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Middle Eel River Watershed Initiative

A Coalition Led By Manchester College

Middle Eel River Watershed Management Plan

January 7, 2011

Miami, Wabash, Kosciusko and Fulton County, Indiana

Funded by IDEM

Clean Water Act Section 319 Grant

and Initiative Partners

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SECTION 1

INTRODUCTION

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1.1 Global & National Freshwater Resources

Clean water is vital to life, it is essential for human survival. Freshwater accounts for only 2.5% of the total water on the planet, much of which is unavailable due to being locked up in glaciers and ice caps. Usable fresh surface water in the form of lakes and rivers accounts for only 0.3% of the total freshwater on the planet (Figure 1-1). It is essential to conserve and protect this very limited and precious natural resource.

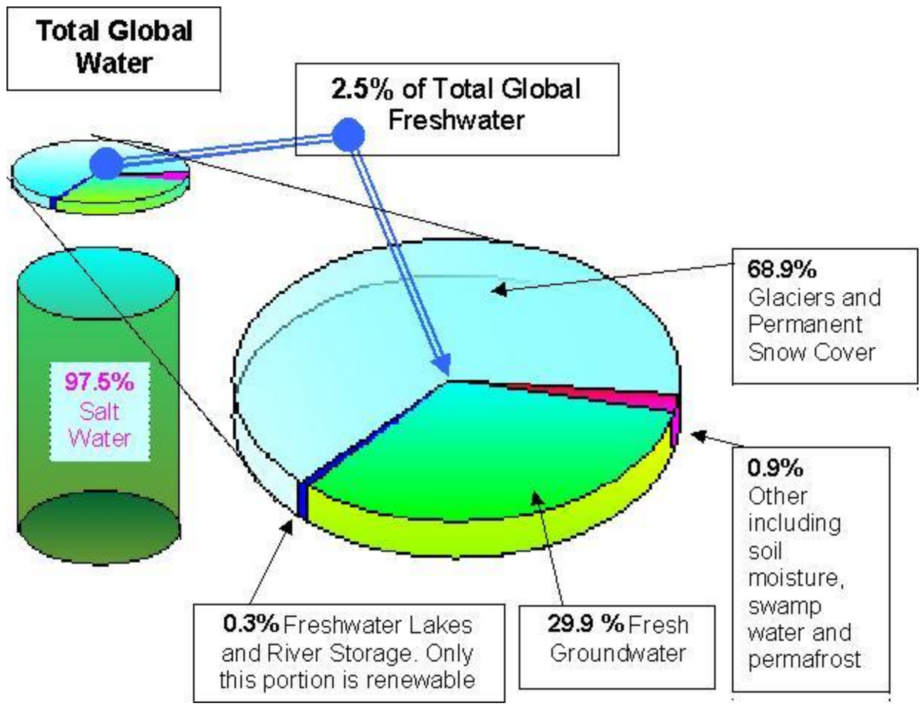

Figure 1-1. UNESCO World Water Resources at the Beginning of the 21st Century.

In the United States, there are more than 3.5 million miles of rivers and streams that are of tremendous value not only to the human population, but also as habitat for aquatic life. Only 25% (870,758 miles) of rivers and streams in the United States have been evaluated for water quality standards and 45.8% (398, 556 miles) of those assessed are impaired or threatened (USEPA National Summary Water Quality Attainment in Assessed Rivers and Streams 2006).

1.2 Indiana Impaired Waters

All states are required to develop and submit a list of impaired waters to USEPA for approval under the Clean Water Act (CWA) Sections 305(b) and 303(d) every two years. River and stream miles in Indiana are assessed by the Indiana Department of Environmental Management (IDEM) for designated beneficial uses and are considered to be impaired if they do not meet standards set by the state for these uses. The 2008 IDEM assessments are listed in Table 1-1, with total designated miles varying with the specific beneficial use. There are 35,673 miles of rivers, streams, ditches, and drainage ways in Indiana.

Table 1-1. Individual Use Support Summary – Indiana Streams.
(Indiana Integrated Water Monitoring and Assessment Report 2008 p. 45).

Designated Beneficial Use	Total Miles Designated	Miles Assessed	Percent Assessed	Miles Fully Supporting	Miles Not Supporting	Percent Assessed Impaired
Aquatic Life Use	32,141	17,535	54.6%	13,913	3,622	21%
Fishable Uses	32,170	4,465	13.9%	1,044	3,420	77%
Drinking Water Supply	102	1	1.0%	0	1	100%
Recreational Use (Human Health	32,173	12,073	37.5%	3,700	8,374	69%

Nonpoint source (NPS) pollution (indirect or scattered sources of pollution that enter a water system through pathways such as drainage or runoff from agricultural fields) is the leading cause of impairment in Indiana rivers and streams, negatively affecting over 6,300 miles (Indiana Integrated Water Monitoring and Assessment Report 2008 p. 48). Degraded water quality negatively affects property values, recreational uses, human and animal health, biotic communities, and our quality of life. Clean water is an essential element to our economic, mental and physical well being.

NPS pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the run-off moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even underground sources of drinking water. These pollutants include:

- excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- oil, grease, and toxic chemicals from urban run-off and energy production;
- sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks;
- salt from irrigation practices and acid drainage from abandoned mines; and,
- bacteria and nutrients from livestock, pet wastes, and faulty septic systems.

Atmospheric deposition (airborne chemical compounds settling onto the land or water surface) and hydromodification (the alteration of the natural flow of water through a landscape) are also sources of NPS pollution.

The origins of NPS pollutants are diffuse and often difficult to trace. Human-related origins of NPS pollution that have been identified as most prevalent in Indiana include:

- animal production operations and feedlots;
- agricultural activities;
- stream bank and shoreline erosion;
- timber harvesting;
- land development;
- on-site sewage disposal units;
- solid waste disposal landfills;
- transportation-related facilities;
- coal mining;
- oil and gas production;
- non-energy mineral extraction; and,
- atmospheric deposition.

Figure1-2 shows the sources of stressors for Indiana's impaired streams by year and miles impacted (IDEM nd).

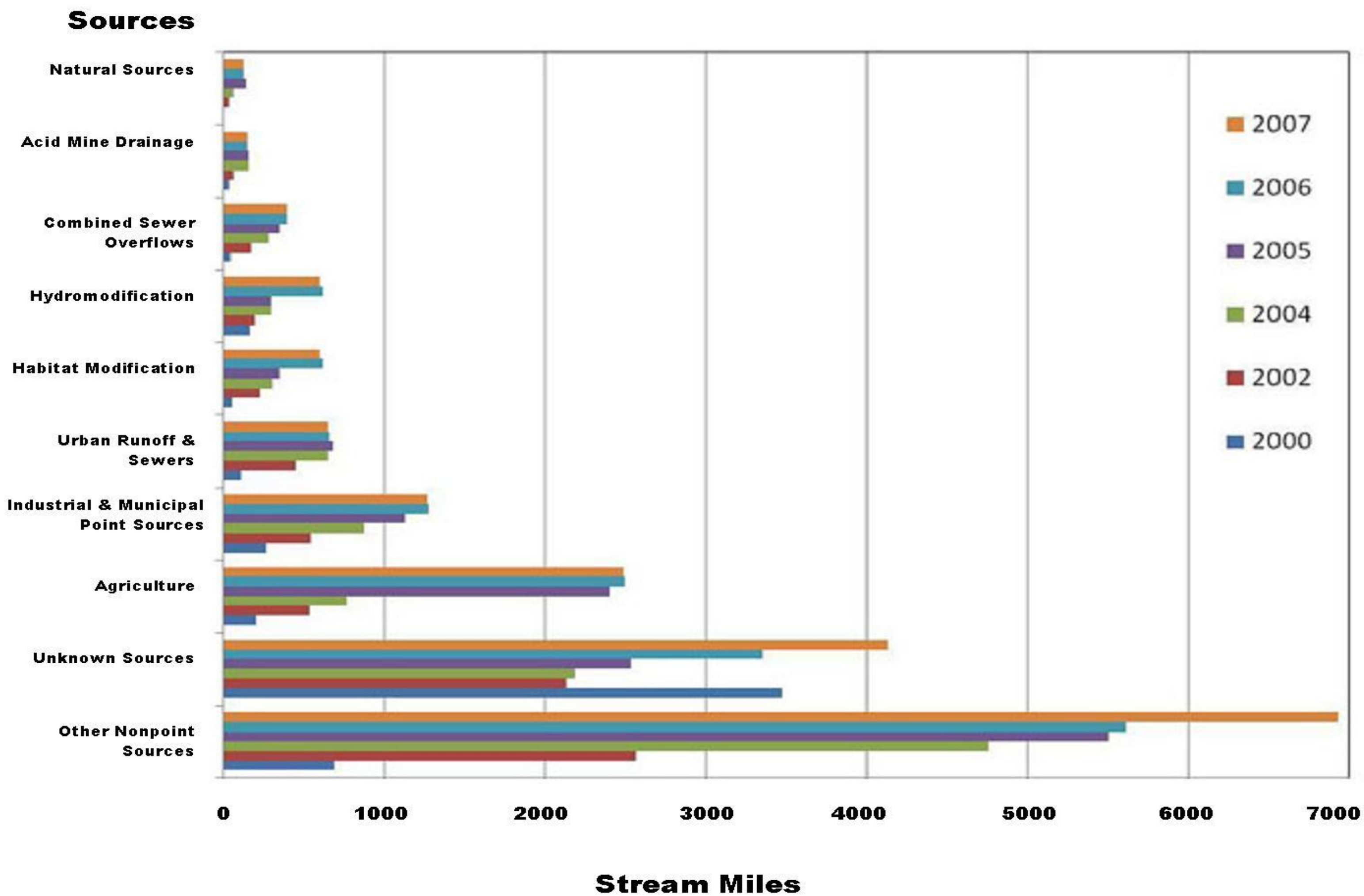

Figure 1-2: Sources of Stressors Impairing Indiana's Streams by year and miles impacted.

1.3 The Watershed Approach

A watershed is an area or region of land that catches precipitation that falls within that area, and funnels it to a particular creek, stream, or river, eventually the water drains into an ocean. Watersheds come in all shapes and sizes, with some only covering an area of a few acres while others are thousands of square miles across.

Watersheds have unique addresses known as hydrologic unit codes (HUCs) which identify their location. The smaller the HUC the larger the watershed, an 8 digit HUC is larger than a 12 digit HUC. The boundaries are geographically defined, ignoring political boundaries. Watersheds are nested within each other as shown below which demonstrates the way a 12 digit HUC may be nested within an 8 digit HUC (Fig. 1-3).

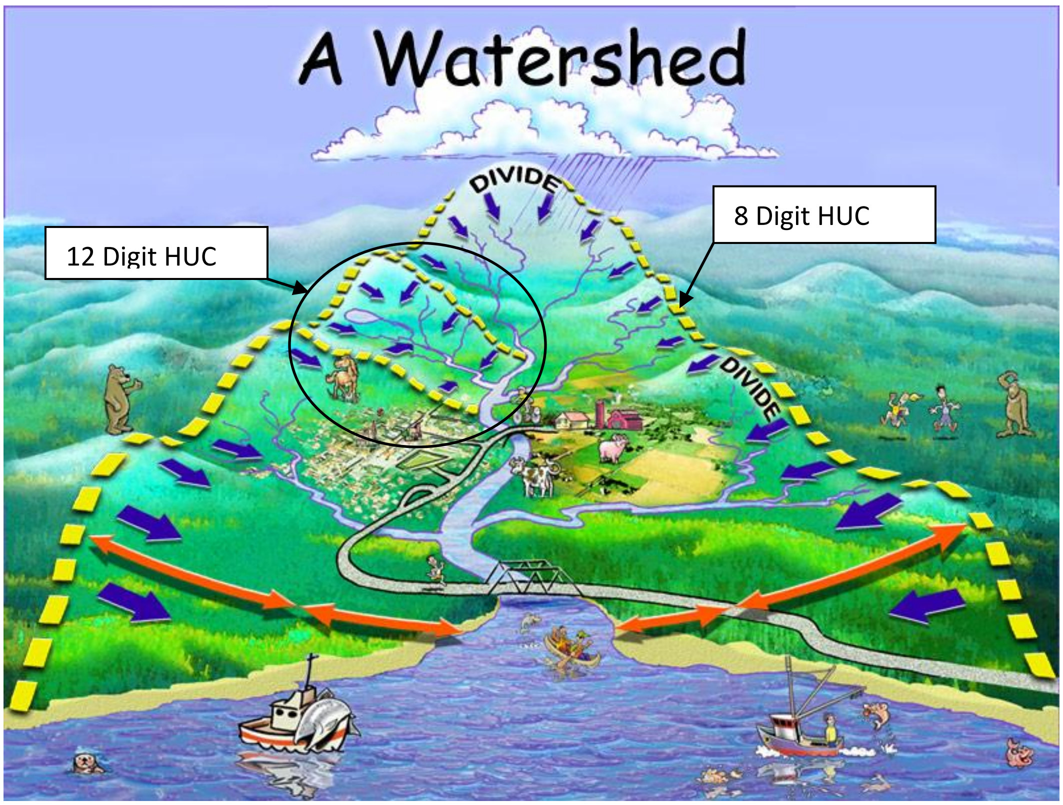

Figure 1-3. Delineation of a watershed. The yellow dashed lines indicate a single watershed. Notice how the smaller subwatershed is within the larger watershed. (RecycleWorks n.d.)

Nonpoint source pollution occurs when it rains or when snow melts and water washes over the land and impervious (incapable of being penetrated) surfaces such as roads, parking lots and compacted soil and removes all of the oil, debris, soil and fertilizer from those surfaces. The water and pollutants then runoff the land or are washed into storm sewers where they flow untreated to the nearest river, lake or groundwater.

Because these pollutants come from several sources instead of one discharge point, it is nonpoint source pollution.

The environmental impacts are gradual, but severe. Over time, the pollutants build up in the waterway and settle in the tissue of fish, sediment bottom and the banks of rivers. Water becomes murky and polluted, rendering it unsafe for people to swim or fish in.

Sediment - ordinary soil - is the number one pollutant of our nation's waterways. When soil enters a waterway as a result of erosion, it prevents sunlight from reaching aquatic plants, clogs fish gills, chokes other organisms, smothers fish spawning beds and negatively affects nursery areas.

Chemical fertilizers contain phosphorous, a nutrient that helps plants grow. Using excessive amounts of fertilizer or applying it close to a shoreline causes the phosphorus to run off. Once in the waterway, the phosphorus feeds algae, causing it to grow rapidly. Large amounts of algae reduce oxygen levels in the water and compromise overall water quality.

Everyone, in some way, contributes to nonpoint source pollution through regular household activities.

You don't have to live near water for your actions to affect water quality. A drop of oil spilled miles from a river will eventually find its way into the ground water, river or lake.

The watershed approach is a flexible framework for managing water resource quality within a specified area. It includes stakeholder involvement and management actions supported by sound science. The watershed plan is a strategy that provides assessment and management information for a geographically defined watershed, including the analysis, actions, participants, and resources related to developing and implementing the plan.

Using a watershed approach to restore impaired waters is beneficial because it addresses the problems in a holistic manner and stakeholders are actively involved in selecting the management strategies that will be implemented to solve the problems.

1.4 Middle Eel River Watershed Management Plan

The Middle Eel River Watershed Management Plan is a comprehensive and collaborative effort that provides a framework for coordinating activities and efforts within the Middle Eel River Watershed to achieve the following mission statement developed by the Steering Committee:

> ***"To protect and enhance the water resources of the Middle Eel River Watershed through education and implementation of soil and water conservation practices".***

The Middle Eel River Watershed Management Plan addresses nonpoint source water pollution of the Middle Eel River by:

- Documenting current water quality conditions, biological integrity and physical characteristics
- Identifying potential causes and sources of pollution
- Identifying strategies to improve water quality
- Raising awareness through a public education and outreach campaign

1.5 Middle Eel River Watershed History

Early in 2007 Manchester faculty began questioning the possibility of a cooperative project that would address the Eel River's water quality. This led to discussions involving Wabash and Miami County Natural Resources Conservation Service (NRCS), Manchester faculty, and IDEM to investigate the possibility of attaining a CWA Section 319 Grant to address water quality concerns in the Eel River. A core group was formed consisting of representatives from Miami County Soil and Water Conservation District (SWCD), Miami County NRCS, Wabash County SWCD, Wabash County NRCS, Indiana Department of Natural Resources (IDNR) Division of Fish and Wildlife, and Manchester College. This core group met numerous times over the course of several months from April 2007 to December 2008. The meetings culminated in Manchester College applying for a CWA Section 319 grant on March 14, 2008.

Without the talented and dedicated effort and support of the core group and our partners, this grant would not have been possible. The partners include businesses, agencies and individuals who are stakeholders within the watershed and are listed in Appendix A.

Notification of grant approval was received by Manchester College on December 12, 2008. The core group met and hired a Watershed Coordinator in December, 2008 to begin work on the project January 1, 2009.

Early in the planning process the Steering Committee for the Middle Eel River Watershed Management Plan (MERWMP) was formed by the core group and the addition of two stakeholders/landowners from Miami County, and two stakeholders/landowners from Wabash County. Kosciusko County SWCD and NRCS joined the group in November 2009.

The Steering Committee meets bimonthly (every other month) to guide the development of the MERWMP and serves as a technical resource to the Watershed Coordinator. In addition to the Steering Committee, two sub-committees were formed: the Education and Outreach Sub-Committee, and the Technical Sub-Committee. The Education and Outreach Sub-Committee meets as needed to coordinate volunteer activities and community outreach, and to encourage public participation. The Technical Sub-committee meets as needed to direct, review, and manage water quality testing analysis for the MERWMP. The Steering Committee and Sub-committees include representatives from Wabash, Miami and Kosciusko Counties SWCDs and NRCS, IDNR Division of Fish and Wildlife, local landowners/farmers, and Manchester College. Steering Committee members are listed in Appendix B.

1.6 Public Participation

To encourage citizen participation, the public was invited to attend Steering Committee meetings. News releases announcing dates and times of the Steering Committee meetings were sent to the local media prior to each meeting. A list of the local news outlets utilized for meeting announcements is listed in Appendix C.

The first annual public meeting was held on Monday, March 16, 2009 at the Honeywell Center in Wabash. Flyers were mailed to partners and churches within the watershed, distributed to libraries and downtown establishments of North Manchester, Peru and Wabash, and an announcement was sent to local media (Appendix C). During this meeting the public was encouraged to ask questions or make comments regarding water quality concerns in the Middle Eel River Watershed. The purpose of this meeting was to gather information from the public, to inform the public about the Middle Eel River Watershed Initiative, and to educate the public about the current water quality conditions through a panel of experts. This was an important initial step in involving the public in the planning process and raising awareness within the watershed. A summary of the meeting is outlined below.

MERWMP – Summary of 1st Public Meeting March 16, 2009

Forty four people attended our first Public Meeting at the Honeywell Center in Wabash, IN, March 16th, 2009. A brief overview of the Initiative was followed by presentations from a panel of experts on the following topics:

- Watershed Management – Angie Brown – IDEM – Watershed Specialist
- Historical Geology – Bill Eberly – President N. Manchester Historical Society
- Fish Communities of the Eel – Ed Braun – DNR District 4 Fisheries Biologist
- *E. coli* – Dr Dave Kreps – Ph. D. Microbiology/Manchester College Professor of Biology
- Suspended sediment – Dr. Jerry Sweeten- Ph.D. Stream Ecology – Director Environmental Studies, Manchester College
- Best Management Practices – Joe Updike and Rick Duff – NRCS Conservationists, Wabash & Miami Counties.

After the presentations there was a period of time for questions and answer. The following questions/comments were raised:

- Concerns about small communities pumping their sewage directly into the river, and failing septic systems.
- Streambank erosion
- Concerns about Flowers Creek and if we were going to be testing there.

- Concerns from a person who lives outside the watershed regarding the possibility of us testing their water. This participant was directed to continue the discussion with Angie Brown from IDEM.
- The question was raised about dam removal and if it is an effective method to improve water quality.

A comment card was handed out upon arrival, and participants were encouraged to complete and return the cards at the end of the meeting. Seventeen cards were completed by participants, a summary of comments received are listed below:

- 14 participants checked the box to be added to our mailing list
- 6 participants checked the box to be added to our volunteer list

How people heard about the meeting

- 2 gave no information
- 1 from the mailing sent to partners
- 1 from the flyers displayed in downtown establishments
- 1 from his work place
- 3 from individual contacts
- 9 from the newspaper announcements

Comments from cards:

- "Just interested in this great project – thanks!"
- "I live next to the river in North Manchester, my kids want to fish and swim in the river but I am hesitant to let them. I have canoed the river and I want to see the river thrive in general."
- "It may be helpful to have periodic releases with recent data results."
- "Amphibian and reptile surveys on the Eel River?"
- "I am 70 years old. The Eel River has been a part of my life for at least 60 years – fishing with my grandfather, hunting along its banks and canoeing."
- "We have been at odds with In Drainage Laws through our adjacent upstream farmer/neighbors in Whitley County. As an artist I walk the Hurricane several times a week and I see first- hand the impact of lagoon pumping, ditch debrushing/spraying with our fish kills – "nutrient' build-up – brown water, loss of frogs, 30 years ago clear water – can see fossils – now all life coated and life there much diminished. – We are technically upstream from your project, but I guarantee you are affected. We own a farm 140 acres directly along Hurricane Creek. I attended the Whitley County Drainage Board Meeting this am. They are planning massive 'debrushing' and spraying over the coming months and of course, some upstream from us (and you as well). Riparian zones are "in the way" of

cropland in Whitley County. Over protest, they remove even fruit trees from home-owners yards so they don't have "drainage problems". And South Whitley sewer treatment plant is on the curve where State Road 14 leaves town to the west. It's completely under water in floods and the sewage is direct to the Eel for it is all on the Eel's bank. We no longer canoe above the Collamer Dam."

- "We are interested in water quality since our property borders the river and our business depends on it."
- 10 No comments

Several people from within the watershed contacted the Watershed Coordinator regarding concerns they have within the watershed. These include:

Silver Lake sedimentation and waste treatment discharge violations due to failing dam.

Severe field run-off, possibly containing pesticides and nutrients as well as sediment from a bottomland field in Laketon, near the old mill race.

Large amount of trash dumped along streambank near the Laketon bog.

Laketon – possible waste water treatment facility

The second annual public meeting was held on February 23, 2010 at Manchester College. An announcement of the meeting was sent to the local media. 50 people attended this meeting. The purpose of this meeting was to educate, inform and update the community on the progress of the Initiative, and to gather information from the community. The 5th draft of the Watershed Management Plan was made available as a hard copy and on CD. An Evaluation Form was distributed to all in attendance to determine if the format of the meeting was helpful to the community. 19 people responded that the information shared was very interesting and informative and that they learned a lot about the watershed and what the water quality concerns are in the Eel River. Good discussion regarding the removal of dams, suspended sediment, excessive nutrients, the level of biotic community followed the meeting. Additionally, there were concerns raised regarding Laketon and their work toward establishing a waste water treatment plant. There was one participant from the Whitley County area of the Eel River, which is outside of the Middle Eel River, concerning dredging, ditching and debrushing in Whitley County.

1.7 Middle Eel River Watershed Location

There are two Eel Rivers in Indiana, one in northern Indiana (HUC 05120104) and one in west central Indiana (HUC 05120203). The focus of this study is the Northern Eel River. The watershed of the Eel River comprises a land area of 529,968 acres (827.07 square miles) and is a state designated canoe/boating route (Figure 2-1) (Natural Resources Commission 2007).

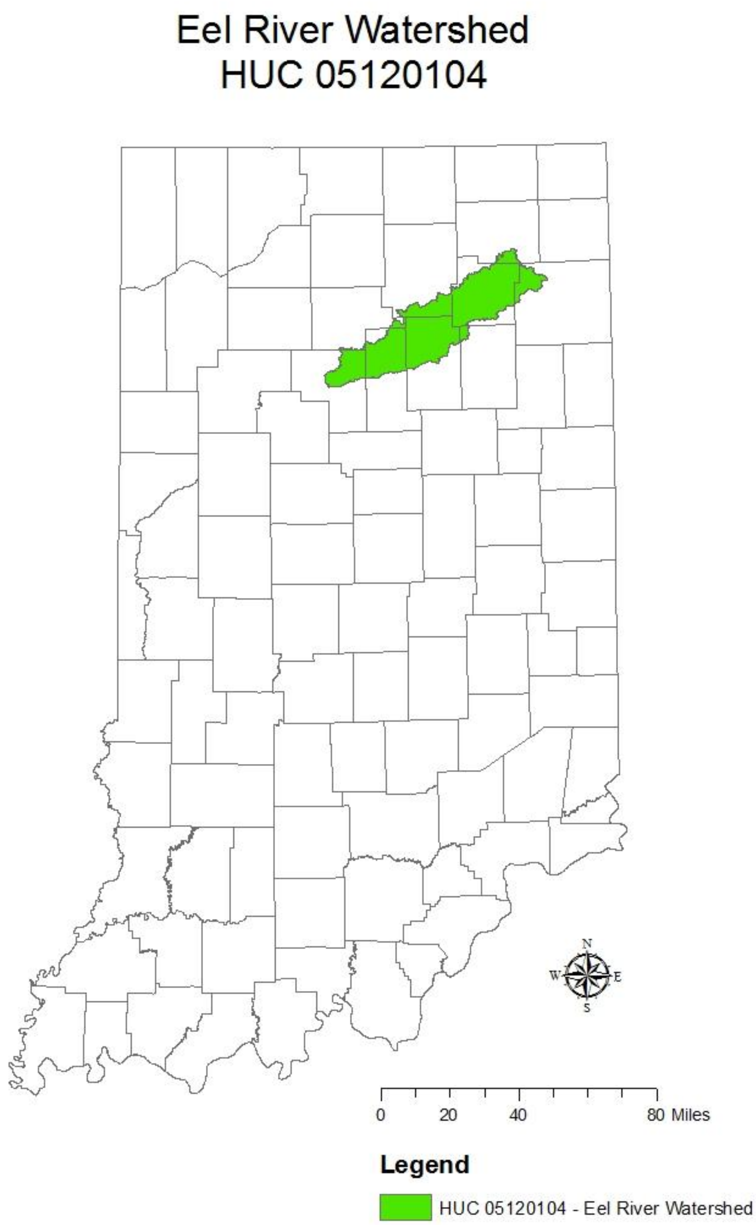

Figure 1-4 Eel River Watershed – 8 Digit HUC 05120104

Many of the Eel River's tributaries, and the mainstem of the Eel River, are on the 2008 Indiana Impaired Water 303(d) List for Escherichia coli (*E. coli)*, Polychlorinated biphenyls (PCBs) and mercury in fish tissue, low dissolved oxygen, impaired biotic community, and excessive nutrients (Table 3-1 pg 3-18 and Figure 3-12, Pg 3-19).

The 30 mile stretch of the Eel River between North Manchester and Mexico, IN is the focus of this project (Figure 1-5).

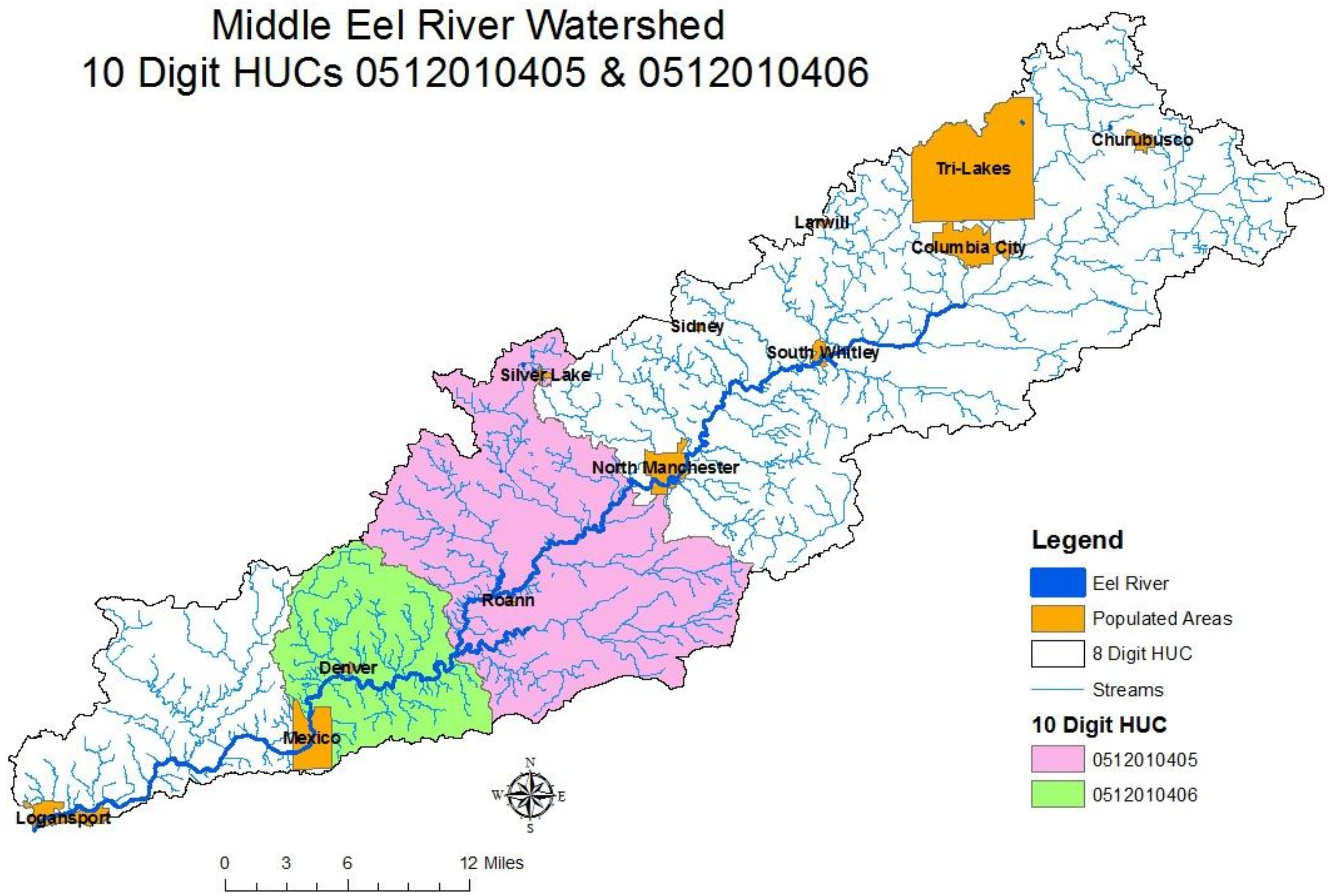

Figure 1-5. Middle Eel River Watershed - 10 Digit HUCS within Eel River 8 Digit HUC

The watershed for this middle section of the river encompasses 169,480 acres (264.812 square miles) predominantly in Miami and Wabash Counties with very small areas in Koskiusko and Fulton Counties (Figure 1-6). Towns within the watershed include Silver Lake, North Manchester, Roann, Denver and Mexico, IN.

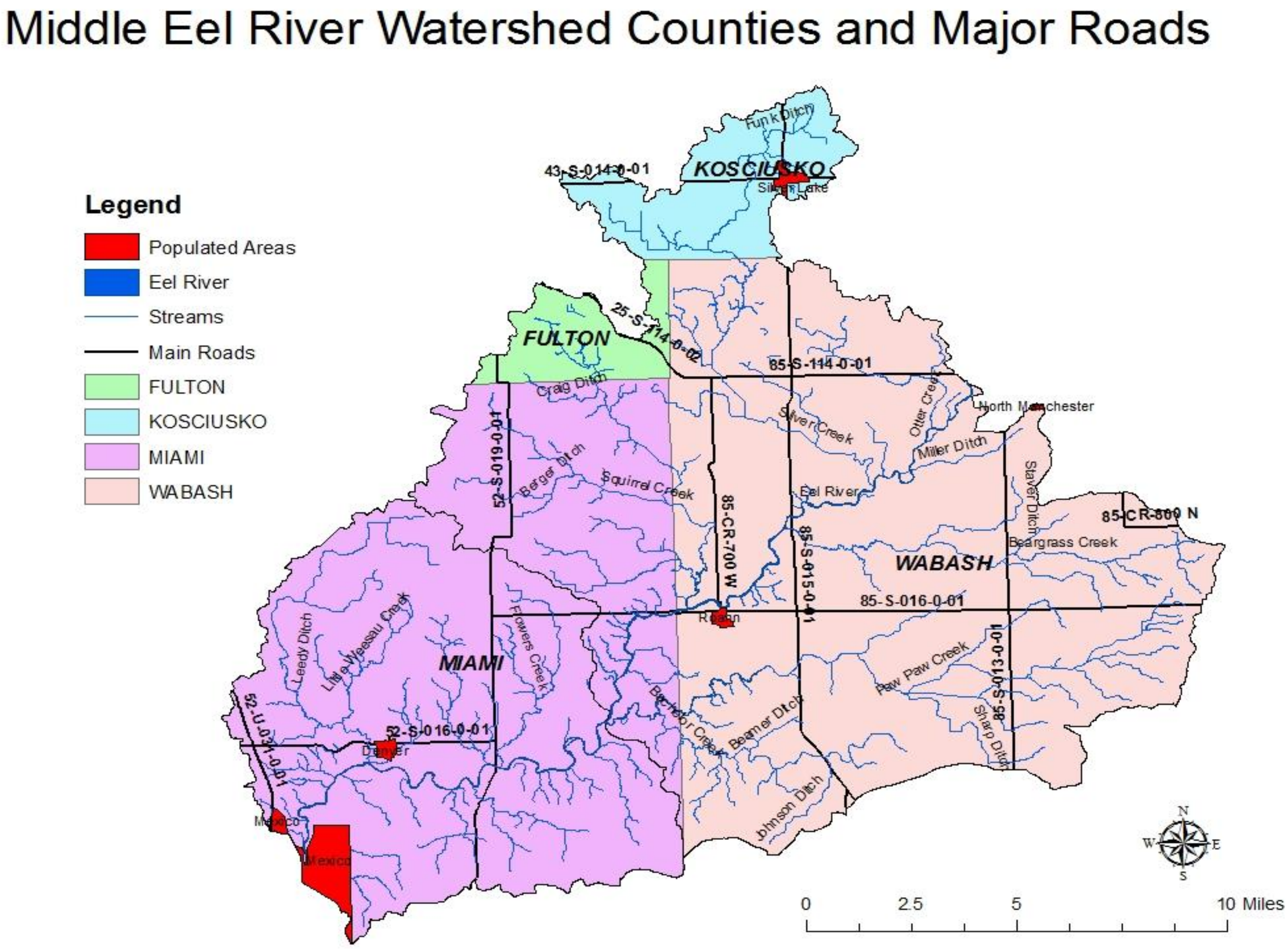

Figure 1-6. Middle Eel River Watershed, Major Roads and Counties

Middle Eel River Watershed Management Plan

SECTION 2

PHYSICAL DESCRIPTION OF THE WATERSHED

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2.1 Middle Eel River Watershed Location

The Eel River Watershed (Figure 2-1), eight digit hydrologic unit code (HUC) 05120104, in north central Indiana is a major tributary to the upper Wabash River (Gammon 1990). With a watershed area of 827.07 square miles, the Eel River is 110 miles long and originates in Allen County, Indiana. The stream flows in a southwesterly direction, passing through a total of six counties, descending approximately 2.41 feet per mile and empties into the Wabash River near Logansport in Cass County, Indiana (Gammon 1990).

The focus of this watershed management plan is the Middle Eel River Watershed (Figure 2-2) which consists of two sub-watersheds of the Eel River Watershed, ten digit hydrologic unit code (HUC) 0512010406 - Weesau Creek-Eel River (downstream) with an average slope of 3.4%, and ten digit HUC 0512010405 - Paw Paw Creek-Eel River (upstream) with an average slope of 3.3%.

The Middle Eel River Watershed is comprised of 30.13 river miles from North Manchester to Mexico, Indiana and drains a land area of 169,480 acres (265 mi^2). The Middle Eel River Watershed is within four counties as displayed in Table 2-1 and Figure 2-3.

Table 2-1. Middle Eel River Watershed – acreage per county.

County	Acres
Wabash	83,180
Miami	71,548
Kosciusko	9,586
Fulton	5,166
TOTAL	169,480

The Eel River, from South Whitley to its confluence with the Wabash River in Logansport (63 river miles), is designated as an outstanding river by the Indiana Department of Natural Resources as noted in the Indiana Register, Volume 16, Number 6, (16 IR 1677) on March 1, 1993 under the title "Natural Resources Commission, Information Bulletin #4, Outstanding Rivers List for Indiana". The outstanding rivers list is a roster of streams in the State which have particular environmental or aesthetic value.

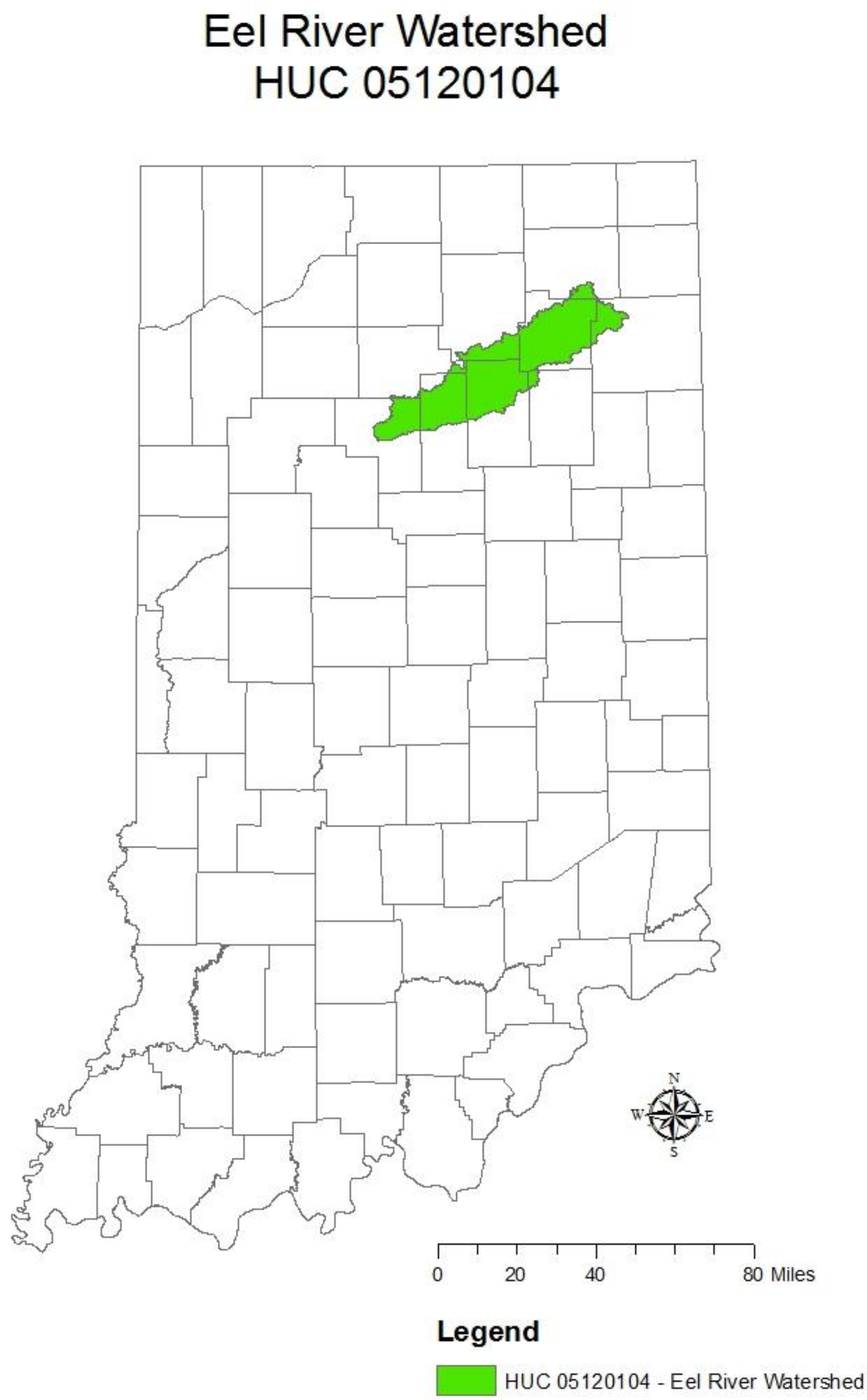

Figure 2-1. Eel River Watershed – 8 Digit HUC 05120104

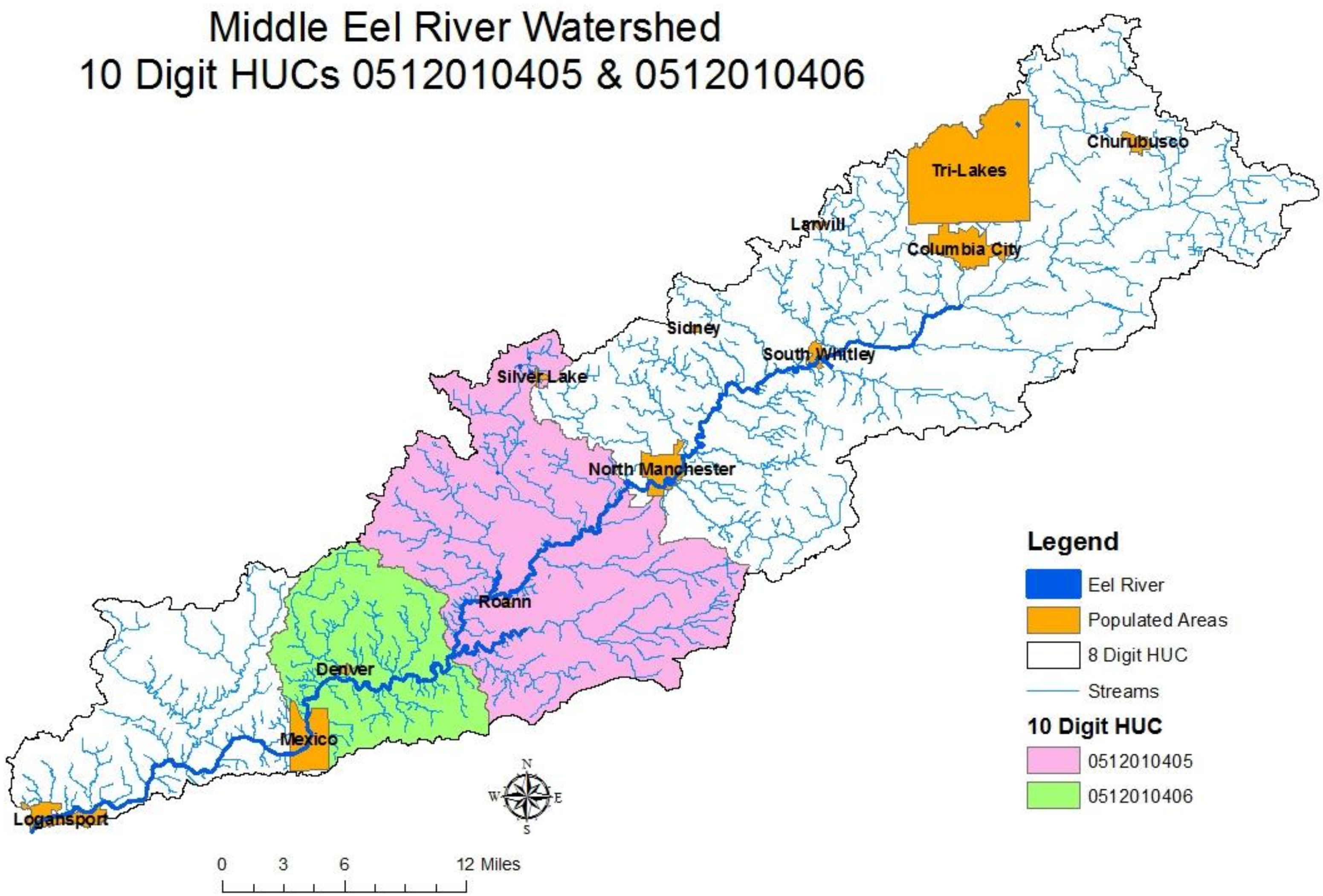

Figure 2-2. Middle Eel River Watershed - 10 Digit HUCS within Eel River 8 Digit HUC

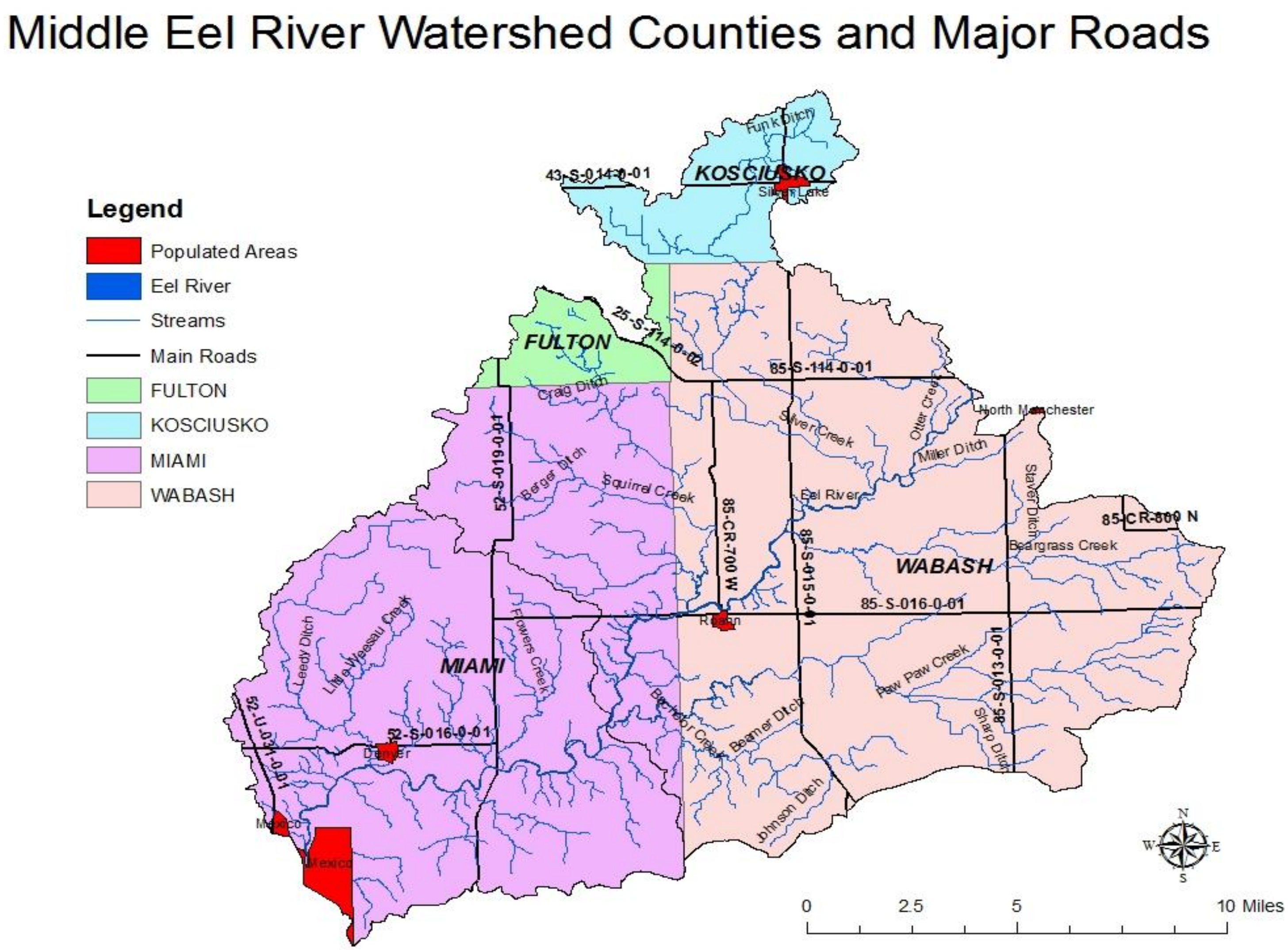

Figure 2-3. – Middle Eel River Watershed, Major Roads and Counties

2.2 – Sub-watersheds - 12 Digit Hydrologic Unit Codes

The Middle Eel River watershed contains twelve - 12 digit HUCs listed in Table 2-2 and Figure 2-4 below.

Table 2-2. Middle Eel River Watershed, 12 Digit Hydrologic Unit Codes, Geographic Names and Watershed Areas (Indiana Natural Resources Conservation Service 2005).

