershed management considers all of the factors affecting a watershed and sets a higher priority on finding comprehensive, lasting solutions to water quality problems. As a result, high quality, financially efficient management projects take time and begin with long-range planning, such as the efforts documented in this plan. In some cases, immediate stream or lake restoration practices are also necessary; however, good management planning will ensure that such immediate restoration efforts are followed by appropriate long-term management practices.

Water Quality Priorities, Goals, and Targets
Based upon this principle of watershed management, a mix of preventive actions and immediate restoration efforts are included in the recommendations for the

Deep River/ Turkey Creek watershed. As a result of the priorities, goals and targets decided upon by watershed stakeholders, a "toolbox" of structural and non-structural management practices have been developed by the consulting team and presented to Steering Committee for the Deep River/ Turkey Creek Watershed Plan.

The complete list of preferred management practices, in order of priority and as selected by watershed stakeholders, is included in **Table 8-2** of this plan. The final recommendations were compiled and organized into the content of the watershed plan and presented in this "Final Draft" version to the Hobart City Council and the public on June 19, 2002.

With approval by the Hobart Board of Works, officials with the City of Hobart intend to apply for additional 319 grant funding in 2002 in order to begin implementation of these recommendations. The City of Hobart looks forward to working further with the Steering Committee and additional stakeholders in the Deep River/ Turkey Creek Watershed towards achieving the mission of this planning effort, which is "to minimize the introduction of sediment and other pollutants into Lake George by addressing local NPS issues and developing partnerships with neighboring communities, businesses, agricultural producers, and interested stakeholders."

I. Introduction

Study Area

The Deep River/ Turkey Creek watershed, identified as hydrologic unit coded (HUC) watershed 04040001030, covers a drainage area of approximately 124 square miles in northwestern Indiana, of which 104 square miles are located in Lake County, and 20 square miles are located in Porter County. The Deep River watershed covers a drainage area of 79.4 square miles and the Turkey Creek watershed covers a drainage area of 38.3 square miles. An additional 6.3 square miles drain directly to Lake George (Hoggatt, 1975).

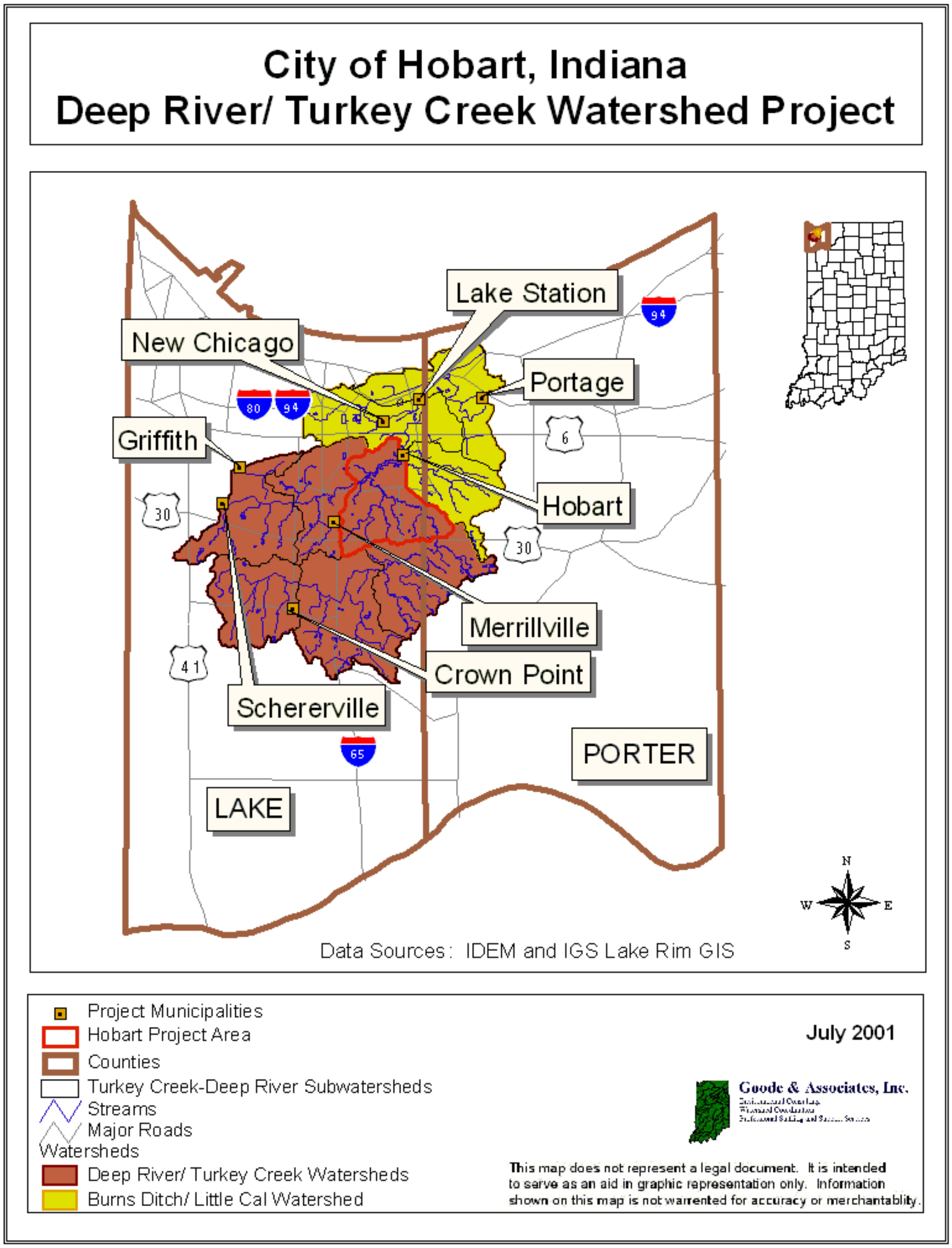
As illustrated in **Figure 1-1**, Turkey Creek and its tributaries drain the northwestern part of the watershed into the upper end of Lake George. Deep River and its major tributaries, Beaver Dam Ditch and Niles Ditch, drain the southern and eastern parts of the watershed before flowing into Lake George. Deep River flows through Lake George and continues through Hobart, Lake Station, and East Gary, Indiana, draining the Deep River/ Turkey Creek watershed into Burns Ditch. A majority of the major stream channels in the area are no longer in a natural state, as all have undergone stream channel alteration and many have been completely constructed or reconstructed for drainage purposes.

In addition to Deep River and Turkey Creek, the other significant water feature within the study area is Lake George, which is located within the City of Hobart. Lake George is a manmade lake that was created by the damming of Deep River circa 1840 by George Earle for a gristmill and community water supply. Today, Lake George is considered to be the central feature in the City of Hobart and has been the focus of significant downtown revitalization and economic development initiatives for the community.

Lake George, as well as the majority of the City of Hobart, is located within the Deep River-Lake George Dam hydrologic unit (HUC 04040001030060), which covers approximately 12,879.1 acres in portions of Lake and Porter Counties in northwest Indiana (See **Figure 1-1**). This HU is a subwatershed of the greater Deep River/ Turkey Creek watershed (HUC 04040001030), which encompasses approximately 79,433.7 acres.

The Deep River/ Turkey Creek watershed encompasses areas of diverse land uses including significant agricultural areas in the southern portion of the watershed to predominately urban areas in the northern portion of the watershed. This region includes the communities of Hobart, Merrillville, Crown Point, and Winfield, Indiana, as well as touching upon small portions of other communities in the area, such as Griffith, Schererville, Gary, Portage, New Chicago, and Lake Station.

Figure 1-1: Deep River/ Turkey Creek Watershed



Evolution of Watershed Planning Efforts for Lake George, Deep River, and Turkey Creek

In the late 1980's, the City of Hobart, in partnership with a local private economic development organization, began a program to improve the community's quality of life and retain and expand business within the City that resulted in a multi-phased lakefront development and downtown revitalization plan. As the central natural feature in the City of Hobart, Lake George became the focus of this partnership, which has resulted in the conversion of a lakeside dump and landfill into what is now known as Festival Park. In 1988, Festival Park was dedicated as part of a community wide festival that was the precursor to Hobart's annual Lakefront Festival. In addition, in 1990, a footbridge was built over the Lake George dam to connect Festival Park to downtown Hobart and other planned lakeside improvement projects.

In a continuing focus on revitalization of Lake George, the City of Hobart received several grants form the Indiana Department of Natural Resources (IDNR), as well as the Indiana Department of Transportation (INDOT), to help construct Phase II of the City's lakefront development plan, Lakefront Park. In addition, the City's first ever park bond was issued to supplement these grants in conjunction with generous private donations. In 1997, Lakefront Park was completed as a complementary extension to Festival Park (See **Figure 1-2**).

The lakefront park system now consists of brick pathways that were built on top of a three block long sea wall that was installed to expand the available parkland. New public parking areas were created behind downtown businesses and a fishing pier with gazebo clock tower, benches, and decorative lighting were also included in the Lakefront Park improvements. The project also added a covered bridge over the lake's dam, a boat launch and a canoe portage, and an entrance plaza with a fountain and a bandshell. These projects were all constructed in conjunction with installation of sea walls to control the lakeshore erosion that was becoming prevalent along the northeast shoreline of Lake George.

In the early 1990's, degrading water quality, recreational uses, and aesthetic issues began to pose a threat to the community's investments in lakefront and downtown revitalization efforts as a growing sedimentation problem in Lake George was becoming obvious. In many areas Lake George had filled with sediments from a historical average depth of 6-8 feet to an average depth of 1-3 feet. Accumulating sediments were precluding the use of the lake as a recreational resource for boating, degrading habitat for biological communities, and reducing recreational fishing opportunities in the lake. In addition, overgrowing plant life began to cause an aesthetic nuisance to lake residents and recreational enthusiasts.

Figure 1-2: City of Hobart, Indiana, Lakefront Park Area

As the result of community concerns, in 1993 the U.S. Army Corps of Engineers (USACE), Chicago District, initiated an extensive evaluation of Lake George and its major tributaries and later published a 1995 Planning/ Engineering feasibility report for the dredging of Lake George. This report was developed to determine the technical and economic feasibility for "removal of silt, aquatic growth, and other material and construction of silt traps or other devices to prevent and abate the deposit of sediment in Lake George" (USACE).

In this study, the Army Corp concluded that Lake George had "trapped large quantities of fine sediment from upstream agricultural areas, reducing water depths, making the lake bottom softer and the water murkier." In addition, the report noted that "Lake George has filled in with sediments, most likely from intensive agricultural production and development construction" and later concluded that "Lake residents are not happy with these conditions, as they interfere with boating, swimming, fishing and clarity of the lake" (USACE).

The USACE report determined that the dredging of Lake George was feasible and economically viable. Consequently, in the spring of 2000 the City of Hobart proceeded with a limited dredging project for the lake. Although dredging was limited from the extent of the original project proposal due to costs and wetland regulations, by the fall of 2000 the City had successfully removed more than 590,000 cubic yards of sediment from Lake George; however, the project was completed at a cost of more than two million dollars to the City of Hobart's taxpayers. These monies had been included in the $3.8 million dollar park bond that had also funded development of Lakefront Park.

Since the success of the Lake George dredging project was achieved at a high cost to the community, officials with the City of Hobart began to evaluate potential options for protecting their public investments in the lake. As the City began to consider these options, it became apparent that in order to address the sediment loads to Lake George from the upstream tributaries of Deep River and Turkey Creek, there would be far reaching implications to achieving the desired reductions in sediment loadings.

Compounding the difficulties associated with reducing the introduction of sediments into Lake George is the fact that the City of Hobart lies within a predominantly urban landscape. Its municipal boundaries border the neighboring communities of Gary, Merrillville, Lake Station, New Chicago, Portage, and unincorporated portions of Lake and Porter County. In addition, the Deep River and Turkey Creek watersheds that drain into Lake George, although dominated by urban landscapes in some reaches, are also largely impacted by significant portions of agricultural land uses.

Consequently, it was very apparent to officials at the City of Hobart that managing their water resource needs would be complex and challenging due to the variety of urban landscapes, multiple political jurisdictions, and upstream farming practices that were providing significant contributions to local water quality problems.

319 Grant

In the fall of 2000, the City of Hobart applied to the Indiana Department of Environmental Management (IDEM) for a Section 319 Watershed Management Grant. During the summer of 2001, the City entered in to a contractual agreement with IDEM, and received 319 funding to begin the development of a Watershed Management Plan for Lake George and its watershed.

The City of Hobart began formal watershed planning activities by forming a steering committee for the project, composed of a variety of stakeholders from throughout the Deep River/ Turkey Creek watershed. The following table lists the board members selected to guide this project.

Table 1-1: Watershed Plan Steering Committee Members

Salutation	First Name	Last Name	Representing
Mr.	Jeff	Greiner	Greiner Enterprises
Mr.	Greg	Bright	Indiana Lakes Management Society
Mr.	Pete	Julovich	Community Stakeholder
Ms.	Sandy	O'Brien	Community Stakeholder
Mr.	Craig	Zandstra	Lake County Parks Department
Mr.	Matt	Jarvis	IDEM/ NRCS
Mr.	Jeff	Ban	Crown Point City Engineer
Mr.	Stanley	Dobosz	Council Member, Town of Griffith
Mr.	George	Van Til	Lake County Surveyor
Mr.	Kevin	Breitzke	Porter County Surveyor
Mr.	Shawn	Pettit	Director of Operations, Town of Schererville
Mr.	Jerry	Kousen	Science Teacher, Hobart High School
Mr.	Steve	Fralish	Lake Station City Engineer
Mr.	Robert	Ellenberger	Council Member, City of Hobart
Ms.	Denarie	Kane	Director of Development, City of Hobart
Mr.	Taghi	Arshami	Planning Director, City of Gary
Mr.	Tris	Miles	Merrillville Town Engineer
Mr.	Craig	Hendrix	Portage City Engineer
Mr.	Steve	Truchan	Hobart City Engineer
Mr.	Chuck	Walker	Lake Co. District Conservationist
Mr.	Ron	Trigg	Shirley Heinze Environmental Fund

On August 29, 2001, the City of Hobart hosted its first public meeting to discuss the 319 grant received by the City and reviewed the City's goals for developing a watershed management plan. The Steering Committee members then shared their goals for the project and opened discussion with the public in order to develop a more broad sense of the water quality concerns and goals of the stakeholders in the project. After a series of discussions, the following water quality and land use concerns were identified as issues that needed to be addressed in the project:

Table 1-2: Water Quality Concerns

Contaminated sediments in Lake George
Drinking water protection
Effects of development on water quality, especially erosion and sedimentation
Expansion of local wastewater treatment plants
Failing septic systems
Illegal discharges
Impact of wildlife on water quality (geese/ ducks)
Lack of general public and school water quality education programs
Lack of local water quality monitoring data
Lack of recreational uses of Lake George, Deep River, and Turkey Creek
Need for consistency as Stormwater Management Programs (SW Phase II)
Preservation of critical lands that provide water quality benefits, especially wetlands
Public health implications of increasing public access to Lake George, Deep River, and Turkey Creek for recreational boating and canoeing
Public health implications of swimming in Lake George, Deep River, and Turkey Creek
Sedimentation in Lake George and downstream portions of Deep River/ Burns Ditch
Water quality impacts of diminishing native plants, animals, landscapes, i.e. ETR species

As a result of the concerns discussed by the Steering Committee and other stakeholders in the project, the committee decided on the following mission and goals for the project:

Mission: To minimize the introduction of sediment and other pollutants into Lake George by addressing local NPS issues and developing partnerships with neighboring communities, businesses, agricultural producers, and interested stakeholders.

Goals:
- Protect Lake George from future sediment and water quality impairments
- Improve water quality in Deep River/ Turkey Creek watersheds, upstream of Lake George
- Improve water quality education throughout the watershed
- Eliminate illegal discharges/ failing septic systems
- Promote consistency among communities developing stormwater programs

With a clear mission statement and goals in mind, the Steering Committee decided to establish two subcommittees to facilitate effective information gathering and decision making for the project. The subcommittees and the responsibilities were established as follows:

- **Technical Subcommittee** – The technical committee consisted of the stakeholders interested in guiding the development of the surface water quality monitoring program. This committee was responsible for deciding upon the parameters to be monitored by the project team and for recommending monitoring locations within the watershed. This committee was also responsible for identifying and providing data sources that would be used by the project team to document current and historical water quality impairments and threats within the watershed.

Table 1-3: Technical Subcommittee Members

Salutation	First Name	Last Name	Representing
Mr.	Doris	Blaney	Community Stakeholder
Mr.	Kevin	Breitzke	Porter County Surveyor
Mr.	Greg	Bright	Indiana Lakes Management Society
Mr.	Dan	Fleming	Porter County SWCD/ NW Territory RC&D
Mr.	Steve	Fralish	Lake Station City Engineer
Ms.	Jennifer	Gadzala	NIRPC – Regional Planning Agency
Ms.	Marianne	Giolitto	J.F. New & Associates, Inc
Mr.	Stephen	Hall	Goode & Associates, Inc.
Mr.	Jeff	Janizek	Merrillville Stormwater Board
Mr.	Pete	Julovich	Community Stakeholder
Ms.	Louise	Karwowski	Community Stakeholder
Mr.	Jerry	Kousen	Hobart High School
Mr.	Carroll	Lewis	Community Stakeholder
Mr.	Joseph	Mladenik	Community Stakeholder
Ms.	Sandy	O'Brien	Community Stakeholder
Mr.	Larry	Shrader	Community Stakeholder
Mr.	Steve	Truchan	Hobart City Engineer

- **Land Use/ Planning Subcommittee** – The land use/ planning committee consisted primarily of the Lake and Porter County planning staff, surveyors, and regional planning authorities, as well as interested stakeholders from the community. In addition, this committee included municipal planning and engineering staff persons that were considered to be knowledgeable about the growth and development patterns within their respective communities. This committee was responsible for identifying environmentally sensitive areas where community and regional growth and development patterns were promoting development in close proximity to waterbodies with water quality impairments. In addition, the committee was responsible for providing information to the project team regarding each participating community's economic development strategies and incentive areas within the watershed so that the project team could identify situations where communities were promoting growth and development near environmentally sensitive areas.

Table 1-4: Land Use/ Planning Subcommittee

Salutation	First Name	Last Name	Title	Representing
Mr.	Taghi	Arshami	Planning Director	City of Gary
Mr.	Jeff	Ban	City Engineer	City of Crown Point
Mr.	Kevin	Breitzke	Surveyor	Porter County
Mr.	Dan	Fleming	Director	NW Territory RC&D
Mr.	Steve	Fralish	City Engineer	City of Lake Station
Ms.	Jennifer	Gadzala	Environmental Planner	NIRPC
Mr.	Jeff	Greiner	Director	Greiner Development
Mr.	Craig	Hendrix	City Engineer	City of Portage
Ms.	Janet	Herrick	Park Board President	Hobart Park Board
Ms.	Denarie	Kane	Director of Development	City of Hobart
Mr.	Tris	Miles	Town Engineer	Town of Merrillville
Ms.	Sandy	O'Brien	Community Stakeholder	
Mr.	Larry	Osterholz	Stormwater Specialist	DNR - Division of Soil Conservation
Mr.	Shawn	Pettit	Director of Operations	Town of Schererville
Mr.	Ron	Trigg	Executive Director	Shirley Heinze Environmental Fund
Mr.	Steve	Truchan	City Engineer	City of Hobart
Mr.	Chuck	Walker	District Conservationist	NRCS - Lake/ Porter Counties, Indiana
Mr.	Craig	Zandstra	Park Planner	Lake County Parks

Public Participation

In order to continue encouraging participation by additional stakeholders, the City of Hobart developed press releases announcing all steering committee and subcommittee meetings as being open to the public and provided the press releases to local newspapers and media outlets for all committee and subcommittee meetings. All meetings for the project were open to the public. Examples of press releases that were developed for these public meetings are included in **Appendix 1-1**. In addition, the City of Hobart also produced articles for magazines that were published by the Indiana Lakes Management Society.

Watershed Approach

Although the study area for this project is focused on the Deep River/ Lake George (HU 04040001030060) watershed in Hobart, Indiana, participants in this planning effort recognized from the beginning that the water quality issues discussed within this plan could not be adequately addressed without significant actions to manage pollutant loads from the larger Deep River/ Turkey Creek watershed. Rather than limiting the focus and scope of this planning effort to developing specific recommendations for water quality improvements within the Deep River-Lake George watershed and the City of Hobart, this plan also provides additional recommendations for improving water quality throughout the larger Deep River/ Turkey Creek watershed and encourages the development of sub-watershed specific planning efforts.

In addition to understanding the fundamentals of watershed based planning, the project's Steering Committee inherently understood the challenges of working across mulitple jurisdictions and the potential for generating "turf" issues. In order to minimize these potential obstacles and build stronger partnerships throughout the watershed, the group recognized that the planning effort would need to establish and maintain a "shared" leadership structure and a unifying approach to tackling watershed wide issues. Consequently, although the grant for this project was applied for and received by the City of Hobart, the Steering Committee decided to title the project "The Deep River/ Turkey Creek Watershed Plan" to embody a truly watershed based perspective and to avoid association with only a single municipality within the watershed.

II. Watershed Description & History

Geologic History

Glaciation

The geography of northwest Indiana is largely a product of the extreme climatological and geological events that have shaped the surficial geology and topography of the Lake Michigan Region.

The Wisconsin Age glaciers of the Pleistocene Epoch played the primary role in influencing the surficial geology of this region through several stages of glacial deposition and erosion. Due to general warming of the climate and intermittent periods of cooling that occurred between 25,000 and 14,000 years ago, the Lake Michigan lobe of the Wisconsin glacier experienced three major advances and retreats from its front edge, which was located near Indianapolis, Indiana about 25,000 years ago, to what is now the northern Lake County area within northwestern Indiana (DNR, 1994).

As a result of these major glacial advances and recessions, unconsolidated sediments cover the bedrock features present throughout Lake and Porter Counties. This glacial activity resulted in the deposition of three significant moraines consisting of ground up, eroded bedrock materials: the Valparaiso Moraine, the Tinley Moraine, and the Lake Michigan Border Moraine.

Within these moraines, the soil mantel covering the bedrock is typically 50 to 150 feet thick. Broad till plains and morainal deposits of finer grained soils are interrupted by outwash deposits and outwash plains consisting of more granular materials. Near Lake Michigan, dune and beach sand deposits, inland lake deposits and organic deposits are common, the result of poorly developed drainage systems.

Ancient Lakes

In addition to the glaciation of the Wisconsin Age, the coastal features of the ancient lakes (Lake Calumet, Lake Algonquin, Lake Chippewa, Lake Nipissing, etc.) continued to have significant impacts on the development of land topography and river channel formation, as well as the shaping of modern day Lake Michigan and other prominent coastal features of northern Indiana (DNR, 1994). These impacts were the result of the climatological warming trends of the period (13,000 to 2,000 years ago). During this period, lake levels experienced substantial changes in elevation due to the freezing and thawing of the northern glaciers. As a result, each major change in lake stage deposited or rearranged previous sedimentary deposits on top of glacially deposited moraine till materials.

It is during this period that dunes became increasingly important landscape features.

Bedrock

Two principal features control regional bedrock structure in the Lake Michigan Region: the Kankakee Arch to the southwest and the Michigan Basin to the northeast. Sedimentary rocks dip away form the northern flank of the Kankakee Arch toward the Michigan Basin at an average rate of about 35 feet per mile (DNR, 1994).

Bedrock in the Deep River/ Turkey Creek watershed consists of Devonian and Mississippian shale and Devonian limestone and dolomite. The bedrock surface topography does not resemble the present surface topography, but has gentle relief and drains in a north or northeasterly direction (USGS, 1994).

Natural History

Pre-settlement conditions within Lake and Porter Counties in northwestern Indiana provided an incredible diversity of natural features and habitats for many different species of flora and fauna. Much of the original natural features of the region have been lost to development, with a few notable exceptions, such as the National Lakeshore, Dunes National Park, and the Hobart Prairie Grove.

For a period of approximately 3,000 years, beginning about 12,000 years ago, the rim region's ecosystem underwent a series of dramatic changes (Adams, 2000). As conditions became warmer and wetter, the ice-sheets of the Wisconsin glacial era retreated, transforming the newly exposed terrain into a cold, tundra-like region, seasonally laced with rapidly flowing streams of melt-water. This tundra in turn gave way to boreal forests dominated by spruce, fir and paper birch. As the climate continued to warm, these forests were transformed into mixed deciduous-coniferous forests dominated by oaks and white pine (AES, 2001, Petty and Jackson, 1966).

At the present time, Indiana's rim region is part of the "prairie peninsula" (Transeau, 1935). This region, which extends through Indiana as far east as Pennsylvania and as far south as Kentucky and Tennessee, consists of an archipelago of shifting prairie "islands" within a matrix of forest (AES, 2001).

What makes the rim region unique is the way in which Lake Michigan and the region's dune-swale topography has stratified these habitats. The interplay of grasslands and forests throughout the eastern United States typically assume chaotic, shifting, fractal configurations resembling ice on a pane of glass.

Throughout the rim region, however, the plant communities are organized into relatively clear strata arranged on a north-south axis. A walk southward through an undisturbed portion of the Indiana's southern rim region would typically reveal the following succession of habitat: 1) beaches, which contain little or no rooted vegetation; 2.) fore-dunes and "blowouts", which are dominated by dune grasses, in particular Ammophila, and occasional shrubs such as beach plum. Beyond the dunes, later successional communities dominate, in particular black-oak savannas with periodic blowouts, prairie openings and stands of jack and white pine. Further south, the landscape is dominated by oak-hickory forests, which are periodically interrupted by swamps, marshes, bogs and other types of wetlands (AES, 2001).

Soils

Three main types of surficial deposits are dominant in the Deep River/ Turkey Creek watershed portions of Lake and Porter Counties, Indiana: clean sands and associated still water deposits, clayey till and end moraine deposits of predominantly clayey soils, and granular soils, muck and marl associated with outwash deposits. The northern most third of the region lying adjacent to Lake Michigan and bordered on the south by U.S. 30 consists of beach sands, soft saturated clay and muck soils. The central portion of the County, south of U.S. 30 is predominantly silty clay glacial till with localized outwash and lacustrine deposits of muck and clay. The deposits of clay till found south of U.S. 30 are typically on the order of ten to twenty feet thick (US ACOE, 1995).

Soil associations in the Deep River/ Turkey Creek watershed are of four main types. The northern portion of the watershed is composed of two soil associations: the Alida-Del Rey-Whitaker association and the Plainfield-Watseka association. The Alida-Del Rey Whitacker association consists of nearly level and somewhat poorly drained lands with moderately coarse textured and medium textured soils that formed in glacial outwash and lake sediments. The Plainfield-Watseka association consists of moderately sloping to nearly level lands with excessively to somewhat poorly drained soils that formed in the coarse-textured glacial outwash (USDA, SCS, 1971).

The southern portion of the watershed is also composed of two soil associations: the Morley-Blount-Pewamo association and the Elliott-Markham-Pewamo association. The Morley-Blount-Pewamo association consists of steep to nearly level lands that are moderately well drained to poorly drained soils that formed in moderately fine textured glacial till. The Elliott-Markham-Pewamo association consists of nearly level and gently sloping lands that are well drained to poorly drained soils that formed in moderately fine textured glacial till (USDA, SCS, 1971).

Highly Erodible Lands (HEL)

The Natural Resources Conservation Service (NRCS) uses the soil erodibility index (EI) to provide a numerical expression of the potential for a soil to erode considering the physical and chemical properties of the soil and the climatic conditions where it is located. As a result, the basis for identifying highly erodible land is the erodibility index of a soil map unit.

The erodibility index of a soil is determined by dividing the potential erodibility for each soil by the soil loss tolerance (T) value established for the soil. The T value represents the maximum annual rate of soil erosion that could take place without causing a decline in long-term productivity. The higher the index value, the greater the investment needed to maintain the sustainability of the soil resource base if intensively cropped (See **Figure 2-1**). Erodibility index scores equal to or greater than 8 are considered to be highly erodible land (NRI, 1992).

Highly erodible lands within the Deep River/ Turkey Creek watershed are primarily associated with the Morley-Blount-Pewamo soil associations. The following soils are considered to have HEL classifications in Lake and Porter Counties:

Table 2-1: U.S. Department of Agriculture, Lake Co. Highly Erodible Lands

Symbol	Component Name	HEL Classification	Slope Length	% Slope
MuB	Morley	1	200	4
MuC2	Morley	1	200	9
MuD2	Morley	1	150	15
MuE	Morley	1	150	21
MvB3	Morley	2	200	4
MvC3	Morley	1	200	9
MvE3	Morley	1	150	21
OaE	Oakville	2	100	18
OsB	Oshtemo	2	250	4
OsC	Oshtemo	2	200	9
PlC	Plainfield	2	100	9
TcB	Tracy	2	350	4
TcC	Tracy	1	250	9
TrB	Tracy	2	350	4

Although the NRCS is scheduled to complete a GIS based digital soil survey in the next 5 years that will allow for more accurate mapping of highly erodible lands (HEL) Deep River/ Turkey Creek watershed, HELs were digitized and mapped for the Deep River-Lake George subwatershed to fulfill contractual requirements of the City of Hobart's 319 grant. In all, the Deep River – Lake George subwatershed contains approximately 248 acres of HEL. Highly erodible lands in the Deep River-Lake George subwatershed are illustrated in **Figure 2-2**)

Figure 2-1: Deep River/ Turkey Creek Soil Erodibility Map

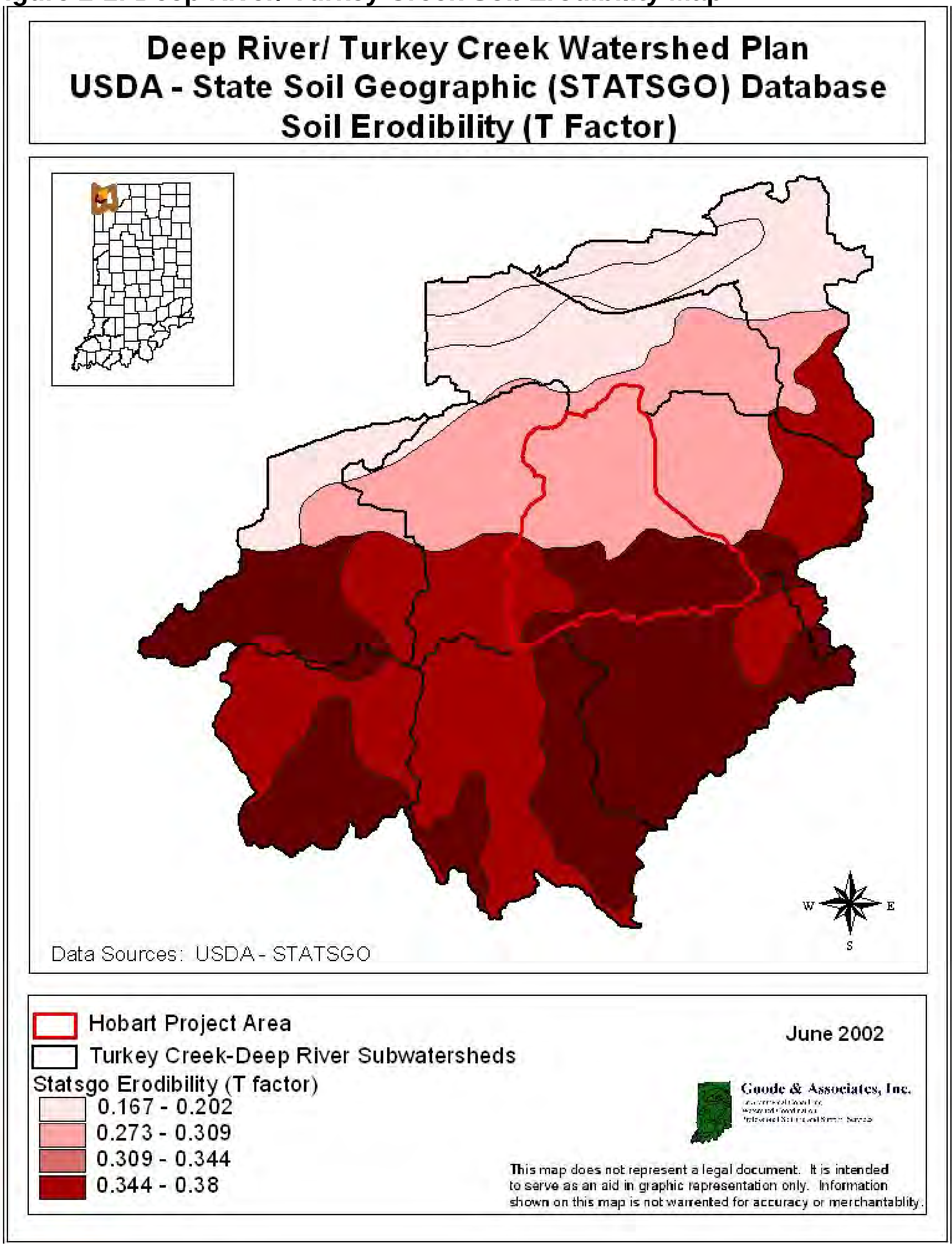
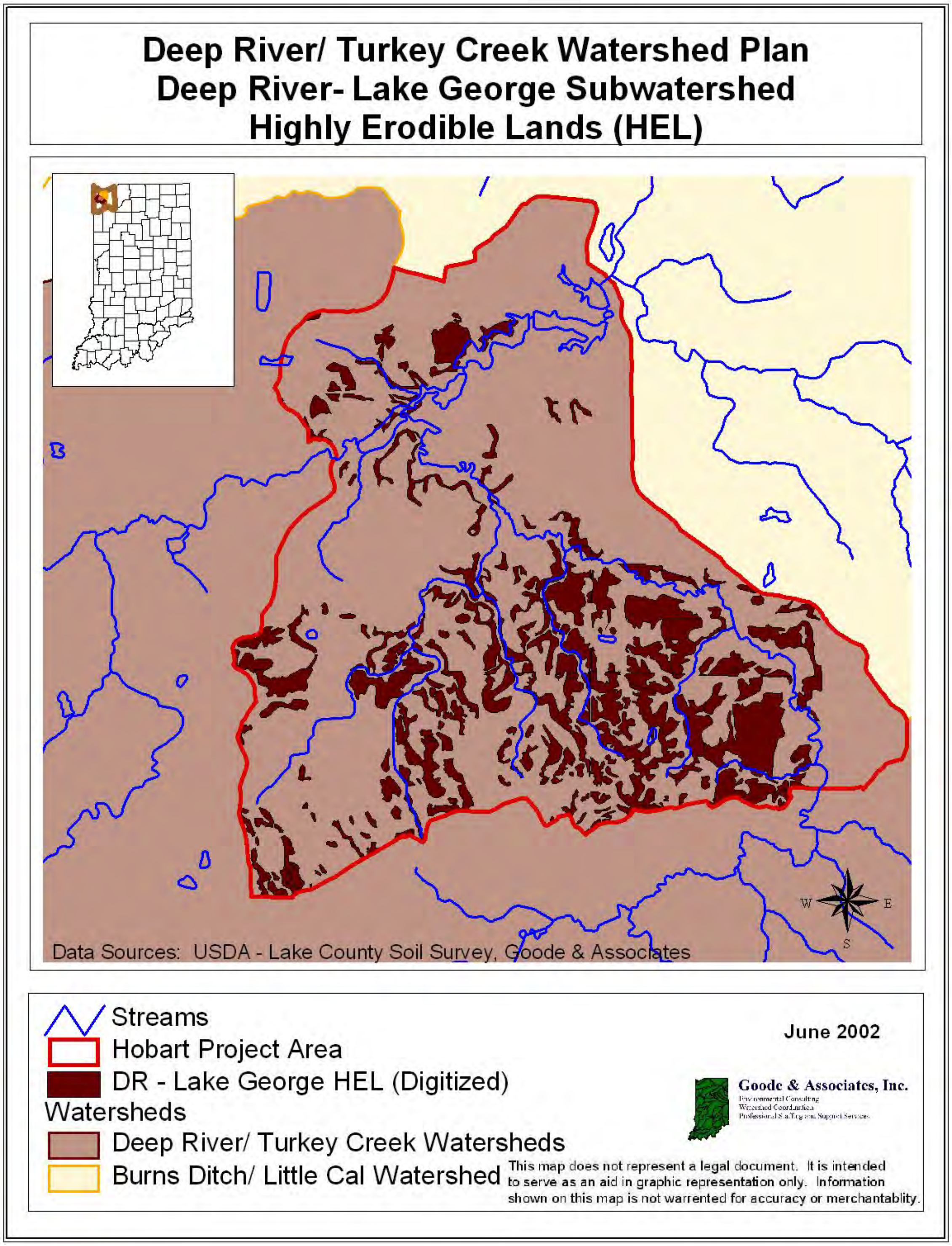


Figure 2-2: Highly Erodible Lands in the Deep River - Lake George Subwatershed



Hydrology

Surface Water

Turkey Creek and its tributaries drain the northwestern part of the watershed into the upper end of Lake George. Deep River and its major tributaries, Beaver Dam Ditch and Niles Ditch, drain the southern and eastern parts of the watershed before flowing into Lake George. Deep River flows through Lake George and continues through Hobart, Lake Station, and the eastern portion of Gary, Indiana, draining the Deep River/ Turkey Creek watershed into Burns Ditch (**Figure 2-3**).

In addition to Deep River and Turkey Creek, the other significant water feature within the study area is Lake George, which is located within the City of Hobart. Lake George is a manmade lake that was created by the damming of Deep River circa 1840 by George Earle for a gristmill and community water supply. Today, Lake George is considered to be the central feature in the City of Hobart and has been the focus of significant downtown revitalization and economic development initiatives for the community.

Lake George, as well as the majority of the City of Hobart, is located within the Deep River-Lake George Dam hydrologic unit (HUC 04040001030060), which covers approximately 12,879.1 acres in portions of Lake and Porter Counties in northwest Indiana. This HU is a subwatershed of the greater Deep River/ Turkey Creek watershed (HUC 04040001030), which encompasses approximately 79,433.7 acres.

Outstanding State Resource Waters (OSRW)

In 1993, the Indiana Natural Resources Commission (NRC) adopted its "Outstanding Rivers" List for Indiana. This listing is referenced in the standards for utility line crossings within floodways, formerly governed by IC 14-28-2 and now controlled by 310 IAC 6-1-16 through 310 IAC 6-1-18. Except where incorporated into a statute or rule, the "Outstanding Rivers List" is intended to provide guidance rather than to have regulatory application (NRC 1997). To help identify the rivers and streams that have particular environmental or aesthetic interest, a special listing has been prepared by IDNR's Division of Outdoor Recreation. This listing is a corrected and condensed version of a list compiled by American Rivers and dated October 1990. The NRC has adopted the IDNR listing as an official recognition of the resource values of these waters. A river included in the "Outstanding Rivers List" qualifies under one or more of 22 categories. **Table 2-2** presents the rivers in the Deep River/ Turkey Creek watershed that are on the "Outstanding Rivers List" and their significance.

