Lauramie Creek Watershed Management Plan

Tippecanoe County, Indiana and Clinton County, Indiana

"The Lauramie Creek Watershed Steering Committee is committed to developing a Watershed Management Plan that will increase public awareness of water quality issues, identify water quality problems, and make economically and environmentally friendly recommendations that will improve water resources of the Lauramie Creek Watershed."

May 2004 – November 2005

IDEM 205j Project: ARN# A305-4-50

LAURAMIE CREEK WATERSHED MANAGEMENT PLAN

Prepared for the:

Tippecanoe County Commissioners
20 North Third Street
Lafayette, IN 47901

November 2005

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CBBEL Project Number 04-338

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EXECUTIVE SUMMARY

Christopher B. Burke Engineering, Inc. (CBBEL) was retained by the Tippecanoe County Commissioners to help lead the investigation, development, and drafting of a Watershed Management Plan (WMP) for the Lauramie Creek Watershed. Interest in developing this WMP stems from historical water quality and quantity problems associated with the watershed. It is hoped that, through the implementation of this WMP, improved water quality conditions will be realized that will benefit all residents of the Lauramie Creek Watershed.

The Lauramie Creek Watershed drains portions of Tippecanoe and Clinton County and is a tributary to the South Fork of Wildcat Creek. The Lauramie Creek Watershed covers approximately 23 square miles within the larger area of the Wildcat Creek Watershed. Both watersheds are located east and southeast of the City of Lafayette.

Chapter 1: Introduction describes the planning objective, process, and participation that are pertinent to watershed planning and management. The watershed planning effort began with the organization of a Steering Committee that assessed conditions in the watershed, examined water quality issues important to the community, and made decisions as to the direction and content of the plan. **Chapter 2: Identifying Water Quality Problems and Causes** examines and discusses information that describes the current water quality conditions in the Lauramie Creek Watershed. To help facilitate this planning effort, CBBEL researched and compiled information on past studies, analyzed trends, and conducted a chemical monitoring program in the watershed to provide the Steering Committee with a comprehensive picture of water quality conditions in the watershed. General conclusions reported in recent and past studies showed that habitat conditions were fair to good, and the chemical monitoring study confirmed that *Escherichia coli (E. coli)* bacterium is a special concern and significant impairment exists within Lauramie Creek and its tributaries. **Chapter 3: Identifying Pollutant Sources** describes the potential sources and possible locations of pollutants that are causing impairment that were identified in Chapter 2. These sources of pollution included agricultural tillage practices, fertilizer and pesticide applications, inadequate septic systems and many others. **Chapter 4: Identifying Critical Areas** details general locations where these pollutant sources may be addressed to help preserve and improve water quality conditions in the Lauramie Creek Watershed. Results of Steering Committee discussions yielded a map of critical areas that were recognized as requiring either preservation, or improvement. **Chapter 5: Setting Goals, Management Measures, and Indicators** identifies specific management actions and recommendations for preserving and improving water quality in the Lauramie Creek Watershed. Finally, **Chapter 6: Monitoring Effectiveness** defines how the WMP will be reviewed, evaluated, and updated as a living and dynamic planning document into the future.

Additional input for this WMP was sought from the public. Six public meetings were conducted to provide a forum and conduit for review and comment on the development of the WMP. Individuals that are interested in learning more about the project or obtaining a copy of the Lauramie Creek WMP can contact:

Contact Name	
Steve Murray	Zach Bishton
Tippecanoe County Surveyor's Office	Christopher B. Burke Engineering, Ltd
20 North Third Street	115 West Washington, Suite 1368
Lafayette, Indiana 47901	Indianapolis, IN 46204
Phone: 765-423-9228	Phone: 317-266-8000

This Plan is the culmination of an 18-month planning effort and is intended to be a guiding document that describes the current water quality conditions, prioritizes water resource issues, and identifies specific management actions that can be implemented to help the Lauramie Creek Watershed community manage their water resources into the future.

1.0 INTRODUCTION

Christopher B. Burke Engineering, Inc. (CBBEL) was retained by the Tippecanoe County Commissioners to help lead the investigation, development, and drafting of a Watershed Management Plan (WMP) for the Lauramie Creek Watershed. Interest in developing this WMP stems from historical water quality and quantity problems associated with the watershed. It is hoped that, through the implementation of this WMP, improved water quality conditions will be realized that will benefit all residents of the Lauramie Creek Watershed. This plan documents the study and its results.

1.1 WATERSHED BASED PLANNING

A watershed is an area of land that collects and drains water to a specific point. Similar to water poured into a bowl, a portion of the precipitation that falls on a watershed will move through the landscape, collecting and concentrating in low areas, creeks, and streams, until it exits through an outlet point. All water, whether in the ground or traveling over the ground surface, moves from the highest to the lowest points in an area of land. Using this definition, watersheds can be defined for any location. For planning purposes, the watershed is a measurable and practical landscape feature that is based on how water moves, interacts with, and behaves on the landscape.

Water in the form of precipitation can take several paths once it has reached the earth. Some portion of the precipitation will never reach the ground; instead it is caught by vegetation and/or ground litter and evaporates. That portion of precipitation that does reach the ground can infiltrate the ground, becoming shallow or deep groundwater, or travel over the surface as runoff. Runoff is excess rainfall that can not be absorbed or retained in the landscape. As water travels through the watershed by these pathways it interacts with the landscape, in a physical and chemical manner, that interaction determines the character of water quality in a receiving waterbody. Human activities alter the landscape and thus influence the physical and chemical interaction of water in a watershed. Recognition and an understanding of the hydrologic cycle in the context of human influence on watershed processes are fundamental to good watershed management planning.

Human interaction with the environment helps to define the characteristics of the watershed, and thus, the quality of the water. A logical way to approach water resource management is to use the watershed as the primary management unit. Since water collects and moves through the landscape via watersheds, the physical, chemical, and biological conditions of the water will be unique to each watershed. Therefore, planning and management would be most effective if they address the unique character and conditions of the watershed in question.

Watersheds, and watershed management areas, can be considered at a regional or very local level; where watersheds can be as small as a ¼ acre plot or as large as the Mississippi River Basin that covers millions of square miles. The Center for Watershed Protection classifies watersheds into five management units; these are catchment, sub-watershed, watershed, sub-basin, and basin and are listed in **Table 1-1**. The primary planning authority and suggested management focus for each of the five management units varies depending on the size of the watershed. According to this classification system the Lauramie Creek Watershed (approximately 23 square miles) would be considered a “Watershed” and is therefore best managed at the local or multi-local level.

Table 1-1: Watershed Management Units

Watershed Management Unit	Typical Area (Square miles)	Primary Planning Authority	Suggested Management Focus
Catchment	0.05-0.50	Local property owner	Best Management Practices (BMP)
Subwatershed	1-10	Local government	Stream Management & Classification
Watershed	10-100	Local or multi-local	Watershed-based Planning
Subbasin	100-1,000	Local, regional, and State	Basin Planning
Basin	1,000-10,000	State, multi-State, Federal	Basin Planning

(Schueler, 1995)

Watershed Planning

The Watershed Management Plan (WMP) is intended to benefit communities in the watershed by helping to improve the local economy, increase effectiveness of government, and preserve the environment through comprehensive water resource planning. Watershed planning can benefit the local economy by helping to protect drinking water supply, decrease losses related to floods, and increase property values by providing attractive and safe living and recreation areas. Good watershed planning can improve the effectiveness of government through more direct public involvement that earns the trust and support of the community and guarantees that all community interests are treated fairly. The planning effort also helps to ensure that current water quality in the community is preserved and that the community will not suffer significant financial losses due to loss of natural resource buffers and other natural resources.

The planning process is not without some complications as members of watershed communities can have competing desires for how water is used. For example, a large proportion of the Lauramie Creek watershed is agricultural with many farming interests. A farmer will view water quality issues differently than will others in the community. However, the interests of that farmer must be taken into consideration if the WMP is to be a benefit to the whole community. Likewise, the homeowner in Stockwell that uses a private well for water supply has an interest in clean drinking water that is not polluted from other watershed users. Further complication of the planning process is realized when there are several government jurisdictions with different sets of ordinances and rules for water use. Nonetheless, it is imperative that the planning process formulate a workable WMP that is sensitive to the values and desires of all members of the community and is developed with the input and support of a good cross-section of the community. Input from the farmer, home-owner, government administrator, elected official and others in the community will help to ensure that there is balance and equitable distribution of responsibility for and benefits of good water quality in the watershed.

Watershed planning is especially important to help prevent future water resource problems, preserve watershed functions, and ensure future economic, political, and environmental health. Everyone in a watershed is involved in watershed management; however, there are typically no water resource specific agreements on how water should be used and managed by all users in a community. However, a WMP is a start toward a better understanding of community values and watershed processes and can provide

guidance toward the betterment of watershed management and living conditions in the community.

Regulatory Context of Watershed Planning

Watershed management has been widely promoted by the Environmental Protection Agency (EPA) and other public and private organizations concerned with water quality. In fact, by developing WMPs, targeted areas become eligible for funding to implement a wide array of water quality related projects. Funding sources include, but are not limited to, the Indiana Department of Environmental Management (IDEM), the Environmental Protection Agency (EPA), the Indiana Department of Natural Resources (IDNR), and the United States Department of Agriculture (USDA).

Watershed planning can also be a response to regulatory interest in impaired water quality in the watershed. Section 303(d) of the Clean Water Act requires states to identify waters that do not, or are not expected to, meet federal water quality standards. States are also required to develop a priority ranking for these waters taking into account the severity of the pollution and state defined designated uses of the waters. For those waters identified as having impaired water quality, the states are required to develop Total Maximum Daily Loads (TMDLs) in order to achieve compliance with federal water quality standards and the Clean Water Act.

The IDEM has identified the entire reach of Lauramie Creek as being impaired for pathogens (*E. coli*). In addition, all tributary streams in the watershed including Hentz Ditch, JB Anderson Ditch, and McClellan Fickle Ditch are impaired for pathogens. An effective watershed plan will help to address the water quality impairments identified by the IDEM, and will help to demonstrate community involvement and commitment to addressing impaired water quality in the watershed.

Lauramie Creek Watershed Management Plan

A WMP is a guiding document that examines the historical and existing water resource issues in a particular watershed and presents specific actions to address those water resource issues based on the values and needs of the community. The intent of the WMP is to provide better living conditions, economic viability, and environmental health benefits for those that reside in the watershed and for communities downstream. Developers of the WMP are interested stakeholders that investigated prior and existing watershed conditions, identified watershed priority areas, and formulated strategies for implementing specific actions. The WMP document represents the earnest efforts of the community to understand, analyze, and be an integral part of the solution to improve impaired water quality in the watershed. Furthermore, active community involvement in the development of the WMP helps to ensure that there is commitment by the community to implement projects identified in the WMP.

There were four key reasons why the Lauramie Creek Watershed was identified as a priority watershed in Tippecanoe County.

- Lauramie Creek is listed on the IDEMs 303 (d) list of impaired waters due to the presence of *E.coli*.
- Lauramie Creek is a tributary to the South Fork of Wildcat Creek, which is listed as an Outstanding State Resource Water.
- According to a recent study by Purdue University, the Lauramie Creek Watershed had the highest potential pollution ranking of all watersheds within the larger Wildcat Creek Watershed.

- Lauramie Creek receives runoff from both the Town of Clarks Hill and Stockwell which have long histories of water quantity and quality problems.

The Lauramie Creek WMP presents the overall watershed analysis and inventory conducted by Christopher B. Burke Engineering, Ltd (CBBEL), the project Steering Committee, and the public, and offers recommendations for water quality improvement, preservation, and protection. This WMP meets the requirements of the IDEM 2003 "What Needs to be in a Watershed Management Plan" Checklist.

1.2 WATERSHED PARTNERSHIPS

In January of 2004, the Tippecanoe County Commissioners submitted a Clean Water Act Section 205(j) grant application to the IDEM in order to address water quality issues in the Lauramie Creek Watershed. The Federal Clean Water Act Section 205(j) program provides funding for various types of projects designed to determine the nature, extent, and causes of point and nonpoint source pollution problems and to develop plans to resolve these problems. The County's Section 205(j) grant application requested funding to develop a Watershed Management Plan for the Lauramie Creek Watershed. The application included the following action plan.

1) Hire a qualified consultant to coordinate the project
2) Develop a Steering Committee
3) Notify and solicit comments from the public
4) Collect data
5) Identify problems
6) Determine the cause of the problems
7) Develop potential solutions

In May of 2004, the County Commissioners were awarded a grant of $94,835. In June 2004, the County Commissioners selected CBBEL from Indianapolis to coordinate the 18 month watershed planning project. The Lauramie Creek Planning Process was led by a Steering Committee made of local stakeholders that acted as advisors to help guide the direction of the project, as informational resources and as decision makers that recommended projects and management strategies designed to improve water quality of the Lauramie Creek Watershed. Steering Committee Members are identified in **Table 1-2** below.

Table 1-2: Lauramie Creek Watershed Steering Committee

Name	Representing
Steve Murray	Tippecanoe County Surveyor
Ruth Shedd	Tippecanoe County Commissioner
Allen Orr	Farm Manager
Tom Osborne	Landowner/ Contractor
John Barton	Clarks Hill Town Board
Rae Schnapp	Land Owner/ Wabash River Keeper
James King	SWCD Board president
Krista Trout-Edwards	Tippecanoe Area Plan Commission
RJ Beck	Tippecanoe County Health Department
Steve Yeary	Clinton County Health Department
Jeff Phillips	Purdue Extension

The Lauramie Creek Watershed Steering Committee held monthly meetings from August 2004 through November 2005. Topics of discussion included the need for an education and outreach program, agricultural issues, septic system and wastewater issues, and land use planning issues.

1.3 PUBLIC PARTICIPATION

In addition to monthly Steering Committee Meetings, six quarterly Public Stakeholder Meetings were held to introduce the project to the public, to solicit their input on potential problems, and to assist with the prioritization of water quality problems. The first two meetings consisted of a PowerPoint Presentation introducing the project and summarizing water quality and natural resource data collected to date, and concluded with a question and answer session where Stakeholders could ask questions, state concerns, and make recommendations regarding the project.

The third Stakeholder Meeting utilized a slightly different format, in which stakeholders were divided into two groups, and asked to identify areas and issues that they believed to be potential threats to water quality and areas and issues that needed to be protected or enhanced.

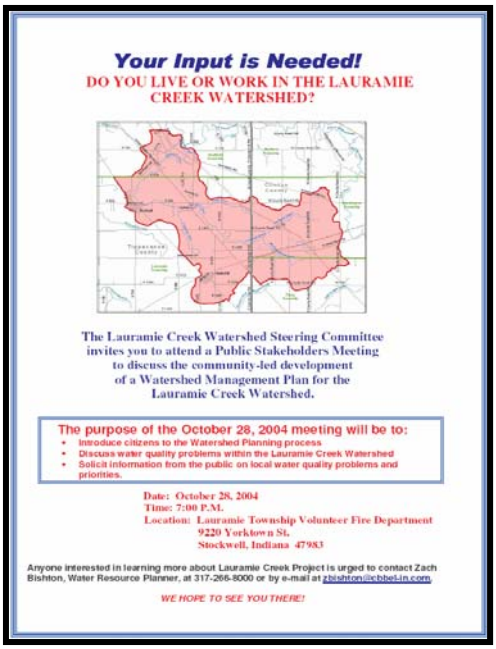
The fourth meeting focused on summarizing water quality information collected to date and provided attendees with an opportunity to gain hands on experience with water quality monitoring and habitat evaluation techniques. The first portion of this meeting was conducted in Wainwright Middle School, which is located in the watershed just to the east of US 52 on County Road 700 South in Tippecanoe County. The second portion of the meeting was conducted along a portion of Lauramie Creek a few blocks from Wainwright Middle School. During this portion of the meeting, stakeholders were shown how to collect chemical water quality samples using Hoosier Riverwatch Equipment, and RJ Beck of the Tippecanoe County Health Department discussed the value of monitoring for bacteria and demonstrated how the Health Department collects bacteria samples from surface waters across the County.

In addition, Don Emmert of the Tippecanoe County SWCD led a discussion on how to evaluate in stream habitat using the Citizens Qualitative Habitat Evaluation Index (CQHEI) and discussed how the macroinvertebrates or bugs in a stream can be used to evaluate the quality of a stream. Stakeholders then participated in the evaluation of instream habitat and assisted in the collection and identification of macroinvertebrates. Information on future Hoosier Riverwatch training events was distributed to all those in attendance.

All Stakeholder Meetings were advertised through press releases to Tippecanoe and Clinton County area media, and through direct mailings sent to all landowners along open creeks and ditches and hundreds of other residents in the watershed. **Figure 1-1** identifies examples of meeting notices that were sent to watershed stakeholders for each Stakeholder Meeting.

The Fifth Stakeholder Meeting was conducted in October of 2005 and consisted of a PowerPoint Presentation of the draft WMP, and provided citizens with an opportunity to raise questions or concerns about the recommendations in the plan. The sixth public meeting was conducted in November. This meeting was combined with a Steering Committee meeting and was a more informal meeting where attendees were encouraged to raise any final questions regarding the plan.

Figure 1-1
Stakeholder Meeting Mailing



Your Input is Needed!

DO YOU LIVE OR WORK IN THE LAURAMIE CREEK WATERSHED?