HUC Name	12 digit HUC	Watershed Acres
Sub-watershed 0512010406		
Flowers Creek-Eel River	051201040601	13581
Little Weesau Creek - Weesau Creek	051201040602	14853
Washonis Creek – Eel River	051201040603	20789
Sub-watershed 0512010405		
Silver Creek	051201040501	20163
Otter Creek - Eel River	051201040502	13101
Beargrass Creek	051201040503	14793
Bolley Ditch	051201040504	10586
Squirrel Creek	051201040505	15192
Sharp Ditch - Paw Paw Creek	051201040506	14161
Bachelor Creek - Paw Paw Creek	051201040507	11175
Oren Ditch - Paw Paw Creek	051201040508	9782
Town of Roann – Eel River	051201040509	11304
	TOTAL ACRES	169480

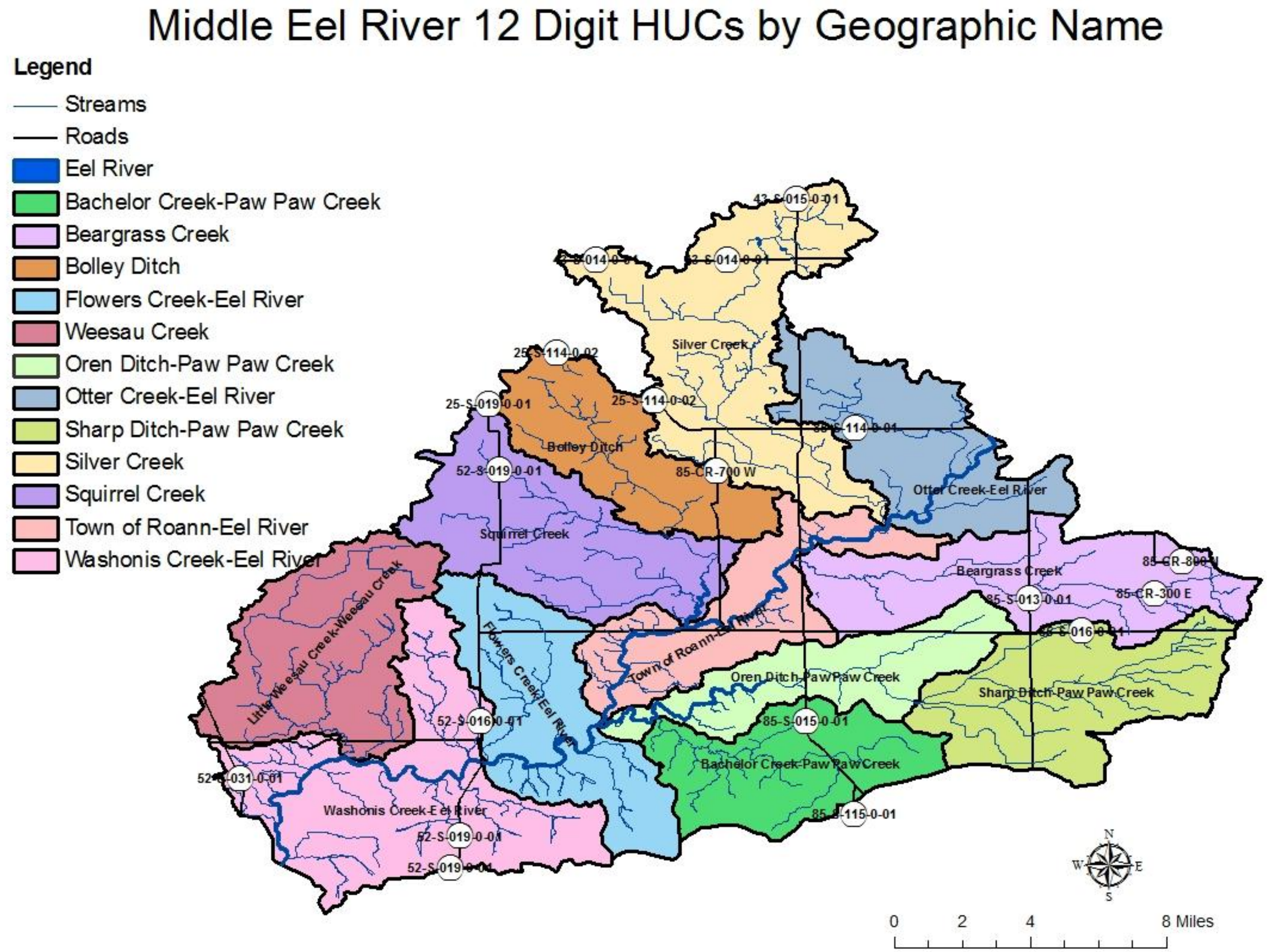

Figure 2-4 – Middle Eel River 12 Digit HUCs with Geographic Names - U.S. Geological Survey and Natural Resources Conservation Service.

2.3 Natural Regions

The Eel River is the dividing line between two natural regions, the Central Till Plain to the south of the river and the Northern Moraine and Lake Region to the north of the river, Figure 2-5.

The **Central Till Plain Natural Region** extends throughout the central portion of Indiana and is the largest natural region in the state. Nearly all the region was thickly covered and reshaped by glaciers of the Quaternary age. Glaciers covered parts of present-day Indiana at least three times during the Pleistocene Epoch (Center for Earth and Environmental Science 2003). Wisconsin and pre-Wisconsin (Illinoian and pre-Illinoian) age glaciers covered central Indiana and left deposits of till containing clay, silt, sand and gravel. Large amounts of sand and gravel outwash (glacial material which is deposited by water melting off glaciers) were deposited as both outwash plains and valley trains (Center for Earth and Environmental Science 2003). Patchy thin loess (A buff to gray windblown deposit of fine-grained, calcareous silt or clay) occurs on parts of the Wisconsin glacial deposits and swamp and lake deposits are common in poorly drained parts of the landscape. Unconsolidated deposits may be several hundred feet thick (Center for Earth and Environmental Science 2003).

Parts of glaciated Indiana are hilly and the **Northern Lakes Natural Region** typifies this kind of terrain and is noted for its spectacular scenery. Part of the topographic expression is the result of moraine (accumulated earth and stones deposited by a glacier) formation by active ice and by the overspreading of the region with ablation (the melting of snow or ice that runs off the glacier) or flow till that formed during times of glacial retreat. Large depressional areas, some of which contain lakes, form when large blocks of the melting glacial ice are buried beneath outwash sediments. With time, the buried ice blocks melt leaving behind a kettle hole or a kettle lake (Center for Earth and Environmental Science 2003).

2.4 Ecoregions

Ecoregions are areas of relative homogeneity in the quality and quantity of ecological systems and their components including soils, vegetation, climate, geology and physiography and are determined by different patterns of human stresses on the environment and different patterns in the existing attainable quality of environmental resources (EPA Ecoregions of the United States 1999).

The approach used to compile ecoregion maps is based on the premise that ecological regions can be identified by analyzing the patterns and composition of biotic (living) and abiotic (non-living) phenomena that affect or reflect differences in ecosystem quality and integrity. These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology (EPA Ecoregions of the United States 1999).

The relative importance of each factor varies from one ecological region to another, regardless of the hierarchical level. Because of possible confusion with other meanings of terms for different levels of ecological regions, a Roman numeral classification scheme has been adopted for this effort. Level I is the coarsest level, dividing North America into 15 ecological regions. At Level II, the continent is subdivided into 52 classes, and at Level III the continental United States contains 99 ecoregions. Level IV ecological regions are further subdivisions of level III units (EPA Ecoregions of the United States 1999).

The Eel River serves as a dividing line between two Level III Ecoregions as defined by the Environmental Protection Agency (EPA) (Figure 2-6). The watershed north of the Eel River falls within the Level III Ecoregion of The Southern Michigan/Indiana Drift Plains, while the watershed south of the Eel River falls within The Eastern Corn Belt Plains Region.

The eastern portion of the watershed north of the river is located in The Lake Country, Ecoregion Level IV. The Lake Country, is a hummocky and pitted morainal area characterized by many pothole lakes, ponds, marshes, bogs, and clear streams. The well drained end moraines and kames (a hill of sorted and layered gravel and sand, deposited in openings in stagnating or retreating glaciers) once supported oak-hickory forests whereas wetter areas had been beech forests or northern swamp forests. The very poorly drained kettles had tamarack swamp, cattail-bulrush marshes, or sphagnum bogs (Griffith & Omernik 2008).

The western portion of the watershed north of the river is located in The Middle Tippecanoe Plains, Ecoregion Level IV. The Middle Tippecanoe Plains is level to rolling and covered by ground moraine, dunes, end moraines, and lacustrine deposits (material deposited by or settled out of lake waters and exposed by the lowering of water levels or the elevation of land) (Griffith & Omernik 2008).

The entire watershed south of the river is located in The Clayey, High Lime Till Plains, Ecoregion Level IV. The Clayey, High Lime Till Plains is a transitional area with soils that are less productive and more artificially drained than the southern portion of this ecoregion, with fewer swampy areas than the northeastern portion of this ecoregion. Corn, soybean, wheat, and livestock farming are dominant and have replaced the original beech forests and scattered elm-ash swamp forests (Griffith & Omernik 2008).

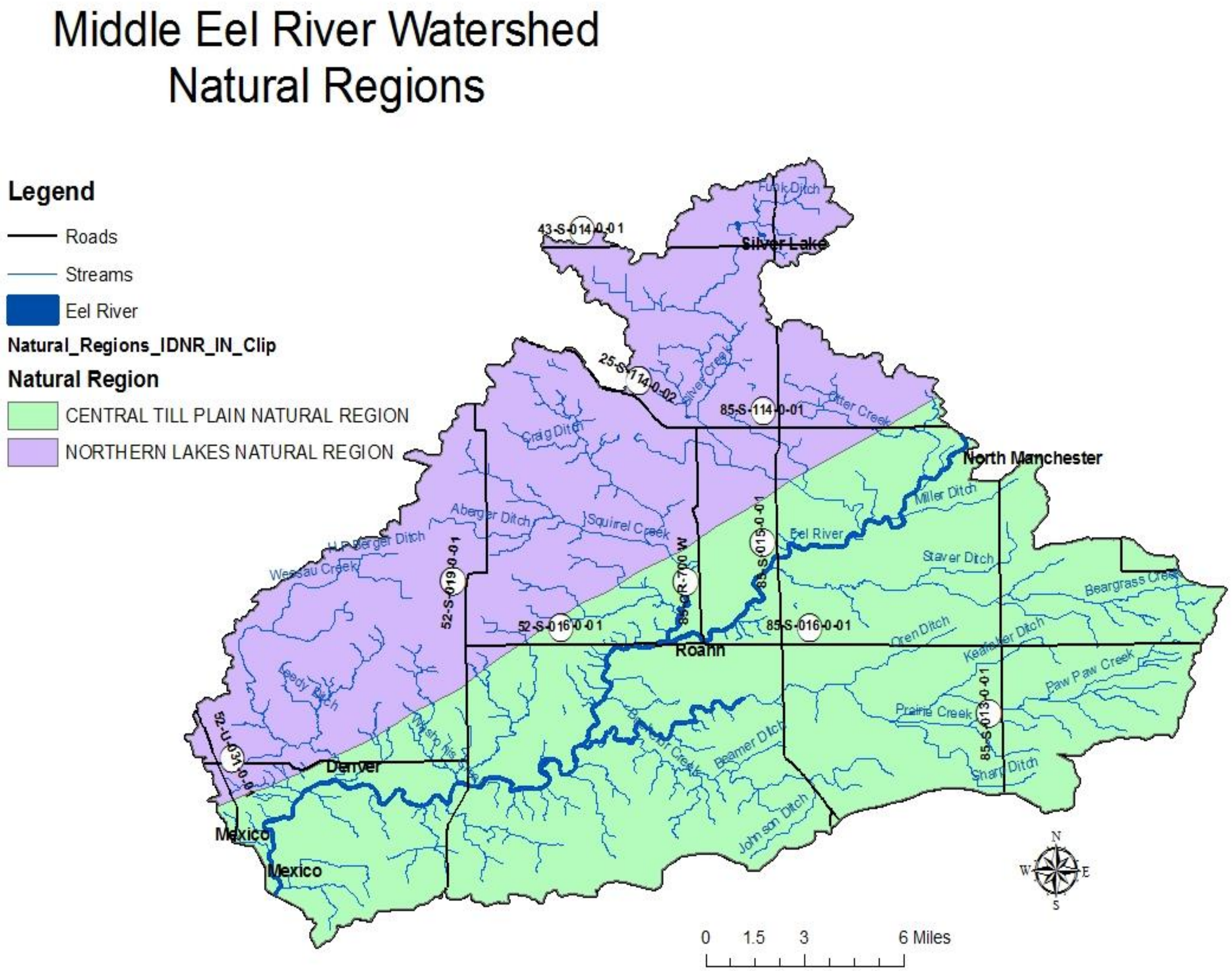

Figure 2-5. Natural Regions of Indiana - Indiana Geological Survey 1984.

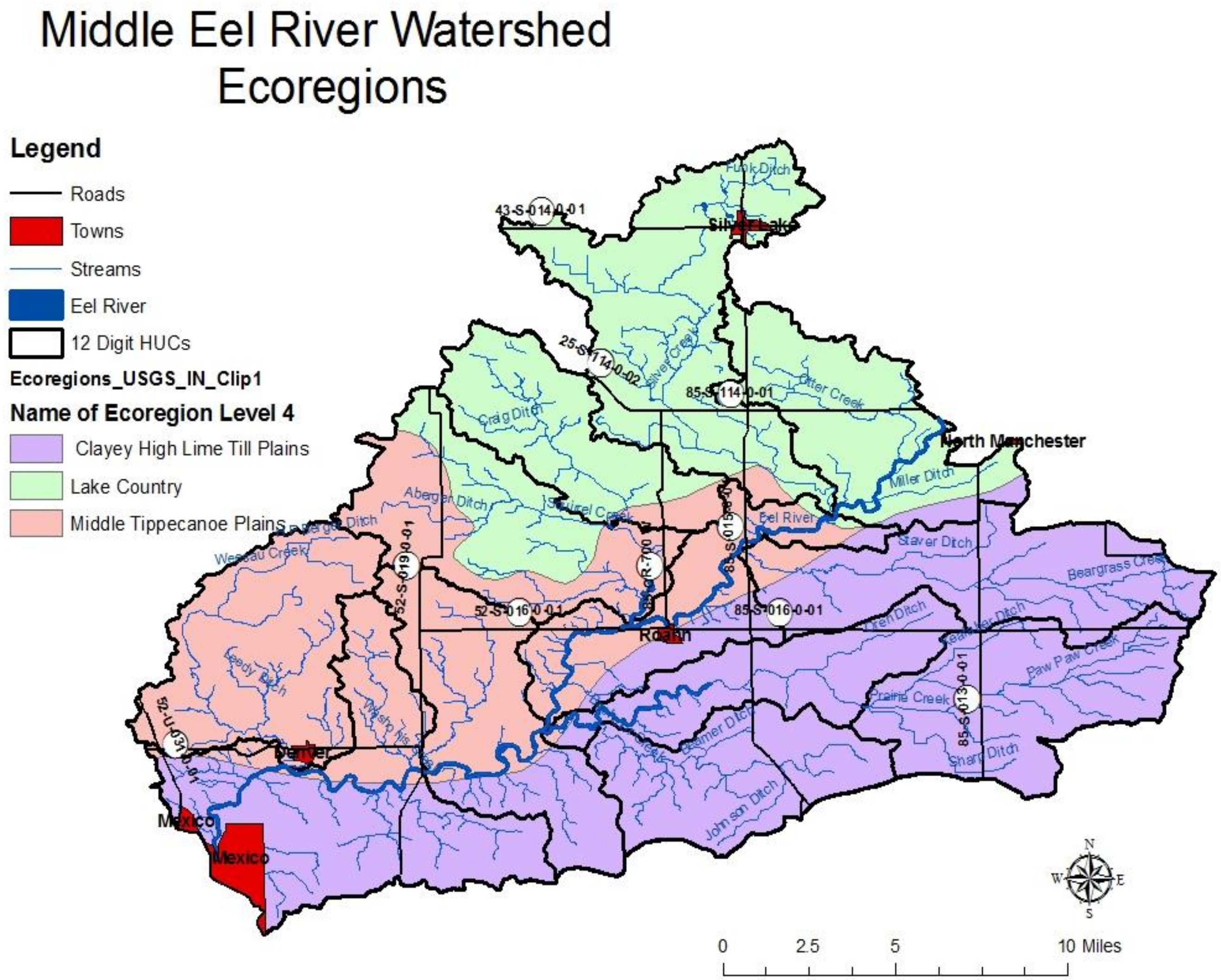

Figure 2-6. Middle Eel River Watershed, Ecoregions - Indiana Geological Survey 1984.

2.5 Soils

2.5.1 Hydrologic Soil Groups

Hydrologic group is a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonally high water table, and saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently.

Hydrologic groups are used in equations that estimate runoff from rainfall. These estimates are needed for solving hydrologic problems that arise in planning watershed-protection and flood-prevention projects, for planning or designing structures for the use, control, and disposal of water. They pertain to the minimum steady ponded infiltration under conditions of a bare wet surface.

Soils are classified by the Natural Resource Conservation Service (NRCS) into four Hydrologic Soil Groups based on the soil's runoff potential. The four Hydrologic Soil Groups are A, B, C and D. Where A soils generally have the smallest runoff potential and D soils the greatest (USDA TR-55).

Group A is sand, loamy sand or sandy loam types of soil. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This soil has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

Hydrologic soils in the Middle Eel River Watershed consists of 49.3% Group C, and 46% Group B, with very small percentages of Group D (2.2%) and Group A (2.6%). Hydrologic Soil and their percent of the watershed are listed in Table 2-3.

Table 2-3. Middle Eel River Watershed hydrologic soils by subwatershed including number of acres and percentage of watershed. (Choi, Engel & Theller, 2005)

Hydrologic Soil Group	**Group A Lowest Potential Runoff**	**Group B**	**Group C**	**Group D Highest Potential Runoff**
HUC 0512010405				
Acreage	1,389.4	17,560.9	29,397.4	365.9
% of Watershed	2.8%	36.0%	60.3%	0.7%
HUC 0512010406				
Acreage	2,997.6	59,989.3	53,752.3	3,276.8
% of Watershed	2.5%	50.0%	44.8%	2.7%
Watershed Totals				
Acreage	4,387.0	77,550.2	83,149.7	3,642.7
% of Watershed	2.6%	46.0%	49.3%	2.2%

2.5.2 Soil Associations

A soil association is a geographic area consisting of landscapes on which soils are formed. A soil association consists of one or more major soils series (soils that are very similar) and at least one minor soil series and is named for the major soil series in the geographic area (Figure 2-7). Soil associations provide a broad perspective of the soils and landscapes in the watershed, and provide a basis for comparing the potential of large areas of the watershed for general kinds of land use.

Soil Associations north of the Eel River consist primarily of Miami-Wawasee-Crosier, Blount-Glynwood-Morley, Oshtemo-Kalamazoo-Houghton with very small sections of Spinks-Houghton-Boyer and Houghton-Adrian-Carlisle Associations (Figure 2-7).

Soil Associations south of the Eel River consist of: Oshtemo-Kalamazoo-Houghton, Blount-Glynwood-Morley, Blount-Pewamo-Glynwood, Crosier-Brookston-Barry, Rensselaer-Darroch-Whitaker and Fincastle-Brookston-Miamian (Figure 2-7).

Soil series definitions (Soil Survey of Wabash County 1979):

The Blount series consists of very deep soils that are moderately deep or deep to dense till. They are somewhat poorly drained, slowly permeable soils. They formed in till. These soils are on till plains and have slopes ranging from 0 to 6 percent. Almost all areas of Blount soils are cultivated. Corn, soybeans, small grain, and meadow are the principal crops. Native vegetation is hardwood forest.

The Crosier series consists of very deep, somewhat poorly drained soils formed in till on till plains and moraines. They are moderately deep to dense till. Slope ranges from 0 to 4 percent. Soils are used to grow corn, soybeans, and small grain (wheat and oats). Some areas are used for hay and pasture. A few areas are in woods. Native vegetation is deciduous forest.

The Fincastle series consists of very deep, somewhat poorly drained soils that are deep to dense till. The Fincastle soils formed in loess or other silty material and in the underlying loamy till. They are on till plains. Slope ranges from 0 to 6 percent. These soils are mostly cultivated. Corn, soybeans, wheat, and clover-grass mixtures are the principal crops. Native vegetation is hardwood forest.

The Houghton series consists of very deep, very poorly drained soils formed in herbaceous organic deposits more than 51 inches thick in depressions on lake plains, outwash plains, ground and end moraines and on floodplains. These soils have moderately slow to moderately rapid permeability. Slope ranges from 0 to 2 percent. A considerable area of these soils is used for cropland or pasture. Common crops are onions, lettuce, potatoes, celery, radishes, carrots, mint, and some corn. Native vegetation was primarily of marsh grasses, sedges, reeds, buttonbrush, and cattails. Some water-tolerant trees were near the margin of the bog.

The Miami series consists of very deep, moderately well drained soils that are moderately deep to dense till. The Miami soils formed in as much as 46 cm (18 inches) of loess or silty material and in the underlying loamy till. They are on till plains. Slope ranges from 0 to 60 percent. Most areas are used to grow corn, soybeans, small grain, and hay. Much of the more sloping part is in permanent pasture or forest. Native vegetation is deciduous forest.

The Oshtemo series consists of very deep, well drained soils formed in stratified loamy and sandy deposits on outwash plains, valley trains, moraines, and beach ridges. Permeability is moderately rapid in the upper loamy materials and very rapid in the lower sandy materials. Slope ranges from 0 to 55 percent. Most areas are cultivated. Principal crops are small grains, soybeans, corn, and hay. The remainder is in forest or permanent pasture. Native vegetation is hardwood forest of oak, hickory, and sugar maple.

The Rensselaer series consists of very deep, poorly drained or very poorly drained soils formed in loamy sediments on till plains, stream terraces, outwash terraces, outwash plains, glacial drainage channels, and lake plains. Permeability is moderate. Slope ranges from 0 to 2 percent. Soils are used to grow corn, soybeans, and small grain. Native vegetation is swamp grasses and deciduous hardwood forest.

The Spinks series consists of very deep, well drained soils formed in sandy eolian or outwash material. They are on dunes, moraines, till plains, outwash plains, beach ridges, and lake plains. Permeability is moderately rapid. Slope ranges from 0 to 70 percent. Spinks soils are used mostly for hay production or pasture. Some areas are cropped to corn, wheat, oats, and soybeans. A small part is in orchards. Steeper areas are in forest or permanent pasture. The native vegetation is hardwoods, dominantly of oak and hickory.

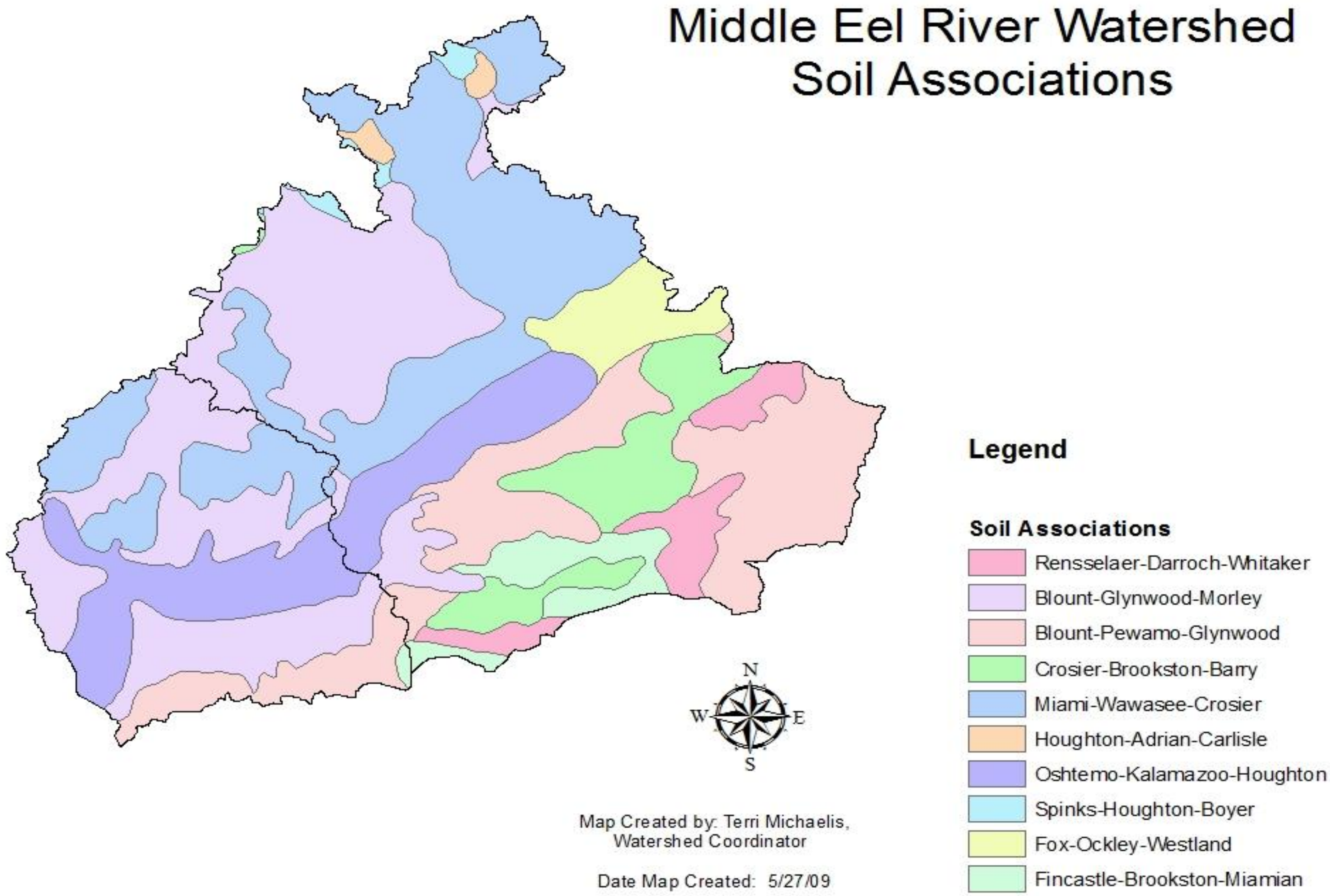

Figure 2-7. Middle Eel River Watershed Soil Associations - Indiana Geological Survey 1994.

2.5.3 Highly Erodible Land

Highly erodible soils in the Watershed were determined using the Indiana NRCS Highly Erodible Land (HEL) list uses soil type to determine HEL category. Highly erodible lands are more vulnerable to erosion which may result in an increase of total suspended solids (TSS) in rivers, creek and ditches, negatively impacting the biological community. In addition, phosphorus binds with soil particles, and as soil erodes it carries phosphorus with it and deposits it in streams, ditches and rivers. This can cause excess total phosphorus in the water, resulting in excessive algal growth and low dissolved oxygen. A map of HEL within the Middle Eel River Watershed is shown in Figure. 2-8.

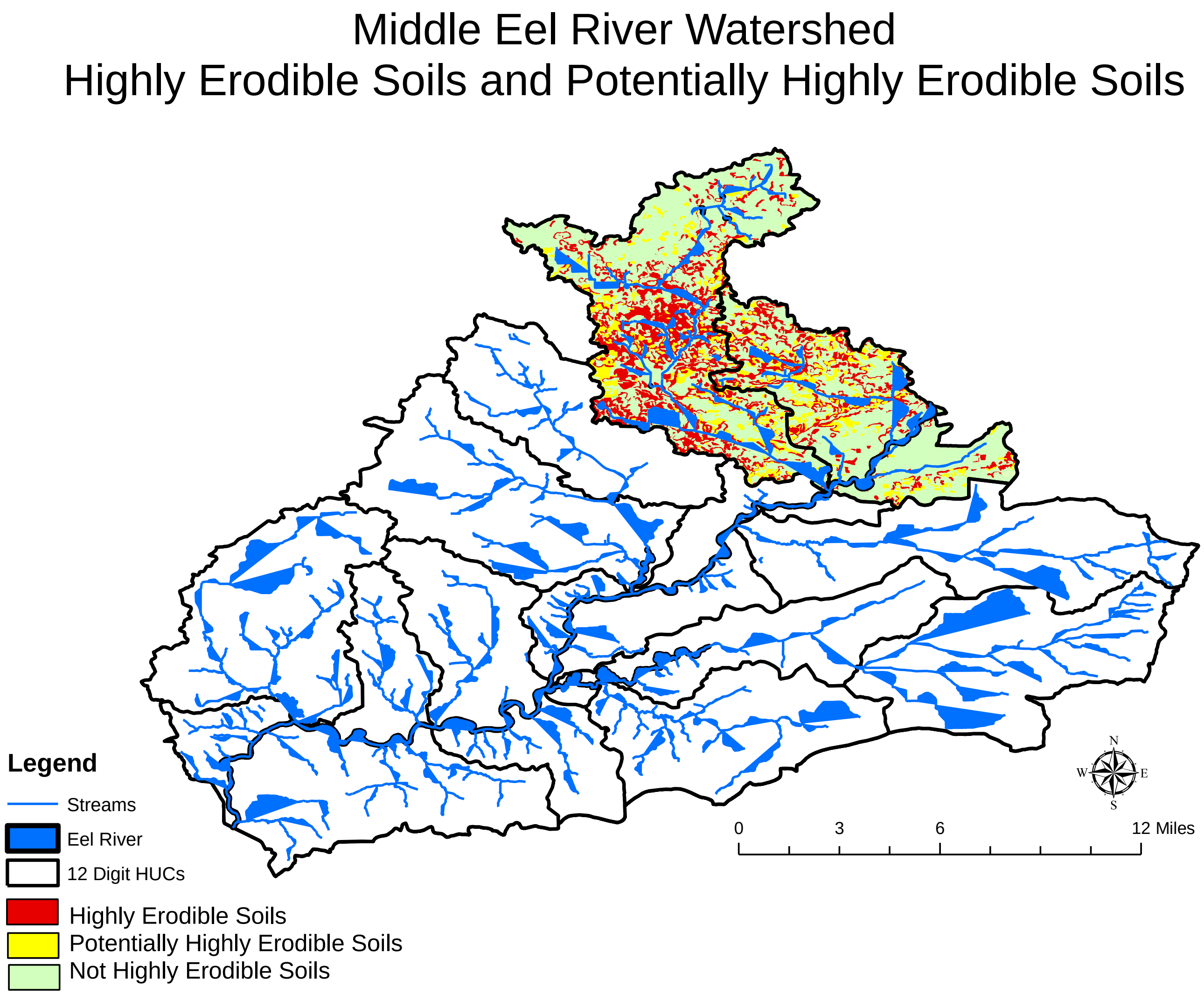

Figure 2-8. Middle Eel River Watershed Highly Erodible Land (HEL)

2.6 Aquifers

2.6.1 Bedrock Aquifers

The occurrence of bedrock aquifers depends on the original composition of the rocks and subsequent changes which influence the hydraulic properties. Post-depositional processes which promote jointing, fracturing, and solution activity of exposed bedrock generally increase the hydraulic conductivity (permeability) of the upper portion of bedrock aquifer systems. Because permeability in many places is greatest near the bedrock surface, bedrock units within the upper 100 feet are commonly the most productive aquifers.

The bedrock aquifer system for the Middle Eel River Watershed is the Silurian (425 million to 405 million years ago) and Devonian (405 million to 345 million years ago) Carbonates, Figure 2-9. Rock types exposed at the bedrock surface include moderately productive to prolific limestones and dolomites with varying amounts of interbedded shale. Most of the bedrock aquifers in the watershed are under confined conditions, meaning the water level in most wells completed in bedrock rises above the top of the water-bearing zone.

The yield of a bedrock aquifer depends on its hydraulic characteristics and the nature of the overlying deposits. Shale and clay act as aquitards, restricting recharge to underlying bedrock aquifers. However, fracturing and/or jointing may occur in aquitards, which can increase recharge to the underlying aquifers. Hydraulic properties of the bedrock aquifers are extremely variable.

The susceptibility of bedrock aquifer systems to surface contamination is largely dependent on the type and thickness of the overlying sediments. However, because bedrock aquifer systems may have complex fracturing systems, once a contaminant has been introduced into a bedrock aquifer system, it will be difficult to track and remediate.

The Silurian and Devonian Carbonate Aquifer System includes carbonate rock units (limestone and dolomite) with some interbedded shale units. In Miami County the system consists of Pleasant Mills formation and Wabash formation of Silurian age, and the Muscattauck group of Devonian age. The total thickness of the Silurian and Devonian Carbonates Aquifer System in Miami County ranges from about 100 feet to 500 feet. In Wabash County the system outcrops/sub-crops throughout nearly all the county. This aquifer system consists primarily of Silurian age carbonates and middle Devonian age carbonates of the Muscatatuck Group. Total thickness of this aquifer in Wabash County ranges from 0 to about 500 feet.

Wells penetrating the Silurian and Devonian Carbonates Aquifer in Miami County have reported depths ranging from 35 to 500 feet, but are commonly 80 to 170 feet deep. The amount of rock penetrated in this system in Miami County typically ranges from 35 to 120 feet. Wells in Wabash County penetrating this system have reported depths of 32 to 514 feet, but are typically 100 to 200 feet deep. The amount of rock penetrated in this system in Wabash County typically ranges from 30 to 90 feet.

The Silurian and Devonian Carbonate Aquifer System is generally not very susceptible to surface contamination because thick clay deposits overlay the system. However, in areas where overlying clays are thin or absent, the system is at moderate to high risk to contamination (Indiana Department of Natural Resources – Division of Water 2007).

2.6.2 Unconsolidated Aquifers

Unconsolidated aquifers (Figure 2-10) are the most widely used aquifers in Indiana. Types of unconsolidated aquifers include surficial, buried, and discontinuous layers of sand and gravel. Most of the surficial sand and gravel is located in large outwash plains in northern Indiana and along the major rivers in the southern two-thirds of the State. Buried sand and gravel aquifers underlie much of the northern two-thirds of Indiana, where they are typically interbedded with till deposits and can be 10 to 400 ft deep. Discontinuous sand and gravel deposits are present as isolated lenses, primarily in glaciated areas.

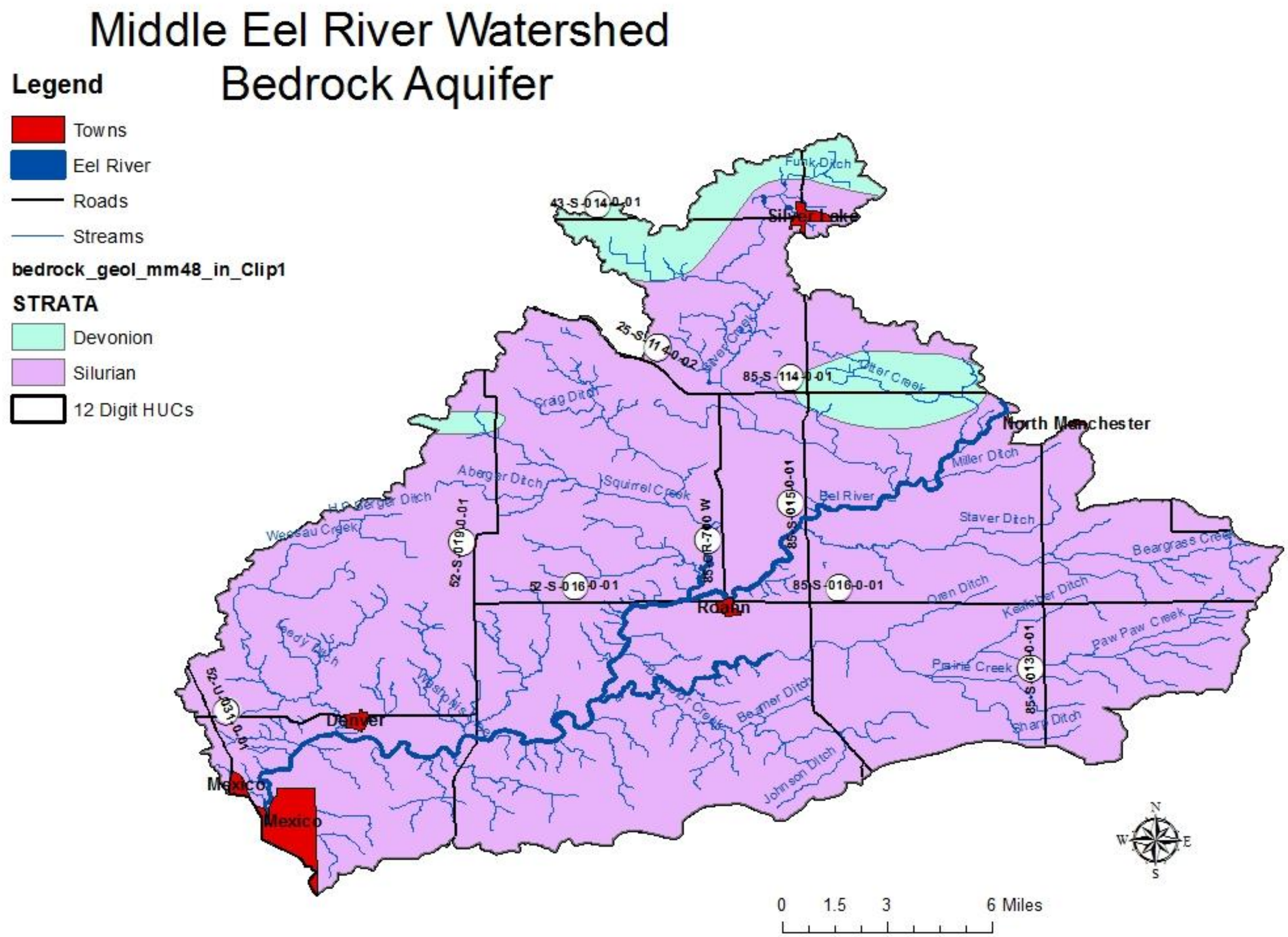

Figure 2-9. Middle Eel River Bedrock Aquifer (Indiana Geological Society 1994)

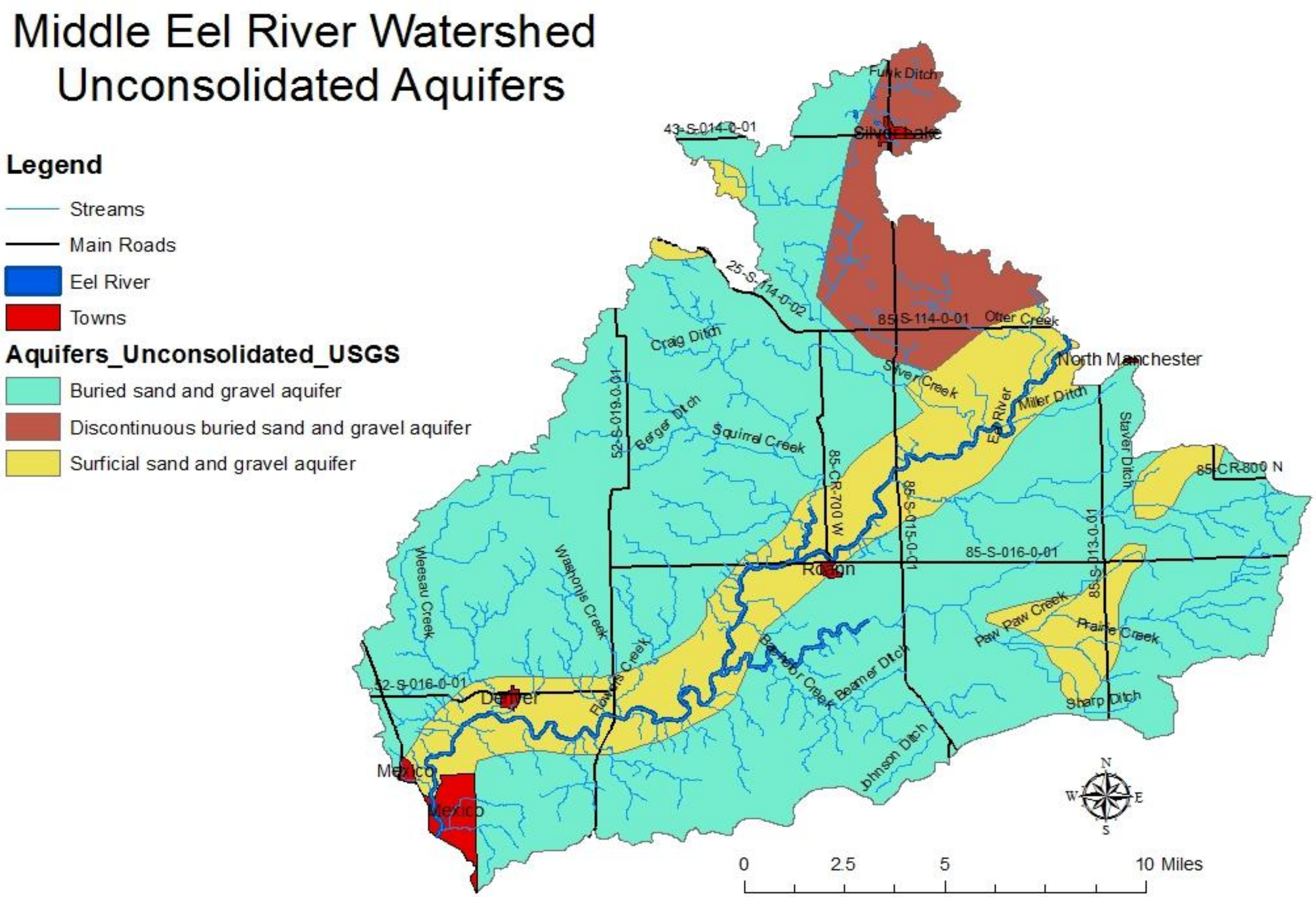

Figure 2-10. Middle Eel River Watershed Unconsolidated Aquifers - Indiana Geological Survey 1994.

2.7 Climate

Indiana's climate is classified as temperate continental and humid. Continental climates have a pronounced difference in average seasonal temperatures between summer and winter. Humid climates are those where the normal annual precipitation exceeds annual evapotranspiration. In north central Indiana the wettest seasonal period is late spring and more than half (54%) of the annual precipitation occurs during the five-six month frost free growing season. The average annual temperature for north central Indiana is 50-52°F and annual precipitation is 36-38" (Center for Earth and Environmental Science, 2003).

2.8 Land Use

Prior to European settlement of Indiana in the 1800s, the landscape was one large natural area that contained 36,291 square miles of about 20 million acres of forestland, 2 million acres of prairie, 1.5 million acres of water and wetlands, plus glades, barrens and savanna totaling perhaps another million acres (Jackson, 1997). Over the recent past, land use in the Middle Eel River Watershed has seen a dramatic transition from natural area to intense agricultural use.

Current land use in the Middle Eel River Watershed is predominantly agricultural (89%), with only small acreage of residential and forested areas. Figure 2-11 shows the land use in the Middle Eel River Watershed. Figures 2-12 through 2-29 show land use within each of the 12 digit HUCs. Figure 2-30 shows land use as a percent of total area within each subwatershed, broken down into six categories: Cultivated Crops (corn, soybeans, winter wheat, hay and alfalfa), Pasture/Range/Grasslands, Forested, Urban, Wetlands and Other (other small acreage crops, fallow cropland, clouds, and open water). As can be seen in Figure 2-30, the predominant land use within the Middle Eel River Watershed is Cultivated Crops.

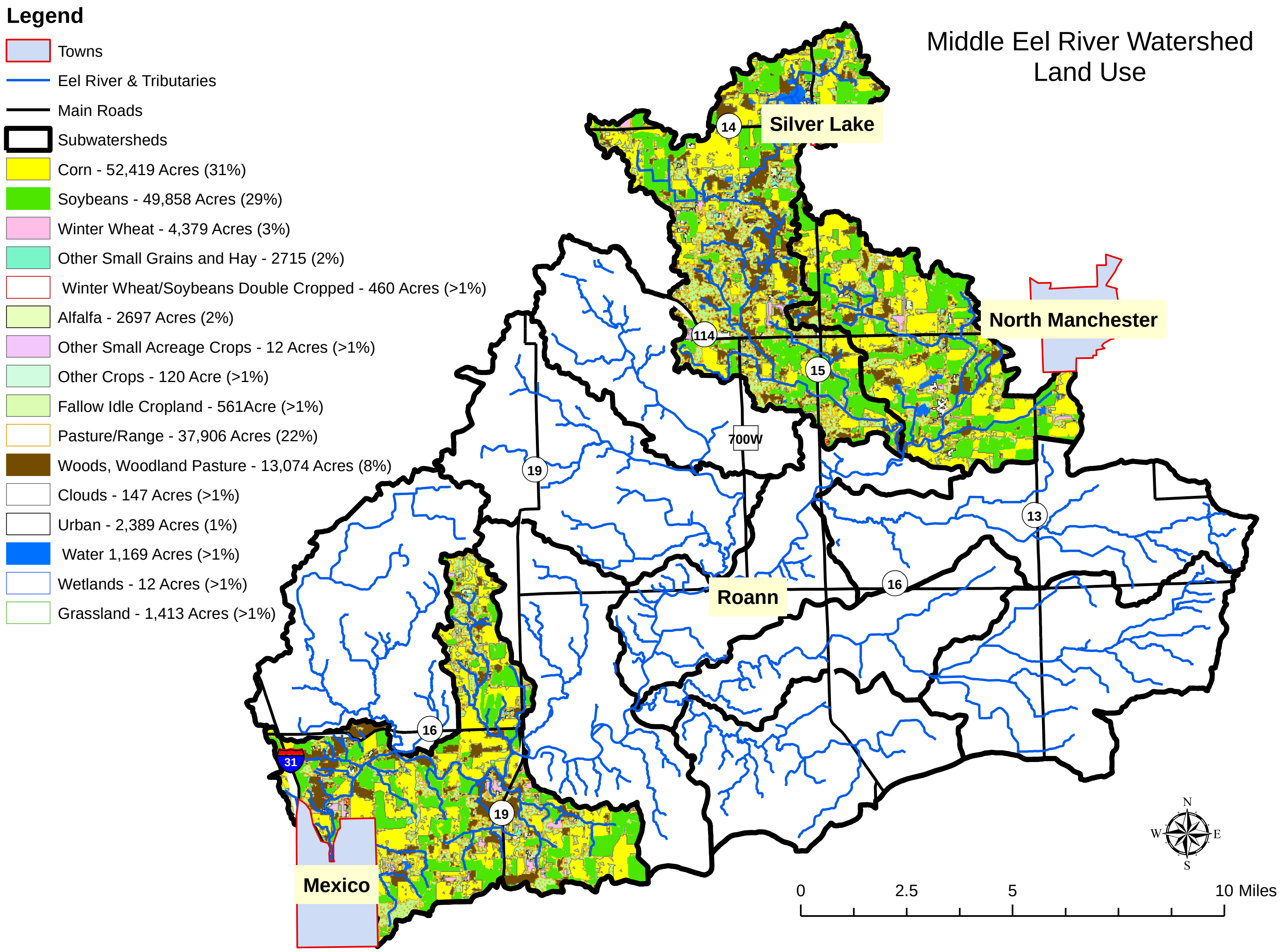

Figure 2-11. Middle Eel River Watershed Land Use

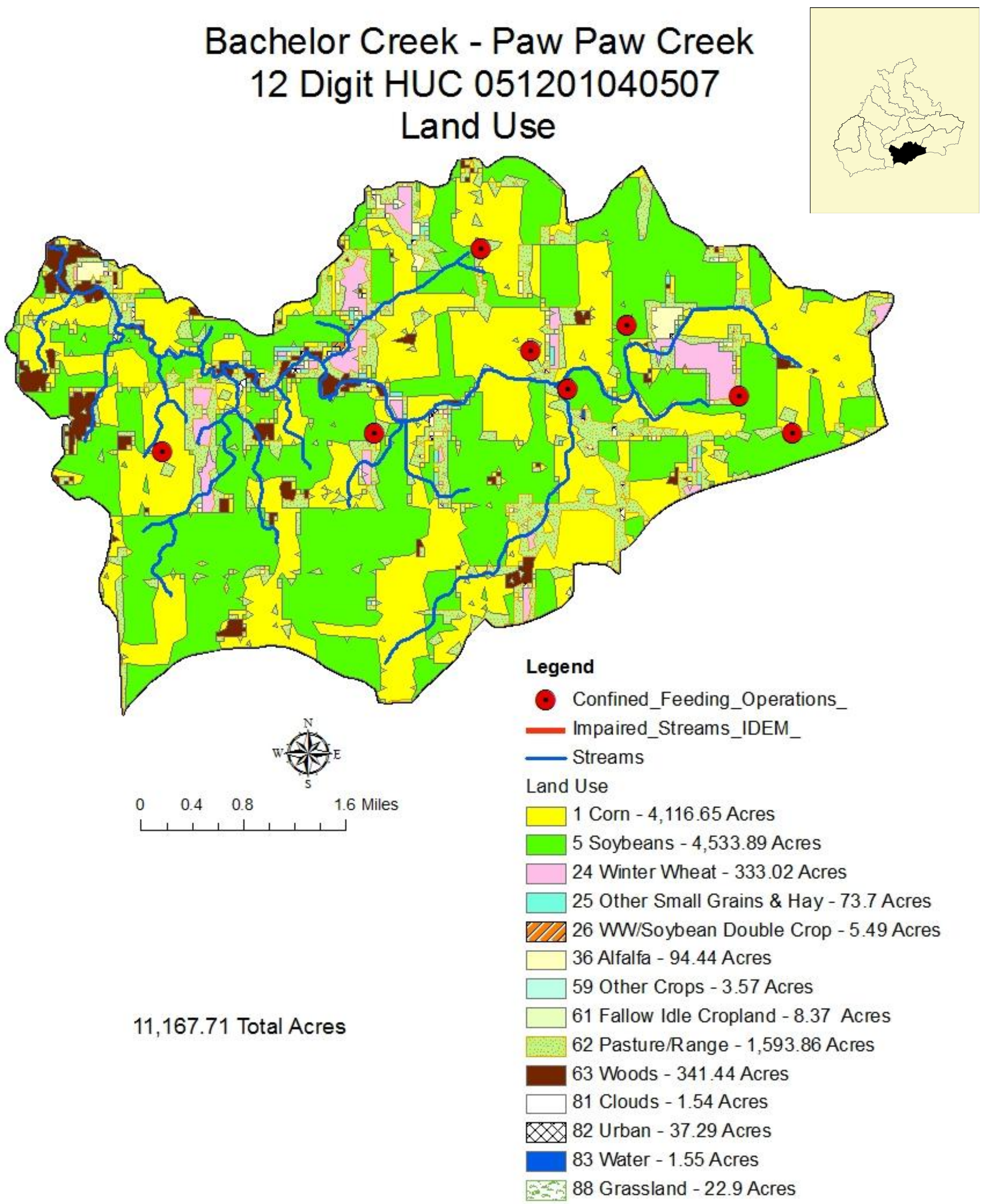

Figure 2-12. Land use in Bachelor Creek Subwatershed.