Figure 2-3: Subwatersheds and Streams of the Deep River/ Turkey Creek Watershed

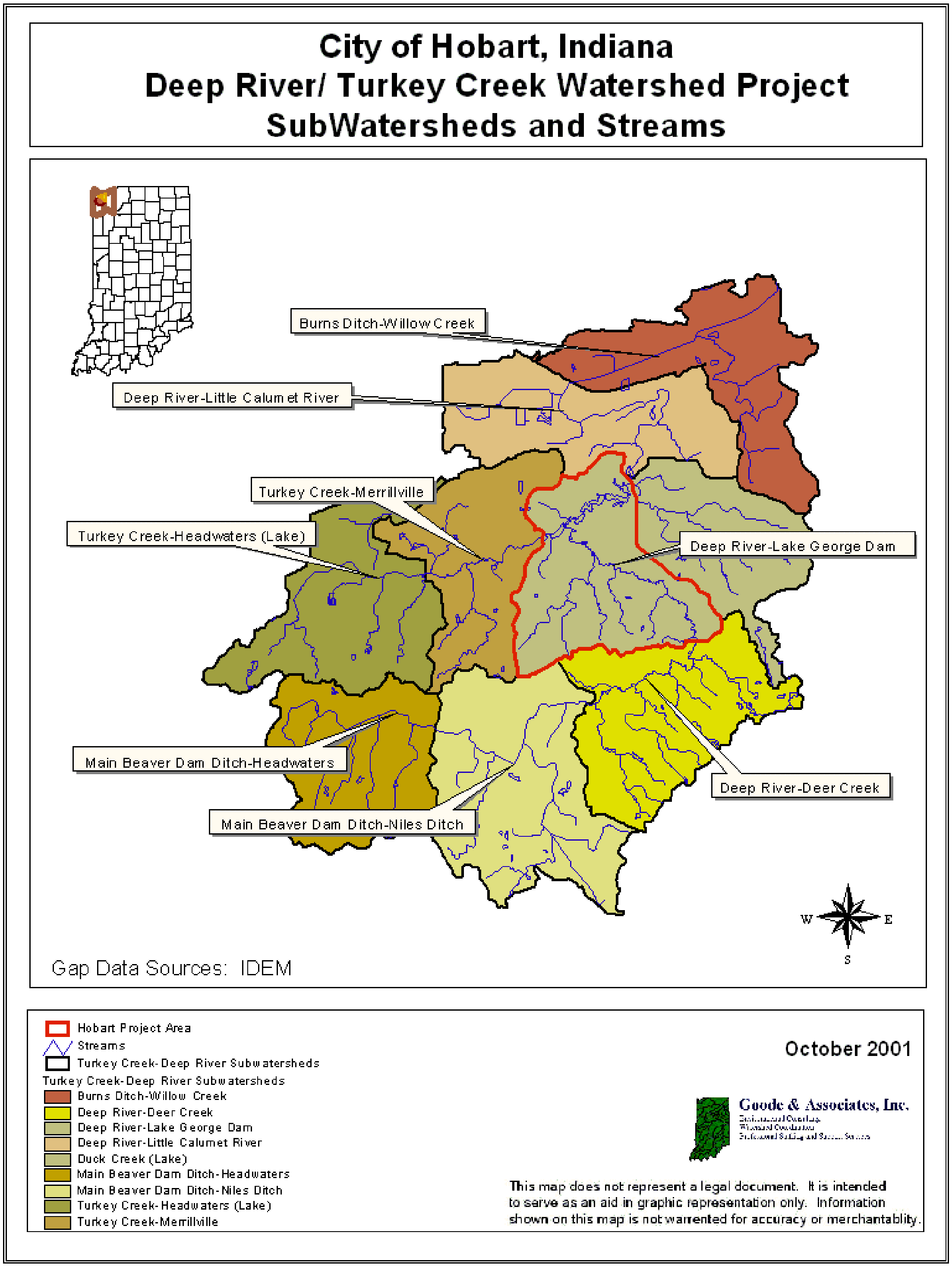


TABLE 2-2: Outstanding State Resource Waters in the Deep River/ Turkey Creek Watershed

Name: Deep River
Location: Lake, Porter Counties
Description: From 1 mile south of U.S. 30 to Little Calumet River

Wetlands

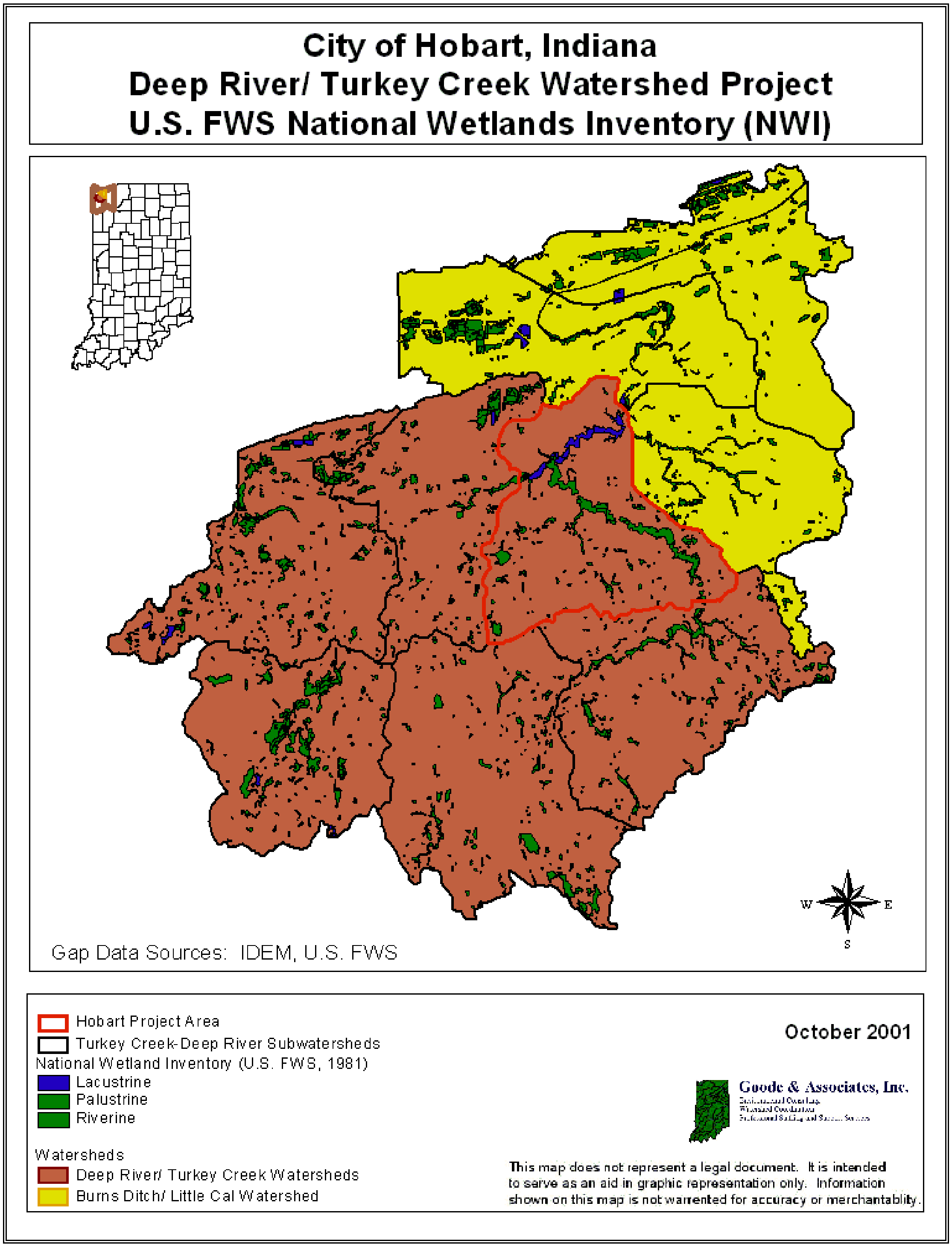
Wetlands are a significant hydrologic feature of northwestern Indiana, especially within the Deep River/ Turkey Creek watershed. Generally speaking, wetlands occur at points where ground water elevations exist at or near the ground surface, or where the ground is at least periodically covered by shallow water. Wetlands provide unique and valuable habitat for a variety of plants and wildlife.

Wetland types in Indiana are typically categorized according to the classification system used by the U.S. Fish and Wildlife Service. This system of classification is hierarchical, progressing from general levels to more specific levels of classes and subclasses according to water regime (duration and frequency of flooding), water chemistry, soil type, and dominant plants or animals (Cowardin and others, 1979, 1982; U.S. FWS 1986).

According to this classification system, there are three predominant wetland systems in Indiana and the Deep River/ Turkey Creek watershed. Lacustrine wetlands include permanently flooded lakes or reservoirs of at least 20 acres, and smaller impoundments whose maximum depths exceed 6.6 feet at low water. Riverine wetlands are contained within a natural or artificial channel that at least periodically carries flowing water. Palustrine wetlands are associated with areas and/or shallow bodies of water which are usually dominated by wetland plants, including marshes, swamps, bogs, sloughs, or fens (Cowardin and others, 1979).

In 1981, the U.S. Fish and Wildlife Service, as part of its National Wetlands Inventory (NWI), initiated a comprehensive inventory of Indiana's wetlands. The NWI identified and classified wetlands based upon high-altitude aerial photographs, and then digitized the wetland information in a geographic information system (GIS) format. The wetlands identified via the NWI have been mapped and illustrated in **Figure 2-4**.

Figure 2-4: NWI for the Deep River/ Turkey Creek Watershed



Wetlands have historically been dredged and filled in conjunction with agriculture and urban development practices. In fact, the Indiana Department of Natural Resources (IDNR) has estimated that Indiana had lost 85% of its natural wetlands by the 1980's (DNR, 1996).

In addition to mapping the NWI areas for the Deep River/ Turkey Creek Watershed, the State Soil Geographic (STATSGO) database was used to map addition areas of hydric soils within the watershed. The Statsgo data set is a digital general soil association map developed by the National Cooperative Soil Survey. It consists of a broad based inventory of soils and nonsoil areas that occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. The soil maps for STATSGO are compiled by generalizing more detailed soil survey maps. Where more detailed soil survey maps are not available, data on geology, topography, vegetation, and climate are assembled, together with Land Remote Sensing Satellite (LANDSAT) images. Soils of like areas are studied, and the probable classification and extent of the soils are determined (USDA NRCS, 1994). STATSGO data are designed for use in a Geographic Information System (GIS).

A hydric soil is a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the soil. Identifying hydric soils is important for locating areas for potential wetland protection efforts, wetland mitigation, and development. Hydric soils in the Deep River/ Turkey Creek watershed are illustrated in **Figure 2-5**.

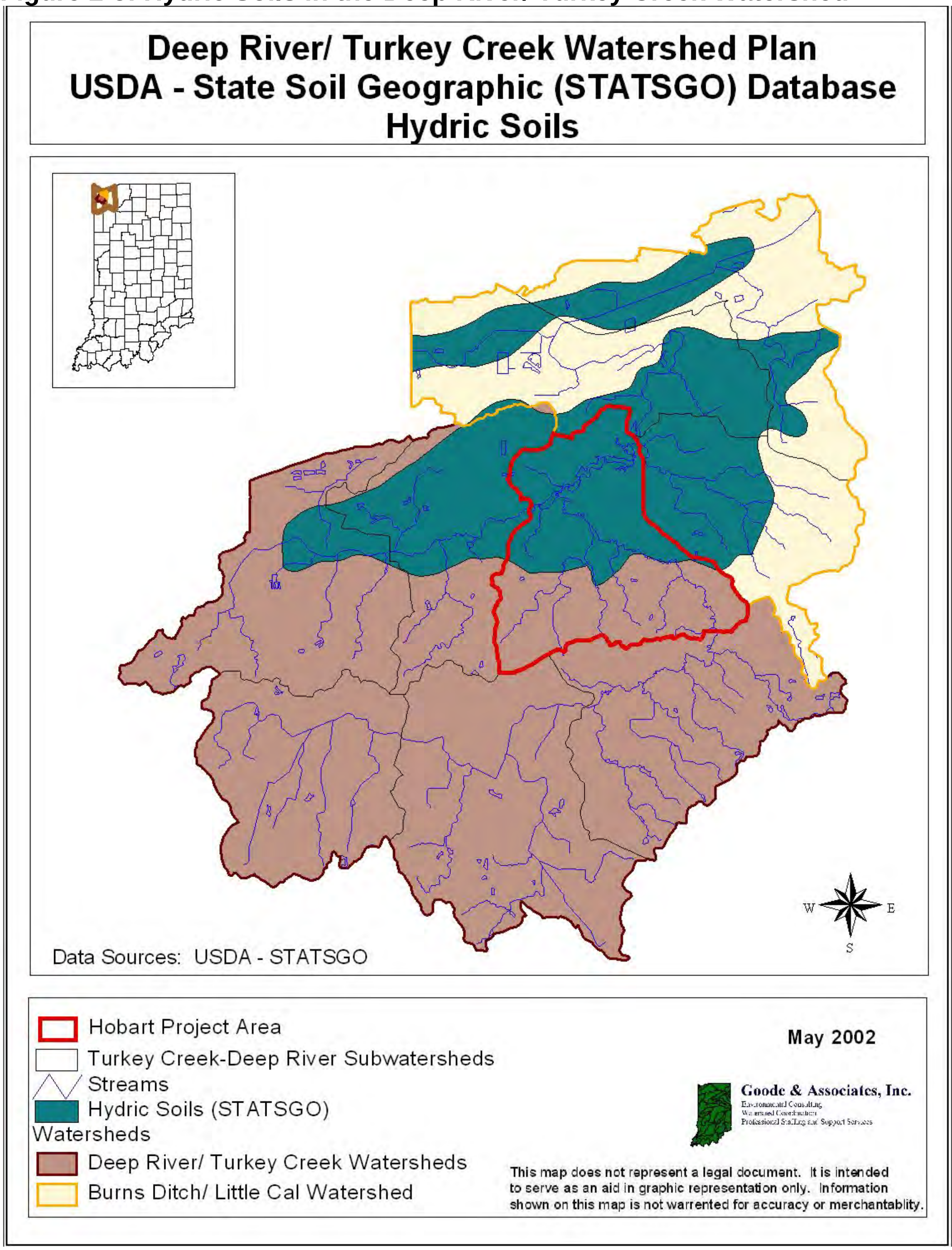
Significant Natural Areas/ Preserves

Although some of the original natural features of the Deep River/ Turkey Creek watershed have be lost to development, several significant natural features, such as the National Lakeshore and several smaller examples of the presettlement "prairie peninsula". These features are illustrated in **Figure 2-6**.

Cressmoor Prairie Preserve - Cressmoor Prairie is the largest protected example of a silt-loam or "black soil" prairie in Indiana. Black soil prairies were once the most common prairies in Indiana. However, their rich, fertile soil was among the very finest agricultural ground anywhere in the world, so most were plowed under for farming. As a result, black soil prairies are exceedingly rare.

Over 250 species of plants have been found at Cressmoor Prairie. Typical prairie species occurring here in great numbers include wild quinine, dense blazing star, rattlesnake master, prairie dock, and compass plant. Much of the preserve is typical of pure prairie habitat, with large stands of big and little bluestem, Indiana

Figure 2-5: Hydric Soils in the Deep River/ Turkey Creek Watershed



and other grasses interspersed with a wide variety of flowering plants. Cressmoor also has some savanna and low-lying wet areas. Amethyst aster was recently found in the savanna, making its first known appearance in Lake County, Indiana. American hazelnut is abundant in the transitional zone between Cressmoor's savanna and prairie.

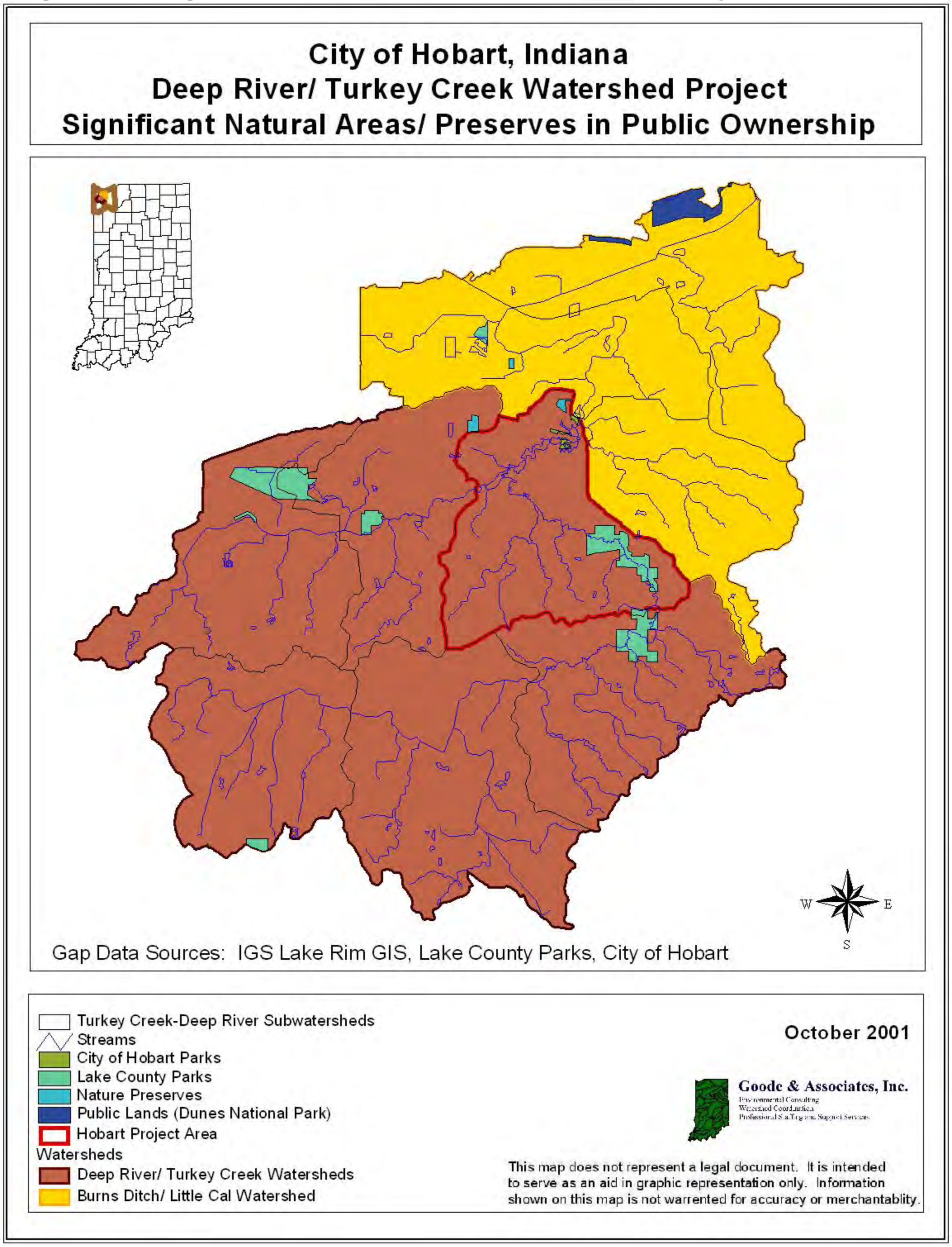
The prairie wildflowers, including six types of goldenrod and blue and white varieties of aster, reach their peak in late summer and fall. But midsummer, when coreopsis, sunflowers, blazing star, ironweed, gray-headed coneflower, and eight species of milkweed are in bloom. Birds, butterflies, and small mammals and reptiles abound. Five rare remnant-dependent insects, including leaf hoppers, a skipper, and a butterfly , have been found in areas of Cressmoor with a history of fire.

Lake County Parks

Lake County Parks and Recreation Department (LCPRD) is dedicated to improving the quality of life in Lake County. The LCPRD has been actively pursuing opportunities to acquire, reclaim, and preserve natural systems and open space resources, and expand its recreational, cultural, and educational programs. The Deep River/ Turkey Creek watershed planning process has additionally highlighted the benefits to water quality from the acreage that the LCPRD manages along the rivers and streams in the Deep River/ Turkey Creek watershed. Oak Ridge Prairie, Turkey Creek Golf Course, Deep River, Oak Savanna Trail, and Erie Lackawana Trail are components of the over 2,500 acres of parkland that the LCPRD manages within the watershed.

These acres will become more important over the years as stakeholders in the Deep River/ Turkey Creek watershed and the LCPRD strive to improve water quality as waterbodies flow through and off of these parks. In addition to these sites, LCPRD is in the process of adding another 300 acres of nature preserves in the Lake George Watershed that will restore wetlands, prairie, savanna, and will become a model for future acquisitions in the watershed. The LCPRD hopes that other Northwest Indiana municipalities and governmental agencies around the Deep River/ Turkey Creek Watershed will take these same measures and help improve water quality in Lake County.

Figure 2-6: Significant Natural Areas in Public Ownership



Land Cover, Population, and Growth Trends

Gap Analysis Program (GAP)

The U.S. Geological Survey - Biological Resources Division and the U.S. Fish and Wildlife Service are overseeing the National Gap Analysis Program (GAP). In Indiana, Indiana State University and Indiana University are carrying out the Indiana GAP Project that involves an analysis of current vegetative land cover through remote sensing (ISU 2001). This analysis provides vegetative land cover data in 30 by 30-meter grids (See **Figure 2-7**). The following is a summary of vegetative cover in the watershed determined from the GAP image:

Table 2-3: GAP Land Use Statistics

Land Use Type	**Percentage of Watershed**
Agricultural vegetation (row crop and pasture)	61.17%
Urban (impervious, low and high density)	17.5%
Forest vegetation (shrubland, woodland, forest)	13.9%
Wetland vegetation (Palustrine: forest, shrubland, herbaceous)	6.4%
Open Water	1.0%
Insufficient Data	0.03%
Total	**100%**

Population and Growth Trends

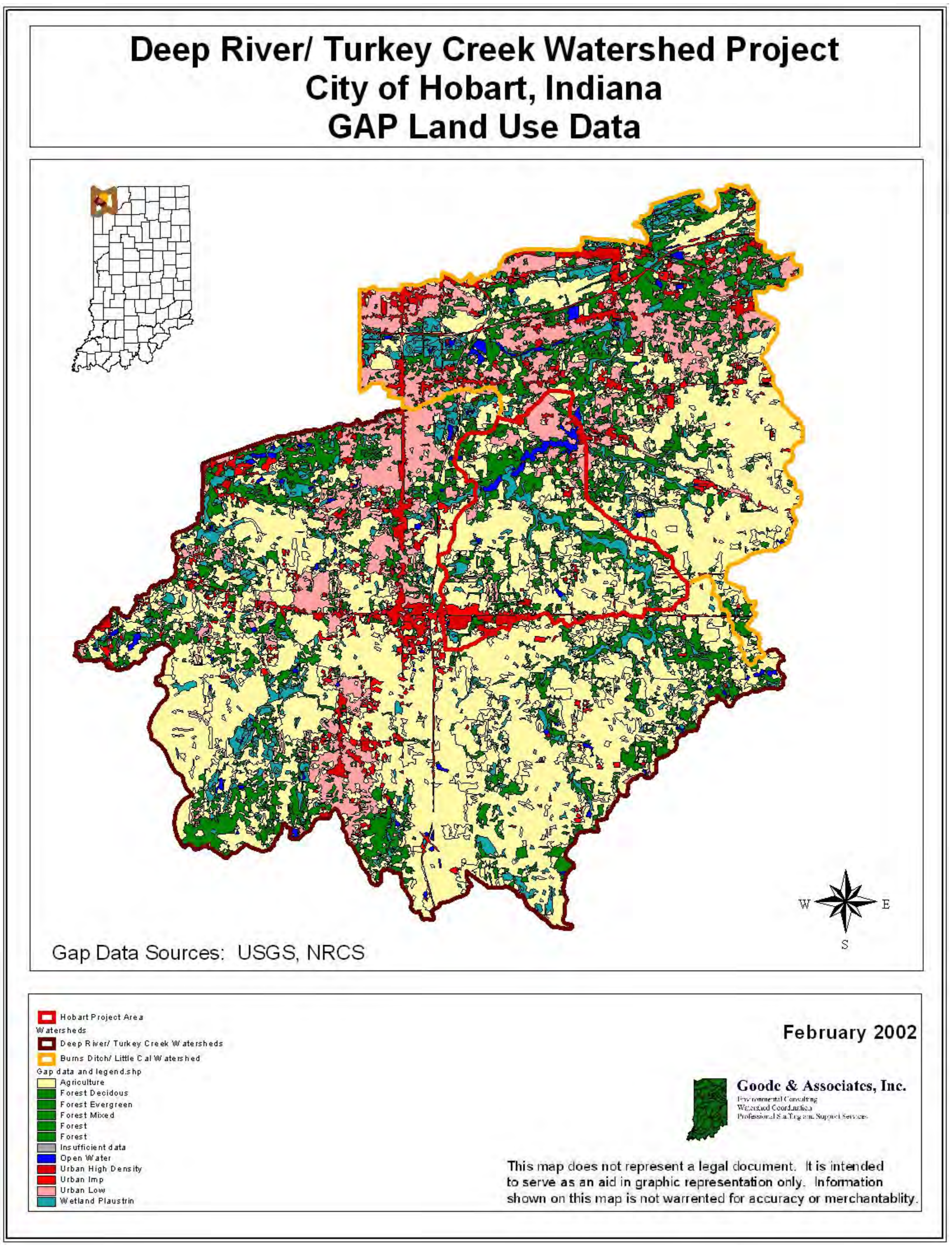
In the year 2000, the total population living within Lake and Porter County portions of the Deep River/ Turkey Creek watershed is estimated to be 107,000 persons, based upon Lake and Porter County 2000 population statistics. It should be noted, however, that these numbers do not reflect the exact population living in the Deep River/ Turkey Creek watershed. Population statistics were estimated using a simplified calculation dividing the population of each county by the percentage of the land area of the watershed within each county. The general statistics used for these calculations are listed in **Table 2-4**.

It is also interesting to note that the 2000 population statistics indicate a positive population growth trend for both Lake and Porter Counties between 1990 and 2000. Although the growth rate in Porter County is significantly higher (13.9%) than that of Lake County (1.9%), population increased 16,720 in Porter County and 49,377 in Lake County. Should this increase in population rate continue over the next decade, it would likely result in additional development that could have a negative impact upon water quality in the Deep River Turkey watershed via increased impervious surfaces and increasing quantities of stormwater runoff.

Table 2-4: Deep River/ Turkey Creek Population Statistics, Census Bureau 2000

Population Statistics	
Lake County Population, 2000	484,564
Lake County Population, percent change, 1990 to 2000	1.9%
Porter County Population, 2000	146,798
Porter County Population, percent change, 1990 to 2000	13.9%
Lake County Acreage - DR/ TC Acreage	501 sq. miles/ 104 sq. miles
Porter County Acreage – DR/ TC Acreage	419 sq. miles/ 20 sq. miles
Estimated Population, Deep River/ Turkey Creek Watershed	107,595

Figure 2-7: GAP Land Cover Map



Natural Communities and Endangered, Threatened and Rare (ETR) Species

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

Results from the database search for the Deep River/ Turkey Creek Watershed are presented in **Appendix 2-1**. (For additional reference, a listing of endangered, threatened, and rare species documented in Lake County is included in **Appendix 2-2**). According to the database, a high quality community of wet floodplain forest existed in Lake County, just east of Merrillville in 1967. In 1978, Clay Street Kettle Woods, located in the southern portion of the watershed, supported three different high quality community types: dry upland forest, dry-mesic upland forest, and marsh. In 1989, Hobart Prairie Grove was home to a state endangered plant species, the smooth veiny pea (*Lathyrus venosus*). McCloskey's Burr Oak Savanna Nature Preserve, west of Hobart, supported two high quality community types in 1984: mesic prairie and mesic savanna. In the early 1990's, earleaf foxglove (*Agalinis auriculata*), a state endangered plant species, was identified within these natural communities.

Several endangered, threatened, or rare species and high quality natural communities recently or presently exist within the Lake George Watershed. The IDNR database documents the presence of a state endangered plant, earleaf foxglove (*Agalinis auriculata*) at a 31-acre prairie site located northwest of Hobart in 1999. The database also records the sighting of three state rare plants: forked aster (*Aster furcatus*), small purple-fringed orchis (*Platanthera psycodes*), and eastern jointweed (*Polygonella articulata*) on Van Buren Street, north of Hobart in the 1980's and 1990's. Database records show two high quality community types, wet-mesic wetland forest and upland mesic forest, in Deep River County Park in the 1970's and 1980's. These communities did, and still may, support a state endangered plant, highbush cranberry (*Viburnum americanum*), and a state rare plant, small purple-fringe orchis (*Platanthera psycodes*). A dry-mesic upland forest community existed, and still may exist, northwest of Hobart (T38N, R8W, Section 36). A high quality community, mesic prairie, presently exists at Cressmoor Prairie Nature Preserve. The bunchgrass skipper (*Problema byssus*), a state rare insect species, and several plant species including downy gentian (*Gentiana puberulenta*), small sundrops (*Oenothera perennis*), Leiberg's witchgrass (*Panicum leibergii*), and ladies' tresses (*Spiranthes magnicamporum*) inhabit the prairie. All of the plants species in the prairie preserve are state threatened with the exception of the ladies' tresses, which is a state endangered species.

Four state endangered bird species have also been reported in the Deep River-Turkey Creek Watershed near Hobart. In the 1930's, the loggerhead shrike (*Nycticorax nycticorax)* and king rail (*Rallus elegans*) were observed; the marsh wren (*Cistothorus palustris*) and black-crowned night-heron (*Nycticorax nycticorax*) were noted in the mid 1980's.

III. Understanding Designated Uses, Water Quality Standards, Basin Assessments, and Problem Pollutants

In order to identify water quality problems in the Deep River/ Turkey watershed, stakeholders in the watershed planning process felt that readers of this plan needed to understand the basis for measuring or quantifying water quality problems. Consequently, this section of the Deep River/ Turkey Creek Watershed Plan provides a technically detailed discussion of how water quality standards, the measures of quality in rivers, streams, and lakes, are developed and used to protect the quality of Indiana's surface waters. This section of the plan will also briefly discuss the programs actively monitoring water quality within the watershed and explain the process used to assess the quality of surface waters in the Deep River/ Turkey Creek watershed.

Understanding Designated Uses and Water Quality Standards

Rivers, streams, and lakes have naturally occurring plants, animals, and microorganisms that break down, or consume, water quality contaminants. This process, in conjunction with the rate and volume of stream flow, oxygen levels, temperature, and other naturally occurring conditions dictates the rate at which streams are able to breakdown and absorb contaminants. Historically, many waterbodies have received more contaminants than they could naturally absorb. Waterbodies that received more contaminants than they can absorb are considered to be polluted.

In order to prevent waterbodies from becoming polluted, in 1972, Congress established the Clean Water Act and the National Pollutant Discharge Elimination System (NPDES) to regulate the discharges of pollutants into lakes, rivers, and streams from industrial and municipal wastewater treatment plants, and other direct sources of pollution. The NPDES Program uses water quality standards and discharge limitations to restrict the introduction of contaminants that would exceed a waterbody's ability to naturally absorb and consume a pollutant.

In order to determine appropriate discharge limitations for a NPDES regulated facility, the State of Indiana first established designated uses and water quality standards to support those uses for the waters of the State. Indiana's current designated uses for surface waters are described in **Table 3-1**.

A water quality standard is the combination of a designated use (i.e. swimmable or fishable) and a narrative or numeric water quality criterion designed to protect that use (i.e. an ammonia discharge limit of 3.0mg/L or an E. coli discharge limit of 125 cfu/100ml). Designated uses and resulting water quality standards form the foundation for the NPDES program to control the amount of pollutants being discharged into the rivers, streams, and lakes of Indiana.

In Indiana, effluent limitations are implemented through NPDES permit conditions established by the Indiana Department of Environmental Management (IDEM). Effluent limitations are designed to limit the quantities, discharge rates, and concentrations of pollutants that are discharged, from "point sources" of pollution. These limitations represent the minimum effluent quality or quantity that must be achieved prior to discharge of a treated wastewater into a waterbody (river, stream, or lake). The NPDES permits issued by the IDEM contain specific effluent limits designed to meet the State's water quality standards.

Great Lakes Initiative (GLI) Standards

In l995, the Environmental Protection Agency (EPA) and States in the Great Lakes region agreed to develop a comprehensive plan to restore the health of the Great Lakes. In order to facilitate consistent implementation of water quality improvements in the Great Lakes Region, the EPA developed "The Final Water Quality Guidance for the Great Lakes System", also known as the Great Lakes Initiative. **Figure 3-2** illustrates the GLI area and the States involved in the GLI.

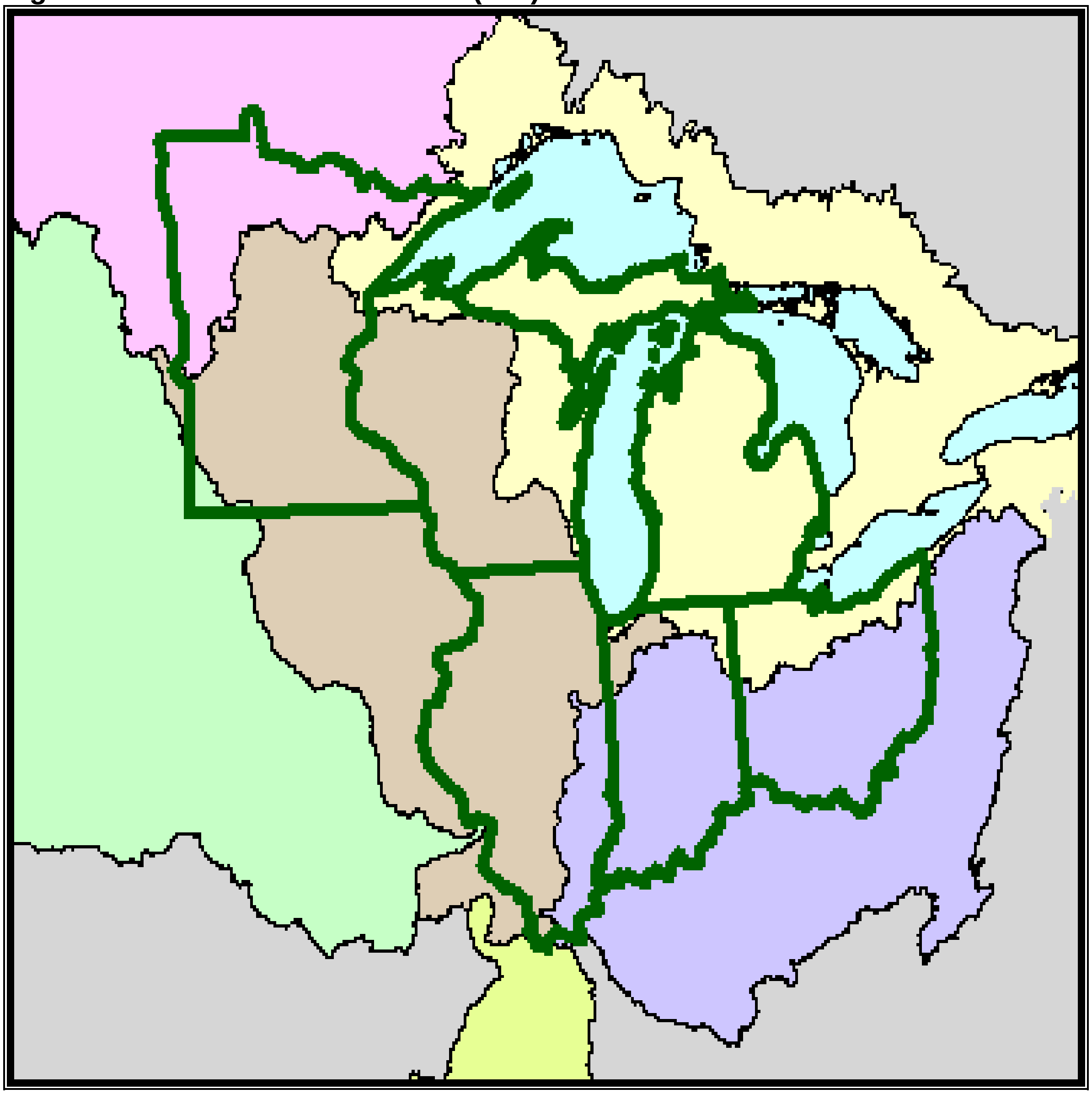
During 1995, Indiana began the process of creating regulations within the Great Lakes Basin to incorporate the various criteria and procedures identified in EPA's guidance into Indiana's water quality standards. As a part of this rulemaking process, Indiana also developed procedures to implement an antidegradation policy for all substances discharged to waters into the Great Lakes Basin. These revisions were adopted by the Indiana Water Pollution Control Board in February 1997 and were submitted to USEPA for approval. The GLI has resulted in the development of more stringent criteria for the use of 29 pollutants, including bioaccumulative chemicals of concern, and prohibited the use of mixing zones for these toxic chemicals.

Table 3-1: Surface Water Use Designations and Classifications

The following uses are designated by the Indiana Water Pollution Control Board (327 IAC 2-1-3):

- Surface waters of the state are designated for full-body contact recreation during the recreational season (April through October).
- All waters, except limited use waters, will be capable of supporting a well-balanced, warm water aquatic community.
- All waters, which are used for public or industrial water supply, must meet the standards for those uses at the point where water is withdrawn.
- All waters, which are used for agricultural purposes, must meet minimum surface water quality standards.
- All waters in which naturally poor physical characteristics (including lack of sufficient flow), naturally poor or reversible man-induced conditions, which came into existence prior to January 1, 1983, and having been established by use attainability analysis, public comment period, and hearing may qualify to be classified for limited use and must be evaluated for restoration and upgrading at each triennial review of this rule.
- All waters, which provide unusual aquatic habitat, which are an integral feature of an area of exceptional natural beauty or character, or which support unique assemblages of aquatic organisms may be classified for exceptional use.
- All waters of the state, at all times and at all places, including the mixing zone, shall meet the minimum conditions of being free from substances, materials, floating debris, oil, or scum attributable to municipal, industrial, agricultural, and other land use practices, or other discharges:
    - that will settle to form putrescent or otherwise objectionable deposits,
    - that are in amounts sufficient to be unsightly or deleterious,
    - that produce color, visible oil sheen, odor, or other conditions in such degree as to create a nuisance,
    - which are in amounts sufficient to be acutely toxic to, or to otherwise severely injure or kill aquatic life, other animals, plants, or humans, or
    - which are in concentrations or combinations that will cause or contribute to the growth of aquatic plants or algae to such degree as to create a nuisance, be unsightly, or otherwise impair designated uses.

Figure 3-1: Great Lakes Initiative (GLI) Area and States



The 305(b) Process – Assessing Indiana's Watersheds
In order to assess the effectiveness of a State's water quality standards, effluent limitations, and NPDES permitting program, Section 305(b) of the Clean Water Act (CWA) requires each State to develop a program to monitor the quality of its waters and prepare a report describing their quality. This process of monitoring and assessment produces an evaluation of the degree to which each waterbody supports a State's designated uses and water quality standards. Each waterbody assessed is rated as supportive, partially supportive, or not supportive of it's designated uses. **Table 3-1** illustrates the criteria used by the IDEM for assessing a waterbody's ability to support its designated uses.

TABLE 3-2: CRITERIA FOR EVALUATING DESIGNATED USE SUPPORT*

Parameter	Fully Supporting	Partially Supporting	Not Supporting
Aquatic Life Use Support			
Toxic Pollutants	Metals were evaluated on a site by site basis and judged according to magnitude of exceedance and the number of times exceedances occurred.		
Conventional Inorganic Pollutants	There were very few water quality violations, almost all of which were due to natural conditions.		
Benthic aquatic macroinvertebrate Index of Biotic Integrity (mIBI)	mIBI $\geq$ 4.	mIBI < 4 and $\geq$ 2.	mIBI < 2.
Qualitative habitat use evaluation (QHEI)	QHEI $\geq$ 64.	QHEI < 64 and $\geq$ 51.	QHEI < 51.
Fish community (fIBI) **(Lower White River only)**	IBI $\geq$ 44.	IBI < 44 and $\geq$ 22	IBI < 22.
Sediment **(PAHs = polynuclear aromatic hydrocarbons. AVS/SEM = acid**	All PAHs $\leq$ 75th percentile. All AVS/SEMs $\leq$ 75th percentile.	PAHs or AVS/SEMs > 75th percentile. (Includes Grand Calumet River and Indiana Harbor	Parameters > 95thpercentile as derived from IDEM Sediment Contaminants

volatile sulfide/ simultaneously extracted metals.)	All other parameters ≤ 95th percentile.	Canal sediment results, and so is a conservative number.)	Database.
Indiana Trophic State Index (lakes only)	Nutrients, dissolved oxygen, turbidity, algal growth, and sometimes pH were evaluated on a lake-by-lake basis. Each parameter judged according to magnitude.		
Fish Consumption			
Fish tissue	No specific Advisory*	Limited Group 2 - 4 Advisory*	Group 5 Advisory*
* Indiana Fish Consumption Advisory, 1997, includes a state wide advisory for carp consumption. This was not included in individual waterbody reports because it obscures the magnitude of impairment caused by other parameters.			
Recreational Use Support (Swimmable)			
Bacteria (cfu = colony forming units.)	No more than one grab sample slightly > 235 cfu/100ml, and geometric mean not exceeded.	No samples in this classification.	One or more grab sample exceeded 235 cfu/100ml, and geometric mean exceeded.

***From Indiana Water Quality Report for 1998**

Participants in the 305(b) Process

In Indiana, the primary agencies involved in collecting, analyzing, and assessing surface water quality data for the state's 305(b) report are as follows:

1. **Indiana Department of Environmental Management (IDEM), Office of Water Quality, Assessment Branch – River Basin Monitoring Program**

   The Water Quality Assessment Branch of the Office of Water Quality (OWQ) is responsible for assessing the quality of water in Indiana's lakes, rivers and streams for the state's 305(b) Report. In 1995, in response to the growing demand for more and better water quality data, the IDEM Water Assessment Branch developed a Surface Water Quality Monitoring Strategy. The strategy was designed to direct the efforts of the Assessment Branch in the light of increased workloads, as well as new 305(b) reporting guidelines to states from the Environmental Protection Agency (EPA).

   IDEM's monitoring strategy was crafted to provide technical data and information to support the 305(b) report, the NPDES permitting program, and the annual Fish Consumption Advisory. As a result, the Assessment Branch operates on a rotating basin approach that is designed to sample, analyze, and assess one of the state's five (5) major river basins each year and to provide a statewide assessment every 5 years.

   River Basin Monitoring Cycle

   The five-year rotating river basin monitoring cycle began in 1996 and continues to be the basis for Indiana's Surface Water Quality Monitoring Strategy. The state of Indiana has been divided geographically into five major hydrological groupings or sampling units for the purpose of sampling, analysis and assessment. The five-year monitoring cycle listed below indicates the timeframes by which the IDEM plans to complete surface water quality surveys throughout the state.

Major River Basin	**Sampling Year(s)**
West Fork White River and Patoka River Basins	1996, 2001
East Fork White River and Whitewater River Basins	1997, 2002
Upper Wabash River Basin	1998, 2003
Lower Wabash River and Kankakee River Basins	1999, 2004
Great Lakes and Ohio River Basins	**2000, 2005**

IDEM Assessment Branch Monitoring Programs
The Assessment Branch is composed of two sections that work together to collect data and assess the quality in Indiana's surface waters via the 305(b) report. These sections are as follows:

- **The Surveys Section** is responsible for collecting chemical and physical water quality data, assessing the quality of Indiana's river and streams, and determining the effect of approximately 1,800 permitted point sources on the rivers and streams of Indiana. The Surveys Section provides data for models, 305(b) water quality reports and wasteload allocations for NPDES permitting purposes, as well as an assessment of non-point sources. The OWQ biological and surface water monitoring programs identify stream reaches, watersheds or segments where physical, chemical and/or biological quality has been or would be impaired by either point or nonpoint sources. This information is used to help allocate waste loads equitably among various pollutant sources in a way that would ensure that water quality standards are met along stream reaches in each of the nearly 100 stream segments in Indiana.

- **The Biological Studies Section (BSS)** is responsible for determining the biological integrity of aquatic communities in Indiana lakes, rivers and streams. They do this through a variety of field, laboratory, and cooperative studies that involve several different forms of aquatic life as well as surface water and sediment chemistry, physical and habitat information. These data are used to determine compliance with the existing narrative biological criteria in the Indiana water quality standards, and form the basis for new specific numerical biological criteria. Additionally, the data determine the extent of ecological harm and recovery, and make correlations to physical and/or chemical impairments that may occur.

  The BSS conducts fish tissue and sediment sampling to assess the level and extent of contamination by toxic and bioaccumulating substances whose concentrations in other environmental media are often too low to be easily measured with routine sampling and laboratory procedures. The fish tissue monitoring program provides the majority of data used to make decisions for Indiana's fish consumption advisories. In addition these data are also used for wildlife health risk assessments for fish-eating birds and mammals, and to provide the information needed to develop models to assess changes in Indiana ecosystems that affect aquatic life and human health.

The BSS also oversees lake monitoring efforts conducted under contract by staff and students of the Indiana University School of Public and Environmental Affairs, as well as by a group of trained volunteer monitors. Both programs include the monitoring of physical, chemical and/or biological parameters useful in assessing the impacts of nutrients in Indiana lakes and reservoirs.

2. **The Indiana Department of Natural Resources (IDNR) - Division of Fish and Wildlife**
   The IDNR Division of Fish and Wildlife maintains a network of fishery biologists that conduct research throughout the state to assess and manage fishery populations in Indiana's rivers, streams and lakes. The IDNR biologists routinely conduct macroinvertebrate sampling, electrofishing, netting surveys, and creel surveys to evaluate the status of local fisheries. The IDNR works cooperatively with the IDEM Biological Studies Section to assess the State's fisheries populations and to provide data to the Indiana State Board of Health to be used in the annual Fish Consumption Advisory.

The 303(d) List - Impaired Streams and Problem Pollutants

As a result of the waterbody assessments performed in the 305(b) process, a number of the rivers, streams, and lakes within the state are determined to be only partially supportive or non-supportive of each waterbody's designated uses. Section 303(d) of the CWA requires that waters not meeting or not expected to meet water quality standards after the implementation of regulatory controls (NPDES permits) to be compiled and listed as "impaired waters" by the IDEM. In other words, impaired waters are considered to be those waterbodies that don't meet the state's water quality standards for one or more designated uses.

Total Maximum Daily Loads (TMDL)

Based on Indiana's 2002 303(d) list, the streams listed in **Table 3-2** have been identified as having impairing pollutants by the IDEM. Streams identified on the state's 303(d) list are also required to undergo a planning process designed to reduce the amount of the pollutant coming from both point and nonpoint sources of pollution. This process is called Total Maximum Daily Loads (TMDL).