The Lauramie Creek Watershed Steering Committee invites you to attend a Public Stakeholders Meeting to discuss the community-led development of a Watershed Management Plan for the Lauramie Creek Watershed.

The purpose of the October 28, 2004 meeting will be to:

- Introduce citizens to the Watershed Planning process
- Discuss water quality problems within the Lauramie Creek Watershed
- Solicit information from the public on local water quality problems and priorities.

Date: October 28, 2004
Time: 7:00 P.M.
Location: Lauramie Township Volunteer Fire Department
9220 Yorktown St.
Stockwell, Indiana 47983

Anyone interested in learning more about Lauramie Creek Project is urged to contact Zach Bishton, Water Resource Planner, at 317-266-8000 or by e-mail at zbishton@cbbel-in.com.

WE HOPE TO SEE YOU THERE!

In addition to Steering Committee and Stakeholder Meetings, two surveys designed to assess local constituent knowledge of water quality and natural resource issues were developed. The first survey, entitled *Lauramie Creek Watershed Management Plan Public Opinion Survey*, consisted of natural resource and water quality questions and was sent to 180 randomly selected residents of the watershed and was distributed at the first Stakeholder Meeting. The survey was sent again to the same sample of watershed residents and was distributed a second time at the final Public Stakeholder Meeting. Results of the survey are discussed in **Section 2** of this report.

The second survey developed as a part of the project, entitled *Lauramie Creek Watershed Management Plan: Survey of Landowners along Open Ditches* was designed to solicit information about the condition of waterways in the Lauramie Creek Watershed through direct contact with landowners who own property that is intersected by Lauramie Creek, JB Anderson Ditch, Hentz Ditch or McClellan Fickle Ditch. Landowners in Tippecanoe County were identified through the County's GIS database and Clinton County landowners were identified via the 2004 Clinton County Plat Book. A copy of the surveys are included in **Appendix 1**.

1.4 WATERSHED LOCATION

The Lauramie Creek Watershed (HUC 05120107040120) is one of forty-four 14-digit HUC watersheds located in the larger Wildcat Creek Watershed. The Wildcat Creek Watershed is located in north central Indiana, and is identified in **Exhibit 1-1**. The Lauramie Creek Watershed is shown in **Exhibit 1-2.**

Lauramie Creek drains 15,091 acres of predominantly agricultural land in Tippecanoe and Clinton County, Indiana. There are approximately 20.6 miles of perennial streams and drainage ditches in the Lauramie Creek Watershed, all of which eventually drain to the South Fork of Wildcat Creek. Major streams in the Lauramie Creek Watershed are identified in **Exhibit 1-3**.

The Lauramie Creek Watershed sits in southeast Tippecanoe County and southwest Clinton County in west-central Indiana. The watershed is relatively flat and agricultural land uses dominate. Clinton County accounts for approximately 38% of the Lauramie Creek Watershed, and consists of predominately agricultural land uses with limited pockets of commercial and residential development.

Tippecanoe County accounts for approximately 62% of the Lauramie Creek Watershed. Agricultural land uses dominate in Tippecanoe County as well, but urban land uses are more common. The Towns of Clarks Hill (Population 680) and Stockwell (Population

400) are both located within the Tippecanoe County portion of the watershed. While forested land within the watershed is somewhat limited, the most northwest stream corridor of Lauramie Creek, between the Town of Stockwell and the confluence with the South Fork of Wildcat Creek is covered by a healthy forest buffer.

1.5 DESCRIPTION AND HISTORY

The Wisconsin Glacier formed the present landscape of the Lauramie Creek Watershed. When the glacier receded, it deposited glacial till consisting of sand, gravel, clay, and boulders. The soils found in the Lauramie Creek Watershed are the result of direct glacial deposits or materials carried by the streams of melting ice and snow and generally consist of a deep black loam three to four feet thick resting on a layer of clay.

Prior to settlement in the mid to early 1800s, much of the Lauramie Creek Watershed was covered in prairie, wetlands, and woods. The trees removed by the early settlers to make room for farming would have consisted of upland hardwood forest species characteristic of a Maple-Beech association. Plant associations or communities are broad generalizations of vegetation based on a geographic region. The upland areas of the Lauramie Creek Watershed would have been densely covered in sugar maple, basswood, beech, yellow birch, American elm, mulberry, buckeye, and red maple. Species such as silver maple, American elm, willow, basswood, sycamore, and ash would have been more abundant in the river corridors and low-lying marsh areas. According to the 1998 Gap Analysis Program (GAP) datum, currently only 5% of the Lauramie Creek Watershed is forested.

Land Use

The land use of the Lauramie Creek Watershed began to significantly change from dense woods and wetlands to agriculture following settlement of the Europeans in the mid to early 1800s. The upland areas were cleared and drained to facilitate better crop production. As shown in **Table 1-3**, agricultural land uses dominate the current landscape. In fact, 91% of the Lauramie Creek Watershed is currently in agricultural production. Row crops dominate the agricultural land use with approximately 13,283 acres in production.

Table 1-3: Lauramie Creek Watershed Land Use

Land Use Types	Acres	Percentage
Row Crops	13,282.87	88.32
Herbaceous/Shrubland	70.62	0.47
Deciduous Forest (mixed woodland & shrubland)	736.29	4.90
Pasture	411.73	2.75
Urban High and Low Density	461.34	3.07
Open Water	29.27	0.19
Commercial	45.01	0.30
Total	**15,037.03**	**100**

(USGS, 1997)

The waterways in the Lauramie Creek Watershed consist of small headwater streams or drainage ditches and only a small portion, 836 acres (5.5%), of the watershed is

classified as shrubland, deciduous forest, or open water. According to National Wetland Inventory (NWI) maps, as shown in **Exhibit 1-4** approximately 452 acres are classified as wetlands. However, it is important to note that NWI maps should be used only as references, and not as an indicator of whether or not wetlands exist on a given site.

As shown in **Exhibit 1-5**, very little (3%) of the Lauramie Creek Watershed has been developed for residential, commercial, or industrial use. Although individual residential developments are somewhat scattered through the watershed, the Towns of Clarks Hill and Stockwell are the primary urbanized areas. In all of 2003, the Tippecanoe Area Plan Commission issued only 14 building permits within their portion of the watershed.

Soils

The soils of the Lauramie Creek Watershed formed from Wisconsin glacial till, glacial outwash, and recently deposited alluvium. According to the Soil Surveys for Clinton and Tippecanoe County and shown in **Table 1-4**, there are six predominant soil associations in the Lauramie Creek Watershed. In the low-lying, floodplain areas Miami-Crosby-Richardville soils dominate, whereas in the upland areas, the Drummer-Toronto-Millbrook, Starks-Fincastle, and Ragsdale-Fincastle soils are more prevalent.

Table 1-4: Soil Associations

Soil Association	Characteristics
Starks-Fincastle	Nearly level, somewhat poorly drained soils that formed in silty material and in the underlying glacial till or glaciofluvial deposits; on till plains.
Miami-Crosby-Richardville	Gently sloping to strongly sloping, well drained and somewhat poorly drained soils that formed in silty material and in underlying glacial till or glaciofluvial deposits, on till plains and recessional moraines.
Drummer-Toronto-Millbrook	Nearly level, poorly drained and somewhat poorly drained soils that formed in silty materials and in the underlying glacial till or glaciofluvial deposits; on till plains.
Ouiatenon-Ceresco, gravelly substratum-Cohoctah, gravelly substratum-Hononegah	Nearly level, somewhat excessively drained, somewhat poorly drained, very poorly drained, and excessively drained soils that formed in alluvial deposits or outwash deposits; on flood plains and stream terraces.
Ragsdale-Fincastle	Nearly level, very poorly drained and somewhat poorly drained, silty soils; on till plains.
Drummer-Raub	Nearly level, poorly drained and somewhat poorly drained, silty soils on till plains.

(USDA, 1971 and 1979)

The NRCS has assigned a soil erodibility index to each soil type. This value is based on the soils chemical and physical properties, as well as climatic conditions. Highly erodible soils are discussed in detail in Section 3. Septic systems need well-drained soils to properly function. More than 90% of the soils in the Lauramie Creek Watershed have severe limitations for septic systems due to seasonal high water table and slow permeability.

Topography

As is the case for most of Tippecanoe and Clinton County, the topography of the Lauramie Creek Watershed is relatively flat. However, the watershed is somewhat rolling in the northwest portion near the confluence of Lauramie Creek and the South Fork of Wildcat Creek. The photograph shown in **Figure 1-2** was taken from the headwaters of Lauramie Creek and shows the flat terrain that characterizes much of the eastern portion of the Lauramie Creek Watershed.

Figure 1-2: Flat Agricultural Lands

Hydrology

There are approximately 20.6 miles of waterways in the Lauramie Creek Watershed. These waterways are comprised of natural streams and constructed drainage ditches. Exhibit 1-3 identifies Lauramie Creek, JB Anderson Ditch, Hentz Ditch, and McClellan Fickle Ditch as the four major waterways in the watershed. Lauramie Creek is a tributary to the South Fork of Wildcat Creek a State of Indiana Outstanding Water Resource.

Land Ownership

Land within the Lauramie Creek Watershed is privately owned. There are no significant holdings of land by the State, military, or local land trusts in the Lauramie Creek Watershed.

Cultural Resources

In Clinton County the Lauramie Creek Watershed sits in both Washington and Perry Townships and in Tippecanoe County the watershed sits in both Sheffield and Lauramie Townships. According to the 2000 Census, the population of Clinton County has increased by 9.3% from 30,974 to 34,148 since 1990. Of that county wide total, approximately 49% of the population lives in the Town of Frankfort, which is located approximately 7 miles to the east of the Lauramie Creek Watershed. Approximately 5.4% of the workforce in Clinton County continues to work in the agricultural industry, while the majority of the workforce has employment in manufacturing (30.6%), services (22.5%), or retail (14.6%). However, these industrial and manufacturing employers are very limited in the watershed.

Tippecanoe County has experienced a slightly increased rate of growth compared to Clinton County since 1990. According to the 2000 Census, the population has increased by 14.1% from 130,598 to 152,042 since 1990. Fifty-nine percent of the County population lives in Lafayette (61,229), and only 1% of the workforce in Tippecanoe County continues to work in the agricultural industry. The largest employers in Tippecanoe County are manufacturing (16.6%), retail (11.9%), or health care and social services (9.6%).

Endangered, Threatened, and Rare Species

As shown in **Table 1-5** and **1-6**, there are a number of endangered, threatened, or rare plants and animals that have been identified in Clinton and Tippecanoe County. A detailed study to verify if these plants and animals are located in the Lauramie Creek Watershed was not conducted.

Table 1-5: Endangered, Threatened, and Rare Species for Clinton County

Scientific Name	Common Name	State Listing	Federal Listing
Poa wolfii	Wolf Bluegrass	Rare	Not Listed
Veronica anagallis-aquatica	Brook-pimpernell	Threatened	Not Listed
Alasmidonta viridis	Slippershell Mussel	Warrants Concern	Not Listed
Ardea herodias	Great Blue Heron	Warrants Concern	Not Listed
Buteo lineatus	Red-shouldered Hawk	Special Concern	Not Listed
Nycticorax nycticorax	Black-crowned Night Heron	Endangered	Not Listed
Lutra Canadensis	Northern River Otter	Endangered	Not Listed
Lynx rufus	Bobcat	Endangered	Not Listed
Myotis sodalis	Indiana Bat	Endangered	Endangered
Taxidea taxus	American Badger	Endangered	Not Listed
Forest	Central Till Plain Flatwoods	Significant	Not Listed
Prairie – Mesic	Mesic Prairie	Significant	Not Listed

(IDNR, 1999)

Table 1-6: Endangered, Threatened, and Rare Species for Tippecanoe County

Scientific Name	Common Name	State Listing	Federal Listing
Cyprogenia Stegaria	Eastern Fanshell Pearlymussel	Endangered	Endangered
Epioblasma Torulosa Rangiana	Northern Riffleshell	Endangered	Endangered
Epioblasma Torulosa Torulosa	Tubercled Blossom	Endangered	Endangered
Epioblasma Triquerta	Snuffbox	Endangered	Not Listed
Fusconaia Subrotunda	Long-Solid	Endangered	Not Listed
Plethobasus Cicatricosus	White Wartyback	Endangered	Endangered
Plethobasus Chyphyus	Sheepnose	Endangered	Not Listed
Pleurobema Clava	Clubshell	Endangered	Endangered
Pleurobema Plenum	Rough Pigtoe	Endangered	Endangered
Pleurobema Pyramidatum	Pyramid Pigtoe	Endangered	Not Listed
Potamilus Capax	Fat Pocketbook	Endangered	Endangered
Quadrula Cylindrica Cyclindrica	Rabbitsfoot	Endangered	Not Listed

Scientific Name	Common Name	State Listing	Federal Listing
Paracloeodes Minutus	A Small Minnow mayfly	Rare	Not Listed
Lissobiops Serpentinus	A Rove beetle	Endangered	Not Listed
Merope Tuber	Earwig Scorpionfly	Endangered	Not Listed
Speyeria Idalia	Regal Fritillary	Endangered	Not Listed
Etheostoma Camurum	Bluebreast Darter	Endangered	Not Listed
Clemmys Guttata	Spotted Turtle	Endangered	Not Listed
Emydoidea Blandingii	Blanding's Turtle	Endangered	Not Listed
Aimophila Aestivalis	Bachman's Sparow.	Endangered	Not Listed
Asio Flammeus	Short-Eared Owl	Endangered	Not Listed
Bartramia Longicaudia	Upland Sandpiper	Endangered	Not Listed
Botaurus Lentiginosus	American Bittern	Endangered	Not Listed
Falco Peregrinus	Peregrine Falcon	Endangered	Endangered
Haliaeetus Leucocephalus	Bald Eagle	Endangered	Threatened
Ixobrychus Exilix	Least Bittern	Endangered	Not Listed
Lanius Ludovicianus	Loggerhead Shrike	Endangered	Not Listed
Nycticorax Nycticorax	Black Crowned Night Heron	Endangered	Not Listed
Rallus Elegans	King Rail	Endangered	Not Listed
Lynx Rufus	Bobcat	Endangered	Not Listed
Myotis Sodalis	Indiana Bat	Endangered	Endangered
Spermophilus Franklinit	Franklin's Ground Squirrel	Endangered	Not Listed
Taxidea Taxus	American Badger	Endangered	Not Listed

(IDNR, 1999)

In addition to the species listed here, there are 37 vascular plants located in Tippecanoe County that are listed as endangered, threatened, rare, or extirpated species. Of those, 12 are endangered, 11 are threatened, 10 are rare, and 4 are extirpated. **Appendix 2** shows the complete listing of endangered, threatened, and rare species as identified by the Indiana Natural Heritage List for both Clinton and Tippecanoe County.

2.0 IDENTIFY WATER QUALITY PROBLEMS & CAUSES

As part of the watershed planning process, an inventory and assessment of the watershed and existing water quality studies relevant to the watershed must be conducted. Examination of previous work may show that data already gathered is sufficient for determining the magnitude and extent of water quality conditions, or it may indicate that additional studies are needed to characterize the water quality problems. In either case, assessing water quality information that has already been completed is part of the initial process of building a WMP and will help to guide the identification of water quality problems and links to pollution sources in the watershed. The following section provides a summary of past and current assessments of the Lauramie Creek Watershed.

2.1 STAKEHOLDER CONCERNS

Individuals living and working in the Lauramie Creek Watershed have proven to have a wealth of knowledge as it relates to water quality, water quantity, and other natural resource issues within the watershed. Listed in **Table 2-1** are water quality issues of concern that were identified by members of the Lauramie Creek Steering Committee, residents, landowners, and other stakeholders in the Lauramie Creek Watershed throughout the planning process.

Table 2-1: Stakeholder Concerns in the Lauramie Creek Watershed

Need for Education
- Impacts of over application of fertilizers and pesticides
- Importance of proper septic system maintenance
- Benefits of implementing conservation practices on rural and agricultural lands
- Impacts of Illegal dumping & Household Hazardous Waste

Agriculture
- Tillage practices
- Nutrients & pesticides management
- Highly erodible soils
- Manure Runoff from pasture lands farm fields
- Livestock with waterway access
- Lack of riparian buffers

Human Waste Disposal
- Failing septic systems and straight pipe discharges
- Wastewater Treatment Plant overflows

Land Use Planning and Development
- Erosion from construction & development
- Impervious surfaces
- Inadequate drainage, flooding, and streambank erosion

Public Opinion Survey

Approximately 180 Public Opinion Surveys were distributed to stakeholders at the beginning of the planning process. A total of 31 surveys were returned. The goal of the survey was to gain an accurate understanding of how local stakeholders use and perceive Lauramie Creek and its tributaries. Eighty-one percent of respondents agree that Lauramie Creek is a valuable resource, while seventy-four percent of respondents agree that Lauramie Creek is polluted. The three leading contributors to pollution in the

Lauramie Creek Watershed according to respondents were agriculture, septic systems, and urban runoff. **Table 2-2** identifies complete results from the Public Opinion Survey.