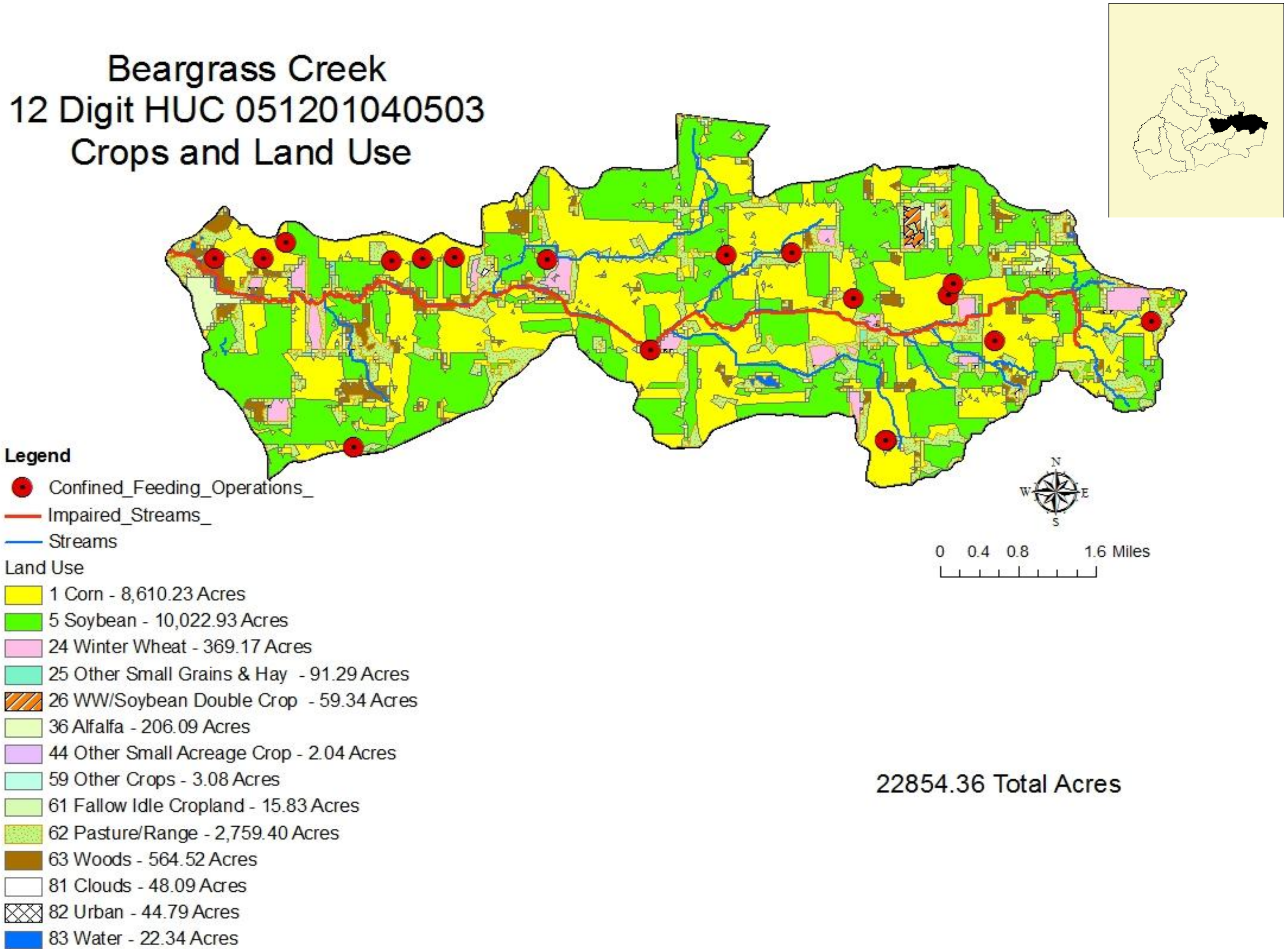

Figure 2-13. Land Use in Beargrass Creek Subwatershed.

Figure 2-14. Beargrass Creek, low stream flow with heavy algal mat growth suggesting high nutrient load. This condition is typical (9-10 times) during summer months when low flow conditions exist throughout the Middle Eel River Watershed. Photograph by Craig Colvin 2009.

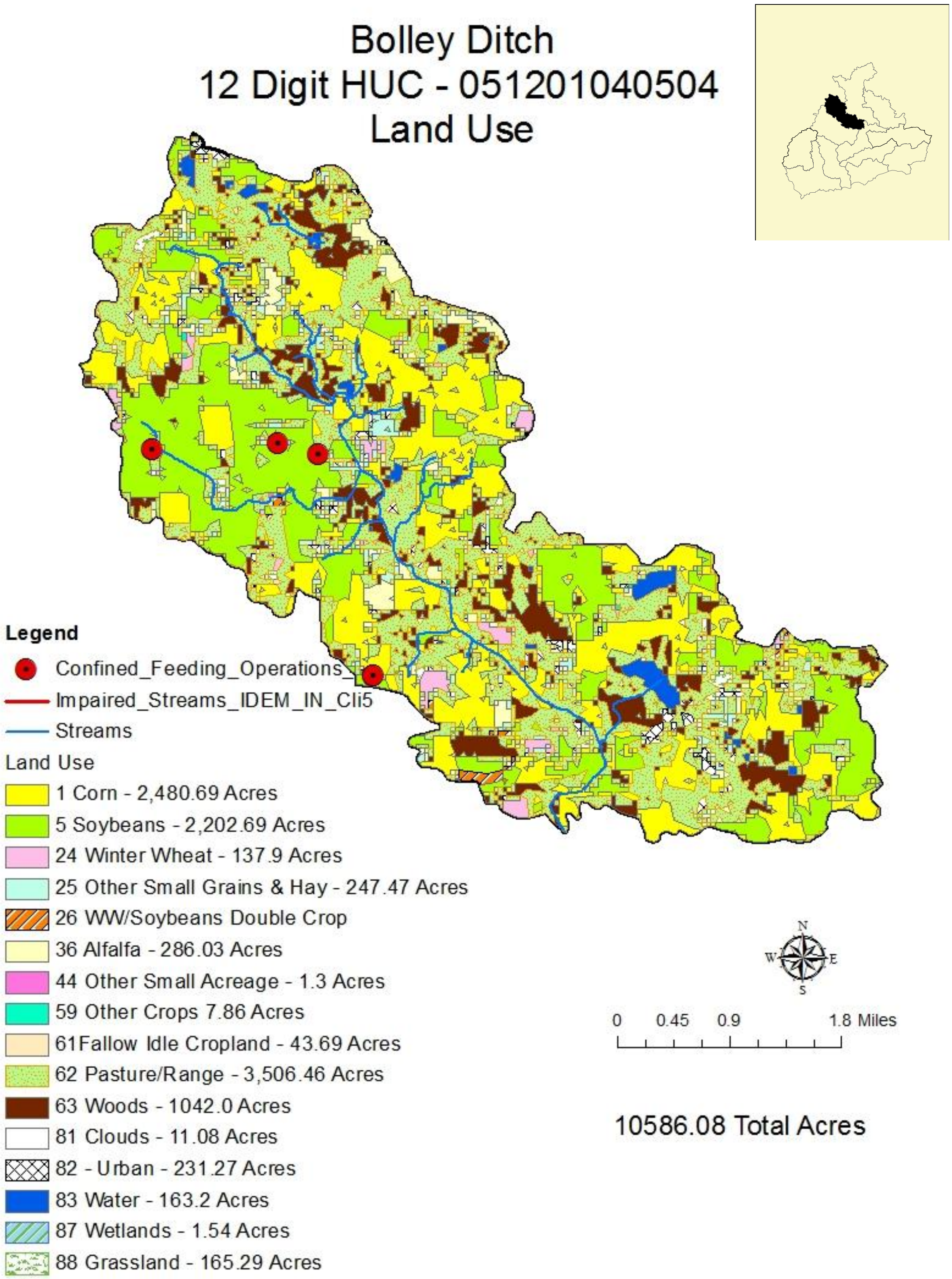
Bolley Ditch
12 Digit HUC - 051201040504
Land Use
Legend
Confined_Feeding_Operations_
Impaired_Streams_IDEM_IN_Cli5
Streams
Land Use
1 Corn - 2,480.69 Acres
5 Soybeans - 2,202.69 Acres
24 Winter Wheat - 137.9 Acres
25 Other Small Grains & Hay - 247.47 Acres
26 WW/Soybeans Double Crop
36 Alfalfa - 286.03 Acres
44 Other Small Acreage - 1.3 Acres
59 Other Crops 7.86 Acres
61Fallow Idle Cropland - 43.69 Acres
62 Pasture/Range - 3,506.46 Acres
63 Woods - 1042.0 Acres
81 Clouds - 11.08 Acres
82 - Urban - 231.27 Acres
83 Water - 163.2 Acres
87 Wetlands - 1.54 Acres
88 Grassland - 165.29 Acres
N
W
E
S
0
0.45
0.9
1.8 Miles
10586.08 Total Acres

Figure 2-15. Land Use in Bolley Ditch Subwatershed.

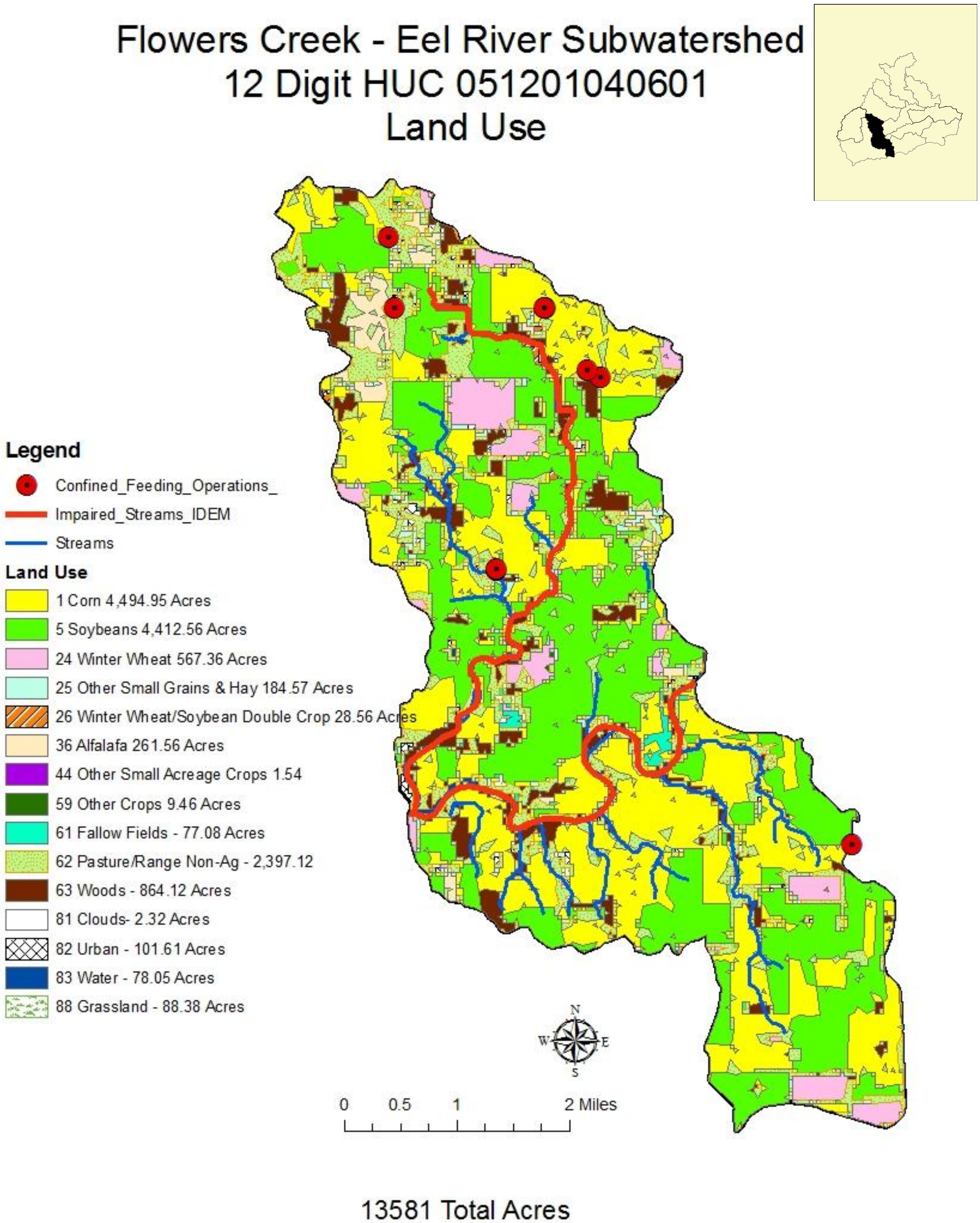

Figure 2-16. Land Use in Flowers Creek – Eel River Subwatershed.

Figure 2-17. Wilson Rhodes Ditch, part of Flowers Creek watershed. Subsurface tile drainage is typical throughout the Middle Eel River Watershed. Photo by Craig Colvin 2009.

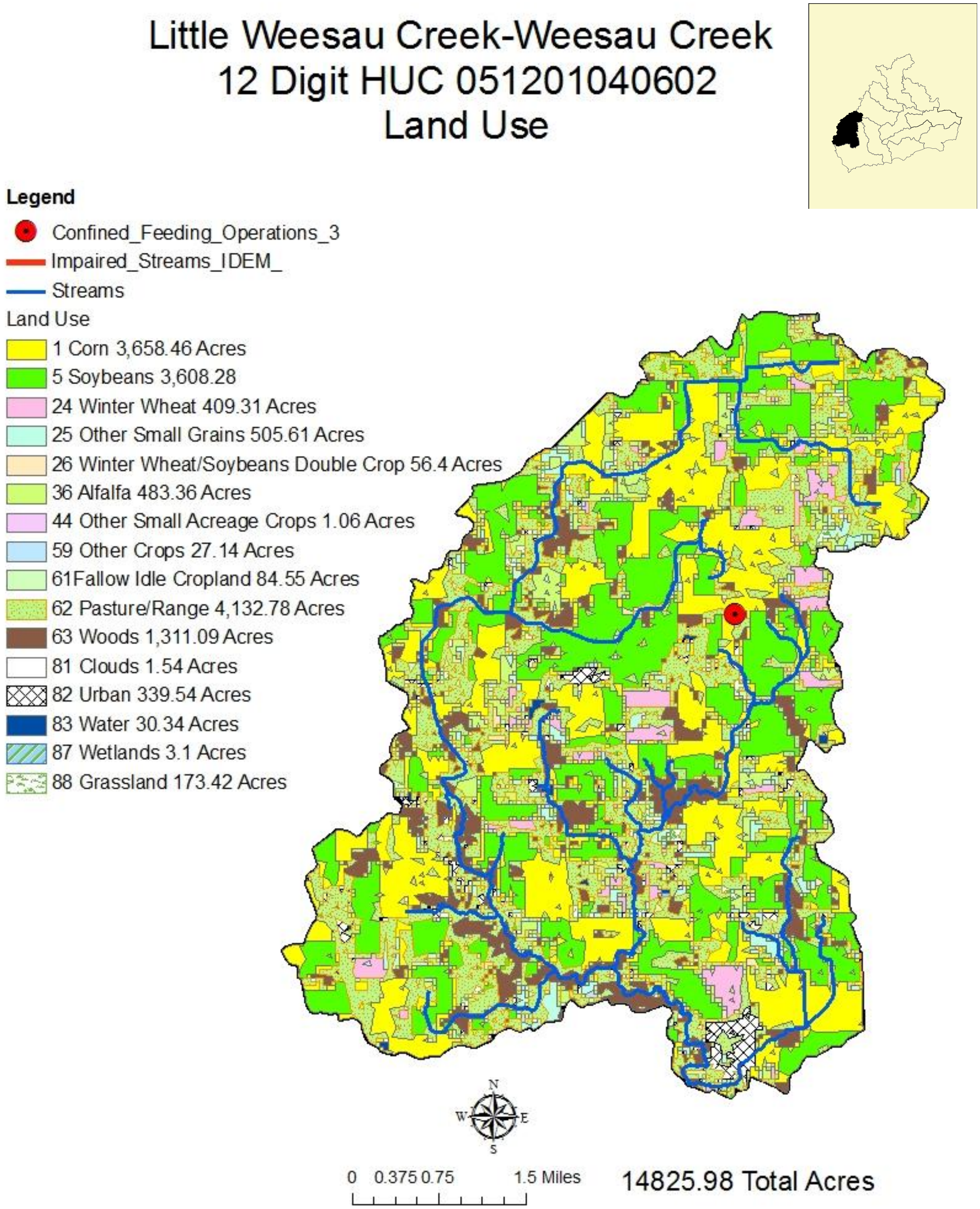

Figure 2-18. Land Use in Little Weesau-Weesau Creek Subwatershed.

Figure 2-19. In spring and fall spreading manure is typical throughout the Middle Eel River Watershed. Manure has been seen being spread on frozen fields 3 times during 2010.

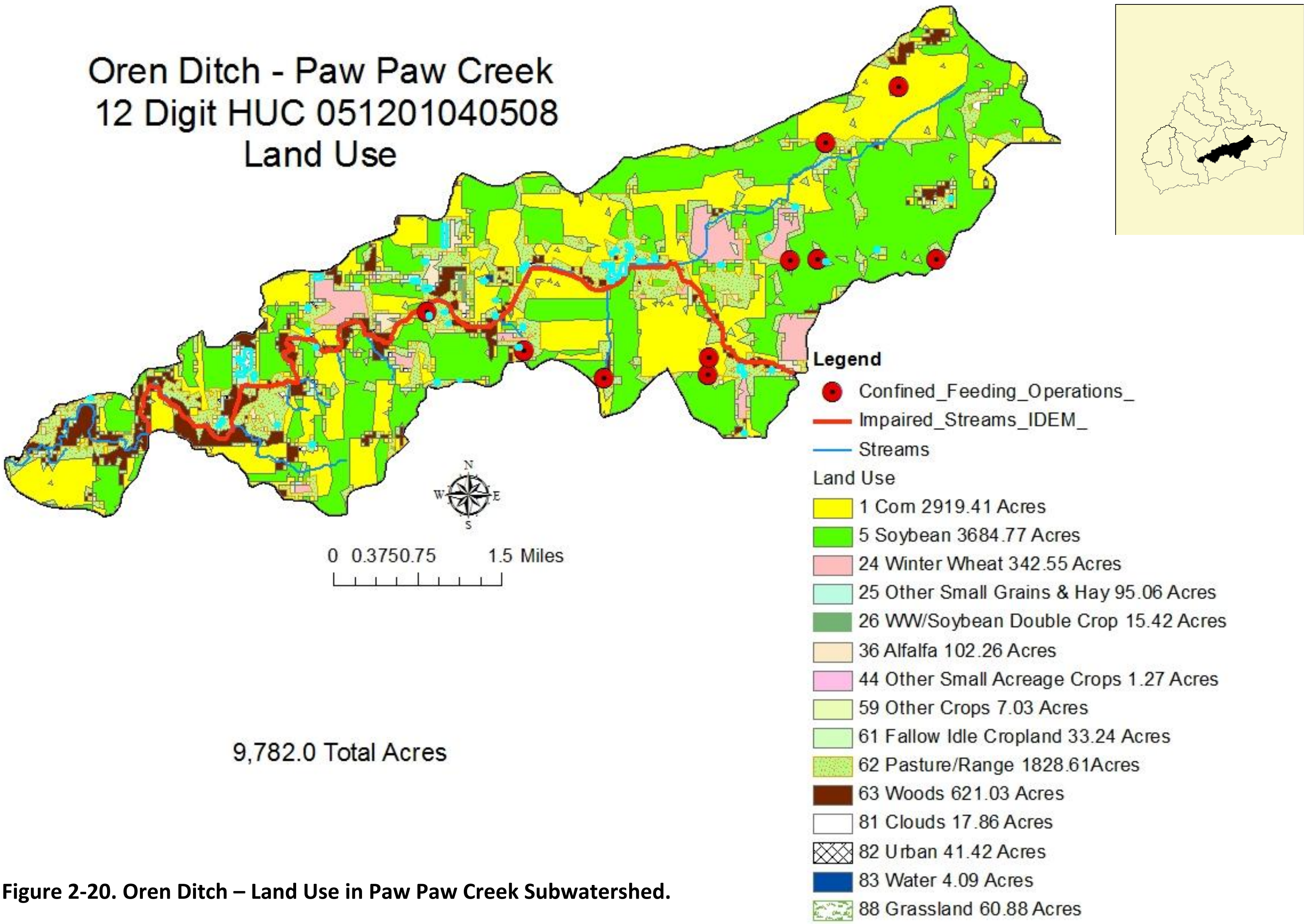

Figure 2-20. Oren Ditch – Land Use in Paw Paw Creek Subwatershed.

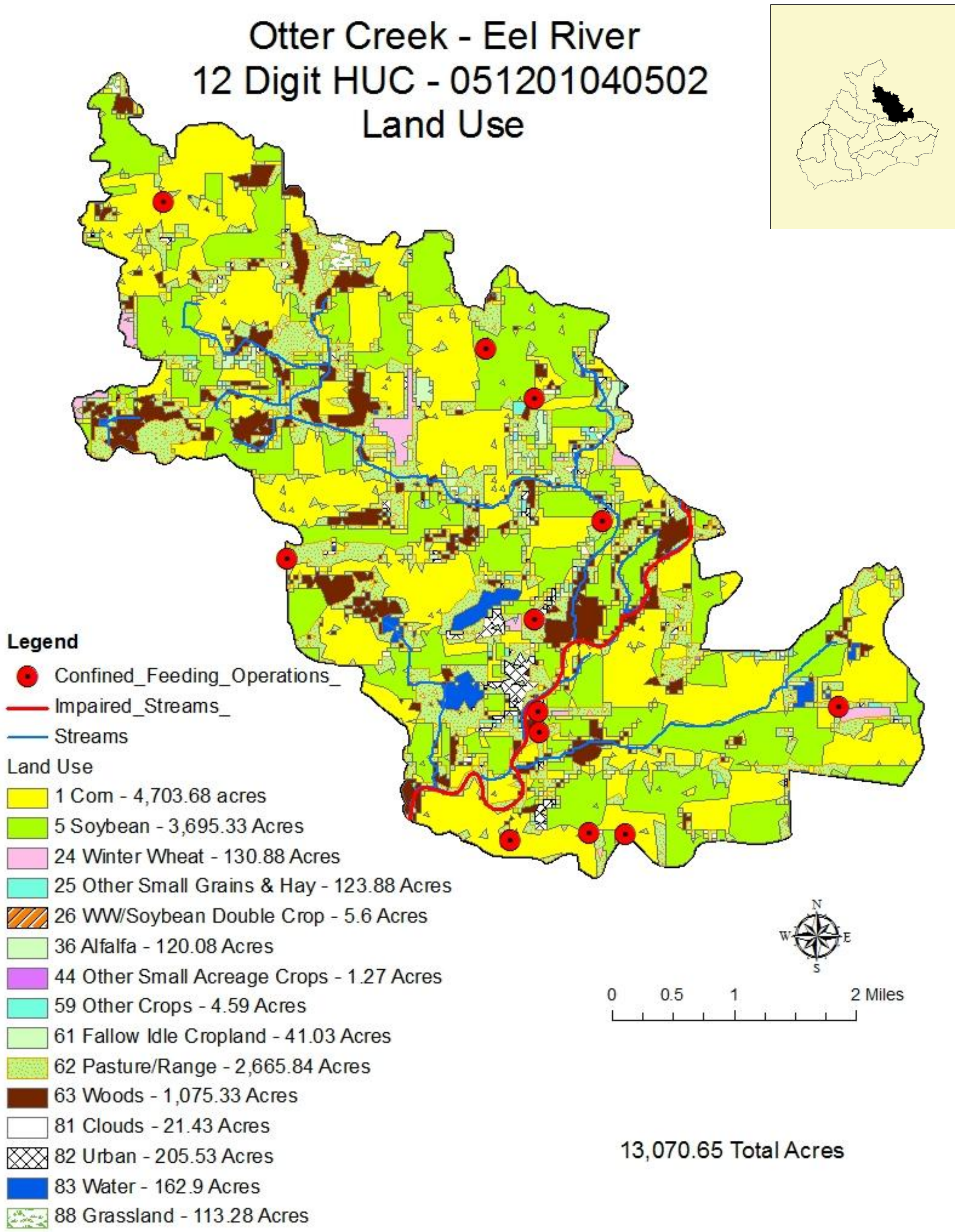

Figure 2-21. Land Use in Otter Creek – Eel River Subwatershed.

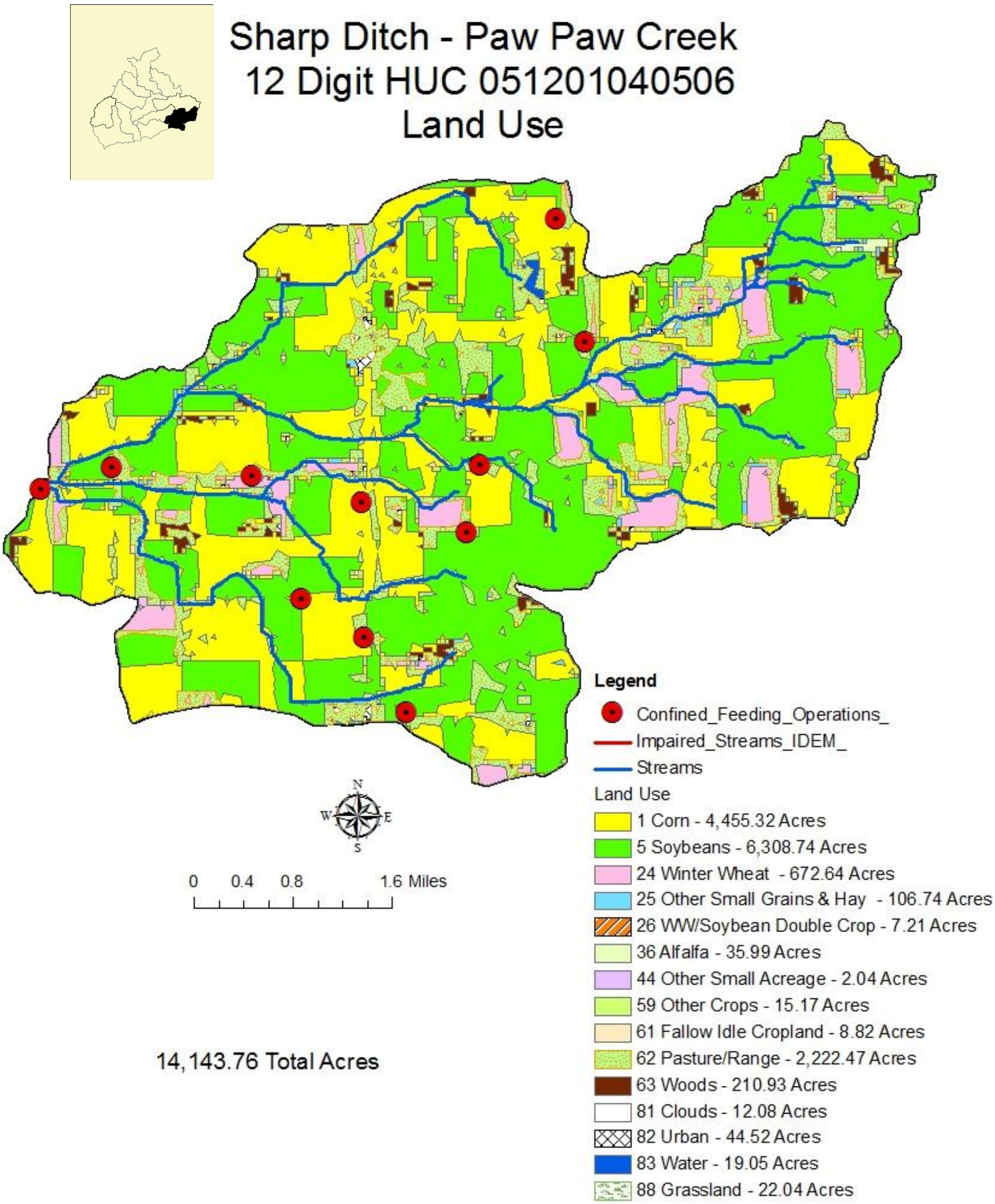

Figure 2-22. Land Use in Sharp Ditch – Paw Paw Creek Subwatershed.

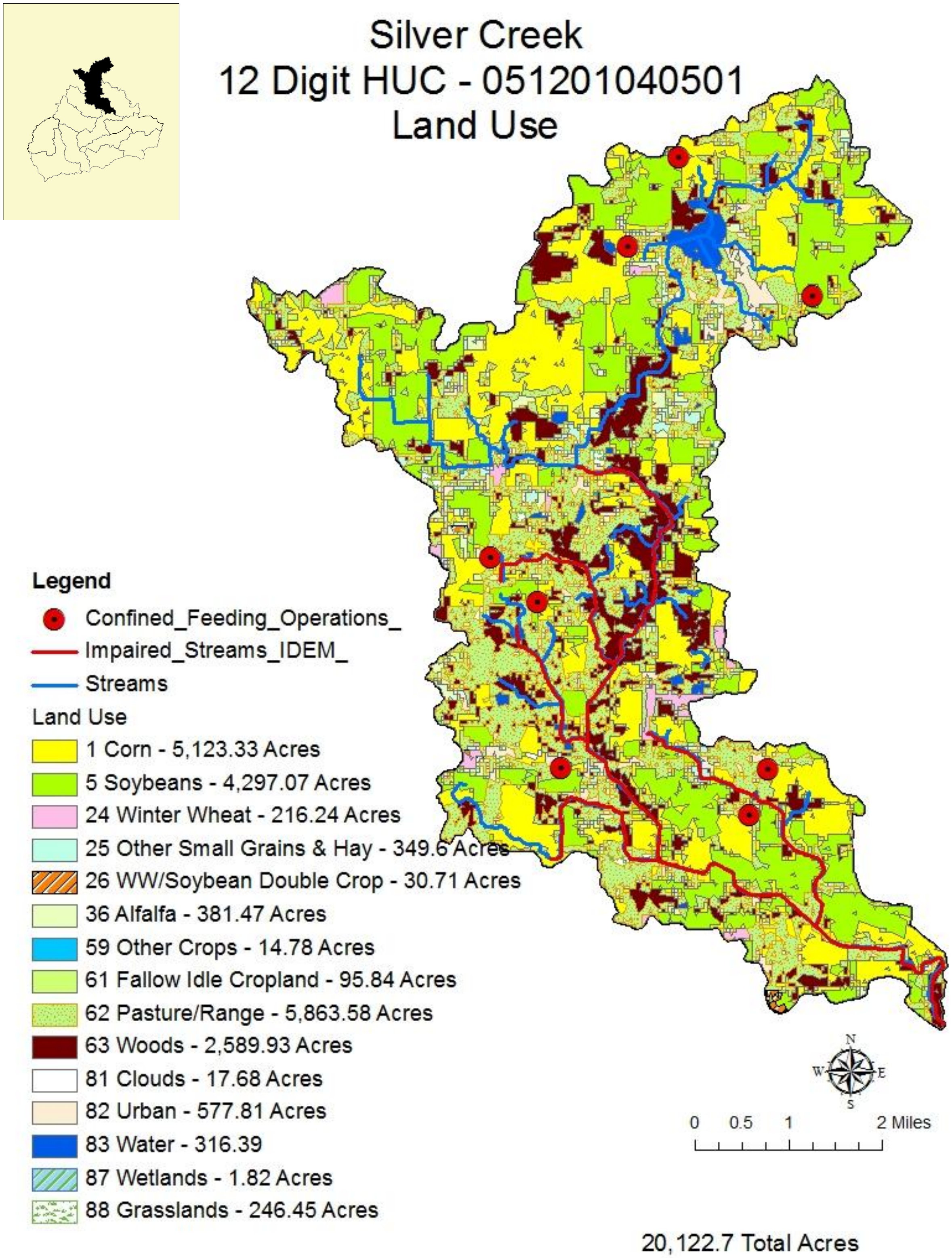

Figure 2-23. Land Use in Silver Creek Subwatershed.

Figure 2-24. Silver Creek, cattle are free to wade in the creek. Livestock access to streams is typical throughout the Middle Eel River Watershed. Photo by Craig Colvin, 2009.

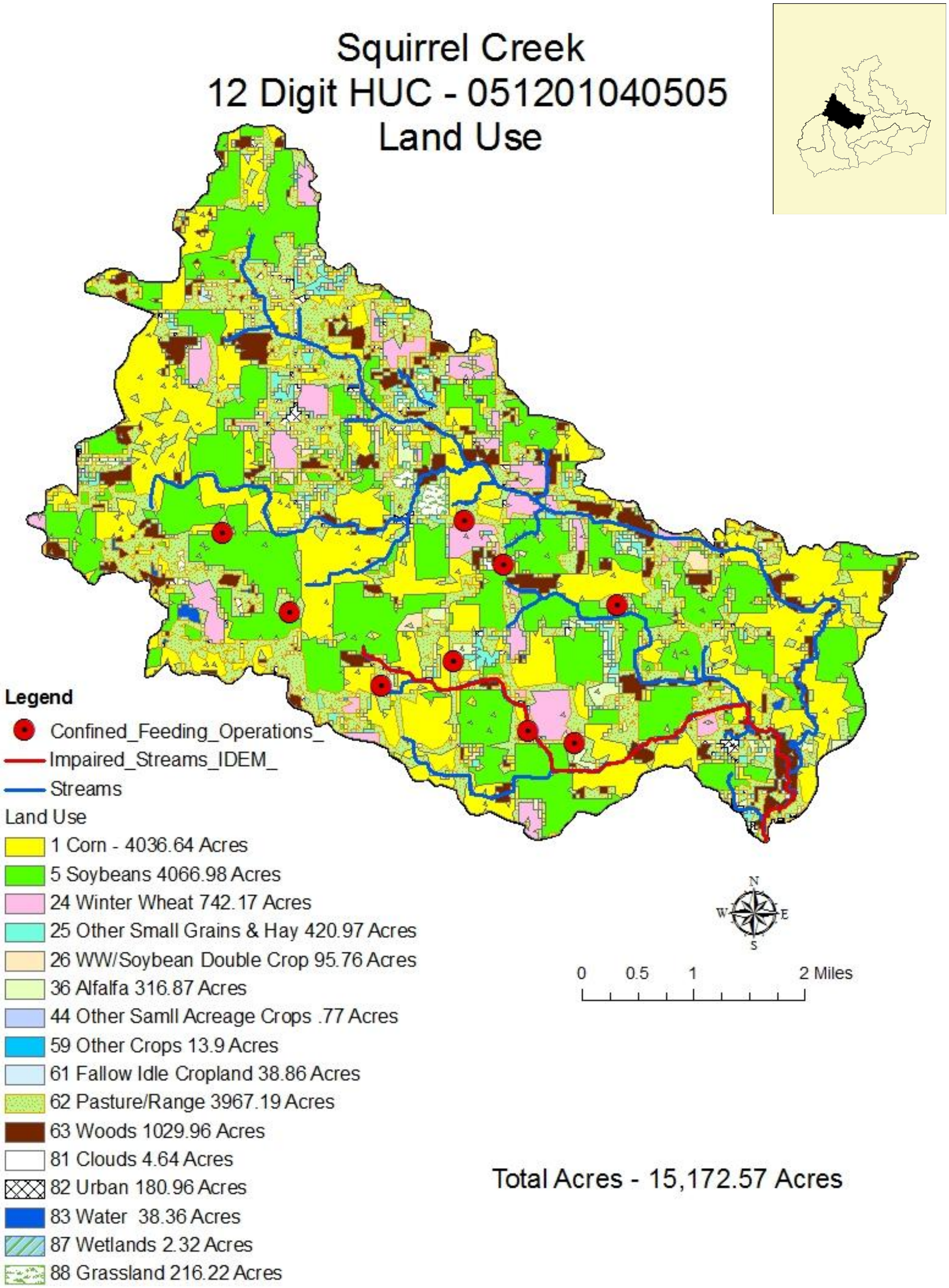

Figure 2-25. Land Use in Squirrel Creek Subwatershed

Figure 2-26. Erosion in Squirrel Creek –cattle have full access to stream and drainage tile present, the pasture empties directly into the creek, thus easy transport for pathogens and nutrients. Photo by Craig Colvin, 2009.

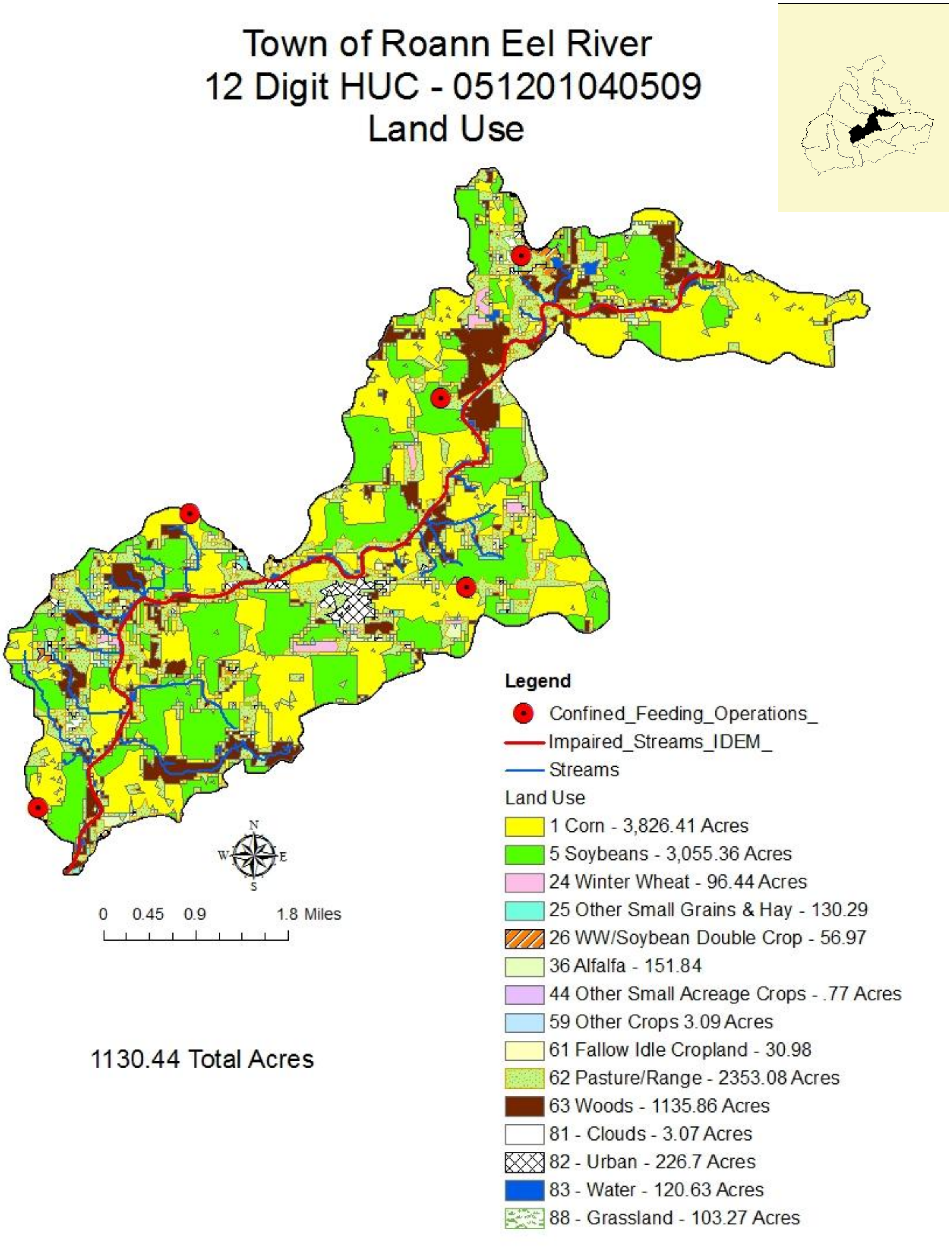

Figure 2-27. Land Use in Town of Roann – Eel River Subwatershed

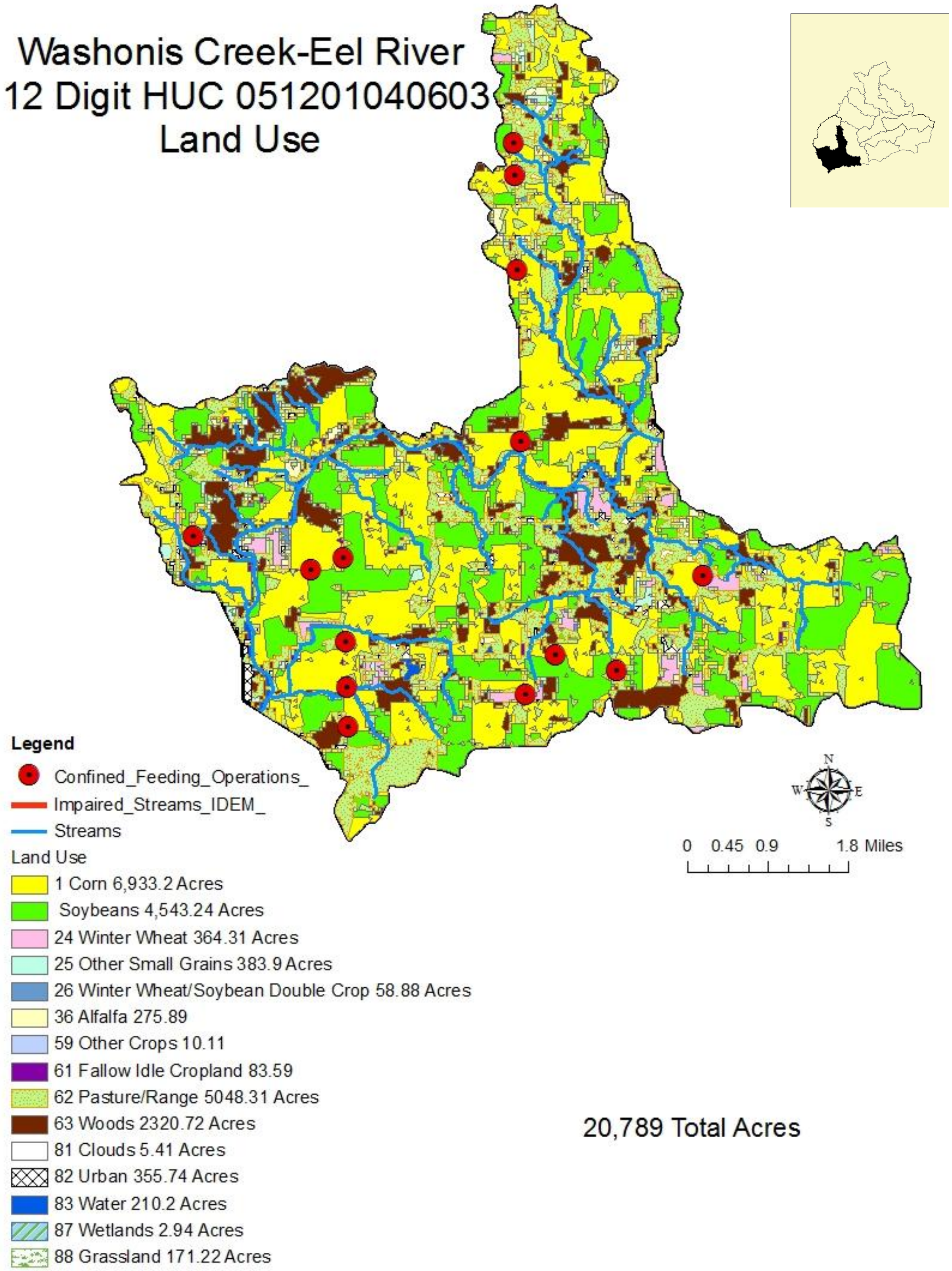

Figure 2-28. Land Use in Washonis Creek – Eel River Subwatershed

Figure 2-29. Laying subsurface tile drains (field tile) in Silver Creek Subwatershed, a typical practice throughout the Middle Eel River Watershed.

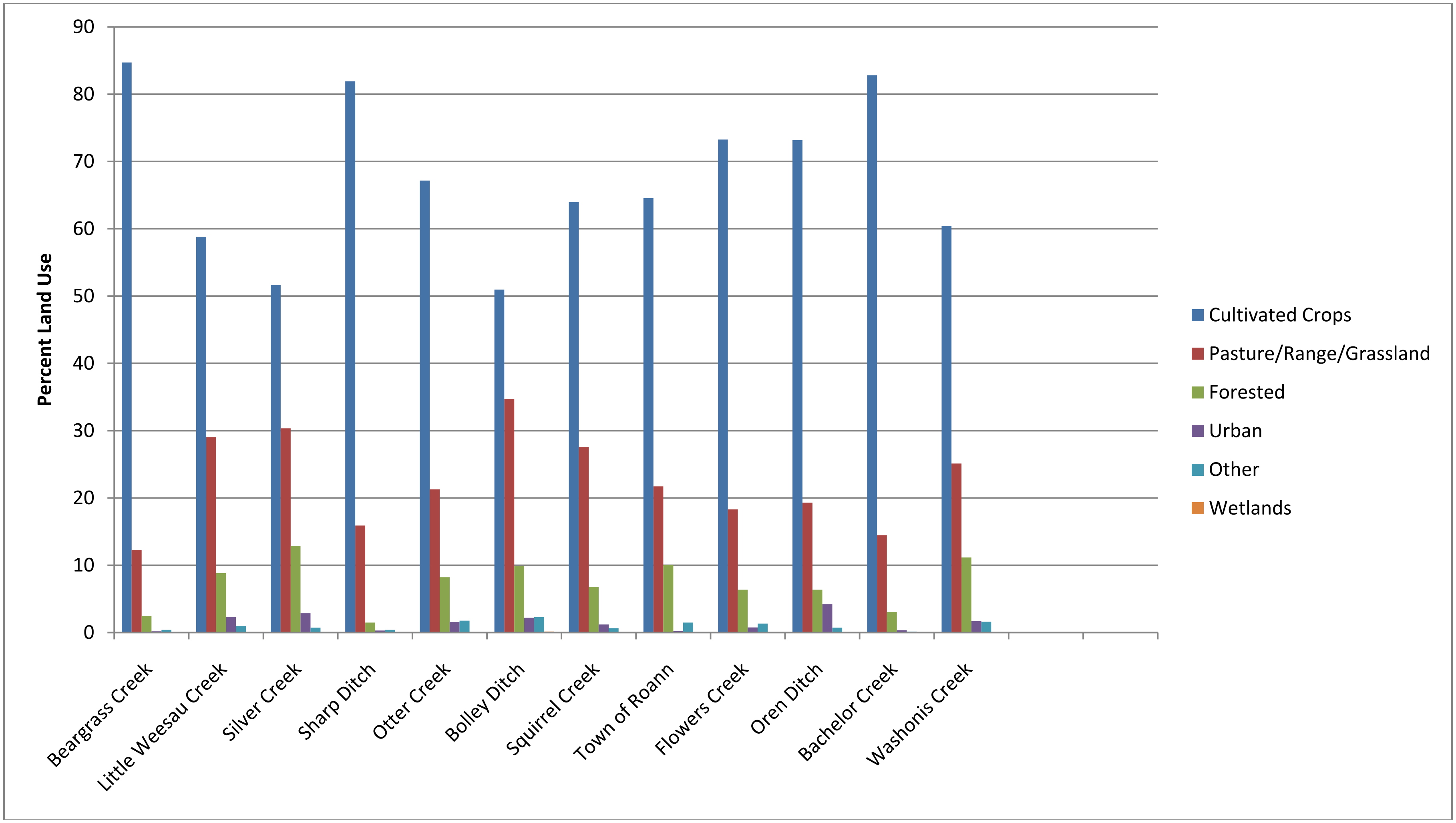

Figure 2-30. Land cover by percent of the 12 Digit HUC subwatersheds. Land cover categories were grouped into the following six categories: Cultivated Crops (corn, soybeans, winter wheat, hay and alfalfa), Pasture/Range/Grasslands, Forested, Urban, Wetlands and Other (other small acreage crops, fallow cropland, clouds, and open water).

2.8.1 –Tillage Practices

Conservation tillage is any tillage and planting system that covers 30 percent or more of the soil surface with crop residue, after planting, to reduce soil erosion by water. Two key factors influencing crop residue are (1) the type of crop, which establishes the initial residue amount and its fragility, and (2) the type of tillage operation prior to and including planting (USDA 2000).

Conservation Tillage Systems Include (USDA 2000):

No-till—The soil is left undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, in-row chisels, or roto-tillers. Weed control is accomplished primarily with herbicides. Cultivation may be used for emergency weed control.

Ridge-till—The soil is left undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between ridges. Weed control is accomplished with herbicides and/or cultivation. Ridges are rebuilt during cultivation.

Mulch-till—The practice of managing the amount, orientation and distribution of plant residues on the soil surface throughout the year round. The soil is disturbed prior to planting. Tillage tools such as chisels, field cultivators, disks, sweeps, or blades are used. Weed control is accomplished with herbicides and/or cultivation.

Reduced tillage (15-30% residue)—Tillage types that leave 15-30 percent residue cover after planting, or 500-1,000 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. Weed control is accomplished with herbicides and/or cultivation.

Conventional Tillage (USDA 2000):

Conventional tillage (less than 15% residue)—Tillage types that leave less than 15 percent residue cover after planting, or less than 500 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. Generally includes plowing or other intensive tillage. Weed control is accomplished with herbicides and/or cultivation. Conventional tillage systems include:

Conventional tillage with moldboard plow—Any tillage system that includes the use of a moldboard plow.

Conventional tillage without moldboard plow—Any tillage system that has less than 30 percent remaining residue cover and does not use a moldboard plow.

There are numerous benefits to a no-till system, according to Purdue University (Conservation Technology Information Center 2006), the top ten benefits of no-till are:

Reduces labor, saves time – As little as one trip for planting compared to two or more tillage operations means fewer hours on a tractor and fewer labor hours to pay…or more acres to farm. For instance, on 500 acres the time savings can be as much as 225 hours per year. That's almost four 60-hour weeks.

Saves fuel – Save an average 3.5 gallons an acre or 1,750 gallons on a 500 acre farm.

Reduces machinery wear – Fewer trips save an estimated $5 per acre on machinery wear and maintenance costs – a $2,500 savings on a 500 acre farm.

Improves soil tilth – A continuous no-till system increases soil particle aggregation (small soil clumps) making it easier for plants to establish roots. Improved soil tilth also can minimize compaction. Of course, compaction is also reduced by reducing trips across the field.

Traps soil moisture to improve water availability – Keeping crop residue on the surface traps water in the soil by providing shade. The shade reduces water evaporation. In addition, residue acts as tiny dams slowing runoff and increasing the opportunity for water to soak into the soil. Another way infiltration increases is by the channels created by earthworms and old plant roots. In fact, continuous no-till can result in as much as two additional inches of water available to plants in late summer.

Reduces soil erosion – Crop residues on the soil surface reduce erosion by water and wind. Depending on the amount of residues present, soil erosion can be reduced by up to 90% compared to an unprotected, intensively tilled field.

Improves water quality – Crop residue helps hold soil along with associated nutrients (particularly phosphorus) and pesticides on the field to reduce runoff into surface water. In fact, residue can cut herbicide runoff rates in half. Additionally, microbes that live in carbon rich soils quickly degrade pesticides and utilize nutrients to protect groundwater quality.

Increases wildlife – Crop residue provides shelter and food for wildlife, such as game birds and small animals.