The IDEM defines a TMDL as "a process that leads to the quantification of the amount of a specific pollutant discharged into a waterbody that can be assimilated and still meet the water quality standards (designated uses)." This is achieved by specifying the amount of pollutant reductions necessary from point and non-point sources in order to meet the water quality standard set for an impairing pollutant. EPA is responsible for ensuring that TMDLs are completed by States and for approving the completed TMDLs.

IDEM's TMDL Strategy

Under the TMDL approach, states establish priorities and schedules for TMDL development. When TMDL development occurs, IDEM via the TMDL process determines the required reductions in pollutant loads or other actions needed to meet water quality goals. This process promotes a watershed approach driven by local needs and directed by the State's list of priority waterbodies. The overall goal in establishing the TMDL is to implement the pollutant reductions necessary from point and nonpoint sources of pollution that are necessary for a waterbody to meet water quality standards.

IDEM's Office of Water Quality has reorganized its work activities around a five year rotating basin schedule. The waters of the state have been grouped geographically into major river basins, and water quality data and other information will be collected and analyzed from each basin, or group of basins, once every five years. The schedule for implementing the TMDL Strategy is proposed to follow this rotating basin plan to the extent possible. Supplemental data collection (i.e. collection during a year other than the one prescribed in the IDEM's Surface Water Quality Monitoring Strategy) may also be required to complete the TMDL process.

IDEM's TMDL Strategy discusses activities to be accomplished in three phases. Phase One involves planning, sampling and data collection and will take place the first year. Phase Two involves TMDL development (water quality modeling) and will occur in the second year. Phase Three is the TMDL implementation period and is expected to occur during the third year; however, it is expected that some phases, especially the implementation of a TMDL, may take more than one year to fully accomplish.

The TMDL goals that are chosen in conjunction with watershed stakeholders during Phase Two will be used to develop a plan to implement the TMDL. During this process, stakeholder participation will be essential. IDEM's Basin Coordinator, in conjunction with the stakeholder groups, will develop a plan to implement the TMDL. Once the draft plan has been finalized through comments from stakeholder groups and IDEM, the plan becomes a "final draft" and is open to public review.

IV. Identifying Problems… Known Surface Water Quality Problems in the Deep River/ Turkey Creek Watershed

The Indiana Department of Environmental Management (IDEM) and the Indiana Department of Natural Resources (IDNR) are the primary agencies involved in surface water quality monitoring and assessment in the state of Indiana. In conjunction with the requirements of the Clean Water Act and the State's goals for protecting its natural and recreational resources, IDEM and IDNR operate several monitoring programs designed to monitor and assess the chemical, physical, and biological conditions of Indiana's waters. In addition, several volunteer water quality monitoring programs have been actively conducting chemical and biological monitoring within the Deep River/ Turkey Creek watershed.

The following section provides a summary of historical water quality monitoring efforts within the Lake George, Deep River, and the Turkey Creek watersheds, summarizes historical 305(b) waterbody assessments, and identifies impairments documented through other reports and studies.

Historical Surface Water Quality Monitoring

IDEM 2000 Basin Survey

The Indiana Department Environmental Management (IDEM) Surveys Section has conducted many water quality monitoring surveys within the Deep River/ Turkey Creek Watershed throughout the past several decades. However, for the purpose of this project, it was determined that since significant improvements in wastewater collection and treatment infrastructure had occurred in the watershed within the past five years, chemical water monitoring data no older than five years would be used to evaluate water quality in the watershed. Consequently, the Surveys Section's data from the 2000 Great Lakes Basin Survey provided the most current chemical water quality for evaluating water quality.

The sites monitored by IDEM in the Deep River/ Turkey Creek watershed are illustrated in **Figure 4-1**. In all, the IDEM monitored seven sites within the watershed for a variety of bacteriological, chemical, and physical indicators of water quality. Two monitoring programs operated by the Surveys Section were involved in data collection within the watershed: The Watershed Monitoring Program and the E.coli Monitoring Program.

Although the Watershed Monitoring Program collects data that provides a more in-depth chemical analysis of water quality at each site, the program only monitored one site within the Deep River watershed. In contrast, the E.coli. Monitoring Program provided the most spatially complete data set within the watershed, but the program only collects data for E. coli bacteria (five samples/ 30 days) and associated field data parameters. As a result, data from the E. coli monitoring program provided the primary historical data set by which the watershed could be evaluated (See **Figure 4-2**).

IDEM Basin Monitoring Summary

In summary, although the IDEM's chemical monitoring dataset for the Deep River/ Turkey Creek watershed is very limited in spatial extent, depth, and duration, it provides the most current water quality monitoring data available for the Deep River/ Turkey Creek Watershed. The data indicates a general concern regarding violations of state water quality standards for E.coli bacteria (WQS = 125cfu/ 100ml). The data indicates exceedances at most monitoring locations throughout the watershed.

In addition, field data collected by the IDEM's monitoring programs identified consistently elevated observations of specific conductance. Elevated specific conductance values can be used as an indicator of other physical, chemical or metallic ions (cations or anions) in the water column. Although specific conductance data collected by IDEM appears to indicate elevated ionic concentrations within stream samples throughout the watershed, especially within Turkey Creek, no additional data is available to identify the type of ions present.

Hobart High School – Water Analysis Class

Hobart High School Biology teacher, Mr. Jerry Kousen, has been working with his students to identify and correct water quality problems within the community. On January 15, 2002, Mr. Kousen's "Water Analysis" class conducted a presentation summarizing their water quality monitoring activities to the Steering Committee for the Deep River/ Turkey Creek Watershed Plan. Monitoring locations for the class are listed in **Figure 4-3** and data summaries from this presentation are included in **Appendix 4-1**.

The students provided monitoring results and conclusions that identified water quality concerns for both Turkey Creek and Deep River, including elevated nutrient values, fecal coliform levels, and illegal dumping. Additional information regarding Mr. Kousen's Water Analysis Class is located at www.hobart.k12.in.us/jkousen/Biology/classinfo.html. This site contains information about the watershed, including monitoring site photos, monitoring data, and class information.

Figure 4-1

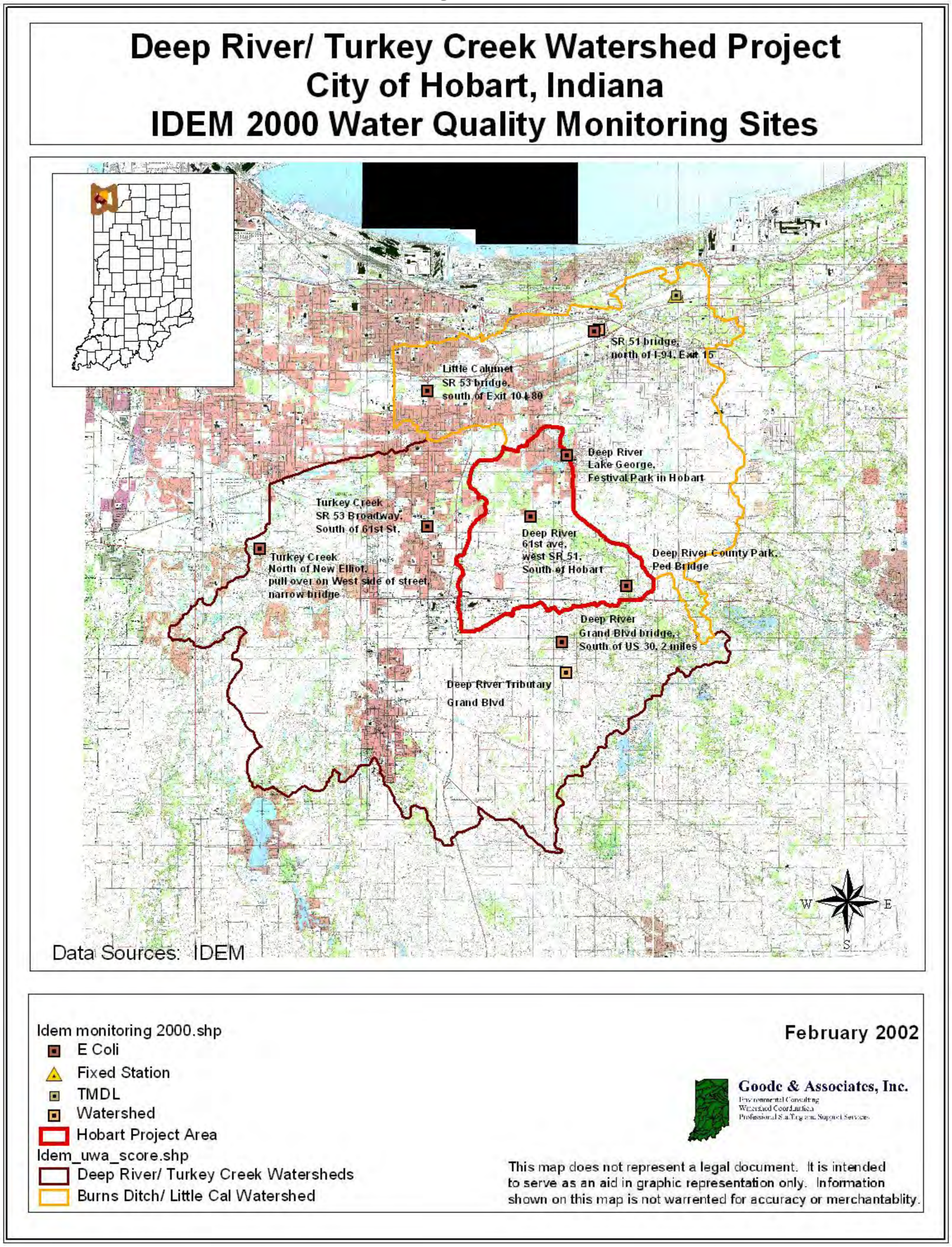

Deep River/ Turkey Creek Watershed Project
City of Hobart, Indiana
IDEM 2000 Water Quality Monitoring Sites
SR 51 bridge, north of I-94, Exit 15
Little Calumet SR 53 bridge, south of Exit 10 I-80
Deep River Lake George, Festival Park in Hobart
Turkey Creek SR 53 Broadway, South of 61st St.
Turkey Creek North of New Elliot, pull over on West side of street, narrow bridge
Deep River 61st ave, west SR 51, South of Hobart
Deep River County Park, Ped Bridge
Deep River Grand Blvd bridge, South of US 30, 2 miles
Deep River Tributary Grand Blvd
W
E
S
Data Sources: IDEM
Idem monitoring 2000.shp
E Coli
Fixed Station
TMDL
Watershed
Hobart Project Area
Idem_uwa_score.shp
Deep River/ Turkey Creek Watersheds
Burns Ditch/ Little Cal Watershed
February 2002
Goode & Associates, Inc.
This map does not represent a legal document. It is intended to serve as an aid in graphic representation only. Information shown on this map is not warrented for accuracy or merchantablity.

Figure 4-2

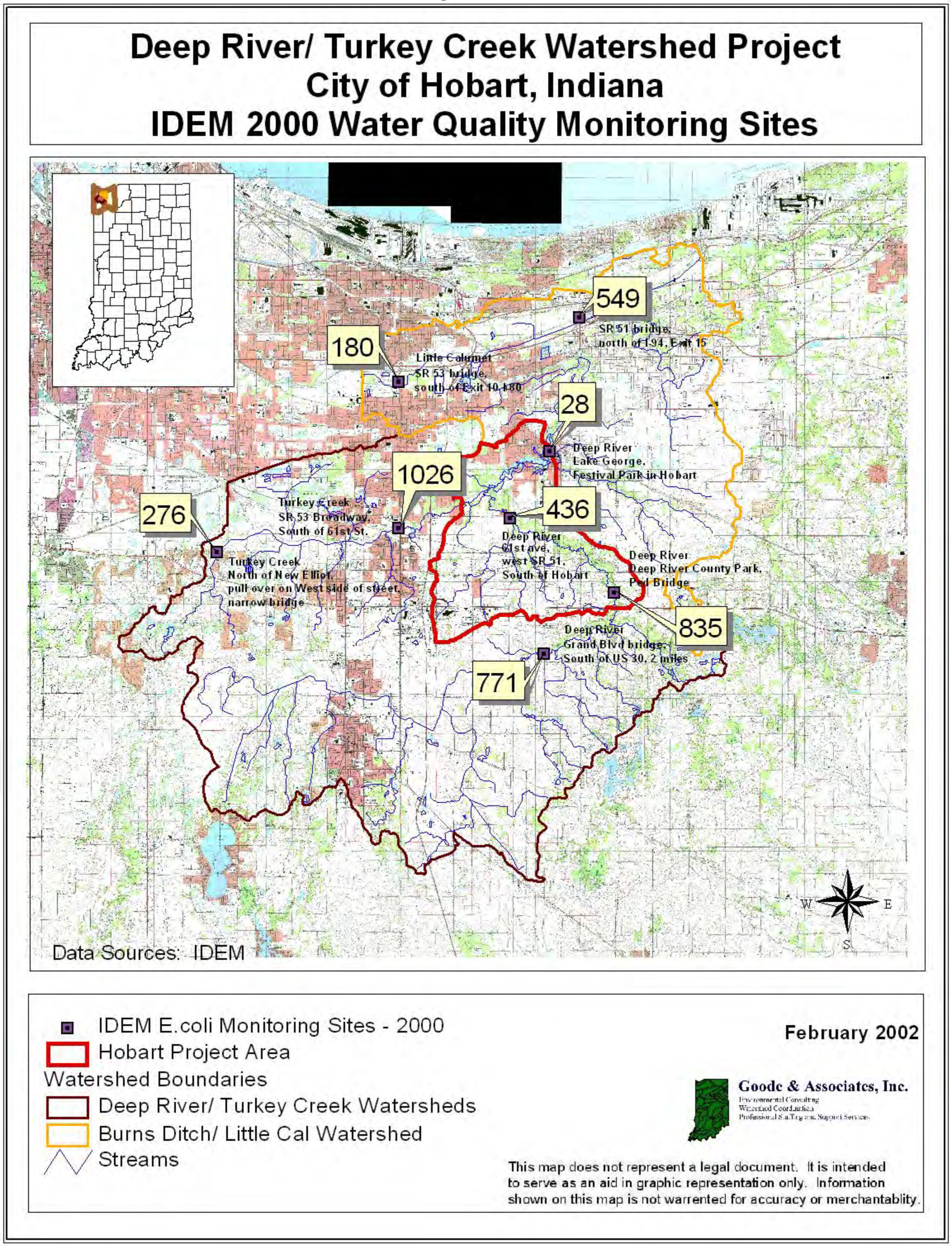

Deep River/ Turkey Creek Watershed Project
City of Hobart, Indiana
IDEM 2000 Water Quality Monitoring Sites
549
SR 51 bridge, north of I 94, Exit 15
180
Little Calumet SR 53 bridge, south of Exit 10 I 80
28
Deep River Lake George, Festival Park in Hobart
1026
Turkey Creek SR 53 Broadway, South of 61st St.
436
Deep River 61st ave, west SR 51, South of Hobart
276
Turkey Creek North of New Elliot, pull over on West side of street, narrow bridge
Deep River Deep River County Park, Red Bridge
835
Deep River Grand Blvd bridge, South of US 30, 2 miles
771
W
E
S
Data Sources: IDEM
IDEM E.coli Monitoring Sites - 2000
Hobart Project Area
Watershed Boundaries
Deep River/ Turkey Creek Watersheds
Burns Ditch/ Little Cal Watershed
Streams
February 2002
Goode & Associates, Inc.
This map does not represent a legal document. It is intended to serve as an aid in graphic representation only. Information shown on this map is not warrented for accuracy or merchantablity.

Figure 4-3: Hobart High School Water Quality Monitoring Sites

Site Number	Location	City/ Town
1	Brookview Subdivision	Hobart
2	Glenwood Subdivision	Hobart
3	Devonshire Subdivision	Merrillville
4	Brookwood Subdivision	Merrillville
5	Hidden Lake Park	Merrillville
6	Hendricks Road	Merrillville
7	Oak Ridge County Park	Griffith
8	Joliet Road & Cline Ave.	Schererville
9	US 30 and Cline Ave.	Schererville
10	Hobart Middle School	Hobart
11	Deep River County Park	Hobart
12	Winfield & 101 Street	Crown Point
13	Madison Street	Crown Point
14	Main Street	Crown Point
15	105th Street	Crown Point
16	Lake George Dam	Hobart
17	Old Sewage Plant	Hobart
18	Riverview Park	Lake Station
19	Memorial Park	Lake Station

Macroinvertebrate Surveys

The Indiana Department Environmental Management (IDEM) Biological Studies Section and Indiana Department of Natural Resources (IDNR) Hoosier RiverWatch volunteers conducted several macroinvertebrate surveys within Lake George and the Deep River/ Turkey Creek Watershed throughout the 1990's and into the 2000's. At the stream sampling sites, IDEM and Hoosier RiverWatch volunteers utilized a variety of biological indices, including the family-level Hilsenhoff Biotic Index (FBI) (Hilsenhoff, 1988) and a macroinvertebrate Index of Biotic Integrity (mIBI) (IDEM, unpublished), to evaluate the biological health of the invertebrate community. Indices of biotic integrity are valuable because aquatic biota integrates cumulative effects of sediment and nutrient pollution (Ohio EPA, 1999). In conjunction with their macroinvertebrate surveys, IDEM also assessed habitat at stream survey locations using the Qualitative Habitat Evaluation Index (QHEI) (Rankin, 1989).

IDEM Surveys

In September of 1990, IDEM conducted three macroinvertebrate surveys in the Deep River/ Turkey Creek Watershed following a specific sampling and subsampling protocol (See **Figure 4-4**). IDEM assessed the data using the family-level Hilsenhoff biotic index. IDEM biologists calculate the FBI by multiplying the number of organisms collected, or sub-sampled, by their family tolerance value, summing the products, and dividing by the total number of organisms collected, or sub-sampled (Hilsenhoff, 1988). Organisms of greater tolerance to organic pollution are assigned a greater value from 1-9; therefore, the higher FBI value, the greater the extent of organic pollution in the stream.

Table 4-1 presents the FBI scores for each sampling site in the watershed. **Table 4-2** correlates the FBI score with water quality and degree of organic pollution. By this measure, Deep River at the County Park and Turkey Creek 1 at S.R. 55 exhibited “Fair” water quality and Turkey Creek 2 at S.R. 55 exhibited “Good” water quality in 1990. Streams classified as “Fair” likely possess fairly substantial organic pollution while streams classified as “Good” probably possess some organic pollution.

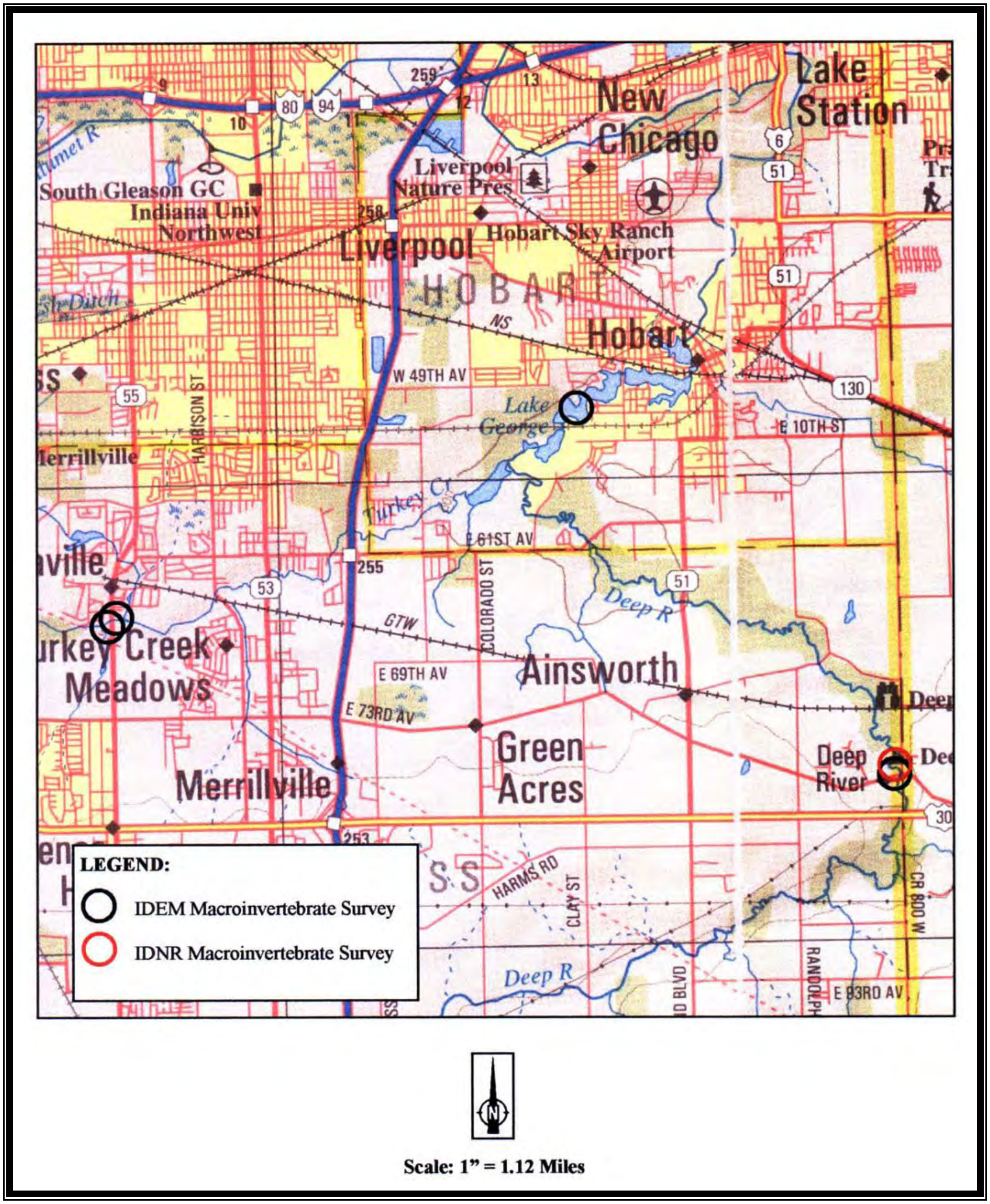
Table 4-1: Family-level Hilsenhoff Biotic Index at three survey sites

Site	FBI
Deep River (Co. Park)	5.65
Turkey Creek 1 (S.R.55)	5.21
Turkey Creek 2 (S.R.55)	4.76

TABLE 4-2: Water Quality Correlation to Hilsenhoff Biotic Index Score

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

FIGURE 4-4: Macroinvertebrate survey sites in the Deep River/ Turkey Creek Watershed



In addition to the FBI, IDEM analyzed macroinvertebrate data using the mIBI (IDEM, unpublished). **Table 4-3** lists the ten scoring metrics along with classification scoring ranges for each metric. The metrics include family-level FBI, number of taxa, number of individuals, percent dominant taxa, EPT Index, EPT count, EPT count to total number of individuals, EPT count to chironomid count, chironomid count, and total number of individuals to number of square sorted. (EPT stands for the Ephemeroptera, Plecoptera, and Trichoptera orders.) To calculate the mIBI, biologists assign the invertebrate community a classification score for each metric. Biologists then average the classification scores to obtain a mean score that equals the mIBI. MIBI scores of 0-2 indicate the sampling site is severely impaired; scores of 2-4 indicate the site is moderately impaired; scores of 4-6 indicate the site is slightly impaired; and scores of 6-8 indicate that the site is non-impaired. IDEM developed the classification criteria based on five years of wadeable riffle-pool data collected in Indiana.

Table 4-3: Benthic macroinvertebrate scoring metrics and classification scores used by IDEM in evaluation of riffle-pool streams in Indiana

SCORING CRITERIA FOR THE FAMILY LEVEL MACROINVERTEBRATE INDEX OF BIOTIC INTEGRITY (mIBI) USING PENTASECTION AND CENTRAL TENDENCY ON THE LOGARITHMIC TRANSFORMED DATA DISTRIBUTIONS OF THE 1990-1995 RIFFLE KICK SAMPLES					
	CLASSIFICATION SCORE				
	0	2	4	6	8
Family Level HBI	↩5.63	5.62- 5.06	5.05-4.55	4.54-4.09	≤4.08
Number of Taxa	≤7	8-10	11-14	15-17	↩18
Number of Individuals	≤79	129-80	212-130	349-213	↩350
Percent Dominant Taxa	↩61.6	61.5-43.9	43.8-31.2	31.1-22.2	≤22.1
EPT Index	≤2	3	4-5	6-7	↩8
EPT Count	≤19	20-42	43-91	92-194	↩195
EPT Count To Total Number of Individuals	≤0.13	0.14-0.29	0.30-0.46	0.47-0.68	↩0.69
EPT Count To Chironomid Count	≤0.88	0.89-2.55	2.56-5.70	5.71-11.65	↩11.66
Chironomid Count	↩147	146-55	54-20	19-7	≤6
Total Number of Individuals To Number of Squares Sorted	≤29	30-71	72-171	172-409	↩410

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

Table 4-4 presents the mIBI scores for each of the three sampling sites. In general, the scores indicate that the three sites possess very similar macroinvertebrate communities. The survey revealed each site supported a similar number of families and individuals. The Deep River site supported more members of the intolerant Ephemeroptera, Plecoptera, and Trichoptera orders than the Turkey Creek sites. At the same time, more chironomids, a tolerant family, inhabited the Deep River site compared to the Turkey Creek sites. IDEM biologists collected more tolerant organisms at the Deep River site than at the Turkey Creek site resulting in a lower Hisenhoff FBI score at Deep River compared to Turkey Creek. Taken together, these slight differences in macroinvertebrate community suggest Turkey Creek possesses slightly better water quality and habitat than the Deep River site.

Table 4-4: Classification scores and mIBI score for sampling sites in the Deep River/ Turkey Creek Watershed

	Deep River (Co. Park)	Turkey Creek 1 (S.R. 55)	Turkey Creek 2 (S.R. 55)
HBI	0	2	4
Number of Taxa (families)	2	2	2
Number of Individuals	4	4	4
% Dominant Taxa	2	2	2
EPT Index	4	2	0
EPT Count	2	4	4
EPT Count/Total Count	2	6	6
EPT Count/Chironomid Count	2	4	4
Chironomid Count	6	4	4
Total Count/Number Squares Sorted	4	2	4
mIBI Score	2.8	3.2	3.4

To assist in differentiating the influence of water quality from the influence of habitat on the macroinvertebrate community, the IDEM evaluated the habitat at each of its three sites using the Qualitative Habitat Evaluation Index (QHEI). The Ohio Environmental Protection Agency (Ohio EPA) developed the QHEI for streams and rivers in Ohio (Rankin 1989, 1995). The QHEI is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic macrohabitat (Ohio EPA, 1989). While the Ohio EPA originally developed the QHEI to evaluate fish habitat in streams, IDEM and other agencies routinely utilize the QHEI as a measure of general “habitat” health. The QHEI is composed of six metrics including substrate composition, in-stream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle-run quality, and map gradient. Each metric is scored individually then summed to provide the total QHEI score. The best possible score is 100.

The QHEI evaluates the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of stream segments in Ohio have indicated that values greater than 60 are generally conducive to the existence of warmwater faunas. Scores greater than 75 typify habitat conditions that have the ability to support exceptional warmwater faunas (Ohio EPA, 1999).

Table 4-5 lists the QHEI scores for the Deep River and Turkey Creek sites. (Due to the proximity of the two sites, IDEM combined the two Turkey Creek sites for the QHEI calculation.) The Deep River site received a score of 73, while the Turkey Creek site received a score of 57. The Deep River site scored better in each of the six QHEI metrics. **Table 4-5** also shows that substrate composition and channel morphology account for the greatest difference in habitat between the two sites. Turkey Creek possesses a silty, shifting substrate and a highly channelized morphology at the sampling site compared to the gravelly substrate and more natural, meandering channel morphology at the Deep River site. Turkey Creek's low QHEI score suggests that this reach may not be capable of supporting a healthy aquatic invertebrate community.

Combining the mIBI and QHEI scores at the two sites helps determine whether water quality or habitat quality is limiting the aquatic community at each site. Because the Deep River site scored above 60 and close to 75, habitat at the Deep River site is likely sufficient to support an aquatic invertebrate community of at least moderate quality. The Deep River mIBI's score was low. Collectively, these data suggest that water quality as opposed to habitat quality may be limiting the ability of the Deep River site to support an aquatic invertebrate community of moderate quality. In contrast, Turkey Creek scored low on the QHEI. It is likely that both water quality and habitat limit the establishment of a moderately healthy aquatic invertebrate community in Turkey Creek.

Table 4-5: QHEI scores for sampling sites on Deep River (County Park) and Turkey Creek (S.R. 55)

Site	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Possible Score	20	20	20	10	12	8	10	100

Deep River (County Park)	19	13	17	7	7	4	6	73
Turkey Creek 1 and 2 (S.R. 55)	14	12	13	5	5	4	4	57

IDEM Lake Survey

In the summer of 2000, the IDEM conducted a macroinvertebrate survey in Lake George (See **Figure 4-4**). Two hundred fifty five individuals insects representing 15 families and two classes were identified as documented in **Table 4-6**. An assessment index equivalent to the mIBI and other invertebrate biotic index indices does not exist for Indiana lakes. In general, tolerant taxa dominated the lake macroinvertebrate community. While IDEM biologists collected several organisms from mayfly and caddisfly orders, which are typically associated with healthy aquatic systems, two thirds of the mayflies and caddis flies belonged to the tolerant Caenidae family. The lake survey species list also included members from the Coenagrionidae and Corixidae families and the Oligochaeta order. Members of these taxa are very tolerant of degraded habitat and water quality conditions. Many remaining individuals belong to fairly tolerant taxa; very few organisms collected represented intolerant families. Lake's George's poor invertebrate community reflects the lake's poor water quality (high turbidity) and lack of suitable habitat (rooted plants).

TABLE 4-6. Macroinvertebrate species from sites within the Deep River-Lake George Watershed

Order or Class	Family	Deep River (County Park) (IDEM, 1990)	Turkey Creek 1 (S.R. 55) (IDEM, 1990)	Turkey Creek 2 (S.R. 55) (IDEM, 1990)	Lake George (IDEM, 2000)	Deep River (County Park) (IDNR, 1990)
Ephemeroptera						1
	Heptageniidae	4	1			
	Baetidae	10	1		4	
	Caenidae	2			56	
	Leptophlebiidae				1	

Odonata						1
	Corduliidae				1	
	Coenagrionidae				9	
Hemiptera						
	Corixidae				46	
	Notonectidae				1	
Trichoptera						1
	Hydropsychidae	8	62	91		
	Hydroptilidae				14	
	Leptoceridae				3	
Coleoptera						
	Elmidae	5				
	Scirtidae				4	
Diptera						
	Ceratopagonidae			1		
	Empididae		3			
	Simulidae	81	2	5		
	Chironomidae	19	20	20	55	
Arthropoda						
	Asellidae	3	21	12		
	Acarina					
	Hyalellidae				5	
Decapoda						
	Palamonidae				6	
Gastropoda						
	Planorbidae				7	
	Lymnae				6	
Turbellaria			1	2		
Oligochaeta		9	21	24	35	1
Hydrozoa					2	
TOTALS	**9 Families**	**9 Families**	**7 Families**	**15 Families**	**4 Orders**	**2 Classes**

Hoosier RiverWatch Survey

In April of 2001, Hoosier RiverWatch volunteers conducted a macroinvertebrate survey on the Deep River within Deep River County Park (**Figure 4-4**). The volunteers collected macroinvertebrates from riffle habitat using the Kicknet Seine Method. The volunteers identified organisms from four orders, Ephemeropterans (mayflies), Trichopterans (caddisflies), Odonates (dragnonflies), and Oligochaetes (aquatic worms). To evaluate the macroinvertebrate community, volunteers utilized the Hoosier RiverWatch's own Pollution Tolerance Index (PTI). RiverWatch volunteers calculate the PTI by placing each organism collected into one of four pollution tolerance groups (PT groups). Volunteers then sum the number of taxa in each PT group and multiply that sum by the PT group's weighting factor. To obtain a PTI rating, the volunteers sum the weighted totals from each of the four PT groups. Because the index weights intolerant PT groups more than tolerant PT groups, a higher PTI score indicates a more intolerant (usually higher quality) macroinvertebrate community. **Table 4-7** correlates PTI score to macroinvertebrate community quality. (See the Indiana Hoosier RiverWatch for more details on the program and its PTI. www.HoosierRiverWatch.com) Based on the 2001 Hoosier RiverWatch survey of the site, the Deep River site received a score of 14 indicating that the reach supported a fair macroinvertebrate community.

Table 4-7: Indiana Hoosier RiverWatch Pollution Tolerance Index score and the corresponding quality of the macroinvertebrate community in Deep River.

Pollution Tolerance Index Score	Macroinvertebrate Community Quality
10 or less	Poor
11-16	Fair
17-22	Good
23 or more	Excellent

Macroinvertebrate Summary

The results of the various macroinvertebrate community studies indicate that the streams in the Deep River/ Turkey Creek watershed support poor to fair macroinvertebrate communities. Pollution tolerant species generally dominated the communities at each site; as IDEM and Hoosier RiverWatch volunteers collected few intolerant species at each site. Poor water quality likely played a larger role than degraded habitat in shaping the poor macroinvertebrate community found at the Deep River site. The Deep River's QHEI score was 73 suggesting the site is physically capable of supporting a macroinvertebrate community of at least moderate quality. Both poor water quality and degraded habitat likely influence the macroinvertebrate community at the Turkey Creek site. Turkey Creek received a QHEI score of 59 suggesting sufficient habitat degradation was present to impair the creek's macroinvertebrate community. In addition, poor water quality may be at least partially responsible for the dominance of tolerant species in the Lake George macroinvertebrate survey.

Lake George Fishery Survey

One survey has been conducted to assess the fishery of Lake George (Robertson, 1971). In August of 1970, the Indiana Department of Natural Resources (IDNR) used a combination of electrofishing and gillnets to survey the fish community within the lake. The survey resulted in the collection of 445 fish representing six families and 15 species (See **Table 4-8**). Common carp (Cyprinus carpio) dominated the sampling effort by number (58%), followed by white crappie (Pomoxis annularis) (14%), brown bullhead (Ameiurus nebulosus) (10%), and yellow bullhead (Ameiurus natalis) (8%). The following species were also observed but collectively accounted for less than 10% of the total sample: black bullhead (Ameiurus melas), pumpkinseed (Lepomis gibbosus), largemouth bass (Micropterus salmoides), bluegill (Lepomis macrochirus), black crappie (Pomoxis nigromaculatus), warmouth (Lepomis gulosus), white sucker (Catostomus commersoni), bowfin (Amia calva), yellow perch (Perca flavescens) and green sunfish (Lepomis cyanellus). One hybrid sunfish was also collected during the survey.

TABLE 4-8. Species list and number of each species sampled from Lake George in 1970.

Common Name	Scientific Name	Number	Percentage
*Common Carp	*Cyprinus carpio*	257	57.7
White crappie	*Pomoxis annularis*	64	14.3
*Brown bullhead	*Ameiurus nebulosus*	43	9.6
*Yellow bullhead	*Ameiurus natalis*	35	7.8
*Black bullhead	*Ameiurus melas*	9	2
Pumpkinseed	*Lepomis gibbosus*	8	1.7
Largemouth bass	*Micropterus salmoides*	7	1.5
Bluegill	*Lepomis macrochirus*	7	1.5
Black crappie	*Pomoxis nigromaculatus*	5	1.1
Warmouth	*Lepomis gulosus*	3	0.6
*White sucker	*Catostomus commersoni*	3	0.6
Bowfin	*Amia calva*	1	0.2
*Hybrid sunfish	*Lepomis sp.*	1	0.2
Yellow perch	*Perca flavenscens*	1	0.2
*Green sunfish	*Lepomis cyanellus*	1	0.2
Totals		445	100%

Source: IDNR Fishery Report (Robertson, 1971). *Indicates tolerant or moderately tolerant fish species.

Tolerant species (species capable of inhabiting waterbodies with poor water quality) dominated the catch in the 1970 survey. Common carp, brown and yellow bullhead, white sucker, green sunfish, white crappie, and hybrid sunfish comprised 76% of the fish collected in 1970. Carp are among the most tolerant of fish species. Although some anglers fish for carp, it is often considered a nuisance fish known for uprooting aquatic vegetation and decreasing water clarity. The abundance of common carp in Lake George probably added to the turbidity problem noted in the 1971 report. Brown and yellow bullhead, white sucker, and green sunfish are also tolerant of poor water quality and habitat conditions. White crappie have wide ecological tolerances but prefer more turbid waters of well-vegetated lakes and larger rivers. Given the lake's poor water clarity, it is not surprising that Lake George supported more white crappie than black crappie, a species that is less tolerant of turbidity. The presence of a hybrid sunfish is also indicative of poor water quality. Interbreeding occurs due to poor water clarity or competition for spawning habitat. The dominance of tolerant species suggests, at least in 1970, water quality and fish habitat conditions were poor and likely limited the lake's fish community.

In contrast to the abundance of tolerant non-game fish, IDNR biologists collected relatively few game species in 1970. White crappie was the only game fish collected in significant numbers. The collected white crappie exhibited average to above average condition factors (relative plumpness). However, of the 64 collected, most white crappie were 5.5-6.5 inches, a length considered too small to harvest. Bass, bluegill, and pumpkinseed, members of the sunfish family (Centrarchidae), accounted for only 4.7% of the fish collected. According to Robertson (1971), they were "insignificant" in the Lake George fishery.

Lake George Fishery Summary

Lake George offered little for anglers in 1970. Non-game species including common carp, brown and yellow bullhead, white sucker, green sunfish, and hybrid sunfish populations comprised over 60% of the total fish collected in the IDNR survey. The lake supported small populations of bluegill and largemouth bass, two popular game species. White crappie was the only game species with sufficient numbers for anglers to catch. Their small size, however, rendered them unharvestable. Overall, the lake possessed highly turbid waters and lacked sufficient submerged vegetation at the time of survey. Consequently, the lake supported a poor fish community. Robertson (1971) suggested that an entire fish eradication of Lake George and its watershed would be needed to create a sustainable fishery. Robertson (1971) believed it was physically possible to chemically treat the watershed, but not economically or biologically sensible.

Deep River/ Turkey Creek Fish Community Surveys

In 1990, Simon (1991) conducted nine fish community surveys within and around the Deep River/ Turkey Creek Watershed (**Figure 4-5**). Simon utilized the Index of Biotic Integrity (IBI) to determine the existing health of fish communities in Turkey Creek, Deep River, and several of their tributaries. The IBI is designed to assess biotic integrity directly through twelve attributes of fish communities in streams. Karr, who first developed the IBI, and Dudley (1981) define biological integrity as, "the ability of a aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region". Simon conducted the nine surveys in and around the Deep River/ Turkey Creek Watershed as part of his effort to modify Karr's IBI (Karr, 1981) for use in the watershed's specific ecoregion, the Central Cornbelt Plain (Omernik and Gallant, 1988).

The twelve fish community attributes that form the basis of the IBI fall into such categories as species richness and composition, trophic composition, and fish abundance and condition. Biologists calculate a stream reach's IBI by comparing reach data to expected values for each of the twelve metrics. For each metric, the reach receives a rating of 1, 3, or 5 depending on whether it strongly deviates from, somewhat deviates from, or closely approximates the expected values. The sum of these ratings gives a total IBI score for the site. The best possible IBI score is 60 (**Table 4-9**).

TABLE 4-9. Attributes of Index of Biotic Integrity classification

IBI	Integrity Class	Attributes
58-60	Excellent	Comparable to the best situation without human disturbance.
48-52	Good	Species richness somewhat below expectations.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists.
12-22	Very Poor	Few fish present. Mostly introduced or tolerant forms.
0	No Fish	Repeat sampling finds no fish.

Source: Development of Index of Biotic Integrity Expectations for the Ecoregions of Indiana I. Central Corn Belt Plains (Simon, 1991).

FIGURE 4-5. Fisheries Sample Site Map

In 1990, Simon (1991) conducted four fish community surveys in the Deep River/ Turkey Creek Watershed and five surveys just outside the study watershed (See **Figure 4-5**). Simon then determined IBI scores for each sampling location. **Table 4-10** presents the IBI scores for each sampling location in or near the Deep River/ Turkey Creek Watershed. IBI values ranged from a high of 31 (Poor) on Deep River at County Line Road to a low of 12 (Very Poor) on Turkey Creek at S.R. 53. No scores fell between 40 (Fair) and 60 (Excellent). These results indicated that stream fish communities within the Deep River/ Turkey Creek Watershed were of poor quality in 1990. Omnivores, tolerant forms, and habitat generalists typically dominate poor quality fish communities. Poor quality fish communities also support few top predators, and fish in these communities exhibit depressed growth rates and condition factors (Simon, 1997). In the Deep River/ Turkey Creek Watershed, a lack of darter, sucker, and sensitive species and a small proportion of simple lithophilic spawners negatively affected IBI scores.

TABLE 4-10. IBI and Integrity Class by site using the Index of Biotic Integrity

Site (Location)	IBI	Integrity Class
Deep River (101 Ave)	18	Very Poor
Main Beaver Dam Ditch (S.R. 53)	25	Poor-Very Poor
Main Beaver Dam Ditch (S.R. 55)	20	Very Poor
Turkey Creek (S.R. 53)	12	Very Poor
Turkey Creek (S.R. 73)	18	Very Poor
Deep River (County Line Road)	31	Poor
Deep River (S.R. 51)	20	Very Poor
Deep River (S.R. 6)	13	Very Poor
Unnamed Trib. to Turkey Creek	29	Poor

Although Simon (1991) does not specifically identify the factors that may be responsible for the degraded fish communities observed in the Deep River/ Turkey Creek Watershed, Applied Ecological Services (AES, 2001) noted several conditions in the watershed that would inhibit high quality fish communities. At Deep River, just south of Lake George, AES reported significant bank erosion, mass wasting, and tree falls. The streambed and bank in this area consisted of sandy silt. Few intolerant and lithophilic species are capable of successfully reproducing on such unstable substrate. In addition, the AES field biologists observed a contaminating oily substance, mass wasting, eroded slopes and tree falls on Turkey Creek, just west of Lake George. These habitat conditions favor tolerant species over intolerant ones and likely played a role, along with poor water quality, in shaping both of the stream's fish communities.

Deep River/ Turkey Creek Fish Community Summary
To summarize, the fish community surveys conducted in Deep River, Turkey Creek, and its tributaries revealed the presence of poor quality fish communities dominated by tolerant species. Both poor water quality and degraded habitat likely limited the ability of these streams to support high quality fish communities. Simon and Stewart (1999) support this hypothesis. In their work on the southern Lake Michigan basin, which includes Deep River/ Turkey Creek Watershed, they reported that the number of native species has declined 22% since European settlement. They list channelization, water quality degradation, toxins and agrichemicals, sedimentation, wetland drainage and filling, deforestation, and the introduction of exotic species as factors responsible for degrading fish habitat and, consequently, fish communities.

Draft 2002 305(b) Report – Deep River/ Turkey Creek Watershed Assessments

Section 305(b) of the Clean Water Act (CWA) requires each State to monitor the quality of its waters and prepare a report describing their quality. This process of monitoring and assessment produces an evaluation of the degree to which each waterbody supports a State's designated uses and resulting water quality standards.