Table 2-2: Public Opinion Survey

Question	Response
1. I live in (please select one)…	• Town of Stockwell (19%) • Town of Clarks Hill (29%) • Other (52%)
2. Lauramie Creek is a valuable resource to Tippecanoe County.	• Strongly Agree (39%) • Agree (42%) • Disagree (6%) • Strongly Disagree (0%) • Unsure (13%)
3. I use Lauramie Creek and its tributaries for... (check all that apply).	• Boating (0) • Fishing (3) • Swimming (2) • Drinking Water (2) • Watering Livestock (3) • Other (Drain fields, skipping stones, watering flowers, nature walks)
4. How often do you utilize Lauramie Creek or its tributaries for recreation?	• Multiple Times A Year (16%) • Once a Year (3%) • Once Every Few Years (3%) • Never (78%)
5. Lauramie Creek is polluted.	• Strongly Agree (29%) • Agree (45%) • Disagree (6%) • Strongly Disagree (0%) • Unsure (20%)
6. The largest contributor of pollution to Lauramie Creek and its tributaries is	• Agriculture (1st) • Flooding (4th) • Industry (5th) • Septic Systems (2nd) • Urban Runoff (3rd) • Other
7. The water quality of Lauramie Creek should be protected and enhanced.	• Strongly Agree (45%) • Agree (45%) • Disagree (0%) • Strongly Disagree (0%) • Unsure (10%)
8. Lauramie Creek is a tributary to the South Fork of Wildcat Creek.	• True (72%) • False (4%) • Unknown (24%)
9. I am interested in learning more about water quality in the Lauramie Creek Watershed.	• Strongly Agree (32%) • Agree (45%) • Disagree (7%)

Question	Response
	• Strongly Disagree (0%) • Unsure (16%)

2.2 WATER QUALITY BASELINE STUDIES

The following section provides a summary of baseline water quality conditions present in the Lauramie Creek Watershed.

Indiana 305(b) Report

The Indiana Department of Environmental Management (IDEM) is the primary agency 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, the IDEM operates several monitoring programs designed to monitor and assess the chemical, physical, and biological conditions of Indiana's rivers, streams, and lakes.

The IDEM's Office of Water Quality's surface water quality basin strategy is designed to describe the overall environmental quality of each major river basin in the state and to identify monitored water bodies that do not fully support designated uses. The IDEM's surface water monitoring was revised in 2001 to meet the goals of assessing all waters of the state within five years.

The 305(b) report is compiled by the IDEM at a frequency prescribed by the US EPA, but at least every four years. The report provides a compilation and summary of all of the IDEM's water quality monitoring and assessment data (compiled from AIMS database and other datasets/reports within the IDEM). All IDEM water quality data is evaluated by the IDEM's 305(b) Coordinator and interpreted for each 14-digit HUC subwatershed. Each subwatershed is given a water quality rating relative to its streams status in meeting Indiana's Water Quality Standards (WQS). WQS are set at levels necessary for protecting a waterway's designated use(s), such as swimmable, fishable, or drinkable. Each subwatershed is given a rating of fully, partially, or not supportive of its designated uses. **Table 2-3** below identifies Lauramie Creek's impairments as identified by the 2002 and 2004 305(b) reports.

Table 2-3: Lauramie Creek 2002 and 2004 305(b) Report

Watershed Name	HUC	Use Support	Cause (stressor) Rating
Lauramie Creek (2002 and 2004)	05120107040120	Fully Supporting- Aquatic Life Not Supporting- Full Contact Recreations	Moderately Impaired- Pathogens

2002 and 2004 303(d) List of Impaired Waters

Chapter 303(d) of the Clean Water Act requires states to identify waters that do not or are not expected to meet applicable water quality standards with technology based standards alone. States are also required to develop a priority ranking for these waters, taking into account the severity of the pollution and the designated use of the waters. Once this listing and ranking of waters is completed, States are required to develop Total

Maximum Daily Loads for these waters in order to achieve water quality standards. Lauramie Creek was listed on both the 2002 and 2004 303(d) List of Impaired Waters because of an E.coli impairment. Lauramie Creek received a priority ranking of 319.

IDEM TMDL Study for E.coli Bacteria in Lauramie Creek

During the spring of 2003, the IDEM collected water quality sampling throughout the Lauramie Creek Watershed in order to assess water quality in the watershed with respect to *E.coli* bacteria. The purpose of the study was to determine whether to remove Lauramie Creek from the 303(d) List of Impaired Waters, if the impairment was not found, or to develop the Total Maximum Daily Load (TMDL) to eliminate the impairment for *E. coli* if the impairment was confirmed. The result of the sampling confirmed that *E. coli* concentrations in Lauramie Creek and its tributaries were in violation of State Water Quality Standards.

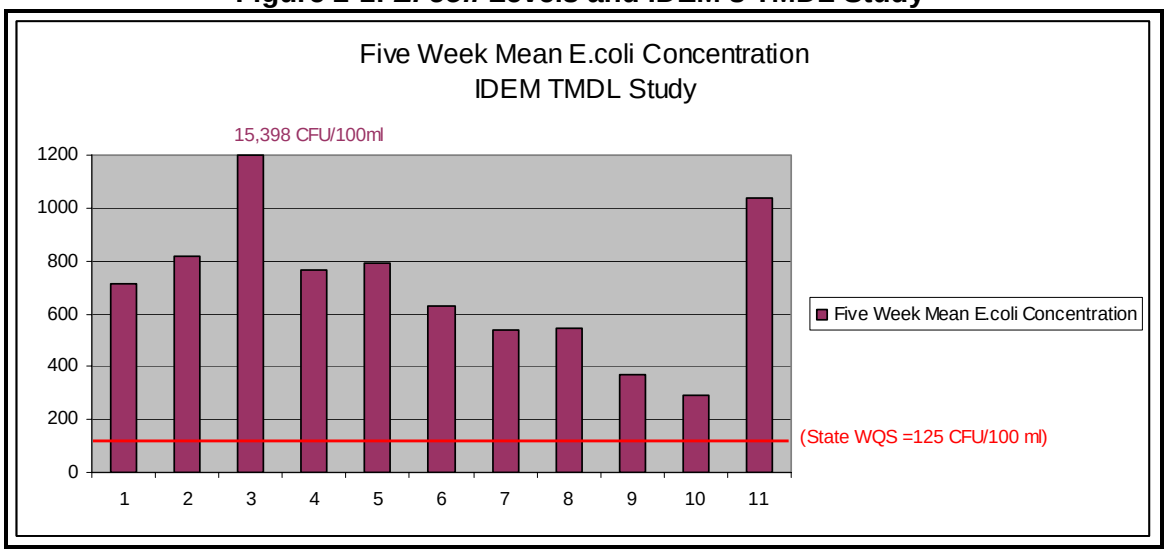
As recommended by the EPA, the water quality standard for full body contact recreation in Indiana is based on *E.coli* bacteria. Water quality monitoring results for *E. coli* are given in terms of the number of *E. coli* colony forming units (or CFU) in 100 mL of water. For water to meet the recreation standards, the geometric mean of 5 samples over a 30-day period is required to be less than 125 CFU/100 mL, with no single sample testing higher than 235 CFU/100 mL.

The IDEM TMDL study collected five water quality samples at eleven sites within the Lauramie Creek Watershed. State Water Quality Standards were violated at all eleven sampling locations. **Table 2-4** and **Figure 2-1** identify the 5-week geometric mean *E. coli* concentration for each of the eleven sites sampled as apart of this study. The exact locations of the sampling sites identified in the IDEM TMDL study are shown in **Exhibit 2-1**.

Table 2-4: IDEM TMDL Study Mean *E.coli* Concentrations

Site Number	Waterbody	Location	Mean *E. Coli* (CFU/100ML)
1	Lauramie Creek	CR 600 S	711
2	Lauramie Creek	CR 700 S	818
3	Unnamed Tributary	Ag. ditch north by northeast from Wainwright MS	15,398
4	Lauramie Creek	CR 800 S	764
5	Lauramie Creek	CR 900 S	790
6	Hentz Ditch	CR 900 S Upstream from Stockwell	626
7	Anderson Ditch	CR 1000 S	540
8	Lauramie Creek	CR 1000/1000 S	544
9	Lauramie Creek	Co Line RD	369
10	Lauramie Creek	CR 100 S (Clinton County)	291
11	Lauramie Creek	CR 800 W (Clinton County)	1,035

Figure 2-1: *E. coli* Levels and IDEM's TMDL Study



As indicated in the tables and figures above, the IDEM TMDL study confirmed that there is an *E.coli* impairment in the Lauramie Creek Watershed. All sites had mean *E.coli* concentrations at least twice the legal limit, and Site 3 had concentrations more than 123 times the legal limit.

The IDEM TMDL Study identified the following sources of *E. coli* in the watershed:

- County field tile drainage networks
- Rainfall events exceeding 1 inch
- Cattle grazing in or near creeks
- Land application of animal waste
- Inadequate/ improperly functioning septic systems.

In addition, the following best management practices (BMPs) were recommended in order to reduce the amount of *E. coli* entering surface waterbodies in the Lauramie Creek Watershed:

- Identification and repair of improperly functioning septic systems
- Installation of livestock barrier fences to reduces the number of cattle with direct access to creeks
- Limiting land application of manure to periods of dry weather
- Implementation of various BMPs available to landowners through the Natural Resource Conservation Service.

Fish Consumption Advisory (FCA)

Each year since 1972, three agencies have collaborated to create the Indiana Fish Consumption 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 2004 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. 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. There are no specific fish consumption advisory listings for the Lauramie Creek Watershed, but a statewide PCB advisory for carp in all Indiana streams, the Indiana portion of Lake Michigan, and inland lakes is in effect.

CBBEL Chemical Water Quality Monitoring

In an effort to establish baseline water quality conditions in the Watershed, CBBEL developed a chemical water quality monitoring program. Two water quality sampling events, one wet weather and one dry weather event were collected from seven sites in the Lauramie Creek Watershed between April and June 2005. Monitoring parameters were selected to characterize pollutants generally associated with non-point sources of pollution and included, dissolved oxygen, pH, specific conductance, total phosphorus, ammonia, turbidity, nitrate, and E. coli. **Table 2-5** and **Exhibit 2-2** identify water quality sampling sites within the Lauramie Creek Watershed.

Table 2-5: Narrative Description of Chemical Monitoring Sites

Site Identification Number	Waterbody name	Location
1	Lauramie Creek	County Line Road
2	JB Anderson Ditch	Headwall just north of SR 28
3	Hentz Ditch	County Road 900 South
4	Lauramie Creek	US Highway 52
5	Lauramie Creek	County Road 725 East
6	Lauramie Creek	County Road 800 South
7	Lauramie Creek	County Road 700 South

Oxygen Consuming Wastes

Since maintaining sufficient levels of dissolved oxygen in a waterbody is critical to the survival of most forms of aquatic life, evaluating oxygen consuming wastes in a river or stream is central to diagnosing the health of a river system. Pollutants associated with oxygen consuming wastes are typically composed of either decomposing organic matter or chemicals that bind with otherwise available in stream oxygen to reduce the available concentrations of dissolved oxygen in the water column. Organic causes of oxygen consuming wastes are measured as biological oxygen demand (BOD) and chemical causes of oxygen demand are known as chemical oxygen demand (COD). However, the concentration of dissolved oxygen available in water is typically used as an indicator of the general health of a stream.

Indiana WQS state that dissolved oxygen levels shall average at least five milligrams per liter per day and shall not be less than four milligrams at any time. Dissolved oxygen concentrations are affected by numerous factors. Physical conditions, such as lower temperatures generally result in higher concentrations of dissolved oxygen. Turbulent water action, associated with in stream riffles also result in increased dissolved oxygen concentrations, by injecting air into the water column.

Table 2-6 shows that dissolved oxygen concentrations in the Lauramie Creek Watershed dipped below the 5 mg/L level at three sampling sites during the June 2005 dry weather sampling event.

Table 2-6: Lauramie Creek Dissolved Oxygen Concentrations

Site Number	April	June
Site 1	7.99	**2.66**
Site 2	7.95	6.72
Site 3	8.62	**1.58**
Site 4	5.57	6.04
Site 5	7.75	7.22
Site 6	7.79	**4.94**
Site 7	8.16	6.48

With the exception of Site 4, dissolved oxygen concentrations were reduced at all sampling points within the watershed from April to June. Seasonal water temperature variations are partially responsible for these fluctuations, however the substantial drop in dissolved oxygen concentrations from April to June at Sites 1, and 3 are indicative of elevated levels of oxygen consuming wastes. The typical sources of pollution that contribute to low dissolved oxygen levels include inadequate treatment of wastewater from improperly functioning septic systems or wastewater treatment plants, manure runoff associated with land applications, and other sources of organic waste. It is likely that all of these sources are contributing to the low dissolved oxygen concentrations found in the Lauramie Creek Watershed. However, based on the limited nature of the water quality sampling conducted as a component of this grant program, the exact source of the dissolved oxygen impairment cannot be identified.

Table 2-7 identifies examples of dissolved oxygen concentrations in natural waterways and classifications associated with each range of concentrations. Dissolved oxygen concentrations below 3.0 mg/L are considered to be stressful to fish and levels below 2.0 mg/L will not typically support aquatic life.

Table 2-7: Dissolved Oxygen Concentrations and Waterway Classification

Dissolved Oxygen Concentration (mg/L)	Waterway Classification
5.4 to 14.8	Typical Range of healthy waterway
5.0 to 6.0	Optimal Range for Aquatic Growth
.1 to 5.0	Low Range in Natural Waterways

Overall dissolved oxygen levels in the Lauramie Creek Watershed were very typical of most waterways around the state, with 11 of 14 sample sites considered to be within the typical range of a healthy waterway.

Nutrients

The term nutrients primarily refers to the two major plant macronutrients, phosphorus, and nitrogen. These nutrients are common components of fertilizers, animal and human wastes, vegetation, and some industrial processes. Nutrients up to certain levels are both necessary and beneficial to water bodies. However, an overabundance of nutrients can stimulate the occurrence of algal blooms and excessive plant growth, which can

result in the reduction of dissolved oxygen concentrations in surface water through respiration and the decomposition of dead algae.

Total Phosphorus

Nonpoint discharges are the major sources of phosphorus in most watersheds. Phosphorus can be present as organic matter and can be either dissolved or suspended in the water column. Phosphorus may also occur in inorganic compounds released from various minerals, fertilizers, and detergents, which may also be either dissolved or suspended in the water column. Phosphorus is the primary nutrient associated with the production of algae and aquatic plants, as it is often a limiting nutrient in aquatic environments.

Elevated levels of phosphorus concentrations are a cause of pollution in the Lauramie Creek Watershed. In the absence of a specific surface water quality standard for phosphorus, results from water quality samples taken as a component of this project were compared to the results of a statistically based study of the Upper Wabash River Basin completed by the IDEM in 1998, entitled *1998 Watershed Monitoring Program Study of the Upper Wabash River Basin.* This study was a probabilistic monitoring study that consisted of a one time sampling of 64 randomly chosen sites designed to gain an understanding of ambient water quality during low flow conditions in the basin. The data from this study were statistically evaluated to create a classification metric based on quartile ranges. The quartile ranges were high, upper ambient, ambient, lower ambient, and low, and summary statistics were developed appropriate for establishing metrics for each eight digit HUC watersheds within the Upper Wabash Basin as well as for the Upper Wabash Basin as a whole.

In order to best evaluate phosphorus data collected within the Lauramie Creek Watershed, monitoring results were compared to summary statistics and classification metrics developed in the 1998 IDEM study. An evaluation of the phosphorus data collected during the 1998 IDEM study within the Wildcat Creek Watershed indicated that the mean concentration of phosphorus was 0.18 mg/L, while the median concentration within the larger Upper Wabash Basin was 0.13 mg/L.

In addition, concentrations of phosphorus exceeding 0.22 mg/L in the Wildcat Creek Watershed were considered to be significantly elevated, while phosphorus concentrations exceeding 0.18mg/L within the entire Upper Wabash Basin were considered to be significantly elevated or high. Concentrations of phosphorus in the Lauramie Creek Watershed exceeded the 'high' classification metric for phosphorus in the larger Upper Wabash Basin 36% of the time (5 of 14 samples), and exceeded the 'high' classification metric for phosphorus in the Wildcat Creek Watershed 29% of the time (4 of 14 samples). Site 2 in the Lauramie Creek Study was the only site to exceed both the Wildcat Creek and Upper Wabash high classification metric during both sampling events. Phosphorus concentrations were significantly elevated according to historical levels in the Wildcat Creek Watershed at Sites 2, 3, and 5. As shown in Exhibit 1-5 the primary upstream land uses associated with these sites are associated with agricultural activities. Therefore, it seems likely that the primary sources associated with the elevated phosphorus levels include runoff from fertilizer and manure application on agricultural lands as well as livestock with direct access to creeks and ditches. However, based on the limited nature of our sampling the exact source of these elevated phosphorus concentrations cannot be determined.

Ammonia

Point source discharges, such as wastewater treatment plants can be a significant source of ammonia in surface waters; however nonpoint discharges such as untreated effluent from septic systems, decaying organisms, and bacterial decomposition of organic waste from improper disposal of fertilizers in stormwater runoff can also contribute to the level of ammonia in a waterbody.