Improves air quality – Crop residue left on the surface improves air quality because it: reduces wind erosion, thus it reduces the amount of dust in the air; reduces fossil fuel emissions from tractors by making fewer trips across the field; and reduces the release of carbon dioxide into the atmosphere by tying up more carbon in organic matter.

Tillage data for the Miami and Wabash County are displayed in Figures 2-31 and 2-32. No-till soybeans have been fairly well adopted within the watershed, however, no-till corn is still very limited (Indiana State Department of Agriculture, 2009).

Estimated acreage of conventional tillage corn in Wabash County is 18,779 acres and Miami County 11,465 acres. Estimated acreage of conventional tillage soybeans in Wabash County is 5,671 and Miami County 1,057. With the high percentage of agriculture within the watershed it is likely that conventional agricultural tillage may be contributing to excess sediment, nutrients and *E. coli* in the tributaries and mainstem of the Middle Eel River.

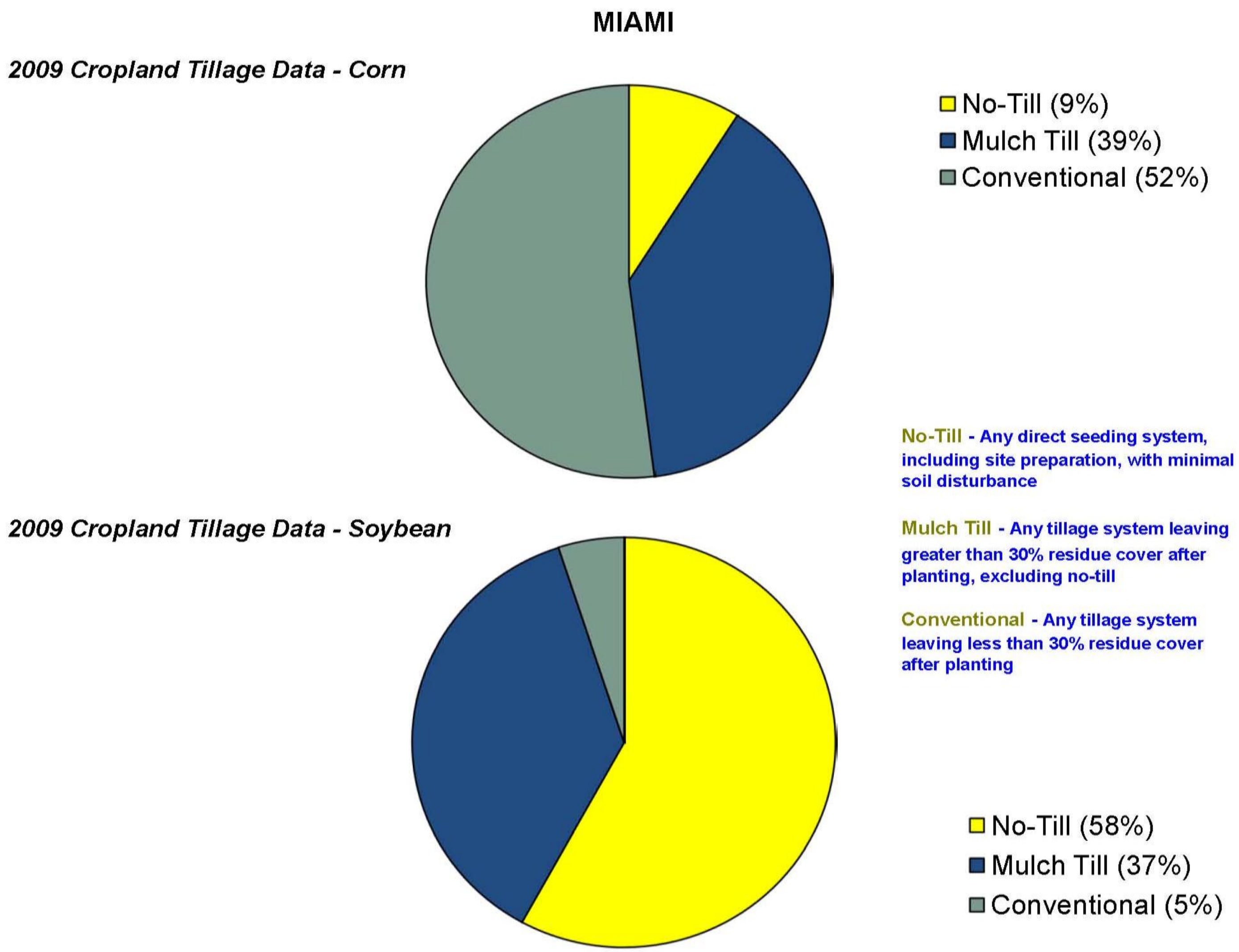

Figure 2-31. Tillage Data for Miami County, IN, 2009. Indiana State Department of Agriculture 2009.

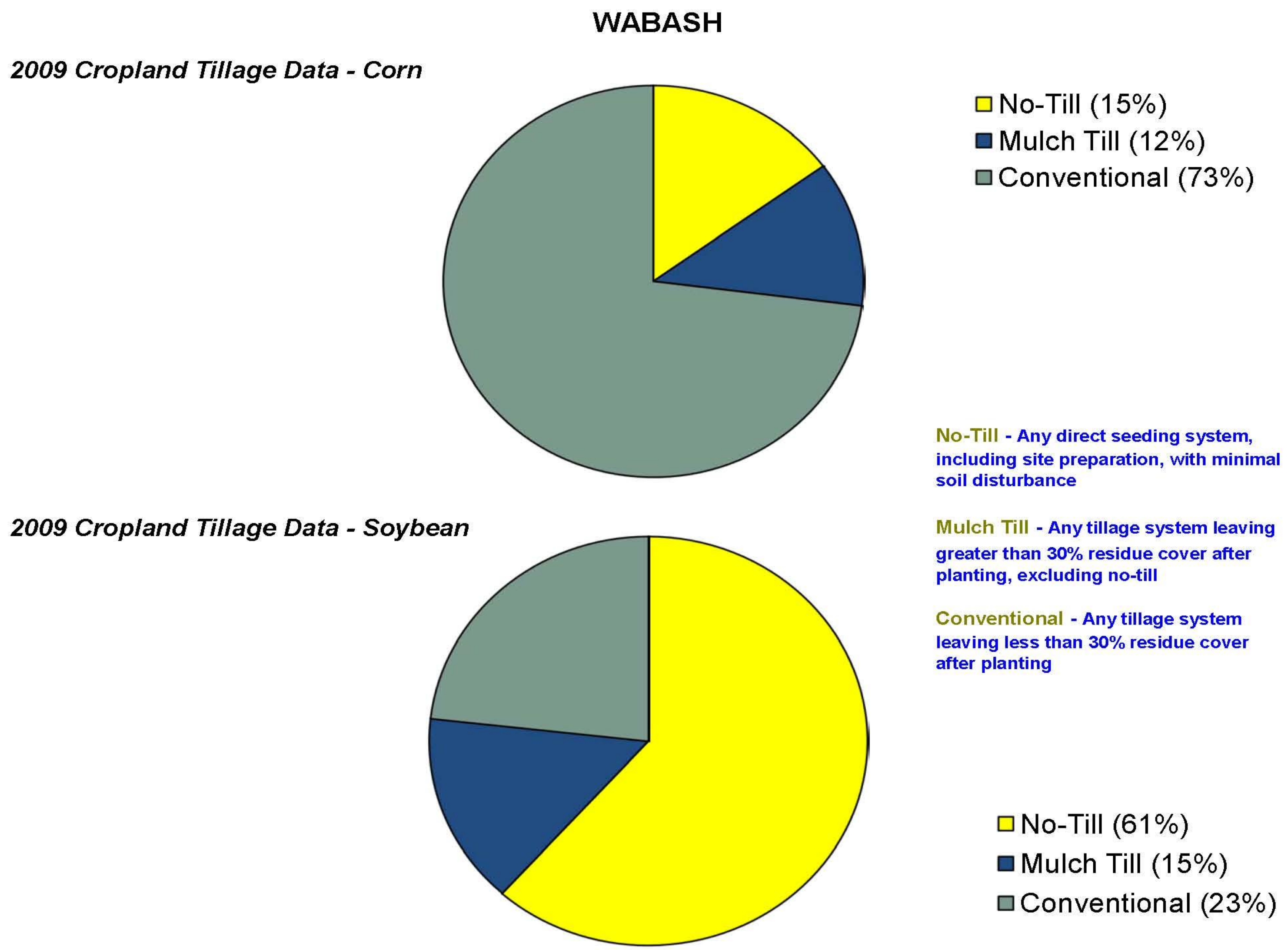

Figure 2-32. Tillage Data for Wabash County, IN, 2009. Indiana State Department of Agriculture

2.8.2 –Riparian Buffers

Riparian (along the waters' edge) buffers are extremely important to water quality. Conservation riparian buffers are small areas or strips of land in permanent vegetation, designed to intercept pollutants and manage other environmental concerns. Buffers include: riparian buffers, filter strips, grassed waterways, shelterbelts, windbreaks, living snow fences, contour grass strips, cross-wind trap strips, shallow water areas for wildlife, field borders, alley cropping, herbaceous wind barriers, and vegetative barriers.

Strategically placed buffer strips in the agricultural landscape can effectively mitigate the movement of sediment, nutrients, and pesticides within farm fields and from farm fields. When coupled with appropriate upland treatments, including crop residue management, nutrient management, integrated pest management, winter cover crops, and similar management practices and technologies, buffer strips should allow farmers to achieve a measure of economic and environmental sustainability in their operations. Buffer strips can also enhance wildlife habitat and protect biodiversity.

The literature shows that a 30 meter buffer strip is the most effective, "The most effective buffers are at least 30 meters, or 100 feet wide, composed of native forest, and are applied to all streams, including very small ones." (Wenger and Fowler 2000). Figure 2-33 displays the type of land use within a 30 meter riparian buffer of all streams within the Middle Eel River Watershed as a percentage. Land use was broken down into the following five categories: Row Crops, Grassland/Pasture, Urban, Wetlands, and Forest. Figures 2-34 through 2-38 show land use within a 30 meter buffer of all tributaries and the mainstem of the Eel River located in the Middle Eel River Watershed. It is important to note that in order to show land use in the buffers for the entire watershed, maps need to be zoomed out to a level that may cause the land use within the buffers to appear to overlap.

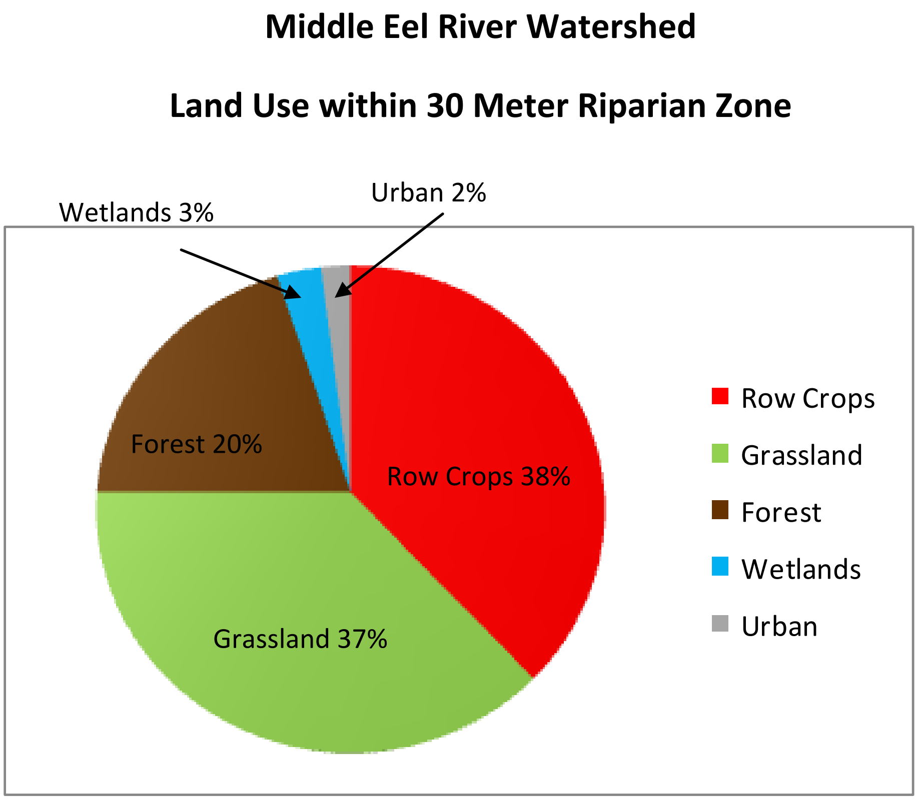

Figure 2-33. Land use within 30 meter riparian buffer of all streams within the Middle Eel River Watershed as a percentage of total land in the 30 meter buffer.

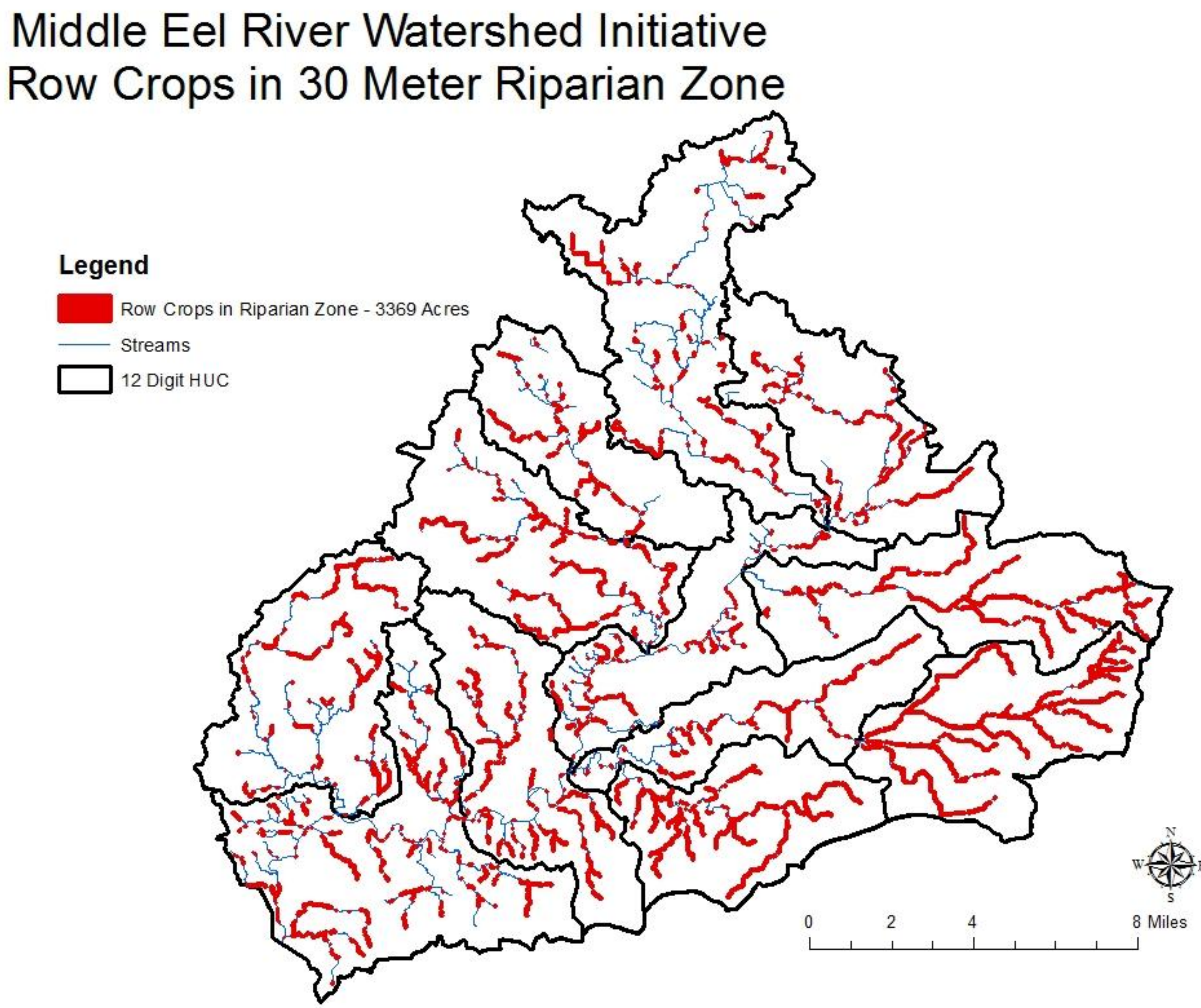

Figure 2-34. Row Crops within 30 meter riparian zone of all streams within the Middle Eel River Watershed.

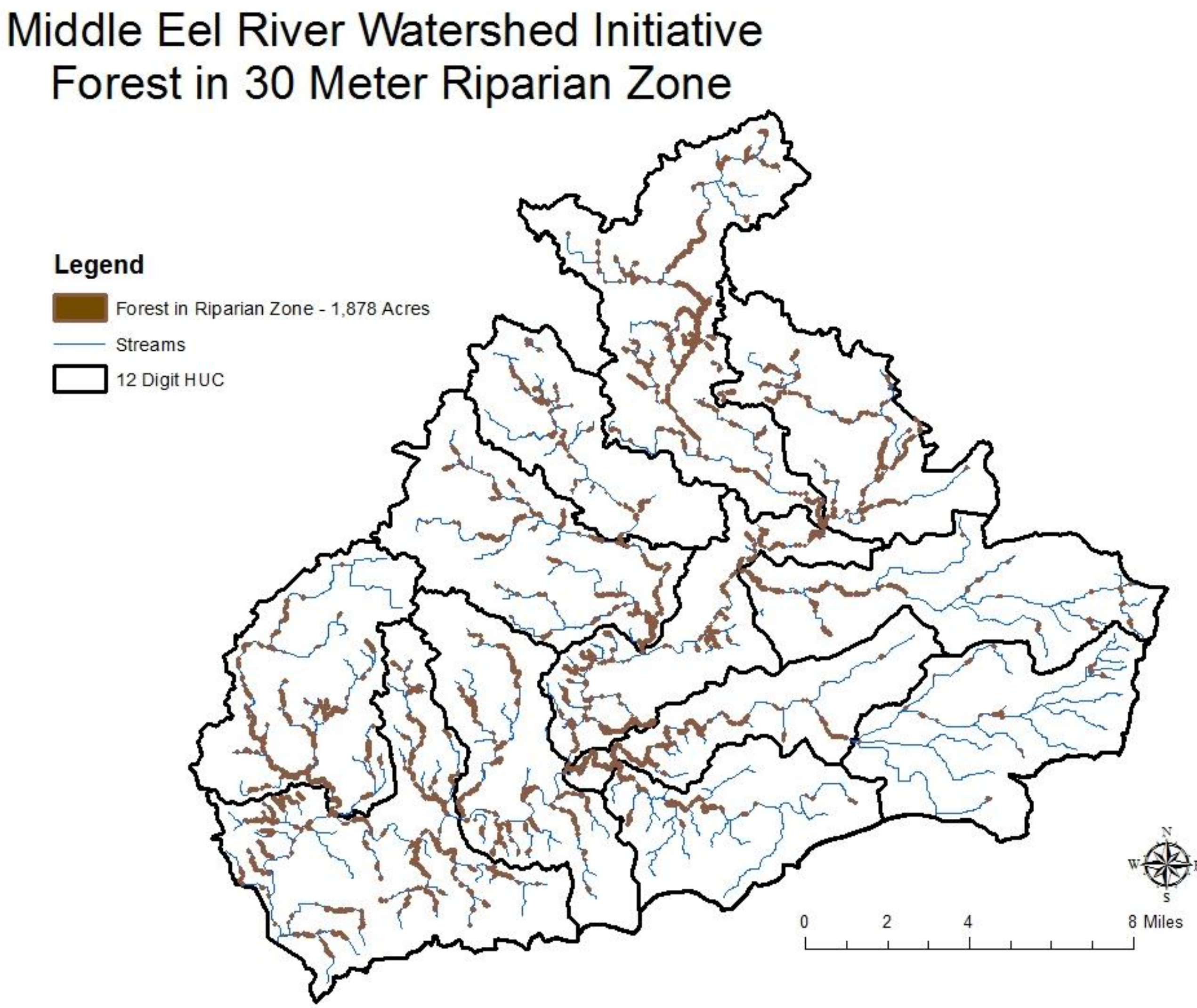

Figure 2-35. Forests within 30 meter riparian zone of all streams within the Middle Eel River Watershed.

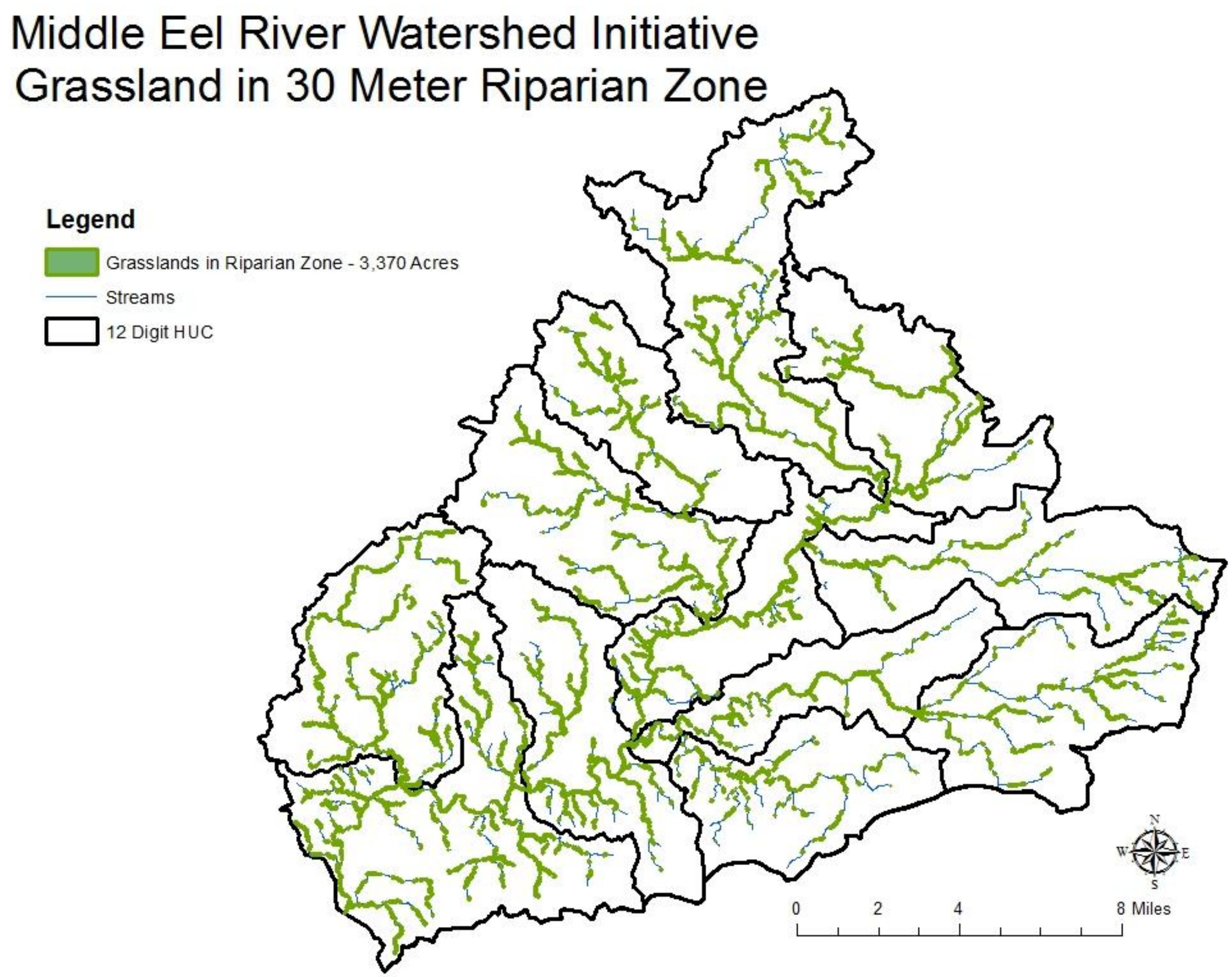

Figure 2-36. Grasslands within 30 meter riparian zone of all streams within the Middle Eel River Watershed.

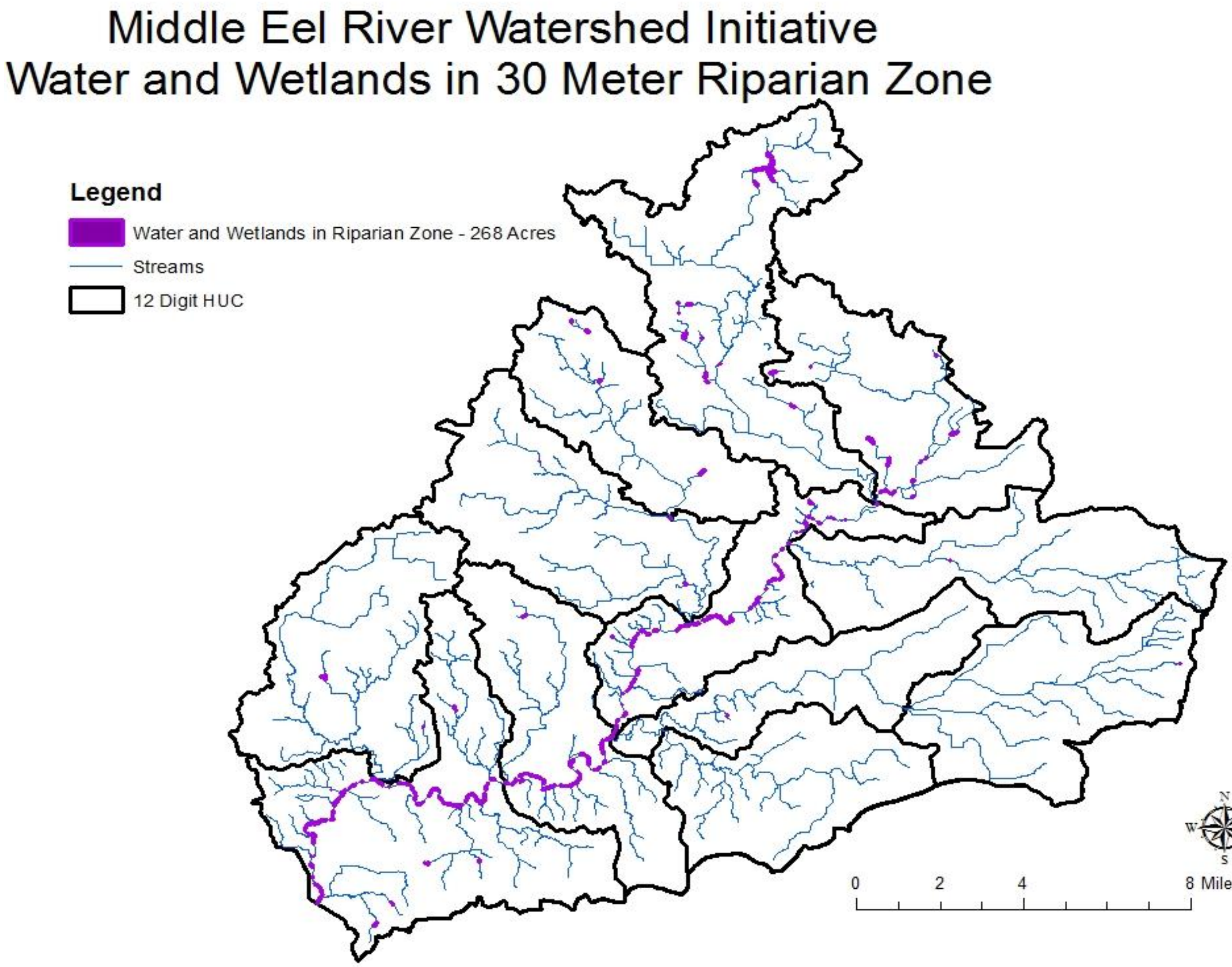

Figure 2-37. Wetlands & water within 30 meter riparian zone of all streams within the Middle Eel River Watershed.

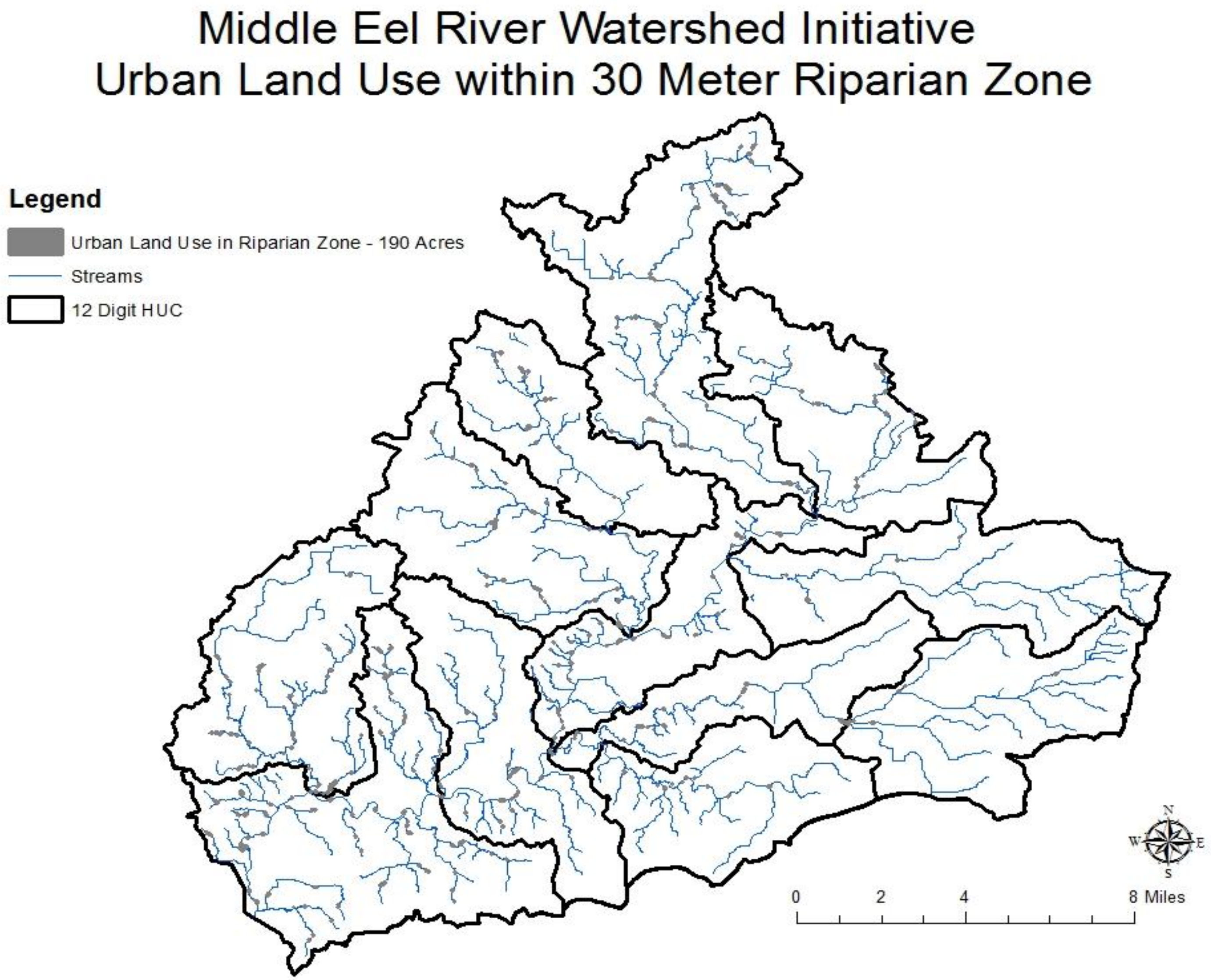

Figure 2-38. Urban areas within 30 meter riparian zone of all streams within the Middle Eel River

2.8.3 Impervious Cover

Impervious cover within the watershed is 2.84% using the Purdue Watershed Delineation model (Choi, J.Y., B. Engel and L. Theller, 2005). Estimation of impervious cover based on land use was recommended as an affordable approach by Cappiella and Brown (2001). The mean impervious cover based on land use that was used in estimating the impervious area in the watershed is presented in the Table 2-4 below. While impervious cover can create run-off problems in many areas, it is not a serious concern in the Middle Eel River Watershed due to the small amount of impervious cover within the watershed.

Table 2-4. Impervious Cover % Based on Land Use Category (Cappiella and Brown, 2001).

Land Use Category	Impervious Cover %
Agriculture, Pasture/Grass, Forest	1.9
Water/Wetland	0.0
Low Density Residential	15.4
High Density Residential	36.4
Industrial	53.4
Commercial	72.2

2.9 Hydrology

2.9.1 Stream Order

Stream order is a common stream classification system which helps describe a river's size and watershed area; the greater the stream order, the greater the size and watershed area. Using this system, the Eel River is a 5^{th} order stream. A large number of first order streams are present in the watershed and most, if not all of these first order streams have been modified for agricultural drainage through straightening, ditching, dredging, and/or removal of riparian buffer areas. This has a direct influence on the amount of sedimentation, nutrients and E. coli reaching the streams. The drainage modifications do not only affect first order streams, however, first order streams comprise the majority of the watershed in terms of stream miles, and are where the largest amount on nonpoint source pollution enters the streams.

2.9.2 Stream Modification

According to the US Environmental Protection Agency's National Water Quality Inventory: Report to Congress (2004), hydromodification is the second leading cause of nonpoint source pollution in our rivers and streams. Hydromodification includes the laying of field tile, ditch maintenance, dam installation, and stream channelization in the tributaries. From the town of Collamer in Whitley County to its source in Allen County, the mainstem of the Eel River is considered a legal drain and has been channelized resulting in degraded biotic habitats (Henschen 1987). From North Manchester downstream the mainstem of the river has not been channelized (Henschen, 1987), however the watershed was extensively ditched and drained prior to 1900 for agricultural use (Gammon 1990). Extensive tile drainage and ditching continues to this day within the watershed. Dredging and debrushing of the open drains destroys habitat, increases suspended sediment and nutrients, and is expensive to maintain. Stream modification, driven by agriculture, is a major contributing factor to nonpoint source pollution in the watershed.

Lowhead dams are one of the main sources of disturbance on streams. Dams convert free flowing streams to stillwaters, changing the flow regime, physical stream characteristics, increasing siltation upstream and causing scouring down stream, altering fish assemblages, and blocking host fishes. Low head dams can alter the freshwater mussel fauna, including restricting distributions and isolating populations, reducing native species richness and abundance, increasing non-native species richness and abundance (Tiemann et al. 2007).

Low head dams were historically constructed at various locations on the Eel River to power mills, many of which are currently in disrepair (Gammon 1990). There is only one dam within the Middle Eel River Watershed on the mainstem that remains intact, the dam at the Stockdale Mill near Roann. The mill has been renovated and is historically significant. There are two other dams very near the watershed, one at North Manchester just upstream of the watershed break, and one in Mexico, IN, just downstream of the watershed break.

Dams have a negative impact on the natural ecology of the stream, resulting in large pooling areas in the river that would not naturally occur. The Eel River is a low gradient stream dropping only approximately 2.41 feet per mile, consequently water backs up for approximately 2.5 miles for each foot of dam height (Gammon, 1990). In addition to changing the natural flow of the river, it also creates a barrier for genetic diversity and host species for mussel reproduction, resulting in a depressed fish and mussel community.

There are control dams at Silver Lake, Lukens Lake, Long Lake and Dean Gifford Pond. These dams have been installed to control the water level in the lakes.

Dams maintained by the state within the Middle Eel River Watershed are shown in Figure 2.39.

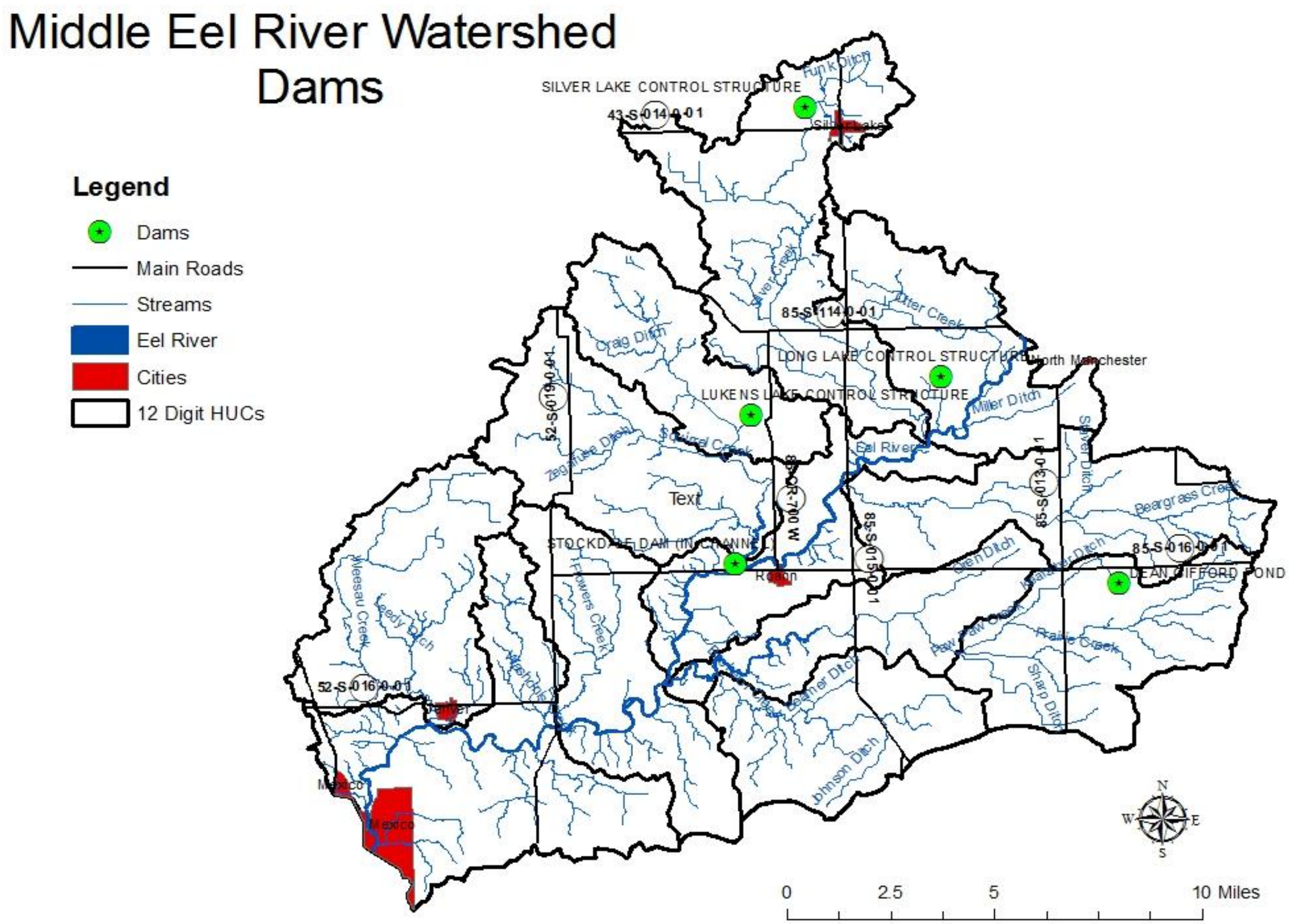

Figure 2-39. Middle Eel River Watershed Dam Locations.

2.9.3 Major Tributaries

The major tributaries of the Eel River within the watershed are listed in Table 2-5 along with stream length in miles and shown in Figure 2-40. These tributaries have very few areas of natural running stream length and are almost completely modified due to agricultural land use, resulting in changes in the hydrology of the watershed. These hydrological changes in the landscape have a negative impact on the river, including increased flooding, increased nutrients entering the stream, and increased sediment entering the river.

Table 2-5. Middle Eel River Watershed – Major Tributaries, Geographic Name and Length in Stream Miles.

Major Tributary Name	Length (stream miles)
Silver Creek	18.22
Beargrass Creek	12.20
Squirrel Creek	9.92
Paw Paw Creek	18.32
Flowers Creek	5.51
Weesau Creek	13.86

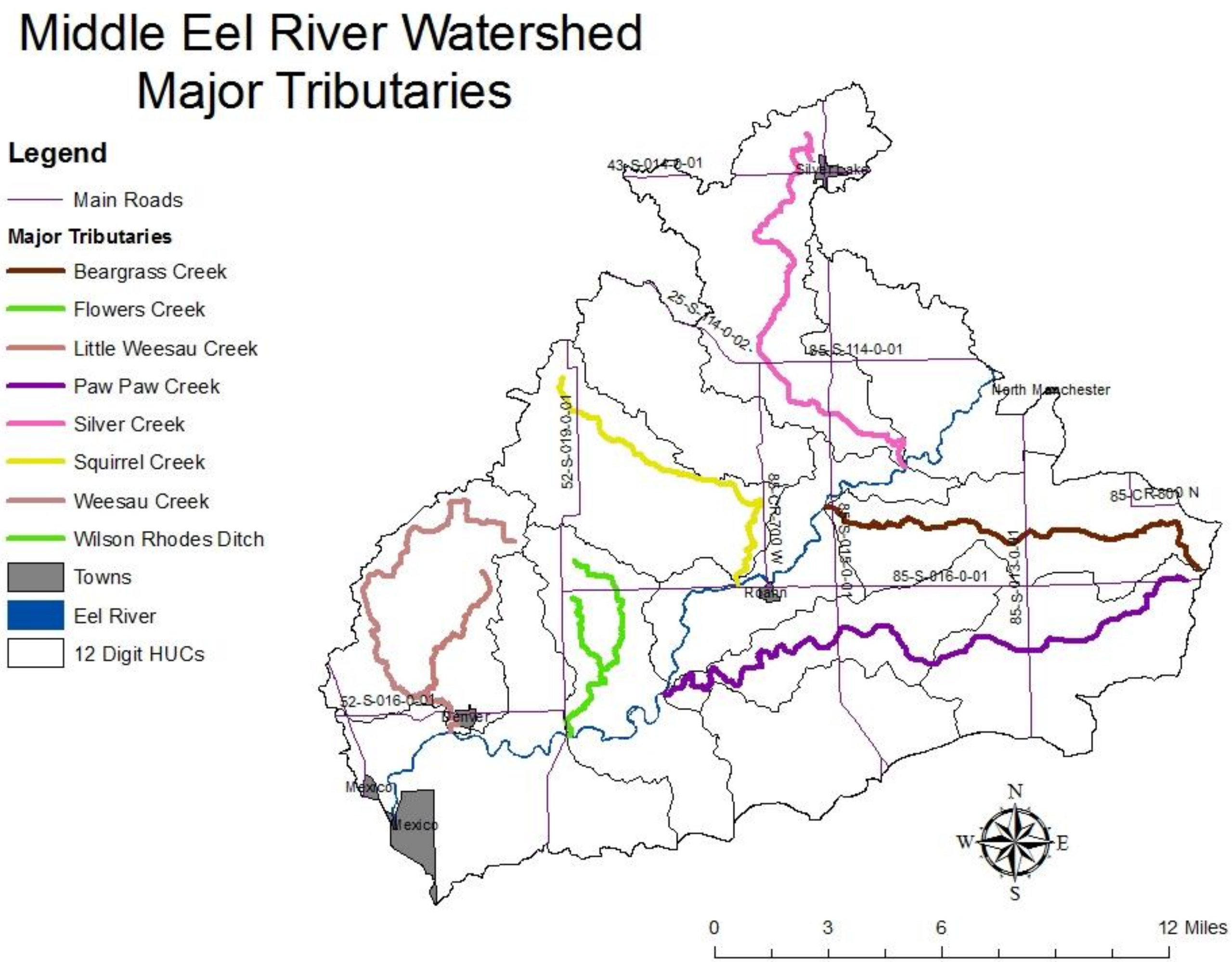

Figure 2-40. Middle Eel River Watershed – Location of Major Tributaries.

2.9.4 Lakes

The majority of lakes within the watershed are located in the most northeastern part of the watershed. The largest lake in the watershed is Silver Lake that covers 120.3 acres, and the smallest is Gaerte Lake that covers 4.45 acres. All lakes in the Middle Eel River Watershed are located within three 12 digit HUCs: 051201040501, 051201040502, and 051201040504, the three most northern 12 digit HUCs. The largest lakes, area in acres, and 12 digit HUC location are listed in Table 2-6 below, and shown in Figure 2-41.

Lakes serve many functions in a watershed; they store water, thereby helping to regulate stream flow; recharge ground water aquifers; moderate droughts; and serve as sinks and sediment traps. They provide habitat to aquatic and semiaquatic plants and animals, which in turn provide food for many terrestrial animals; and they add to the diversity of the landscape. Lakes are used by humans for many commercial purposes, including fishing, transportation, irrigation, industrial water supplies, and receiving waters for wastewater effluents.

Table 2-6. Middle Eel River Watershed Lakes, Names, Area in Acres, 12 digit HUCs, Lake Perimeter (Ft), % of Perimeter forested, grassed/row crop, or developed.

Lake Name	Acres	12 Digit HUC	Lake Perimeter (Ft)	% of Perimeter Forested	% of Perimeter Grass/row crop	% or Perimeter Developed
Brown Lake	9.14	51201040501	3,301	84%	16%	0%
Bull Lake	5.93	51201040501	2,310	0%	100%	0%
Flat Lake	6.92	51201040501	239	0%	100%	0%
Lotz Lake	10.38	51201040501	2,503	50%	50%	0%
North Little Lake	12.35	51201040501	2,710	100%	0%	0%
Silver Lake	120.34	51201040501	24,130	12%	1%	87%
South Little Lake	5.93	51201040501	2,982	18%	0%	82%
Twin Lakes	10.62	51201040501	5,438	41%	59%	0%
Bear Lake	4.94	51201040502	17,621	100%	0%	0%
Long Lake	47.44	51201040502	8,184	0%	28%	62%
Mud Lake	10.13	51201040502	2,703	100%	0%	0%
Round Lake	48.43	51201040502	6,758	0%	49%	51%
Gaerte Lake	4.45	51201040504	1,213	56%	44%	0%
Landis Lake	12.35	51201040504	2,992	0%	100%	0%
Lukens Lake	46.7	51201040504	6,494	36%	0%	64%
McColley Lake	28.17	51201040504	5,691	97%	3%	0%
Summit Lake	6.18	51201040504	2,323	0%	100%	0%
Upper Summit Lake	8.65	51201040504	2,776	74%	26%	0%
Total Acreage	**392.87**					

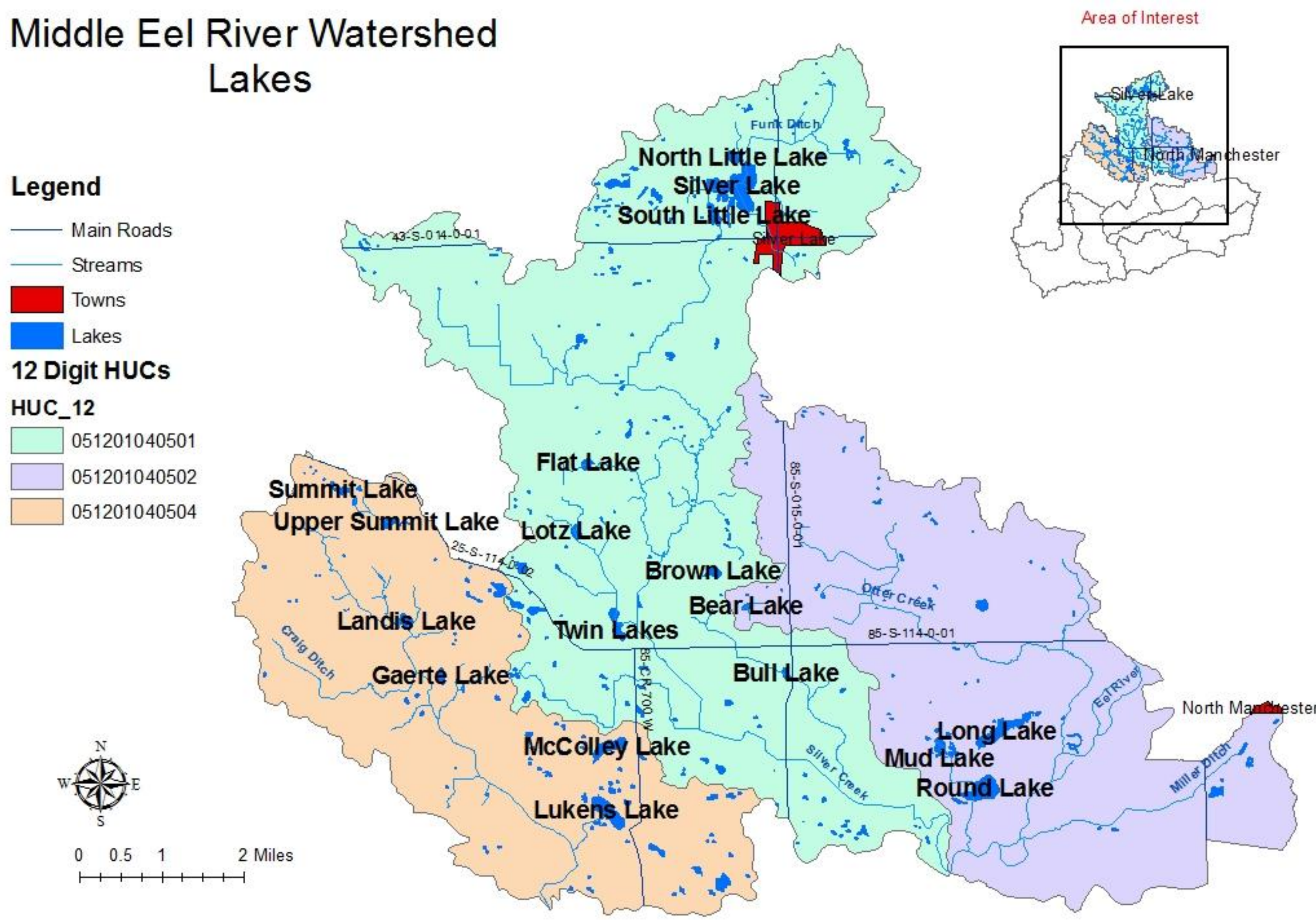

Figure 2-41. Lake of the Middle Eel River Watershed.