Appendix 4-1 provides an excerpt from the draft 2002 305(b) report that includes the waterbody assessments that have been compiled to date by IDEM for the Deep River Turkey Creek Watershed. The draft report indicates that multiple stream segments within the Deep River/ Turkey Creek Watershed are not supporting designated uses for aquatic life support and primary contact recreation. In addition, the draft report identifies multiple sources causing waterbodies to be impaired. Waterbodies assessed during the 2002 305(b) process are listed in **Table 4-11**.

Draft 2002 303(d) List – Impaired Streams in the Deep River/ Turkey Creek Watershed

Section 303(d) of the CWA requires that waters not meeting or not expected to meet water quality standards after the implementation of regulatory controls (NPDES permits) be compiled and listed as "impaired waters" by IDEM. Impaired waters are considered to be those waterbodies that do not meet the State's water quality standards for one or more designated uses. The statewide list of impaired streams was recently updated in March of 2002. **Figure 4-6** illustrates the locations of 303(d) listed streams within the Deep River/ Turkey Creek watershed that will be required to undergo TMDL development. A list of impaired streams in the Deep River/ Turkey Creek watershed is also listed in **Table 4-12**.

Table 4-11: Draft 2002 305(b) Waterbody Assessments

Waterbody Name	Designated Use/ Support*	Pollutant/ Stressor	Source(s)
Turkey Creek – Mainstem	ALUS – Not Supporting; Recreation – Not Supporting	Impaired Biotic Communities; Pathogens	Municipal Point Sources; Landfills; Urban Runoff
Turkey Creek – Merrillville	ALUS – Not Supporting; Recreation – Not Supporting	Impaired Biotic Communities; Pathogens	CSO
Main Beaver Dam Ditch	ALUS – Not Supporting	Impaired Biotic Communities	Nonpoint Sources
Main Beaver Dam Ditch above Niles Ditch	ALUS – Not Supporting	Impaired Biotic Communities; Habitat alterations	Nonpoint Sources; Channelization
Niles Ditch	ALUS – Not Supporting	Impaired Biotic Communities;	Nonpoint Sources
Deep River U/S of US 30	Recreation – Not Supporting	Pathogens	Nonpoint Sources
Deep River Tributary - Merrillville	ALUS – Not Supporting	Impaired Biotic Communities; Siltation	Habitat Modification
Lake George	Recreation – Fully Supporting		
Deep River above Lake George Dam	Recreation – Not Supporting	Pathogens	Nonpoint Sources

*ALUS – Aquatic Life Use Support

Figure 4-6

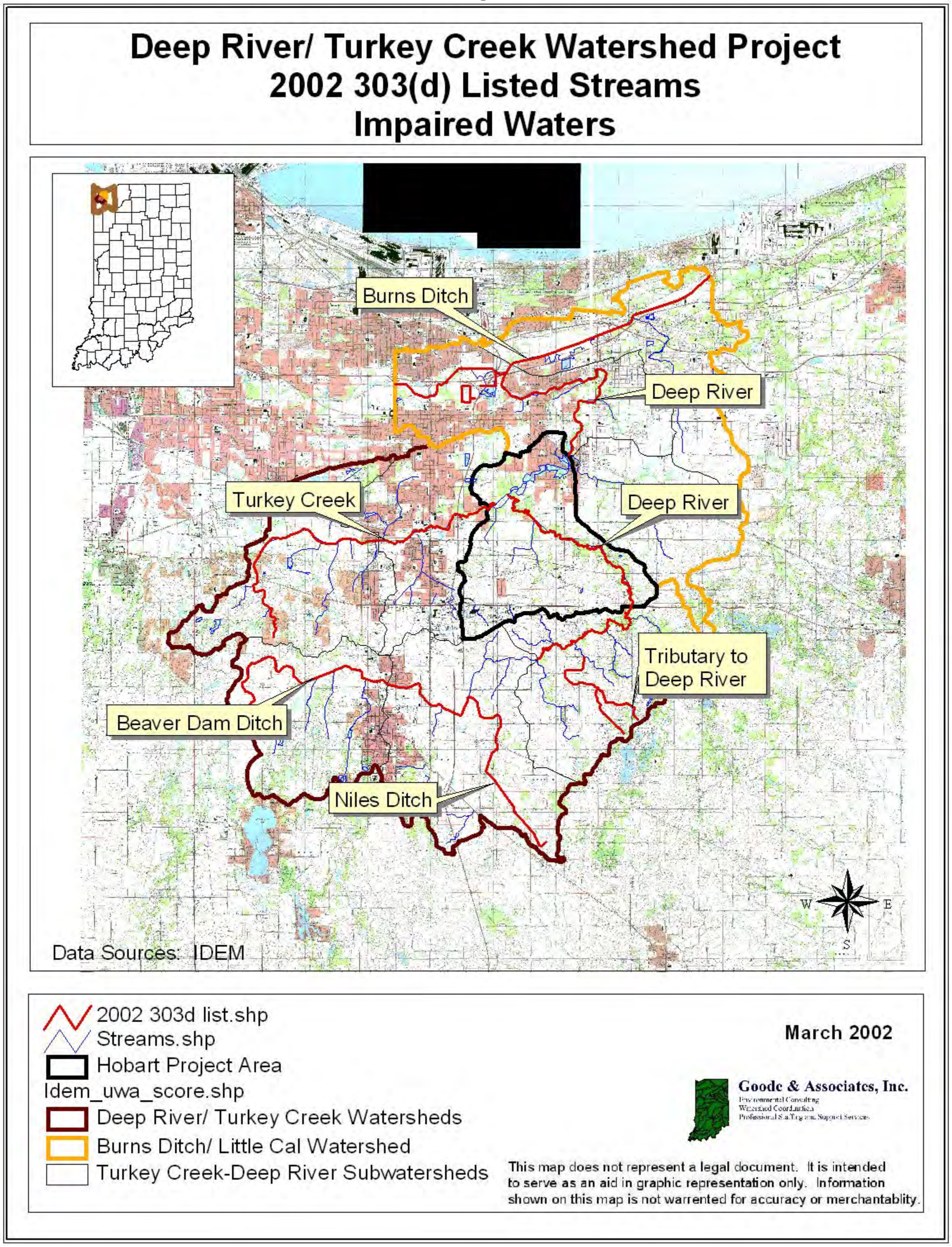

Deep River/ Turkey Creek Watershed Project
2002 303(d) Listed Streams
Impaired Waters
Burns Ditch
Deep River
Turkey Creek
Deep River
Tributary to Deep River
Beaver Dam Ditch
Niles Ditch
W
E
S
Data Sources: IDEM
2002 303d list.shp
Streams.shp
Hobart Project Area
Idem_uwa_score.shp
Deep River/ Turkey Creek Watersheds
Burns Ditch/ Little Cal Watershed
Turkey Creek-Deep River Subwatersheds
March 2002
Goode & Associates, Inc.
This map does not represent a legal document. It is intended to serve as an aid in graphic representation only. Information shown on this map is not warrented for accuracy or merchantablity.

Table 4-12: Impaired Streams in the Deep River/ Turkey Creek Watershed

Waterbody Name	County	Major Basin	Parameter(s) of Concern	TMDL Development Schedule**
Deep River – Burns Ditch	Lake	GREAT LAKES	E. coli	2000 - 2004
Deep River – Burns Ditch	Lake	GREAT LAKES	Impaired Biotic Communities	2005 - 2007
Main Beaver Dam Ditch - above Crown point WWTP	Lake	GREAT LAKES	Impaired Biotic Communities	2015 - 2017
Lake George	Lake	GREAT LAKES	FCA for PCB	2015 - 2017
Niles Ditch	Lake	GREAT LAKES	Impaired Biotic Communities	2015 - 2017
Turkey Creek mainstem; Turkey Creek - Merrillville	Lake	GREAT LAKES	E. coli	2015 - 2017
Turkey Creek mainstem; Turkey Creek - Merrillville	Lake	GREAT LAKES	Impaired Biotic Communities	2015 - 2017
Deep river tributary Merrillville	Lake	GREAT LAKES	Impaired Biotic Communities; Siltation	2015 - 2017
Deep River U/S U.S. 30; Deep River above Lake George Dam	Lake	GREAT LAKES	E. coli	2015 - 2017

Fish Consumption Advisory (FCA)

Each year since 1972, three agencies have collaborated to create the Indiana Fish Advisory. These agencies include the Indiana Department of Environmental Management (IDEM), the Indiana Department of Natural Resources (IDNR), and the Indiana State Board of Health (ISBH). Each year, members from these agencies meet to discuss the findings of recent fish monitoring data and to develop the new statewide fish consumption advisory.

The 2001 advisory is based on levels of polychlorinated biphenyls (PCBs) and mercury found in fish tissue. In each area, samples were taken of bottom-feeding fish, top-feeding fish, and fish feeding in between. More than 1,600 fish tissue samples were analyzed for polychlorinated biphenyls (PCBs), pesticides, and heavy metals. Of those samples, the majority contained at least some mercury. However, not all fish tissue samples had mercury at levels considered harmful to human health. If they did, they are listed in the fish consumption advisory.

Because of past, widespread agricultural and industrial use of these materials, their great stability and persistence in the environment, and the potential for bioaccumulation, it is not surprising that concentrations exceeding safe levels have been found in some species. Criteria for the statewide 2000 Indiana Fish Consumption Advisory are developed from the Great Lakes Task Force risk-based approach.

Fish Consumption Advisories that are currently in effect for the Deep River/ Turkey Creek Watershed are listed in **Table 4-13**. ISBH criteria for fish consumption advisory groups are outlined in **Table 4-14**.

Table 4-13: FCA for the Deep River/ Turkey Creek Watershed

Location	Species	Fish Size(inches)	Contaminant	Group (See Table 4-14)
Lake George				
Lake County	Northern Pike	18+	■	2
All Rivers and Streams				
	Carp	15-20 inches	■❍	3
	Carp	20-25 inches	■❍	4
	Carp	25 +	■❍	5

❍ = Mercury; ■= PCB

TABLE 4-14: ISDH DEFINITIONS FOR FISH CONSUMPTION ADVISORY GROUPS

Group 1	Unrestricted consumption
Group 2	One meal per week (52 meals per year) for adult males and females. One meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.
Group 3	One meal per month (12 meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat.
Group 4	One meal every two months (six meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat.
Group 5	No consumption (DO NOT EAT)

Unified Watershed Assessment (UWA) – Natural Resources Conservation Service

The Clean Water Action Plan, released in February 1998, presented a plan and certain incentives directed toward accelerating the control of nonpoint source pollution in America. States were requested, as one of the 111 Action Items presented in the Plan, to prepare a Unified Watershed Assessment (UWA). This Assessment was developed through the cooperation of state, federal, and local agencies and the public. The guidance for completing the UWA, published by the USEPA in June 1998, charged the USDA Natural Resources Conservation Service (NRCS) and the state water quality agency (IDEM) with convening the assessment process. What sets this assessment apart from other lists and reports regarding watersheds is the involvement of numerous organizations, the participation of all states, and the recognition of both impaired and healthy watersheds. UWA scores for the Deep River/ Turkey Creek Watershed are located in **Table 4-15**.

1998 UWA

As a requirement of the Clean Water Action Plan, the Unified Watershed Assessment was organized as a multi-agency effort to prioritize watershed restoration needs in each state. In Indiana, a workgroup appointed by the Watershed Agency Team for Enhancing Resources (WATER Committee) developed the first Assessment in September 1998 for FFY 1999-2000 in accordance with EPA guidelines.

In the first version of the UWA, the workgroup ranked the 8-digit hydrologic unit watersheds according to the present condition of the water in lakes, rivers, and streams. The data provided information about the water column, organisms living in the water, or the suitability of the water for supporting aquatic ecosystems. Each layer of data was partitioned by percentiles into 5 scores, with "1" being indicative of good water quality or minimum impairment, and "5" indicating heavily impacted or degraded water quality.
Scores for each 8-digit watershed were compiled, and the watersheds were sorted into four categories as required by the USEPA guidance.

The four categories are as follows:

I. Watersheds in need of restoration: waters do not meet designated uses or other natural resource goals. 25% or more of the waters that have been assessed do not meet state water quality standards. (Note that in some watersheds, only a very small percentage of waters have been recently assessed.)

II. Watersheds that on average meet state water quality goals and require attention to sustain water quality. In most of these watersheds, there is habitat that is recognized as critical for threatened or endangered species.

III. Watersheds with pristine or sensitive aquatic systems on federal or state managed lands.

IV. Watersheds with insufficient data to make an assessment.

1999 UWA

During the summer of 1999, the UWA workgroup used additional layers of information to identify resource concerns and stressors for each of the 361 11-digit watersheds in Indiana (See **Table 4-15**). This time, the UWA examination included more information about human activities that have the potential to impact ecosystems and information to help planners to focus on those areas where restoration may be most critical.

The UWA process was conducted to illuminate areas where the interests of two or more partner agencies may converge. It was intended that this would lead to more effective allocation of resources for restoration and protection activities. At the local level, it was hoped that the UWA could assist groups in prioritizing watershed activities and providing discussion points for planning.

The amended UWA assessment provided the following benefits:

- Provided a logical process for targeting funds, which may be expanded or updated without changing the basic framework.
- Provided information at a finer resolution (11-digit hydrologic units) to agencies and local groups interested in watershed assessment.
- Identified data gaps.

- Could be used as a complement to other assessments, such as the 305(b) Report and 303(d) List.

2000-2001 UWA
In order to target the allocation of FFY 2001-2002 Section 319 funds that were made available through the Clean Water Action Plan, 11-digit hydrologic units with the greatest indication of existing or potential problems were given a higher priority. Based on the additional information gathered in this iteration of the UWA, all watersheds in the state are now considered to be in Category I.

Watersheds (11-huc) with two or more scores of 5, one score of 5 and two or more scores of 4, or three or more scores of 4 (in any category) were given a higher priority. Note that there are significant gaps in data, especially for water quality, and this assessment should be evaluated in the context of available local information. This funding targeting process is known to be imperfect, but used the best information available at the time.

TABLE 4-15: Unified Watershed Assessment, 2000-2001.

Deep River/ Turkey Creek Watershed Scores for Each Parameter Used in the Unified Watershed Assessment [2000-20001]															
	Measured Parameters														
11 Digit Hydrologic Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
04040001030 (DEEP RIVER/ TURKEY CREEK)	nd	nd	nd	nd	nd	nd	3	4	3	1	5	3	1	2	1

ND = No Data

Parameters:
1 - Mussel Diversity and Occurrence
2 - Aquatic Life Use Support
3 - Recreational Use Attainment
4 - Stream Fishery
5 - Lake Fishery
6 - Eurasian Milfoil Infestation Status
7 - Lake Trophic Status
8 - Critical Biodiversity Resource
9 - Aquifer Vulnerability
10 - Population Using Surface Water for Drinking Water
11 - Residential Septic System Density
12 - Degree of Urbanization
13 - Density of Livestock
14 - % Cropland
15 - Mineral Extraction Activities

V. Deep River/ Turkey Creek Water Quality Monitoring Project

To facilitate the development of the Deep River/ Turkey Creek Watershed Management Plan, the scope of work for this project also included an assessment of existing water quality in the watershed to supplement the historical water quality data collected during the initial phases of plan development. With assistance from the consulting team, the Water Quality subcommittee selected nine water quality sampling sites located throughout the watershed. **Figure 5-1** illustrates each of the sampling site locations and **Table 5-1** describes the location of each sampling site.

Figure 5-1. Deep River/ Turkey Creek watershed sampling locations

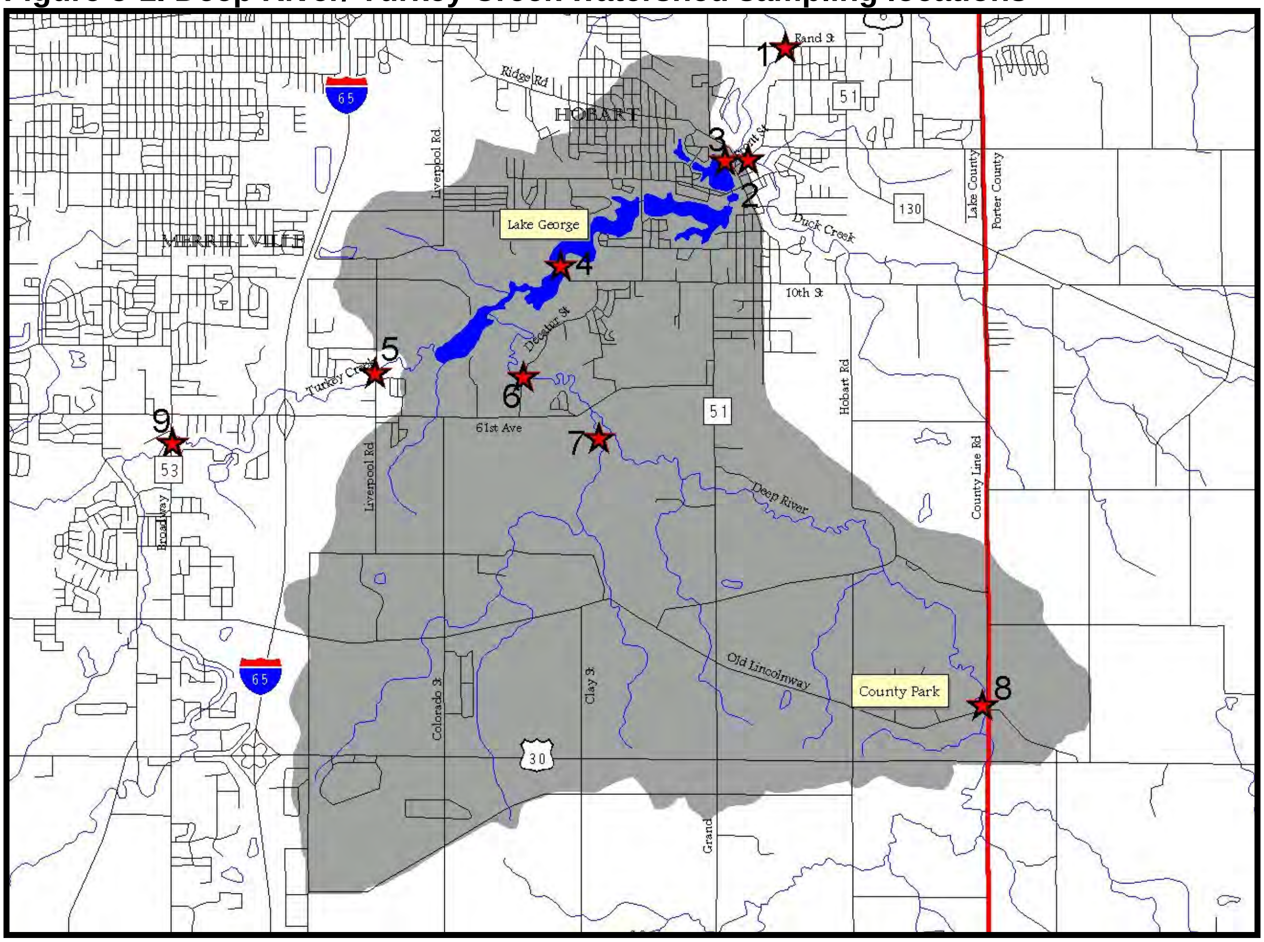


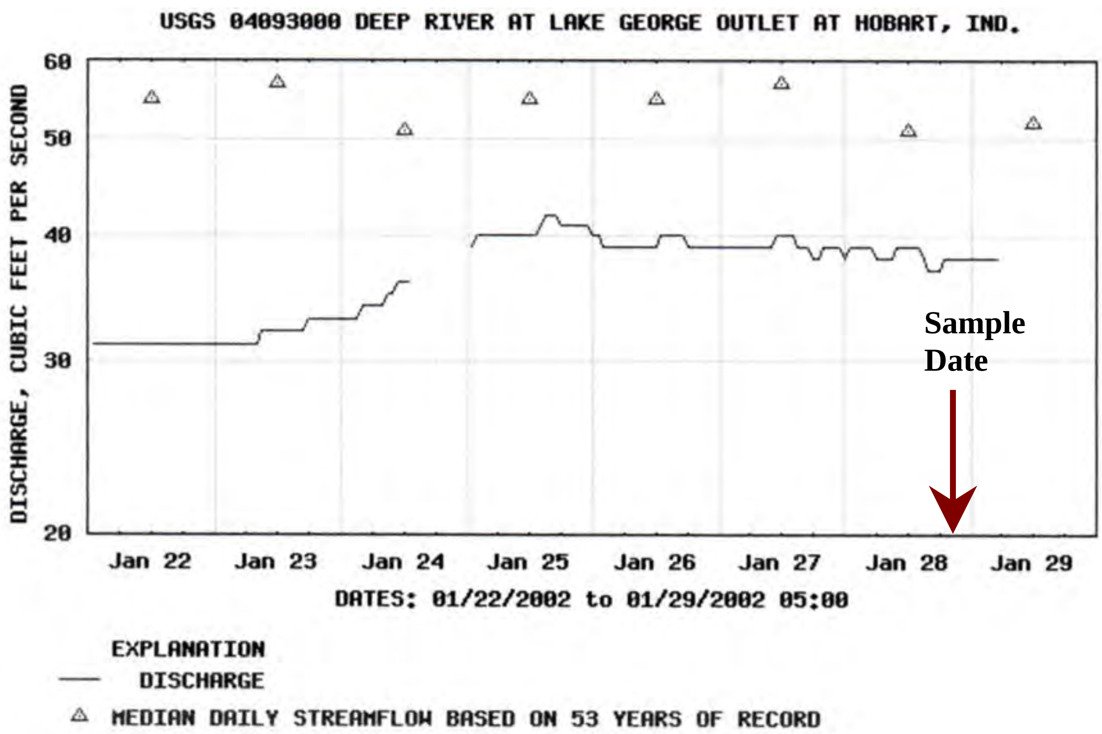
Table 5-1: Sampling Site Locations:

Site 1: Deep River at Rand Street, immediately west of Kelly Street.
Site 2: Duck Creek at Front Street, immediately north of Center Street.
Site 3: Deep River, immediately below the Lake George dam.
Site 4: Lake George, immediately downstream of the wetland at the southwest end of the lake.
Site 5: Turkey Creek at Liverpool Road, immediately north of 16th Street.
Site 6: Deep River at Decatur Street.
Site 7: Unnamed tributary to Deep River.
Site 8: Deep River, immediately northwest of the intersection of County Line Road and the Old Lincoln Highway.
Site 9: Turkey Creek at State Road 53.

J.F. New & Associates (New) collected water quality samples from the sampling sites in the Deep River/ Turkey Creek watershed twice during the study period. The first sampling effort occurred on January 28, 2002 following a period of little precipitation. The hydrograph for the United States Geological Survey (USGS) Lake George gaging station shows discharge at the gage was below the historical median discharge (See **Figure 5-2)**. The historical median is based on 53 years worth of data. This data suggests streams in the watershed were at base flow conditions. Base flow sampling provides an understanding of typical conditions in streams.

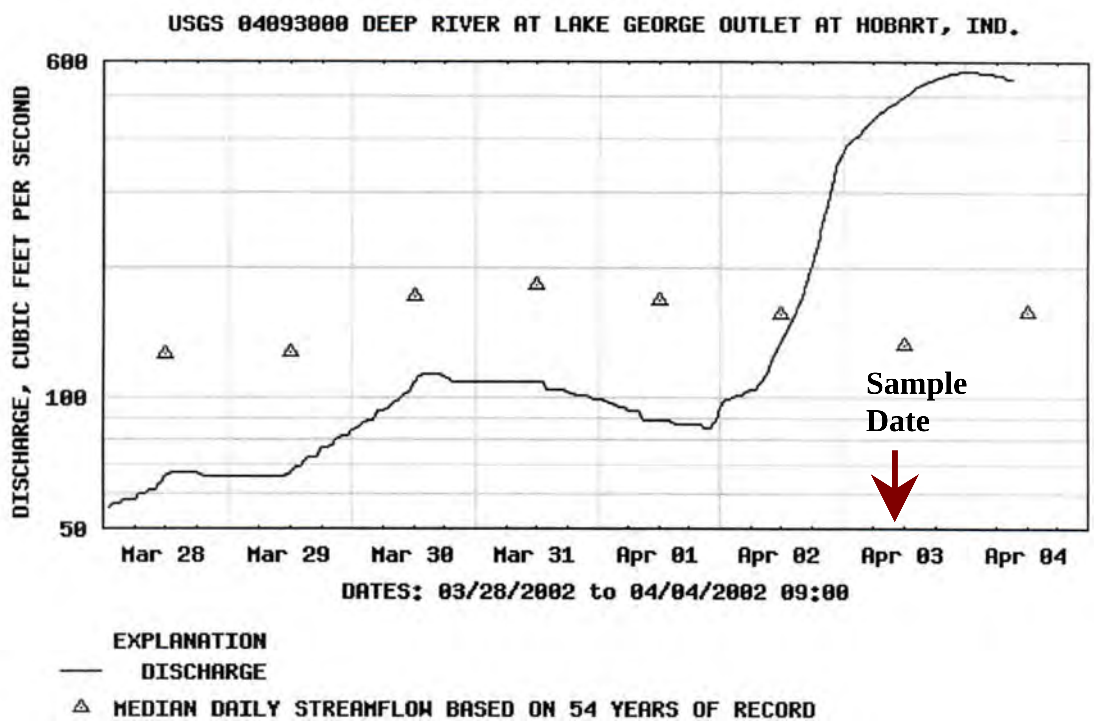
The second sampling effort occurred on April 3, 2002 following two days of rain. Local monitoring stations reported precipitation totals of approximately 0.5 to 1 inch in Lake and Porter Counties (http:/shadow.agry.purdue.edu/sc.index.html/). Discharge at the Lake George gaging station exceeded the historical median discharge peaking at nearly six times the historical value (See **Figure 5-3**). Based on the hydrograph, the April 3rd sampling effort documented storm flow conditions in the watershed streams. Following storm events, the increased overland water flow results in increased erosion of soil and nutrients from the land. In addition, precipitation washes pollutants from hardscape into the watershed. Thus, stream concentrations of nutrients and sediment are typically higher following storm events. In essence, storm sampling presents a "worst case" picture of watershed pollutant loading.

Figure 5-2. Mean daily discharge for the Deep River at Lake George with base flow sampling date noted.



During the collection and analysis of the water quality samples, the sampling crewmembers and the contract laboratory, Severn Trent Laboratories (STL) in Valparaiso, followed the methodologies outlined in the Deep River/ Turkey Creek Quality Assurance Project Plan. The specifics of these methodologies will not be repeated here, but are described in detail in the Quality Assurance Project Plan (QAPP) that was developed for this project. At each sampling site, the sampling crew measured temperature, dissolved oxygen, pH, conductivity and water velocity *in situ*. The sampling crew also measured the cross-sectional area of each stream in order to calculate the stream's discharge.

Figure 5-3. Mean daily discharge for the Deep River at Lake George with storm flow sampling date noted.



The sampling crew collected water at each site in sterile, pre-preserved (where appropriate) sample containers supplied by STL. Based on input from the Water Quality subcommittee and the consulting team, STL analyzed the water quality samples for the following parameters:

- Nitrate-nitrogen (NO_3^--N)
- Ammonia-nitrogen (NH_3-N)
- Total Kjeldahl Nitrogen (TKN)
- Total Phosphorus (TP)
- Total Suspended Solids (TSS)
- Biological Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- *Escherichia coli* bacteria (*E. coli*)

Description of Parameters Monitored

Comprehensive evaluations of stream water quality require collecting data on a variety of different water quality parameters. A brief description of each parameter monitored for this project is as follows:

Temperature
Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. Likewise, water temperature regulates the species composition and activity of life associated with the aquatic environment. Since essentially all aquatic organisms are ‘cold-blooded’ the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (EPA, 1976). The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits for Indiana streams. Temperatures should not exceed 10.0 ^{o}C by more than 1.7 ^{o}C during the month of January and 21.1 ^{o}C during the month of April. (Water quality sample collection for this assessment occurred in these two months.) At no time should water temperatures exceed 32.2 ^{o}C. In addition, the Indiana Administrative Code states that “the maximum temperature rise at any time or place…shall not exceed 2.8 ^{o}C in streams and 1.7 ^{o}C in lakes and reservoirs.”

Oxygen
Like their terrestrial counterparts, aquatic fauna require oxygen to live. During respiration, aquatic fauna consume oxygen in the water column. The degradation of certain organic substances also utilizes oxygen in the water column. Much of the oxygen in the water column originates from the air above the water body. Plants (rooted and algae) also produce oxygen as a byproduct of photosynthesis. Occasionally, excessive algae growth can over-saturate a waterbody with oxygen.

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

The amount of DO in a lake can affect a variety of chemical reactions in the water. For example, in many lakes, particularly lakes that stratify (become layered due to differences in temperature along the lake's depth gradient), decomposition processes that use up available oxygen coupled with limited mixing with the oxygenated upper layer of the lake lead to a lack of oxygen in the lake's lower water layer. Without the presence of oxygen, phosphorus bound to the lake sediments may be released into the water column. The phosphorus is released as soluble reactive phosphorus (SRP), the form that is readily used by algae. The lack of oxygen also prevents the conversion of ammonium to nitrate. Thus, more of the usable form of nitrogen is available for algae growth.

The Indiana Administrative Code (IAC) requires that all waterbodies possess a daily dissolved oxygen average concentration of at least 5 mg/L and that at no time shall the DO concentration drop below 4 mg/L. The State set these standards to ensure aquatic life survival. In addition, DO concentrations above 1 mg/L are necessary to prevent the release of phosphorus from the bottom sediments. These thresholds should be considered when using DO to evaluate the aquatic ecosystem health.

pH

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

Conductivity

Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, on their total concentration, mobility, and valence (APHA, 1995). At low discharge, conductivity is higher than following storm events because the water moves more slowly across or through ion-containing soils and substrates during base flow. Carbonates and other charged particles dissolve into the slow-moving water, thereby increasing the conductivity of a water body.

The Indiana Administrative Code standard for conductivity is reported as 750 mg/L of dissolved solids. Multiplying the dissolved solids concentrations by a conversion factor of 0.55 to 0.75 ɥmhos per mg/L of dissolved solids roughly converts dissolved solid concentrations to specific conductance (Allan, 1995). Multiplying 750 mg/L by the conversion factor range yields a specific conductance range of approximately 1000 to 1360 ɥmhos.

Nutrients (Nitrogen and Phosphorus)

Nutrients are a necessary component of aquatic ecosystems. Ecosystem primary producers (i.e. plants) require nutrients for growth. Growth of the primary producers ultimately supports the remainder of the organisms in the ecosystem's food web. Insufficient nutrient levels in stream and lake water can limit the size and complexity of biological communities living in the stream or lake. In contrast, excessive levels of nutrients in lake or stream water alter biological communities by promoting nuisance species growth. For example, high concentrations of total phosphorus in lake water (>0.03 mg/L) create ideal conditions for nuisance algae growth. In extreme cases, lake algae growth can exclude rooted macrophyte growth and shift fish community composition.

In low to middle order streams such as Duck Creek, Turkey Creek, and Deep River, aquatic plants exist primarily as periphyton. Light availability and flow regime limit the establishment of rooted macrophytes and phytoplankton populations that are more common in lakes and large river systems. As small stream ecosystems' primary producers, periphyton support higher members of the stream food web (invertebrates, fish). Nutrients are one of the factors that limit periphyton growth in streams and thus are included in stream water chemistry analyses.

Phosphorus and nitrogen are common nutrients governing plant growth. (When diatoms dominate the periphyton or planktonic community, silica is also an important nutrient.) Sources of phosphorus and nitrogen include fertilizers, human and animal waste, atmospheric deposition in rainwater, and yard waste or other plant material that reaches streams. Nitrogen can also diffuse from the air into streams. Atmospheric nitrogen is then "fixed" by certain algae species (cyanobacteria) into a usable form of nitrogen. Because of this readily available source of nitrogen (via the air), phosphorus is usually the "limiting nutrient" in aquatic ecosystems.

Phosphorus and nitrogen exist in several forms in water. The two common phosphorus forms are soluble reactive phosphorus (SRP) and total phosphorus (TP). SRP is the dissolved form of phosphorus. It is the form that is "usable" by algae. Algae cannot directly digest and use particulate phosphorus for growth. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. The most commonly measured nitrogen forms are nitrate-nitrogen (NO_3), ammonium-nitrogen (NH_4^+), and total Kjeldahl nitrogen (TKN). Nitrate is a dissolved form of nitrogen that is commonly found in surface water where oxygen is readily available. In contrast, ammonium-nitrogen is generally found in water where oxygen is lacking. Like SRP, ammonium is a dissolved form of nitrogen and the one utilized by algae for growth. The TKN measurement parallels the TP measurement to some extent. TKN is a measure of the total organic nitrogen (particulate) and ammonium-nitrogen in the water sample.

Indiana possesses nitrate-nitrogen and ammonia-nitrogen standards for its water bodies. These standards apply to all state water bodies except those designated as Limited Use waters. The nitrate-nitrogen standard is 10 mg/L; nitrate-nitrogen concentrations exceeding 10 mg/L in drinking water are considered hazardous to human health (Indiana Administrative Code IAC 2-1-6). Because both temperature and pH govern the toxicity of ammonia for aquatic life, these factors are weighted in the ammonia the standard. According to the IAC, maximum unionized ammonia concentrations within the temperature and pH ranges measured for the study streams should range between 0.022-0.076 mg/L.

Total Suspended Solids

Total suspended solids (TSS) refer to all particles suspended or dissolved in stream water. Sediment, or dirt, is the most common solid suspended in stream water. The sediment in stream water originates from many sources, but a large portion of sediment entering streams comes from active construction sites or other disturbed areas such as unvegetated stream banks.

Suspended solids impact streams in a variety of ways. When suspended in the water column, solids can clog the gills of fish and invertebrates. As the sediment settles to the creek bottom, it covers spawning and resting habitat for aquatic fauna, reducing the animals' reproductive success. Suspended sediments also impair the aesthetic and recreational value of a waterbody. In lakes and reservoirs, sediment accumulation limits boating opportunities and shortens the waterbody's lifespan. Similarly, few people are enthusiastic about having a picnic near a muddy creek or wading in silty water. Pollutants attached to sediment also degrade water quality.

Pathogens

Bacteria, viruses, and other pathogens are contaminants of concern in urban watersheds. Common sources of these pathogens include human and wildlife waste, fertilizers containing manure, previously contaminated sediments, septic tank leachate, combined sewer overflows, and illicit connections to stormwater sewers. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. Thus, pathogens can impair the recreational value of a stream. Some pathogens can also impair biological communities. Water quality researchers and monitoring programs utilize *E. coli* as an indicator for the presence of pathogens in water. According to the IAC, *E. coli* concentrations should not exceed 235 colonies/100 mL in any one sample within a 30-day period.

Water Quality Monitoring Results

Introduction

There are two useful ways to report water quality data in flowing water. Concentrations express the mass of a substance per unit volume, for example milligrams of total suspended solids per liter (mg/L). Mass loading describes the mass of a particular material being carried per unit time (kg/d). Loading is important when comparing among sites and among sampling dates because: 1) Flow can be highly variable; therefore, normalizing concentrations to flow eliminates variability and 2) Delivery of materials is important to consider. For example, a stream with high discharge but low pollutant concentration may deliver a larger portion of a pollutant to its receiving body than a stream with higher pollutant concentration but lower discharge.

The total amount of nutrients, suspended solids, and pathogens entering the stream is of greatest concern when considering the effects of these materials downstream. Because consideration of concentration and mass loading data is important, the following sections will discuss 1) physical parameter concentrations, 2) chemical and bacterial parameter concentrations, and 3) chemical and sediment parameter mass loading.

Physical Parameter Concentrations

Table 5-2 presents the physical parameter results measured during base flow and storm flow. The following discussion addresses these physical parameters. During base flow sampling, temperatures in the streams varied from 37º F (3º C) at Sites 1 (Deep River), 2 (Duck Creek), and 3 (Deep River) to 43º F (6º C) at Site 9 (Turkey Creek). Water temperatures during storm flow varied from 41º F (5º C) to 43º F (6º C) at all sampling sites.

Dissolved oxygen (DO) concentrations varied from 9.2 mg/L to 12.2 mg/L. DO in all streams exceeded the Indiana state minimum standard of 5 mg/L indicating that oxygen was sufficient to support aquatic life. Since DO varies with temperature (cold water can hold more oxygen than warm water), it is also important to examine DO saturation values. DO saturation refers to the amount of DO dissolved in water compared to the total amount possible when equilibrium between the stream water and the atmosphere is achieved. Stream dissolved oxygen concentrations that are less than 100% saturated imply one of two things: decomposition processes within the stream consume oxygen more quickly than it can be replaced or flow in the stream is not turbulent enough to entrain sufficient oxygen.

Table 5-2. Physical parameter data collected during stream chemistry sampling events in the Deep River watershed on 1/28/2002 and 4/3/2002. A double dash (--) indicates that no sample collection occurred at that site.

Site	Date	Timing	Flow (cfs)	Temp (ºC)	DO (mg/L)	DO Sat (%)	Conductivity (ɥmhos/cm)	pH (SU)	BOD (mg/L)
1	1/28/2002	Base	53.43	3.0	12.20	92.0	900	6.9	2.3
	4/3/2002	Storm	525.99	6.0	10.72	84.9	900	8.1	<2.0
2	1/28/2002	Base	5.79	3.0	11.10	85.0	700	8.1	<2.0
	4/3/2002	Storm	78.83	5.0	9.70	75.3	400	8	<2.0
3	1/28/2002	Base	40.65	3.0	12.20	92.0	900	8.1	<2.0
	4/3/2002	Storm	592.52	7.0	10.96	89.4	900	8.5	<2.0
4	1/28/2002	Base	41.27	3.5	11.60	90.0	800	8.4	<2.0
	4/3/2002	Storm	633.50	6.0	9.98	78.5	500	7.8	4
5	1/28/2002	Base	8.32	5.5	9.20	75.0	900	8.3	<2.0
	4/3/2002	Storm	139.13	6.0	9.88	78.7	700	8.5	2.8
6	1/28/2002	Base	18.11	5.0	11.00	88.0	800	8.4	<2.0
	4/3/2002	Storm	335.34	6.0	9.95	79.1	400	8.5	3.2
7	1/28/2002	Base	0.75	5.5	10.80	88.0	1200	8.2	<2.0
	4/3/2002	Storm	--	--	--	--	--	--	--
8	1/28/2002	Base	1.30	5.0	11.20	90.0	700	8.1	3.6
	4/3/2002	Storm	364.17	6.0	10.56	83.8	500	8.7	3.3
9	1/28/2002	Base	11.25	6.0	10.80	89.0	800	6.8	<2.0
	4/3/2002	Storm	87.48	6.0	10.01	80.5	700	8.1	3.4

Stream data indicate that saturated dissolved oxygen conditions did not occur at any of the sample sites. Saturation ranged from 75% at Site 5 (Turkey Creek) to 92% at Sites 1 (Deep River Mouth) and 3 (Deep River at Lake George Dam). The slow glide (long, slow moving pool) habitat that exists at Site 5 likely plays a larger role in limiting dissolved oxygen content at that site than decomposition processes since BOD concentrations were below the detection limit at the time of sampling. In contrast, the Lake George spillway provides an excellent opportunity for oxygen to become entrained in water. Water collected below the Lake George dam (Site 3) contained a higher percentage of oxygen compared to other sites. Under storm flow conditions, water at Sites 2, 4, 5, and 6 exhibited the lowest dissolved oxygen content. At Sites 4, 5, and 6 the low dissolved oxygen saturation accompanied high (relative to other sites in the watershed) BOD concentrations. Given the high BOD concentrations, decomposition processes likely played a role in lowering the DO content of the water at these three sites. Site 3 exhibited the highest DO saturation during storm flow conditions. Again the proximity of Site 3 to the Lake George spillway is likely responsible for the relatively high DO saturation observed in the water.

In general, both conductivity and pH values fell within acceptable ranges. Conductivity values in Deep River watershed streams ranged from 700 to 1200 µmhos during base flow, and 400 to 900 ųmhos during storm flow. All of these measurements fell below the upper end of the range and most fell below the lower end of the range obtained by converting the IAC dissolved solids standard to specific conductance. For the most part, conductivity measured during storm flow was lower than conductivity measured during base flow. Higher flows tend to dilute ion concentrations and do not allow enough time for soil ion dissolution to occur. Values of pH fell within the range of 6-9 units established as acceptable by the IAC for warm water aquatic life. On a site-by-site basis, pH levels during storm flow were generally greater than those measured during base flow.

BOD levels were relatively low in the Deep River/ Turkey Creek watershed. During base flow, seven of the nine sites exhibited BOD values below the detection limit. Sites 1 and 8 had BOD concentrations of 2.3 mg/L and 3.6 mg/L, respectively. Under storm flow conditions, five of the nine sites exhibited BOD concentrations above the detection limit with the highest concentration observed at Site 4 (4 mg/L). The high BOD levels observed at Site 4 following the storm event likely resulted from a flushing of the wetland immediately upstream of Site 4. If storm flow is of sufficient magnitude, the force of the water may scour out organic material previously trapped in the wetland.

BOD levels are consistent with levels found in other Indiana streams. In a review of selected Indiana streams (IDEM 1991 data), White (unpublished) found the average BOD concentration to be 2.2 mg/L. Most Indiana streams possessed BOD concentrations between 1.1 mg/L and 3.3 mg/L. Recent IDEM data suggests that White's average is still applicable. The average BOD concentration reported at IDEM fixed monitoring stations from 1995 to 2000 was 2.5 mg/L (IDEM, unpublished). The median concentration was 1.9 mg/L.

Chemical and Bacterial Parameter Concentrations

Table 5-3 lists the chemical and bacterial concentration data for Deep River watershed streams by site. **Figures 5-4 to 5-10** present concentration information graphically. Again, because the data objective goals for the water quality assessment were to obtain relative measures of non-point source pollutants, the following discussion again focuses on a comparison of concentrations found at the sampling sites in the watershed rather than the raw data itself. However, to provide larger context for understanding the water quality data, **Table 5-4** presents the minimum, maximum, average, and median values for selected water quality parameters collected at IDEM fixed monitoring stations from 1995 to 2000.

Figure 5-5 presents the nitrate-nitrogen concentration data for both base and storm flow conditions. Nitrate-nitrogen concentrations were relatively low. Only two of the sites exceeded the median concentration reported at the IDEM fixed monitoring stations. Nitrate-nitrogen concentrations measured during base flow sampling were greater than concentrations measured in storm flow samples at all but three sample sites (Sites 4, 5, and 9). Duck Creek (Site 2) exhibited the highest nitrate-nitrogen concentration (2.37 mg/L), while Turkey Creek (Site 9) possessed the lowest nitrate-nitrogen concentration (0.19 mg/L). Concentrations at all sites remained below 10 mg/L, the concentration set by the IAC for safe drinking water.