Ammonia is a significant source of pollution in the Lauramie Creek Watershed. 43% (6 of 14 samples) of samples collected in the Lauramie Creek Watershed exceeded the State's WQS for ammonia. Violations occurred at Site 1, 2, 3, 5, and 6. Site 2, which is located at the headwall of JB Anderson Ditch and directly down stream from the Town of Clark's Hills Waste Water Treatment Plant, was the only sampling site to violate the ammonia standard during both events. Site 5, which is located just downstream from the Lauramie Township Regional Sewer District's Treatment Plant also violated the standard during the April sampling event, and although the water quality standard was not violated during the June sampling event, the ammonia concentration of .174 mg/L was higher than the high classification metric established for samples collected in the Wildcat Creek Watershed of .14 mg/L and just below the high classification metric of .18 mg/L established for the Upper Wabash River Basin in IDEM's 1998 study.

Adjacent land uses to these sites are primarily made up of agricultural uses and potential sources of ammonia include wastewater treatment plants, land application of manure, failing septic systems, and the application of ammonia in the form of fertilizers.

Based on previous NPDES Permit violations it has been determined that the Clarks Hill Wastewater Treatment Plant is contributing to elevated ammonia concentrations identified at Site 2. However, the treatment plant has recently undergone changes designed specifically to reduce ammonia concentrations found in the plant's effluent. While these upgrades will be beneficial to water quality at Site 2, infiltrations problems and straight pipe connections to the Town of Clark's Hills storm sewer system are also considered to be impacting ammonia concentrations at Site 2.

In addition, the elevated concentrations of ammonia identified at Site 5 are associated with the Lauramie Township Regional Sewer District's Wastewater Treatment Plant, which has violated its ammonia permit requirements in the past. However, considering the numerous inadequate and failing septic systems that the treatment plant now provides sanitary sewer service to, the treatment plant is considered to be a benefit to water quality in the area. In order for the treatment plant to continue to be considered as a benefit, it will need to fulfill its NPDES permit requirements. The treatment plant is not the only suspected contributing source of ammonia at Site 5. There are livestock with direct access to streams and residential areas that are suspected of having inadequate septic system located within the drainage area of Site 5.

E.coli Bacteria

E.coli bacteria are associated with the intestinal track of warm blooded animals. Although not a pollutant in itself, *E.coli* is widely used as an indicator of sewage pollution, which may harbor additional waterborne disease causing bacteria, protozoa, and viruses.

E.coli is also used as an indicator because it is easier and less costly to monitor for and detect than the actual pathogenic organisms such as Giardia, Cryptosporidium, and

Shigella, which require special sampling protocols and sophisticated laboratory techniques in order to measure. The presence of waterborne disease causing organisms can cause outbreaks of diseases such as typhoid fever, dysentery, cholera, and chrypotsporidiosis.

Indiana WQS for *E.coli* have been established in order to ensure safe use of surface waters for recreation and drinking water. The State WQS for E.coli states that the 5-week geometric mean concentration shall not exceed 125 CFU/100ml and that a single grab sample shall not exceed 235 CFU/100ml.

E.coli can enter surface waterbodies from nonpoint source runoff from septic systems, straight pipe discharges from septic tanks, livestock, domestic pets, and wildlife. In addition, *E. coli* can also come from improperly treated discharges of domestic wastewater.

In addition to the *E. coli* data collected by IDEM in 2003, which identified E.coli impairments at eleven sites in the watershed, the water quality monitoring conducted as a component of this project identified *E.coli* violations throughout the watershed. All seven sampling sites exceeded the single grab sample WQS for *E.coli* of 235 CFU/100ml during at least one of the two events. The violations ranged from 278 CFU/100ml to 2,143 CFU/100ml. On a watershed scale the samples exceeded the State WQS 71% (10 of 14 samples) of the time. As shown in **Table 2-8**, Sites 2, 3, and 4 had the highest average E.coli concentrations.

Table 2-8: Lauramie Creek *E.coli* Concentrations

Site Number	April *E.coli* Concentration (CFU/100mL)	June *E.coli* Concentration(CFU/100mL)
Site 1	74	**560**
Site 2	**2143**	**1149**
Site 3	**278**	**1248**
Site 4	**331**	**1094**
Site 5	158	**466**
Site 6	216	**328**
Site 7	187	**269**

Concentrations shown in bold violated the WQS for E.coli.

Likely sources of *E.coli* in the Lauramie Creek Watershed are associated with inadequate septic systems, straight pipe discharges, as well as land application of manure, and cattle with direct access to creeks. Given the nature of our sampling it is not possible to pinpoint the largest contributing sources of *E.coli* bacteria at each site. However, certain sources are more likely to contribute to *E.coli* problems at a given site as compared with others. A discussion on the likely *E.coli* sources at each site is shown below.

Specific sources were especially hard to identify at Sites 1, 3, 6, and 7. Land uses surrounding Sites 1 and 3 are primarily agricultural in nature and therefore the likely sources associated with the elevated *E.coli* concentrations found at these sites are a result of land application of manure, cattle with direct access to creeks, straight pipe discharges, and wildlife waste. However, an obvious source of the elevated concentration of *E.coli* identified at these sites has not been identified.

Overall, Sites 6 and 7 had the lowest concentrations of *E.coli* in the Watershed according to the sampling conducted as a component of this grant. Both of these sites are located in well buffered stream reaches that are primarily surrounded by agricultural land uses. However, given the number of known septic systems in this area and given that the IDEM TMDL study identified elevated *E.coli* concentrations on an unnamed tributary to Lauramie Creek along County Road 700 South, just across from Wainwright Middle School in Tippecanoe County (This was considered to be Site 3 in the IDEM TMDL Study), inadequate septic systems and straight pipe discharges have been determined to be substantial contributors to *E.coli* problems at Sites 6 and 7.

Considering the elevated levels of *E.coli* found at Site 2 and the documented ammonia permit violations associated with the Clark's Hill Wastewater Treatment Plan, which discharges at Site 2, it is possible that the treatment plant is a contributor to the elevated *E.coli* concentrations found at Site 2. However, since *E.coli* was added to the treatment plant's monitoring requirements in May of 2005, no violations for *E.coli* have been identified. While stakeholders have suggested that the treatment plant may be failing during periods of wet weather, representatives from Clark's Hill are not aware of any such failures. Whatever the specific source of the elevated ammonia and *E.coli* concentrations identified at Site 2, illicit straight pipe connections from landowners within and adjacent to the Town of Clark's Hill and infiltration problems associated with the Town's storm and sanitary sewer systems seem to be a large part of the problem.

According to data from the IDEM, NPDES Permit violations for *E.coli* occurred during the months of March and April 2005 at the Lauramie Township Regional Sewer District's Wastewater Treatment Plant, which is located just upstream from Site 5. Again, considering the numerous inadequate and failing septic systems that the treatment plant now provides sanitary sewer service to, the treatment plant is considered to be a benefit to water quality in the area. However, in order for the treatment plant to continue to be considered as a benefit, it will need to fulfill its NPDES permit requirements. Other potential sources of *E.coli* associated with Site 5 include small livestock facilities located just upstream from the treatment plant and adjacent residential areas that are suspected of having inadequate septic systems.

Finally, it seems likely that the elevated E.coli concentrations identified at Site 4 are primarily associated with the failing and inadequate septic systems and straight pipe discharges suspected to be occurring in and around the Town of Monroe.

Citizens Qualitative Habitat Evaluation Index

In addition to conducting chemical monitoring, habitat evaluations were also conducted at all seven sites using the Citizens Qualitative Habitat Evaluation Index (CQHEI). This Index was developed buy the Ohio Environmental Protection Agency as a citizen's companion to the Qualitative Habitat Evaluation Index, which is used by the states professional staff. The purpose of the index is to provide a measure of the stream habitat and riparian health which correspond to the physical factors affecting fish and other aquatic life. The CQHEI allows changes at a site over time to be compared and analyzed and allows two sites to be compared by utilizing a consistent evaluation protocol. In general, CQHEI scores greater than 60 have been found to be "generally conducive to supporting aquatic life." However, scores for very poor, poor, medium, and excellent have not been developed for the CQHEI. The maximum possible score is 114.

Overall habitat scores in the watershed ranged from as low as 39 to as high as 86 out of a possible 114. **Table 2-9** identifies the CQHEI evaluation score for each site during the April and June sampling events as well as an average score and priority ranking for each Site.

Table 2-9: Priority Habitat Ranking

Site #	April CQHEI Score	June CQHEI Score	Average CQHEI Score	QHEI Priority Ranking
1	71	64.5	68	6
2	38	40	39	7
3	75.5	73	74.25	3
4	65	72	68.5	5
5	71	76	73.5	4
6	86	79	82.5	1
7	74	82	78	2

(7=Greatest Priority and 1=Lowest Priority)

Generally speaking, when a site scored higher during April evaluations than it did during June, the change in scoring was typically associated with increased stream shading and less evidence of erosion as a result of increased tree and shrub foliage. On the other hand, where sites scored higher during April evaluations than during June evaluations, the change was typically associated with the increased stream flows present during the April sampling event, which resulted in a greater depth and an increase in the diversity of flow patterns present at a given site.

Water Quality Prioritization

In an effort to prioritize sampling sites based on data collected throughout the watershed, a water quality matrix was developed to rank the overall aquatic ecology present at each site. In **Table 2-10** the average concentration of each parameter discussed above and its corresponding ranking are compared for each site and overall priority rankings are identified.

Table 2-10: Comprehensive Water Quality Ranking

Site #	Dissolved Oxygen (mg/L)		Ammonia (mg/L)		Phosphorus (mg/L)		Nitrate (mg/L)		E.coli (CFU/100ml)		Habitat (mg/L)		Ranking	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Total	Rank
1	5.33	**6**	0.25	**7**	0.12	**1**	3.34	**4**	317	**4**	68	**6**	28	**6**
2	7.34	**2**	0.20	**6**	0.37	**7**	4.23	**7**	1646	**7**	39	**7**	36	**7**
3	5.10	**7**	0.14	**4**	0.14	**3**	3.95	**6**	763	**6**	74	**3**	29	**5**
4	5.80	**5**	0.12	**2**	0.12	**2**	3.43	**5**	713	**5**	69	**5**	24	**4**
5	7.49	**1**	0.18	**5**	0.17	**6**	2.25	**3**	312	**3**	74	**4**	22	**3**
6	6.37	**4**	0.13	**3**	0.15	**5**	1.88	**2**	272	**2**	83	**1**	17	**2**
7	7.32	**2**	0.10	**1**	0.14	**4**	1.86	**1**	228	**1**	78	**2**	11	**1**

(7 = Greatest Priority and 1 = Lowest Priority)

Based on the information shown in Table 2-10, it is clear that Site 2, which is located just downstream of the J.B. Anderson Ditch Headwall, has the lowest water quality. Site 2 had the highest concentrations of *E.coli*, ammonia, total phosphorus, and nitrate, and scored lowest on the CQHEI. Generally, sampling results indicate that water quality was poorest on JB Anderson Ditch at Site 2, Lauramie Creek at Site 1, and on Hentz Ditch at Site 3.

However, sampling results also indicate that water quality along the main stem of Lauramie Creek tends to improve as it flows down stream. Sites 4 has a lower ranking than Site 1, Site 5 has a lower ranking than Site 4, Site 6 has a lower ranking than Site 5, and Site 7 has a lower ranking than Site 6.

Hoosier Riverwatch Data

The Hoosier Riverwatch is a volunteer-based program sponsored by the Indiana Department of Natural Resources (IDNR), Division of Soil Conservation, and Purdue University. Hoosier Riverwatch trains volunteers to collect chemical, biological, and physical water quality data in local waterways. The data that is collected is distributed to anyone that is interested via the internet at http://www.hoosierriverwatch.com.

In addition to the two water quality sampling events conducted at seven sites in the watershed. A summer intern with the Tippecanoe County SWCD collected samples from three sites in the watershed, using Hoosier Riverwatch equipment and protocols. The intern was a trained Hoosier Riverwatch volunteer and all data collected within the watershed is posted on line at www.hoosierriverwatch.com. As required by the grant, a total of four water quality samples were collected from three sites in the watershed. Samples were collected from Lauramie Creek at County Line Road and County Road 800 South and County Road 900 South in Tippecanoe County. Each site was evaluated for dissolved oxygen, pH, phosphorus, nitrates, and turbidity. Generally speaking dissolved oxygen values ranged from 6 – 12mg/L, pH levels ranged from 8 – 9, orthophosphate levels ranged from 0 -1mg/L, nitrate levels ranged from 2.2 - 4.4mg/L, and turbidity levels ranged from 15 -23mg/L. The pollutant concentrations for all studied parameters seem to be typical for agricultural watersheds in Indiana. All water quality data collected as a part of this project is included in **Appendix 3.**

2.3 BASELINE WATER QUALITY: CONCERNS, CAUSES, AND PROBLEMS

Linking stakeholder concerns with known and discovered water quality issues in the watershed helps to validate initial observations and provides evidence to dismiss others. Thus, a review of historic water quality studies can help to guide the planning process toward management actions that are most appropriate and efficient for improving water quality conditions. The following descriptions, detail water quality baseline conditions that have been established by prior studies as they relate to stakeholder concerns. These descriptions are organized by listed stakeholder concerns as shown in Section 2.1, and provide the foundation for the watershed management strategies identified in this WMP.

Need for Education

The Water Quality Studies listed above indicate that there are indeed water quality problems within the Lauramie Creek Watershed. Those problems are primarily associated with elevated levels of nutrients and pathogens, both of which can be directly

impacted by human behaviors and awareness. Steering Committee Members and stakeholders indicated early on in the planning process that there is a need to educate citizens on the impacts that their day-to-day activities can have on water quality. The results of existing studies indicate that increased education and outreach efforts will have a positive effect on water quality in the Lauramie Creek Watershed.

Agricultural Lands

The studies listed above indicate that water quality in the Lauramie Creek Watershed is being impacted by agricultural activities occurring within the watershed. Pathogen impairments are likely related to land application of manure, manure storage, and livestock with access to waterways. In addition, the elevated levels of nutrients indicate that fertilizer and manure applications are likely impacting water quality. Prior studies support the concerns of the Steering Committee regarding nutrient and pesticide runoff impacts to water quality from agricultural sources.

Human Waste Disposal

Study after study has indicated that *E.coli* is a major water quality problem in the Lauramie Creek Watershed. The Indiana State Department of Health (ISDH) estimates that approximately 20% – 30% of all septic systems in Indiana are currently failing. In the Lauramie Creek Watershed, problems associated with bacteria and failing septic systems in and around the Town of Stockwell led to the development of the Lauramie Township Regional Sewer District. In addition, some Stakeholders raised concerns regarding wet weather failures of the Clarks Hill Wastewater Treatment Plant. Prior studies and ongoing local projects support the concerns of the Steering Committee regarding the impacts that failing and improperly functioning wastewater treatment systems have on water quality.

Land Use Planning and Development

New development has the potential to increase runoff volumes and peak discharge flows in a watershed through the creation of impervious surfaces and the installation of stormwater collection systems. Additionally, new development can increase the amount of soil that is delivered to a waterway through ground disturbing activities. While water quality data researched and collected for the Lauramie Creek Watershed did not indicate that current development is impacting water quality in the watershed, if new development is not required to install measures that are designed to limit soil erosion and control runoff increases, then conditions in the waterways will likely deteriorate.

3.0 IDENTIFYING POLLUTANT SOURCES

A number of substances including oxygen demanding wastes, nutrients, bacteria, metals, and toxic substances, cause water pollution. Sources of these pollutants are divided into two broad categories: point sources and non-point sources. Prior sections of the WMP have identified stakeholder concerns, presented historic evidence of impairment, and discussed whether that evidence supports or negates those stakeholder concerns. This section attempts to present, in detail, possible sources of pollution to the waterways that have been identified as issues or concerns. Where possible, the magnitude and extent of pollutant sources are supported by pollutant loading estimates.

3.1 POINT SOURCES OF POLLUTION

Point source 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, town, or 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 systems (MS4s) operated by municipalities and counties.

The primary pollutants associated with point source discharges are oxygen demanding wastes, nutrients, sediment, toxic substances, 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, which is delegated to Indiana by the EPA.

As shown in **Table 3-1**, there are four active permitted NPDES facilities within the Lauramie Creek Watershed. **Exhibit 3-1** illustrates where in the Lauramie Creek Watershed the NPDES permitted facilities are located.

Table 3-1: NPDES Facilities in the Lauramie Creek Watershed

Permit Number	Facility Name	City	County	Receiving Stream
ING080153	Amoco	Frankfort	Clinton	Tributary/ Lauramie Creek
IN0039853	Clarks Hill Municipal	Clarks Hill	Tippecanoe	JB Anderson Ditch /Lauramie Creek
IN0061964	Lauramie Township Regional Sewer District	Stockwell	Tippecanoe	Lauramie Creek
IN0055697	Wainwright Middle School	Stockwell	Tippecanoe	Tributary/ Lauramie Creek

According to NPDES compliance information obtained from IDEM, permit violations have occurred at the Clarks Hill Municipal Wastewater Treatment Plant, the Lauramie Township Regional Sewer District, and Wainwright Middle School. In order to minimize the water quality impact that these facilities have on water quality in the Lauramie Creek

Watershed, it is important that these facilities fulfill their NPDES permit requirements and operate as designed.