2.9.5 Wetlands

It is estimated that 24.1% of Indiana's surface was covered by wetlands before European settlement (Jackson, 1997). Indiana ranks fourth in the nation in percentage of wetlands lost, with an estimated 85% of wetlands lost. Much of Indiana's original wetlands were concentrated in northeastern Indiana. The Middle Eel River Watershed contains approximately 1,974 acres of wetlands, lakes, streams, ponds and other water resources, which cover only 1.35% of the watershed.

According to USDA-NRCS soil data, 63,709 acres of the watershed have hydric soils. The acreage of hydric soils provides a rough estimate of the acreage that may have historically been wetlands. Current wetland acreage compared to hydric soils indicates a loss of 32.3% of wetlands within the watershed. Hydric acres within each county and percent of watershed are listed in Table 2-7. By using this information, it is estimated that historically 12% of the Watershed was water and wetlands.

Table 2-7. Hydric Soils, Acreage and Percent of watershed by county within the Middle Eel River Watershed.

County	Hydric Acreage	% of watershed
Kosciusko County	8,315	1.57%
Miami County	19,918	3.76%
Wabash County	35,476	6.69%
TOTAL	63,709	12.02%

The wetlands that remain in the Middle Eel River Watershed are very small areas that are widely scattered. The most concentrated area of wetlands is in the northeastern section of HUC 0512010405 as shown in Figure 2-42.

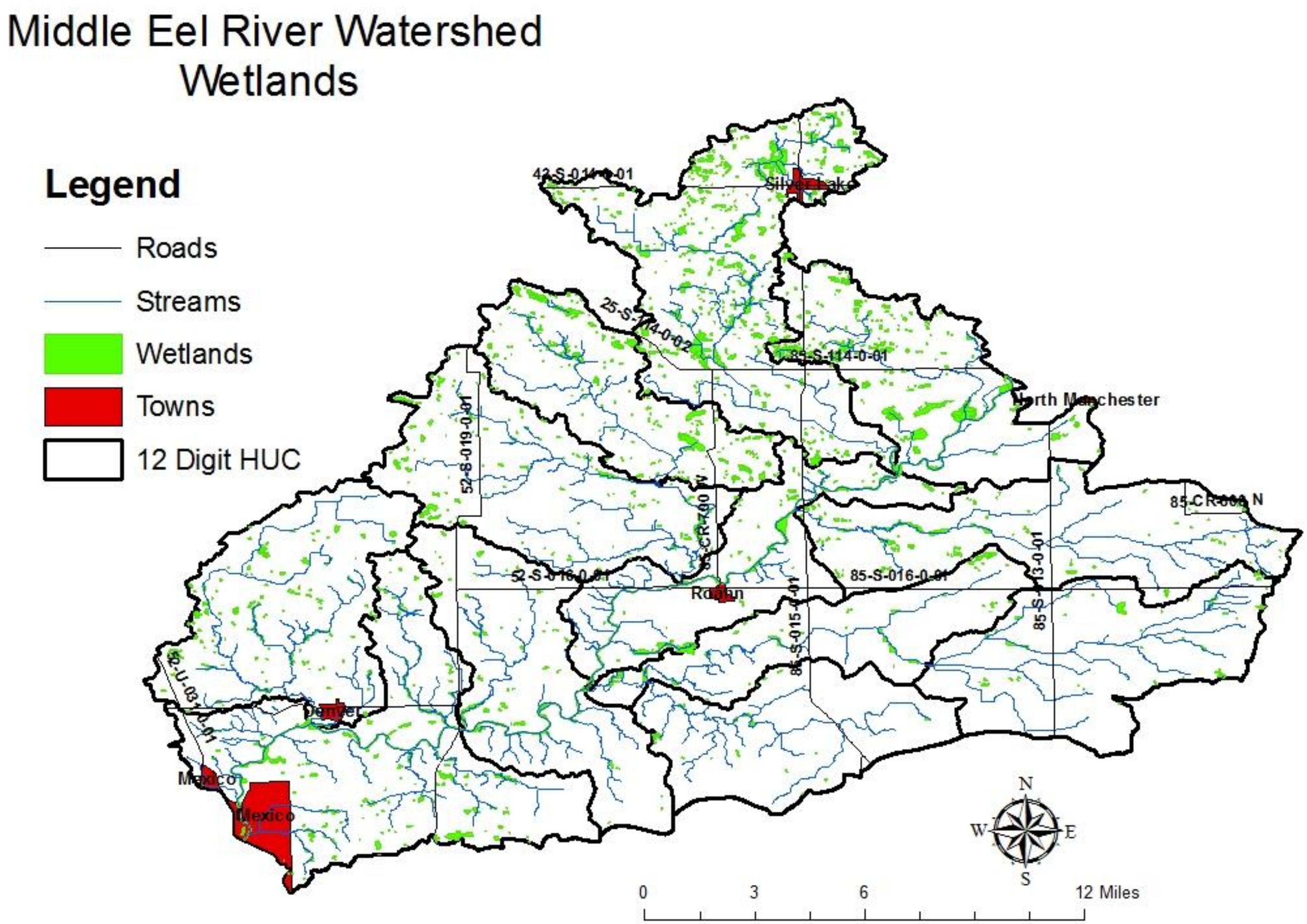

Figure 2-42. Wetlands in the Middle Eel River Watershed.

2.10 Threatened and Endangered Species

The Indiana Department of Natural Resources (IDNR) maintains information on threatened and endangered species. The IDNR posts lists for each county, however, specific locations of these species is not available. Since specific locations of these species are not available, we must assume that since the Middle Eel River Watershed encompasses large portions of both Miami and Wabash Counties, that it is possible for any of the listed species to occur within the watershed. The Indiana Endangered, Threatened and Rare Species Lists for Miami County (Table 2-8.) and Wabash County (Table 2-9.) are included below.

Table 2-8. Miami County Indiana, Endangered, Threatened and Rare Species List (Indiana Department of Natural Resources 2005).

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Epioblasma triquetra	Snuffbox		SE	G3	S1
Lampsillis fasciola	Wavyrayed lampmussel		SSC	G4	S2
Lampsillis teres	Yellow Sandshell			G5	S2
Ligumia recta	Black Sandshell			G5	S2
Obovaria subrotunda	Round Hickorynut		SSC	G4	S2
Plethobasus cyphyus	Sheepnose	C	SE	G3	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrical cylandrica	Rabbitsfoot		SE	G3T3	S1
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Venustaconcha elipsiformis	Ellipse		SSC	G3G4	S2
Villosa fabalis	Rayed Bean	C	SSC	G1G2	S1
Fish					
Ammocrypta pellucid	Eastern Sand Darter			G3	S2
Moxostoma valenciennesi	Greater Redhorse		SE	G4	S2
Reptile					
Emydoidea blandingi	Blanding’s Turtle		SE	G4	S2
Thamnophis proximus	Western Ribbon Snake		SSC	G5	S3
Bird					
Ardea Herodias	Great Blue Heron			G5	S4B
Circus cyaneus	Northern Harrier		SE	G5	S2
Mammal					
Lynx rufus	Bobcat	No Status		G5	S2
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Crataegus succulent	Fleshy Hawthorn		SR	G5	S2
Hypericum pyramidatum	Great St. John’s-wort		SR	G3	S2
Napaea dioica	Glade Mallow		SR	G3	S2
High Quality Natural Community					
Forest- upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest – upland-mesic	Mesic Upland Forest		SG	G3?	S3

LEGEND: FED: LE = Endangered; LT **LEGEND: FED:** LE = Endangered; LT = Threatened; C = Candidate; PDL = proposed for delisting
STATE: SE = State Endangered; ST State Threatened; SR = State Rare; SSC = State Species of Special Concern; SX = State Extirpated; SG = State Significant; WL = Watch List
GRANK: Global Heritage Rank: G1 = Critically Imperiled Globally; G2 = Imperiled Globally; G3 = Rare or Uncommon Globally; G4 = Widespread and abundant globally but with long term concerns; G5 = Widespread and abundant globally; G? = unranked; GX = Extinct; Q = Uncertain Rank; T = Taxonomic Subunit Rank
SRANK: State Heritage Rank: S1 = Critically Imperiled in State; S2 Imperiled in State; S3 = Rare or Uncommon in State; S4 = Widespread and abundant in state but with long term concern; SG = State Significant; SH = Historical in State; SX = State Extirpated; B = Breeding Status; S? = Unranked; SNR = Unranked; SNA = Nonbreeding Status Unranked

Table 2-9. Wabash County Indiana, Endangered, Threatened and Rare Species List (Indiana Department of Natural Resources 2005).

Species Name	Common Name	FED	STATE	GRANK	SRANK
Crustacean: Branchiopoda					
Lynceus brachyurus	Holarctic Clam Shrimp		WL	G5	S1?
Mollusk: Bivalvia (Mussels)					
Cyprogenia stegaria	Eastern Fanshell Pearlymussel	LE	SE	G1	S1
Epioblasma triquetra	Snuffbox		SE	G3	S1
Lampsillis teres	Yellow Sandshell			G5	S2
Ligumia recta	Black Sandshell			G5	S2
Obovaria subrotunda	Round Hickorynut		SSC	G4	S2
Pleurobema clava	Clubshell	LE	SE	G2	S1
Pleurobema cordatum	Ohio Pigtoe		SSC	G3	S2
Quadrula cylindrical cylandrica	Rabbitsfoot		SE	G3T3	S1
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Villosa fabalis	Rayed Bean	C	SSC	G1G2	S1
Insect: Lepidoptera (Butterflies/ Moths)					
Calephelis muticum	Swamp Metalmark		ST	G3	S2
Euphydryas phaeton	Baltimore		SR	G4	S2
Euphyes bimacula	Two-spotted Skipper		ST	G4	S2
Euphyes dukesi	Scarce Swamp Skipper		ST	G3	S1S2
Fixsenia favonius	Northern Hairstreak		SR	G4	S1S2
Hesperia leonardus	Leonard’s Skipper	No Status	SR	G4	S2
Lycaena epixanthe	Bog Copper		SX	G4G5	SX
Lycaena helloides	Purplish Copper		SR	G5	S2S4
Poanes viator viator	Big Broad-winged Skipper		ST	G5T4	S2
Speyeria idalia	Regal Fritillary		SE	G3	S1
Fish					
Ammocrypta pellucid	Eastern Sand Darter			G3	S2
Clinostomus elongates	Redside Dace		SE	G4	S1
Moxostoma valenciennesi	Greater Redhorse		SE	G4	S2

Species Name	Common Name	FED	STATE	GRANK	SRANK
Reptile					
Emydoidea blandingi	Blanding's Turtle		SE	G4	S2
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Bird					
Ardea herodias	Great Blue Heron			G5	S4B
Buteo platypterus	Broad-winged Hawk	No Status	SSC	G5	S3B
Certhia americana	Brown Creeper			G5	S2B
Chlidonias niger	Black Tern		SE	G4	S1B
Circus cyaneus	Northern Harrier		SE	G5	S2
Dendroica cerulean	Cerulean Warbler		SSC	G4	S3B
Dendroica virens	Black-throated Green Warbler			G5	S2B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Rallus limicola	Virginia Rail		SE	G5	S3B
Sterna hirundo	Common Tern			G5	SXB
Tyto alba	Barn Owl		SE	G5	S2
Wilsonia citrine	Hooded Warbler		SSC	G5	S3B
Mammal					
Condylura cristata	Star-nosed Mole		SSC	G5	S2?
Lutra canadensis	Northern River Otter			G5	S2
Lynx rufus	Bobcat	No Status		G5	S2
Mustela nivalis	Least Weasal		SSC	G5	S2?
Myotis sodalist	Indiana Bat or Social Myotis	LE	SE	G2	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Arenaria stricta	Michaux's Stitchwort		SR	G5	S2
Carex flava	Yellow Sedge		ST	G5	S2
Carex lupuliformis	False Hop Sedge		SR	G4	S2
Cypripedium calceolus var. parviflorum	Small Yellow Lady's-slipper		SR	G5	S2
Cypripedium candidum	Small White Lady's-slipper		WL	G4	S2
Erysimum capitatum	Prairie-rocket Wallflower	No Status	ST	G5	S2
Schizachne purpurascens	Purple Oat		SE	G5	S1
Waldsteinia fragarioides	Barren Strawberry		SR	G5	S2
Zigadenus elegans var. glaucus	White Camas		SR	G5T4T5	S2

High Quality Natural Community					
Forest – flatwoods central till plain	Central Till Plain Flatwoods		SG	G3	S2
Forest – floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3
Forest- upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest – upland-mesic	Mesic Upland Forest		SG	G3?	S3
Primary – cliff limestone	Limestone Cliff		SG	GU	S1
Wetland – fen	Fen		SG	G3	S3

LEGEND: FED: LE = Endangered; LT = Threatened; C = Candidate; PDL = proposed for delisting
STATE: SE = State Endangered; ST State Threatened; SR = State Rare; SSC = State Species of Special Concern; SX = State Extirpated; SG = State Significant; WL = Watch List
GRANK: Global Heritage Rank: G1 = Critically Imperiled Globally; G2 = Imperiled Globally; G3 = Rare or Uncommon Globally; G4 = Widespread and abundant globally but with long term concerns; G5 = Widespread and abundant globally; G? = unranked; GX = Extinct; Q = Uncertain Rank; T = Taxonomic Subunit Rank
SRANK: State Heritage Rank: S1 = Critically Imperiled in State; S2 Imperiled in State; S3 = Rare or Uncommon in State; S4 = Widespread and abundant in state but with long term concern; SG = State Significant; SH = Historical in State; SX = State Extirpated; B = Breeding Status; S? = Unranked; SNR = Unranked; SNA = Nonbreeding Status Unranked

It is important to note the following species have been identified within the watershed and deserve special attention. These species were taken into consideration when designating critical areas in which to concentrate our efforts.

The Greater Redhorse (*Moxostoma valenciennesi*) and the Eastern Sand Darter (*Ammocrypta pellucid*) have both been identified in the Middle Eel River Watershed. The presence of the Greater Redhorse in the Eel River is unique as this is the only known location within the entire Ohio River Drainage Basin (Simon, 2006). An Eastern Sand darter was located in the mainstem of the Middle Eel River close to North Manchester in 2007, and in 2009 was found in Squirrel Creek and the mainstem of the Eel River.

Several shells of two federally endangered mussels were found in the watershed within the mainstem of the Middle Eel River in 2008, however, they were weather dead, which means the shells did not contain a living organism and the shells were separated from each other. The two mussels were the Northern Riffleshell (*Epioblasma torulosa rangiana*), and Clubshell (*Pleurobema clava*). One state endangered mussel, Rabbitsfoot (*Quadrula cylindrical cylindrical*) was found living in the mainstem of the Middle Eel River, and was documented in 2009 as far north as Chili, IN.

River otters (*Lutra canadensis*), a species of special concern, were reintroduced into the Eel River from 1995-1999 with much success.

The range of the Indiana bat (*Myotis sodalis*), a federally endangered species, is within the watershed.

Even though there are several plants of concern that may exist within the watershed, a plant survey for the watershed has not been completed and is not part of this project.

The Tippecanoe Audubon Society is in the process of compiling a breeding bird survey listing the presence/absence of nesting birds within the Watershed, see Appendix H.

2.11 Incorporated Cities

There are only three incorporated cities completely within the Middle Eel River Watershed; Silver Lake, Roann and Denver, with two additional cities partially within the watershed; North Manchester and Mexico (Figure 43). Demographics for each city are listed below.

2.11.1 Silver Lake

Total land area 0.3 square miles, elevation 899 feet, located in Kosciusko County. As of the census of 2000, there were 546 people, 207 households, and 156 families residing in the town. The population density was 1,874.9 people per square mile (726.9/km²). There were 221 housing units at an average density of 758.9/sq mi (294.2/km²). The racial makeup of the town was 95.79% White, 0.37% Native American, 0.18% Asian, 2.75% from other races, and 0.92% from two or more races. Hispanic or Latino of any race were 3.48% of the population.

There were 207 households out of which 35.7% had children under the age of 18 living with them, 59.9% were married couples living together, 9.7% had a female householder with no husband present, and 24.6% were non-families. 18.8% of all households were made up of individuals and 8.2% had someone living alone who was 65 years of age or older. The average household size was 2.64 and the average family size was 2.97. In the town the age of the population varied out with 27.3% under the age of 18, 6.6% from 18 to 24, 29.3% from 25 to 44, 22.9% from 45 to 64, and 13.9% who were 65 years of age or older. The median age was 36 years. For every 100 females there were 88.3 males. For every 100 females age 18 and over, there were 90.9 males.

The median income for a household in the town was $33,088, and the median income for a family was $36,875. Males had a median income of $31,442 versus $21,000 for females. The per capita income for the town was $13,561. About 9.4% of families and 12.1% of the population were below the poverty line, including 14.5% of those under age 18 and 10.2% of those age 65 or over.

Silver Lake has a wastewater treatment facility that discharges only 2 to 3 times per year. They do not treat for phosphorus before discharge.

2.11.2 Roann

Total land area 0.2 square miles, elevation 755 feet, located in Wabash County. As of the census of 2000, there were 400 people, 153 households, and 117 families residing in the town. The population density was 2,226.4 people per square mile (858.0/km²). There were 164 housing units at an average density of 912.8/sq mi (351.8/km²). The racial makeup of the town was 98.00% White, 0.25% from other races, and 1.75% from two or more races. Hispanic or Latino of any race were 0.25% of the population.

There were 154 households out of which 36.6% had children under the age of 18 living with them, 61.4% were married couples living together, 8.5% had a female householder with no husband present, and 22.9% were non-families. 21.6% of all households were made up of individuals and 11.1% had someone living alone who was 65 years of age or older. The average household size was 2.61 and the average family size was 2.99. In the town the age of the population was spread out with 27.5% under the age of 18, 9.0% from 18 to 24, 26.0% from 25 to 44, 25.0% from 45 to 64, and 12.5% who were 65 years of age or older. The median age was 35 years. For every 100 females there were 91.4 males. For every 100 females age 18 and over, there were 94.6 males.

The median income for a household in the town was $41,000, and the median income for a family was $42,955. Males had a median income of $29,833 versus $22,411 for females. The per capita income for the town was $20,880. About 4.8% of families and 9.5% of the population were below the poverty line, including 12.7% of those under age 18 and 9.1% of those age 65 or over.

Roann has a wastewater treatment facility that does not treat for phosphorus before discharging.

2.11.3 Denver

Total land area 0.2 square miles, elevation 712 feet, located in Miami County.
As of the census of 2000, there were 541 people, 189 households, and 158 families residing in the town. The population density was 2,318.0 people per square mile (908.2/km²). There were 200 housing units at an average density of 856.9/sq mi (335.7/km²). The racial makeup of the town was 98.89% White, 0.55% Native American, and 0.55% from two or more races. Hispanic or Latino of any race were 0.37% of the population.

There were 189 households out of which 48.7% had children under the age of 18 living with them, 64.0% were married couples living together, 16.9% had a female householder with no husband present, and 15.9% were non-families. 13.8% of all households were made up of individuals and 6.3% had someone living alone who was 65 years of age or older. The average household size was 2.86 and the average family size was 3.11. In the town the age of the population was spread out with 30.9% under the age of 18, 6.8% from 18 to 24, 34.2% from 25 to 44, 18.5% from 45 to 64, and 9.6% who were 65 years of age or older. The median age was 33 years. For every 100 females there were 104.2 males. For every 100 females age 18 and over, there were 88.9 males.

The median income for a household in the town was $36,250, and the median income for a family was $36,985. Males had a median income of $29,286 versus $21,250 for females. The per capita income for the town was $15,224. About 5.0% of families and 9.5% of the population were below the poverty line, including 14.8% of those under age 18 and 4.9% of those age 65 or over.

Denver has a wastewater treatment plant and a separate storm drain system. The presence of a separate storm drain eliminates any raw sewage discharge into the river during heavy rain events. They do not treat for phosphorus prior to discharge.

2.11.4 North Manchester

Total land area within the watershed is .04 square miles, elevation 771 feet, located in Wabash County. As of the census of 2000, there were 6,260 people, 2,192 households, and 1,374 families residing in the town. The population density was 1,735.5 people per square mile (669.5/km²). There were 2,327 housing units at an average density of 645.1/sq mi (248.9/km²). The racial makeup of the town was 96.15% White, 0.93% African American, 0.27% Native American, 0.83 Asian, 0.06 Pacific Islander, and 0.96% from two or more races. Hispanic or Latino of any race were 1.74% of the population.

There were 2,192 households out of which 26.0% had children under the age of 18 living with them, 51.0% were married couples living together, 8.9% had a female householder with no husband present, and 37.3% were non-families. 31.1% of all households were made up of individuals and 13.9% had someone living alone who was 65 years of age or older. The average household size was 2.29 and the average family size was 2.85. In the town the age of the population was spread out with 17.8% under the age of 18, 21.9% from 18 to 24, 20.1% from 25 to 44, 17.9% from 45 to 64, and 22.3% who were 65 years of age or older. The median age was 36 years. For every 100 females there were 81.4 males. For every 100 females age 18 and over, there were 78.2 males.

The median income for a household in the town was $35,448, and the median income for a family was $46,781. Males had a median income of $31,795 versus $23,388 for females. The per capita income for the town was $17,140. About 4.8% of families and 8.7% of the population were below the poverty line, including 6.9% of those under age 18 and 5.0% of those age 65 or over. North Manchester has a wastewater treatment plant that is in the process of separating its sewage from its stormwater. In 2009 there were 40 episodes of discharge of raw sewage to the Eel River from North Manchester. The North Manchester wastewater treatment plant does not treat for the removal of phosphorus and may be contributing to high phosphorus and *E. coli* counts in the mainstem of the Eel River.

2.11.5 Mexico, IN

Total land area within the watershed is 2.19 square miles, elevation 984 feet, located in Miami County. As of the census of 2000, there were 984 people, 402 households, and 297 families residing in the town. The population density was 179.6 people per square mile (69.3/km²). There were 416 housing units at an average density of 75.9/sq mi (29.3/km²). The racial makeup of the town was 98.27% White, 0.30% African American, 0.71% Native American, 0.10 Pacific Islander, and 0.61% from two or more races. Hispanic or Latino of any race were 0.51% of the population.

There were 402 households out of which 29.4% had children under the age of 18 living with them, 62.7% were married couples living together, 8.5% had a female householder with no husband present, and 26.1% were non-families. 22.1% of all households were made up of individuals and 8.7% had someone living alone who was 65 years of age or older. The average household size was 2.45 and the average family size was 2.86. In the town the age of the population was spread out with 21.1% under the age of 18, 8.5% from 18 to 24, 27.0% from 25 to 44, 28.4% from 45 to 64, and 14.9% who were 65 years of age or older. The median age was 42 years. For every 100 females there were 102.9 males. For every 100 females age 18 and over, there were 97.5 males.

The median income for a household in the town was $49,234, and the median income for a family was $55,776. Males had a median income of $37,778 versus $26,389 for females. The per capita income for the town was $19,150. About 2.9% of families and 5.1% of the population were below the poverty line, including none of those under age or 65 or over. Mexico is in the process of installing a wastewater treatment plant, however as of this writing waste is still handled with all septic systems.

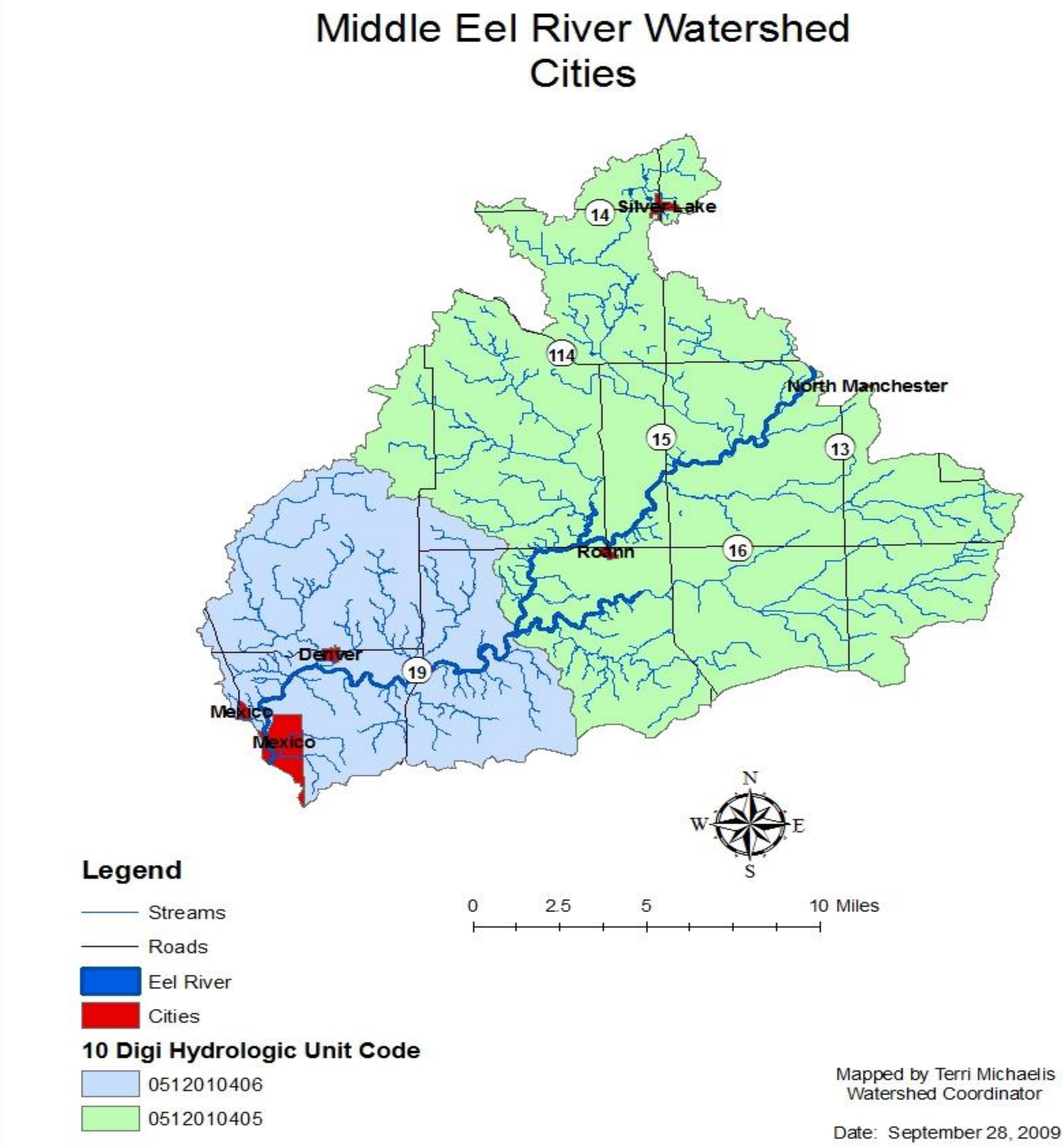

Figure 2-43. Middle Eel River Watershed, Incorporated Cities (Indiana Geological Survey 2001).

2.12 NPDES Permits

IDEM administers the National Pollution Discharge Elimination System (NPDES) permit program required by the Clean Water Act (CWA). IDEM addresses activities that cause or may cause discharge of pollutants into the waters of the State. According to IDEM, the purpose of NPDES permits is to control point source pollution of the state's waters. The NPDES permit requirements must ensure that, at a minimum, any new or existing point source discharger must comply with technology-based treatment requirements that are contained in 327 IAC 5-5-2. According to 327 IAC 5-2-2, "Any discharge of pollutants into waters of the State as a point source discharge, except for exclusions made in 327 IAC 5-2-4, is prohibited unless in conformity with a valid NPDES permit obtained prior to discharge." This is the most basic principal of the NPDES permit program. (IDEM Office of Water Quality, 2009). There are nine NPDES permits for wastewater facilities in the watershed, Figure 2-44, please note there are two NPDES Permits issued for Denver, IN. Confined Animal Feeding Operations also require NPDES permits and are addressed in the next section.

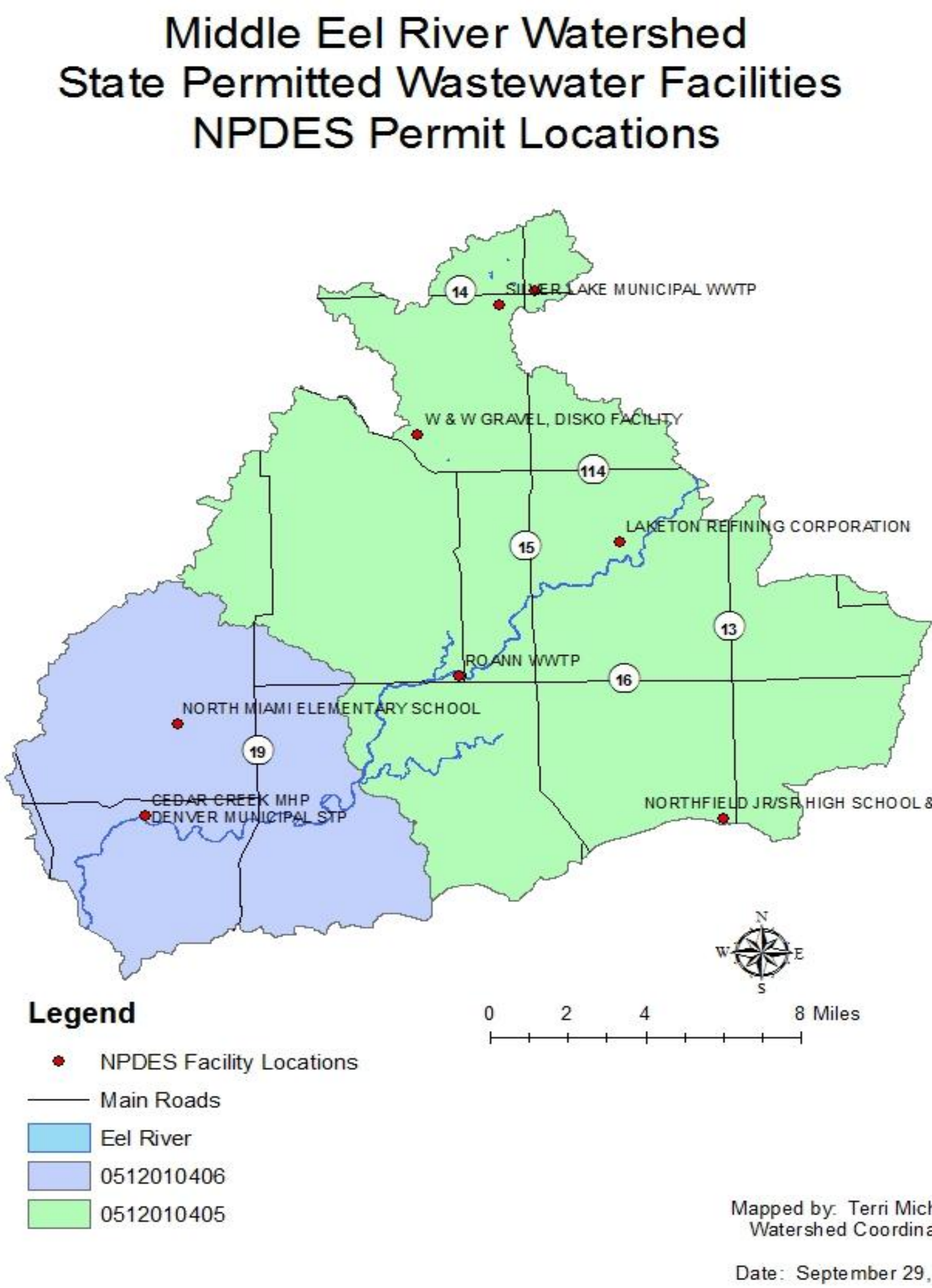

Figure 2-44. Middle Eel River Watershed Wastewater Facilities - National Pollutant Discharge Elimination System Permits (NPDES), 2002. (IDEM - Office of Water Quality, 2009). Note there are two NPDES permits at Cedar Creek MHP and Denver Municipal Sewage Treatment Plant.

2.13 Animal Feeding Operations

There are 11 large, 48 medium and 12 small Confined Feeding Operations (CFO) in the watershed and 19 large, 1 medium and 1 small Concentrated Animal Feeding Operations (CAFO). There are different regulations and guidelines for CFOs and CAFOs which are defined below. The total numbers and types of animals being housed in a CFO and/or CAFO in the watershed as of 9/30/09 (Dunn, 2009) are listed below:

- Hogs - 189,709
- Beef Cattle - 1,598
- Dairy Cattle - 1,590
- Veal - 11,330
- Chickens - 5,191,296
- Ducks - 24,700
- Sheep - 10

2.13.1 Confined Feeding Operations (CFOs)

Confined feeding is the raising of animals in any confined area for at least 45 days during any year where there is no ground cover or vegetation over half of the confined area. CFOs are defined by Indiana law as any feeding operation engaged in the confined feeding of at least:

- 300 cattle or
- 600 swine or
- 600 sheep or
- 30,000 fowl (chickens, turkey or other poultry)

IDEM regulates the CFOs through the Office of Land Quality which is responsible for permitting, compliance monitoring and enforcement activities as outlined in the Confined Feeding Control Law. The following criteria must be met in order to be a permitted CFO:

- Must have at least 180 days storage for manure and wastewater
- Be designed according to the design standards outlined in the CFO Guidance Manual
- Have sufficient acreage available for application of manure generated
- Provide adequate seperation distances of the manure storage structures and confinement lots from roads, wells, and surface waters
- Include a manure management plan detailing soil testing, manure testing and manure application areas
- Provide record keeping at the CFO which includes:
    - Manure type
    - Amount of manure generated
    - Amount of manure applied to land
    - Manure storage methods

- Type of application equipment used
- Application rates based on laboratory analysis

2.13.2 Confined Animal Feed Operations (CAFOs)

The CAFO permit process and operational requirements are slightly different than for CFOs. CAFOs in Indiana are required to obtain an NPDES permit through IDEM according to the USEPA Clean Water Act regulations for CAFOs finalized in 2003. CAFOs are considered to be point sources for pollution by the USEPA. IDEM developed a general permit for CAFOs (327 IAC 15-15) effective in February 2004. Two types of NPDES permits are available for CAFOs:

1. The general permit establishes uniform criteria to be followed by those with a general permit.

2. An individual permit provides an opportunity for IDEM to require additional protective measures, or for the farm to construct or operate in a manner different than that prescribed by the general permit regulation.

All of the 21 CAFOs within the Middle Eel River Watershed have general permits.

The main determining factor for requirement of an NPDES permit is the number and species of animals. The threshold for each species is shown in Table 2-10.

Table 2-10. Threshold number and species that require CAFO NPDES permit.

Threshold Number Requiring NPDES Permit	Species
700	Mature Dairy Cows
1,000	Veal Calves
1,000	Cattle - other than mature dairy cows
2,500	Swine - above 55 pounds
10,000	Swine - less than 55 pounds
500	Horses
10,000	Sheeps or Lambs
55,000	Turkeys
30,000	Laying Hens/Broilers with liquid manure handling system
125,000	Broilers with solid manure handling system
82,000	Laying Hens with solid manure handling system
30,000	Ducks with solid manure handling system
5,000	Ducks with a liquid manure handling system

Any CAFO seeking an NPDES permit must provide to IDEM the following information:

- A completed NPDES permit application form;
- A completed CFO approval application form;
- Confirmation that any necessary public notice requirements were conducted ;
- Plans and specifications for the design and construction of the animal confinement structure and manure treatment and control facilities;
- At least two soil borings within the area of any liquid waste storage structures;
- A manure management plan outlining procedures for soil testing and manure testing;
- Soil Survey and Topographic Maps of manure application areas which outline field borders, identify the owner, and acres available;
- Farmstead plan showing the location of the buildings and waste storage structures in relation to the following features within 500 feet:
    - water wells
    - drainage patterns
    - property lines
    - roads
    - streams, ditches and tile inlets

The following conditions must be satisfied for IDEM to issue an NPDES permit:

- The submitted application forms must be complete with no missing applicable information;
- Confirmation that public notice requirements were satisfied;
- Provides at least 6 months of manure and wastewater storage capacity;
- Has sufficient acreage available for application of the manure and wastewater;
- Provides adequate separation distances of the manure storage structures and confinement lots from property lines, roads, wells, and surface waters;
- If a construction application is submitted that the structures are designed to be built according to the design standards outlined in the CFO rule and CFO Guidance Manual.

There are 17 large CAFOs, 1 medium CAFO and 1 small CAFO within the watershed. Figures 2-45 through 2-47 show the total number and type of animals in CAFOs within the watershed. Figure 2-48 shows the percentage of each type of animal in CAFOs within the watershed. Figures 2-49 through 2-52 show the total number and type of animals in CFOs within the watershed. Figure 2-53 shows the percentage of each type of animal in CFOs within the watershed, and Figure 2-54 shows the locations of CAFOs and CFOs within the Middle Eel River Watershed.

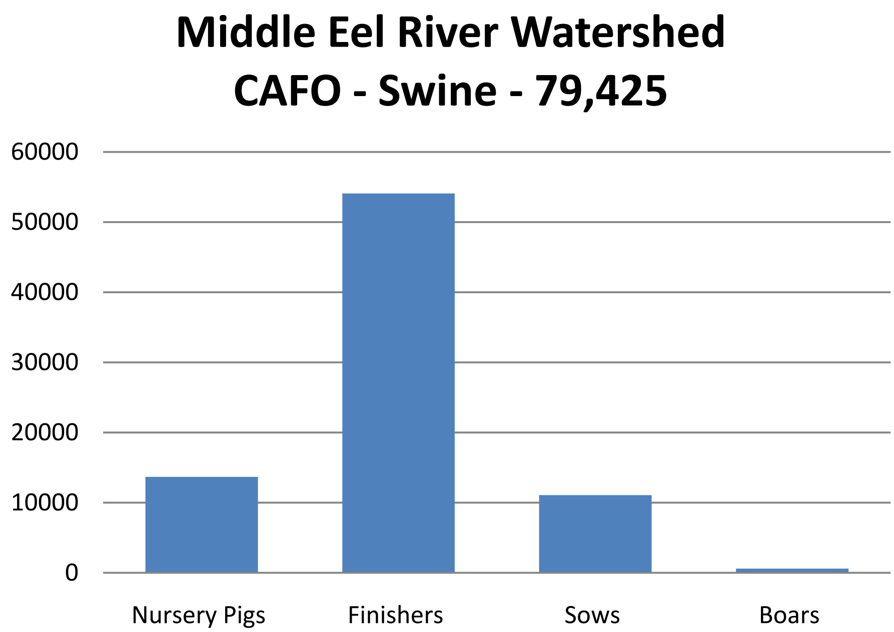

Figure 2-45. Middle Eel River Watershed - Number of swine in CAFOs within the watershed (Dunn, 2009).

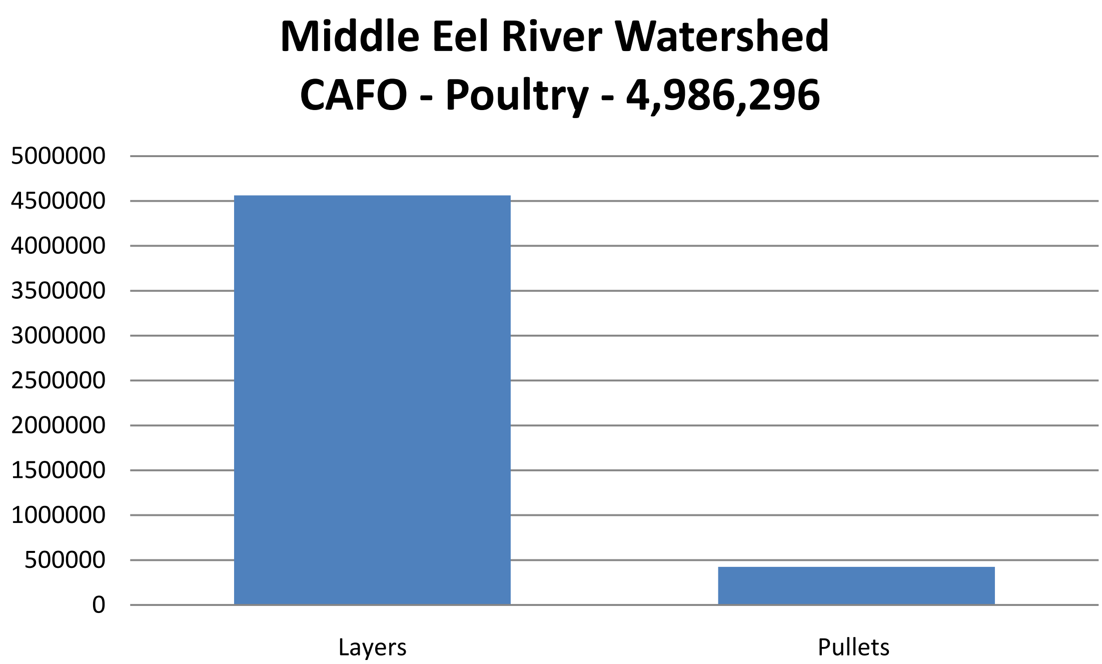

Figure 2-46. Middle Eel River Watershed - Number of chickens in CAFOs within the watershed (Dunn, 2009).

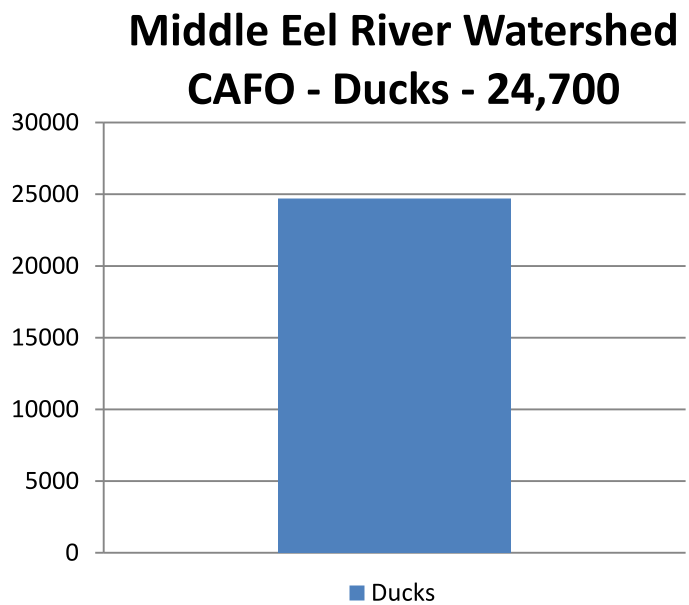

Figure 2-47. Middle Eel River Watershed - Number of ducks in CAFOs within the watershed (Dunn, 2009).

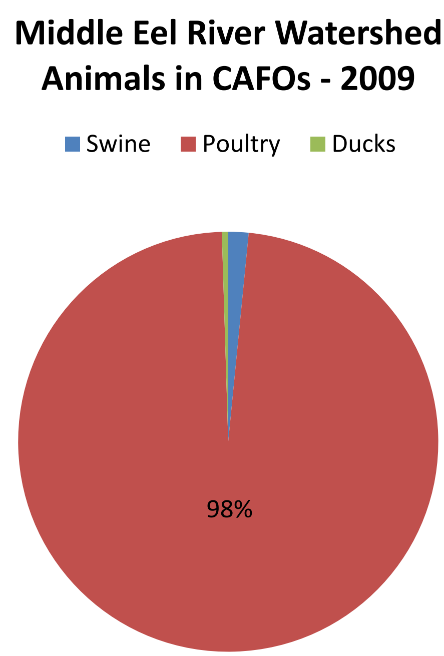

Figure 2-48. Middle Eel River Watershed, percentage of animal type in CAFOs within the watershed.

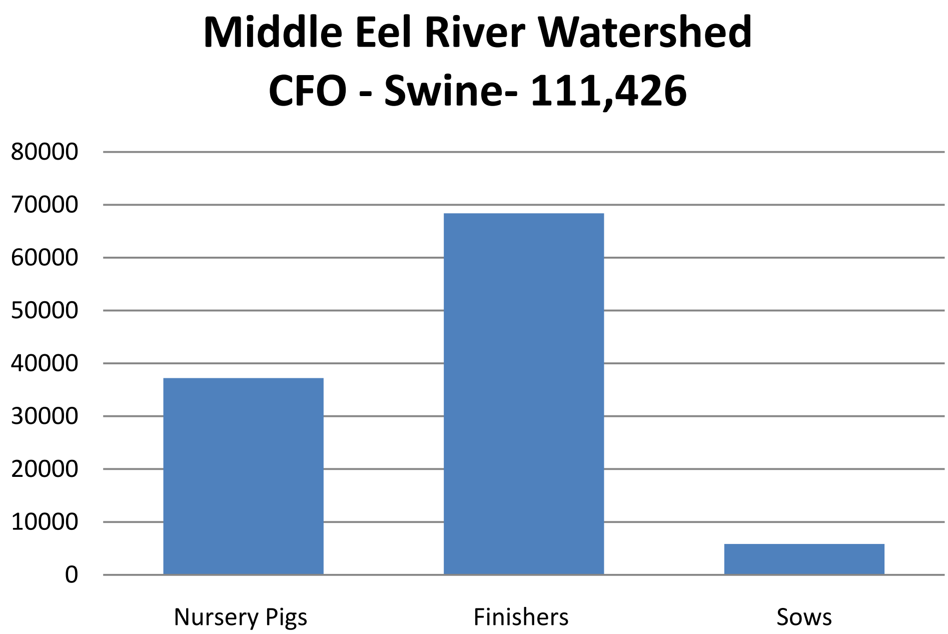

Figure 2-49. Middle Eel River Watershed - Number of hogs in CFOs within the watershed (Dunn, 2009).

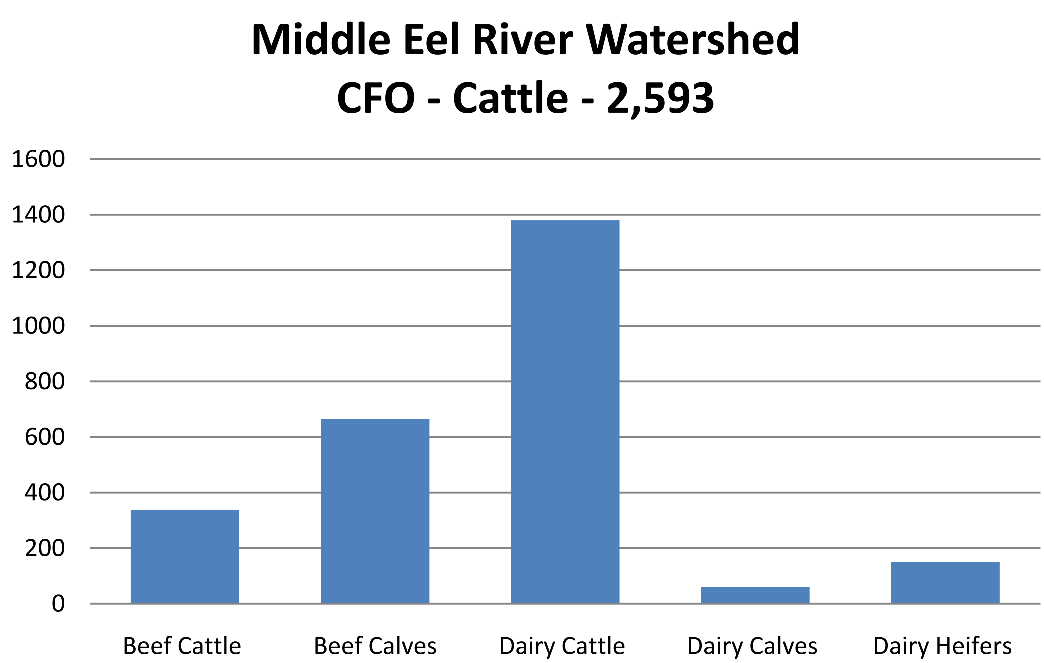

Figure 2-50. Middle Eel River Watershed - Number of cattle in CFOs within the watershed (Dunn, 2009).

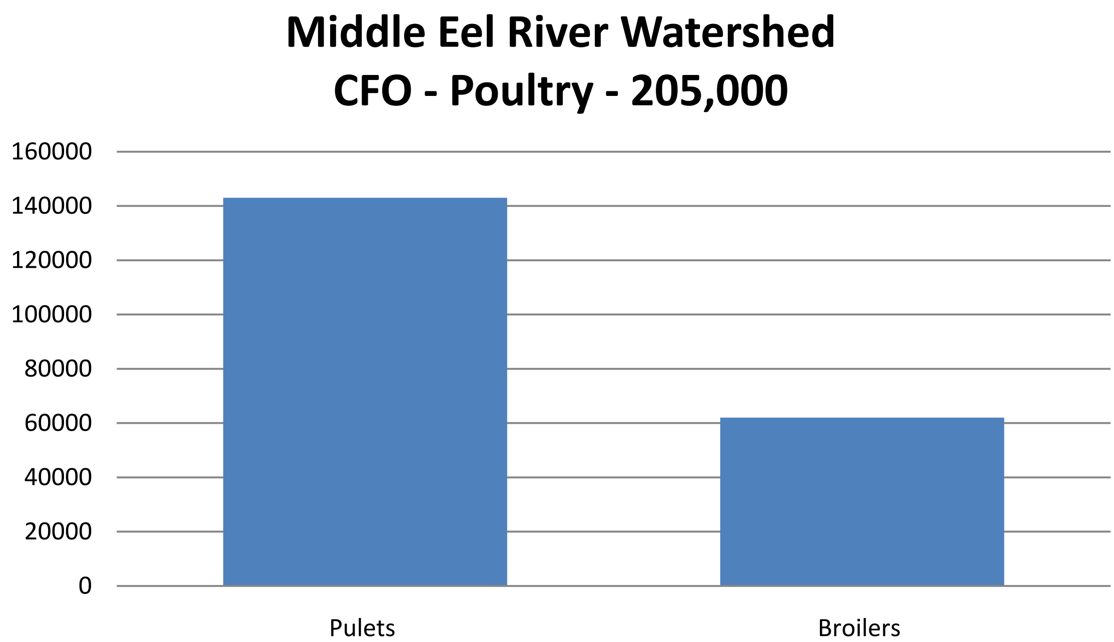

Figure 2-51. Middle Eel River Watershed - Number of chickens in CFOs within the watershed (Dunn, 2009).