Table 5-3. Chemical and bacterial data for Deep River watershed streams collected during stream chemistry sampling events on 1/28/2002 and 4/3/2002.

Site	Date	Timing	NO_3^--N (mg/L)	NH_3-N (mg/L)	TKN (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
1	1/28/2002	Base	1.62	0.07	1.30	0.17	5.2	48
	4/3/2002	Storm	0.55	0.39	0.55	<0.10	43.0	180
2	1/28/2002	Base	2.37	0.04	1.00	<0.10	22.0	140
	4/3/2002	Storm	1.20	0.13	1.20	0.24	48.0	760
3	1/28/2002	Base	1.53	0.07	1.60	0.14	14.0	42
	4/3/2002	Storm	0.71	0.36	0.71	<0.10	29.0	80
4	1/28/2002	Base	0.88	0.10	1.00	<0.10	18.0	48
	4/3/2002	Storm	1.10	0.27	1.10	0.26	150.0	800
5	1/28/2002	Base	0.21	0.10	1.10	<0.10	13.0	94
	4/3/2002	Storm	0.77	0.16	0.77	0.11	56.0	440
6	1/28/2002	Base	1.75	0.24	1.80	<0.10	8.4	24
	4/3/2002	Storm	1.00	0.31	1.00	0.28	120.0	1000
7	1/28/2002	Base	0.36	<0.01	0.71	<0.10	<5.0	50
	4/3/2002	Storm	--	--	--	--	--	--
8	1/28/2002	Base	2.23	1.50	5.20	0.18	<5.0	110
	4/3/2002	Storm	1.30	0.40	1.30	0.30	120.0	2100
9	1/28/2002	Base	0.19	0.15	1.30	<0.10	8.0	480
	4/3/2002	Storm	0.71	0.36	0.71	0.10	62.0	310

Table 5-4. The minimum, maximum, average and median values for selected water quality parameters collected at IDEM fixed monitoring stations from 1995 to 2000.

	TSS (mg/L)	TKN (mg/L)	NO_2+NO_3 (mg/L)	NH_3 (mg/L)	TP (mg/L)	BOD (mg/L)	COD (mg/L)
Minimum	2	0.0	0.04	0.0	0.03	0.0	3.9
Maximum	836	16.0	32.0	13.0	38.4	32	234
Median	19	0.7	2.1	0.2	0.14	1.9	16.4
Average	37	0.86	2.9	0.3	0.2	2.5	18.4

Figure 5-5. Nitrate-nitrogen concentrations measured in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.

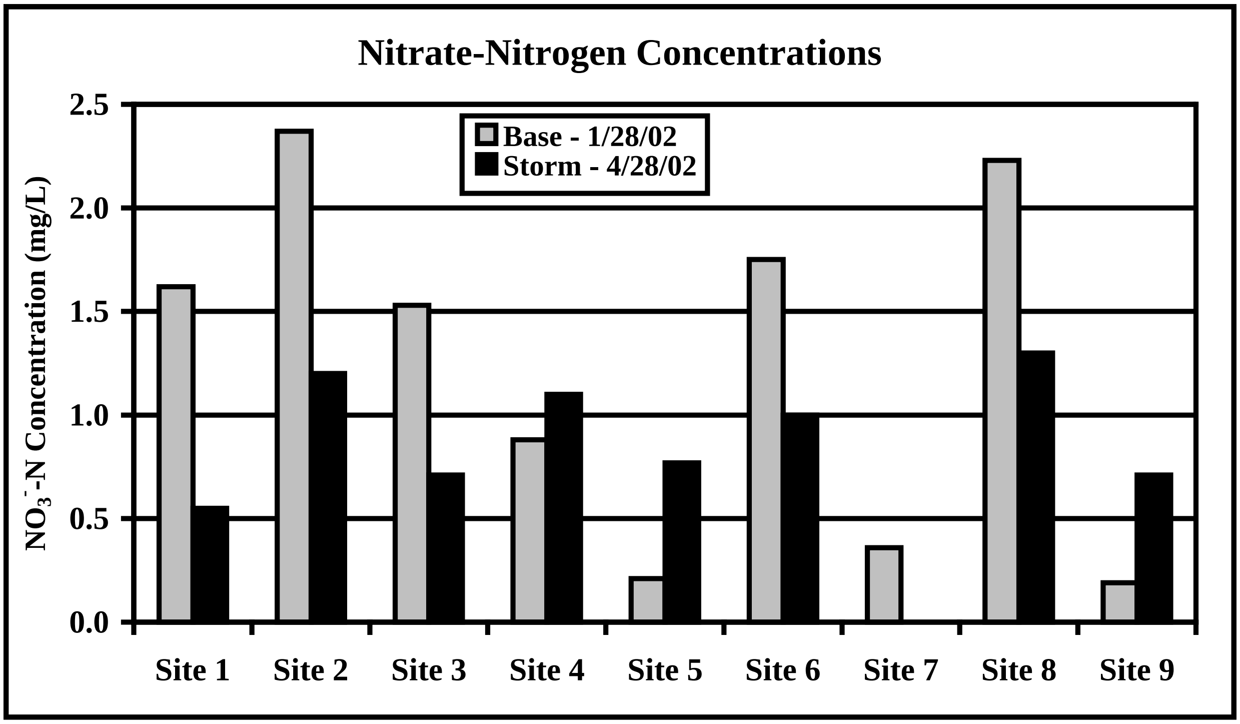
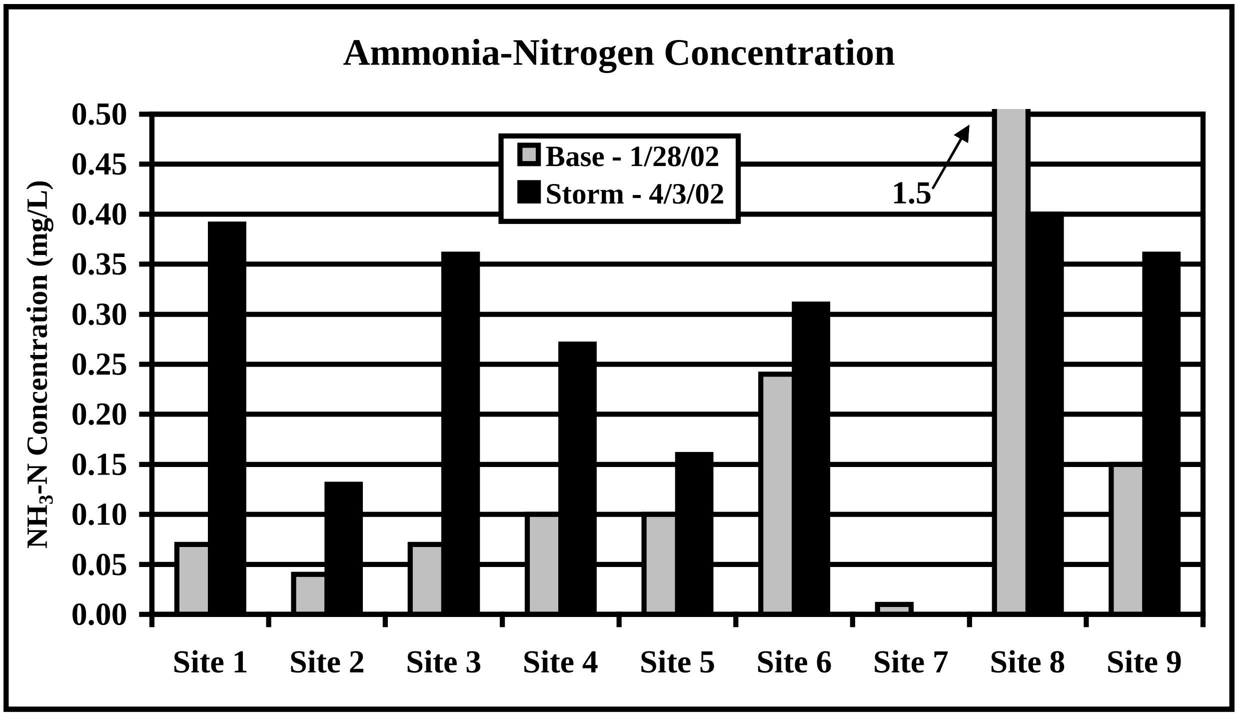


Figure 5-6 presents the ammonia-nitrogen data concentration. During base flow conditions, all Sites except Site 8 possessed low concentrations relative to the IDEM reported median concentration of ammonia-nitrogen. Several of the sites exceeded the IDEM reported median concentration of ammonia-nitrogen during storm flow conditions, but not by a great amount. Ammonia-nitrogen concentrations measured during base flow sampling were lower than concentrations measured in storm flow samples at all but one sample site (Sites 8). The base flow sample collected at the Deep River County Park (Site 8) exhibited the highest ammonia-nitrogen concentration (1.5 mg/L), while the Deep River tributary (Site 7) base flow sample possessed the lowest ammonia-nitrogen concentration (<0.01 mg/L). None of the base flow concentrations exceeded the IAC ammonia-nitrogen standard for the protection of aquatic life. In contrast, all sites sampled during the storm event exceeded the IAC standard.

Figure 5-6. Ammonia-nitrogen concentrations measured in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.



Unlike the dissolved parameters, many of the Sites' total Kjeldahl nitrogen (TKN) concentrations exceeded the median concentration found at IDEM fixed monitoring stations (See **Figure 5-7**). Generally, TKN concentrations measured during base flow sampling exceeded the concentrations measured in storm flow samples. The base flow sample collected at the Deep River County Park (Site 8) possessed the highest TKN concentration (5.2 mg/L). Although ammonia was also elevated at this site, the presence of particulate organic nitrogen pollutants is likely here.

Figure 5-7. Total Kjeldahl nitrogen (TKN) concentrations measured in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.

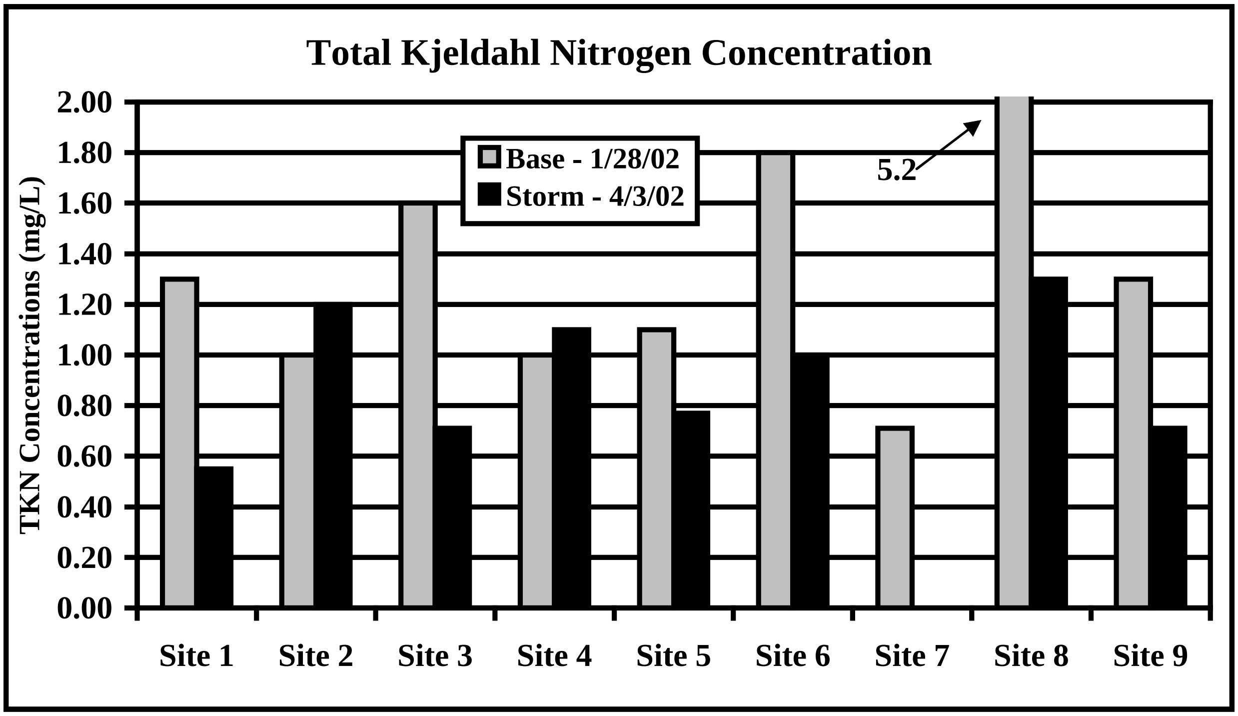


Figure 5-8 shows the total phosphorus concentration data for the sampling sites. Under base flow conditions, total phosphorus concentrations were generally low with six of the nine sites exhibiting total phosphorus concentrations below the laboratory detection limit. At six of the Sites, total phosphorus concentrations measured during storm flow sampling exceeded concentrations measured in base flow samples. Higher overland flow velocities typically results in the increase in sediment particles and the particulate phosphorus associated with them in runoff. Additionally, greater streambank and streambed erosion occurs during high flow. Therefore, higher concentrations of particulate phosphorus are typically measured in storm flow samples. Only Site 1 and Site 3 exhibited storm flow total phosphorus concentrations below those measured during base flow. The sample collected at the Deep River County Park (Site 8) contained the highest total phosphorus concentration (0.30 mg/L).

Figure 5-8. Total phosphorus (TP) concentrations measured in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. Although many samples are graphically displayed with concentrations of 0.10 mg/L, all of these except Site 9 during storm flow are actually below the laboratory detection level of 0.10 mg/L. They are only included for visual comparison purposes. No storm flow sample collection occurred at Site 7.

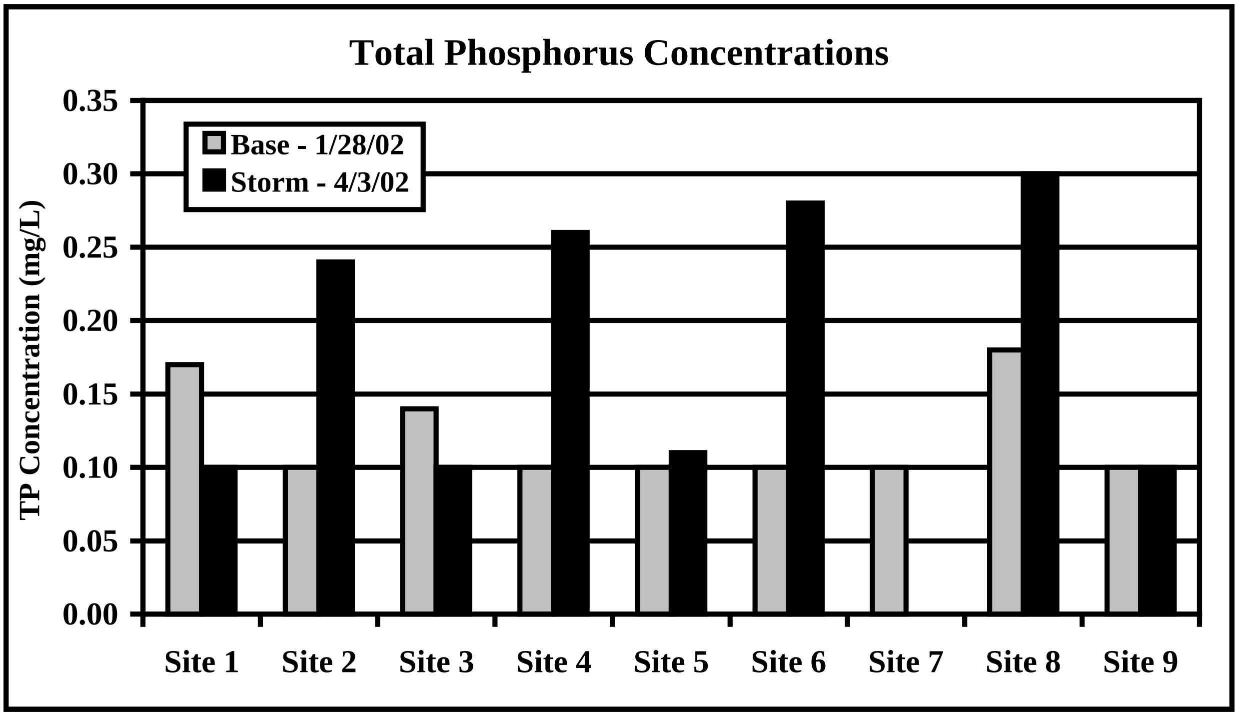


Figure 5-9 presents the total suspended solid (TSS) concentration data for the study streams. Total suspended solids concentrations measured during storm flow sampling exceeded concentrations measured in base flow samples at all sample sites. As noted in the total phosphorus discussion, higher overland flow velocities typically result in the increase in sediment particles in runoff. Greater streambank and streambed erosion occurs during high flow as well. Therefore, higher concentrations of suspended solids are typically measured in storm flow samples. The storm flow sample collected in Lake George (Site 4) contained the highest recorded total suspended solids concentration (150 mg/L); storm flow samples collected at Sites 6 (Turkey Creek) and 8 (Deep River County Park) contained the second highest TSS concentrations (120 mg/L). High TSS concentrations at Site 4 following a storm event may have resulted from the flushing of previously settled sediment in the wetland upstream of Site 4. Storm flow sample concentrations at Sites 4, 6, and 8 exceeded 80 mg/L, the concentration found to be deleterious to aquatic life (Waters, 1995).

Figure 5-9. Total suspended solids (TSS) concentrations measured in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.

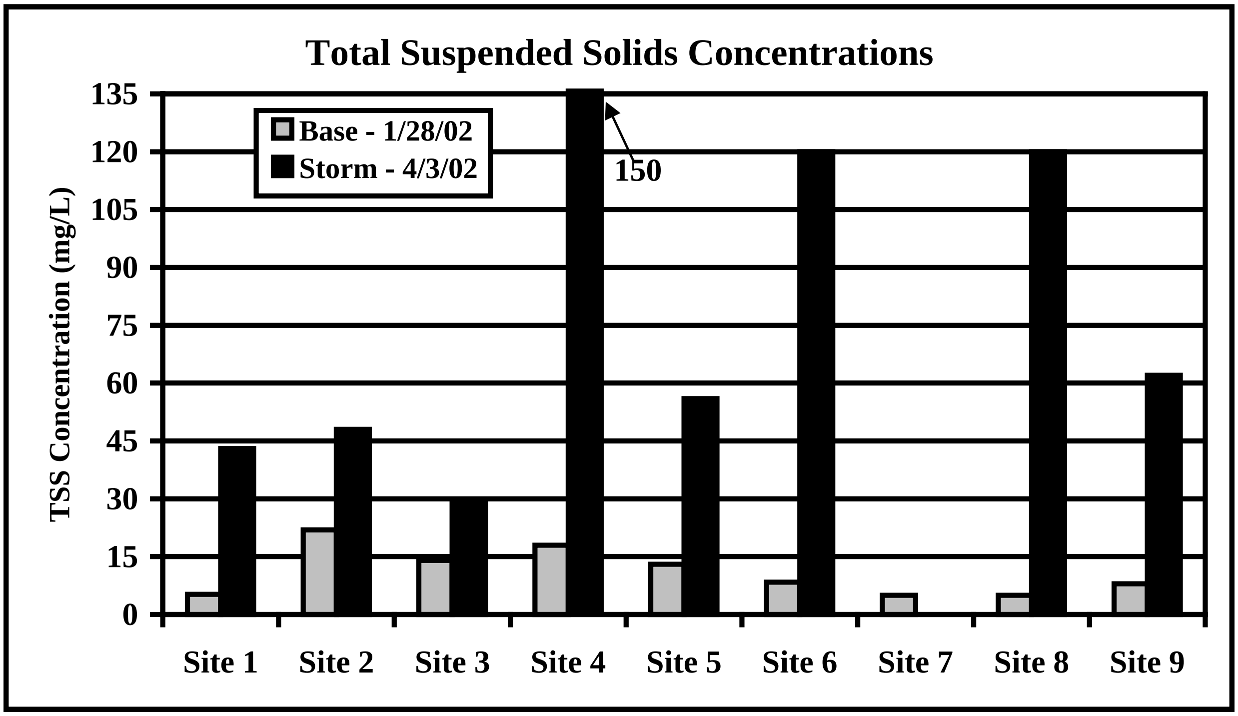
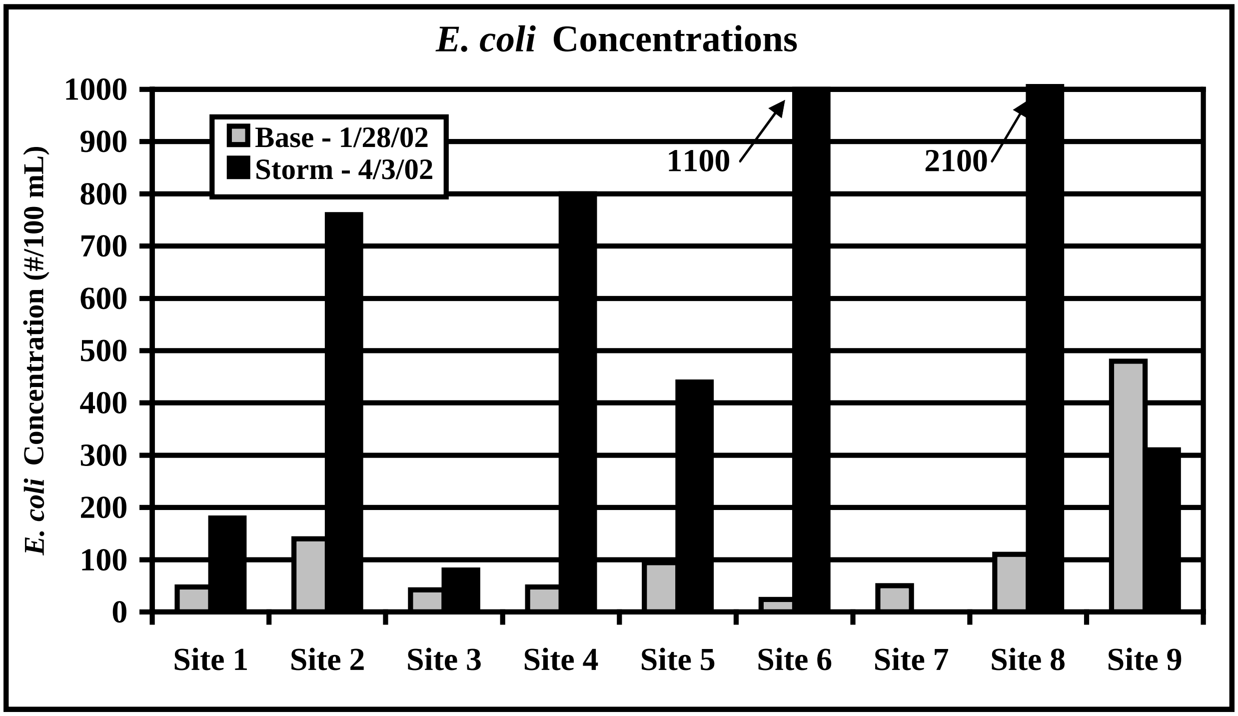


Figure 5-10 displays the *E. coli* concentration data for the two sampling events. As expected, the *E. coli* concentrations observed during base flow conditions were low. High *E. coli* concentrations were not likely given the low water temperature. Despite this, the *E. coli* concentration at Site 9 exceeded the state standard (235 col/100 mL) for state waters. *E. coli* concentrations measured during storm flow sampling exceeded concentrations measured in base flow samples at all sites except at Site 9. The storm flow sample collected at the Site 8 possessed the highest *E. coli* concentration (2100 colonies/100 mL), while Site 3 exhibited the lowest storm flow *E. coli* concentration (24 colonies/100 mL). During storm flow conditions, only two sample sites, Site 1 and Site 3, exhibited *E. coli* concentrations below the state standard. Low *E. coli* concentrations downstream of Lake George are likely the result of the exposure to ultraviolet light afforded to the water in the lake. Relative to other streams in the state, the storm water *E. coli* concentrations in the Deep River/ Turkey Creek watershed are similar or slightly low. White (unpublished) found the average *E. coli* concentration in Indiana streams to be approximately 650 colonies/100 mL. Only Site 8 possessed an *E. coli* concentration significantly above this value (p=0.05).

Figure 5-10. ***E. coli*** **concentrations measured in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.**



Chemical and Sediment Parameter Mass Loading

Table 5-5 lists the chemical and sediment mass loading data for Deep River/ Turkey Creek watershed by site. **Figures 5-10 to 5-14** present mass loadings information graphically.

Table 5-5. Chemical and sediment loading data for Deep River watershed streams collected during stream chemistry sampling events on 1/28/2002 and 4/3/2002.

Site	Date	Timing	NO_3^--N (kg/d)	NH_3-N (kg/d)	TKN (kg/d)	TP (kg/d)	TSS (kg/d)
1	1/28/2002	Base	2,451.3	9.2	170.0	22.2	679.8
	4/3/2002	Storm	29,494.2	501.9	707.9	<128.7	55,341.8
2	1/28/2002	Base	388.6	0.6	14.2	<1.42	311.6
	4/3/2002	Storm	9,844.6	25.1	231.5	46.3	9,247.9
3	1/28/2002	Base	1,761.3	7.0	159.1	13.9	1,392.5
	4/3/2002	Storm	260,009.0	521.9	1,029.4	<145.0	42,044.0
4	1/28/2002	Base	1,028.5	10.1	101.0	<0.36	1,817.7
	4/3/2002	Storm	30,678.6	418.5	1,705.1	403.0	232,511.7
5	1/28/2002	Base	49.5	2.0	22.4	<2.03	264.7
	4/3/2002	Storm	4,885.8	54.5	262.1	37.5	19,064.1
6	1/28/2002	Base	897.4	10.6	79.8	<4.4	372.2
	4/3/2002	Storm	20,988.0	254.4	820.5	229.8	98,463.1
7	1/28/2002	Base	7.6	<0.02	1.3	<0.2	<9
	4/3/2002	Storm	--	--	--	--	--
8	1/28/2002	Base	82.0	4.8	16.5	0.6	<16
	4/3/2002	Storm	30,733.6	356.4	1,158.4	267.3	1,206,928.2
9	1/28/2002	Base	60.5	4.1	35.8	<2.8	220.2
	4/3/2002	Storm	2,997.6	77.1	152.0	21.4	13,270.7

Figure 5-10. Nitrate-nitrogen loading in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.

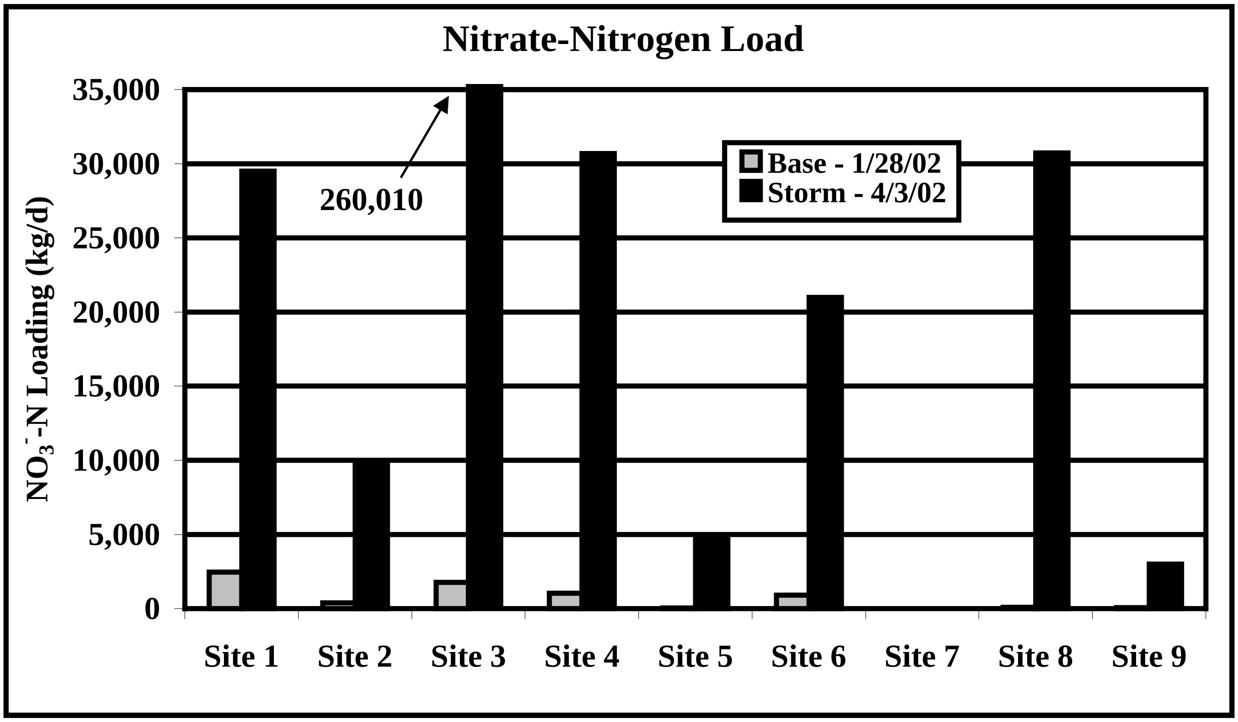


Figure 5-11. Ammonia-nitrogen loading in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.

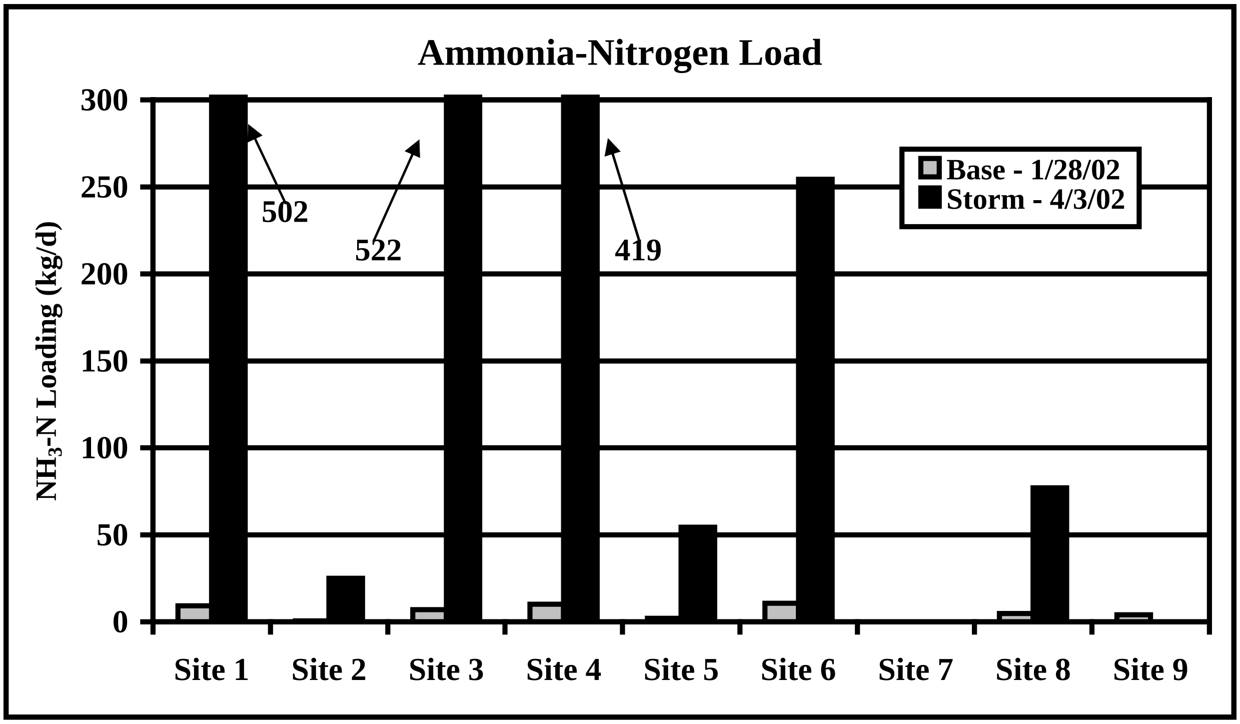


Figure 5-12. Total Kjeldahl nitrogen loading in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.

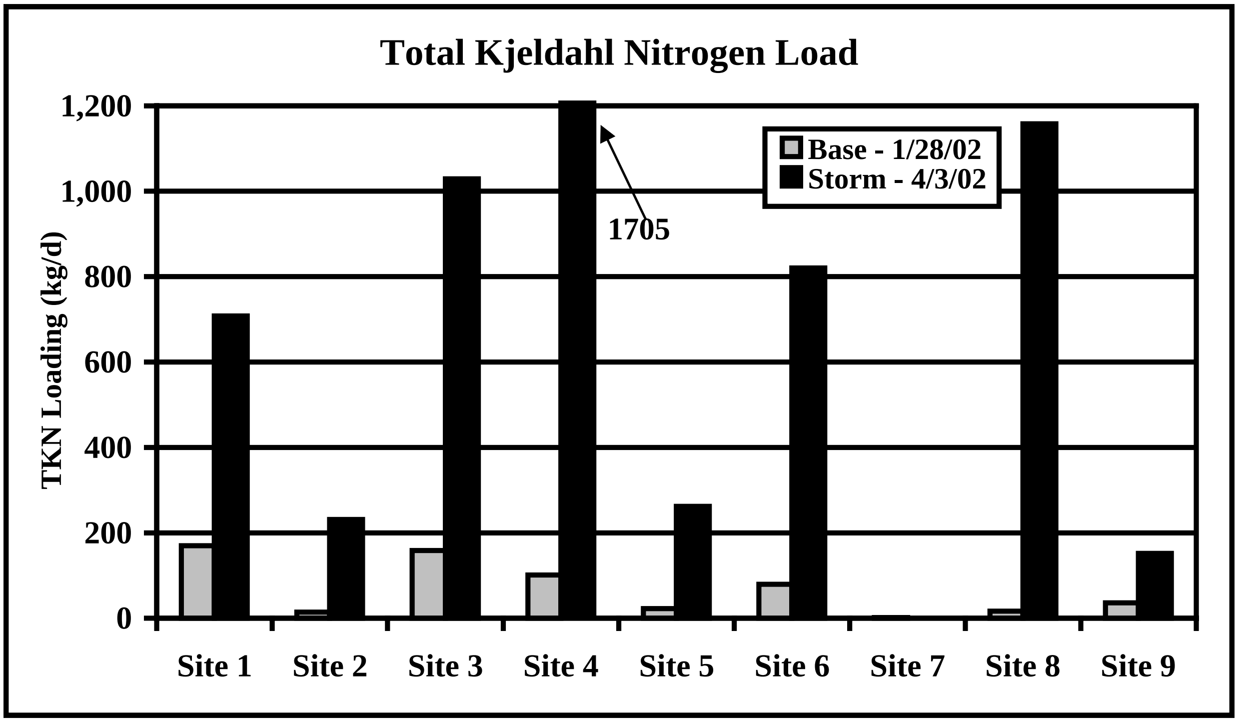


Figure 5-13: Total phosphorus loading in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.

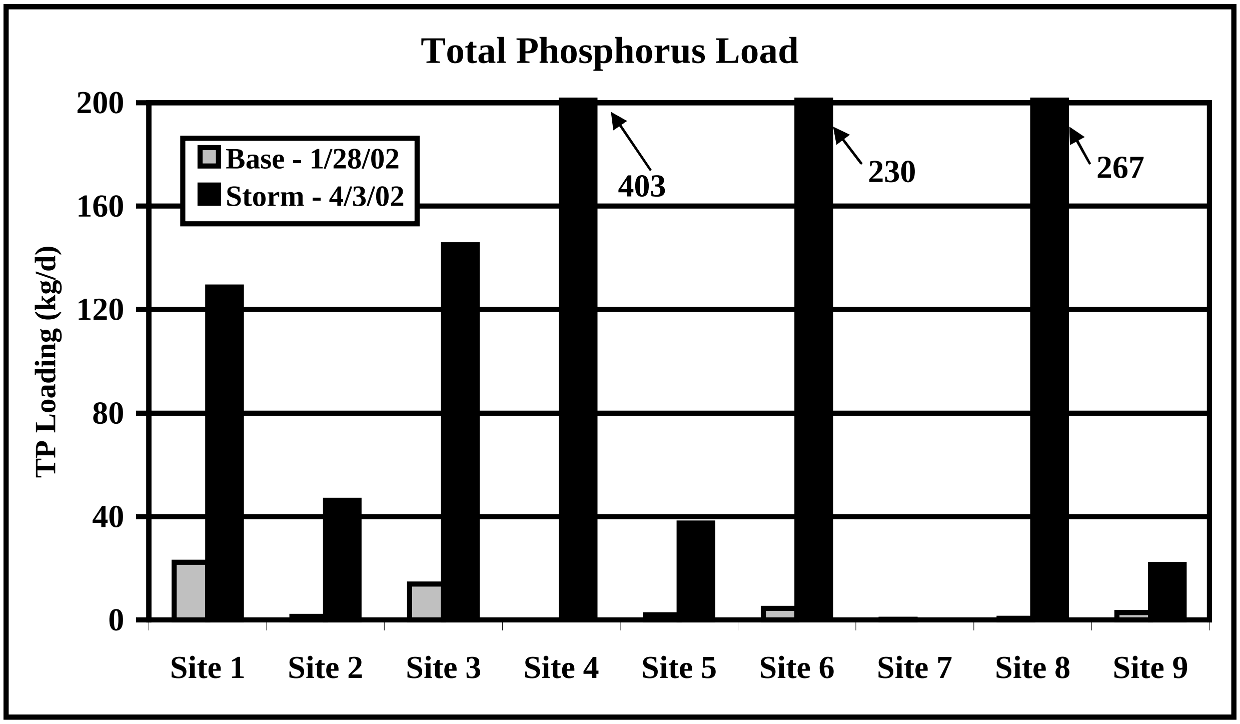
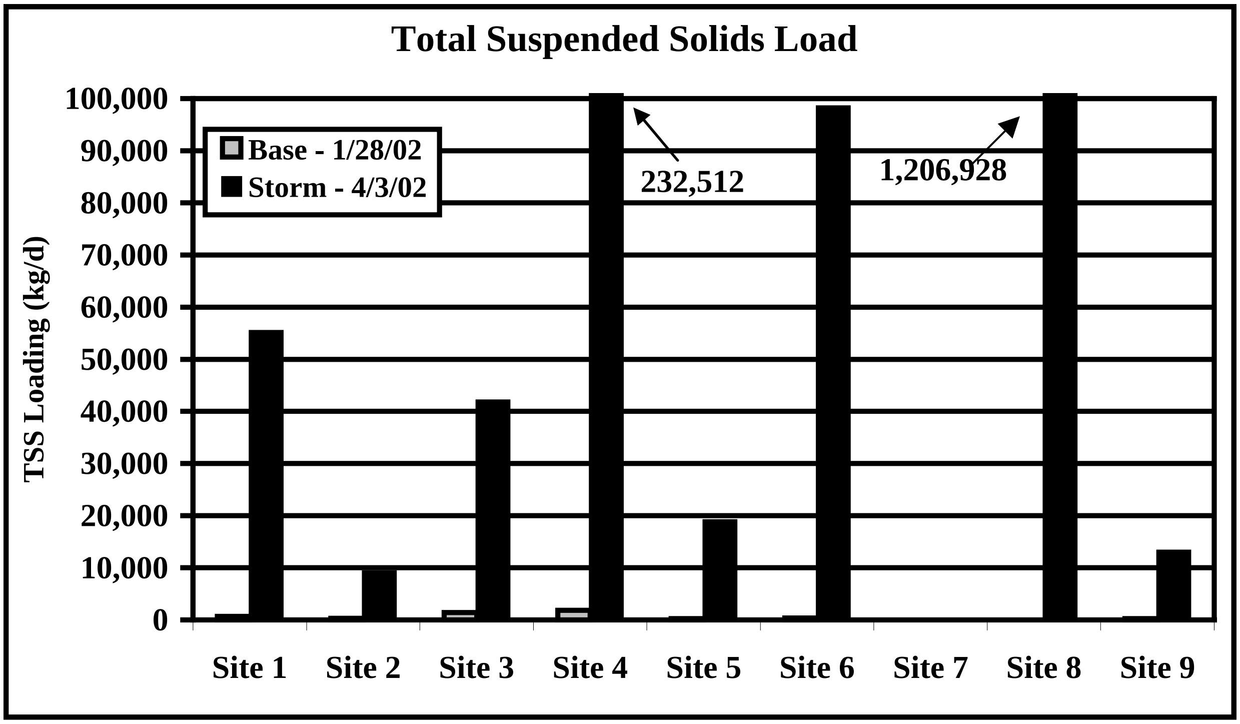


Figure 5-14: Total suspended solids loading in Deep River water quality samples collected on 1/28/2002 and 4/3/2002. No storm flow sample collection occurred at Site 7.



Under base flow conditions, Site 1 possessed the greatest load of nitrate-nitrogen, total Kjeldahl nitrogen, and total phosphorus. This is to be expected. As the site located furthest downstream, Site 1 receives the pollutants from all the other sites. In contrast, Site 4 possessed the greatest load of total suspended solids. The decrease in load observed in Site 3 indicates that the lake is trapping sediment. It is important to note that the total suspended solid load decreases further at Site 1, suggesting additional deposition occurs between the Lake George dam and Site 1.

Under storm flow conditions, Site 3 possessed the greatest nitrate-nitrogen and ammonia-nitrogen loads. Site 4 exhibited the greatest total Kjeldahl nitrogen and total phosphorus loads. High TKN and total phosphorus loads suggest organic matter may be flushed from the wetland in the southwest corner of Lake George. Similarly, the high total suspended solid load at this point may be the result of materials being flushed from the wetland under storm flows. This hypothesis is consistent with the relatively high BOD concentration observed during the storm flow sampling at Site 4. TKN, total phosphorus, and total suspended solid loads decrease at Site 3 suggesting that the lake is trapping particulate nutrients and sediment.

Site 8 exhibited the greatest total suspended solid load under storm flow conditions. This high load indicates a large amount of solids entering the Deep River/ Turkey Creek watershed from areas upstream of the 14 digit watershed. Urban land uses (high percent of impervious surface) dominate the land use in the area immediately upstream of Site 8. Agricultural land uses dominate the majority of the headwaters region of the larger Deep River/ Turkey Creek watershed. Both land uses have the potential to contribute large amounts of sediment to the river. In addition, the hardscape covering the urban area immediately upstream of Site 8 alters the landscape's natural hydrology. Rather than infiltrating the soil, rainwater that falls on impervious surface becomes surface runoff. Even if stormwater runoff is detained in detention basins, there is still a net increase in the volume of water reaching the creek. The impact of the increased water volume is evident in the bank erosion present at Site 8. This erosion contributes further to the total suspended solid load at Site 8.