3.2 NONPOINT SOURCES OF POLLUTION

Non-point source (NPS) pollution refers to runoff that enters surface waters by stormwater runoff, contaminated ground water, snowmelt, or atmospheric deposition. There are many types of land use activities that can serve as sources of non-point source pollution due to the presence of impervious surfaces, including land development, construction, mining operations, crop production, animal feeding lots, agricultural drainage tiles, timber harvesting, failing septic systems, landfills, roads and paved areas, and wildlife. These sources may contribute a single pollutant or a combination of pollutants such as, *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.

3.2.1 NONPOINT SOURCES FROM AGRICULTURAL LANDS

The National Water Quality Inventory (NWQI), sponsored by the EPA, reports that agricultural nonpoint source pollution is the leading source of water quality impacts to surveyed rivers and lakes, the third largest source of impairments to surveyed estuaries, and a major contributor to ground water contamination and wetlands degradation.

NPS pollutants that result from agricultural activities are nutrients, pesticides, pathogens, and sediment. Nutrients, pesticides, pathogens, and sediment can migrate from agricultural lands to surface and ground waters through processes including surface runoff, erosion, and infiltration. It is important to note that these pollutants are not specific to agriculture and can originate from residential and urban lands as well. **Table 3-2** identifies common agricultural nonpoint source pollutants and their associated sources.

Table 3-2: NPS Pollution and Agriculture

Pollutants	Agriculture Sources
Nutrients	Commercial Fertilizers and Manure
Toxic Chemicals	Herbicides, Insecticides, Fungicides
Sediment	Tillage, sheet, rill, gully and stream bank erosion
Pathogens	Manure runoff from fields, pastures, and feedlots

There are a number of activities associated with agriculture that can serve as potential sources of water pollution.

1) Land clearing and tilling make soils susceptible to erosion, which can then cause stream sedimentation,
2) Pesticides and fertilizers (including synthetic fertilizers and animal wastes) can be washed from fields or improperly designed storage or disposal sites, and
3) Construction of drainage ditches on poorly drained soils enhances the movement of oxygen consuming wastes, sediment and soluble nutrients into groundwater and surface waters.

Agriculture is the predominant land use in the Lauramie Creek Watershed. According to the 2002 Indiana Agricultural Census, approximately 94% or 244,590 acres of land in Clinton County are used for crop and livestock production, and approximately 69% or 220,779 acres of land in Tippecanoe County are used for crop and livestock production. Although only a very limited amount of Clinton and Tippecanoe County's agricultural land is located within the Lauramie Creek Watershed, approximately 91% (13,694 acres) of the Lauramie Creek Watershed is in agricultural production.

Like most of Indiana, corn and soybeans dominate the crops grown in both Clinton and Tippecanoe County. In 2003, Clinton County producers planted 108,000 acres of corn, 99,600 acres of soybeans, 2,900 acres of wheat, and 1,500 acres of alfalfa. The County ranks 5th in the State for corn production and 10th in the State for soybean production. In 2003, Tippecanoe County producers planted 100,000 acres of corn, 91,500 acres of soybeans, 4,400 acres of wheat, and 4,900 acres of alfalfa. The County ranks 13th in the State for corn production and 19th in the State for soybean production.

Nutrients

Nutrients such as phosphorus (P) and nitrogen (N) in the form of commercial fertilizers, manure, sludge, 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. Fish and aquatic insects need the oxygen that is dissolved in water to live, and when decaying algae uses up that oxygen, fish kills can result.

The Office of Indiana State Chemist annually publishes the total tonnages of commercial fertilizers sold in each Indiana County. The list includes single nutrient fertilizers, multi-nutrient fertilizers, as well as, organic and micronutrient fertilizers. **Table 3-3** estimates the annual nutrient application in the watershed. Total county wide application rates for both Clinton and Tippecanoe County were multiplied by the percent of each County's land area in the Lauramie Creek Watershed to estimate watershed wide application.

Table 3-3: Estimate of Nutrient Applications

County	% of county in the watershed	x	Total Nutrients (tons)		X 2,000 lbs/ton	Nutrients in watershed (lbs)	
			N	P2O5		N	P2O5
Clinton	.022	x	6,463	1,819	X 2000	284,372	80,036
Tippecanoe	.029	x	6,802	1,956	X 2000	394,156	113,448
Totals						**678,528**	**193,484**

(Purdue University, 2000)

The table shown above describes an estimate of the amount of fertilizer applied in the Lauramie Creek Watershed and is not an estimate of loading to waterways. It is expected that only a portion of the applied fertilizer nutrients would be mobilized to local waterways. Estimated nutrient loadings in the watershed are identified if **Section 4.3.**

Pesticides

Pesticides include a broad array of chemicals used to control plant growth (herbicides), insects (insecticides), and fungi (fungicides). 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, contaminate food and drinking water 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 Indiana State Chemist does not track pesticide sales within Indiana counties. In order to determine how much pesticide is being applied within the Lauramie Creek Watershed, a rough estimation was calculated using Purdue University's Guide for Watershed Partnerships, as shown in **Table 3-4.**

Table 3-4: Estimate of Pounds of Pesticides Applied

Crop	Crop Acres	X	Pesticide	1998 Fraction of Acres Treated in Indiana	X	1998 Average Rate of Application	=	Estimated Pounds of Pesticides Applied
Corn	6,641	X	Atrazine	.89	X	1.36	=	8038.27
			Metolachlor	.42		2.04		5690.00
			Acetochlor	.32		1.97		4186.48
			Primisulfuron	.14		0.03		27.89
			Cyanazine	.13		1.43		1234.56
Soy-bean	6,641		Glyphosate	.55		.85		3104.66
			Chlorimuronethyl	.27		0.02		35.86
			2,4-D	.26		0.39		673.4
			Imazethapyr	.25		0.04		66.41
			Paraquat	.19		0.89		1122.99
Total								16,150.63

(NASS, 2004) *Data from National Center for Food & Agriculture Policy, 1997.

The table shown above describes an estimate of the amount of pesticides applied in the Lauramie Creek Watershed and is not an estimate of loading to waterways. It is expected that only a portion of the applied pesticides would be mobilized to local waterways. Runoff from agricultural fields is the primary source of pesticides to waterways in the Lauramie Creek Watershed.

Further water quality monitoring focusing on pesticide concentrations would be required in order to gain a better understanding of the impacts that pesticides are having on water quality in the Lauramie Creek Watershed.

Erosion and Sedimentation

Erosion and sedimentation occur 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.

Furthermore, pollutants such as phosphorus, pathogens, and heavy metals move through the landscape attached to microscopic soil and organic particles; these same microscopic particles are easily transported in overland flow and are stored in and carried by streams throughout the watershed.

Areas with highly erodible soils, if not managed properly, can erode at an accelerated rate and may lead to excessive soil deposition in waterways. HELs are determined based on slope and other erodibility factors and if not managed properly can erode at a rate higher than the tolerable rate. According to the USDA, the soil of an entire crop field is considered erodible if at least one-third of the field has highly erodible soils. Livestock with access to a creek can accelerate soil erosion of the stream bank by walking up and down the bank.

Erosion from highly erodible lands has been identified as a primary concern, as land disturbing activities occurring on these lands such as livestock grazing, crop tillage, or clearing and grading associated with new development are likely to increase sediment loadings to nearby waterbodies. HELs in the Tippecanoe Lauramie Creek Watershed are illustrated in **Exhibit 3-2**.

Tillage Practices

According to the 2004 Cropland Tillage Data from Indiana DNR, 6% of corn and 76% of soybeans acreage in Clinton County and 19% of corn and 76% of soybeans in Tippecanoe County was in no-till or mulch till. No till refers to any direct seeding system including strip preparation, with minimal soil disturbance. Mulch till refers to any tillage system leaving greater than 30% crop residue cover after planting, excluding no-till. No-till and mulch till are often grouped together into conservation tillage.

The low no-till corn numbers can be attributed to the fact that many of the soils within this area are not conducive to no-till farming due to their hydric conditions. Hydric soils covered by crop residue delays the drying time of soils potentially creating an unsuitable seedbed for spring planting. **Table 3-5** shows an estimation of the percentage of crop acres in no-till, mulch-till, reduced-till, and conventional tillage practices.

Table 3-5: Percent of Crop Acres in Conservation Tillage

County	Crop	% No Till (2004)	% Mulch-Till	% Reduced-Till	%Conventional Till	State Rank
Clinton	Corn	4%	2%	18%	76%	83 of 92
	Soybeans	63%	13%	18%	6%	50 of 92
Tippecanoe	Corn	12%	7%	20%	60%	60 of 92
	Soybeans	64%	11%	13%	12%	46 of 92

An increase in conservation tillage practices in the Lauramie Creek Watershed will likely reduce the loading of fine clay particulates and surface erosion materials that are delivered to adjacent waterways. Load reductions associated with increased conservation tillage practices are identified in **Section 4.3**.

Bacteria and Pathogens

Manure, whether applied for crop nutrition or simply the by-product of grazing is a water quality concern in the Lauramie Creek Watershed. The nitrogen and phosphorus that make manure so productive on farm fields can create an over-fertilized "soup" when they run off into waterways, leading to undesirable algae blooms.

Figure 3-1: Pasture Lands

However, land application of manure is not the only potential source of bacteria to waterways associated with agricultural lands. Livestock and pasture lands are also significant contributors. Clinton County ranks 2nd in the State for hog production with approximately 182,700 head of hog and 88th in the State for cattle production with approximately 1,900 head of cattle. Tippecanoe County ranks 36th in the State for hog production with approximately 77,500 head, 61st in the State for cattle production with approximately 5,500 head, and 7th in the State for sheep production with approximately 16,730 head.

A Confined Feeding Operation (CFO) is a livestock operation that has in excess of 600 hogs, 300 cattle, or 600 sheep. These facilities are required, by IAC 16-2-5, to obtain a permit from IDEM's Office of Land Quality. According to IDEM's records, there are three Combined Feeding Operations (CFOs) located in the Lauramie Creek Watershed. These facilities are identified in **Exhibit 3-1**. It is important to note that based on evaluation of IDEM records there have been no enforcement actions taken on these CFOs, and they are believed to be in compliance with all their permit requirements. It is important to identify that these facilities exist in the Lauramie Creek Watershed, but that identification is not intended to indicate that these facilities are negatively impacting water quality.

In addition to these regulated facilities there are numerous small (hobby) farms in the Lauramie Creek Watershed with small numbers of horse, sheep, and/or poultry. Pasture management can be an effective management measure to reduce any water quality impacts that livestock operations have on water quality. Pasture management leads to

better weed control, better soil structure, increased productivity over longer periods of time, and healthier animals. It also helps the soil absorb excess water, manure, nutrients and other pollutants and ultimately protects water quality by reducing the amount and improving the quality of runoff.

Pastures can be grazed intensively during peak periods of growth, but they need regular attention. Rest periods are critical to proper pasture growth. A grazing rotation that allows 21 to 28 days of regrowth between grazing periods is usually best. Pasturing too many animals on a given parcel of land or allowing them to graze for too long in the same area reduces plant vigor and compacts soils, reducing absorption capacity and pasture recovery. Overgrazing can lead to additional runoff and a poorer quality of runoff.

Figure 3-2: Livestock Impacts

Relative to other similar watersheds, there seems to be relatively few livestock operations within the Lauramie Creek Watershed. However, as shown in **Figures 3-1** and **3-2** these facilities can impact water quality. Again based on the relative extent of our sampling it is not possible to pinpoint the extent to which specific sources are the leading contributors to water quality degradation in the watershed.

Unbuffered Stream Reaches

Conservation buffers are vegetated corridors along natural waterways and drainage ditches. Such buffers are an integral part of the form and function of a healthy waterway system. Although the appearance of conservation buffers differs between natural streams and drainage ditches, the functions remain the same - to improve water quality by filtering and trapping sediments and pollutants carried by stormwater, to store large quantities of stormwater and gradually release it to receiving waterways, and to create important aquatic and terrestrial habitats.

Figure 3-3: Inadequate Filter Strip

Conservation buffers along natural streams usually consist of a natural and dense network of grasses, shrubs, and trees. Whereas buffers along drainage ditches usually consist of swaths of mowed cool season grasses, regularly maintained to prevent the development of woody plants. Funds are available through the Conservation Reserve Program (CRP) and the Environmental Quality Incentives Program (EQIP) to assist with the implementation of a conservation buffer initiative. These programs function as cost share programs and are accessible through the Clinton County and Tippecanoe County SWCD offices.

In an effort to determine natural streams and drainage ditches that lacked sufficient conservation buffers, a windshield survey of the waterways was conducted and 2004

aerial photography was reviewed. Of the 20.6 miles of waterways in the Lauramie Creek Watershed, 9.2 miles of waterways lacked sufficient conservation buffers. Priority areas for buffer or filter strip creation are identified in **Exhibit 3-3**. Priority areas should be field verified, prior to implementation. **Figure 3-3** identifies a stretch of Lauramie Creek, which is not protected by an adequate filter strip.

3.2.2 NONPOINT SOURCES FROM URBANIZATION

A change in land use, especially from field or forest to urban development, has a significant impact on water quality. Not only is the permeability of the soil affected by construction compaction and impervious coverage such as rooftops, driveways, and parking areas, but there is an increase of biological and chemical waste from human use. The sources of water quality pollution from urbanization focus on three main topics: human & animal waste, household & yard waste, and development practices.

Failing Septic Systems

Septic systems can be a safe and effective method for treating wastewater if they are sized, sited, and maintained properly. However, in Clinton County, 96% of the soils have severe limitations for conventional septic systems, and 95% of soils in the Tippecanoe County portion of the Lauramie Creek Watershed are unsuitable for conventional septic systems.

In rural areas such as the Lauramie Creek Watershed, septic systems are often the primary source of wastewater treatment. However, often times homeowners are unaware of how septic systems function, where their system is located, or how they should maintain their system. In addition, sometimes septic systems are tied directly into local drainage tiles or ditches. While this connection may have been intentional at one time, often times current home owners or tenants are unaware that their wastewater is tied directly into nearby drainage structures. Some of the potential water quality problems associated with malfunctioning and illegally connected septic systems include elevated concentrations of bacteria, nutrients, toxic substances, and oxygen consuming wastes. **Exhibit 3-4** identifies the known septic systems within the Tippecanoe County portion of the Watershed as provided by the Tippecanoe County Health Department.

Figure 3-4: Lauramie Township Regional Sewer District

Within the Lauramie Creek Watershed the Towns of Clarks Hill, Stockwell, and Monroe all have a history of failing septic systems. In particular the problems associated with Stockwell were the driving force behind the development of the Lauramie Township Regional Sewer District. The Lauramie Township Regional Sewer District's Wastewater Treatment Plant was completed in 2004. The plant provides sewer service to approximately 185 homes in and around the Town of Stockwell, as well as Cole Elementary School. The $2.9 million plant was funded through a grant from the United States Department of Agriculture (USDA) and a loan from the Supplemental Wastewater Assistance Fund. **Figure 3-4** shows an advertisement of the project located in the Town of Stockwell. The plant is currently functioning at approximately 30% of its designed capacity.

During the planning process for the Lauramie Creek Watershed Management Plan, stakeholders made many comments regarding instances of failing septic systems or straight pipe discharges, and discussions with staff from the Clinton County and Tippecanoe County Health Departments affirmed that improperly functioning septic systems are a significant source of water quality problems in the Lauramie Creek Watershed. **Exhibit 3-5** identifies the approximate Sewer Service Area for the Towns of Stockwell and Clarks Hill.

Wildlife and Pet Waste

Wildlife and pet wastes can contribute significantly to the concentrations of bacteria and organic matter in stormwater runoff. 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. In addition, waterfowl activity can increase sediment loadings by pulling up grasses and sprouts and trampling emergent vegetation along streambanks and shorelines, significantly impacting erosion causing and sedimentation.

Recent studies have shown that pet waste is the third or fourth most common source of bacteria in contaminated waters. 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.

Household & Yard Waste

Every home, regardless of size or age, has potential pollution sources that can impact ground and surface water quality. These may include the use, storage and disposal of pesticides, solvents, and petroleum products. Located in Tippecanoe County, the Wildcat Creek Waste District provides citizens and residents of both Clinton and Tippecanoe County with free disposal of Household Hazardous Waste products.

Toxic Materials

Proper use, storage, and disposal of household waste such as used motor oil, paints, furniture stains, and mercury thermostats for example are important to prevent contamination of ground and surface water. The Wildcat Creek Waste District has excellent public education and tox-drop programs available to residents in the Lauramie Creek Watershed.

Lawn & Garden Practices

Urban activities may create conditions that result in higher-than-normal concentrations of ammonia and phosphorus in water bodies downstream. While professional lawn and garden chemical applicators receive training and are required to maintain application records, the average homeowner does not. This often results in over-application of lawn and garden chemicals and contributes significant nutrient loads to adjacent to waterbodies.

Yard waste such as grass clippings, leaves, and dead plants are high in organic matter. Yard waste that is piled or dumped on nearby stream banks results in:

1) Smothering of the vegetation that is naturally stabilizing the bank and preventing soil erosion.
2) Depleted dissolved oxygen levels of nearby waterways.

The Wildcat Creek Waste District has information on the benefits of composting or mulching yard waste as opposed to disposing of it.

Development Practices & Encroachment

Nationwide, more than 1.5 million acres of land is developed each year. Even through very little of that development is occurring within the Lauramie Creek Watershed, development practices and encroachment directly impact water quality and should be considered a potential source of pollution. Planning and development practices are effective methods to control not only where development occurs but also how it occurs.