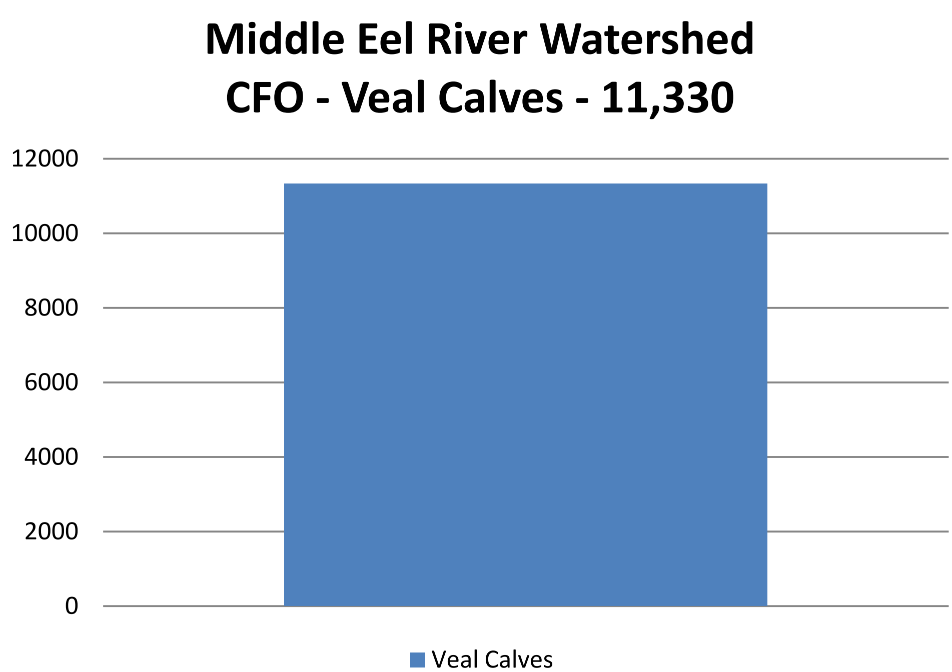

Figure 2-52. Middle Eel River Watershed - Number of veal calves in CFOs within the watershed (Dunn, 2009).

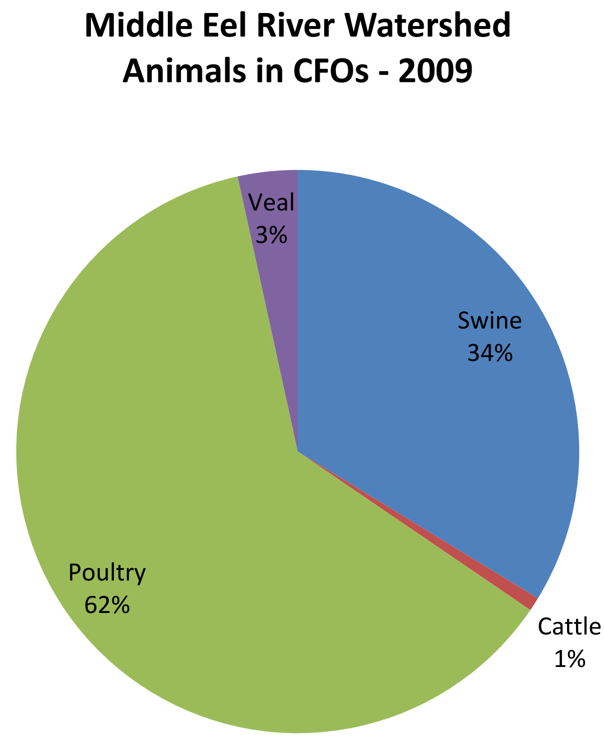

Figure 2-53. Middle Eel River Watershed, percentage of animal type in CFOs within the watershed.

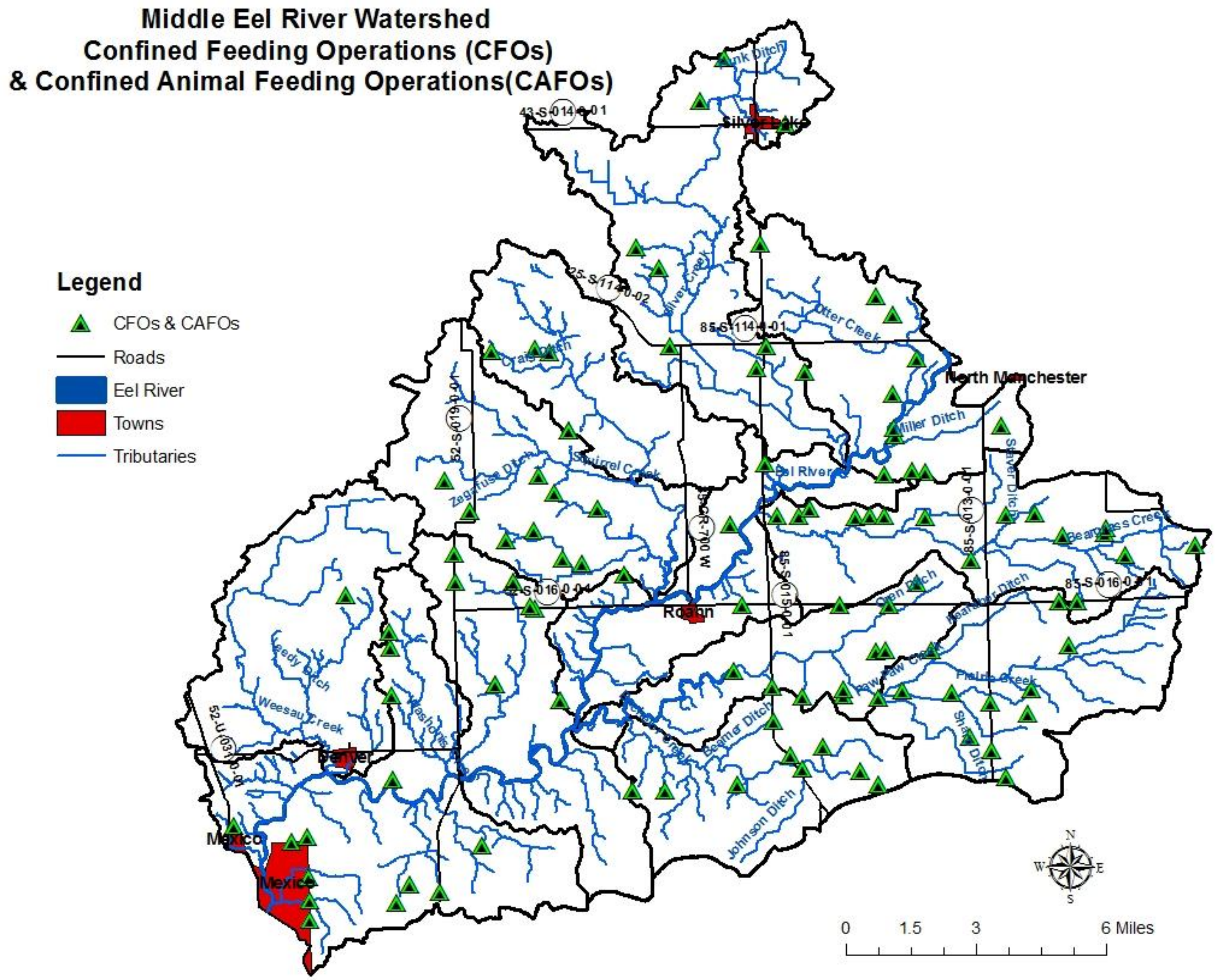

Figure 2-54. Middle Eel River Watershed, location of CFOs & CAFOs

2.14 Combined Sewer Overflow(CSO) & Septic Systems

The city of North Manchester is in the process of transitioning from a combined sewer overflow system to separated storm drains. In a combined sewer overflow system, storm water and sewage waste use the same pipes. Consequently when a heavy rain occurs, the water draining off the land and the sewage combine together and exceed the capacity of the drainage pipe. In order to maintain sewage service to the city, valves are opened that allow discharge of untreated sewage to the Eel River. This may cause an increase in nutrients, particularly phosphorus and nitrogen as well as an increase in E. coli concentrations, however this is a point source and is beyond the scope of this watershed management plan.

Using the EPA STEPL Model for the Eel River Watershed, it is estimated that there are 1,526 septic systems within the watershed. The estimated rate of failure for septic systems in the Middle Eel River Watershed using the EPA STEPL Model is 1.09%. It is therefore estimated that 17 septic systems within the Watershed are failing.

2.15 Agricultural Tile Drainage

Tile drainage in Indiana is intimately tied to row crop agriculture. No agency tracts the placement or number of tile drains in Indiana fields or watersheds. Subsurface tile drains are common across the watershed and can be found by the discharge pipes seen in ditches and streams. It is well known that nitrate binds and moves with water. As water drains off the land through the tile drains it may carry excess nitrogen from the fields and cause an increase in the nitrogen concentrations in rivers and streams.

Middle Eel River
Watershed Management Plan

SECTION 3

WATER MONITORING

1/6/11

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3.0 Water Monitoring

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3.0 Water Monitoring

3.1 Water Monitoring Locations

For this watershed study, there were nine primary sites for water monitoring; three on the mainstem, and six tributaries of the Middle Eel River.

The Quality Assurance Project Plan that was approved by IDEM outlines the monitoring program for the Initiative (Appendix D).

Three automatic water samplers with data loggers and stream discharge gages were installed on the mainstem: the most upstream site near North Manchester as the water enters the watershed (Blocher Gage), one at the watershed break between the two 10 digit HUCs near Chili (Paw Paw Gage), and one at the most downstream site of the watershed near Mexico as the water exits the watershed (Mexico Gage) (Figure 3-1). The upstream site is located just downstream from the town of North Manchester at river mile 49 or 85^{o} 48’ 34.5” and 40^{o} 59’ 45.1”. The middle site is just downstream from the confluence of Pawpaw Creek at river mile 32.4 or 85^{o} 58’ 38.7” and 40^{o} 52’ 23.9”. The most downstream site is near the town of Mexico, Indiana near old U.S. 31 or river mile 18.26 or 80^{o} 06’ 42.1” and 40^{o} 48’ 49.4”. These sites were strategically chosen in order to more precisely determine the contribution of nonpoint source pollution (NPS) from each 10 digit HUC and to determine the water quality coming into and leaving the watershed. Gage stations water monitoring consisted of six automatic daily samples, with four of the six analyzed daily at base flow, and all six analyzed daily following rain events.

The six tributaries were selected as sampling sites because of their large watershed areas and major contribution to the mainstem. These six tributaries include: Beargrass Creek, Pawpaw Creek, Squirrel Creek, Weesau Creek, Silver Creek, and Flower’s Creek. Testing tributary water monitoring consisted of weekly grab samples during base flow and daily grab samples following rain events. Figure 3-1. shows all of the testing locations.

The sampling approach for this project was a targeted design that focused on the assessment and quantification of the chemical, physical, and biological attributes of the stream reach. Due to the lack of consistent, rigorous water quality monitoring of the Middle Eel River, baseline data was established using only the first year of data collected at sampling locations.

All water monitoring data is available by request.

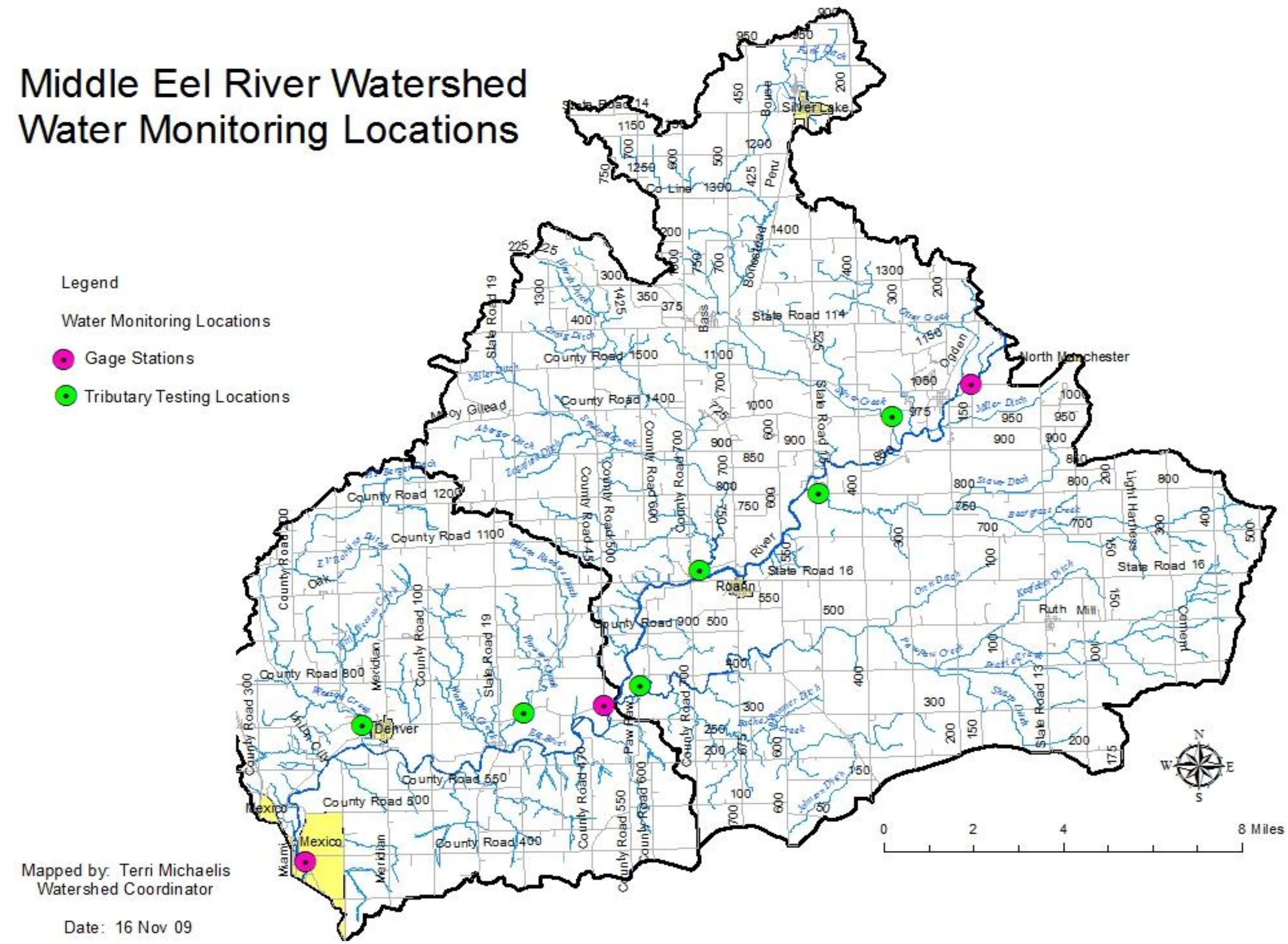


Figure 3-1. Middle Eel River Watershed Monitoring Locations.

3.2 Historical Water Monitoring

Long term studies in north central Indiana have been focused primarily on the Wabash and Tippecanoe Rivers, consequently there is not a great deal of historical data available for the Middle Eel River.

Historical water quality monitoring data for the Middle Eel River Watershed was obtained through the United States Environmental Protection Agency STORET Legacy Data center. Parameters gathered included that of temperature (Degrees Celcius), Nitrogen (Kjeldahl mg/L), Ammonia (mg/L), Escherichia coli (CFU's per 100mL), pH, Total Supended Solids (mg/L), Turbidity (NTU), Specific Conductance (uS cm), and Dissolved Oxygen (mg/L) (U.S. Enivronmental Protection Agency, 2007). The record number is RECORD~0~40.94~-85.89~NAD83, which indicates the location of the monitoring and is shown on Figure 3-2.

STORET data files contained abundant information, but held incomplete data regarding Nitrogen, Ammonia, and Escherichia coli. Data was typically present from the year of 1991 to 2005, with the exception of 1992. The data for 1992 includes only 6 temperature and pH readings and only 5 TSS results. The reason for a lack of data in 1992 is unknown. Most parameters typically contained enough data to calculate an annual mean. Data that did present enough information to calculate an annual mean were compared using a bar graph to indicate any large fluctuation in data. Parameters that did not contain enough information were analyzed using a bar graph to compare data values over a range of years, typically 3-4 years. Figures 3-3 through 3- 9 show annual mean results and bar graphs for the STORET data.

The historical data is from grab samples collected from 1991 – 2005 in only one location. Because these are grab samples, from only one location, it is not possible to compare them to the current water monitoring results. The historical data is included in this report for information purposes.

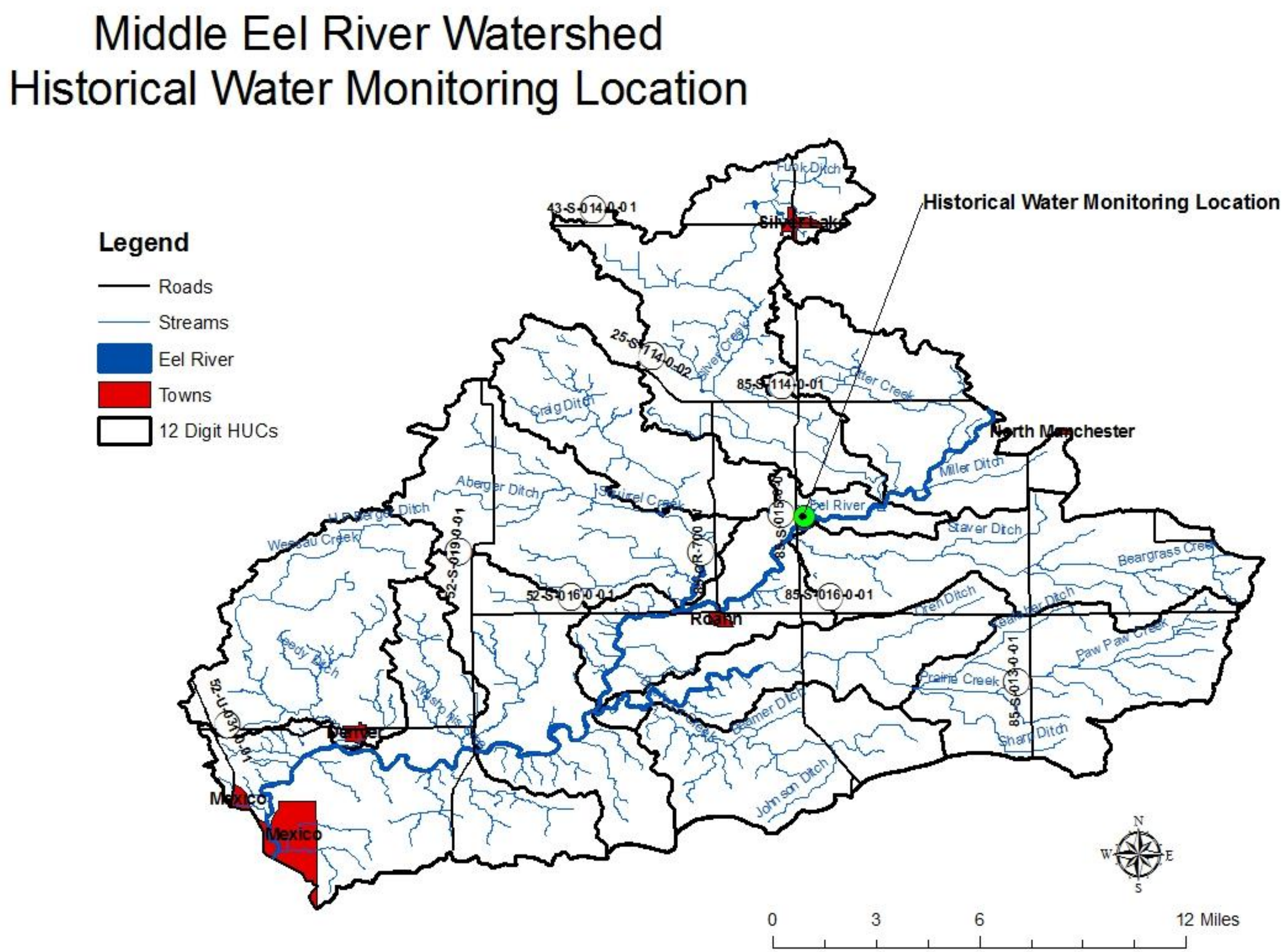


Figure 3-2. Historcial Water Monitoring Location, Latitude 40.94, Longitude -85.95 for STORET data.

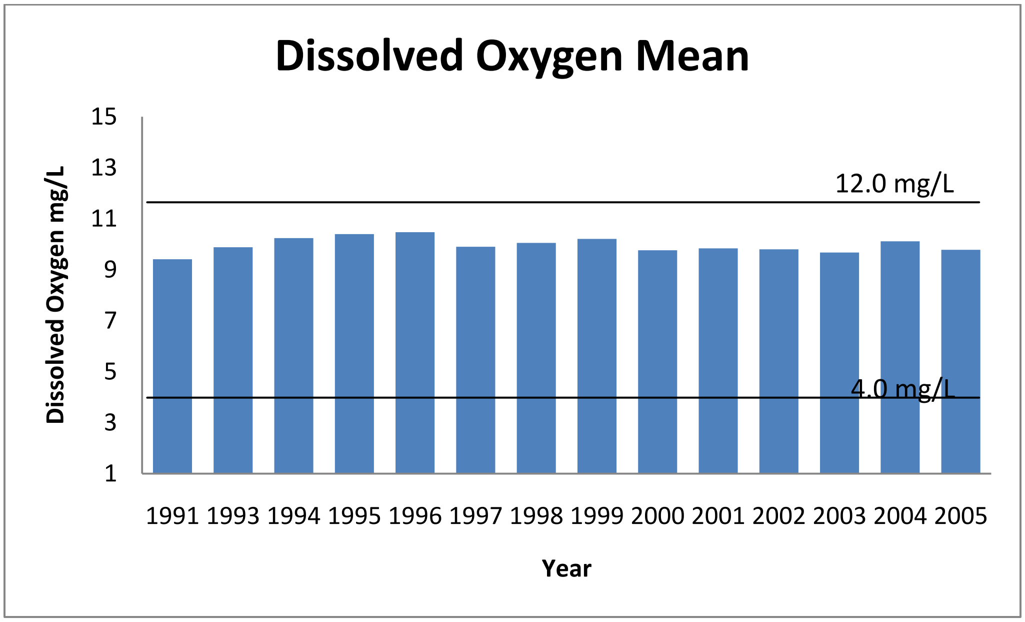


Figure 3-3. Historical water monitoring data, annual mean of dissolved oxygen in mg/L from 1991-2005, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83 (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). IDEM target for Dissolved Oxygen is a minimum of 4.0 mg/L and maximum of 12.0 mg/L.

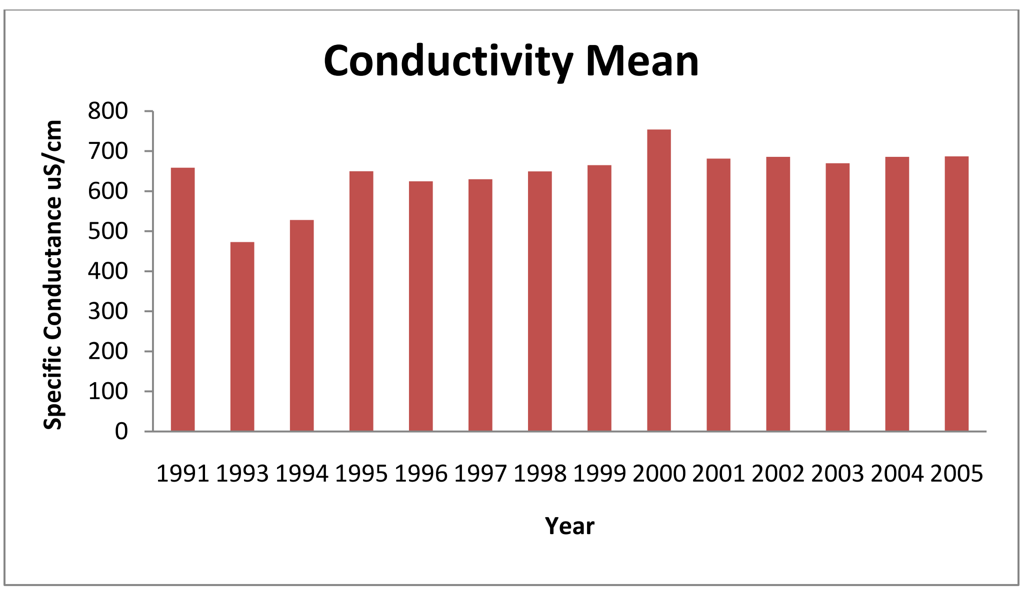


Figure 3-4. Historical water monitoring data, annual mean of specific conductivity in uS/cm from 1991-2005, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. There is no designated target for conductivity since it varies from stream to stream. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104).

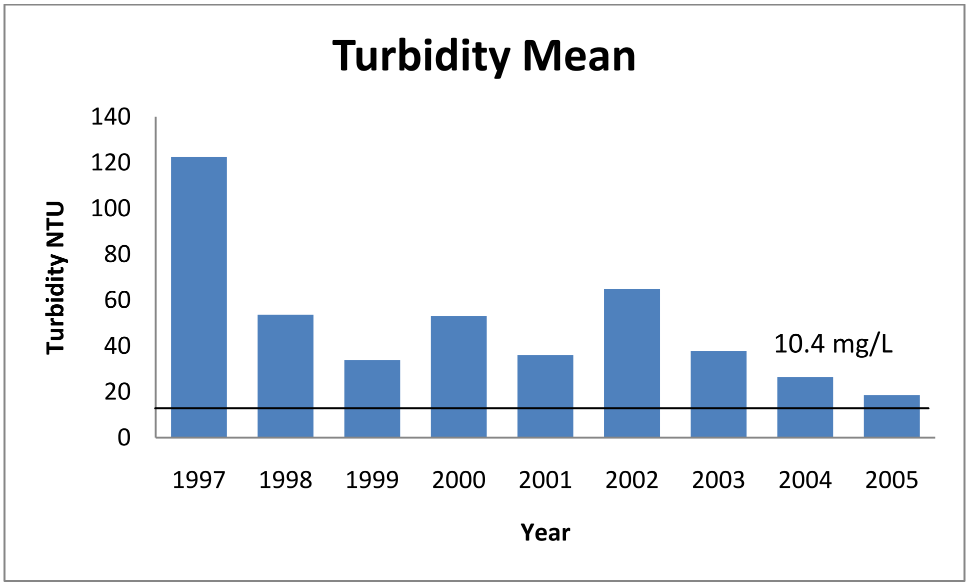


Figure 3-5. Historical water monitoring data, annual mean turbidity in NTU from 1997-2005, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). USEPA recommendation for Turbidity maximum of 10.4 NTU.

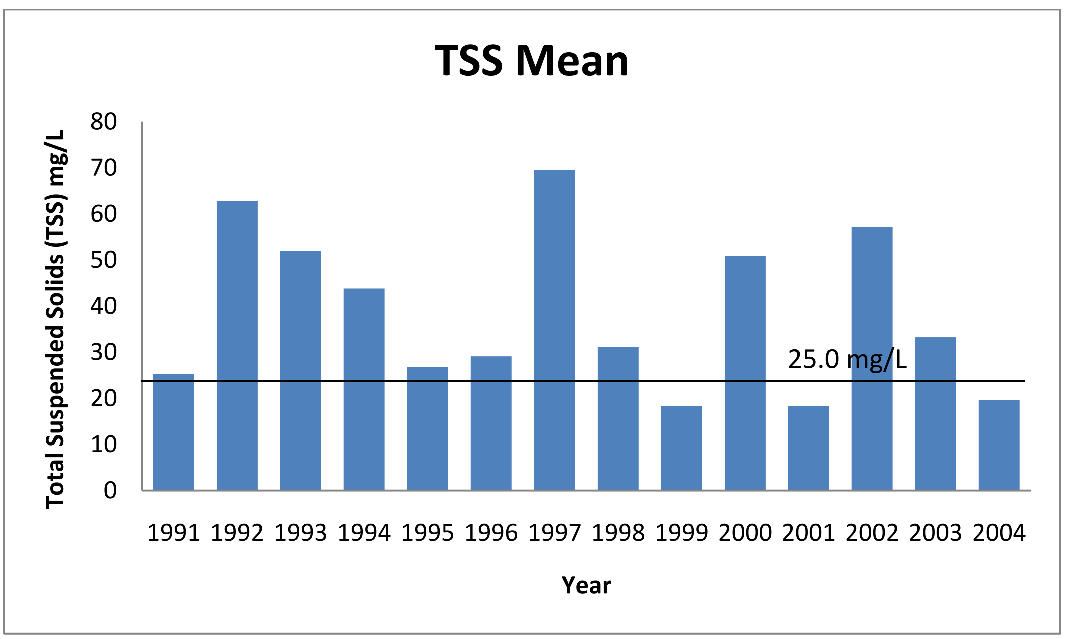


Figure 3-6. Historical water monitoring data, annual mean of Total Suspended Solids (TSS) in mg/L from 1991-2004, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). IDEM draft TMDL for TSS maximum of 30.0 mg/L.

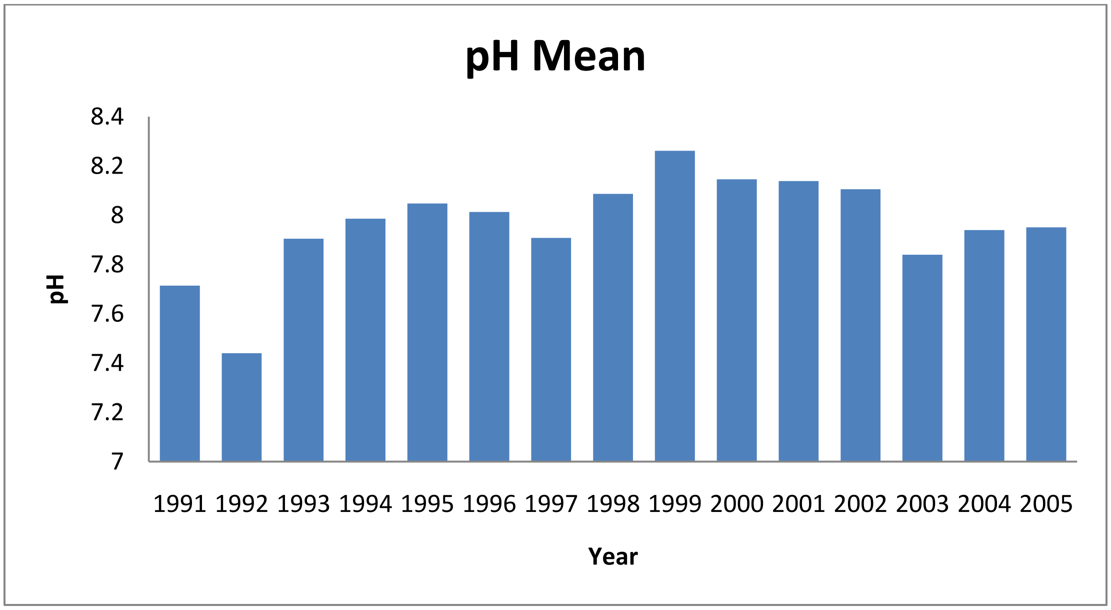


Figure 3-7. Historical water monitoring data, annual mean of pH from 1991-2005, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104).

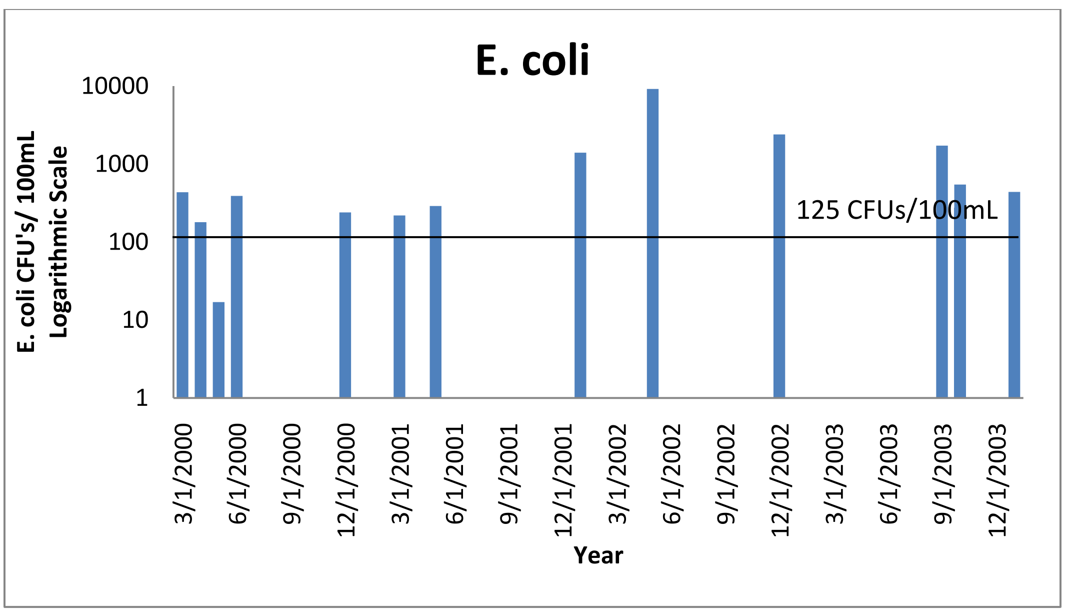


Figure 3-8. Historical water monitoring data, *E. coli* in CFUs/100 ml, using a logarithmic scale, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). IDEM target for E. coli maximum of 235 CFU/100mL in a single sample.

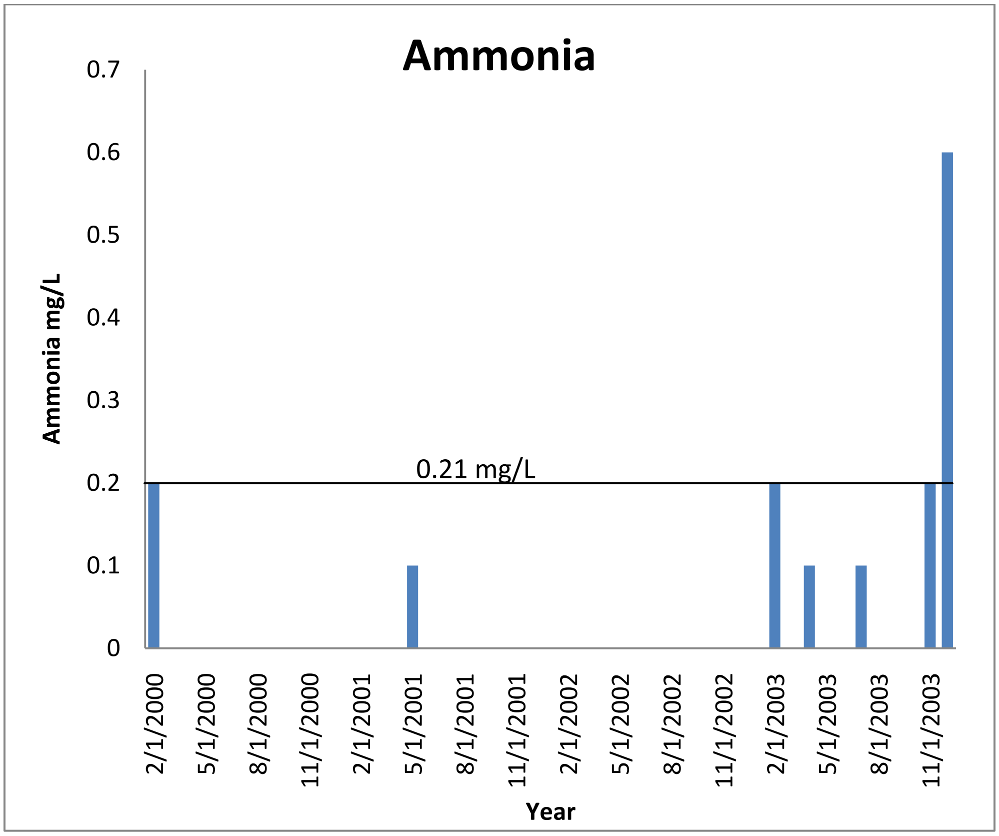


Figure 3-9. Historical water monitoring data, ammonia in mg/L, information gathered from STORET Database, RECORD~0~40.94~-85.89~NAD83. (http://iaspub.epa.gov/tmdl_waters10/attains_get_services.storet_huc?p_huc=05120104). IDEM target for ammonia 0.0-0.21 mg/L depending on temperature and pH.

More recent water monitoring data was made available through IDEM at this same location that included monthly grab samples from April 2007 – Feb 2010. The results for total phosphorus and TSS are shown in Figure 3-10 and 3-11 below. This data is from monthly grab sampling and cannot be compared to the current water monitoring results and is provided for information purposes.

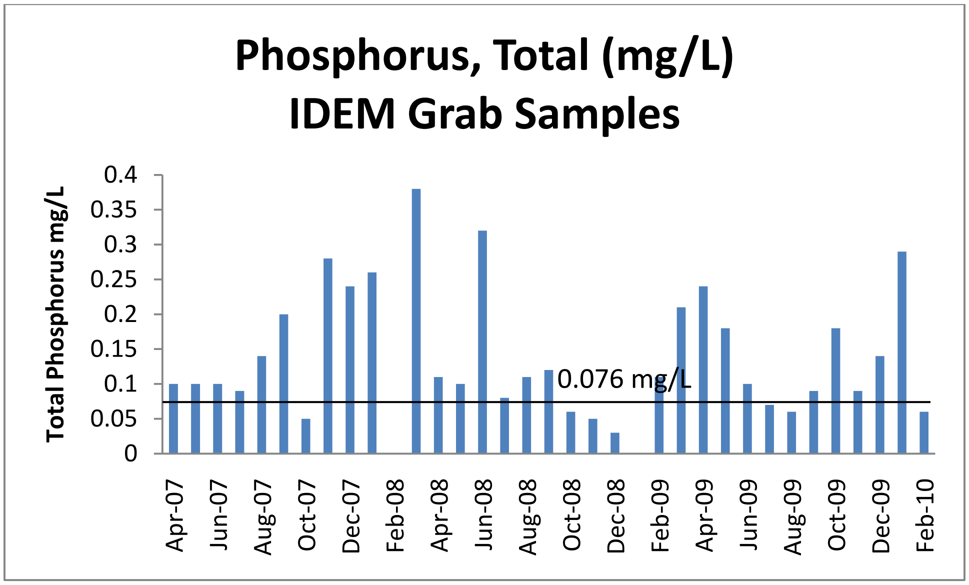


Figure 3-10. IDEM monthly grab samples, total phosphorus in mg/L, data from Angie Brown, IDEM Watershed Specialist. IDEM target for total phosphorus maximum 0.076 mg/L.

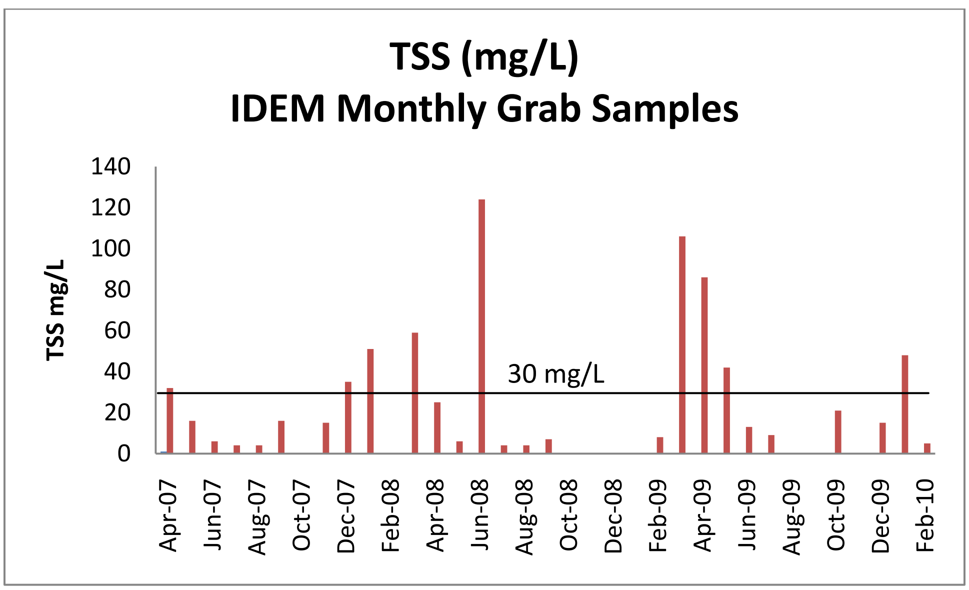


Figure 3-11. IDEM monthly grab samples, TSS in mg/L, data from Angie Brown, IDEM Watershed Specialist. IDEM target for TSS maximum 30 mg/L.

3.3 IDEM 303(d) List of Impaired Waters

IDEM is required to perform water monitoring as part of the Clean Water Act Section 303(d) to identify waters that do not meet the state's water quality standards for designated uses. IDEM has divided the state into five major water basins and the water quality monitoring strategy calls for rotating through each of the five basins once every five years. The Middle Eel River Watershed was included in the 2008 rotation. According to IDEM's Surface Water Quality Monitoring Strategy, the following data is collected within each 12 digit Hydrologic Unit Code to determine if the state water quality standards are being met:

- Physical or chemical water monitoring
- Fish Community Assessment
- *E. coli* monitoring
- Benthic aquatic macroinvertebrate community assessment
- Fish Tissue and superficial aquatic sediment contaminants monitoring
- Habitat evaluation

Water quality standards for the state of Indiana are designed to ensure that all waters of the state, unless specifically exempt, are safe for full body contact recreation and are protective of aquatic life, wildlife and human health. The Middle Eel River and its tributaries are required to be fishable, swimmable, and able to support warm water aquatic life. The Middle Eel River and many of its tributaries were listed on the 1998, 2002, 2004, 2006 and 2008 IDEM 303(d) Impaired Waters List. Each waterbody listed on the 303(d) list is placed into one or more of five (5) categories depending on the degree to which it supports its designated uses as determined by IDEM's assessment process. The following is a summary of the five (5) categories:

Category 1 **All designated uses are supported and no use is threatened**.

Category 2 **Available data and/or information indicate that some, but not all of the designated uses are supported.**

Category 3 **There is insufficient available data and/or information to make a use support determination.**

Category 4 **Available data and/or information indicate that at least one designated use is impaired or is threatened, but a TMDL is not needed.**

A. A TMDL has been completed that is expected to result in attainment of all applicable WQS and has been approved by U.S. EPA.

B. Other pollution control requirements are reasonably expected to result in the attainment of the WQS in a reasonable period of time

C. Impairment is not caused by a pollutant.

Category 5 Available data and/or information indicate that at least one designated use is not supported impaired or is threatened, and a TMDL is needed.

A. The waterbody AU is impaired or threatened for one or more designated uses by a pollutant(s) and require a TMDL.

B. The waterbody AU is impaired due to the presence of mercury and/or PCBs in the edible tissue of fish collected from them at levels exceeding Indiana's human health criteria for these contaminants.

All of the listed impaired water bodies within the Middle Eel River Watershed are Catergory 5, A or B. There are currently no TMDLs for the Middle Eel River Watershed. The locations and specific impairments listed in the Indiana 2008 303(d) list within the Middle Eel River Watershed are listed in Table 3-1 and shown on Figure 3-12.

Table 3-1. Middle Eel River Watershed Impairments by 12 Digit Hydrologic Unit Code (IDEM 2008 303(d) List).

12 Digit HUC	**HUC Name**	**Impairment**	**Category**
051201040502	Otter Creek	*E. coli*, PCBs in Fish Tissue	5A & B
051201040501	Silver Creek	Phosphorus, *E. coli*, PCBs in Fish Tissue	5A & B
051201040503	Beargrass Creek	*E. coli*	5A
051201040505	Squirrel Creek	*E. coli*	5A
051201040509	Town of Roann – Eel River	*E. coli*	5A
051201040509	Town of Roann – Eel River	PCBs in Fish Tissue	5B
051201040508	Oren Ditch-PawPaw Creek	*E. coli*	5A
051201040601	Flowers Creek-Eel River	Dissolved Oxygen, Impaired Biotic Community, Nutrients, Mercury and PCBs in Fish Tissue	5A & B
051201040603	Washonis Creek-Eel River	*E. coli*, Mercury and PCBs in Fish Tissues	5A & B

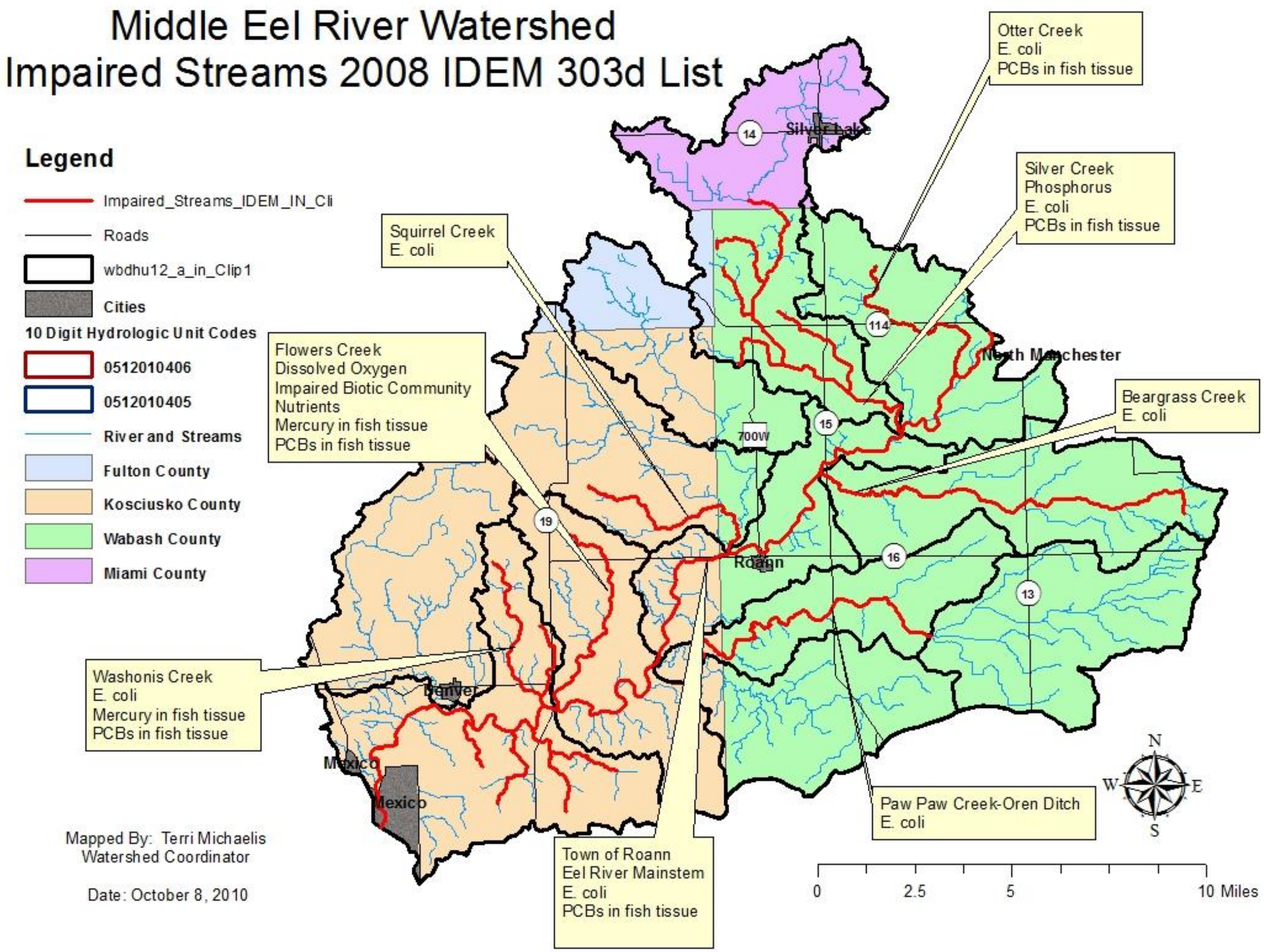


Figure 3-12. Middle Eel River Watershed, 2008 Impaired Streams, IDEM 303(d) List.

3.4 Mussels

Freshwater mussels are some of the most imperiled organisms in North America as shown in Figure 3-13. Freshwater mussels play a number of important roles in aquatic ecosystems. As sedentary suspension feeders, mussels remove a variety of materials from the water column, including sediment, organic matter, bacteria, and phytoplankton.

Historically, the Eel River was ranked fourth among Indiana rives in terms of pounds of shells commercially harvested in 1922, and supported a diverse population of 29 species of mussels. However, Henschen (1986-1987) found only 15 species of living mussels in the Eel River and noted that the water was so muddy that it may have impacted his results. According to Henschen most of the mussels were confined to the lower Eel in Cass and Miami Counties. The connection between fish species and mussels is noted in his work, the mussel life cycle includes an obligate parasitic larval stage and requires host fish species for survival. Additionally, he noted that turbidity, primarily from agriculture, and channelization of the upper portion of the Eel River may be adversely affecting not only the mussel populations but also the fish populations. Some mussels are able to utilize a variety of host fishes, but others are restricted to only one or a few fish hosts. Consequently, a change in the composition of fish species present in the Eel River would affect the mussel population (Henschen 1987).

The Eel River fauna is represented by 29 species of mussels (Fisher personal communication). Of these 29 species, 24 species have been documented alive and 5 species have been documented as weather dead shells (which means there was no living organism and the shells were detatched) in the entire Eel River Watershed. Within the Middle Eel River, 13 species have been identified live. There are two federally endangered species, Clubshell and Northern Riffleshell, that have been documented as weather dead shells and one state endangered species, Rabbitsfoot, which has been found alive in the Middle Eel River Watershed with weather dead specimens in the upper portion of the river.

A survey of mussel species was taken once during the grant period at each of the three mainstem monitoring locations and at each of the testing tributaries. A standard one hour roving survey was used to document location of mussel species and mussel beds. Species verification was provided by Brant Fisher, Aquatic Nongame Biologist for the Indiana Department of Natural Resources.

Eighteen riffles were sampled for mussels in 2009. Of the 29 species historically found in the Eel River, 13 live species were identified. A list of mussel species found alive in the Middle Eel River Watershed and a map showing sampling locations can be found in Appendix F-1. Eight live Rabbitsfoot Mussels, a State Endangered species, were identified at 2 locations in 2009, riffle 11 & 12 (Appendix F-2).