To a large extent, flow governed nutrient and sediment loading of streams of the Deep River watershed (i.e., streams with higher flow rates also carried higher nutrient and sediment loads). **Table 5-6** summarizes sampling locations that loaded disproportionate amounts of the various parameters relative to discharge rate (i.e., these streams loaded more nutrients and/or sediment despite having smaller discharges than other streams where data was collected). Flow governed nitrate-nitrogen loads at all sites except Site 3 and Site 8, which carried more nitrate-nitrogen relative to discharge during storm flow sampling (Figure J). During base flow sampling Site 6 and Site 8 carried more ammonia-nitrogen despite lower flows (Figure K). Likewise, Site 4 carried a higher ammonia-nitrogen load relative to flow during the storm event. Site 1 carried a higher TKN load relative to other sites (Figure L). During the storm event, Site 4, Site 6, and Site 8 all carried disproportionately higher TKN and TP loads relative to flow rate (Figures L and M). These three sites, 4, 6, and 8, also carried larger amounts of suspended solids relative to rate of discharge (Figure N). Sediment loading rates varied from <9 to 1,206,928 kg/d (19.8 to 2,668,821 lb/d) depending on the flow regime and location.

Table 5-6: Watershed sites with disproportionate amount of pollutant loads relative to flow.

Site	Parameter	Event
Deep River Mouth (Site 1)	TKN	Base
Deep River Mouth (Site 1)	NH_3-N	Storm
Deep River at Lake George Dam (Site 3)	NO_3^--N	Storm
Lake George (Site 4)	TSS	Base
Lake George (Site 4)	NH_3-N	Storm
Lake George (Site 4)	TP	Storm
Lake George (Site 4)	TKN	Storm
Lake George (Site 4)	TSS	Storm
Deep River (Site 6)	NH_3-N	Base
Deep River (Site 6)	TKN	Storm
Deep River (Site 6)	TP	Storm
Deep River (Site 6)	TSS	Storm
Deep River County Park (Site 8)	NH_3-N	Base
Deep River County Park (Site 8)	NO_3^--N	Storm
Deep River County Park (Site 8)	TKN	Strom
Deep River County Park (Site 8)	TP	Storm
Deep River County Park (Site 8)	TSS	Storm

VI. Causes and Sources of Pollution

Types of Pollution

A number of substances including nutrients, bacteria, oxygen demanding wastes, metals, and toxic substances, cause water pollution. Sources of these pollution causing substances are divided into two broad categories: point sources and nonpoint sources (IDEM, 2002). Point and nonpoint sources of pollution are described as follows:

Point source of pollution refers to discharges that enter surface waters through a pipe, ditch or other well defined point of discharge. The term applies to wastewater and stormwater discharges from a variety of sources. Wastewater point source discharges include municipal (city and county) and industrial wastewater treatment plants and small domestic wastewater treatment systems that may serve schools, commercial offices, residential subdivisions and individual homes. Stormwater point source discharges include stormwater discharges associated with industrial activities and stormwater discharges from municipal separate storm sewer (MS4s) systems for municipalities that meet the requirements of 327 IAC 5-13.

The primary pollutants associated with point source discharges are oxygen demanding wastes, nutrients, sediment, color and toxic substances including chlorine, ammonia and metals. Point source dischargers in Indiana must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the state. Discharge permits are issued under the NPDES program (See Section III), which is delegated to Indiana by the US Environmental Protection Agency (EPA).

Nonpoint source pollution refers to runoff that enters surface waters through stormwater runoff, contaminated ground water, snowmelt or atmospheric deposition. There are many types of land use activities that can serve as sources of nonpoint source pollution including land development, construction, mining operations, crop production, animal feeding lots, timber harvesting, failing septic systems, landfills, roads and paved areas, and wildlife.

Sediment and nutrients are major pollution causing substances associated with nonpoint source pollution. Others include *E. coli* bacteria, heavy metals, pesticides, oil and grease, and any other substance that may be washed off the ground or removed from the atmosphere and carried into surface waters. Unlike point source pollution, nonpoint pollution sources are diffuse in nature and occur at random depending on rainfall events.

Causes of Pollution

Causes of pollution refer to the substances that enter surface waters from point and nonpoint sources and result in water quality degradation and impairment. Major causes of water quality impairment include biochemical oxygen demand (BOD), nutrients, toxicants (such as polychlorinated biphenyls [PCBs] and ammonia), and *E. coli* bacteria. The following discussion provides a general overview of causes of impairment and the activities that may lead to their introduction into surface waters (IDEM, 2002).

E. coli Bacteria

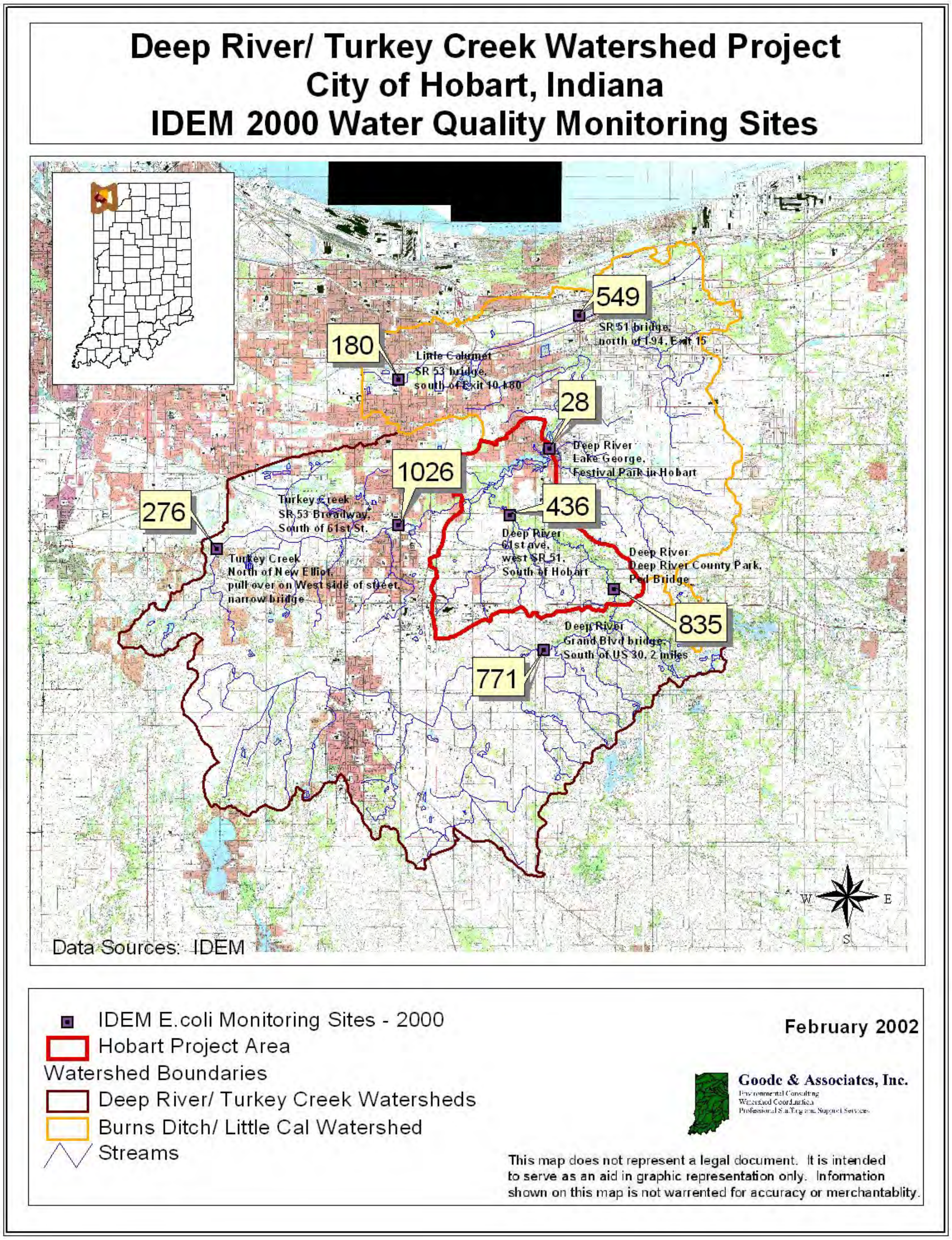
E. coli bacteria are associated with the intestinal tract of warm blooded animals. They are widely used as an indicator of the potential presence of waterborne disease causing (pathogenic) bacteria, protozoa, and viruses because they are easier and less costly to detect than the actual pathogenic organisms. The presence of waterborne disease-causing organisms can lead to outbreaks of such diseases as typhoid fever, dysentery, cholera, and cryptosporidiosis. The detection and identification of specific bacteria, viruses, and protozoa (such as *Giardia*, *Cryptosporidium*, and *Shigella*), require special sampling protocols and very sophisticated laboratory techniques that are not commonly available.

E. coli water quality standards (WQS) have been established in order to ensure safe use of waters for water supplies and recreation. 327 IAC 2-1-6 Section 6(d) states that *E. coli* bacteria, using membrane filter count (MF), shall not exceed 125 per 100 milliliters as a geometric mean based on not less than five samples equally spaced over a 30 day period nor exceed 235 per 100 milliliters in any one sample in a 30 day period.

E. coli bacteria may enter surface waters from nonpoint source runoff, but they also come from improperly treated discharges of domestic wastewater. Common potential sources of *E. coli* bacteria include leaking or failing septic systems, direct septic discharge, leaking sewer lines or pump station overflows, runoff from livestock operations, urban stormwater and wildlife. *E. coli* bacteria in treatment plant effluent are controlled through disinfection methods including chlorination (often followed by dechlorination), ozonation or ultraviolet light radiation.

E. coli monitoring by the IDEM in the Deep River/ Turkey Creek watershed identified several locations where the WQS for *E. coli* was violated during 2000. Three streams are listed as impaired by *E. coli* on the Indiana 303(d) list. These waterbodies include Deep River - Burns Ditch, Turkey Creek, and the Deep River from US 30 to the Lake George Dam. These stream segments are scheduled for TMDL development from 2000-2017.

Figure 6-1: *E.coli* Violations in the Deep River/ Turkey Creek Watershed



In addition to IDEM's data, water quality monitoring conducted for this project identified one location where *E.coli* standards were violated during dry weather and six locations where *E.coli* standards were violated during wet weather conditions (See **Table 5-3**).

Violations of the *E.coli* water quality standard were present throughout the Deep River/ Turkey Creek watershed. Data from IDEM and project monitoring identified *E.coli* concentrations in Turkey Creek to be of most concern, as monitoring indicates both dry and wet weather violations. Since both IDEM's monitoring and the monitoring completed from this project showed the highest concentrations of *E.coli* to be from upstream of State Road 53, an evaluation of land uses in this area seem to indicate that the E.coli measured at this site were generated from primarily urban land uses.

The magnitude of dry weather violations of the *E.coli* standard observed during this project seem to suggest a more continuous discharge of *E.coli* similar to discharges associated with failing septic systems or point sources. This theory is also supported by the fact that *E.coli* concentrations decreased, most likely due to dilution, during the wet weather monitoring, while all other sites experienced an increase in *E.coli* concentrations due to additional nonpoint source inputs.

E.coli violations were also observed in the Deep River subwatersheds. However, since these violations of the *E.coli* standard occurred only during wet weather, they are of a lesser concern than Turkey Creek, due to a reasonable assumption that the less contact should occur with these waterbodies during the wet weather conditions and associated high water conditions.

Although elevated concentrations of *E.coli* were observed only during wet weather conditions, the highest concentrations of *E.coli* in a single sample was observed in Deep River at Deep River County Park. As discussed in Section V, the significant nonpoint source loadings observed at this site appears to be correlated with the agricultural land uses dominate in these subwatersheds; however, upstream contributions from point sources is also likely.

Toxic Substances

327 IAC 2-1-9(45) defines toxic substances as substances, which 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. Standards for individual toxic substances are listed in 327 IAC 2-1-6. Toxic substances frequently encountered include chlorine, ammonia,

organics (hydrocarbons and pesticides), heavy metals and pH. 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 (IDEM, 2002).

Whole effluent toxicity testing is required for major NPDES dischargers (discharge over 1 million gallons per day or population greater than 10,000). This test shows if the effluent from a treatment plant is toxic, but it does not identify the specific cause of toxicity. If the effluent is found to be toxic, further testing is done to determine the specific cause. Other testing, or monitoring, done to detect aquatic toxicity problems include fish tissue analyses, chemical water quality sampling and biomonitoring.

Polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) were first created in 1881 and subsequently began to be commercially manufactured around 1929 (Bunce 1994). Because of their fire-resistant and insulating properties, PCBs were widely used in transformers, capacitors, and in hydraulic and heat transfer systems. In addition, PCBs were used in products such as plasticizers, rubber, ink, and wax. In 1966, PCBs were first detected in wildlife, and were soon found to be ubiquitous in the environment (Bunce 1994). PCBs entered the environment through unregulated disposal of products such as waste oils, transformers, capacitors, sealants, paints, and carbonless copy paper. In 1977, production of PCBs in North America was halted. Subsequently, the PCB contamination present in our surface waters and environment today is the result of historical waste disposal practices (IDEM, 2002).

In the Deep River/ Turkey Creek watershed, Lake George is the only waterbody on Indiana's draft 2002 Section 303(d) list due to impairments by PCBs; however, all rivers and streams in Indiana are considered to have PCB and Mercury impairments for carp as noted in **Table 6-1**. Lake George is currently scheduled for TMDL development from 2015-2017.

Table 6-1: FCA for the Lake George, Hobart, Indiana

Location	**Species**	**Fish Size(inches)**	**Contaminant**	**Group (See Table 4-14)**
Lake George				
Lake County	Northern Pike	18+	■	2
All Rivers and Streams				
	Carp	15-20 inches	■❍	3
	Carp	20-25 inches	■❍	4
	Carp	25 +	■❍	5

❍ = Mercury; ■= PCB

Nutrients
The term "nutrients" refers to two major plant nutrients, phosphorus and nitrogen. These are common components of fertilizers, animal and human wastes, vegetation, and some industrial processes. Nutrients in surface waters come from both point and nonpoint sources. Nutrients are beneficial to aquatic life in small amounts. However, in over abundance and under favorable conditions, they can stimulate the occurrence of algal blooms and excessive plant growth in quiet waters or low flow conditions. The algal blooms and excessive plant growth often reduce the dissolved oxygen content of surface waters through plant respiration and decomposition of dead algae and other plants. This is accentuated in hot weather and low flow conditions because of the reduced capacity of the water to retain dissolved oxygen (IDEM, 2002).

Phosphorus
Nonpoint source discharges are the major sources of phosphorus. Phosphorus can be present as organic matter (living or dead organisms and excreted organic material) either dissolved in water or suspended in the water column as particulate matter. Phosphorus may also occur as inorganic compounds released from various minerals, fertilizers or detergents that may also be either dissolved in water or suspended in the water column as particulate matter. Phosphorus is the primary nutrient associated with primary production of algae and macrophytes (plants) in waterbodies, as it is generally the nutrient in shortest supply (Phillip et al, 2000).

Phosphorus is a significant source of pollution in the Deep River/ Turkey Creek watershed. Six of the sites monitored for this project had total phosphorus concentrations measured during wet weather conditions that exceeded concentrations measured during dry weather. With the additional inputs and the increased stream velocities from stormwater runoff, greater pollutant migration and streambank/ streambed erosion typically occurs during periods of wet weather. As a result, higher concentrations/ loadings of particulate phosphorus are usually measured during wet weather. The data collected via project monitoring indicates that the greatest phosphorus loadings were contributed from the Deep River watershed, as highlighted in **Table 6-2** (See Sampling Locations Map Figure 5-1).

Table 6-2. Chemical and sediment loading data for the Deep River/ Turkey Creek watershed highlighting Total Phosphorus (TP) loadings

Site	Date	Timing	NO_3^--N (kg/d)	NH_3-N (kg/d)	TKN (kg/d)	TP (kg/d)	TSS (kg/d)
1	1/28/2002	Base	2,451.3	9.2	170.0	22.2	679.8
	4/3/2002	Storm	29,494.2	501.9	707.9	<128.7	55,341.8
2	1/28/2002	Base	388.6	0.6	14.2	<1.42	311.6
	4/3/2002	Storm	9,844.6	25.1	231.5	46.3	9,247.9
3	1/28/2002	Base	1,761.3	7.0	159.1	13.9	1,392.5
	4/3/2002	Storm	260,009.0	521.9	1,029.4	<145.0	42,044.0
4	1/28/2002	Base	1,028.5	10.1	101.0	<0.36	1,817.7
	4/3/2002	Storm	30,678.6	418.5	1,705.1	403.0	232,511.7
5	1/28/2002	Base	49.5	2.0	22.4	<2.03	264.7
	4/3/2002	Storm	4,885.8	54.5	262.1	37.5	19,064.1
6	1/28/2002	Base	897.4	10.6	79.8	<4.4	372.2
	4/3/2002	Storm	20,988.0	254.4	820.5	229.8	98,463.1
7	1/28/2002	Base	7.6	<0.02	1.3	<0.2	<9
	4/3/2002	Storm	--	--	--	--	--
8	1/28/2002	Base	82.0	4.8	16.5	0.6	<16
	4/3/2002	Storm	30,733.6	356.4	1,158.4	267.3	1,206,928.2
9	1/28/2002	Base	60.5	4.1	35.8	<2.8	220.2
	4/3/2002	Storm	2,997.6	77.1	152.0	21.4	13,270.7

Ammonia (NH_3)

Point source dischargers are one of the major sources of ammonia. In addition, discharges of untreated septic effluent, decaying organisms that may come from nonpoint source runoff and bacterial decomposition of animal waste also contribute to the level of ammonia in a waterbody. In surface waters, nitrate is the most likely form of nitrogen due to the natural degradation of ammonia to nitrate, then nitrite (Phillip et al, 2000). Total Kjeldahl Nitrogen (TKN) is defined as organically bound nitrogen. TKN is the combination of ammonia and organic nitrogen. Organic nitrogen can be calculated by subtracting ammonia-nitrogen from total Kjeldahl nitrogen.

Ammonia is also a significant source of pollution in the Deep River/ Turkey Creek watershed. During dry weather conditions, all sites (except site 8) possessed low concentrations relative to the IDEM reported median concentration of ammonia-nitrogen. Several of the sites exceeded the IDEM reported median concentration of ammonia-nitrogen during storm flow conditions. Ammonia-nitrogen concentrations measured during dry weather sampling were lower than concentrations measured in storm flow samples (site 8, Deep River County Park). The base flow sample collected at the County Park exhibited the highest ammonia-nitrogen concentration (1.5 mg/L). None of the dry weather concentrations exceeded the IAC ammonia-nitrogen standard for the protection of aquatic life. In contrast, all sites sampled during the storm event exceeded the standard.

Nitrate-nitrogen concentrations within the watershed were relatively low. Only two of the sites exceeded the median concentration reported at the IDEM fixed monitoring stations. Nitrate-nitrogen concentrations measured during dry weather sampling events were greater than concentrations measured in storm flow samples at all but three sample sites (sites 4, 5, and 9). Duck Creek (site 2) exhibited the highest nitrate-nitrogen concentration (2.37 mg/L), while Turkey Creek (site 9) possessed the lowest nitrate-nitrogen concentration (0.19 mg/L). Concentrations at all sites remained below 10 mg/L, the concentration set by the IAC for safe drinking water.

Most TKN concentrations measured during dry weather sampling events exceeded the concentrations measured in storm flow samples. The base flow sample collected at the Deep River County Park (site 8) possessed the highest TKN concentration (5.2 mg/L). Although ammonia was also elevated at this site, the presence of particulate organic nitrogen pollutants is likely.

The data collected via project monitoring indicates that the greatest ammonia loadings were contributed from the Deep River watershed, as highlighted in **Table 6-3**.

Table 6-3. Chemical and sediment loading data for the Deep River/ Turkey Creek watershed highlighting ammonia (NH3-N), nitrate-nitrite (NO3-N), and TKN loadings

Site	Date	Timing	NO_3^--N (kg/d)	NH_3-N (kg/d)	TKN (kg/d)	TP (kg/d)	TSS (kg/d)
1	1/28/2002	Base	2,451.3	9.2	170.0	22.2	679.8
	4/3/2002	Storm	29,494.2	501.9	707.9	<128.7	55,341.8
2	1/28/2002	Base	388.6	0.6	14.2	<1.42	311.6
	4/3/2002	Storm	9,844.6	25.1	231.5	46.3	9,247.9
3	1/28/2002	Base	1,761.3	7.0	159.1	13.9	1,392.5
	4/3/2002	Storm	260,009.0	521.9	1,029.4	<145.0	42,044.0
4	1/28/2002	Base	1,028.5	10.1	101.0	<0.36	1,817.7
	4/3/2002	Storm	30,678.6	418.5	1,705.1	403.0	232,511.7
5	1/28/2002	Base	49.5	2.0	22.4	<2.03	264.7
	4/3/2002	Storm	4,885.8	54.5	262.1	37.5	19,064.1
6	1/28/2002	Base	897.4	10.6	79.8	<4.4	372.2
	4/3/2002	Storm	20,988.0	254.4	820.5	229.8	98,463.1
7	1/28/2002	Base	7.6	<0.02	1.3	<0.2	<9
	4/3/2002	Storm	--	--	--	--	--
8	1/28/2002	Base	82.0	4.8	16.5	0.6	<16
	4/3/2002	Storm	30,733.6	356.4	1,158.4	267.3	1,206,928.2
9	1/28/2002	Base	60.5	4.1	35.8	<2.8	220.2
	4/3/2002	Storm	2,997.6	77.1	152.0	21.4	13,270.7

Siltation/ Sedimentation

Siltation is a problem generated by both point and nonpoint sources. Caused by erosion, siltation occurring in waterbodies decreases water clarity, which causes a decrease in aquatic plant production, obscures sources of food, habitats, refuges, and nesting sites of fish. In rivers and streams silt fills the gravel spaces in stream bottoms, smothering fish eggs and juvenile fish. Siltation is also associated with attached nutrient and pesticides particles that enter waterways attached to soil particles. In many parts of Indiana, siltation problems are considered to decrease recreational, commercial, and aesthetic values of streams and lakes as well as decrease quality of drinking water sources.

Total suspended solids concentrations measured during wet weather sampling events exceeded concentrations measured in base flow samples at all sample sites. With the additional inputs and the increased stream velocities from stormwater runoff, greater sediment migration and streambank/ streambed erosion typically occurs during periods of wet weather.. As a result, higher concentrations of suspended solids are usually measured during wet weather. The wet weather sample collected in Lake George (site 4) contained the highest recorded total suspended solids concentration (150 mg/L); storm flow samples collected at sites 6 (Turkey Creek) and 8 (Deep River County Park) contained the second highest TSS concentrations (120 mg/L). High TSS concentrations at site 4 during wet weather may have resulted from the flushing of previously settled sediment in the wetland upstream of site 4. The data collected via project monitoring indicates that the greatest TSS loadings were contributed from the Deep River watershed, as highlighted in **Table 6-4**.

Table 6-4. Chemical and sediment loading data for the Deep River/ Turkey Creek watershed highlighting Total Suspended Solids (TSS) loadings

Site	Date	Timing	NO_3^--N (kg/d)	NH_3-N (kg/d)	TKN (kg/d)	TP (kg/d)	TSS (kg/d)
1	1/28/2002	Base	2,451.3	9.2	170.0	22.2	679.8
	4/3/2002	Storm	29,494.2	501.9	707.9	<128.7	55,341.8
2	1/28/2002	Base	388.6	0.6	14.2	<1.42	311.6
	4/3/2002	Storm	9,844.6	25.1	231.5	46.3	9,247.9
3	1/28/2002	Base	1,761.3	7.0	159.1	13.9	1,392.5
	4/3/2002	Storm	260,009.0	521.9	1,029.4	<145.0	42,044.0
4	1/28/2002	Base	1,028.5	10.1	101.0	<0.36	1,817.7
	4/3/2002	Storm	30,678.6	418.5	1,705.1	403.0	232,511.7
5	1/28/2002	Base	49.5	2.0	22.4	<2.03	264.7
	4/3/2002	Storm	4,885.8	54.5	262.1	37.5	19,064.1
6	1/28/2002	Base	897.4	10.6	79.8	<4.4	372.2
	4/3/2002	Storm	20,988.0	254.4	820.5	229.8	98,463.1
7	1/28/2002	Base	7.6	<0.02	1.3	<0.2	<9
	4/3/2002	Storm	--	--	--	--	--
8	1/28/2002	Base	82.0	4.8	16.5	0.6	<16
	4/3/2002	Storm	30,733.6	356.4	1,158.4	267.3	1,206,928.2
9	1/28/2002	Base	60.5	4.1	35.8	<2.8	220.2
	4/3/2002	Storm	2,997.6	77.1	152.0	21.4	13,270.7

Sources of Pollution in the Deep River/ Turkey Creek Watershed

Point Source Discharges

As of November 2000, there were 25 active NPDES permits within the Deep River/ Turkey Creek watershed are mapped in **Figure 6-1**.

Other point sources covered by NPDES permits are combined sewer overflows (CSO). A combined sewer system is a wastewater collection system that conveys sanitary wastewater (domestic, commercial and industrial wastewater) and stormwater through a single pipe system to a Publicly Owned Treatment Works (POTW). A CSO is the discharge from a combined sewer system at a point prior to the POTW. CSOs are point sources subject to NPDES permit requirements including both technology based and water quality based requirements of the Clean Water Act. The City of Crown Point has two CSOs in the Deep River watershed.

In addition to the NPDES permitted dischargers in the watershed, there may be many unpermitted, illegal discharges to the Deep River/ Turkey Creek watershed system. Illegal discharges of residential wastewater (septic tank effluent) to streams and ditches from straight pipe discharges and old inadequate systems are a problem within the watershed.

Stormwater from large urban areas (greater than 100,000 people) and from certain industrial and construction sites is technically considered a point source since NPDES permits are required for discharges of stormwater from these areas. By the end of 2002, it is anticipated that the State of Indiana will adopt regulations implementing phase two of the federal Stormwater (SW) NPDES Program. The SW Phase II program will require designated entities to develop stormwater management programs. Designated SW Phase II entities within the Deep River/ Turkey Creek Watershed are illustrated in **Figure 6-2**.

Figure 6-1: NPDES Facilities in the Deep River/ Turkey Creek Watershed

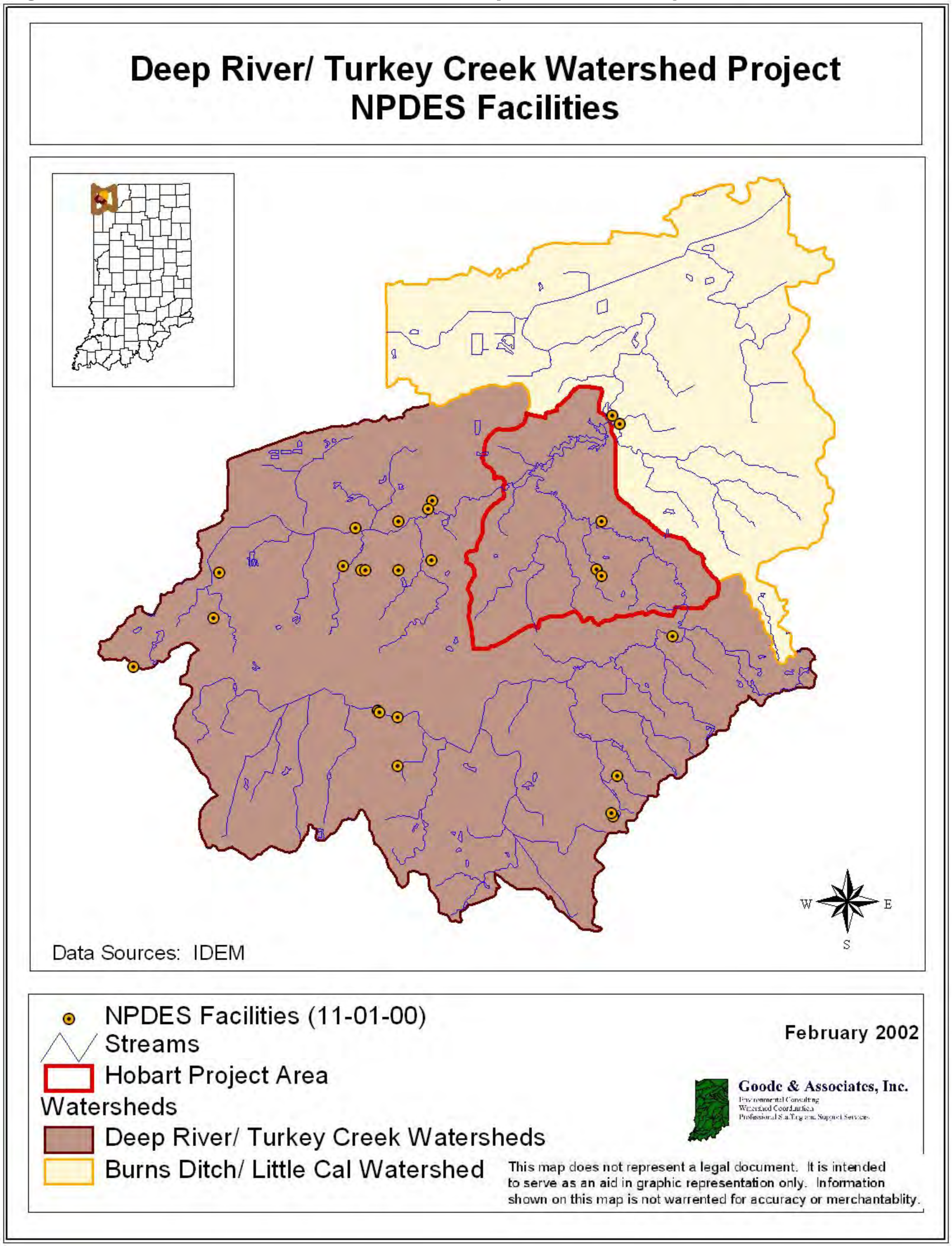
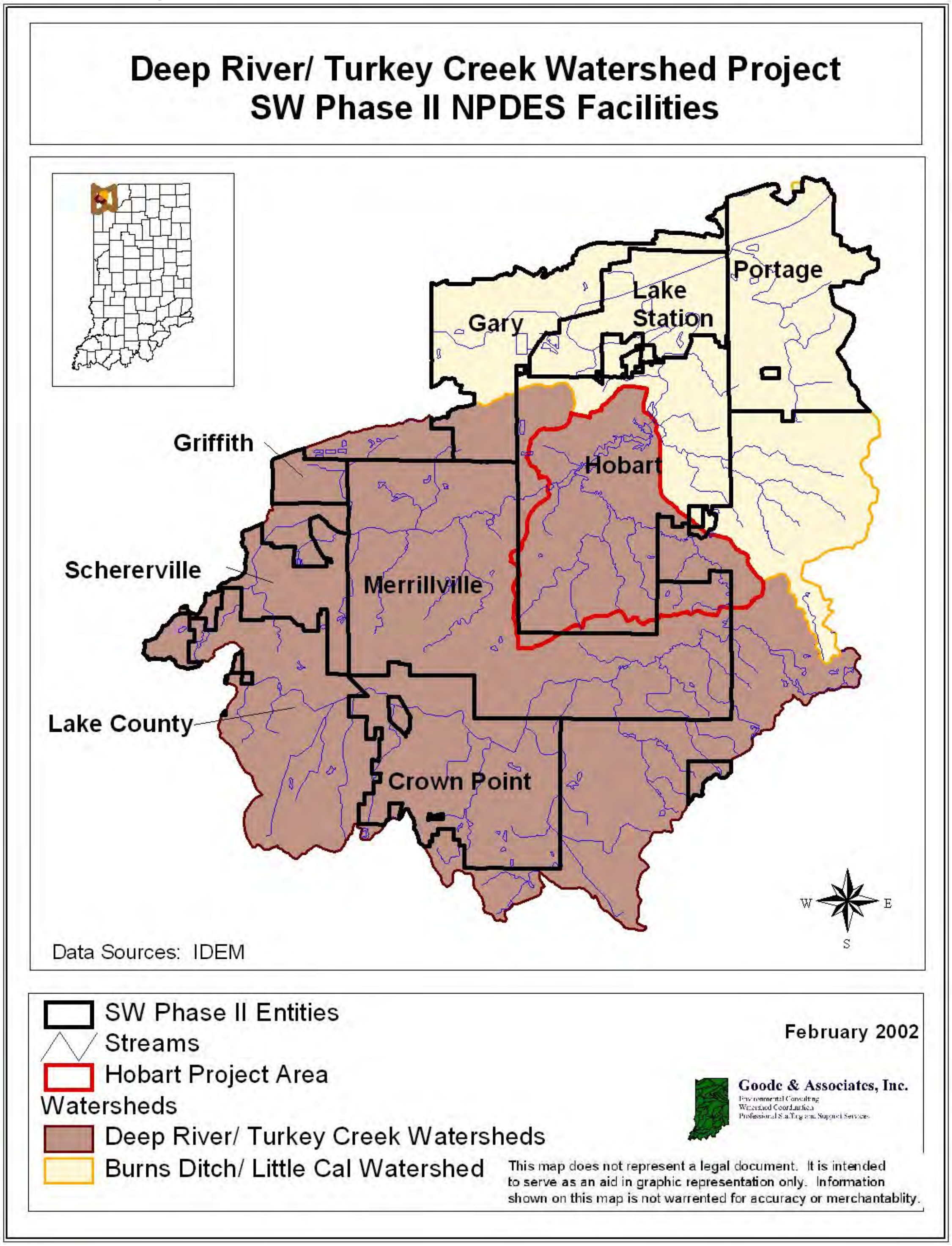


Figure 6-2: Designated Stormwater Phase II NPDES Entities in the Deep River/ Turkey Creek Watershed



Nonpoint Sources of Pollution

Sediment and nutrients are major pollution causing substances associated with nonpoint source pollution. Others include *E. coli* bacteria, heavy metals, pesticides, oil and grease, and any other substance that may be washed off the ground or removed from the atmosphere and carried into surface waters. Below is a brief description of major areas of nonpoint source of pollution in the Deep River/ Turkey Creek watershed.

Agricultural Sources

There are a number of activities associated with agriculture that can serve as potential sources of water pollution. Land clearing and tilling make soils susceptible to erosion, which can then cause stream sedimentation. Pesticides and fertilizers (including synthetic fertilizers and animal wastes) can be washed from fields or improperly designed storage or disposal sites. Construction of drainage ditches on poorly drained soils enhances the movement of oxygen consuming wastes, sediment and soluble nutrients into groundwater and surface waters (IDEM, 2002).

Contrary to popular belief, land uses within Lake County are predominately agricultural with approximately 149,000 acres of land in agricultural production. 34% of those acres lie within the Deep River/ Turkey Creek watershed (See **Figure 6-3**). The Deep River/ Turkey Creek watershed encompasses 79,434 acres, of which 51,364 are in agricultural production. Agricultural practices include grain production, beef cow production, and milk cow production.

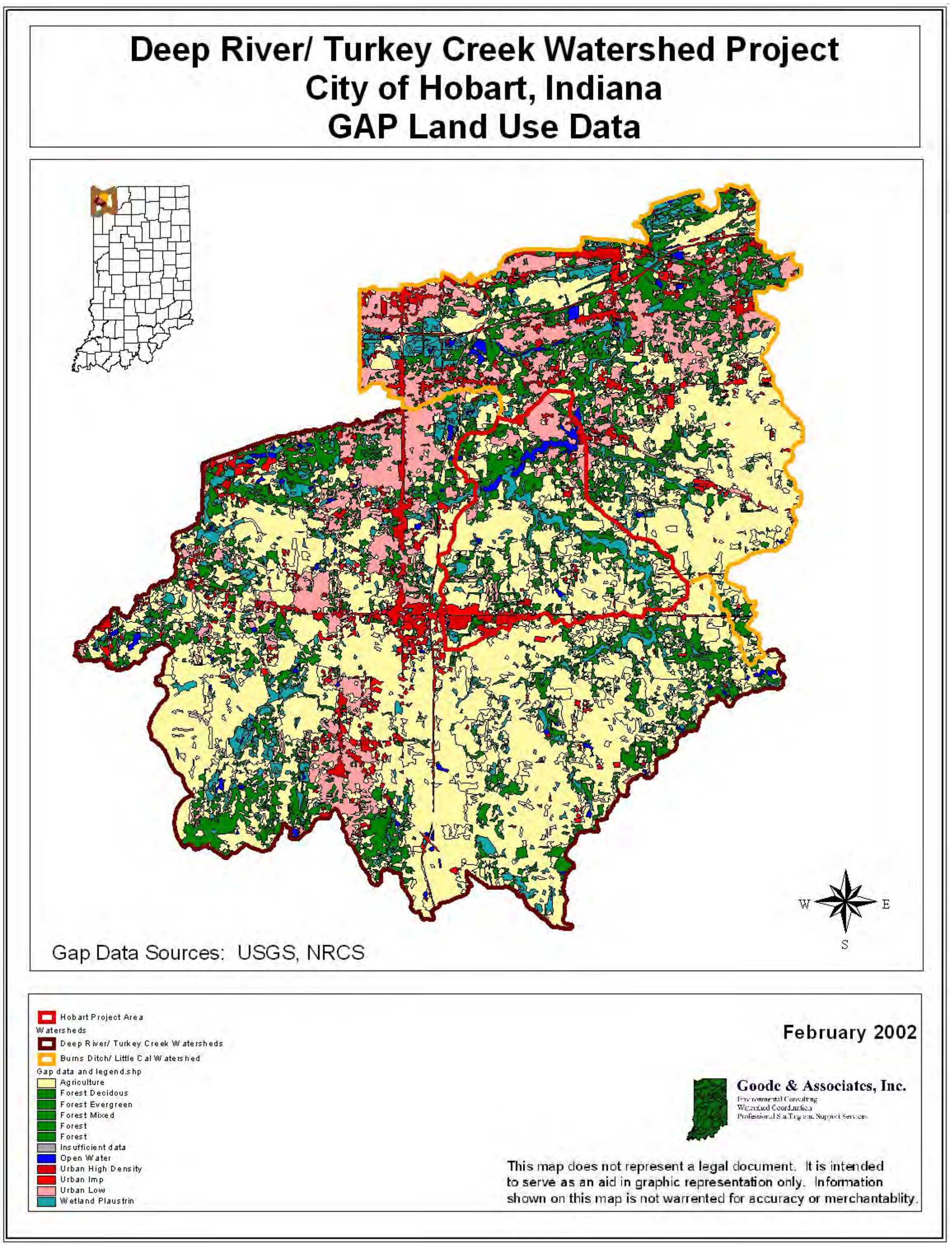
Grain Production

Like most other counties in Indiana, corn and soybeans dominate the grain crops grown in Lake County. In 2001, Lake County producers planted 64,600 acres of corn, 56,500 acres of soybeans, and 2,200 acres of wheat. The majority of the tillable acres in Lake County are farmed on a yearly rotation of corn and soybeans.

Cattle Production

Cattle production is not widely practiced in Lake County. The cattle operations that do exist, however, typically involve both beef and dairy cattle. In 2001, Lake County ranked 81st out of 92 counties in total number of cattle (beef and dairy). More specifically, beef cattle populations in Lake County ranked 82nd out of the 92 Indiana counties (approximately 900 head) and dairy cattle populations ranked 32nd out of 92 counties (approximately 800 head).

Figure 6-3: Land Usage in the Deep River/ Turkey Creek Watershed



Due to current thresholds for confined animal feeding operation regulations, there are no (0) regulated cattle operations in the Deep River/ Turkey Creek watershed. According to IAC 16-2-6, an individual livestock facility must contain 300 head of cattle or more to necessitate a permit. Livestock farms in the Deep River/ Turkey Creek watershed contain populations far below the regulatory threshold levels.

1997 Lake County Census

Agriculture is an important economic partner in Lake County and the watershed; however, county census data reveals that a diminishing percentage of the work force is directly involved in agricultural production. This decrease reflects the dramatic trend away from the family farm and towards an increasing trend in farm operation size and mechanization. As economic and technological trends promote larger farming operations, the challenge associated with careful management of soil and water resources increases.

The 1997 Lake County Agriculture Census indicates that while land in farms increased 3% from 144,305 acres in 1992 to 148,872 acres in 1997, the number of full time farms in Lake County decreased from 271 in 1992 to 219 farms in 1997 while the average size of farms increased 13% from 299 acres in 1992 to 337 acres in 1997 (See **Tables 6-5 and 6-6**).

Table 6-5: Lake County Agricultural Statistics

Year	Land in Farms (acres)	Average Size of Farms (acres)	Full Time Farms
1992	144,305	299	271
1997	148,872	337	219
% Change	+ 3%	+ 13%	-20%

Table 6-6: 1997 Lake County, Indiana Census of Agriculture, USDA

1997 Census of Agriculture

County Profile

United States Department of Agriculture, Indiana Agricultural Statistics Service

LAKE

INDIANA

Ranked Items Within State and U.S., 1997

Item	Quantity	State Rank	State Universe*	U.S. Rank	U.S. Universe*
MARKET VALUE OF AGRICULTURAL PRODUCTS SOLD ($1,000)					
Total value of agricultural products sold	47,827	54	92	1,243	3,076
Value of crops including nursery	42,747	34	92	667	3,070
Value of livestock and poultry	5,080	79	92	2,355	3,069
TOP FIVE ALL COMMODITIES - VALUE OF SALES ($1,000)					
Corn for grain	21,825	26	92	297	2,582
Soybeans	14,269	48	92	429	2,136
Nursery and greenhouse crops	3,375	7	92	524	2,790
Hogs and pigs	1,879	75	92	828	2,976
Dairy products	1,620	40	91	1,158	2,563
TOP FIVE COMMODITIES - LIVESTOCK SOLD (number)					
Turkeys sold	(D)	20	50	322	1,353
Hogs and pigs sold	15,903	75	92	883	2,976
Rabbits and their pelts sold	(D)	1	55	19	1,593
Cattle and calves sold	1,517	84	92	2,723	3,063
Layers, pullets, and pullet chicks sold	(D)	41	68	1,020	2,203
TOP FIVE COMMODITIES - LIVESTOCK INVENTORY (number)					
Hogs and pigs inventory	9,435	74	92	833	3,005
Cattle and calves inventory	3,204	84	92	2,723	3,064
All turkeys inventory	(D)	24	75	366	2,361
Layers 20 weeks and older inventory	999	37	92	1,201	3,002
Horse and pony inventory	480	38	92	1,648	3,066
TOP FIVE COMMODITIES - CROP AREA					
Corn for grain-acres	68,344	38	92	380	2,691
Soybeans for beans-acres	55,698	45	92	470	2,144
Hay crops-acres	3,754	68	92	2,461	3,061
Wheat-acres	3,101	68	92	1,259	2,612
Land used for vegetables-acres	1,258	4	88	392	2,741

Some counties do not have five commodities in a group.

Other County Summary Highlights

Item	1997	1992	Percent Change
Farms by value of sales:			
Less than $10,000	166	184	-10
$10,000 or more	276	298	-7
Total farm production expenses ....$1,000..	34,712	25,500	36
Average per farm ....dollars..	78,534	52,904	48
Net cash return from agricultural sales			
for the farm unit ....$1,000..	13,510	6,049	123
Average per farm ....dollars..	30,566	12,550	144
Farms by type of organization:			
Individual or family	356	394	-10
Partnership or corporation	82	83	-1
Other	4	5	-20
OPERATOR CHARACTERISTICS			
Operators by principal occupation:			
Farming	219	271	-19
Other	223	211	6
Operators by sex:			
Male	400	449	-11
Female	42	33	27
Operators by race:			
White	439	482	-9
Black and other races	3	-	
Average age of operator	54.7	52.7	4

(D) Cannot be disclosed. See "Census of Agriculture Volume 1 Geographic Area Series" for complete footnotes.
* Universe is number of counties in state or U.S. with item.