Comprehensive Plans, Zoning Ordinances, and Subdivision Control Ordinances are documents that almost every community uses to guide growth and development. These same documents can also be used to effectively protect natural resources and improve water quality. The Clinton and Tippecanoe County Plan Commissions have done a good job of controlling haphazard and unplanned growth outside of designated urban areas.

Figure 3-5: Unprotected Sediment

Soil erosion from construction activities can contribute to the filling of nearby waterways affecting water quality, aquatic habitats, and recreational opportunities. There are a number of best management practices (BMP) including silt fencing, straw bales, and turf seeding, that when installed and maintained properly, can successfully limit sediment from leaving the site. **Figure 3-5** identifies a stockpile of unprotected sediment associated with development in the watershed. All developments disturbing greater than or equal to one acre of land in unincorporated areas of Tippecanoe County are required to develop and implement erosion and sediment control plans, which specify how a given development will control and minimize erosion and runoff from their site.

Loss of Riparian Corridors

Interchangeably called streamside forests, riparian corridors are an integral part of the stream ecosystem. These areas consist of large overstory trees, smaller woody shrubs, and herbaceous groundcover. Riparian corridors naturally function to filter and trap sediments and pollutants, anchor the stream bank to prevent erosion, and shade the creek making it more habitable for aquatic species. Currently, the portion of Lauramie Creek between Stockwell and the confluence of Wildcat Creek has a healthy riparian buffer system. Riparian buffers provide a valuable water quality benefit and should be protected from encroaching development or neighboring land uses and stretches lacking sufficient cover should be reforested.

Streambank Erosion

Streambank erosion often results from increased stream flows associated with heavy rainfall events. When stream flow rates exceed the resistance ability of nearby soils and vegetation, bank erosion occurs. Streambank erosion can have numerous negative impacts ranging from increased turbidity, loss of in stream habitat, and damage to public infrastructure such as roads and bridges. Localized stream bank problems, such as are shown in **Figure 3-6** have been identified as a water quality issue that needs to be addressed in more detail.

Figure 3-6: Streambank Erosion

Impervious Areas

Many activities associated with urban or residential land uses can generate NPS pollution. In most urbanized areas, large quantities of impervious or hard surfaces such as roads, driveways, parking lots, and rooftops, cause an increase in stormwater runoff resulting in flash floods and stream bank erosion.

Managing NPS pollution in urban areas typically includes 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. Interstate 65 was identified consistently identified at Stakeholder meetings as the impervious area in the watershed of greatest concern. Transportation accidents along the I-65 are common and within the watershed accidents seem to occur most frequently at the bridge over Lauramie Creek near mile marker 163. This bridge is located just upstream from the confluence of Lauramie Creek and the South Fork of Wildcat Creek, which is listed as a State Outstanding Resource.

The amount of imperviousness in a watershed can be directly related to the health of the receiving streams. As shown in **Table 3-6**, the Center for Watershed Protection has developed a classification system for managing headwater streams based on the percent of impervious land in the watershed. According to the Center for Watershed Protection, watersheds with more than 10% imperviousness are considered impaired and pose an additional challenge to achieve water quality standards.

In the Lauramie Creek Watershed there are approximately 461 acres of land classified as high and low density urban. In order to calculate imperviousness in the Lauramie Creek Watershed it was assumed that three-quarters of high density urban and half of low density urban is impervious. The estimated imperviousness of the Lauramie Creek Watershed is 1.5%.

According to Table 3-6, the streams in the Lauramie Creek Watershed fall into the most protective category known as “Sensitive Streams”. In order to prevent further degradation of these waterways, the Center for Watershed Protection suggests strict zoning, site impervious restrictions, stream buffers, and stormwater practices.

Table 3-6: Stream Classification Based on Imperviousness in Watershed

Urban Stream Classification	Sensitive Stream (0-10% Impervious)	Impacted Stream (11-25% Impervious)	Non-supporting Stream (26-100% Impervious)
Channel stability	Stable	Unstable	Highly Unstable
Water quality	Good	Fair	Fair-Poor
Stream biodiversity	Good-Excellent	Fair-Good	Poor
Resource objective	Protect biodiversity and channel stability	Maintain critical elements of stream quality	Minimize downstream pollutant loads
Water quality objectives	Sediment and temperature	Nutrient and metal loads	Control bacteria
Stormwater practice selection factors	Secondary environmental impacts	Removal efficiency	Removal efficiency
Land use controls	Watershed-wide	Site limits	Additional infill and redevelopment
Monitoring and enforcement	GIS mapping of impervious areas and biomonitoring	GIS mapping of impervious areas and biomonitoring	Pollutant load modeling
Development rights	Transferred out	None	Transferred in
Riparian buffers	Widest buffer network	Average buffer width	Greenways

(Schueler, 2000)

4.0 IDENTIFYING CRITICAL AREAS

Water quality data, trends in land use development, and comments from stakeholders in the watershed were utilized to identify critical areas within the Lauramie Creek Watershed. Critical areas include both areas that are of benefit to water quality in the watershed as well as areas that are suspected of degrading water quality. Areas that are considered to be beneficial to water quality in the Lauramie Creek Watershed should be protected or enhanced, and those areas or activities suspected of degrading water quality should be targeted for implementation of management measures.

4.1 BENEFICIAL CRITICAL AREAS

Identifying land uses and activities that have a negative impact on water quality is usually the first and is often times the primary focus of watershed planning, and while managing the impacts of those activities can and does improve water quality, it is equally important to identify the existing land use conditions and activities in a watershed that enhance or protect water quality.

Well Buffered Stream Reaches

Based on information collected during windshield assessments of the Lauramie Creek Watershed and through the examination of aerial photography it has been determined that approximately 55% of waterways in the watershed have adequate riparian buffers. In particular, the portion of Lauramie Creek from CR 900 South just east of Stockwell in Tippecanoe County to the confluence with the South Fork of Wildcat Creek is protected by a forested buffer that is typically at least 100 feet wide, and in many cases the buffer is much larger than 100 feet.

Buffers along streams and drainage ditches are very beneficial to water quality, as they allow for filtrations of sediments, and the pollutants that attach to them. Considering this, it is not surprising that the water quality samples collected and evaluated during this study indicate that the 3 sampling sites (Site 5, 6, and 7) located between CR 900 South and the confluence with the South Fork of Wildcat Creek had the best water quality and were considered to be the three lowest priority sites. In addition, water quality monitoring results for these three sites, indicate that pollutant concentrations decrease as water moves downstream through these well buffered reaches.

One potential method for protecting the well buffered portion of Lauramie Creek from Stockwell to the confluence of the South Fork of Wildcat Creek would be to develop a Greenways Plan specific to that area, which would ensure the long term maintenance and protection of this area, while providing the community with a recreational opportunity in the watershed.

Municipal Wastewater Treatment Plants

There are two wastewater treatment plants located within the Lauramie Creek Watershed. The Town of Clark's Hill's Wastewater Treatment Plant serves the entire incorporated area of Clark's Hill and has recently added a pretreatment grinder to the plant.

However, at stakeholder meetings concern were expressed that the Clarks Hill Municipal Wastewater Treatment Plant may be bypassing and/or failing during times of wet weather. Our water quality sampling did indicate that Site 2, which is located just downstream from the treatment plant, was a priority sampling site, and NPDES records do indicate previous violations at the treatment plant. However, based on our sampling

the extent that the treatment plant is a contributing source of pollution at this site cannot be determined, and upgrades have recently been made to the plant to specifically address previously identified pollution problems. Overall, the treatment plant is considered to be a benefit to water quality in the watershed.

In addition, the Town of Stockwell recently acquired sewer service through the creation of the Lauramie Township Regional Sewer District. Construction of the plant was primarily funded through a Supplemental Wastewater Assistance Fund grant from the USDA. The new sewer system provides sanitary sewer service to approximately 185 residents in the Town of Stockwell, and as of July 2005 was operating at approximately 30% of its designed capacity. Many of the homes currently served by the treatment plant were suspected of having inadequate or improperly functioning septic systems prior to establishment of the Sewer District. Considering this available capacity, expanding sewer service to residents not currently required to connect to the Waste Water Treatment Plant would maximize the water quality benefits associated with the Waste Water Treatment Plant.

As documented, both of these treatment plants have violated there NPDES permits in the past. In order for these plants to continue to be considered as benefits to the watershed it is important that they fulfill their NPDES permit requirements and operate as designed. As long as that happens these plants are considered beneficial to the watershed.

Stormwater Ordinance

With the addition of sanitary sewer service in the Town of Stockwell it seems likely that additional growth and development could occur in and adjacent to the rural community. Tippecanoe County's recently adopted Stormwater Ordinance, which was designed to minimize the water quality impacts associated with new developments disturbing greater than or equal to one acre of land within unincorporated portions of the County will be of great benefit to water quality in the Lauramie Creek Watershed. The ordinance requires such sites to implement erosion and sediment control practices and post-construction practices designed to minimize water quality impacts associated with developments once they are completed.

4.2 CRITICAL AREAS AS POTENTIAL SOURCES OF POLLUTION

Critical areas identified below are considered to be potential sources of pollution in the watershed. In order to minimize the water quality impacts associated with these areas, it will be important to target the implementation of management measures identified in **Tables 5-1, 5-2, and 5-3** toward these critical areas.

Failing Septic Systems

A major source of the elevated *E.coli* concentrations in the watershed is associated with failing septic systems. These failures have been identified throughout the watershed. However, based on the water quality sampling conducted as a portion of this study, the data collected as a component of the IDEM's 2003 TMDL assessment, and conversations with stakeholders, five regions should be considered priority critical areas above all other areas. The first area is the Town of Monroe, which located about 1.5 miles east of the Town of Stockwell. The second area is the drainage area adjacent to and surrounding Site 3 from the IDEM TMDL Study, which is located along an unnamed tributary to Lauramie Creek near CR 700 North directly north of Wainwright Middle

School in Tippecanoe County. The third area consists of areas within and adjacent to the Town of Clarks Hill. The fourth area consists of a few residential areas just east of the Town of Stockwell along CR 900 South and adjacent to Site 5 in Tippecanoe County. The fifth area consists of the Ken-Do-Lake Campground, which is located just west of I-65 near the intersection of County Line Road and CR 900 South in Tippecanoe County. These areas are identified in **Exhibit 4-1.**

Unbuffered Streams Reaches

There are approximately 9.2 miles of waterways within the Lauramie Creek Watershed that lack an appropriately sized riparian buffer. In the case of open streams and ditches in the Lauramie Creek Watershed, buffers or filter strips of at least 50 feet were considered to be appropriate. The NRCS has developed a minimum standard for assessing the adequacy of stream side buffers. According to this NRCS standard, a buffer is considered to be adequate if it is two and a half times the stream's bank full width or 50 feet, whichever is less. In general, streams widths in the Lauramie Creek Watershed tend to be less than 20 feet, and for all streams greater than or equal to 20 feet in width, a 50-foot buffer is considered to be more than adequate. However, we utilized 50 feet as the measure of appropriateness for purpose of this plan, in recognition of the fact that pollutant removal increases as buffer width increases. If buffer strips are installed as described above it is estimated that phosphorus loadings in the watershed could be reduced by 243 lbs/year and nitrogen loadings could be reduced by 484 lbs/year.

Given that the water quality sampling collected as a component of this grant project indicated that water quality was improved in downstream reaches as compared width upstream reaches, the headwater areas along Lauramie Creek and McClellan Fickle Ditch should be prioritized for buffer implementation.

In addition, numerous landowners along creeks and ditches in the watershed expressed an interest in implementing conservation measures on their property if financial assistance were made available. These landowners will be targeted in any future buffer initiatives.

Transportation Corridors and Impervious Areas

In addition to critical areas contributing nutrients and pathogens to the watershed, Interstate 65 (I-65), runs through the Lauramie Creek Watershed for approximately 5.5 miles. Concern regarding the water quality impact that hazardous spills associated with vehicular accidents along I-65 was expressed quite often by stakeholders both in public meetings and in public opinion surveys. Of particular concern, is the bridge crossing at Lauramie Creek and I-65 near mile marker 163. There are frequent accidents at this site especially during winter weather conditions, and the relative steep topography at this site provides liquid chemicals associated with spills with an excellent conduit to Lauramie Creek. Of additional concern is the fact that this bridge crossing is located approximately one half mile from Lauramie Creek's confluence with the South Fork of Wildcat Creek, which is listed as an Outstanding State Water Resource. However, hazardous spills are not the only water quality issue of concern associated width large impervious transportation corridors such as I-65. Untreated stormwater runoff from impervious areas carries potential pollutants such as vehicular fluids, glass, rubber, road salt, and sand into nearby waterways.

Highly Erodible Lands

Highly erodible lands were consistently identified by watershed stakeholders as areas of concern, and are prevalent in both the Clinton and Tippecanoe County portions of the watershed. As previously mentioned, land disturbing activities occurring on these lands are more likely to contribute increased loads of sediments and pollutants attached to sediments to nearby waterways. Highly erodible lands in the watershed are identified by Exhibits 3-2 and 4-1. Management measures addressing highly erodible soils will target owners of cropped fields located on HELs.

Agricultural Lands

As previously stated, approximately 13,000 acres in the watershed are considered to be agricultural lands. The relative extent of water quality impacts associated with these lands is not clear based on our water quality sampling. However, by increasing the number of agricultural lands practicing conservation tillage and other agricultural field practices by 10% (1,300 acres) it is estimated that there will be a reduction in phosphorus loadings in the watershed by as much as 4,378 lbs/year and nitrogen loadings by as much as 8,761 lbs/year. Owners of farm fields adjacent to Sampling Sites 1, 2, 3, and 4, which were considered the four water quality sampling sites of greatest concern, will be considered priority areas for the implementation of agricultural management measures. Again, all landowners that expressed interest in implementing conservation measures on their property if financial assistance were made available will also be targeted for future implementation of appropriate management measures.

Pasture Lands and Livestock Facilities

Several small livestock operations were identified in the watershed. The extent of the water quality impacts associated with these facilities is not clear based on our water quality sampling, and in some instances identified landowners may already be implementing recommended practices. However, these areas should be targeted for future implementation of management measures addressing livestock facilities. It was estimated that phosphorus loading in the watershed could be reduced by 296 lbs/year if 100 foot buffer strips were installed between newly installed exclusionary fencing and adjacent waterways.

Streambank Erosion

As identified in Figure 3-6 there is some extreme streambank erosion occurring along Lauramie Creek near CR 900 South and CR 725 East just upstream and to the east of the Town of Stockwell. Based on the IDEM's Load Reduction Workbook, streambank stabilizations in the Lauramie Creek watershed could reduce nitrogen loadings by 410 lbs/year and phosphorus loadings by 209 lbs/year.

4.3 ESTIMATING POLLUTANT LOADS

In order to determine the overall effectiveness of management measures identified in this plan, it is important to have an understanding of the existing pollutant loads in the Watershed.

Existing pollutant loads in the Lauramie Creek Watershed were determined by:

- Identifying the closest downstream USGS gauging station located on the South Fork of Wildcat Creek.

- Calculating the Lauramie Creek Watershed's proportion of that gauging station's contributing drainage area.
- Assuming that the Lauramie Creek Watershed's proportion of the USGS gauging station's drainage area was equivalent to the watershed's proportion of the station's average discharge rate. It was determined that the average annual discharge rate for Lauramie Creek was 24.3 cubic feet/second.
- Multiplying the average annual discharge rate of 24.3 cubic feet/second, by the mean pollution concentrations for nitrate, ammonia, phosphorus, and *E.coli* based on all samples collected as a component of this grant.

Target pollutant loads were determined by multiplying the average annual discharge rate by a target concentration determined for each pollutant. Targets concentrations for ammonia were set at .1. This target was set by determining the estimated average annual temperature and pH concentrations in the watershed and determining what ammonia concentration would ensure that water quality standards were fulfilled. At an average temperature of 10°C and an average pH of 8.15, it was determined that .1 mg/L was the appropriate ammonia concentration. The target nitrate concentration was set to be below the mean concentration for the entire Wildcat Creek Watershed, which is 2.56 mg/L based on a 1998 IDEM study. The target nitrate concentration is set at 2.4 mg/L. The target phosphorus concentration was set to be at the low range of average Indiana waters, and was set at .1mg/L. Finally, the target *E.coli concentration* was set at the water quality standard of 235 CFU/100ml.

Target load reductions were then determined by subtracting the targeted loadings from the estimated existing loadings. Based on these calculations, the pollutant benchmarks, targets, and target reductions shown in **Table 4-1** were developed for nitrate, ammonia, phosphorus, and *E.coli.*

Table 4-1: Estimated Pollutant Loads and Load Reductions

Parameter	Mean Flow	Existing Average Concentration	Estimated Existing Loadings	Target Concentration	Targeted Loadings	Target Load Reduction
Nitrate	24.3	2.85 (mg/L)	136,248.82 (lbs/year)	2.4 (mg/l)	114,735.85 (lbs/year)	21,512.97 (lbs/year)
Phosphorus	24.3	0.171(mg/L)	8,174.93 (lbs/year)	0.1(mg/L)	4,780.56 (lbs/year)	3,394.27 (lbs/year)
Ammonia	24.3	0.159 (mg/L)	7,601.75 (lbs/year)	0.1 (mg/L)	4,780.56 (lbs/year)	2,820.59 (lbs/year)
E.coli	24.3	607 (CFU/100ml)	3.67E+09 (CFU/day)	235 CFU/100ml	1.40E+08(CFU/day)	3.53E+09(CFU/day)

There is no known effective way to estimate load reductions associated with implementing all management measures recommended in this plan. However, by implementing buffer strips and exclusionary fencing, increasing agricultural landowner implementation of conservation field practices, and by conducting streambank restoration as discussed in Section 4.2, it is estimated that pollutant loadings in the Lauramie Creek Watershed would be largely reduced.