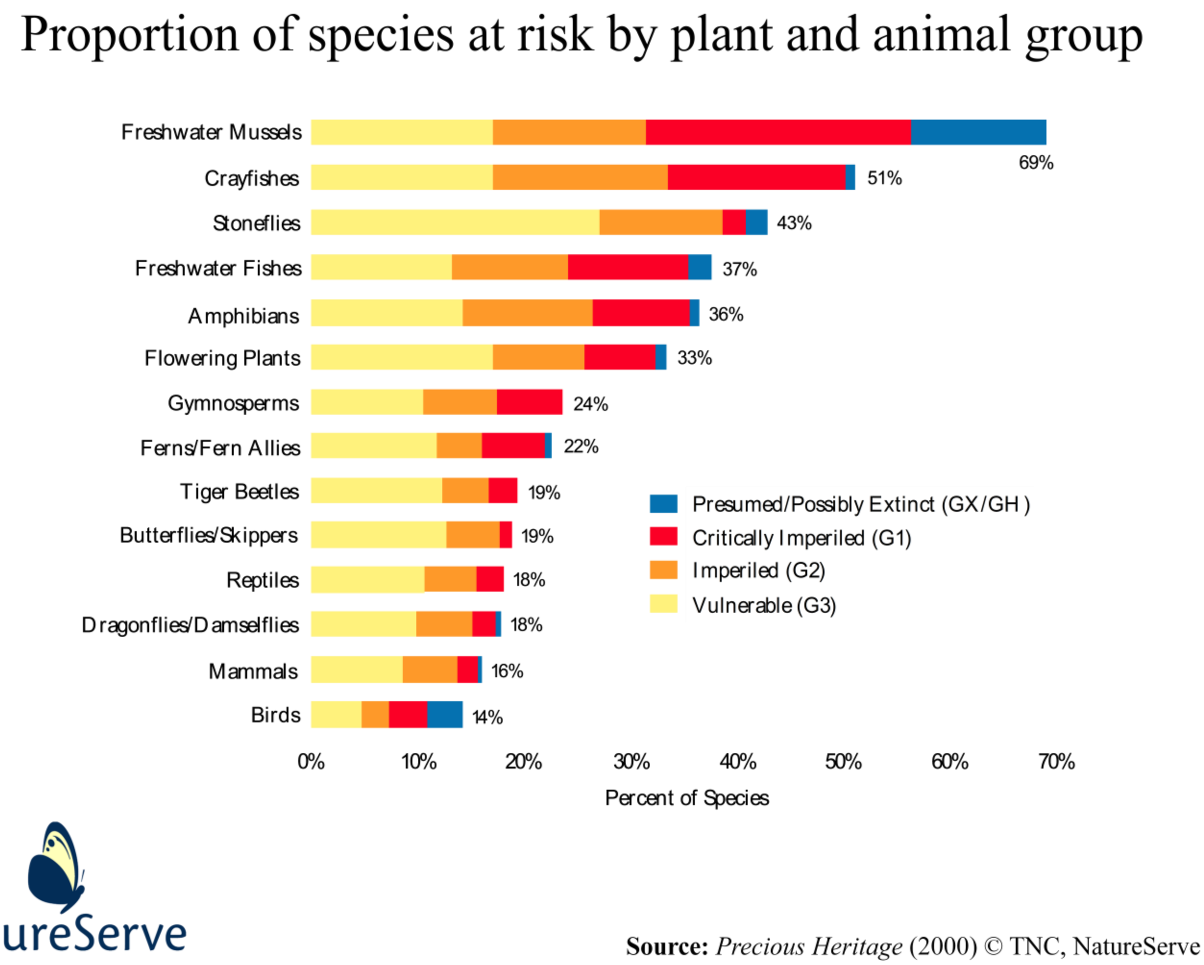


Figure 3-13. US species at risk by animal group. Note freshwater mussels are the highest risk for extinction.

3.5 Qualitative Habitat Evaluation Index (QHEI)

Stream habitat was quantified annually for each of the three mainstem monitoring sites and for each of the six testing tributaries. Habitat scores are based on the Qualitative Habitat Evaluation Index (QHEI) (Rankin 1989). The QHEI provides an assessment tool used widely by stream biologists to quantify the physical parameters that provide habitat for fish and benthic macroinvertebrates. Research has clearly shown positive correlations between QHEI scores and biological-base indices like the Index of Biotic Integrity (IBI) (Rankin 1989). The QHEI is a tool that connects land use to habitat availability or degradation. QHEI scores greater than 60 suggest the stream reach is suitable for warm water habitat.

The QHEI is composed of six metrics which take into account variables such as bottom substrate, channel morphology, riparian cover, and other modifications to the stream or river. A QHEI measurement can have a maximum score of 100. QHEI scores greater than 60 are suitable for warmwater habitat without use impairment. The following is a brief description of the metrics comprising Ohio EPA's QHEI as outlined by Ohio EPA (1989).

- **Substrate** - measures two components - substrate type and substrate quality; takes into account variables like parent material, embeddedness of cobble, gravel and boulders and silt cover. The maximum score is 20

- **Instream Cover** - measures instream cover type and amount. The maximum score is 20

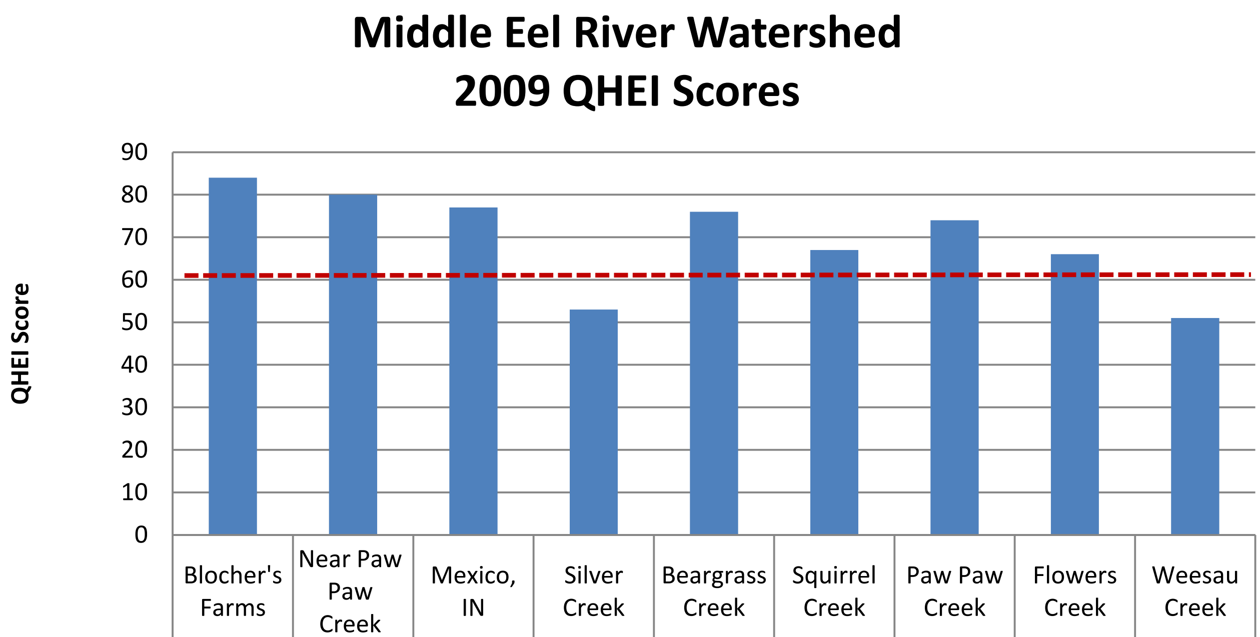
- **Channel Morphology** - includes channel sinuosity, development, stability and channelization; indicates the quality of the stream channel in relation to creation and stability of the macrohabitat. The maximum score is 20

- **Riparian Zone and Bank Erosion** - measures floodplain quality, extent of bank erosion and the width of the riparian zone; serves as indication of the quality of the riparian buffer and floodplain vegetation. The maximum score is 10

- **Pool and Riffle Quality** - component measures include overall diversity of current velocities, pool depth and morphology and riffle-run depth, substrate and substrate quality; serves as indication of the quality of the pool and riffle habitats. The maximum score is a combined 20 (12 for pool, 8 for riffle)

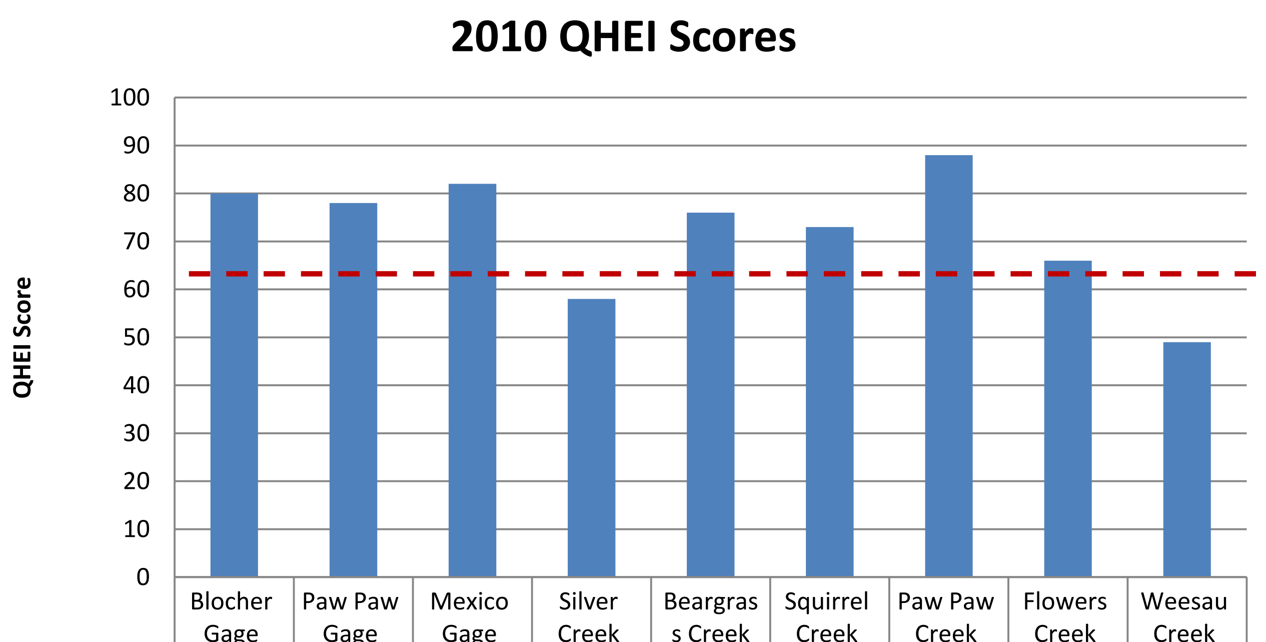
- **Map Gradient** - calculation of elevation drop through sampling area; accounts for varying influence of gradient with respect to stream size. The maximum score is 10

The QHEI was calculated annually for each of the three mainstem gage sites and the six tributaries, results are shown in Figures 3-14 and 3-15.



	Blocher's Farms	Near Paw Paw Creek	Mexico, IN	Silver Creek	Beargrass Creek	Squirrel Creek	Paw Paw Creek	Flowers Creek	Weesau Creek
QHEI Score	84	80	77	53	76	67	74	66	51

Figure 3-14. Middle Eel River Watershed - QHEI scores for 2009. The red dashed line indicates the acceptable score to support warm water aquatic life without impairment.



	Blocher Gage	Paw Paw Gage	Mexico Gage	Silver Creek	Beargrass Creek	Squirrel Creek	Paw Paw Creek	Flowers Creek	Weesau Creek
QHEI Score	80	78	82	58	76	73	88	66	49

Figure 3-15. Middle Eel River Watershed - QHEI scores for 2010. The red dashed line indicates the acceptable score to support warm water aquatic life without impairment.

The QHEI scores for 2009 and 2010 indicate that there is good habitat in all the tributaries and mainstem testing sites except for Silver Creek and Weesau Creek. The low QHEI scores will be taken into consideration when determining critical areas.

3.6 Fish Assemblages & Index of Biotic Integrity (IBI)

The structure and function of fish communities has been widely used by biologists to provide an indication of stream ecosystem health. The earliest recording of a fish survey on the Eel River was conducted by David Starr Jordan who reported 24 fish species found in the Eel River (Jordan 1888). Jordan commented that the Eel was, "…a rather clear stream." Collecting methods and equipment improvements have allowed a greater accuracy for fish surveys since Jordan's time.

Over the recent past, the most commonly used tool for assessing the fish community is the Index of Biotic Integrity (IBI) (Karr 1981 and Simon 1995). The IBI assesses the fish community based on 12 indices that reflect fish species richness and composition, number and abundance of sensitive species, trophic (feeding) organization and function, reproductive guilds, abundance, and individual fish condition. Scores range from 0 (no fish present) to 60.
A score of 60 represents an excellent fish community as compared to the best reference site for a particular ecoregion. Research from across the United States has clearly demonstrated the effectiveness and reliability of using the IBI as a stream monitoring tool.

The IBI was calculated for each of the three mainstem sites and each of the six tributaries once each year. Fish were identified to species level and scoring will be based on IBI calibration for the Eastern Cornbelt Ecoregion (Simon 1995).

A maximum score of 60 is possible and an IBI score of less than 35 is considered poor or very poor (Sobat, 2009). Table 3-2 below, modified from a table developed by Karr et al. 1986, displays total IBI score, integrity class and attributes to define the fish community characteristics in Indiana streams and rivers.

Table 3-2. IBI Scoring Methodology, integrity class and attributes to define fish community in Indiana streams and rivers.

Total IBI Score	Integrity Class	Attributes
58-60	Excellent	Comparable to "least impacted" conditions, exceptional assemblage of species.
45-52	Good	Decreased species richness (intolerant species in particular), sensitive species present.
35-44	Fair	Intolerant and sensitive species absent, skewed trophic structure.
28-34	Poor	Top carnivores and many expected species absent or rare, omnivores and tolerant species dominant.
12-22	Very Poor	Few species and individuals present, tolerant species dominant, diseased fish frequent.
<12	No Fish	No fish captured during sampling.

Historical IBI scores were compiled by Gammon and are displayed in Table 3-3 below (Gammon 1991).

Table 3-3. Historical IBI Scores in the mainstem and three tributaries, 1972-1990 (Gammon 1990). There has been an improvement in IBI scores for the mainstem from 1972 to 1990

Location	1972 – IBI Score	1982 – IBI Score	1990 – IBI Score
#1 South of Beargrass Creek (RM 37.8) Mainstem	38	42	46
#2 North of Beargrasss Creek (RM 41.4) Mainstem	32	34	36
#3 South of N. Manchester (RM 51.7) Mainstem	42	44	44
Paw Paw Creek Tributary			40
Squirrel Creek Tributary			40
Beargrass Creek Tributary			40

2009 IBI results are listed below in Figure 3-16. The number species and individuals per species collected in 2009 are reported in Appendix E.

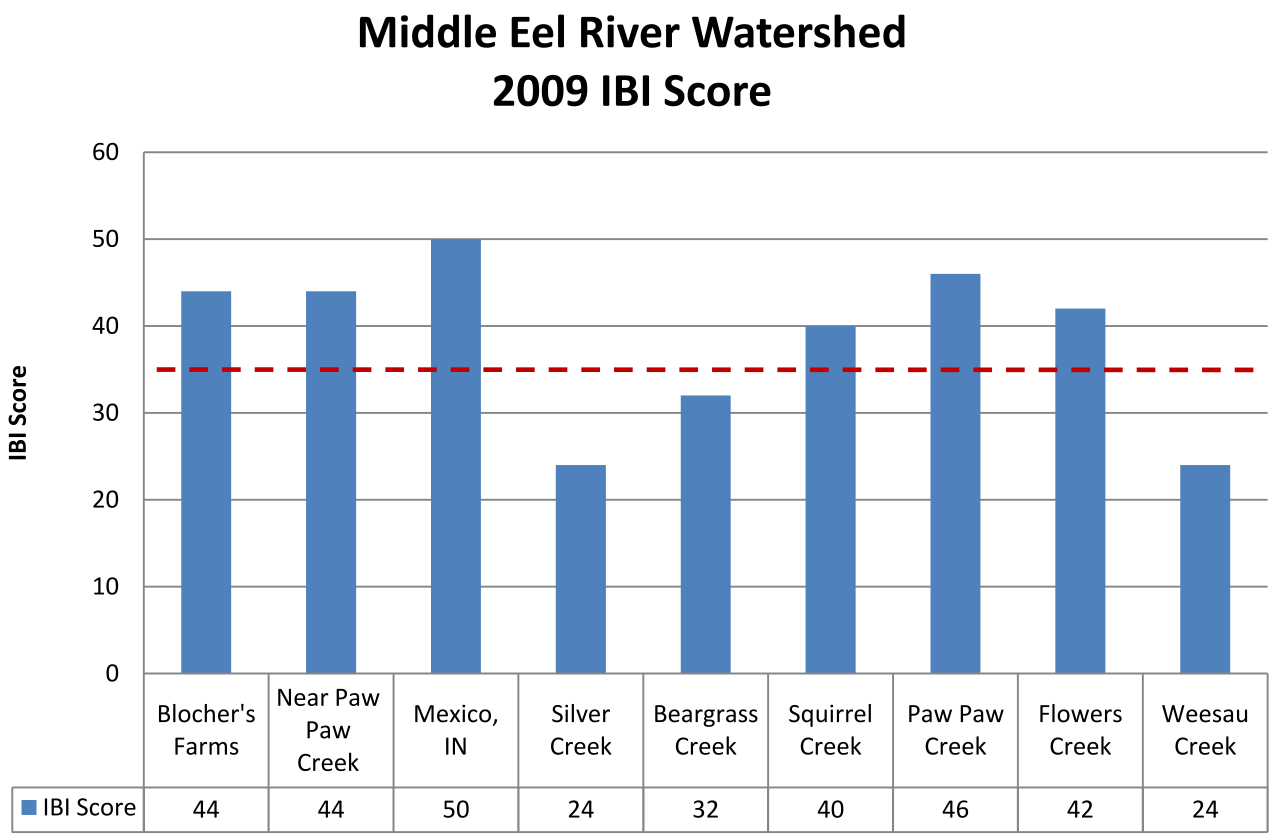
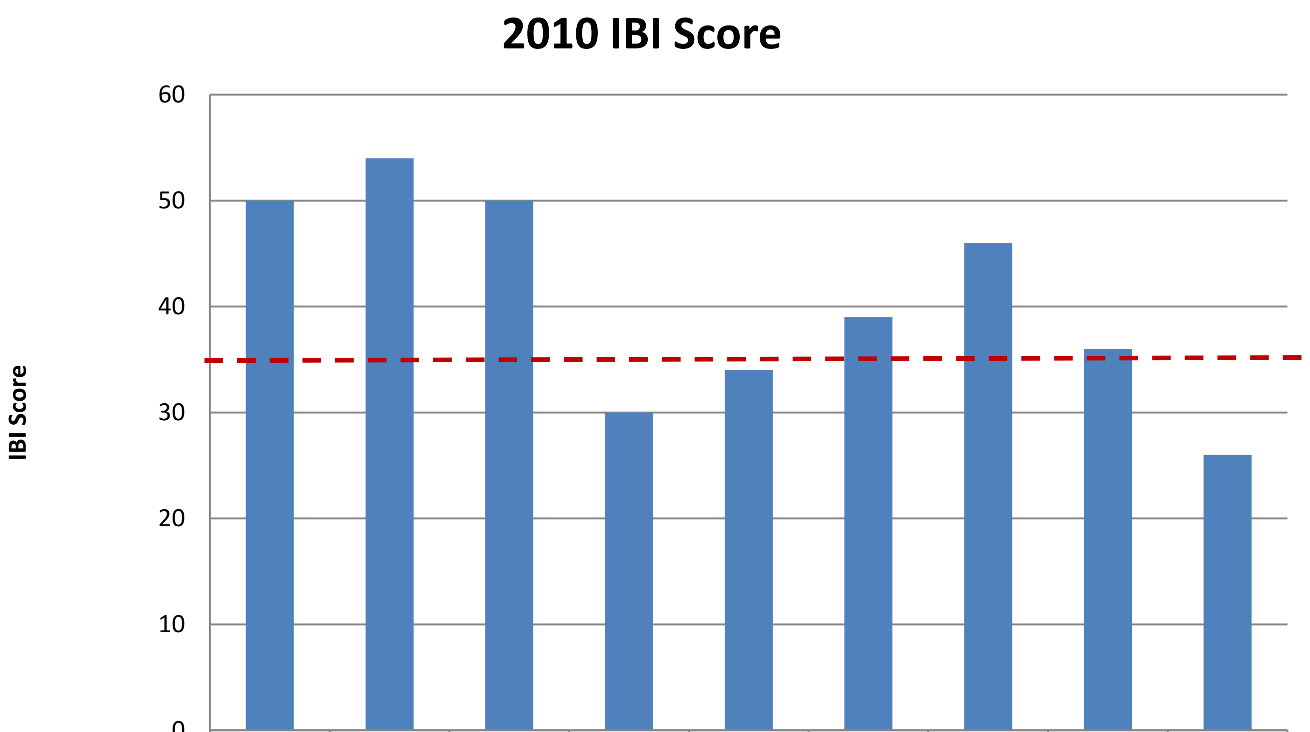


Figure 3-16. Middle Eel River Watershed 2009 IBI scores. The red dashed line indicates the IBI score that represents fair conditions with intolerant and sensitive species absent, skewed trophic structure.

2010 IBI results are listed below in Figure 3-17.



	Blocher's Farms	Near Paw Paw Creek	Mexico, IN	Silver Creek	Beargrass Creek	Squirrel Creek	Paw Paw Creek	Flowers Creek	Weesau Creek
2010 IBI Score	50	54	50	30	34	39	46	36	26

Figure 3-17. Middle Eel River Watershed 2010 IBI scores. The red dashed line indicates the IBI score that represents fair conditions with intolerant and sensitive species absent, skewed trophic structure.

There have been numerous fish kills in the Middle Eel River Watershed reported to IDEM. Figures 3-18 through 3-20 show the number of fish kills reported, number of fish killed, and number of fish kills by watershed that have been reported to IDEM from 2005-2009 (Campbell 2010).

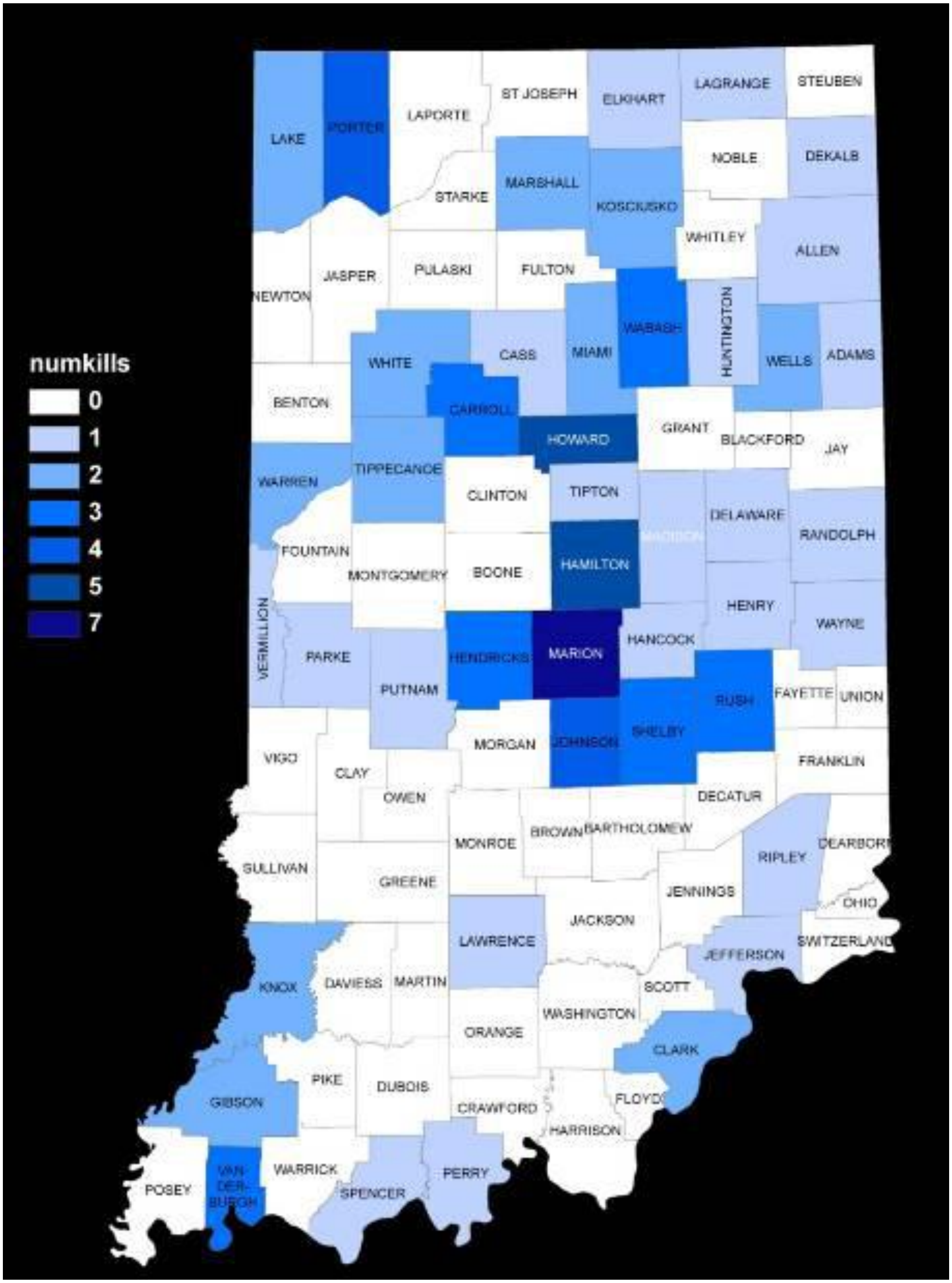


Figure 3-18. Fish kills by Indiana County 2005-2009 (Campbell 2010).

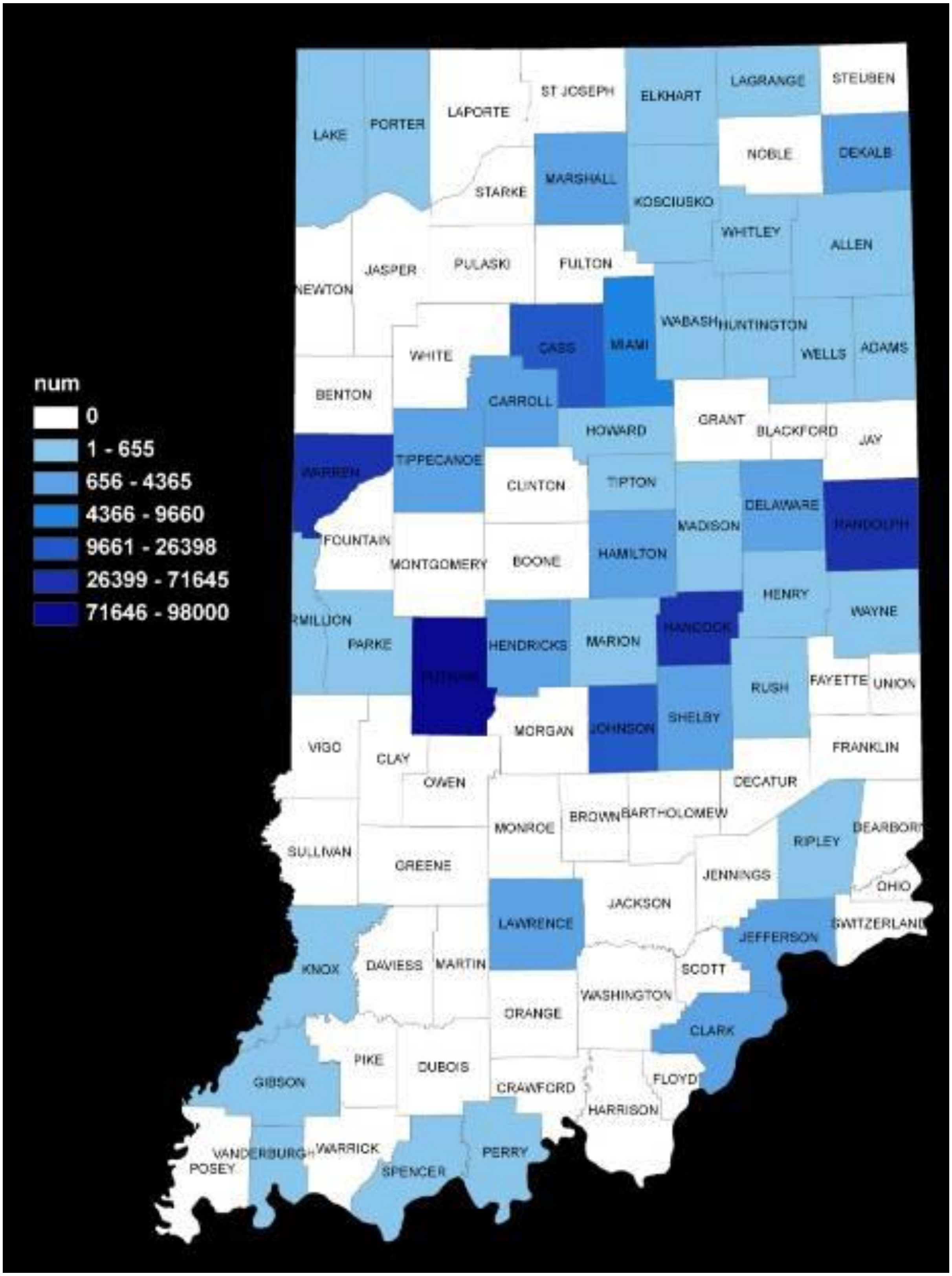


Figure 3-19. Number of fish killed by Indiana County 2005-2009 (Campbell 2010).

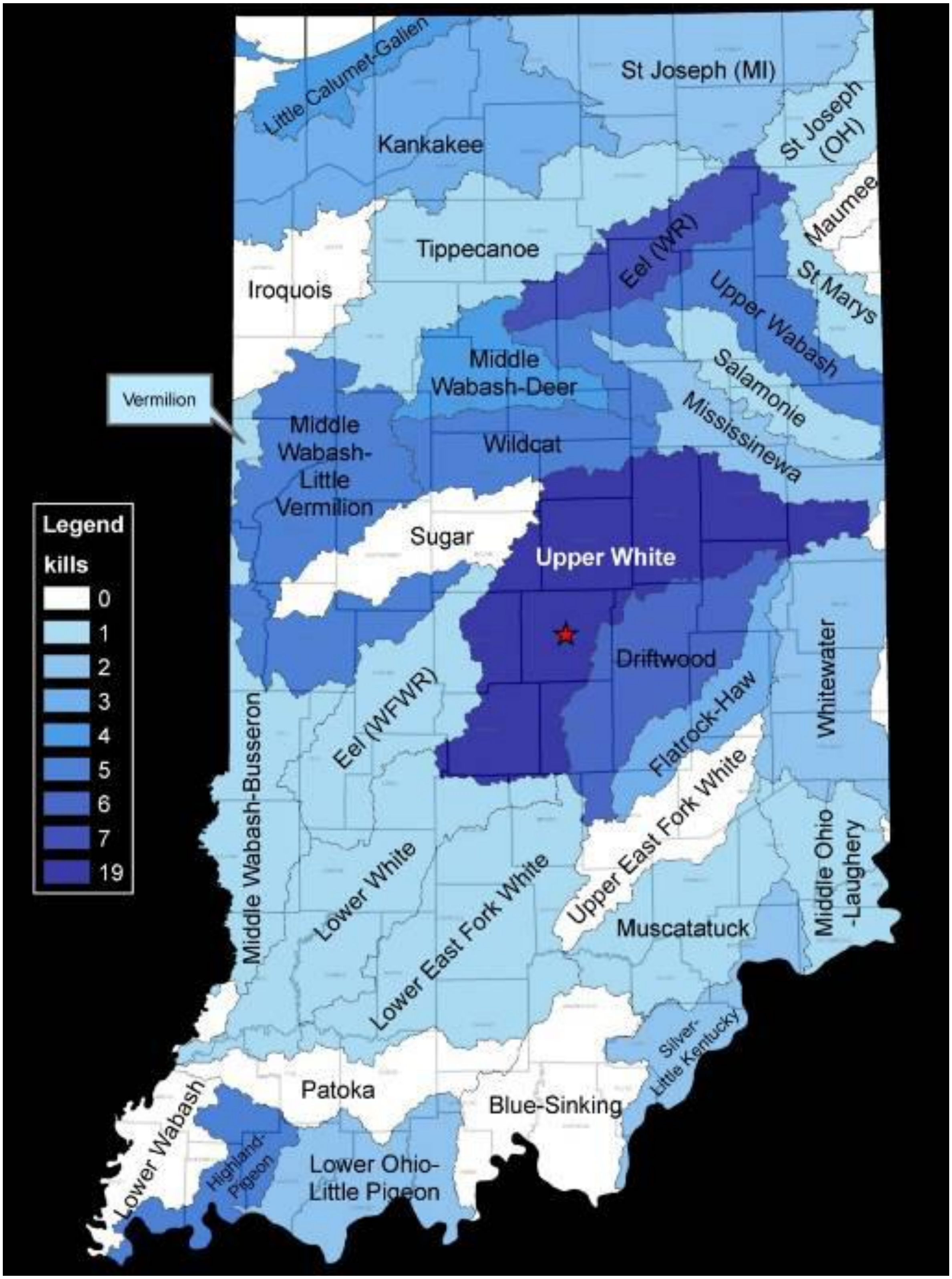


Figure 3-20. Number of fish kills by Indiana Watershed, 2005-2009 (Campbell 2010).

According to Gammon, there has been an improvement in IBI scores from 1972 to 1990. When comparing the 2009 IBI scores to historical data, there has been an increase in IBI scores for Paw Paw Creek, and a decrease in IBI scores for Squirrel Creek and Beargrass Creek. IBI scores for the mainstem are not comparable as they occur historically in different locations than current monitoring.

The 2009 and 2010 IBI scores indicate a fair fish community at all locations except for Silver Creek, Beargrass Creek and Weesau Creek. The low IBI scores will be taken into consideration when identifying critical areas.

A unique situation was discovered in Beargrass Creek where the 2009 QHEI indicated good habitat, but a depressed IBI score indicated a poor fish community. The reasons for this are not yet known and will be taken into consideration when identifying critical areas.

It is also interesting to note that the name of the River, ‘Eel’, originated from the Miami Indian word, **KE NA PO MO CO**, which means snake fish. The American Eel (a snakelike fish) was very common in the Eel River prior to European settlement when dams began to be built and impeded the catadromous (spend most of their lives in fresh water but migrate to salt water to breed) movement of the species. The last American Eel was discovered in the Eel River in 1986. This species is now considered extirpated from the Middle Eel River.

3.6.1 Smallmouth Bass

The history of smallmouth bass in the Eel River has been well documented over the recent past.

Smallmouth bass is the top predator found in the Eel River and a very popular species of fish for fishermen. To assess the status of smallmouth bass in the Middle Eel River a two kilometer section of the river upstream from the location of each of the three monitoring sites was evaluated. Water temperature, stream velocity, water depth, nest diameter, distance from shore, distance from cover, and latitude/longitude were documented for each nest. Number of eggs present in 10% of the nests located were quantified. The Zippin depletion method of population estimation was used to estimate the smallmouth bass population in three one kilometer sections of the river upstream from the mainstem monitoring sites once in 2009 and once in 2011 (Zippin 1958). Table 3-4 shows the population estimate for 2009, and Figure 3-21 compares population with IBI and QHEI.

Table 3-4. The Zippin three pass depletion population estimation of the smallmouth bass (*Micropterus dolomieui*) at Blocher (40 degrees 59’ 31”N and 85 degrees 48’ 31”W), Pawpaw (40 degrees 52’ 22”N and 85 degrees 58’ 42”W), and Mexico (40 degrees 49’ 39”N and 86 degrees 6’ 50”W) for 2009.

Location	SMB Population
Blocher	45.6
Pawpaw	3
Mexico	10.2

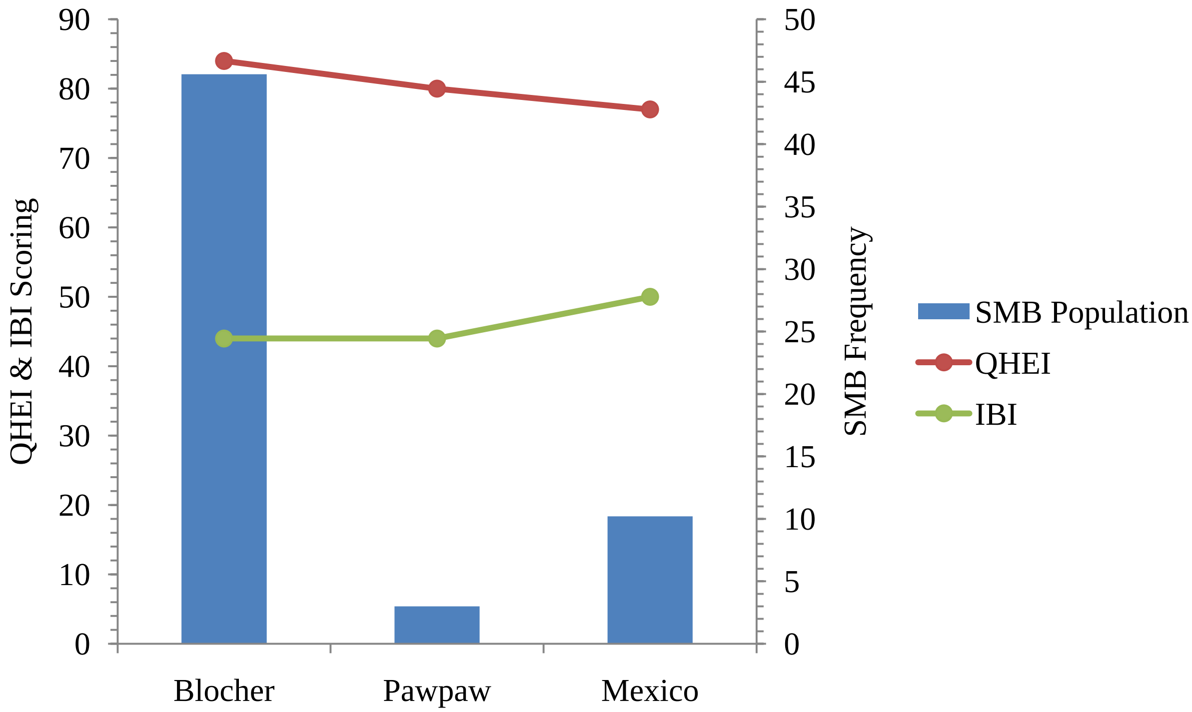


Figure 3-21. The smallmouth bass (*Micropterus dolomieui*) population compared to the QHEI and IBI scores at Blocher (40° 59’ 31”N and 85° 48’ 31”W), Pawpaw (40° 52’ 22”N and 85° 58’ 42”W), and Mexico (40° 49’ 39”N and 86° 6’ 50”W).

The structure of fish populations in streams is dynamic and dependent primarily on available habitat and water quality. While habitat is easily quantifiable and to correlate with fish communities, water quality is more problematic. At the core of this issue is the lack of long-term water quality data sets that are correlated with fish populations. The data presented in this report represents only a one year data set from which it is simply not possible to draw any conclusions at this time. However, historical data (since 2006) suggests that the year class strength and population of smallmouth bass in the Eel River is dynamic. The data indicate that the smallmouth bass population increases after a dry spawning season (May-June) and decreases after a wet spawning season. This trend can be seen after the determination of fish age (from spines) and year class strength compared to stream discharge. During the low flow conditions, there is a significant reduction in total suspended solids (TSS). Research has shown that even low levels of TSS for one or two days may result in a reduction of growth and/or survival of larval and juvenile smallmouth bass. From the fish collected during 2009, there were no fish from the year class of 2008 (a wet year). The large difference in population

Estimations across sites in 2009 are perhaps the result of habitat rather than a difference in water quality. This data set has helped establish a baseline for the next three years and demonstrated the effect of habitat quality. It will be the purpose of this study to continue to examine the population and year class strength of smallmouth bass over the duration of the study in an effort to gain a more clear understanding of the relationship of nonpoint source pollution like TSS and/or habitat.

3.7 Reptiles and Amphibians

This study will not incorporate a reptile and amphibian survey, and there is currently no published data regarding reptiles and amphibians of the Middle Eel River Watershed.

3.8 Water Chemistry

While it is well known that water chemistry is important in any water quality monitoring initiative, most often selected parameters are measured as grab samples and are taken daily, weekly, or at somewhat random intervals without knowledge of stream discharge. These data give only a small glimpse into the dynamic nature of streams and may not provide a clear representation of organismal exposure or loadings of any of the constituents being analyzed.

This study included three sample sites on the mainstem of the river that were equipped with Isco automatic water samplers that allowed water samples to be taken from the river throughout storm events and six times daily during baseflow conditions (Figure 3-1). The sampler was connected to a pressure transducer and a datalogger that continually recorded stream discharge and water temperature. Three samples were analyzed daily at baseflow conditions with all six samples analyzed daily during storm events.

The first year of sampling began May 28, 2009 and continued through July 13, 2009. Monitoring began May 7 and continued through July29 in 2010. Monitoring will occur May 1, through June 31 for the remainder of the grant period (2011 and 2012). These dates coincided well with planting times of agricultural crops and with the spawning activity of most fish and are considered the ‘field season’.

Parameters that were measured on-site daily included: water and air temperature (^oC), pH, conductivity (microsiemens/cm), dissolved oxygen (DO) (mg/L), and stream dishcharge (cubic feet per second). Total phosphorus (mg/L), nitrate (mg/L), total suspended solids (TSS) and turbidity (mg/L and NTU) were performed at the Manchester College laboratory as outlined in the Quality Assurance Project Plan for the Middle Eel River Watershed Initiative (Appendix D).

<u>3.8.1 *Escherichia coli* (*E. coli*)</u>

Escherichia coli (*E. coli*) quantification is routinely used in stream water quality monitoring as an indicator of "safe conditions". Diseases such as Typhoid, Giardia, Cryptosporidium, and Shigella may be transmitted by the ingestion of water contaminated with fecal matter. *E. coli* is associated with the intestinal tract of warm blooded animals and serves as an indicator of fecal pollution in the water. *E. coli* is used as an indicator because it is easier to identify, and less expensive, than monitoring for all the possible types of pathogens (an infectious agent, or more commonly germ, is a biological agent that causes disease to its host) that cause a specific disease.

In Indiana all waters are designated for full body contact recreational use between April and October with a water quality standard for *E.coli* of 125 colony forming units (CFU)/100 mL in a single sample, or as a geometric mean based on not less than 5 samples equally spaced over 30 days, or 235 CFU/100mL in any one sample in a 30 day period.

E. coli were strategically sampled and measured at each of the testing locations every two weeks, and for selected rain events from the three primary monitoring sites on the mainstem of the river.

The collected data indicates that *E. coli* was the main cause of impairment for the Middle Eel River and the testing tributaries. Table 3-5 shows water quality standards for *E. coli* were **not** met one time for Silver Creek and Squirrel Creek. Standards were met once during 2009 in Flowers Creek, and twice in Beargrass Creek. Paw Paw Creek, with 5 samples meeting the state standard, had the most water samples that met the standard.

The gage stations on the mainstem did not meet the geometric mean standard of 125 CFU/100mL for *E. coli*, but were overall lower than the results of the testing tributaries, possibly due to a dilution factor. The gage stations rarely met the single sample standards of 235CFU/100mL in any one sample in a 30 day period. The yellow highlighting in Table 3-5 indicates the samples that failed to meet state water quality standards.

The testing tributaries very rarely met the state standards for geometric mean or single samples which demonstrates the magnitude of the problem within the watershed.

E. coli may come from the feces of any warm blooded animal including livestock, wildlife, domestic animals and humans. It may also come from the application of manure as fertilizer, failing or improperly sited septic systems, and overflow from a combined sewer overflow system. The contamination may occur directly, such as livestock having access to a stream, or indirectly from failed septic systems, in any case it is the main cause of the Eel River and its tributaries being listed on the

IDEM 303(d) List. It is not uncommon to see cattle grazing in a field with direct access to the streams in the watershed (Figure 3-22). Confined animal feeding operations are common in the watershed and are discussed in more detail in Section 2, pages 83-91.

Figure 3-22. Middle Eel River Watershed, cattle in stream. Photograph by Terri Michaelis.

Table 3-5. Middle Eel River Watershed, *E. coli* single sample results for all sites sampled in 2009 from the most upstream gage and convergence with the Eel River to the most downstream. Highlighted results do not meet Indiana standards for full body contact of 235 CFU/100mL in any one sample in a 30 day period.

Date	Blocher Gage	Paw Paw Gage	Mexico Gage	Silver Creek	Beargrass Creek	Squirrel Creek	Paw Paw Creek	Flowers Creek	Weesau Creek
28-May-09		480	97						
01-Jun-09				5,500	8,600	4,400	640	1,500	1,150
08-Jun-09	160	160	3	750	230	955	220	1,030	270
10-Jun-09	26,000	9,000	470	7,300	46,000	38,000	260	160,000	21,000
13-Jun-09	8,550	6,200	8,000	5,700	2,700	43,000	9,450	5,600	41,000
20-Jun-09	450	280	290	17,000	903	1,460	430	643	790
24-Jun-09	133	270	240	610	920	620	260	1,080	520
12-Jul-09	2,100	800	250	7,100	2,800	8,700	380	2,800	590
15-Jul-09	240	100	260	500	400	450	200	1,233	200
31-Jul-09	300	760	550	640	240	1,600	240	340	790
18-Aug-09				175,000	22,000	82,000	5,200	>80,000	108,000
29-Aug-09	1,600	780	230	5,800	260	6,300	160	1,066	233
16-Sept-09	160	47	23	740	280	420	150	6,400	340
08-Oct-09	130	26	23	400	200	370	170	3,486	80
02-Nov-09	350	620	670	390	320	980	330	190	490

Due to the high E coli. results in Flowers Creek in 2009, the site was split and sampling began upstream in Wilson Rhodes Ditch above its confluence with Flowers Creek to try to determine the origin of the *E. coli* (Figure 3-23). Table 3-6 displays dates and results for Wilson Rhodes Ditch above its confluence with Flowers Creek. Highlighted results do not meet Indiana standards of 235 CFU/100mL in any one sample in a 30 day period. The source was never identified for these extremely high E. coli counts, however, the results for 2010 were more in-line with the other testing tributaries.

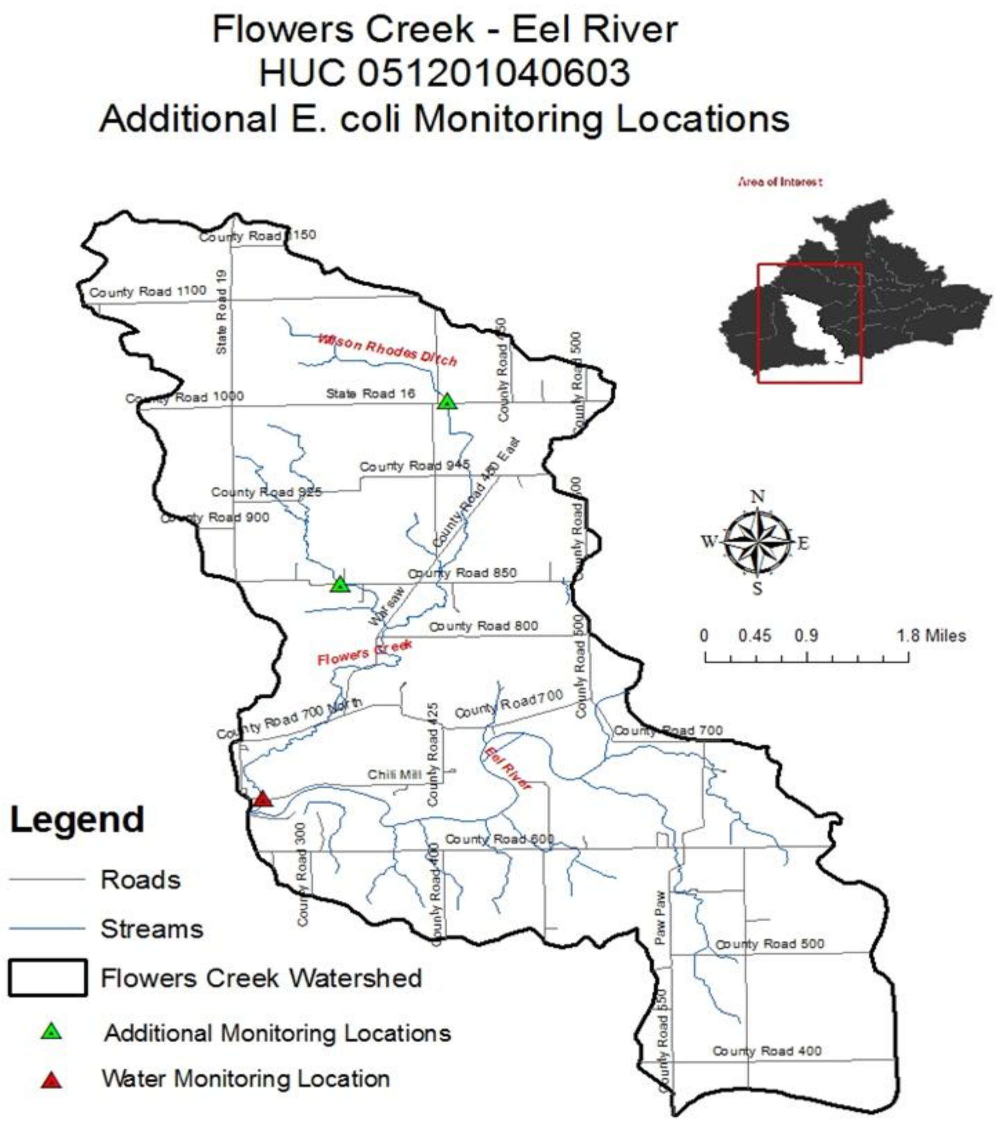


Figure 3-23. Additional E. coli monitoring locations on Wilson Rhodes Ditch.

Table 3-6. *E coli* results from May to July 2009, Wilson Rhodes Ditch above confluence with Flowers Creek. Highlighted results do not meet Indiana standards for full body contact of 235 CFU/100mL in any one sample in a 30 day period.