Agriculture and Water Quality

The most recent National Water Quality Inventory (NWQI), sponsored by the United States Environmental Protection Agency (US EPA), reports that agricultural nonpoint source (NPS) pollution is the leading source of water quality impacts to surveyed rivers and lakes, the third largest source of impairments to surveyed estuaries, as well as a major contributor to ground water contamination and wetlands degradation.

Agricultural activities that cause NPS pollution in the Deep River/ Turkey Creek watershed include livestock facilities, grazing, plowing, pesticide spraying, irrigation, fertilizing, and planting. The major agricultural NPS pollutants that result from these activities are nutrients, pesticides, sediment, and pathogens (See **Table 6-7**). These pollutants can migrate from agricultural lands to surface and ground water through processes including surface runoff, erosion, and infiltration. However, it is important to note that these pollutants are not specific to agriculture and can originate residential and urban lands as well.

Table 6-7: Agricultural Sources of Water Quality Pollutants

Pollutants	**Agriculture Sources**
Nutrients	Chemical Fertilizers and Manure
Toxic Chemicals	Chemical Pesticides
Sediment	Sheet, rill, gully, and streambank erosion
Animal Wastes	Manure runoff from fields, pastures, and feed lots

Bacteria

E. coli bacteria are associated with the intestinal tract of warm-blooded animals. They are widely used as an indicator of the potential presence of waterborne disease. The presence of waterborne disease-causing organisms can lead to outbreaks of such diseases as typhoid fever, dysentery, cholera, and cryptosporidiosis. There are numerous sources of *E. coli* bacteria, however, from an agriculture standpoint, livestock poses the greatest risk.

Using manure to fertilize crops is a cost-effective way to save money on commercial fertilizer and can be an environmentally responsible means of manure management. However, while manure is a good fertilizer on land, it can have undesirable effects when it enters nearby streams and lakes. Pathogens in manure can make water unsafe to drink or use for recreation. The nitrogen and phosphorus that make manure so productive on farm fields can create eutrophic conditions when they run off into the water, leading to undesirable algae blooms. These effects are not only unpleasant for recreation and aesthetics, but they also deteriorate the underwater habitat necessary for fish and other aquatic organisms to live.

Nutrients

Nutrients such as phosphorus (P), nitrogen (N), and potassium (K) in the form of fertilizers, manure, sludge, irrigation water, legumes, and crop residues are applied to enhance crop production. In small amounts, N and P are beneficial to aquatic life, however, in over abundance, they can stimulate the occurrence of algal blooms and excessive plant growth. Algal blooms and excessive plant growth often reduce the dissolved oxygen content of surface waters through plant respiration and decomposition of dead algae and other plants. This situation can be accelerated in hot weather and low flow conditions because of the reduced capacity of the water to retain dissolved oxygen. Since fish and aquatic insects need the oxygen that is dissolved in water to live, when decaying algae uses up oxygen, often resulting in fish kills that can devastate to aquatic ecosystem.

Annually, the Office Of Indiana State Chemist publishes the total tonnages of fertilizers sold in each Indiana County. The list of fertilizers includes single nutrient fertilizers, multi-nutrient fertilizers, and organic and micronutrient fertilizers. **Table 6-8** details the 1991, 1997, and 2000 Lake County fertilizer distribution as provided by the Office of Indiana State Chemist.

The trend in most Indiana Counties over the past 10 years has been a reduction in the tonnages of commercial fertilizers purchased and applied. Lake County is no different. In 1991, Lake County farmers purchased a total of 24,912 tons of fertilizer and in 2001 they purchased 13,519 tons, 46% less. The reduction in overall purchases can be attributed to an increase in technology and managerial skills on behalf of the agriculture community. Many farmers today are practicing precision farming utilizing GPS and GIS technology during fertilizer applications. Such best management practices have greatly reduced the amount of fertilizer applied to farm fields. To date, there are no water bodies in the Deep River/ Turkey Creek watershed on Indiana's 303(d) list because of impairment due to nutrient pollution.

Table 6-8: Summary of Lake County Annual Distributions of Fertilizer for 1991,1997, and 2000

Year of Sale	Grand Total	Single Nutrient Fertilizer	Multi-Nutrient Fertilizer	Organic & Micronutrients Fertilizers
1991	24,169	11,787	10,004	2,378
1997	9,637	4,507	5,128	2
2000	13,519	6,424	6,322	773

Pesticides

Pesticides include a broad array of chemicals used to control plant growth (herbicides), insects (insecticides), fungi (fungicides), and other organisms. These chemicals have the potential to enter and contaminate water through direct application, runoff, wind transport, and atmospheric deposition. They can kill fish and wildlife, poison food sources, and destroy the habitat that animals use for protective cover.

While some pesticides undergo biological degradation by soil and water bacteria, others are very resistant to degradation. Such nonbiodegradable compounds may become "fixed" or bound to clay particles and organic matter in the soil, making them less available. However, many pesticides are not permanently fixed by the soil. Instead they collect on plant surfaces and enter the food chain, eventually accumulating in wildlife such as fish and birds. Many pesticides have been found to negatively affect both humans and wildlife by damaging the nervous, endocrine, and reproductive systems or causing cancer (Kormondy 1996).

Unfortunately, the Office of State Chemist does not track pesticide distribution. However, pesticides are a significant source of pollution in the larger Little Calumet-Galien Basin. There are seven waterbodies within the Little Calumet-Galien Basin listed as impaired by pesticides on Indiana's 303(d) list. These seven waterbodies are scheduled for TMDL development from 2004-2017.

Sedimentation

Sedimentation occurs when wind or water runoff carries soil particles from an area, such as a farm field or stream bank, and transports them to a water body, such as a stream or lake. Excessive sedimentation clouds the water, which reduces the amount of sunlight reaching aquatic plants; covers fish spawning areas and food supplies; and clogs the gills of fish. In addition, other pollutants like phosphorus, pathogens, and heavy metals are often attached to the soil particles and end up in waterbodies with the sediment.

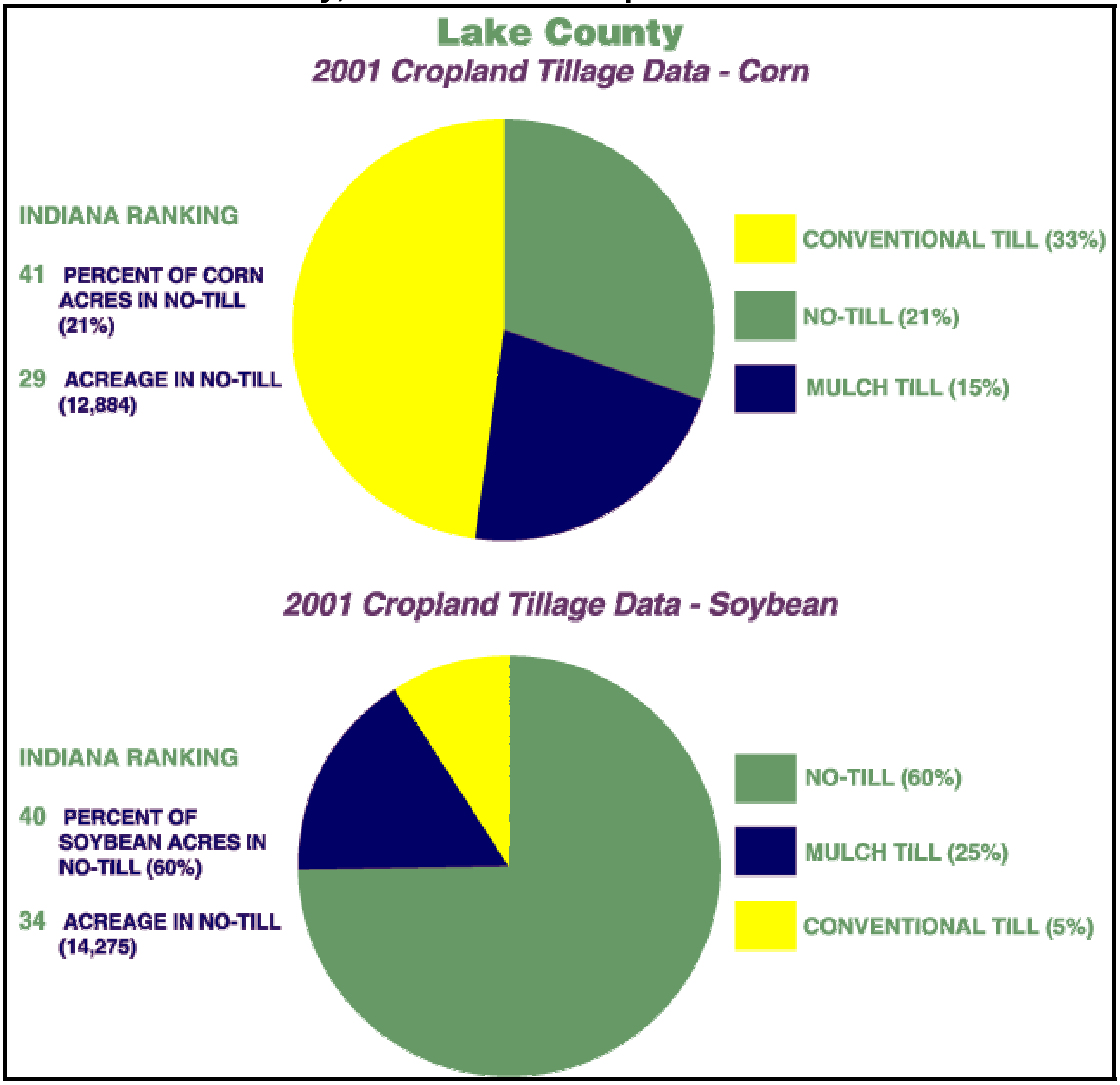
Waterbodies, such as Lake George, feel the ultimate affects of erosion. The sedimentation or "filling in" of such waterbodies has the potential to exacerbate flooding problems, as well as impair water quality and designated uses. The City of Hobart spent 2 million dollars to dredge Lake George in 2000; however, dredging without preventive planning provides only a "band-aid" approach to these problems. Significant erosion and sedimentation will continue to occur until all eroding lands are managed to minimize the erosion rates.

Farmers in Lake County have made efforts to reduce the amount of sediment leaving their farm fields through the adoption of conservation tillage; however, the adoption of such practices is not widespread. According to 2000 Indiana Agricultural Statistics, Lake County farmers planted 27% of their corn crops utilizing no-till technologies, ranking them 37th out of the 92 Indiana counties. In 2000, Lake County farmers also planted 66% of their beans utilizing no-till technologies, ranking them 35th of 92 counties (See **Table 6-9 and Chart 6-1)**. Based on the significant acreage of Highly Erodible Lands (HEL) and the intensive agriculture practices occurring in the Deep River/ Turkey Creek watershed, erosion and sedimentation is considered to be the most significant problem throughout the watershed.

Table 6-9: Lake County, Indiana No-Till Crop Statistics

No-till production	**1990**	**1998**	**2000**	**2001**
Corn	10%	30%	27%	21%
Beans	16%	58%	66%	60%

Chart 6-1: Lake County, Indiana No-Till Crop Statistics



Urban Sources

Many activities or practices associated with urban or residential land uses can generate NPS pollution. In most urbanized areas, large quantities of impervious or hard surfaces cause increased runoff and prevent absorption of stormwater. Consequently, managing NPS pollution in urban areas typically includes management practices for managing water quantity, as well as water quality. In urban environments, NPS pollutants typically include *E. coli* bacteria, sediments, nutrients, heavy metals, oil and grease, and pesticides.

Bacteria

Although urban sources of *E. coli* bacteria are commonly associated with discharges from municipal wastewater treatment plants and combined sewer overflows (CSOs), urban sources of bacteria also include the following sources:

Wildlife, Animal, and Pet Waste

Wildlife, animal, and pet wastes contribute significantly to the numbers of bacteria and organic matter in urban stormwater runoff. In fact, studies done in the last few years put dogs third or fourth on the list of contributors to bacteria in contaminated waters (Watson 2002). Pet wastes can be controlled through ordinances requiring collection and removal of the waste from curbsides, yards, parks, roadways and other areas where the waste can be washed directly into receiving waters.

Waterfowl

Habitually, ducks and geese nest in colonies located in trees and bushes around rivers, streams, and lakes. The presence of waterfowl has been shown to result in elevated levels of ammonia, organic nitrogen, and *E.coli* bacteria (USGS 1997). In addition, waterfowl activity can increase pollutant sediment loadings by pulling up grasses and sprouts and trampling emergent vegetation along streambanks and shorelines, significantly impacting erosion and sediment. This is particularly a problem for the many lake and streamside parks within the Deep River/ Turkey Creek watershed, especially at Festival Park in the City of Hobart.

Septic Systems

Septic systems can be a safe and effective method for treating wastewater if they are sized, sited, and maintained properly. However, if the tank or absorption field malfunctions or if they are improperly sited, constructed or maintained, nearby wells and surface waters may become contaminated (IDEM 2002). Some of the potential problems from malfunctioning septic systems include:

1. Polluted groundwater,

2. Bacteria,
3. Nutrients,
4. Toxic substances, and
5. Oxygen consuming wastes.
6. Nearby wells can become contaminated by failing septic systems.

Pollutants associated with onsite wastewater disposal may also be discharged directly to surface waters through direct pipe connections between the septic system and surface waters (straight pipe discharge). Although, 327 IAC 5-1-1.5 specifically states that "point source discharge of sewage treated or untreated, from a dwelling or its associated residential sewage disposal system, to the waters of the state is prohibited", many cities, towns, and county health departments are overwhelmed by the magnitude of the failing septic system problem.

During the planning process for the Deep River/ Turkey Creek Watershed Plan, many stakeholders made comments about multiple instances of failing septic systems or straight pipe discharges. Discussions with staff from the Lake County Health Department confirmed that failing septic systems was considered to be a significant problem in Lake County; however, a mechanism tracking the magnitude of the problem, such as a spreadsheet or database, was not in place to track multiple instances or locations of failing systems. Records for failing systems were kept in individual files according to homeowner name or by street address.

Nutrients

Urban activities may create conditions that result in higher-than-normal concentrations of the nutrients, ammonia, nitrite plus nitrate and phosphate, as well as trace elements, and synthetic organic compounds including polycyclic aromatic hydrocarbons (PAHs), phthalate esters, phenols, organochlorine pesticides, and polychlorinated biphenyls (PCBs) in water bodies downstream from urban areas. Nutrients can enter water resources by discharge of treated sewage, leaking sewer pipes, domestic septic systems, and fertilizer applications. In fact, ammonia concentrations in urban dominated water samples can be higher in streams draining urban areas than in streams draining agricultural areas (USGS, 1996). In addition, fertilizers and pesticides can wash off lawns and contribute significant nutrient loads to urban waterbodies (USGS, 1995).

Sedimentation

The rate and volume of runoff in urban areas is much greater due both to the high concentration of impervious surfaces and storm drainage systems that transport stormwater to nearby rivers, streams, and lakes. These surfaces include rooftops, parking lots, driveways, and roadways. The increase in volume and stream velocity from runoff can result in streambank and shoreline erosion, compounding sedimentation problems in surface waters such as Lake George.

Although municipal separate storm sewers (MS4s) are a necessity in an urban environment, MS4s also provide direct conduits for transporting urban pollutants, such as eroded sediments, lawn fertilizers and *E. col*i bacteria, to urban streams and lakes. While minimizing the problems associated with flooding and ponding water, MS4s have also eliminated a watershed's natural mechanisms for draining and absorbing stormwater pollutants by replacing natural vegetation (grasses, bushes, and trees) with asphalt and concrete (impervious surfaces). Significant amounts of impervious surfaces in an urban area also eliminate the natural ability of a watershed to filter and absorb sediments before the stormwater drains into streams and lakes.

As discussed in Section I of this plan, the population and growth statistics for Lake County indicate increasing urban development and potential urban water quality impacts in the Deep River/ Turkey Creek watershed. However, it is anticipated that implementation of stormwater quality management programs by the communities identified in **Figure 6-2** will result in significant reductions of sediment from urban areas in the watershed.

Construction Activities

Sedimentation from developing urban areas can be a major source of pollution due to the cumulative number of acres disturbed in a watershed. As a pollution source, construction activities are typically temporary, but the impacts on water quality can be severe and long lasting. Construction activities tend to be concentrated in the more rapidly developing areas of the watershed, which in the Deep River/ Turkey Creek watershed, include the communities of Hobart, Merrillville, and Crown Point.

Although construction activities that involve disturbing more than five acres have historically been regulated by the state; however, pending changes to the rules associated with managing erosion and sediment controls in construction activities will change the regulatory threshold for developments from five acres to one acre in 2003. **Figure 6-4** illustrates the magnitude of construction activities in the past 3 years in the Deep River/ Turkey Creek Watershed under the five acre threshold; however, it is anticipated that a much larger number of sites will be required to control erosion and sedimentation in the future, as municipalities develop local erosion and sediment control authorities and programs.

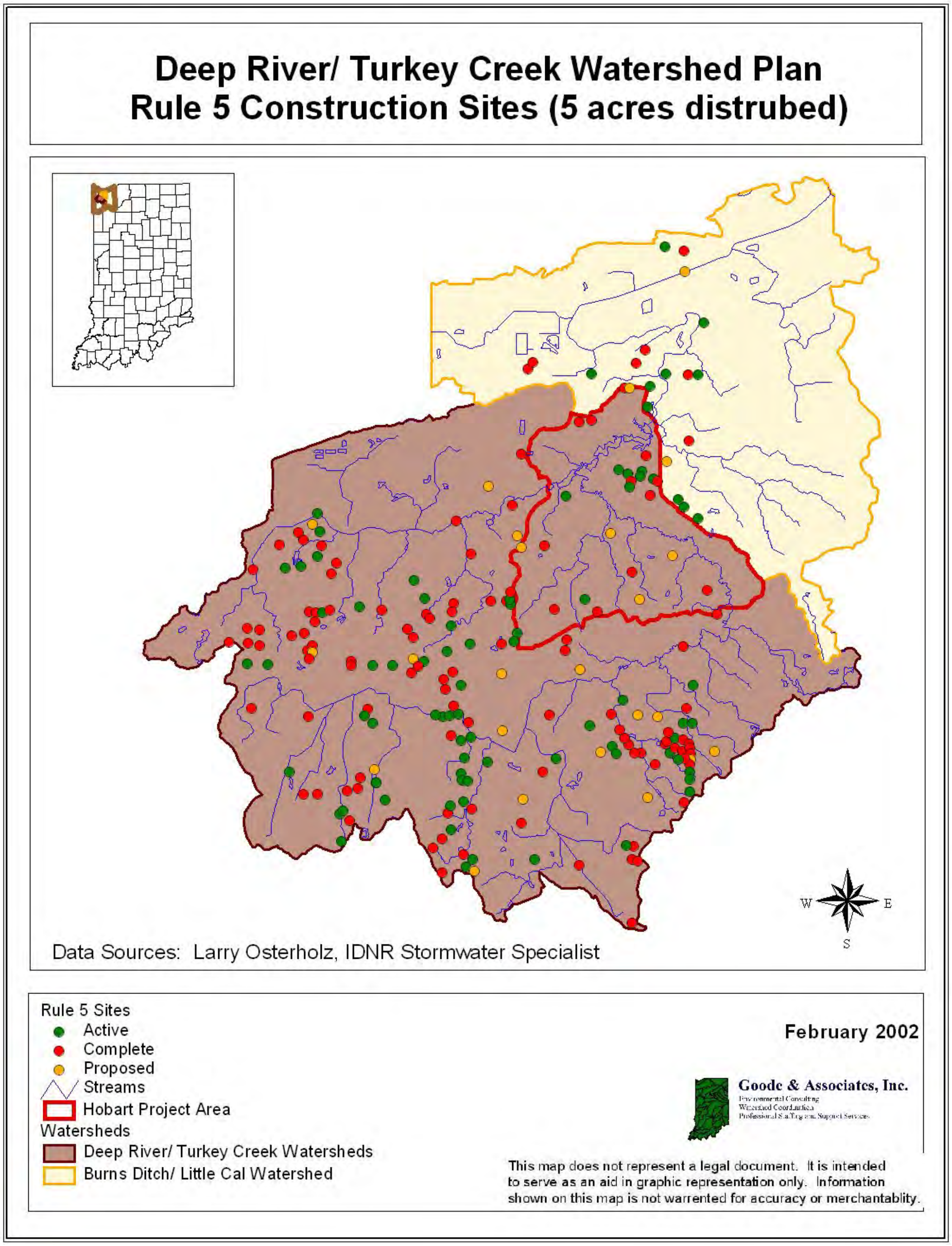
Degraded Wetlands/ Loss of Wetlands

The ability of wetland and riparian areas to remove NPS pollutants from surface water runoff is determined by plant species composition, geochemistry and hydrogeomorphic characteristics. Any changes to these characteristics can affect the filtering capacities of a wetland. Activities such as channelization, which modify the hydrology of floodplain wetlands, can alter the ability of these areas to retain sediment when they are flooded and result in erosion and a net export of sediment from the wetland (Reinelt and Horner, 1990).

Historically, the Section 404 program operated by the U.S. Army Corps of Engineers regulate activities associated with the dredging and filling of all wetlands; however, on January 9th, 2001, the U.S. Supreme Court ruled that the U.S. Army Corps of Engineers (Corps) did not have the authority to regulate certain “isolated” wetlands. Isolated wetlands’ are wetlands that are not adjacent, or directly connected, to navigable waters of the United States. This decision removed isolated wetlands from the jurisdiction of the U.S. Army Corps of Engineers. Historically, Indiana has protected the state’s waters, which include wetlands, by applying our water quality standards through the Section 401 Water Quality Certification program, in conjunction with the Section 404 U.S. Corps of Engineers permit program (IDEM, 2002).

Although isolated wetlands were determined to not be subject to federal jurisdiction, the Indiana Department of Environmental Management (IDEM) desired to continue protecting isolated wetlands. The IDEM determined that the Supreme Court decision did not question the states' authority to enforce its own statutes and regulations, and in fact, reaffirmed the states' primary authority to regulate its water resources and to control water pollution (IDEM). However, on

Figure 6-4: Rule 5 Construction Sites in the Deep River/ Turkey Creek Watershed



February 11, 2002 the Marion County, Indiana Superior Court ruled against IDEM's ability to regulate isolated wetlands in a declaratory judgment.

On February 26, 2002, the Marion Court Environmental Judge granted IDEM's request for a stay pending appeal of the judge's February 11, 2002, order. In addition, on February 15, 2002, IDEM, through the Office of the Attorney General, filed a notice of appeal of the trial court decision in the Indiana Court of Appeals.

In the meantime, the US Army Corps of Engineers and IDEM have developed a Regional General Permit (RGP) to authorize minimal impact activities in waters of the United States, including wetlands. In general, the RGP can be used by the Corps to authorize most projects that affect less than 1 acre of waters of the United States, provided the project complies with the terms and General Conditions of the RGP. All wetland dredge and fill projects are subject to the Corps' restrictions and the RGP General Conditions.

IDEM has issued Section 401 Water Quality Certification (WQC) for the RGP, subject to the restrictions for activities that qualify for a Corps of Engineers Regional General Permit and meets program requirements. Proposed projects that meet programmatic requirements need only to submit a notification form to IDEM. Such projects are authorized by the WQC and no response from IDEM is required prior to initiation of construction (IDEM Website, 2002).

During the planning process for the Deep River/ Turkey Creek Watershed Plan, many stakeholders made comments about significant loss of wetlands due to the changes in wetland protections offered by the former federal Section 404 program. Discussions with staff from the Lake and Porter County Soil and Water Conservation Districts, as well as the DNR Soil Conservationist, confirmed that significant losses have occurred within the Deep River/ Turkey Creek watershed since the rule changes.

Shoreline/ Streambank Erosion

Erosion is a natural process and some sediments will always end up in rivers, streams, and lakes. However, stormwater runoff from some land uses can often cause accelerated rates of erosion, significantly impacting water quality and designated uses. Where land slopes towards the water, leaving the natural shoreland undisturbed is often the best and least expensive protection against erosion (NALMS, 2000). A filter strip of thriving vegetation on and near the shore binds the soil and minimizes soil loss from surface runoff and waves, and from use by people. However, in urban environments where mowed turf grasses dominate, such as around Lake George in the City of Hobart, natural shorelines are most typically seen "weeds" or cluttered messes.

During the planning process for the Deep River/ Turkey Creek Watershed Plan, discussions with stakeholders about shoreline erosion were numerous. Significant shoreline erosion problems were observed at multiple locations around Lake George. **Figure 6-5** illustrates the locations of significant shoreline erosion identified via this project.

Of the shoreline areas evaluated in this project, the most severe locations of shoreline erosion were determined to be located within the City of Hobart's park system, specifically at Jerry Pavese Park and Fred Rose Park. **Figures 6-6 and 6-7** illustrate shoreline erosion at Jerry Pavese Park. **Figure 6-8** illustrates shoreline erosion at Fred Rose Park.

Stakeholders in the project expressed some concerns that the rate of shoreline erosion actually appeared to be increasing since the completion of the Lake George dredging project that was completed in 2000. A likely explanation for this was that in area where dredging occurred near the shoreline, sediments composing the toe of the slope were removed, causing some shoreline banks to exist at an unnatural, or unstable, angle of repose (See **Figure 6-9**). As a result, shoreline banks may be in the process of settling to a more stable slope

Figure 6-9: Illustration of Unstable Shoreline

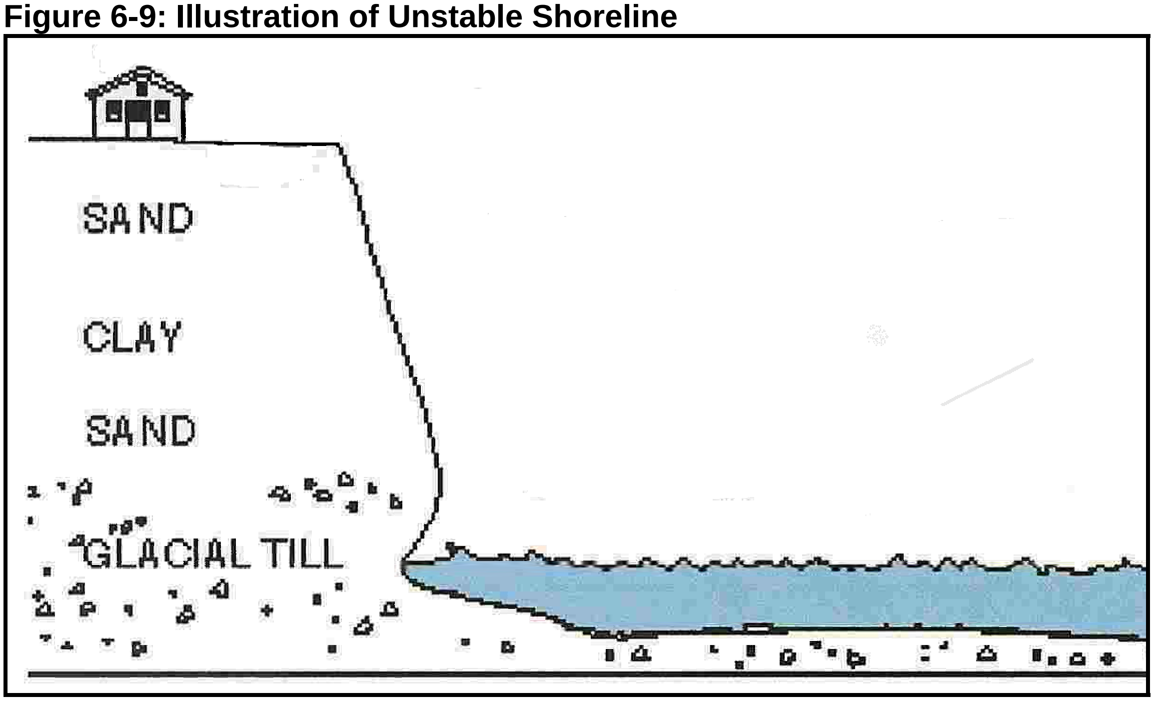


Figure 6-5: Locations of Significant Shoreline Erosion around Lake George

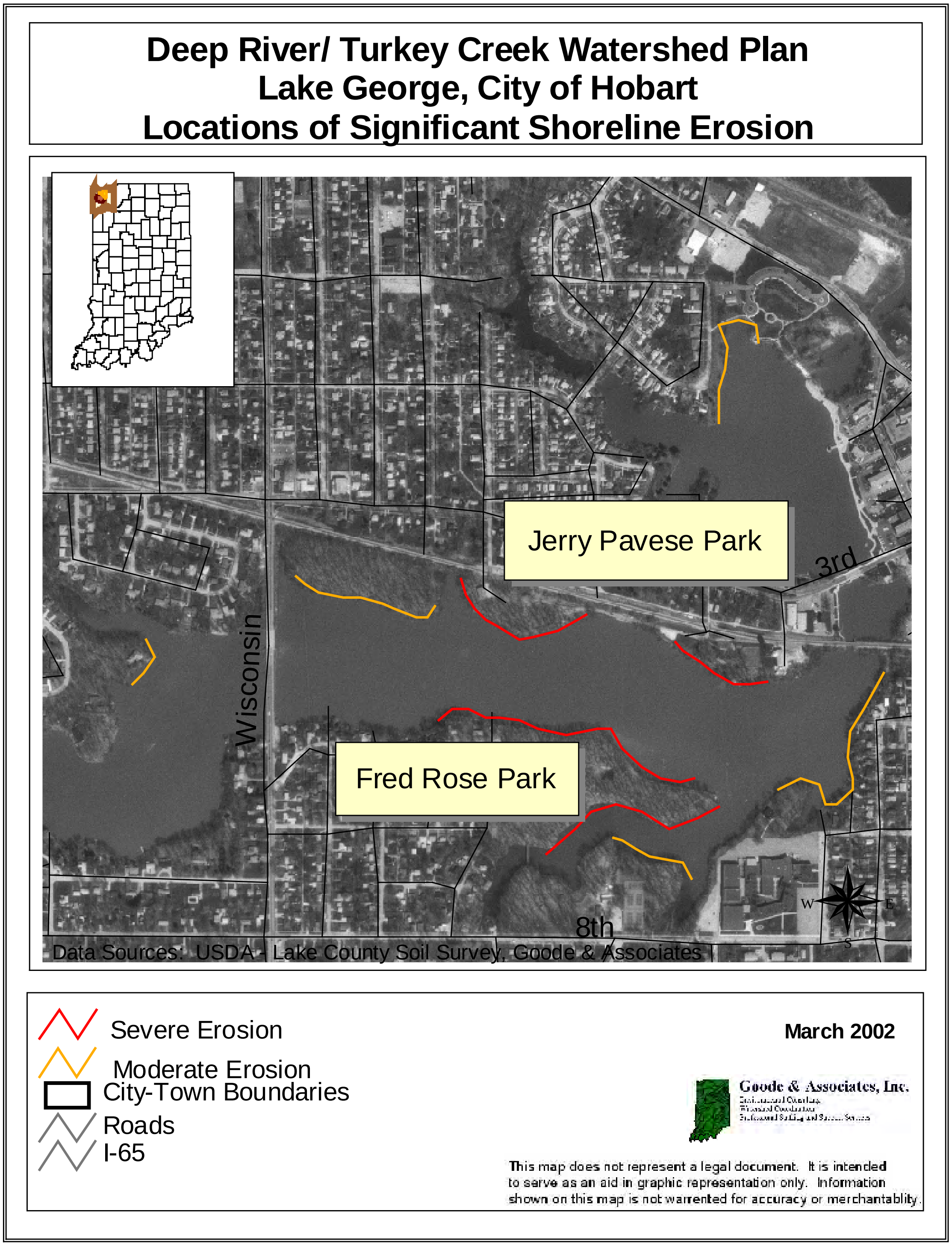


Figure 6-6: Shoreline Erosion at Jerry Pavese Park

Figure 6-7: Shoreline Erosion at Jerry Pavese Park

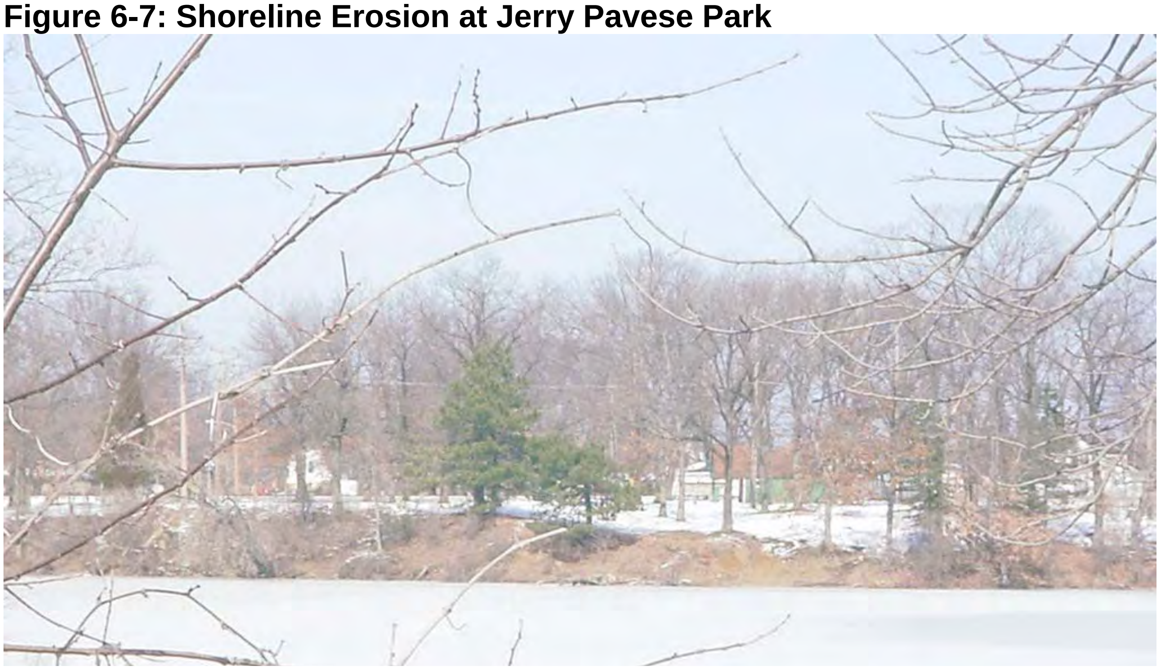


Figure 6-8: Shoreline Erosion at Fred Rose Park

The IDEM's Load Reduction Workbook was used to calculate the sediment loads being contributed from the two locations with the most severe shoreline erosion around Lake George, Jerry Pavese and Fred Rose Parks. Sediment, ammonia, and Phosphorus load reductions from these sites are listed in **Figure 6-10.** Sediment load reductions were estimated at 800 tons per year from these two sites.

Figure 6-10: Load Reduction Estimates for Jerry Pavese Park (Bank #2) and Fred Rose Park (Bank #1)

Bank Stabilization

Please fill in the gray areas below. If estimating for just one bank, put "0" in areas for Bank #2.
Once you have successfully estimated the sediment and nutrient load reductions,
please print two (2) copies of this worksheet. Attach both copies to the 319A or 319U cost-share form.

If you have any questions, please contact Wes Stone (317/233-6299).

		Example
IDEM Project Manager:	Jody Arthur	**WWS**
Project ARN:		**95-992**
Landowner Initials:	Hobart	**HJK**
Date practices completed:		**8/8/1999**

Please select a soil textural class:

- ( ) Sands, loamy sands
- ( ) Sandy loam
- ( ) Fine sandy loam
- ( ) Loams, sandy clay loams, sandy clay
- (•) Silt loam
- ( ) Silty clay loam, silty clay
- ( ) Clay loam
- ( ) Clay
- ( ) Organic

Parameter		Bank #1	Bank #2	Example	
Length (ft)		1983	1542	**500**	
Height (ft)		12	10	**15**	
Lateral Recession Rate (ft/yr)*		0.5	0.5	**0.5**	
Soil P Conc (lb/lb soil)**	DEFAULT	0.0005	0.0005	**0.0005**	**
Soil N Conc (lb/lb soil)**	DEFAULT	0.001	0.001	**0.001**	**

** indicates default values for Total P and Total N soil concentrations
*Lateral Recession Rate (LRR) is the rate at which bank deterioration has taken place and is measured in feet per year. This rate may not be easily determined by direct measurement. Therefore best professional judgement may be required to estimate the LRR. Please refer to the narrative descriptions in Table 1.

Estimated Load Reductions	**Bank #1**	**Bank #2**	**Example**
Sediment Load Reduction (ton/year)	506	328	**150**
Phosphorus Load Reduction (lb/year)	506	328	**150**
Nitrogen Load Reduction (lb/yr)	1011	655	**300**

VII. Summary of Findings

The water quality data evaluated for this project indicate that elevated concentrations/ loadings of nonpoint source pollutants are entering Lake George from both the Deep River and the Turkey subwatersheds.

Deep River
In the Deep River subwatersheds, excessive pollutants, particularly total suspended solids, nutrients, and *E.coli* enter the study watershed from the upper portions of the Deep River subwatersheds. These findings appear to strongly correlate with the potential soil erodiblity (T factor) ratings and the presence of significant highly erodible lands (HEL) in the subwatersheds upstream of the Deep River – Lake George subwatershed.

In addition, when these observations are compared to land uses, there also appears to be a strong correlation between the agricultural land uses that dominate the areas upstream of the study watershed and the elevated concentrations of total suspended solids and nutrients identified through this study. Based upon these observations, management of agricultural and HELs in the upper portions (subwatersheds) of the Deep River watershed should be prioritized for installation of best management practices (BMPs) for controlling erosion/ sedimentation and nutrients.

BMPs planned for this region should be coordinated with the strategies currently under development by the Lake County Surveyor's Office for stormwater management and regional detention in the Deep River/ Turkey Creek watershed. By coordinating these efforts for reducing the volume of water entering the creek and reducing pollutant concentrations, the overall goal of improving and protecting water quality in the Deep River/ Turkey Creek watershed should become more realistically attainable.

Based on the water quality data collected for this project, management of the Deep River watershed should be prioritized due to the greater pollutant loadings being contributed to Lake George by this watershed.

Turkey Creek
In the Turkey Creek subwatersheds, *E.coli* concentrations appear to be the pollutant of most concern, as monitoring indicates both dry and wet weather violations, as well as the highest overall concentrations of *E.coli* (highest geometric mean) per IDEM's monitoring. Since both IDEM's monitoring and the monitoring completed from this project showed the highest concentrations of *E.coli* to be from upstream of State Road 53, an evaluation of land uses in this

area seems to indicate that the E.coli measured at this site were generated from primarily urban or residential land uses.

Instream habitat ratings for the Turkey Creek subwatersheds suggest that channel modifications have diminished the ability of Turkey Creek to support viable biological communities. Habitat improvements within the subwatershed of Turkey Creek should result in measured improvements in fish and macroinvertebrate community scores.

Lake George

Although multiple lakefront redevelopment projects have transformed Lake George into a significant natural resource in downtown Hobart, Indiana, the lake is still plagued with poor water quality due to the NPS pollutant loads that the lake receives from Deep River and Turkey Creek. In addition to poor incoming water quality, the lake harbors a tremendous volume of historically deposited sediments in its upstream wetland areas. These sediments appear to become resuspended in the lake during significant rainfall events, further prolonging recovery of Lake George.

In 2000, dredging efforts removed nearly 600,000 cubic yards of sediment from the lake in a successful effort to improve the usability of the lake; however, additional shoreline stabilization efforts are a necessity for maintaining the depth of the lake, as well as the integrity of the City's public parklands. In addition, posted speed limits on the lake need to be more stringently enforced to minimize the affects of wave erosion on the lake's shoreline.

Streambank Erosion

Residential lawns line the banks of Deep River, Turkey Creek, and Duck Creek. Consequently, bank erosion exists at many of sites along these streams due to manicured turf grasses that lack the ability to stabilize the streambank due to their shallow root structures. In streamside areas, turf grasses should be replaced with deeper rooted herbaceous and shrub species. In open canopy areas there are a variety of low profile prairie species that will provide better bank stabilization while still allowing residents to view the river. In shadier areas, savanna species or native shrubs may be more appropriate. In addition to stabilizing banks, buffers around the creeks would filter overland pollutant runoff. Additional bank stabilization should be also considered for channelized areas of the creeks where the banks are unstable.

Floodplain Protection

The reduction in storm total suspended solid loads and many of the nutrient loads between sites 6 and 8 of the monitoring completed for the project suggests that the Deep River is depositing some of its pollutant loads in the floodplain during storm events. As a result, the riparian zone and floodplain areas between these sites are functioning and should be protected. Other areas in the creek's corridor should be examined to identify additional functioning riparian zones for potential protection or riparian zone restoration. In some cases, grade controls and bank reshaping may be necessary to reconnect the creek with its floodplain.

A functioning riparian zone will, in many cases, sequester nutrients and sediment better than on-line wetlands such as the one upstream of Lake George. Many of the same management techniques listed as applicable for the upper Deep River watershed can be applied to areas upstream of State Road 53 in the Turkey Creek subwatersheds and within the Deep River/ Turkey Creek watershed itself.

Stormwater Management

The magnitude of construction and development within the watershed has exacerbated historical problems associated with erosion and sedimentation in Lake George. Consequently, implementation of stormwater management programs by municipalities, especially local erosion and sediment controls, is seen as a necessity for addressing a portion of the significant NPS pollutant load reductions for sediment within the urbanized portions of the Deep River/ Turkey Creek watershed.

VIII. Setting Water Quality Goals for the Deep River/ Turkey Creek Watershed

Principles of Watershed Management

Although the watershed planning efforts in the Deep River/ Turkey Creek Watershed grew out of community concerns for Lake George, stakeholders involved in the development of this watershed plan realize that initiating water quality improvements in Lake George will require a significant investment of time and resources throughout the larger Deep River/ Turkey Creek watershed.

Generally speaking, watershed management approaches can be divided into two categories: the "quick-fix" approach or "long-term management". The "quick fix" approach to watershed management addresses short-term "solutions," such as the application of aquatic herbicides to quickly kill unwanted algae. Such chemical applications can go on year after year, becoming increasingly less effective if the underlying causes of the algal growth are ignored. The "quick fix" approach treats the symptoms of water quality problems, but fails to address the causes and sources of the problems.

Long-term watershed management considers all of the factors affecting a watershed and sets a higher priority on finding comprehensive, lasting solutions to water quality problems. As a result, high quality, financially efficient management projects take time and begin with long-range planning, such as the efforts documented in this plan. In some cases, immediate stream or lake restoration practices are also necessary; however, good management planning will ensure that such immediate restoration efforts are followed by appropriate long-term management practices.