As discussed in Section 4.2, IDEM's Load Reduction Worksheet estimated that:

- Implementing 9.2 miles of buffer strips could reduce phosphorus loadings in the watershed by 243 lbs/year and nitrogen loadings by 484 lbs/year.
- Increasing conservation tillage practices by 10% in the watershed could reduce phosphorus loadings by 4,378 lbs/year and nitrogen loadings by 8,761 lbs/year.
- Implementing 100 foot buffer strips between adjacent waterways and newly installed exclusionary fencing could reduce phosphorus loading in the watershed by 296 lbs/year.
- Conducting streambank restoration could reduce phosphorus loadings in the watershed by 209 lbs/year and nitrogen loadings by 410 lbs/year.

In total, it is estimated that the implementation of these management measures would reduce nitrogen loadings in the watershed by approximately 9,655 lbs/year and phosphorus loadings by approximately 5,126 lbs/year. Based on this estimate, the implementation of these management measures would account for more than 100% of the targeted phosphorus load reduction, as shown in Table 4-1.

Although the exact percentage of the estimated nitrogen load reductions that can be considered to be associated with nitrate or ammonia loadings cannot be determined, it is assumed that the implementation of these measures would go a long way towards achieving the targeted nitrate and ammonia load reductions, as shown in Table 4-1.

Finally, many of the recommendations made in the following section will result in additional pollutant load reductions, but the relative reduction associated with each measure is not easily predicted.

5.0 GOALS AND DECISIONS

Setting realistic and measurable goals is key to the successful implementation of this Plan. A goal is the desired change or outcome as a result of the watershed planning effort. Depending on the magnitude of the problem, goals may be general, specific, long-term, or short-term. The goals in this plan focus on improving water quality through the implementation of a variety of management measures. The IDEM suggests watershed groups focus on developing goals, management measures, action plans, resources, and legal matters as part of the watershed planning process.

According to the IDEM, management measures describe what needs to be controlled or changed in order to achieve the goal. The anticipated timeline for implementing individual management measures is identified in **Section 5.2**. In order to successfully implement the plan, resources such as people, programs, and money need to be identified. It is important to have the support of individuals identified as resources to successfully execute the goals of the plan. Successful implementation may require some legal matters such as obtaining permits, purchasing easements, or the adoption of an ordinance. The Lauramie Creek Steering Committee decided to focus on goals that improve water quality in the Lauramie Creek Watershed based on education, septic systems, agriculture, and land use planning.

The following goals were identified and agreed upon by the Lauramie Creek Steering Committee:

Agriculture Goal: Reduce *E.coli* and nutrient concentrations in the Lauramie Creek Watershed through the implementation of better agricultural practices and management programs.

Agricultural management measures and action strategies identified in the following tables will need to be targeted toward relevant landowners. For example brochures promoting cost share programs available for land owners on highly erodible lands should be targeted only to the owners of highly erodible lands, and brochures promoting cost share programs to implement exclusionary fencing and alternative watering systems should be targeted only to landowners known to have livestock on their property. Additionally, numerous landowners along creeks and ditches in the watershed expressed interest in implementing conservation measures on their property if financial assistance were made available. These landowners should be targeted for priority implementation.

Wastewater Treatment Goal: Reduce *E.coli* and nutrient concentrations in the Lauramie Creek Watershed through proper planning, design, installation, and long-term maintenance of wastewater treatment systems.

As discussed in Section 4, two areas have been identified as potential priority areas for implementation of septic system management measures in the watershed. Where appropriate, these two areas should be considered first during the implementation of management measures relating to septic systems. However, some of the management measures are broader and will require implementation efforts that target all landowners with septic systems in the watershed and in some cases the management measures will require county-wide participation.

Land Use Planning Goal: Improve water quality in the Lauramie Creek Watershed through better land use planning and land development practices.

Urban development is currently occurring to a limited extent within the watershed, and the current rate of development does not seem to be posing a large threat to water quality in the watershed. However, by implementing the management measures identified in this plan potential future water quality impacts associated with urban development in the watershed can be minimized.

Public Education Goal: Improve water quality in the Lauramie Creek Watershed through education and outreach efforts that focus on changing stakeholders' habits and behaviors.

Public education efforts will be wide spread and will likely reach all landowners in the watershed. However, specific management measures and action plans identified in the following tables will need to be targeted toward relative landowners. For example, workshops and educational brochures focusing on buffer initiatives should target landowners along open creeks and ditches.

Tables 5-1, 5-2, and 5-3 located on the following pages identify management measures, action plans, resources/cost, legal matters, and progress indicators associated with addressing education, wastewater treatment systems, agriculture, and land use planning in the Lauramie Creek Watershed. Table 5-1 identifies all management measures considered high priorities, Table 5-2 identifies all management measures considered medium priorities, and Table 5-3 identifies all management measures considered low priorities.

In order to determine the relative priorities of management measures listed in the tables, each measure was evaluated in terms of its ability to improve water quality within 5-years, the relative ease at which it could be implemented, and the overall public sentiment expressed towards a given measure. It is important to note that regardless of their overall ranking, all management measures listed in these tables are considered priorities.

Estimated costs in the tables are identified as either "Low", "Moderate" or "High". Those activities, materials, or programs estimated to cost less than $1,000 will be considered Low cost. Those activities, materials, and programs that are estimated to cost between $1,001 and $10,000 are considered Moderate cost. Activities, materials, and programs that are estimated to cost more than $10,000 are considered High cost.

"Local Resources" in the tables are intended to provide a list of local organizations that could potentially provide support, advice, or consultation on a particular management measure. These lists are not intended to be comprehensive and are not intended to exclude non-listed organizations from participating in the development or implementation of a particular management measure. Other non-listed organizations are encouraged to participate as available.

In August 2005, the Tippecanoe County Surveyor applied for Supplemental 319 funding to implement many of the management measures and action items identified in this plan. If awarded, this grant will provide funding for implementation of many of the priority issues identified in this plan. Additional funding sources, such as those listed in the

IDEM's Indiana Watershed Planning Guide will need to be pursued in order to ensure successful long-term implementation of the Lauramie Creek Watershed Management Plan.

Table 5-1: High Priority Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Establish 6.1 miles of buffer along natural streams and artificial drainage ditches. A total of 9.4 miles need buffered.	• Identify landowners and stretches of natural waterways that need buffered.
	• Conduct a workshop and/or develop educational materials on the benefits of implementing riparian buffers and filter strips along natural streams and drainage ditches.
	• Develop a cost share program to assist landowners with implementing buffers and filter strips.
	• Use GIS to maintain a graphical database of the installation of buffers. Use the images to illustrate the success of this effort and display at local events.
		• Local Resources
		  • Tippecanoe and Clinton County SWCDs
		  • Tippecanoe and Clinton County Surveyor's Office
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension Service
		  • Nature Conservancy Easements
		  • Wildcat Creek Foundation Land Trust
		  • NICHES
		• Section 319 grant
		• High cost
			Indiana Filter Strip Program	Future water quality sampling indicates a reduction in *E.coli* and nutrient concentrations and loadings in the Lauramie Creek Watershed.

Secure funding for livestock and crop producers that may need financial and technical assistance with implementing conservation measures such as conducting alternative plantings on highly erodible soils, or implementing manure management BMPs.	• Research available financial assistance opportunities and incentives to assist livestock and crop producers with implementing BMPs.
	• Develop a cost share program to assist landowners with implementing BMPs.
		• Local Resources
		  • Tippecanoe and Clinton County SWCDs
		  • Tippecanoe and Clinton County Surveyor's Office
		  • NRCS
		  • DNR
		  • Purdue Extension
		• CRP and EQIP funds
		• 319 Grant
		• High cost
			N/A	Future water quality sampling indicates a reduction in *E.coli* and nutrient concentrations and loadings in the Lauramie Creek Watershed.
				
				Increased watershed wide participation in conservation programs.

Increase detection and enforcement of illicit discharges.	• Build GIS database to track operational status of septic systems in Clinton and Tippecanoe County.
	• Review existing records to compare the number of known septic systems in the watershed with the total number of homes in the watershed.
	• Conduct volunteer dye testing of septic systems to identify failing systems and illicit connections.
	• Require septic system contractors to be certified.
	• Require residents to provide proof that their septic system has been cleaned and inspected every five years by a licensed inspector/hauler.
		• Local Resources
		  • Tippecanoe County and Clinton County Health Departments
		  • Tippecanoe and Clinton County Surveyor's Office
		  • Purdue Extension Service
		• Secure additional funds to develop and amend a watershed wide GIS database.
		• Moderate-High cost
			County Health Departments and Commissioners will need to decide how to enforce proof of cleaning and inspection.
			
			Develop and adopt an ordinance requiring homeowners to document proof of septic system maintenance.
				Future water quality sampling indicates a reduction in *E.coli* and nutrient concentrations and loadings in the Lauramie Creek Watershed.

Table 5-1: High Priority Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Secure funding for low-income landowners that may need financial assistance in installing, repairing, or operating and maintaining their septic systems.	• Research all available private and public sources of funds for addressing septic systems issues including sewer extensions and private WWTP.
	• Seek funding and assistance from funding sources identified and researched in 2006.
		• Local Resources
		  • Tippecanoe County and Clinton County Health Departments.
		  • Purdue Extension Service
		  • USDA RCAP
		• High cost
			N/A	Secure funding for low-income landowners that may need financial assistance in installing, repairing, or operating and maintaining their septic systems.

Increase the number of acres in no-till or mulch till practices.	• Provide educational materials to farmers at SWCD annual meetings, Ag Days, County Fairs, and AgStravaganza.
	• Research and promote incentive programs to improve participation in conservation tillage practices.
	• Develop a cost share program to assist landowners with implementing conservation tillage.
		• Local Resources
		  • Tippecanoe and Clinton County SWCDs
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension Service
		  • Tippecanoe and Clinton County Surveyor's Office
		• CORE 4
		• EQIP funds
		• 319 Grant
		• High cost
				Future surveys and correspondence indicate that stakeholders have changed behaviors and/or practices.

Improve pasture management techniques including rotational grazing and fencing livestock from waterways.	• Create educational materials for livestock landowners about pasture management and limiting access to waterways.
	• Develop a cost-share program to fence livestock from waterways and provide alternative watering mechanisms.
	• Extensively test *E.coli* bacteria sources in the watershed to determine whether the bacterial indicators are in fact the result of animal or human waste.
		• Local Resources
		  • Tippecanoe and Clinton County SWCDs
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension
		  • Tippecanoe and Clinton County Surveyor's Office
		• Section 319 grant
		• High cost
				Future water quality sampling indicates a reduction in *E.coli* and phosphorus concentrations in the Lauramie Creek Watershed.

Increase nutrient management and pest management practices among crop producers.	• Identify landowners and evaluate current manure, nutrient, and /or pest management practices.
	• Conduct a workshop/and or develop a brochure for crop and livestock producers addressing manure, nutrient, and pest management.
	• Develop a cost-share program to provide land-owners with assistance in developing nutrient and pest management plans.
		• Local Resources
		  • Tippecanoe and Clinton County SWCDs
		  • NRCS
		  • Department of Agriculture
		  • Purdue Extension
		  • Tippecanoe and Clinton County Surveyor's Office
		• CORE 4
		• EQIP funds
		• Section 319 Grant
		• High cost
			N/A	Follow up contact indicates that stakeholders attending workshops have changed behaviors and/or practices since attending the workshops.
				
				Future water quality sampling indicates a reduction in *E.coli*, phosphorus, and ammonia concentrations in the Lauramie Creek Watershed.

Table 5-1: High Priority Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Improve the planning process to minimize impacts of septic systems on water quality.	• Ensure that Health Departments continue to participate in development review and approval process.
	• Build a GIS layer that identifies land suitable for septic systems.
	• Include language in updated Comprehensive Plans that addresses potential impacts of septic systems on water quality.
	• Promote existing financial assistance programs to assist homeowners in replacing and repairing inadequate septic systems.
	• Provide economic incentives and assistance to homeowners to repair or replace aging septic systems.
	• Require homeowners to document that their septic system is functioning properly prior to selling their property.
		• Local Resources
		  • Tippecanoe and Clinton County Commissioners
		  • Clarks Hill Town Board
		  • Tippecanoe County and Clinton County Health Departments
		  • Purdue Extension Service
		  • USDA RCAP
		• Secure additional funds to provide economic incentives for repairing failing septic systems.
		• Moderate cost
			Will need to gain legal authority to require landowners to provide documentation that their septic systems are working properly prior to selling their property.	Secure funding for low-income landowners that may need financial assistance in installing, repairing, or operating and maintaining their septic systems.
				
				Future water quality sampling indicates a reduction in *E.coli* and nutrient concentrations and loadings in the Lauramie Creek Watershed.

Secure funding or cost-share assistance to assist interested landowners with connecting to local wastewater treatment plants.	• Work with Lauramie Township Regional Sewer District and Clarks Hill Town Council to ensure political support and identify priority landowners.
	• Research all available private and public sources of funds for providing landowners with financial assistance in connecting to local treatment plants.
	• Secure a funding mechanism to provide financial support and incentives to encourage landowners to connect to local wastewater treatment plants.
	• Develop and conduct an education and marketing campaign educating priority landowners on the benefits associated with connecting to wastewater treatment plants.
	• Begin connecting interested landowners to wastewater treatment plants.
		• Local Resources
		  • Tippecanoe County Commissioners
		  • Clarks Hill Town Board
		  • Lauramie Township Regional Sewer District
		  • Tippecanoe County and Clinton County Health Departments
		  • USDA RCAP
		• Section 319 grant.
		• State Revolving Loan Funds.
		• High cost
			N/A	Secure funding or cost-share assistance to assist interested landowners with connecting to local wastewater treatment plants.

Table 5-2: Medium Priority Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Incorporate water quality BMPs into all future flood control projects designed and implemented in the watershed.	• Update existing Comp Plans, Zoning Ordinances, and Subdivision Control Ordinances.	• Local Resources
		  • Area Plan Commissions, Surveyors, Town Councils, and Drainage Boards
		  • Tippecanoe County and Clinton County SWCDs
		• Moderate Cost
			Approval and adoption of updated planning documents and ordinances.	Updated ordinances and comprehensive plans address water quality issues.

Prepare and distribute an educational brochure about proper septic system operation and maintenance.	• Produced educational brochure on proper septic system operation and maintenance.
	• Identify landowners and distribute brochure. Target known residents and landowners in the watershed with existing septic systems.
	• Distribute educational brochures to all landowners applying for a septic system permit.
		• Local Resources
		  • Tippecanoe and Clinton County Health Departments
		  • Area Plan Commissions
		• Low cost
			N/A	Follow up contact indicates that stakeholders receiving brochures have changed their behaviors and/or practices.

Minimize the water quality impacts associated with transportation corridors.	• Develop educational signage for implementation along I-65 that will encourage travelers to use caution while driving in the watershed, and raises their awareness of water quality impacts associated with vehicular accidents.
	• Work with INDOT to implement hydrocarbon removing BMPs along I-65 roadside ditches.
	• Encourage state and local Highway Departments to utilize a substitute for road salt along stretches of I-65 near Lauramie Creek and its tributaries.
		• Local Resources
		  • Tippecanoe and Clinton County Highway Departments
		  • INDOT
		• Medium cost
			Seek INDOT approval to install signage in right-of-way.	Implementation of signage, BMPs, and change in salt/sand application policies.

Minimize soil erosion and sediment in waterways with better construction management and practices including:
• Education for developers and decision-makers.
• Regular inspection of construction sites
• Issuing fines or stop work orders for construction violations
• Proper installation and maintenance of erosion and sediment controls (ESC)
• Tree preservation/protection
• Temporary seeding/mulching
• Stabilization and vegetation of
	• Work with Clinton County and the Town of Clarks Hill to update their existing ordinances to require ESC from sites disturbing greater than or equal to one acre of land.
	• Implement an educational program focusing on the benefits of implementing construction site BMPs into new development.*
	• Work with local Storm Water Phase II communities to create and distribute a handbook for developers, contractors, engineers, and decision-makers identifying appropriate BMPs
		• Local Resources
		  • Tippecanoe County Stormwater Phase II Communities
		  • Tippecanoe and Clinton County SWCDs*
		  • Area Plan Commissions, Surveyors, Town Councils, and Drainage Boards
		  • Local Builders Associations
		  • Purdue Planning with POWER
		• Moderate cost
		
		*The SWCDs are considered resources associated with the implementation of an
			Approval and adoption of updated planning documents and ordinances.
			
			Enforcement of existing fines for construction violations.
				Post construction practices implemented in 100% of developments greater than or equal to one acre in the Lauramie Creek Watershed.

Table 5-2: Medium Priority Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators
streambanks and drainage ways.	for controlling pollution associated with construction sites.	educational program focusing on the benefits of implementing construction site BMPs into new development as shown in the second Action Plan bullet point.		

Submit bi-annual articles and updates to newspapers and other community organizations in the Lauramie Creek Watershed.	• Biannual submissions beginning in 2006.	• Local Resources
		  • Tippecanoe Journal & Courier and other local media outlets.
		  • Tippecanoe and Clinton County SWCD Newsletters and Mailings
		  • Farm Service Agency Newsletters
		  • Purdue Extension Service
		  • Wildcat Creek Solid Waste District
		• Low cost
			N/A	Analysis of future survey distribution will indicate that water quality awareness of local landowners has improved and that stakeholder behaviors have changed.

Implement streambank stabilization techniques that utilize a combination of vegetation, soil bioengineering, and structural systems.	• Inventory waterways for erosion problems through field work and property owner outreach.
	• Create and distribute educational materials to landowners on streambank stabilization.
	• Develop a cost share program to assist landowners with conducting streambank stabilization.
	• Identify additional funding sources to assist with stabilizing eroded banks
		• Local Resources
		  • Tippecanoe and Clinton County SWCDs
		  • NRCS
		  • DNR
		  • Tippecanoe and Clinton County Surveyor's Office
		• 319 Grant
		• High cost
			N/A	Future water quality sampling indicates a reduction of sediment, phosphorus, and nitrogen loadings and concentrations, within the Lauramie Creek Watershed.

Write a Greenways Plan to maintain a system of healthy riparian/aquatic buffers along Lauramie Creek between Stockwell and the confluence of the South Fork of Wildcat Creek.	• Work with landowners, planners, SWCD staff, and interested group to develop a Greenways Plan.	• Local Resources
		  • Area Plan Commissions
		  • Tippecanoe County and Clinton County SWCDs
		  • Wildcat Creek Foundation
		  • NICHES
		  • Secure additional funds to pay for study writing, and distribution of plan.
		• Moderate cost
			Amendments to the Zoning Ordinance and Comprehensive Plan may be necessary, and if this is the case, approval of the amendments will be necessary.	Greenway Plan developed and riparian buffers maintained.

Table 5-3: Low Priority Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Prepare educational displays and participate in at least four community events annually. These may include: Tippecanoe and Clinton County fairs, SWCD annual meetings and events, AgStravaganza, Wildcat Guardians festival, Ag Days, and Tippecanoe County Stormwater Phase II Events.	• Identify community events that will provide the best results to improve awareness of water quality issues in the watershed.
	• Identify contact persons for respective events.
	• Develop and maintain a display that can easily be updated to emphasize an issue pertinent to the targeted audience (i.e. impacts of residential land use such as car washing, dog waste, and lawn care at the county fair).
		• Display board, laminated images, brochures, flyers, etc.
		• Local Resources
		  • Purdue Extension Service
		  • Tippecanoe and Clinton County SWCDs
		  • Tippecanoe County Stormwater Phase II Communities
		  • Wildcat Creek Solid Waste District
		• Low cost
			N/A	Analysis of future survey distribution will indicate that water quality awareness of local landowners has improved and that stakeholder behaviors have changed.

Survey watershed stakeholders in order to determine their awareness of water quality issues and to identify localized water quality problems.	• Distributed Water Quality Surveys to watershed residents. • Distributed water quality and natural resource survey to landowners along creeks and ditches. • Repeat distribution of water quality and natural resource survey • Repeat distribution of Water Quality Survey.	• Local Resources • Lauramie Creek Watershed Steering Committee • Low cost	N/A	Analysis of future survey distribution will indicate that water quality awareness of local landowners has improved and that stakeholder behaviors have changed.

Update current Comprehensive Plans, Zoning Ordinances, and Subdivision Control Ordinances to address water quality issues including:
• Wetland protection
• Riparian corridor protection
• Tree preservation/protection
• Setbacks and buffer protection
• Limiting impervious areas
• Conservation design
• Drainage (ROW) easements
• Treatment of sewage (septic/sewer)
• Flexible development standards
	• Participate in future updates of the Comprehensive Plans for Tippecanoe and Clinton County.
	• Participate in future updates of Zoning Ordinances, Subdivision Control Ordinances, and Floodplain Ordinances.
	• Update National Flood Insurance Maps.
	• Develop digital zoning maps.
		• List of definitions, suggested language, and model ordinances.
		• Local Resources
		  • Support from local Builders Association
		  • Tippecanoe and Clinton County Area Plan Commissions
		  • Tippecanoe County and Clinton County SWCDs
		  • Tippecanoe and Clinton County Surveyor's Office
		  • Purdue Planning with POWER
		• Moderate cost
			Approval and adoption of updated planning documents and ordinances.	Updated ordinances and comprehensive plans address water quality issues.

Table 5-3: Low Priority Management Measures

Management Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators

Conduct a septic system demonstration project to promote onsite wastewater treatment systems resulting in improved water quality.	• Explore feasibility of implementing an alternative treatment system demonstration project.
	• Locate one or more landowners that are willing to have their septic system(s) become a demonstration site.
	• Conduct an onsite wastewater treatment system demonstration project.
		• Local Resources
		  • Tippecanoe and Clinton County Health Departments
		  • Area Plan Commissions.
		  • Landowners
		• Section 319 grant
		• High cost
				Future water quality sampling indicates a reduction of *E.coli* concentrations in the Lauramie Creek Watershed.

Use geographic information systems (GIS) as a tool to assist with establishing future land use and zoning districts based on appropriateness for:
• Development
  Residential
  Commercial
  Industrial
• Agriculture
• Open Space
  Wetland
  Flood storage
  Forest
	• Develop watershed wide GIS layer to assist in future planning and decision making.	• Digital soil, property, and drainage layers
		• Local Resources
		  • Information Technology Departments
		  • Area Plan Commissions
		  • Tippecanoe County and Clinton County SWCDs
		  • Tippecanoe and Clinton County Surveyor's Office
		• Medium cost
			N/A	Watershed wide GIS layer developed and utilized in future land use decisions.

Improve water quantity and quality management through effective storage and treatment of urban, suburban, and rural stormwater runoff including:
• On-site stormwater treatment
• Bioretention
• Rain Gardens
• Constructed wetlands
• Detention/retention ponds
• Infiltration basins/trenches
• Vegetated filters strips/swales
• Stream buffers
• Limit impervious areas
• Tree conservation/protection
	• Review Clinton County and Clarks Hill drainage ordinances and make recommendations for improvement to the Drainage Board and Town Council.
	• Implement an educational program* focusing on the benefits of implementing stormwater BMPs into new development.
	• Create and distribute a handbook for developers, contractors, engineers and decision-makers identifying appropriate stormwater BMPs.
	• Develop a cost share program to* provide financial assistance to developers implementing stormwater BMPs such as pervious pavement, bioretention swales, rain gardens, etc.
	(For developments subject to Stormwater Phase II standards, cost share dollars would be used to fund BMPs in addition to minimum Phase II requirements.)
		• List of definitions suggested language, and model ordinances.
		• Local Resources
		  • Tippecanoe County Stormwater Phase II Communities
		  • Tippecanoe County and Clinton County SWCDs*
		  • Area Plan Commissions, Surveyors, Town Councils, and Drainage Boards
		  • Local Builders Associations
		  • Organization of Green Builders
		• 319 Grant
		• High cost
		
		The SWCDs are considered resources associated with the implementation of an educational program focusing on the benefits of implementing stormwater BMPs into new development as shown in the second Action Plan bullet point. The SWCDs may also be able to assist with
			Approval and adoption of updated planning documents and ordinances.	Post-construction practices implemented in 100% of developments greater than or equal to one acre in the Lauramie Creek Watershed.

Table 5-3: Low Priority Management Measures

nt Measures	Action Plan	Resources/Cost	Legal Matters	Progress Indicators
		development of a cost share program as shown in the fourth Action Plan bullet point.		
Promote and encourage participation in Wildcat Creek Waste District Tox-Drop and Recycling Programs.	• Include pollution prevention information in published or distributed materials and at local events and workshops.	• Local Resources • Wildcat Creek Solid Waste District • Low cost	N/A	Future surveys indicate changes in stakeholder attitudes and behaviors as they relate to pollution prevention.

5.1 POTENTIAL IMPLEMENTATION TIMELINE

Management measures listed in the tables above as high priorities are likely to provide the greatest short term benefit to water quality in the watershed, however these activities are not always the easiest measures to implement. Likewise some of the measures that may be considered medium or low priorities may be relatively easy to implement. Therefore, implementation of certain medium priority measures may occur prior to certain high priority measures, and implementation of certain low priority measures may occur prior to certain medium priority measures. Additionally, new information or changes in political and economic circumstances may result in a change in the implementation schedule shown below.

While a variety of circumstances may influence when, where, and how a given measure is implemented, **Table 5-4** details the anticipated timeline for when each management measures will be implemented. This table is not intended to identify the length of time that a measure will be implemented, but rather is intended to provide an overall indication of when implementation of a management measure is likely to begin.

Table 5-4: Potential Timeline for Implementation

Management Measures	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Establish buffers along natural streams and artificial drainage ways.	H	H								
Secure funding for livestock and crop producers that may need financial and technical assistance with implementing conservation measures such as conducting alternative plantings on highly erodible soils, or implementing manure management BMPs.	H	H								
Increase detection and enforcement of illicit discharges.			H	H	H	H				
Secure funding for low-income landowners that may need financial assistance in installing, repairing, or operating and maintaining their septic systems.			H	H	H	H				
Increase the number of acres in no-till or mulch till practices.	H	H								
Improve pasture management techniques including rotational grazing and fencing livestock from waterways.	H	H								
Increase nutrient management and pest management practices among crop producers.	H	H	H							
Improve the planning process to minimize impacts of septic systems on water quality.	H	H	H							
Secure funding or cost-share assistance to assist interested landowners with connecting to local wastewater treatment plants.		H	H	H	H	H				

Management Measures	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Incorporate water quality BMPs into all future flood control projects designed and implemented in the watershed.	M									
Prepare and distribute an educational brochure about proper septic system operation and maintenance.	M	M								
Minimize the water quality impacts associated with transportation corridors.	M	M								
Minimize soil erosion and sediment in waterways with better construction management and practices.			M	M						
Submit bi-annual articles and updates to newspapers and other community organizations in the Lauramie Creek Watershed.	M	M								
Implement streambank stabilization techniques that utilize a combination of vegetation, soil bioengineering, and structural systems.	M	M	M	M	M					
Write a Greenways Plan to maintain a system of healthy riparian/aquatic buffers along Lauramie Creek between Stockwell and the confluence of the South Fork of Wildcat Creek.		M	M	M	M					
Prepare educational displays and participate in at least four community events annually. These may include: Tippecanoe and Clinton County fairs, SWCD annual meetings and events, AgStravaganza, Wildcat Guardians festival, Ag Days, and Tippecanoe County Stormwater Phase II Events.		L	L							

Management Measures	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Survey watershed stakeholders in order to determine their awareness of water quality issues and to identify localized water quality problems.		L	L							
Update current Comprehensive Plans, Zoning Ordinances, and Subdivision Control Ordinances to address water quality issues.		L	L	L						
Conduct a septic system demonstration project to promote onsite wastewater treatment systems resulting in improved water quality.			L	L						
Use geographic information systems (GIS) as a tool to assist with establishing future land use and zoning districts.	L	L	L	L						
Improve water quantity and quality management through effective storage and treatment of urban, suburban, and rural stormwater runoff.			L	L	L					
Promote and encourage participation in Wildcat Creek Waste District Tox-Drop and Recycling Programs.		L	L							

6.0 MONITORING EFFECTIVENESS

Progress indicators are used to gauge the progress and success of the watershed planning effort. Indicators may be administrative, such as language added to an ordinance, or programmatic, indicating the total acreage added to a filter strip program. Alternatively, monitoring describes how the above mentioned indicators will be evaluated to determine the level of success reached toward achieving the goal. Monitoring progress can be general, or very specific, such as increasing the number of participants at quarterly meetings or through improvements observed in biological or chemical measurements.

Goal Monitoring

For each goal, it is suggested that progress toward meeting each indicator be documented on a biannual basis. Biannual tracking of progress for each milestone will help to maintain focus on goal objectives and progress, but also to troubleshoot issues where it is clear that tasks may need to be adjusted or modified in order to achieve the goal objective.

Plan Evaluation

The County Surveyor's Office in partnership with the Lauramie Creek Watershed Steering Committee will be responsible for the regular review and update of the Lauramie Creek Watershed Management Plan. This plan should be evaluated on a biannual basis to document and celebrate progress; assess effectiveness of efforts; modify activities to better target water quality issues; and keep implementation of the plan on schedule. The plan should be revised as needed to better meet the needs of the watershed stakeholders and to meet water quality goals.

Chemical Monitoring Re-evaluation

In order to evaluate if management measures are having a beneficial impact on water quality, chemical monitoring of the watershed will be conducted at the same seven monitoring locations that were used for this study at least once prior to 2008. This data will be used to measure the effectiveness of all measures implemented in achieving goals of improving water quality, reducing concentrations of nutrients and *E.coli*, and reaching targeted load reductions as identified in Section 4.3.

By identifying existing pollutant loads and targeting future pollutant loads, the Lauramie Creek Steering Committee has created a framework through which the overall success of individual management measures and goals identified in this plan can be evaluated. Results of future water quality monitoring efforts will identify the relative success and short comings associated with implemented management measures, and can be used to adjust and revise certain portions of the plan as necessary.

REFERENCES

Carver, Andrew and Joseph E. Yahner. "Indiana Land Use Trends: A Series of Illustrative Maps." http://www.agry.purdue.edu/landuse/trends.htm.

Haan, C. T., B. J. Barfield, and J.C. Hayes. 1994. "Design Hydrology and Sedimentology for Small Catchments" Academic Press., p. 38.

Indiana Business Research Center, 2005. Indiana University, Kelly School of Business. http://www.stats.indiana.edu

Indiana Department of Environmental Management, 1999, "1998 Watershed Monitoring of the Upper Wabash River Basin." IDEM 032/02/021/1999.

Indiana Department of Environmental Management, 2001, "Upper White River Watershed Restoration Action Strategy," Office of Water Quality.

Indiana Department of Environmental Management, Office of Water Management, 2002. Section 319 Non-point Source Program. www.in.gov/idem/water/programs.

Indiana Department of Environmental Management, Office of Water Management, 2003, "Indiana Watershed Planning Guide"

Indiana Department of Environmental Management, Office of Water Management, 2003, "Water Quality Assessment for the Development of Total Maximum Daily Loads for *E.coli* in Lauramie Creek Watershed." IDEM/100/29/286/005/2003

Indiana Department of Natural Resources, Division of Fish & Wildlife, www.IN.gov/dnr/fishwild/endangered/

Indiana Department of Natural Resources, Division of Nature Preserves. "Endangered, Threatened, and Rare Vascular Plant Species Documented from Indiana" 2005.

Jackson, Marion T., editor, 1997. "The Natural Heritage of Indiana." Indiana University Press. pp. 482.

Kormondy, Edward J., 1996. "Concepts of Ecology," 4th Edition. Prentice Hall, Upper Saddle River, New Jersey.

Lane, E.W., 1955. "The Importance of Fluvial Morphology in Hydraulic Engineering," American Society of Civil Engineering, Proceedings, 81, paper 745: 1-17.

National Agricultural Statistics Service, United States Department of Agriculture, Indiana County Data, 2002. www.nass.usda.gov

Ohio Environmental Protection Agency, 1989, "The Qualitative Habitat Evaluation Index: Rationale, Methods, and Application," Ecological Assessment Section, Division of Water Quality Planning and Assessment.

Omernik, J.M. and Gallant, A.L., 1988. "Ecoregions of the Upper Midwest States," U.S. Environmental Protection Agency Report, EPA 600/3-88/037, 56pp.

Purdue Agricultural Extension. Farm*A*Syst & Home*A*Syst Program. www.agry.purdue.edu/ext/environment.html

Schueler, Thomas, 1995. "Site Planning for Urban Stream Protection," Center for Watershed Protection.

Schueler, Thomas, 2000. "Hydrocarbon Hotspots in the Urban Landscape," Watershed Protection Techniques. 1(1): 3-5.

Schueler, Thomas and Heather Holland, 2000. "The Practice of Watershed Protection" The Center for Watershed Protection.

U.S. Department of Agriculture, NASS Agricultural Chemical Usage 2003, Restricted Use Summary.

U.S. Department of Agriculture, NASS Agricultural Chemical Usage 2003, Field Crops Summary.

U.S. Environmental Protection Agency, 2000, "1999-2000 Indiana Unified Watershed Assessment Fact Sheet"

U.S. Environmental Protection Agency, 2002, "Non-point Source Pollution from Agriculture."

U.S. Geological Survey, U.S. Department of the Interior, "Concentrations of *Escherichia Coli* in the Upper Wabash River Watershed in Indiana, June – September 1998."

ACRONYMS

BMP	Best Management Practice
CFU	Colony Forming Unit
CWA	Clean Water Act
EPA	U.S. Environmental Protection Agency
HUC	Hydrologic Unit Code
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
NPS	Nonpoint Source Pollution
NRCS	Natural Resource Conservation Service
SWCD	Soil & Water Conservation District
TMDL	Total Maximum Daily Load
USDA	U.S. Department of Agriculture
WMP	Watershed Management Plan