Determining Water Quality Priorities, Goals, and Targets

Based upon these principles of watershed management, a mix of preventive actions and immediate restoration efforts are included in the recommendations for the Deep River/ Turkey Creek watershed. On April 23, 2002, the Steering Committee for the Deep River/ Turkey Creek Watershed Plan held a public meeting to discuss water quality improvement and protection priorities, goals, and targets in the Hobart City Council Chambers.

Table 8-1 lists the water quality improvement and protection priorities, goals, and targets as decided upon by the stakeholders at this public meeting. Each goal includes a statement of desired end-point condition or target as compared to present day conditions, and a time frame for when stakeholders expect the target to be met.

Table 8-1: Water Quality Improvement and Protection Goals for the Deep River/ Turkey Creek Watershed

1. Minimize the deposition of new sediments into Lake George

- Reduce sedimentation in Lake George by 75% over the next 5 years via BMP treatment train principle for both urban/ rural areas

2. Improve water quality in Deep River/ Turkey Creek watersheds

- Reduce sediment, nutrient, and E.coli loads in DR/ TC upstream of Lake George by 15% over the next 5 years
- Improve in-stream habitat in DR/ TC by 15% over the next 5 years

3. Improve education about water quality problems/ concerns

- Educate 75% of Lakeshore residents about watershed protection efforts for Lake George over the next 2 years
- Educate 75% of community officials in the DR/ TC watersheds about watershed protection efforts for Lake George over the next 2 years

4. Eliminate illegal discharges

- Conduct dry weather screening/ surveys of 100% of MS4 outfalls into Lake George/ tributaries over the next 5 years – Hobart
- Conduct dry weather screening/ surveys of 100% of MS4 outfalls in DR/ TC watersheds over the next 5 years – All Designated SW Phase II Entities
- Conduct dry weather screening/ surveys of 25% of outfalls in non-MS4 areas in DR/ TC watersheds over the next 5 years

5. Eliminate Failing septic systems

- Survey 30% of non-sewered areas to identify failing septic systems within municipal jurisdictions over the next 5 years
- Implement appropriate community solutions for 10% of problematic septic systems over the next 5 years

6. Promote consistency among communities developing stormwater management programs

- Develop joint stormwater/ water quality education programs w/ communities in DR/ TC watershed over the next 5 years
- Develop consistent stormwater ordinances w/ communities in DR/ TC watershed over the next 5 years

Management Recommendations for the Deep River/ Turkey Creek Watershed

As a result of the priorities, goals and targets decided upon by watershed stakeholders, a "toolbox" of structural and non-structural management practices or alternatives were developed by the consulting team and presented to Steering Committee for the Deep River/ Turkey Creek Watershed Plan at a public meeting held on May 21, 2002 in the City of Hobart's Council Chambers.

The Steering Committee discussed the pros, cons, and estimated costs of each of the management practices in order to select the preferred alternatives they felt were appropriate for achieving their water quality improvement goals. The stakeholders discussed the necessary sequence of tasks to ensure cohesive implementation of the selected management practices and identified approximate timeframes during which each task should be implemented or completed. In addition, stakeholders identified additional management practices that they recommended for adoption in the recommendations. The final list of preferred management practices, in order of priority and as selected by watershed stakeholders, is included in **Table 8-2**.

The final recommendations were compiled and organized into the content of the watershed plan and presented in this "Final Draft" version to the Hobart City Council and the public on June 19, 2002.

Measuring Progress

In order to ensure that progress is being made towards accomplishing the water quality improvement goals outlined in this Section, the Steering Committee selected specific indicators that they could use to measure the overall success of this plan. The milestones and indicators selected are summarized in **Table 8-3**.

Plan Evaluation

The steering committee will review and approve of any changes or updates to the Deep River/ Turkey Creek Watershed Management Plan on as needed, but will complete a thorough review at least every two years. This plan is intended to be a living document that will grown and change over the years. A copy will always be available for view at the Town Hall in Hobart, Indiana. Any questions regarding this plan should be directed to Ms. Denarie Kane, Director of Development for the City of Hobart (219-942-6112), as Ms. Kane will keep all future records and documents associated with this plan.

Table 8-2: Management Practices/ Alternatives for the Deep River/ Turkey Creek Watershed

Goal # 1:	**Minimize the deposition of new sediments into Lake George - Reduce sedimentation in Lake George by 75% over the next 5 years via treatment train principle for both urban/ rural areas**	**Target Location(s) for Implementation** (Municipal Jurisdictions)	**Estimated Cost of Implementation** (Each $ represents an estimated cost of $10, 000)	**Responsible Party(s)**	**Implementation Schedule** (Years)
Strategies for Achieving Goal # 1:	• Establish a local water quality monitoring program to provide baseline and trends data regarding the introduction of sediment and pollutants into Lake George. The monitoring program will also provide critical information for measuring the success of upstream and Lake water quality improvements. The program should also include TSI monitoring of Lake George in conjunction w/ IDEM's LMP.	City of Hobart, Indiana	$$$	City of Hobart, Indiana	2003-2007
	• Establish local stormwater utility. Stormwater utilities are an effective alternative to traditional financing for stormwater management. Stormwater utilities initiate user fees that provide community financing for stormwater runoff that causes *pollution* and *floodin*g.	City of Hobart, Indiana	$$$$	City of Hobart, Indiana	2007
	• Establish local Stormwater Management Program that includes authority for managing an erosion sediment control program via ordinance or regulatory program. Program will need to include site plan review procedures, site inspection/ enforcement procedures, and the ability to enforce stop work orders. May also include public input/ community policing components	City of Hobart, Indiana	$$$$$	City of Hobart, Indiana	2003
	• Update local zoning/ subdivision control ordinances to require lake/ stream setbacks; minimize curb requirements near streams to promote over land flow, and require additional (native) landscaping requirements along streams/ lakes in new/ redevelopment	City of Hobart, Indiana	$$	City of Hobart, Indiana	2003

	• Revise Comprehensive Plan to include recommended principles/ strategies from Deep River/ Turkey Creek Watershed Management Plan as a foundation for long-range planning/ land use decision making: 1. Stream/ Lake Setbacks 2. Floodplain Protection/ Management 3. Wetland/ Tree Conservation 4. Minimizing Impervious Surfaces 5. Linear Parks/ Open Space Preservation 6. Greenway and Riparian Planning 7. Parking Lot and Native Landscaping Design 8. Conservation Design 9. Planned Unit Development 10. Infill Development	City of Hobart, Indiana	$$	City of Hobart, Indiana	2004
	• Establish Education Program for Developers: 1. Produce materials to inform the development community about anticipated changes to erosion and sediment control (ESC) requirements. 2. Produce educational materials regarding the importance of erosion/ sediment controls for protecting community investments in Lake George. 3. Produce guidance recommending proven/ recommended best management practices (BMPs) and describing proper installation methods/ design specifications	City of Hobart, Indiana Lake County SWCD Lake County Surveyor's Office	$	City of Hobart, Indiana Lake County SWCD	2003
	• Install BMP demonstration projects as an educational tool for the development community (Phase III Lakefront Development near City Hall), using techniques such as catch basin inserts, retrofitting SW pond for quality controls, constructed wetland, bio-filter, etc)	City of Hobart, Indiana Lake County SWCD Lake County Surveyor's Office	$$$	City of Hobart, Indiana Lake County SWCD	2004

	• Construct streambank/ shoreline bioengineering projects in conjunction w/ LCSO's regional detention projects and retention/ infiltration practices to slow down stream velocities: 1. Jerry Pavese Park – Shoreline Stabilization 2. Fred Rose Park – Shoreline Stabilization 3. Hobart Prairie Grove – Streambank Stabilization 4. Deep River @ Deep River County Park – Streambank Stabilization 5. Conduct lake/ stream resident survey to ID additional problem areas in need of restoration	City of Hobart, Indiana Lake County SWCD Lake County Parks Department	$$$$$ per section; overall estimate of $500,000 to $1,000,000 for shoreline restoration	City of Hobart, Indiana Lake County SWCD Lake County Parks Department	2003-2007
	• Construct boardwalks, fishing piers, and natural shorelines in all parks/ recreational fishing locations to protect against significant existing shoreline erosion problems from over use. Existing comprehensive plan identifies park areas as being under served/ overused.	City of Hobart, Indiana	$$$	City of Hobart, Indiana	2003-2007
	• Provide recreational season boat/ paddleboat rental access to public/ fishing community to discourage shoreline fishing/ shoreline erosion.	City of Hobart, Indiana	$	City of Hobart, Indiana	2004-2007
	• Discourage use of turf grasses/ mowing on all public and private lakeside parcels. Use native plants/ bushes along shoreline that provide more extensive root structure and protection against erosion/ wave action.	City of Hobart, Indiana	$	City of Hobart, Indiana	2003
	• Support LC SWCD on Ag issues, such as Core 4: 1. Filters/ Buffers, 2. Reduced Tillage/ Conservation tillage 3. Nutrient, Pest, Manure management 4. Fencing livestock out of streams/lake and installation of alternate supplies of water 5. Water/ sediment control basins	City of Hobart, Indiana Lake County SWCD	$$$$	City of Hobart, Indiana Lake County SWCD	2003
	• Support LC SWCD in storm water inlet stenciling project throughout watershed (Entire Lake George watershed; Deep River/ Turkey Creek watershed)	City of Hobart, Indiana Lake County SWCD	$	City of Hobart, Indiana Lake County SWCD	2004-2007

	• Encourage development of NFP Lake Association w/ goal of improving water quality in Lake George: 1. Establish a new entity with the ability to apply for/ receive grant funds for addressing water quality problems 2. Encourage "no wake" zone to minimize wave erosion of shoreline area with problems	City of Hobart, Indiana Hobart Parks Department	$	City of Hobart, Indiana Hobart Parks Department	2004
	• Establish Lake Resident Education Program: 1. Conduct series of lake resident surveys gauging interest and support of lake improvement efforts/ water quality improvements 2. Create brochure and website to educate residents about the benefits of natural shorelines/ native plants and landscapes to prevent shoreline erosion 3. Conduct hands-on workshop to teach easy bioengineering technologies to lake property owners by installing demonstration practice on public property, such as city/ county park	City of Hobart, Indiana Lake County SWCD	$ - $$	City of Hobart, Indiana Lake County SWCD	2004
	• Encourage partnerships w/ neighboring communities to: 1. Ensure consistency in the development of storm water management programs 2. Promote development of consistent erosion and sediment control ordinances 3. Encourage consistency in BMPs required during construction activities 4. Encourage consistency in education and outreach efforts for all communities in watershed	City of Hobart, Indiana Lake County SWCD	$	City of Hobart, Indiana Lake County SWCD	2005
	• Work w/ Hobart DPW and establish partnerships with the County Highway Department and INDOT to encourage bridge retrofitting of storm water outlets where discharges are causing erosion: 1. Implement construction design standards for new/ rehabbed bridges 2. Apply for pollution prevention grants to pay for/ cost-share for retrofitting 3. Educate City and County Highway/ Street Departments re: erosion problems associated w/ stormwater runoff	City of Hobart, Indiana Lake County Highway Department INDOT	$	City of Hobart, Indiana Lake County Highway Department INDOT	2005

Goal # 2	Improve water quality in Deep River/ Turkey Creek watersheds - Reduce sediment, nutrient, and E.coli loads in DR/ TC upstream of Lake George by 15% over the next 5 years; Improve in-stream habitat in DR/ TC by 15% over the next 5 years	Target Location(s) for Implementation	Estimated Cost of Implementation	Responsible Party	Implementation Schedule
Strategies for Achieving Goal # 2:	• Digitize Lake County Soil Survey (SSURGO) to provide essential tools for erosion/ sedimentation: 1. Targeting agricultural BMPs to Highly Erodible Lands (HEL) throughout watershed 2. Easily identifying HELs in construction project areas so that ESC plans can be targeted for increased BMPs/ protection via Rule 5 Program	Lake County SWCD	$$$	Lake County SWCD	2003-2007
	• Establish regional stormwater utility. Stormwater utilities are an effective alternative to traditional financing for stormwater management. Stormwater utilities initiate user fees that provide community/ regional financing for stormwater runoff that causes *pollution* and *flooding*.	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana City of Hobart, Indiana	$$$$$$	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana City of Hobart, Indiana	2007

	• Establish regional Stormwater Management Programs that includes authority for managing an erosion sediment control program via ordinance or regulatory program. Program will need to include site plan review procedures, site inspection/ enforcement procedures, and the ability to enforce stop work orders. May also include public input/ community policing components	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	$$$$	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	2007
	• Update local zoning/ subdivision control ordinances to require lake/ stream setbacks; minimize curb requirements near streams to promote over land flow, and require additional (native) landscaping requirements along streams/ lakes in new/ redevelopment	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana Lake County, Indiana	$$$	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana Lake County, Indiana	2004

	• Revise Comprehensive Plans to include recommended principles/ strategies from Deep River/ Turkey Creek Watershed Management Plan as a foundation for long-range planning: 1. Stream/ Lake Setbacks 2. Floodplain Protection/ Management 3. Wetland/ Tree Conservation 4. Minimizing Impervious Surfaces 5. Linear Parks/ Open Space Preservation 6. Greenway and Riparian Planning 7. Parking Lot and Native Landscaping Design 8. Conservation Design 9. Planned Unit Development 10. Infill Development	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana Lake County, Indiana	$$	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana Lake County, Indiana	2007
	• Establish Regional Education Program for Developers: 1. Produce materials to inform the development community about anticipated changes to erosion and sediment control (ESC) requirements. 2. Produce educational materials regarding the importance of erosion/ sediment controls for protecting community investments in Lake George. 3. Produce guidance recommending proven/ recommended best management practices (BMPs) and describing proper installation methods/ design specifications	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	$	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	2003-2007

	• Install regional detention/ BMP demonstration projects as an educational tool for the development community (Phase III Lakefront Development near City Hall), using techniques such as catch basin inserts, retrofitting SW pond for quality controls, constructed wetland, bio-filter, etc)	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	$$$	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	2007

	• Construct streambank/ shoreline bioengineering projects in conjunction w/ LCSO's regional detention projects and retention/ infiltration practices to slow down stream velocities: 1. Deep River @ Deep River County Park – Streambank Stabilization 2. Conduct community surveys to identify additional problem areas in need of restoration	Lake County Surveyor's Office City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana City of Hobart, Indiana Lake County SWCD Lake County Parks	$$$$$	Lake County Surveyor's Office City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana City of Hobart, Indiana Lake County SWCD Lake County Parks	2003-2007
	• Discourage use of turf grasses/ mowing on public and private lakeside parcels. Use native plants/ bushes along shoreline that provide more extensive root structure and protection against erosion/ wave action.	Lake County Surveyor's Office City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana City of Hobart, Indiana	$	Lake County Surveyor's Office City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana City of Hobart, Indiana	2003-2007

	• Support LC SWCD on Ag issues, such as Core 4: 1. Filters/ Buffers, 2. Reduced Tillage/ Conservation tillage 3. Nutrient, Pest, Manure management 4. Fencing livestock out of streams/lake and installation of alternate supplies of water 5. Water/ sediment control basins	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	$$$$	Lake County SWCD	2003-2007

	• Support LC SWCD in storm water inlet stenciling project throughout watershed (Entire Lake George watershed; Deep River/ Turkey Creek watershed)	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	$	Lake County SWCD	2005

	• Encourage partnerships w/ neighboring communities to: 1. Ensure consistency in the development of storm water management programs 2. Promote development of consistent erosion and sediment control ordinances 3. Encourage consistency in BMPs required during construction activities 4. Encourage consistency in education and outreach efforts for all communities in watershed	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	$$	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana Town of Schererville, Indiana Town of Griffith, Indiana City of Gary, Indiana City of Portage, Indiana City of Lake Station, Indiana Lake County, Indiana	2004

Goal # 3:	Improve education about water quality problems/ concerns - Educate 75% of Lakeshore residents about watershed protection efforts for Lake George over the next 2 years. Educate 75% of community officials in the DR/ TC watersheds about watershed protection efforts for Lake George over the next 2 years	Target Location(s) for Implementation	Estimated Cost of Implementation	Responsible Party	Implementation Schedule
Strategies for Achieving Goal # 3:	• Establish Lake Resident Education Program: 1. Conduct series of lake resident surveys gauging interest and support of lake improvement efforts/ water quality improvements 2. Create brochure and website to educate residents about the benefits of natural shorelines/ native plants and landscapes to prevent shoreline erosion 3. Conduct hands-on workshop to teach easy bioengineering technologies to lake property owners by installing demonstration practice on public property, such as city/ county park	City of Hobart, Indiana Lake County SWCD Lake County Parks Department	$$	City of Hobart, Indiana Lake County SWCD Lake County Parks Department	2004
	• Establish a forum staff from communities within the DR/ TC watershed to consistently discuss watershed specific water quality/ stormwater issues. Use forum to develop "issue papers" regarding topics where multiple communities should coordinate on watershed basis. Each community's representative would present "issue papers" to their Mayor/ Council to raise awareness of issues and promote collaboration. Issue papers and collaborative activities could be presented and discussed regionally at IACT Mayor's Roundtable meetings and at larger scale, regional watershed meetings, such as NIRPC,	Lake County Surveyor's Office City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana City of Hobart, Indiana	$$$	Lake County Surveyor's Office City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana City of Hobart, Indiana	2004-2007

	• Install signage identifying Deep River/ Turkey Creek Watershed boundaries, such as "Now entering the DR/ TC Watershed. Help keep our streams clean!" Also, install signs identifying stream names at bridge crossings to raise awareness and identity of streams feeding into Lake George.	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana City of Hobart, Indiana	$	City of Crown Point, Indiana Town of Winfield, Indiana Town of Merrillville, Indiana City of Hobart, Indiana	2003-22004
	• Partner with Hobart High School to create an elementary education program, focusing on watersheds and water quality, that will prepare students for more extensive education in High School courses, such as "Water Analysis" class.	City of Hobart, Indiana Hobart School System	$	Hobart Elementary School Hobart High School	2003-2007

Goal # 4	Eliminate illegal discharges - Conduct dry weather screening/ surveys of 100% of MS4 outfalls into Lake George/ tributaries over the next 5 years – Hobart; All Designated SW Phase II Entities. Conduct dry weather screening/ surveys of 25% of outfalls in non-MS4 areas in DR/ TC watersheds over the next 5 years	Target Location(s) for Implementation	Estimated Cost of Implementation	Responsible Party	Implementation Schedule
Strategies for Achieving Goal # 4:	• Map all "named" streams, ditches, and stormwater conveyances within designated MS4 areas.	MS4 Communities/ Designated Areas	$ - $$$$	MS4 Communities/ Designated Entities	2003-2007
	• Establish local illicit discharge ordinance/ program. Program will need to conduct dry weather screening of outfalls discharging to MS4 system. Will require annual staff training and complaint response	MS4 Communities/ Designated Areas	$ - $$$	MS4 Communities/ Designated Entities	2005-2007
	• Establish illicit discharge education program in conjunction with other recommended education endeavors.	MS4 Communities/ Designated Areas	$	MS4 Communities/ Designated Entities	2004-2007
	• Establish partnership with local Scouting, fishing, canoeing clubs, environmental groups or Hoosier RiverWatch volunteers to identify and survey non-MS4 areas outfalls. Develop partnership in conjunction with existing education and outreach recommendations.	City of Hobart, Indiana MS4 communities bordering targeted areas	$	City of Hobart, Indiana MS4 communities bordering targeted areas	2004

Goal # 5	**Eliminate Failing septic systems - Survey 30% of non-sewered areas to identify failing septic systems within municipal jurisdictions over the next 5 years; Implement appropriate community solutions for 10% of problematic septic systems over the next 5 years.**	**Target Location(s) for Implementation**	**Estimated Cost of Implementation**	**Responsible Party**	**Implementation Schedule**
Strategies for Achieving Goal # 5:	• Develop program to identify and track failing septic systems and provide cost share money for sewer connection or alternative treatment. 1. Purchase ArcView software and create GIS to track the operational status of septic systems within the DR/ TC watershed. 2. Conduct review of Health Department records to identify records of failing septic systems around Lake George and tributaries. 3. Use GIS to establish a tiered survey system that prioritizes Lake and stream buffer areas and works progressively outward from waterbodies. 4. Conduct voluntary dye testing of septic systems to identify failing systems/ illicit connections. 5. Work with Lake County SWCD to identify "midnight connections" to field tiles/ ditches.	City of Hobart, Indiana Lake County Health Department	**$$ - $$$**	City of Hobart, Indiana Lake County Health Department	2005-2007
	• If magnitude of failing septic systems considered high after evaluation, conduct an evaluation of management alternatives and funding mechanisms for replacing failed septic systems or connection to sanitary sewer, such as septic management districts, cluster systems, GLNPO, NPS SRF, etc.	City of Hobart, Indiana	$$$	City of Hobart, Indiana	2007
	• Establish partnership with local Scouting, fishing, canoeing clubs, environmental groups or Hoosier RiverWatch volunteers to conduct visual stream assessments. Develop partnership in conjunction with existing education and outreach recommendations.	City of Hobart, Indiana	$	City of Hobart, Indiana	2004

Table 8-3: Milestones and Mechanisms for Measuring Success

Priority	Goal	Milestones/ Mechanisms for Measuring Progress	Estimate Pollutant Load Reduction
# 1:	Minimize the deposition of new sediments into Lake George - Reduce sedimentation in Lake George by 75% over the next 5 years via treatment train principle for both urban/ rural areas	• Milestones: Grant application submitted (Oct 02) for coordination and additional subwatershed planning in Deep River/ Turkey Creek watershed. NPDES Stormwater Quality Management Plan developed and submitted to IDEM by March 2003. Water quality monitoring reports produced by City of Hobart on annual basis, beginning in 2003. Revised Comprehensive Plan completed by end of 2003. Education Brochures sent to all developers working in Hobart by the end of 2003. Semi-annual surveys of stabilization projects to ensure effectiveness/ success. • Measuring Success: Overall progress against goal will be measured based upon reductions observed in sediment loadings from water quality monitoring data; Creation of city stormwater utility; linear feet of shoreline stabilized compared to feet of shoreline severely eroded prior to construction of BMPs; conservation tillage acreage will be compared to 1997 statistics; number of stormwater inlets stenciled; number of brochures distributed to lake/ city residents; number of responses to resident surveys regarding lake quality	
# 2	Improve water quality in Deep River/ Turkey Creek watersheds - Reduce sediment, nutrient, and E.coli loads in DR/ TC upstream of Lake George by 15% over the next 5 years; Improve in-stream habitat in DR/ TC by 15% over the next 5 years	• Milestones: Grant application submitted (Oct 02) for completing digital soil survey. **Creation of stormwater utilities by neighboring cities/ towns;** NPDES Stormwater Quality Management Plans developed and submitted to IDEM by March 2003 for neighboring cities/ towns. Revised Comprehensive Plans completed by end of 2007. Education Brochures sent to all developers working in Deep River/ Turkey Creek watershed by the end of 2007. Semi-annual surveys of stabilization projects to ensure effectiveness/ success. • Measuring Success: Overall progress against goal will be measured based upon reductions observed in sediment loadings from water quality monitoring data; linear feet of shoreline stabilized compared to feet of shoreline severely eroded prior to construction of BMPs; conservation tillage acreage will be compared to 1997 statistics; number of stormwater inlets stenciled.	

# 3	**Improve education about water quality problems/ concerns - Educate 75% of Lakeshore residents about watershed protection efforts for Lake George over the next 2 years. Educate 75% of community officials in the DR/ TC watersheds about watershed protection efforts for Lake George over the next 2 years**	• Milestones: Grant application submitted (Oct 02) for developing educational programs. **Creation of regional watershed coordination organization. Installation of "you're your watershed" signs at all major road crossings in watershed.** • Measuring Success: Number of brochures distributed to lake/ city residents; number of responses to resident surveys regarding water quality; establishment of an elementary school curriculum focusing on watersheds and water quality.
# 4	**Eliminate illegal discharges - Conduct dry weather screening/ surveys of 100% of MS4 outfalls into Lake George/ tributaries over the next 5 years – Hobart; All Designated SW Phase II Entities. Conduct dry weather screening/ surveys of 25% of outfalls in non-MS4 areas in DR/ TC watersheds over the next 5 years**	• Milestones: 25% of MS$ area mapped each year begging 2004; revison of nuisance ordinance to address illicit connections; visual surveys of major streams/ tributaries. • Measuring Success: Number of illicit connections eliminated; number of stream miles surveyed; number of participants in stream surveys
# 5	**Eliminate Failing septic systems - Survey 30% of non-sewered areas to identify failing septic systems within municipal jurisdictions over the next 5 years; Implement appropriate community solutions for 10% of problematic septic systems over the next 5 years.**	• Milestones: create GIS system w/ ability to track/ maintain records regarding failing septic systems. Review County Health department records on failing septic systems from past three years; Establish teams to survey streams/ tributaries. • Measuring Success: Number of failing septic systems identified; number of failing septic systems eliminated; number of stream miles surveyed; number of participants in stream surveys
#6	**Promote consistency among communities developing stormwater management programs -** Develop joint stormwater/ water quality education programs w/ communities in DR/ TC watershed over the next 5 years. Develop consistent stormwater ordinances w/ communities in DR/ TC watershed over the next 5 years	• Milestones: Establish regional watershed coordination organization; hold quarterly coordination meetings w/ city/ town officials in Deep River/ Turkey Creek watershed • Measuring Success: Number of meetings regional coordination meetings held annually; number of participants in attendance.

Section IX: Sources of Funding (adapted from IDEM Little Cal-Galien WRAS)

This listing of funding sources was derived from the May 1999 *Watershed Action Guide for Indiana*, which is available from the Watershed Management Section of IDEM.

FEDERAL CONSERVATION AND WATERSHED PROGRAMS

1. Environmental Protection Agency

- Section 319, 205(j), and 104(b)(3) Grants - Grants for conservation practices, water body assessment, watershed planning, and watershed projects. Available to non-profit or governmental entities. These monies, enabled by the Clean Water Act, are funneled through the Indiana Department of Environmental Management. *For details see IDEM below.*
- EPA Great Lakes Program - Numerous sources of funding are available for the area that drains into the Great Lakes. The complete grants guidance and application package for EPA Great Lakes grants is on the web, and additional funding sources are at the Great Lakes Information Network (http://www.great-lakes.net). Grants are submitted in early spring for most of these sources.
- Wetland Protection Development Grants Program - Provides financial assistance to support wetlands programs/projects or augmentation and enhancement of existing programs. Eligible entities include states and local governments. (http://www.epa.gov/owow/wetlands/2002grant/)
- Environmental Education Program - Grants are available to non-profit organizations to support environmental education programs and projects. All rewards require a 25% local match. Applications are accepted in mid to late November (http://www.epa.gov/Region5/enved/grants.html).

U.S. Department of Agriculture/Natural Resources Conservation Service (NRCS)

- Conservation Reserve Program (CRP)- Administered by the Farm Service Agency with technical assistance from NRCS. Conservation easements in certain critical areas on private property. CRP encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Easements are for 10 or 15 years, depending on vegetative cover, and compensation payments are made yearly to replace income lost through not farming the land. Cost share is available for planting vegetative cover on restored areas (www.fsa.usda.gov/dafp/cepd/crp.htm).

- Environmental Quality Incentive Program (EQIP)- Administered by the NRCS. Provides technical, financial, and educational assistance. Conservation cost-share program for implementing Best Management Practices, available to agricultural producers who agree to implement a whole-farm plan that addresses major resource concerns. Up to $50,000 over a 5- to 10- year period. Some parts of the state are designated Conservation Priority Areas and receive larger funding allotments (www.nhq.nrcs.usda.gov/PROGRAMS/-COD/cit/eqipsmry.htm).

- Forestry Incentive Program (FIP) - Administered by the NRCS. Assists forest management on private lands of at least 10 acres and no more than 1,000 acres. Eligible practices are tree planting, timber stand improvement, site preparation for natural regeneration, and other related activities. Land must be suitable for conversion from nonforest to forest land, for reforestation, or for improved forest management and be capable of producing marketable timber crops. Cost share of up to 65%, with a maximum award of $10,000 per person per year (www.nhq.nrcs.usda.gov/CCS/FB96OPA/FIPfact.html).

- Small Watershed Program - The Small Watershed Program works through local government sponsors and helps participants solve natural resource and related economic problems on a watershed basis. Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres. Both technical and financial assistance are available (www.ftw.nrcs.usda.gov/pl566/pl566.html).

- Wetland Reserve Program (WRP) - Administered by the NRCS. Easement and restoration program to restore marginal agricultural land to wetland. Easements may be for 10 years, 30 years, or permanent. Longer easements are preferred. Partnerships with other acquisition programs are encouraged. Restoration and legal costs are paid by NRCS. Landowner retains ownership of the property and may use the land in ways that do not interfere with wetland function and habitat, such as hunting, recreational development, and timber harvesting (www.nhq.nrcs.usda.gov/PROGRAMS/wrp/).

- Wildlife Habitat Incentive Program (WHIP) - Administered by the NRCS. Cost share and technical assistance to develop and improve wildlife habitat on private land. Private landowners who are agricultural producers are eligible. A wildlife habitat plan is developed that describes landowner's goals for improving wildlife habitat, includes a list of practices and schedule for installing them, and details the steps necessary for maintenance. Cost share up to 75%, and contracts are for 10 years (www.nhq.nrcs.usda.gov/PROGRAMS/whip/).

- Conservation Security Program - Administered by the NRCS. Program provides incentive payments for maintaining and increasing farm and ranch stewardship practices on working lands. The program promotes conservation and improvements to soil, water, and air quality. Participation in the program stipulates that land practices must achieve resource and environmental benefits; however, removal of land from production is not required. Federal reimbursement of up to 75% on conservation practice chosen (http://www.nrcs.usda.gov/programs/farmbill/2002/products.html).

- Emergency Watershed Protection Program - Administered through NRCS. The program is set up to respond to natural disaster induced emergencies. Any land on floodplains that has been impaired within the last 12 months is eligible for funding, however, a project sponsor must represent landowners. NRCS will bear up to 75% of the construction cost of emergency measures. All applications must be submitted within 10 days of the disaster for exigency situations and within 60 days of nonexigency situations (http://www.nrcs.usda.gov/programs/ewp/ewp.html).

- Sustainable Agriculture Research and Education Producer Grant Program - Grants are available to landowners, farmers, researchers, educators and, others in the USDA's North Central Region for farm projects such as erosion and runoff control that are economically viable, environmentally sound, and socially responsible. Awards range from $2,000 to $15,000 and applications are due in mid July (http://www.sare.org/ncrsare/prod.htm).

- Forest Land Enhancement Program (FLEP) - The program provides cost-share support for non-industrial private forest landowners to help them develop and implement Forest Stewardship Plans. Reimbursement of up to 75% of the approved expenses, with a maximum award of $10,000 per year per landowner. In exchange, the landowner agrees to maintain and protect FLEP funded practices for a minimum of 10 years (http://www.usda.gov/farmbill/forestry_fb.html).

- Forest Legacy Program - Program to encourage the protection of privately owned forest lands. Landowners are required to prepare a multiple resource management plan for the land as part of the conservation easement acquisition. Federal cost share of up to 75% of project cost. Priority applications are due in the end of January, but are accepted throughout the year (http://www.fs.fed.us.spf/coop/flp.htm).

U.S. Fish & Wildlife Service

- Partners for Wildlife Habitat Restoration Program - Provides technical and financial assistance to private landowners through voluntary cooperative agreements in order to restore formerly degraded wetlands, native grasslands, riparian areas, and other habitats to conditions as natural as feasible. Landowners agree to maintain restoration projects as specified in the agreement but otherwise retain full control of the land. Agreements are for fixed term of at least 10 years. No more than 60% of project cost is paid by Federal moneys (the program seeks remainder of cost share from landowners and nationally-based and local entities) (http://www.fws.gov).

- Coastal Wetlands Planning, Protection, and Restoration Act - Funds can be used for acquisition of interests in coastal lands or waters, and for restoration, enhancement, or management of coastal wetland ecosystems. All states bordering the Great Lakes are eligible. Federal cost share up to 50% (http://www.epa.gov/owow/watershed/wacademy/fund/coastalwet.html).

- North American Wetlands Conservation Act Grants - Provides matching grants to private or public organizations or to individuals who have developed partnerships to carry out wetlands conservation projects including acquisition, enhancement, and restoration. Federal cost share of up to 50% of project cost (http://www.nws.usace.army.mil/pm/cw/planning.cfm).

U.S. Army Corps of Engineers

- Planning Assistance to States Program - Funding assistance for preparation of comprehensive plans for development, utilization, and conservation of water and related land resources. Recent projects include water quality and conservation projects. Any non-federal entity is eligible. Federal cost share of up to 50% (http:// www.cfda.gov/public/viewprog.asp?progid=250).

- Project Modifications for Improvement of the Environment - Provides funding for programs to restore habitat and improve habitat that has been impacted by existing Corps projects. Federal cost share of up to 75% of project cost (http://www.swg.usace.army.mil/pe-p/projmod.asp).

- Aquatic Ecosystems Restoration - Funds can be used for restoration and protection of aquatic habitat and water quality in lakes, rivers, and streams without any connection to existing Corps projects. State and non-governmental groups are eligible. Federal cost share of up to 65% (http://www.mvp.usace.army.mil/enviro_protection/aqua_eco_rstor/).

STATE CONSERVATION AND WATERSHED PROGRAMS

IDNR Division of Soil Conservation

- Lake & River Enhancement Program (LARE) - Funds diagnostic and feasibility studies in selected watersheds and cost-share programs through local Soil & Water Conservation Districts. Project oversight provided through county-based Resource Specialists and Lake & River Enhancement Watershed Coordinators. Funding requests for Watershed Land Treatment projects must come from Soil & Water Conservation Districts. If a proposed project area includes more than one district, the affected SWCDs should work together to develop an implementation plan. The SWCDs should then apply for the funding necessary to administer the watershed project. Before applying for funding, the SWCDs should contact the Lake & River Enhancement Coordinators to determine (1) the appropriate watershed to include in the project, (2) if the proposed project meets the eligibility criteria, and (3) if funding is available (www.in.gov/dnr/soilcons/lare.htm).
- Hoosier Riverwatch - Grants provide equipment for participating in the statewide volunteer stream-monitoring program, and are awarded to schools, government agencies, non-profit organizations, and etc (http://www.state.in.us/dnr/soilcons/riverwatch/).

IDNR Division of Fish & Wildlife

- Classified Wildlife Habitat Program - Incentive program to foster private wildlife habitat management through tax reduction and technical assistance. Landowners need 15 or more acres of habitat to be eligible. IDNR provides management plans and assistance through District Wildlife Managers (see county listings) (www.ai.org/dnr/fishwild/about/habitat.htm).

IDNR Division of Forestry

- Classified Forest Program - Incentive program to foster private forest management through tax reduction and technical assistance. Landowners need 10 or more acres of woods to be eligible. IDNR provides management plans and assistance through District Foresters (see county listings) (www.state.in.us/dnr/forestry/landassist/clasfor.htm).

- Classified Windbreak Act - Establishment of windbreaks at least 450 feet long adjacent to tillable land. Provides tax incentive, technical assistance through IDNR District Foresters.

- Forest Stewardship Program & Stewardship Incentives Program - Cost share and technical assistance to encourage responsibly managed and productive private forests (www.state.in.us/dnr/forestry/htmldocs/grants.htm)

- Urban Forest Conservation Grants - Program to improve and protect trees in urban areas. Programs should include planning, development, and education. Municipalities and non-profit groups are eligible.

IDNR Division of Outdoor Recreation

- Hometown Indiana Grant Program - A state matching assistance program that provides grants for the acquisition and/or development of recreation sites and facilities, historic preservation and urban forestry. Municipal corporations with a five-year master plan are eligible for the program (http://www.in.gov/dnr/outdoor/grants/hometown.html).

IDNR Division of Reclamation

- Appalachian Clean Streams Initiative - Funds for acid mine drainage abatement.

IDNR Division of Nature Preserves

- State Nature Preserve Dedication - Acquisition and management of threatened habitat. (http://www.in.gov/dnr/naturepr/)

IDEM Office of Water Quality

- State Revolving Fund - Available to municipalities and counties for a range of water quality infrastructure projects. Funds are available for a wide variety of projects including all types of nonpoint source management projects, as well as more traditional wastewater treatment projects. Funding is through very low-interest loans. (http://www.in.gov/idem/water/fasb/srflp.html)

- Section 319 Grants - Nonpoint Source Program - Available to nonprofit groups, municipalities, counties, and universities for implementing water quality improvement projects that address nonpoint source pollution concerns. Twenty-five percent match is required, which may be cash or in-kind. Maximum grant amount for local watershed projects is $112,500, but statewide or larger scale projects may be funded up to $300,000. Projects are usually two to three years in length. Projects may be for land treatment through implementing Best Management Practices, for education, and for developing tools and applications for state-wide use. Proposals are due October 1, 2002 for FY2003 funds. See Section 5.1.5 for more details. (http://www.in.gov/idem/water/planbr/wsm/index.html)

- Section 205(j) Grants - Water Quality Management Planning Program - Available to municipalities, counties, conservation districts, drainage districts, and other public organizations. For-profit entities, non-profit organizations, private associations, and individuals are not eligible for funding through Section 205(j). Grants are for water quality management projects such as studies of nonpoint pollution impacts, nonagricultural NPS mapping, and the development and implementation of watershed management projects. Funds can be requested for up to $100,000 and no match is required. (http://www.in.gov/idem/water/planbr/wsm/index.html)

- Section 104(b)(3) Grants - NPDES Related State Grant Program - Provide for developing, implementing and demonstrating new concepts or requirements that will improve the effectiveness of the NPDES permit program. A project proposed for assistance by this program should deal predominantly with water pollution sources and activities regulated by the NPDES program. These may include innovative demonstration projects to promote statewide watershed approaches for permitted discharges, development of storm water management plans by small municipalities, projects involving a watershed approach to municipal separate sewer systems, and projects that directly promote community based environmental protection. Available to State water pollution control agencies, interstate agencies, Tribes, colleges and universities, and other public or nonprofit organizations. For-profit entities, private associations and individuals are not eligible to receive this assistance. Funds can be requested for up to $100,000. Five percent match is required, either cash or in-kind. (http://www.in.gov/idem/water/planbr/wsm/index.html)

PRIVATE FUNDING SOURCES

National Fish and Wildlife Foundation - *1120 Connecticut Avenue, NW Suite 900, Washington DC 20036. (http://www.nfwf.org/programs/grant_apply.htm)*
Nonprofit, established by Congress 1984, awards challenge grants for natural resource conservation. Federally appropriated funds are used to match private sector funds. Six program areas include wetland conservation, conservation education, fisheries, migratory bird conservation, conservation policy, and wildlife habitat.

Conservation Technology Information Center - Core Four Alliance Grants - Grants are provided to alliances throughout the country implementing programs that will advance the Core 4 Conservation Campaign to realize better soil, cleaner water, greater profits for agriculture, and a brighter future for everyone. (http://www.ctic.purdue.edu/Tammy/Application.pdf)

Individual Utilities - Check local utilities such as IPALCO, CINergy, REMC, NIPSCO. Many have grants for educational and environmental purposes. (http://www.cinergy.com/Environment/default.asp)

Indiana Hardwood Lumbermen's Association - Indiana Tree Farm Program. (http://www.ihla.org/leaders.htm)

Conservation Technology Information Center (CTIC) – "Know Your Watershed" educational materials are available. (http://www.ctic.purdue.edu/CTIC/CTIC.html)

Ducks Unlimited
Land acquisition and habitat restoration assistance. (http://www.ducks.org/)

Quail Unlimited
Funds for quail and wildlife habitat improvement projects. (http://www.qu.org/)

Pheasants Forever
Land acquisition and funds for local habitat improvement projects. (http://www.pheasantsforever.org/)

Indiana Heritage Trust
Land acquisition programs. (http://www.state.in.us/dnr/heritage/)

The Nature Conservancy
Land acquisition and restoration. http://nature.org/wherewework/northamerica/states/indiana/

1. Southern Lake Michigan Conservation Initiative
2. Blue River Focus Area
3. Fish Creek Focus Area
4. Natural Areas Registry
5. Hoosier Landscapes Capitol Campaign

River Network
Watershed Assistance Grants - This program is designed to support the growth and sustainability of local watershed partnerships in the United States. For the purpose of this program, a "watershed partnership" is defined as an inclusive, enduring, diverse, community-based group organized to identify and resolve

watershed problems and issues. Awards range from $1,000 - $3,100 (http://www.rivernetwork.org).

CS Mott Foundation
Re-Grants - Program is designed to help staff members, board members, and volunteers develop skills important to their duties with river and watershed organizations. Funding is used to cover travel expenses and/or registration fees for selective river training opportunities (http://www.rivernetwork.org/howwecanhelp/howregrant.cfm).

Local/Regional Land Trusts - Land acquisition, conservation easements, and restoration.

- Acres Inc. (Fort Wayne, IN)
  - http://www.acres-land-trust.org/
- Buffalo Trace Land Trust, LLC (Mount Saint Francis, IN)
- Central Indiana Land Trust, Inc. (Indianapolis, IN)
  - http://www.cilti.org/
- Clark's Valley Land Trust (Charlestown, IN)
  - http://www.clarkswcd.org/LandTrust/LandTrusthome.htm
- Indiana Karst Conservancy (Indianapolis, IN)
  - http://www.caves.org/conservancy/ikc/
- Laporte County Conservation Trust Inc. (La Porte, IN)
- Mud Creek Conservancy (Indianapolis, IN)
  - http://www.mudcreekconservancy.org/
- NICHES Land Trust (Lafayette, IN)
  - http://dcwi.com/~niches/
- Ohio River Conservancy (Bloomington, IN)
- Oxbow, Inc. (Cincinnati, OH)
  - http://math.uc.edu/~pelikan/OXBOW/wm.html
- Red-tail Conservancy, Inc. (Muncie, IN)
  - http://ourworld.cs.com/rtconserv1/id18.htm
- River Fields, Inc. (Louisville, KY)
  - http://www.riverfields.org/
- Shirley Heinze Environmental Fund (Michigan City, IN)
  - http://www.heinzefund.org
- Sycamore Land Trust (Bloomington, IN)
  - http://www.sycamorelandtrust.org/
- Wabash Heritage Land Trust (New Harmony, IN)
- Wawasee Area Conservancy Foundation (Syracuse, IN)
  - http://www.wacf.com/
- Whitewater Valley Land Trust, Inc. (Centerville, IN)

- Wood-Land-Lakes Resource Conservation & Development (Kendallville, IN)

- http://www.in.nrcs.usda.gov/conservation%20programs/rcd/woodland_lakes.htm

SOURCES OF ADDITIONAL FUNDING OPPORTUNITIES

- Catalog of Federal Funding Sources for Watershed Protection -EPA Office of Water (EPA841-B-99-003) December 1999
  (http://www.epa.gov/owow/watershed/wacademy/fund.html)

- **GrantsWeb**: http://www.srainternational.org/cws/sra/resource.htm

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