Date	Wilson Rhodes Ditch
29-Aug-09	1,100
16-Sept-09	1,700
08-Oct-09	187,000
02-Nov-09	290

The Indiana standards for geometric mean of *E. coli* is 125 CFU/100mL from 5 equally spaced samples over a 30 day period. The geometric mean for each of the testing locations for 2009 and 2010 is shown in Tables 3-7 through Table 3-10. None of the testing locations met the state standards for geometric means of *E. coli* and this will be considered when determining critical areas.

Table 3-7. Middle Eel River Watershed testing tributaries E. coli geometric mean (2009 Field Season) and subwatershed acreage, May 28-July 13, 2009. Highlighted results do not meet Indiana standards for full body contact of 125 CFU/100mL in any one sample in a 30 day period.

Testing Tributaries E. coli Geometric Mean 2009 Field Season (FS) (Indiana Standard Geometric Mean of 125cfu/100mL)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Geometric Mean	2,211	2,705	1,345	2,056	451	1365
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-8. Middle Eel River Watershed gage stations E. coli geometric mean (2009 Field Season) and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations E. coli Geometric Mean 2009 June (Indiana Standard Geometric Mean of 125cfu/100mL)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Geometric Mean	585	613	236
Acreage	92,442	120,179.5	49,192.8

Table 3-9. Middle Eel River Watershed testing tributaries E. coli geometric mean (June 2010 and Field Season) and subwatershed acreage, May 7-July 29, 2010. Highlighted results do not meet Indiana standards for full body contact of geometric mean of 125 CFU/100mL in any one sample in a 30 day period.

Testing Tributaries E. coli Geometric Mean 2010 June and Field Season (FS) (Indiana Standard Geometric Mean of 125cfu/100mL)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Geometric Mean	June 2,419 FS – 3,360	June 5,897 FS – 3,360	June 1,942 FS – 1,468	June 1,853 FS – 1,433	June 1,067 FS – 1,429	June 849 FS – 674
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-10. Middle Eel River Watershed gage stations E. coli geometric mean (June 2010 and Field Season) and subwatershed acreage, May 7-July 29, 2010. Highlighted results do not meet Indiana standards for full body contact of geometric mean of 125 CFU/100mL in any one sample in a 30 day period.

Mainstem Gage Stations E. coli Geometric Mean 2010 June and Field Season (FS)(Indiana Standard Geometric Mean of 125cfu/100mL)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Geometric Mean	June – 1,897 FS – 1,272	June – 2,285 FS – 1,543	June – 1,866 FS – 1,280
Acreage	92,442	120,179.5	49,192.8

3.8.2 Total Suspended Solids (TSS)

Total suspended solids (TSS) is a measure of the amount of particulate solids that are in solution. This is an indicator of nonpoint source pollution problems associated with various land use practices, particularly agricultural land use. The TSS measurement is expressed in (mg/L).

Soil pollution, or suspended sediment, is by volume the largest pollutant in Indiana waters (Sweeten 2002), and the USEPA identifies suspended sediment as the single most widespread pollutant in the Nation's rivers and streams. It is the largest nonpoint source pollutant by volume within the Middle Eel River Watershed.

There are no water quality standards set by the state of Indiana for TSS, however concentrations between 25.0-80.0 mg/L have been shown to reduce fish concentrations (IDEM - Water Quality Targets nd.). Suspended sediment is known to smother spawning habitat, increase water temperature, clog fish gills and limit the ability of young larval sight feeding fish to find their prey which results in a depressed fish community, particularly of non-tolerant species such as Smallmouth Bass. TSS of no more than 25 mg/L is the target for the Initiative.

Middle Eel River Watershed 2009 and 2010 TSS results are displayed in Tables 3-11 through 3-14 below. TSS in the water originates from many sources, but a large portion of sediment entering streams comes from stream bank erosion due to lack of riparian buffers, livestock access to streams, and wind and water erosion on agricultural land. Since 89% of land use within the watershed is agricultural, the largest contributor to TSS is likely cropland erosion, lack of riparian buffers and livestock in the streams.

Table 3-11. Middle Eel River Watershed testing tributaries TSS mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Testing Tributaries TSS mg/L 2009 Field Season (No Indiana Standard, 25 mg/L known to reduce fish concentrations)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	17	14	4	3	4	8
Mean	34	28	28	33	7	39
Maximum	256	148	224	244	40	290
Minimum	0	4	0	0	0	1
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-12. Middle Eel River Watershed mainstem gage stations TSS mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations TSS mg/L 2009 Field Season (No Indiana Standard, 25 mg/L known to reduce fish concentrations)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	16	16	16
Mean	59	41	34
Maximum	807	352	188
Minimum	0	1	1
Acreage	92,442	120,179.5	49,192.8

Table 3-13. Middle Eel River Watershed testing tributaries TSS mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Testing Tributaries TSS mg/L 2010 Field Season (No Indiana Standard, 25 mg/L known to reduce fish concentrations)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	38	22	19	8	14	18
Mean	50	42	58	31	51	51
Maximum	180	219	354	167	404	594
Minimum	4	0	1	0	0	0
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-14. Middle Eel River Watershed mainstem gage stations TSS mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Mainstem Gage Stations TSS mg/L 2010 Field Season (No Indiana Standard, 25 mg/L known to reduce fish concentrations)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	62	58	57
Mean	117	103	94
Maximum	960	1473	923
Minimum	0	1	0
Acreage	92,442	120,179.5	49,192.8

3.8.3 Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen dissolved in water, measured in milligrams per liter (mg/L). DO enters the water by diffusion from the atmosphere and as a byproduct of photosynthesis of algae and plants. DO in the water is critical to the survival of various aquatic life in streams, and is essential for fish respiration. The ability of water to hold oxygen in solution is inversely proportional to the temperature of the water. For example, the cooler the water temperature, the more dissolved oxygen it can hold.

The Indiana standards for dissolved oxygen are 4.0 mg/L to 12 mg/L. All of the testing locations within the Middle Eel River met the state standards. Water can become low in DO due to the respiration of aquatic organisms, such as fish and algae, and also during bacterial decomposition of plant and animal matter. In other words, when an algae bloom has occurred and is dying off and decomposing, this process uses up DO in the water, resulting in a lack of oxygen for other organisms. These algae bloom may be caused from an abundance of nutrients available to the algae. It is the low DO that has caused the 'Dead Zone' or 'Hypoxic Zone' in the Gulf of Mexico. Middle Eel River Watershed 2010 Dissolved Oxygen results are displayed in Tables 3-15 and 3-16 below.

Table 3-15. Middle Eel River Watershed testing tributaries dissolved oxygen mg/L median, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Testing Tributaries Dissolved Oxygen mg/L 2010 Field Season (Indiana Standard 4.0-12 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	7.3	7.9	8.7	7.7	7.8	8.0
Mean	7.4	8.0	8.7	7.7	8.0	8.1
Maximum	8.5	9.4	9.9	9.2	9.6	9.6
Minimum	6.7	7.2	8.1	6.7	6.8	6.5
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-16. Middle Eel River Watershed mainstem gage stations dissolved oxygen mg/L median, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Mainstem Gage Stations Dissolved Oxygen mg/L 2010 Field Season (Indiana Standard 4.0-12 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	7.4	7.7	7.3
Mean	7.7	8.2	7.7
Maximum	16.6	20.0	18.8
Minimum	5.9	6.6	3.7
Acreage	92,442	120,179.5	49,192.8

3.8.4 Nitrate

Nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of degradation in some U.S. waters for more than a decade. Excess nitrogen and phosphorus lead to significant water quality problems including harmful algal blooms, hypoxia and declines in wildlife and wildlife habitat.

Over-fertilization of lawns or agricultural fields, failing septic systems, and livestock having direct access to streams, result in nitrates entering our rivers and streams, which can cause excessive plant growth. These plants can clog canals and streams, increasing flooding and decreasing recreational use, and when the plants die and decay, they can use up too much oxygen which results in an impaired biotic community, or low DO. Nitrate moves easily with water and may enter the streams through field tile runoff and is mobile in the soil profile and can easily leach and contaminant aquifers.

Livestock and humans can be harmed from drinking water high in nitrates, however, since the Eel River is not a drinking water source for humans within the watershed, however, further downstream the city of Logansport draws approximately half of their water from the Eel River. This demonstrates the need to expand the Watershed Initiative to include the southern reaches of the Eel River. The main concern within the Middle Eel Watershed is for livestock health and algae growth. In addition to the local concern for nitrate (and phosphorus) levels, the combined effect of all the Mississippi River Basins' watersheds are contributing to the hypoxic zone in the Gulf of Mexico.

Nitrate (NO^-_3) is a dissolved form of nitrogen that is commonly found in rapidly moving streams and is a form of nitrogen that plants can easily use. There is no state standard for nitrate levels except for waters designated as a drinking water source. The dividing line between mesotrophic and eutrophic streams (Dodd et al. 1998) is 1.5 mg/L. The US EPA recommendation for nitrate is a maximum of 0.633 mg/L, which is the target for this Intitiative. Middle Eel River Watershed 2009 and 2010 Nitrate results are displayed in Tables 3-17 through 3-20 below.

Table 3-17. Middle Eel River Watershed testing tributaries nitrate mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Testing Tributaries Nitrate mg/L 2009 Field Season (USEPA recommended standard is maximum of 0.633 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.900	0.500	1.200	1.800	2.400	2.400
Mean	0.888	1.120	1.633	2.440	2.527	2.813
Maximum	2.000	6.700	4.900	6.300	6.500	8.900
Minimum	0.300	0	0.100	0.700	0	0.400
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-18. Middle Eel River Watershed mainstem gage stations nitrate mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations Nitrate mg/L 2009 Field Season (USEPA recommended standard is maximum of 0.633 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.700	0.800	0.950
Mean	1.124	1.114	1.226
Maximum	6.700	4.700	5.500
Minimum	0	0	0
Acreage	92,442	120,179.5	49,192.8

Table 3-19. Middle Eel River Watershed testing tributaries nitrate mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Testing Tributaries Nitrate mg/L 2010 Field Season (USEPA recommended standard is maximum of 0.633 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	2.550	3.900	5.000	6.600	8.450	9.100
Mean	2.681	4.278	4.975	6.897	8.063	8.897
Maximum	6.100	11.700	10.600	12.600	14.700	15.900
Minimum	1.500	0.700	1.000	0.200	2.300	2.000
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-20. Middle Eel River Watershed mainstem gage stations nitrate mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Mainstem Gage Stations Nitrate mg/L 2010 Field Season (USEPA recommended standard is maximum of 0.633 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	3.300	3.800	3.900
Mean	3.899	3.932	4.024
Maximum	33.800	7.900	7.300
Minimum	0.700	0.300	0.400
Acreage	92,442	120,179.5	49,192.8

3.8.5 Ammonia

Ammonia (NH_3) is highly toxic to aquatic organisms and at low levels acts as a strong irritant, especially to the gills. Prolonged exposure to low levels can lead to skin and gill hyperplasia (an abnormal increase in the number of cells) resulting in a condition in which the secondary gill lamellae (gill filaments) swell and thicken, restricting the water flow over the gill filaments. This can result in respiratory problems and stress on aquatic organisms.

The Indiana standard for total ammonia is between 0.0 and 0.21 mg/L depending upon pH and temperature.

The primary agricultural sources of ammonia are spills of ammonia rich fertilizers and livestock waste from barnyards, feedlots, pastures and rangeland. Other sources are household use of ammonia containing cleaning products and improper disposal of them, and faulty septic systems.

Middle Eel River Watershed 2009 and 2010 Ammonia results are displayed in Tables 3-19 through 3-22 below.

Table 3-21. Middle Eel River Watershed testing tributaries ammonia mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Testing Tributaries Ammonia mg/L 2009 Field Season (Indiana State Standard is maximum of 0.0 to 0.21 mg/L, varies with temperature)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.080	0.076	0.053	0.060	0.050	0.070
Mean	0.096	0.105	0.117	0.108	0.960	0.099
Maximum	0.232	0.352	0.745	0.577	0.519	0.341
Minimum	0.044	0.045	0.009	0.027	0.011	0.013
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-22. Middle Eel River Watershed mainstem gage stations ammonia mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations Ammonia mg/L 2009 Field Season (Indiana State Standard is maximum of 0.0 to 0.21 mg/L, varies with temperature)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.052	0.043	0.040
Mean	0.113	0.072	0.057
Maximum	0.857	0.417	0.463
Minimum	0.006	0	0.004
Acreage	92,442	120,179.5	49,192.8

Table 3-23. Middle Eel River Watershed testing tributaries ammonia mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Testing Tributaries Ammonia mg/L 2010 Field Season (Indiana State Standard is maximum of 0.0 to 0.21 mg/L, varies with temperature)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.071	0.0735	0.065	0.068	0.069	0.067
Mean	0.081	0.129	0.110	0.103	0.102	0.129
Maximum	0.271	0.611	0.384	0.434	0.395	0.814
Minimum	0.043	0.035	0.020	0.024	0.021	0.021
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-24. Middle Eel River Watershed mainstem gage stations ammonia mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Mainstem Gage Stations Ammonia mg/L 2010 Field Season (Indiana State Standard is maximum of 0.0 to 0.21 mg/L, varies with temperature)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.075	0.062	0.056
Mean	0.125	0.095	0.085
Maximum	1.090	1.040	0.714
Minimum	0.019	0.017	0.014
Acreage	92,442	120,179.5	49,192.8

3.8.6 Total Phosphorus

As stated earlier, nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of degradation in some U.S. waters for more than a decade. Excess nitrogen and phosphorus lead to significant water quality problems including harmful algal blooms, hypoxia and declines in wildlife and wildlife habitat.

Phosphorus is often the limiting factor in aquatic ecosystems, and excessive phosphorus may result in algal blooms. Phosphorus binds with soil particles, particularly clay particles, consequently it moves with the soil during run off events. The contribution of phosphorus and nitrates from the agricultural areas of the Mississippi Drainage Basin are a major contributing factor to the Hypoxic Zone in the Gulf of Mexico.

Phosphorus is an essential plant nutrient found in fertilizer and human and animal wastes. Phosphorus can travel attached to particles of soil or manure eroded by water into a stream, or in runoff water from agricultural fields into streams. Conventional tillage, application of fertilizers and/or manure, failing septic systems, feedlot runoff, and combined sewer overflow are potential sources of high phosphorus levels in the watershed.

The recommended US EPA standard for total phosphorus in Indiana waters is a maximum of 0.076 mg/L and is the target for the Initiative. Middle Eel River Watershed 2009 and 2010 Total Phosphorus results are displayed in Tables 3-23 through 3-26 below.

Table 3-25. Middle Eel River Watershed testing tributaries total phosphorus mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Testing Tributaries Total Phosphorus mg/L 2009 Field Season (USEPA recommended standard is maximum of 0.076 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.365	0.416	0.342	0.418	0.310	0.479
Mean	0.484	0.446	0.495	0.602	0.433	0.698
Maximum	2.190	1.100	2.270	2.930	0.762	2.300
Minimum	0.202	0.175	0.224	0.047	0.176	0.302
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-26. Middle Eel River Watershed mainstem gage stations total phosphorus mg/L median, maximum, minimum and subwatershed acreage, May 28-July 13, 2009.

Mainstem Gage Stations Total Phosphorus mg/L 2009 Field Season (USEPA recommended standard is maximum of 0.076 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.449	0.400	0.348
Mean	0.671	0.564	0.460
Maximum	4.59	2.250	1.370
Minimum	0.041	0.103	0
Acreage	92,442	120,179.5	49,192.8

Table 3-27. Middle Eel River Watershed testing tributaries total phosphorus mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Testing Tributaries Total Phosphorus mg/L 2010 Field Season (USEPA recommended standard is maximum of 0.076 mg/L)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	0.522	0.448	0.425	0.545	0.535	0.676
Mean	0.590	0.651	0.700	0.753	0.697	0.944
Maximum	1.660	1.9300	2.900	2.210	3.760	3.150
Minimum	0.226	0.1510	0.109	0.194	0.106	0.138
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-28. Middle Eel River Watershed mainstem gage stations total phosphorus mg/L median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Mainstem Gage Stations Total Phosphorus mg/L 2010 Field Season (USEPA recommended standard is maximum of 0.076 mg/L)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	0.766	0.779	0.714
Mean	1.019	0.961	0.897
Maximum	6.250	6.560	4.860
Minimum	0.258	0.253	0.133
Acreage	92,442	120,179.5	49,192.8

3.8.7 Conductivity

Conductivity is useful as a general measure of stream water quality. Each stream tends to have a relatively constant range of conductivity, that, once established, can be used as a baseline for comparison with regular conductivity measurements. Significant changes in conductivity could then be an indicator that a discharge or some other source of pollution has entered a stream.

Discharges to streams can change the conductivity depending on their make-up. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity. The conductivity of rivers in the United States generally ranges from 50 to 1500 microsiemens per centimeter (µs/cm). Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µs/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates (an animal without a skeletal structure).

Middle Eel River Watershed 2010 Conductivity results are displayed in Tables 3-29 and 3-30 below. There is no state standard or recommended standard for conductivity since it varies by water body.

Table 3-29. Middle Eel River Watershed testing tributaries Conductivity µs/cm median, mean, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Testing Tributaries Conductivity µs/cm 2010 Field Season (No State or Federal Standards)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	292	314	297	314	293	303
Mean	357	400	341	381	323	356
Maximum	628	640	606	651	633	649
Minimum	249	253	210	32	148	148
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-30. Middle Eel River Watershed mainstem Gage Stations Conductivity µs/cm median, mean, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Mainstem Gage Stations Conductivity µs/cm 2010 Field Season (No State or Federal Standards)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	312	303	312
Mean	333	346	333
Maximum	612	607	612
Minimum	139	130	139
Acreage	92,442	120,179.5	49,192.8

3.8.8 Water Temperature

Temperature is important because it governs the kinds of aquatic life that can live in a stream and it can determine the form, solubility, and toxicity of a broad range of aqueous compounds (compounds dissolved in water). Fish, insects, zooplankton, phytoplankton, and other aquatic species all have a preferred temperature range. If temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally they are unable to survive and results in an impaired biotic community.

Temperature also is important because it influences water chemistry. The rate of chemical reactions generally increases at higher temperatures, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it may be "saturated" with oxygen but still not contain enough for survival of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures. Removal of shade-providing vegetation in the riparian corridor may cause an increase in water temperatures.

Indiana water quality standards state that water temperature at no time during the month of May exceed 25.0 °C and during the months of June and July water temperature shall not exceed 30.5 °C. Middle Eel River Watershed 2010 Water Temperature results are displayed in Table 3-31 and 3-32 below. The water temperature at all testing locations fell within the state standards.

Table 3-31. Middle Eel River Watershed testing tributaries Water Temperature °C median, mean, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Testing Tributaries Water Temperature °C 2010 Field Season (Indiana State Standards - no time during the month of May exceed 25.0 °C and during the months of June and July water temperature shall not exceed 30.5 °C.)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median	19.9	19.1	18.8	17.5	20.0	19.2
Mean	19.4	18.8	18.7	17.0	19.5	19.1
Maximum	22.9	22.9	28.8	19.8	24.5	24.5
Minimum	12.6	12.1	13.0	11.7	12.0	11.2
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 3-32. Middle Eel River Watershed mainstem Gage Stations Water Temperature °C median, mean, maximum, minimum and subwatershed acreage, May 11-July 29, 2010.

Mainstem Gage Stations Water Temperature °C 2010 Field Season (Indiana State Standards - no time during the month of May exceed 25.0 °C and during the months of June and July water temperature shall not exceed 30.5 °C.)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median	21.0	21.2	22.1
Mean	20.4	20.4	22.3
Maximum	25.3	25.2	25.1
Minimum	12.8	11.7	19.9
Acreage	92,442	120,179.5	49,192.8

3.8.9 Water Quality Entering the Middle Eel River Watershed

It is important to note that water quality entering the middle section of the Eel River contains high levels of ammonia, total phosphorus, total suspended solids and *E. coli*. For these parameters of concern, the water quality actually improves as it moves through the middle section of the Eel River. In order to attain state or federal standards, it is imperative that the water entering the middle section of the Eel River be improved. This could be accomplished developing watershed management plans and implementing best management practices in the upper reaches of the Eel River

3.9 Fish Consumption Advisory

While testing of fish tissue for mercury and PCBs is not part of this study, it is important to note that this is a serious concern within the watershed. Fish is generally a good source of protein, minerals, and vitamins and can be very healthy for you. However, some fish may absorb contaminants from the water, and soils, where they live and the food that they eat. The major contaminants of concern are polychlorinated biphenyls (PCBs), mercury and pesticides. Older fish and predatory fish (fish that eat other fish) contain larger amounts of pollutants.

Mercury is a naturally occurring metal that does not break down in the environment, but continually cycles between land, water and air. Mercury is released in large amount from coal fired power plants and also from burning household and industrial wastes, and leaching from landfills. Consuming large amounts of mercury may harm an adult's nervous system and is especially toxic to unborn children. Mercury is bound to fish muscles and there is no method of cooking or cleaning the fish that will reduce the mercury.

PCBs are synthetic oils that were once widely used in electrical transformers and capacitors, and break down very slowly in the environment. PCBs and pesticides tend to be stored in the fat of fish, particularly in fatty fish such as carp and catfish. Cooking and cleaning fish to remove fat will lower the amount of PCBs consumed. Most of the fat is located near the skin of the fish. PCBs may cause developmental problems in children and may cause cancer in humans.

A Fish Consumption Advisory is issued by the Indiana Dept. of Health in cooperation with IDEM and IDNR for Indiana waterways and can be found online at http://www.in.gov/isdh/23650.htm. The 2010 Fish Consumption Advisory published by the Indiana Dept. of Health stated that the Eel River is in Advisory Group 3 and states that, "Consumption of fish from the Eel River should be limited to no more than one meal per month (Group 3) by the general population and NO CONSUMPTION by the at-risk population." The only exceptions to this advisory is if the general population is consuming a bluegill larger than six inches, or a carp larger than 24 inches, then it should be treated as an Advisory Group 4 and only one meal every two months should be consumed.

Middle Eel River

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SECTION 4

PROBABLE CAUSES OF WATER QUALITY IMPAIRMENTS

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4.0 Probable Causes of Water Quality Impairments

The 2009 and 2010 water monitoring (Section 3) revealed that the major contaminants in the Middle Eel River Watershed are TSS, *E. coli* and nutrients (nitrogen and phosphorus). Since 89% of land use in the watershed is agricultural, it is most likely that agricultural practices are a main source for these pollutants getting into the Eel River and its tributaries. The National Water Quality Inventory (U.S. Environmental Protection Agency – Office of Water 2009) reported that agriculture is the leading source of degradation of our rivers and streams. According to the Inventory, agricultural activities that may result in nonpoint source pollution include animal feeding operations, grazing, plowing, pesticide spraying, irrigation, fertilizing, planting and harvesting.

TSS, total suspended sediment is the single largest (by volume) nonpoint source contaminant in the watershed. The fact is that if soil could be kept out of the water, many water quality problems would improve. Indiana State Department of Agriculture tracks the tillage practices by county in Indiana. Using these numbers, it is estimated that in 2009 approximately 30,000 acres of conventionally tilled corn and approximately 7,000 acres of conventionally tilled soybeans. Conventional tillage leaves the soil exposed from harvest to plant sprouting (approximately 5 months); exposed soil can be affected by wind and water erosion contributing to TSS in the water. With approximately 37,000 acres of bare ground for about 5 months of the year, it is likely that conventional tillage is a major contributor to the extremely high TSS within the watershed. Other contaminants move with soil particles such as phosphorus which binds and moves with clay particles, nitrates and *E. coli* that are present in animal wastes that are land applied as fertilizer may runoff fields with unprotected soil during rain events or snow melt. A likely source of soil in the water is erosion, from both conventional row crop agriculture and stream-bank erosion.

By comparing discharge to TSS, Figures 4.1 and 4.2, it is clear there is a very strong correlation between discharge and TSS. This suggests that field erosion and run-off caused by rain events within the watershed are a major contributing factor to high levels of TSS in the watershed.

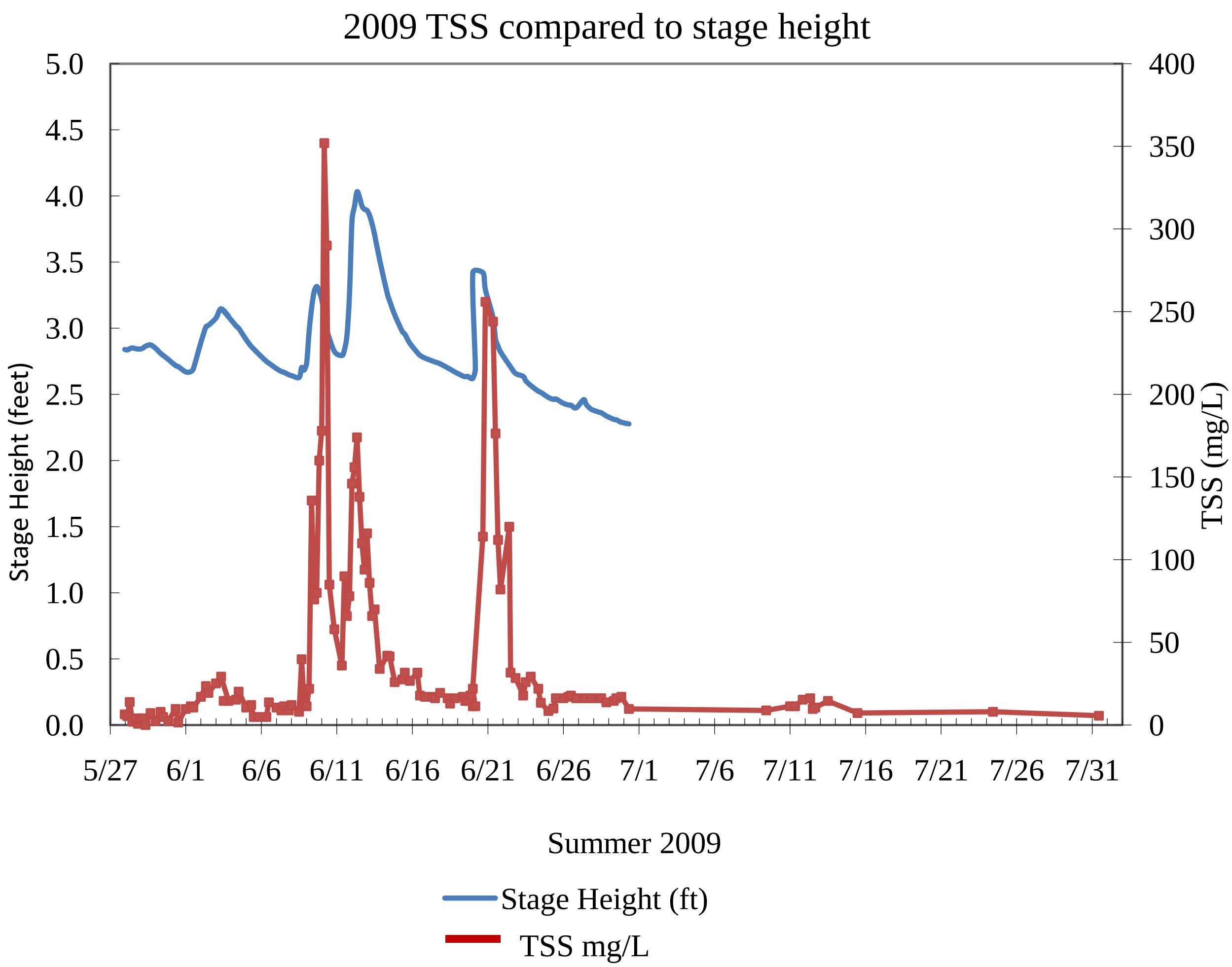

Figure 4-1. Middle Eel River Watershed – Blocher Gage 2009 TSS results compared to stage height at North Manchester.

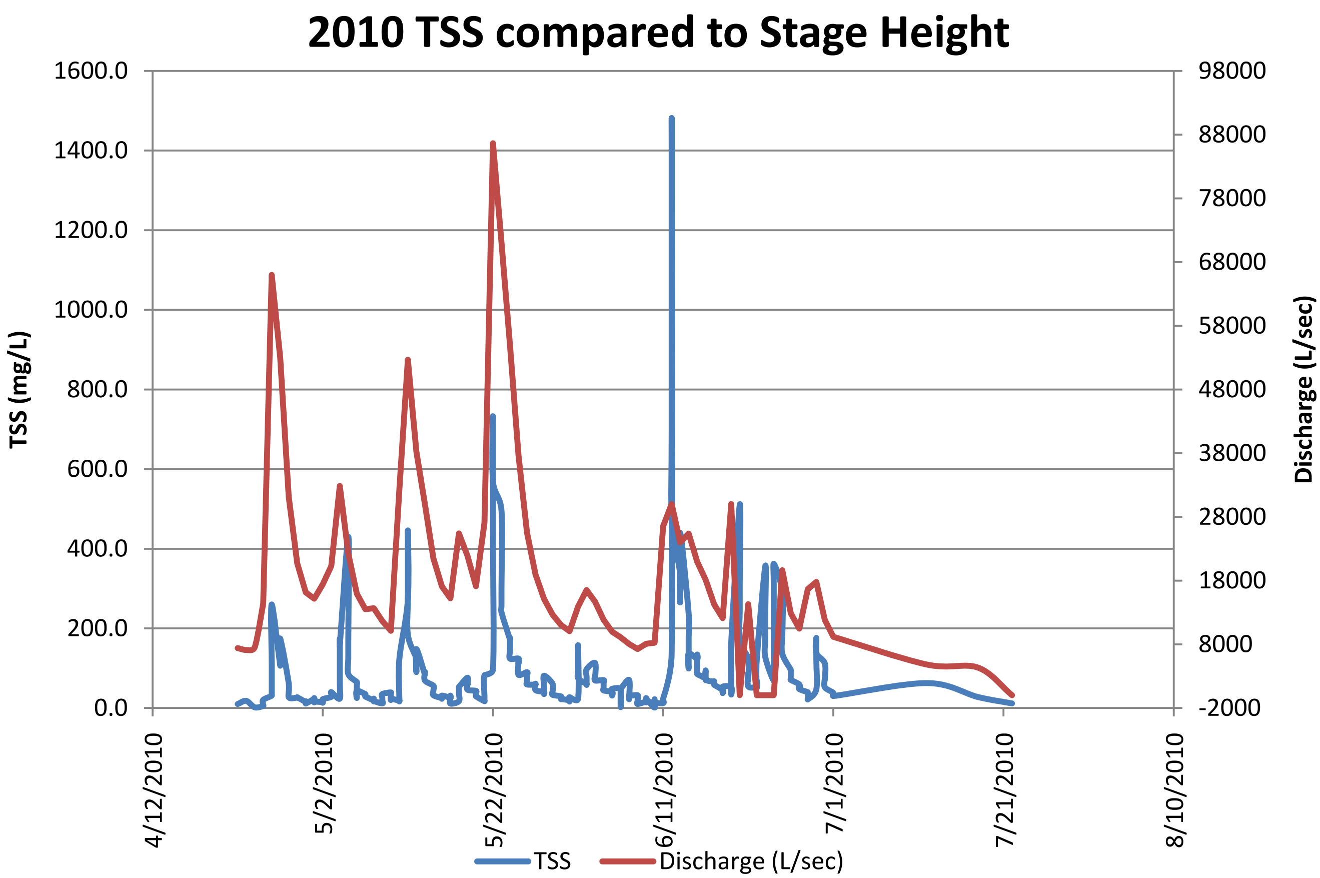

Figure 4-2. Middle Eel River Watershed – Blocher Gage 2010 TSS results compared to discharge in L/sec at North Manchester.

E. coli is the main cause for stream lengths in the Middle Eel River Watershed being included on IDEMs 303d List of Impaired Waters and was identified as a major contaminant during water monitoring in 2009 and 2010 (Section 3, Tables 3-7 through 3-11). Water monitoring indicates that E. coli increases dramatically with rain events which may be due to animal feed operation runoff, accidents (hose ruptures, spills, etc), combined sewer overflows, livestock having direct access to streams, and improper application of manure. Pollutants in animal waste can impact waters through several possible pathways, including surface runoff and erosion, direct discharges to surface waters, spills, and leaching into soil and groundwater.

Nutrients, specifically nitrogen and phosphorus, are also a cause for stream lengths within the Middle Eel River Watershed being included on the IDEM 303d List of Impaired Waters. Excess nutrients cause algal blooms which may result in hypoxic (low oxygen) zones that have a negative effect on wildlife and their habitat as well as effecting the recreational use of water by humans. The probable sources of high nitrogen and phosphorus within the watershed are: improper or over application of nutrients including manure and synthetic fertilizers, erosion due to conventional tillage, agricultural tile drainage, livestock access to the stream, animal feedlot run-off, and combined sewer overflows (CSOs).

By comparing stage height to Total Phosphorus, Figures 4.3 and 4.4, it is clear that there is a strong correlation between discharge and Total Phosphorus. This suggests that a large contributing factor to elevated Total Phosphorus is field erosion and run-off caused by rain events.

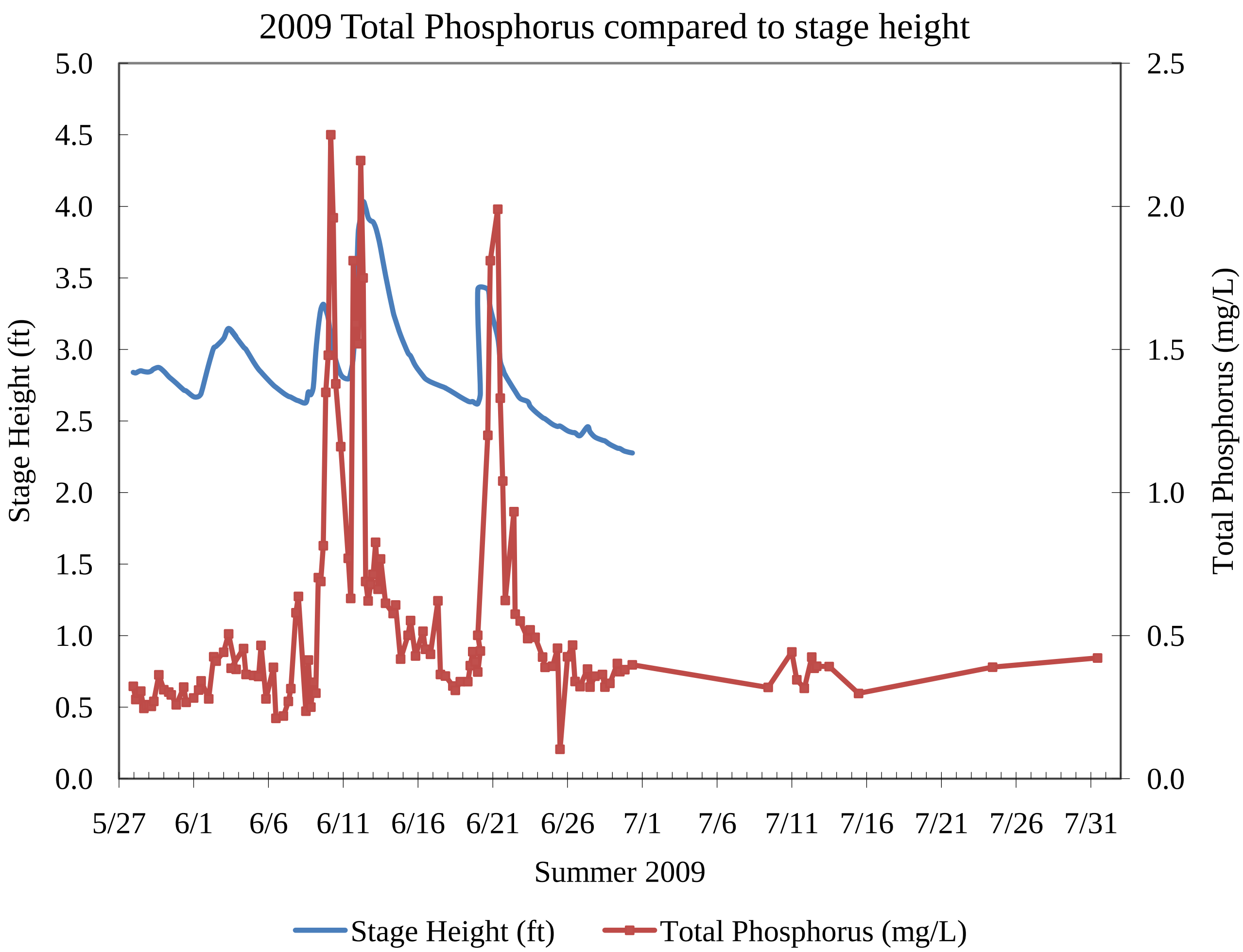

Figure 4-3. Middle Eel River Watershed – Blocher Gage 2009 Total Phosphorus results compared to Stage Height at North Manchester.

In addition to the chemical water quality monitoring, biological studies such as the IBI (Index of Biotic Integrity) has shown impaired biotic communities within the Middle Eel River Watershed (Section 3, Figures 3-16 and 3-17). Impaired biotic community is a cause for stream lengths within the watershed being included on the IDEM 303d List of Impaired Waters. Probable causes of low IBI scores are in-stream habitat degradation, land use changes in the riparian zone, and poor water quality. QHEI (Qualitative Habitat Evaluation Index) has indicated poor habitat availability within the watershed (Section 3, Figures 3-14 and 3-15). Probable causes are substrate degradation, hydrologic modifications and land use changes.

Mercury and PCBs in fish tissue is also cause for stream lengths being on the IDEM 303d List however this problem is beyond the scope of this project.

Potential water quality stressors, sources and causes of excessive nutrients (nitrogen and phosphorus) in tributaries and mainstem	
Potential Source	Basis/Evidence
Tile drainage discharge	Increased nitrogen and phosphorus may be coming from tile drains. Concern for tile drainage was voiced at Steering Committee Meetings. Tile drainage occurs in almost every field throughout the watershed and is likely a source of excess nitrogen and phosphorus entering the stream.
Erosion from cropland	Increased sediment, carrying nutrients, could be coming from agricultural land use. Concern for agricultural land use contributing to high nitrogen and phosphorus was voiced at Steering Committee meetings. 89% of land use within the Middle Eel River Watershed is agricultural and Miami and Wabash County have approximately 37,000 acres of land in conventional tillage.
Fertilizer and manure runoff	Increased nutrient levels could be coming from agricultural operations. Concern for agricultural land use contributing to increased nutrient load was voiced at Steering Committee Meetings and Public Meetings. Over-application and/or timing of application of fertilizers and/or manure could contribute to high nitrogen and phosphorus in tributaries and the mainstem. There is limited precision application occurring in the watershed, and it is not unusual to see manure being field applied to frozen ground.
CFOs, CAFOs and grazing animals	Increased nutrients could be coming from animal feed lots. Concern for animal feeding operations was voiced at Steering Committee meetings and Public Meetings. Run-off from feedlots, accidents, and application of manure on cropland could contribute to high nitrogen and phosphorus levels . Application of manure to frozen fields may contribute to high nitrogen and phosphorus levels. Livestock that have direct access to streams may contribute to high nitrogen and phosphorus levels.
Septic systems or straight pipes	Increased nitrogen and phosphorus could be coming from malfunctioning septic systems or straight pipes. Concern for failing septic systems and straight pipes was voiced at Steering Committee and Public Meetings. The town of Laketon does not have a wastewater treatment facility and is on the mainstem which may contribute to high nitrogen and phosphorus levels. 42% of households in Miami County have septic systems and 40% of households in Wabash County have septic systems.
Wetland loss; filled or drained	Suspected increase in nitrogen and phosphorus related to wetland loss throughout the watershed. Concern voiced at Steering Committee and Public Meetings. Wetland loss could contribute to high nitrogen and phosphorus levels.
Combined sewer overflow (CSOs)	Increased nitrogen and phosphorus could be coming from CSOs. Concern for CSOs was voiced at Public Meetings. Discharge of raw sewage from rain events causing a bypass of the treatment plant in North Manchester could contribute to high nitrogen and phosphorus levels.
Problem statement: High levels of nitrogen and phosphorus are present in the Watershed. Stakeholders expressed concern regarding high nitrogen and phosphorus levels at Steering Committee and Public Meetings. Water quality data confirms these concerns. Extensive tile drainage, conventional tillage, erosion from cropland, fertilizer and manure runoff, run-off from animal feed lots, failing septic systems, wetland loss, and CSO by-pass events are suspected sources of nitrogen and phosphorus.	

Potential water quality stressors, sources and causes of E. coli in tributaries and mainstem	
Potential Source	Basis/Evidence
Erosion from cropland	Increased sediment, carrying E. coli, could be coming from agricultural land use. Concern for agricultural land use contributing to high E. coli was voiced at Steering Committee and Public Meetings. 89% of land use within the Middle Eel River Watershed is agricultural and Miami and Wabash County have large percentages of row crops. Erosion from row crop agriculture could be contributing to high E. coli counts.
Manure Application	Increased E. coli levels could be coming from agricultural operations. Concern for agricultural land use contributing to increased E. coli counts was voiced at Steering Committee Meetings and Public Meetings. Over-application or improper timing of application of manure as fertilizer could contribute to high E. coli counts. Application of manure to frozen fields may contribute to high E. coli counts.
CFOs, CAFOs and grazing animals	Increased E. coli could be coming from animal feed lots. Concern for animal feeding operations was voiced at Steering Committee meetings and Public Meetings. Run-off and accidents could contribute to high E. coli counts. Livestock that have direct access to streams may contribute to high E. coli counts.
Failing septic systems or straight pipes	Increased E. coli could be coming from malfunctioning septic systems or straight pipes. Concern for failing septic systems and straight pipes was voiced at Steering Committee and Public Meetings. The town of Laketon does not have a wastewater treatment facility and is located on the mainstem which may contribute to high E. coli counts.
E. coli loading from combined sewer overflows (CSOs)	Concern for CSOs contributing to elevated E coli counts was voiced at Public Meetings. Discharge of raw sewage from rain events causing a bypass of the North Manchester water treatment plant could contribute to high E. coli counts.
Problem Statement: Elevated E. coli is a problem within the Middle Eel River Watershed. This has been confirmed by water quality data collected. All the sampling locations geometric mean concentrations were greater than the state standard for full body contact recreation. Suspected sources are failing septic systems, combined sewer overflows (CSOs), effluent from wastewater treatment facilities, illicit straight pipe discharges of sewage, and run-off from feed lots and row crop agricultural areas.	

Potential water quality stressors, sources and causes of excessive sediment in tributaries and mainstem	
Potential Source	Basis/Evidence
Erosion from cropland	Increased sediment could be coming from agricultural land use. Concern for agricultural land use contributing to high suspended sediment was voiced at Steering Committee and Public Meetings. 89% of land use within the Middle Eel River Watershed is agricultural. Miami County has 52% conventional tillage corn and 5% conventional tillage soybeans and Wabash County has 73% conventional tillage corn and 23% conventional tillage soybeans. Erosion from conventionally tilled row crop agriculture could be contributing to excessive sediment.
CFOs, CAFOs and grazing animals	Increased sediment could be coming from animal feed lots. Concern for animal feeding operations was voiced at Steering Committee meetings and Public Meetings. Erosion from livestock lots could contribute to high sedimentation. Livestock that have direct access to streams may contribute to excessive sediment from streambank erosion.
Hydrological changes affecting streamflow	Increased velocity may be causing excessive sediment. Tile drainage has altered the hydrology of the natural system resulting in increased flashiness of all the streams within the watershed. This flashiness, that causes an increase in velocity, may be contributing to excessive sedimentation.
Hydrologic modification: Filled or drained wetlands	Suspected increase in sediment related to wetland loss throughout the watershed. Concern was voiced at Steering Committee and Public Meetings regarding the loss of wetlands which may contribute to excessive sediment in the tributaries and the mainstem.
Problem Statement: There are very high levels of Total Suspended Solids within the Watershed. The Stakeholders expressed concern regarding excessive total suspended sediment at Steering Committee and Public Meetings. Water quality data confirms these concerns. Suspected sources are: conventional tillage, erosion from row crop agriculture, animal feed lots, ditching and dredging of streams and loss of wetlands that serve as filters.	

Potential water quality stressors, sources and causes of impaired biotic communities in tributaries and mainstem	
Potential Source	Basis/Evidence
Habitat modification: removal of riparian vegetation and bank modification/destabilization	Concern voiced at Steering and Public Meetings. Forested riparian buffers were virtually non-existent in many of the tributaries resulting in low QHEI scores. In many instances row crops are very close to the stream with no buffer. Ditch maintenance resulting in the removal of most of the vegetated riparian buffer is common within the watershed, decreasing the canopy, removing the buffering capability of the riparian area, and destroying natural aquatic habitats. Channel modifications are seen in almost of the tributaries of the watershed.
Hydrologic modification: Filled or drained wetlands	Concern was voiced at Steering Committee and Public Meetings about wetland loss that has occurred throughout the watershed. Hydric soils in the watershed indicate high wetland losses in the watershed. Loss of wetland services such as water filtering and slowing the flow, may have resulted in an impaired biotic community.
Problem Statement: There are impaired biotic communities and degraded habitats in the watershed. Concern for impaired biotic communities has been substantiated by the IBI and the QHEI. Sources could include land use changes within the riparian areas along the tributaries and mainstem, hydromodification within the Watershed, loss of wetlands and conventional tillage.	

Concern: Lack of Public Awareness	
Potential Source	Basis/Evidence
Public lacks understanding of their actions on water quality	Concern was voiced at Steering Committee meetings that the public lacks understanding of how they contribute to NPS pollution and lack the understanding of what a watershed is. Nonpoint source pollution (NPS) is everyone's problem and comes from all different types of land use.
Problem Statement: Lack of public awareness of nonpoint source pollution and understanding of the watershed concept is a problem in the Watershed. The Steering Committee believes the general public needs to better understand how and why their actions impact water quality.	

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Watershed Management Plan

SECTION 5

CRITICAL AREAS

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5.0 CRITICAL AREAS

High and secondary priority critical areas are considered essential areas for implementation of practices to improve or protect water quality, biotic community and/or habitat. Water monitoring indicates that all the subwatersheds within the Middle Eel River Watershed are impaired and could be considered critical areas. However, it is important to prioritize the subwatersheds to determine the most effective strategy for water quality improvement. To that end the Steering Committee determined critical areas in two categories; high priority and secondary priority. The critical area and priority designations will be used in the ranking process for the cost-share program and implementation.

The critical area ranking of testing tributaries was accomplished by creating a holistic scoring system for water quality impairments that includes the chemical, biological and physical analysis of each testing tributary. A point system was developed to rank testing tributaries within the watershed using the following criteria:

Chemical Analysis:
Highest annual mean for parameter of concern: 5 Points
Second highest annual mean – 4 Points
Third highest annual mean – 3 Points

Biological Analysis:
IBI (As opposed to the chemical analysis, a high IBI score is good)
Lowest IBI – 5 Points
Second lowest IBI – 4 Points
Third lowest IBI – 3 Points

Physical Analysis:
QHEI (As opposed to the chemical analysis, a high QHEI score is good)
Lowest QHEI – 5 Points
Second lowest QHEI – 4 Points
Third lowest QHEI - 3 Points

This is a relative ranking process and only ranks the testing tributaries in comparison to each other and does not indicate the overall stream health

The critical area ranking results for each testing tributary in the watershed are shown in Tables 5-1 through 5-3.

Table 5-1. Middle Eel River Watershed point ranking results of Testing Tributaries – 2009.

Testing Tributary	QHEI Ranking	IBI Ranking	E. coli Ranking	Nitrate Ranking	Ammonia Ranking	Total Phosphorus Ranking	TSS Ranking	2009 TOTAL Score
Silver Creek	4	5	4	0	0	0	4	17
Beargrass Creek	0	4	0	5	0	5	5	19
Squirrel Creek	3	0	5	0	3	0	0	11
Paw Paw Creek	0	0	0	4	0	0	0	4
Flowers Creek	0	0	3	3	4	4	3	17
Little Weesau-Weesau Creek	5	5	0	0	5	3	0	18

Table 5-2. Middle Eel River Watershed point ranking results of Testing Tributaries – 2010.

Testing Tributary	QHEI Ranking	IBI Ranking	E. coli Ranking	Nitrate Ranking	Ammonia Ranking	Total Phosphorus Ranking	TSS Ranking	2010 TOTAL Score
Silver Creek	4	4	4	0	5	3	5	25
Beargrass Creek	0	3	0	4	0	5	0	12
Squirrel Creek	0	0	5	0	4	0	4	13
Paw Paw Creek	0	0	0	5	3	4	0	12
Flowers Creek	3	0	0	3	0	0	0	6
Little Weesau-Weesau Creek	5	5	3	0	0	0	3	16

Table 5-3. Middle Eel River Watershed point ranking results of Testing Tributaries – total combined scores 2009 and 2010.

Testing Tributary	QHEI Ranking	IBI Ranking	E. coli Ranking	Nitrate Ranking	Ammonia Ranking	Total Phosphorus Ranking	TSS Ranking	2009 and 2010 Combined TOTAL Score
Silver Creek	8	9	8	0	5	3	9	42
Beargrass Creek	0	7	0	9	0	10	5	31
Squirrel Creek	3	0	10	0	7	0	4	24
Paw Paw Creek	0	0	0	9	3	4	0	16
Flowers Creek	3	0	3	6	4	4	3	23
Little Weesau-Weesau Creek	10	10	3	0	5	3	3	34

Using this methodology, the highest priority critical areas are those that scored the highest number of points relative to each other. Using this ranking criteria, the high priority critical areas in the Middle Eel River Watershed are Silver Creek (HUC - 051201040501), Beargrass Creek (HUC - 051201040503), and Little Weesau-Weesau Creek (HUC – 051201040602) (Figure 5-1). Table 5-4 shows the parameters of concern for each high priority critical subwatershed in the Middle Eel River Watershed.

The secondary priority critical areas chosen by the Steering Committee have somewhat lower combined impairments and are: Flowers Creek (HUC - 051201040601), Oren Ditch-Paw Paw Creek (HUC - 051201040508), Otter Creek (HUC-051201040502), Squirrel Creek (HUC - 051201040505), Town of Roann (HUC – 051201040509), and Washonis Creek (HUC – 051201040603) (Figure 5-1). Table 5-5 shows the parameters of concern for each secondary priority critical subwatershed in the Middle Eel River Watershed. The secondary critical subwatersheds of Otter Creek (HUC-051201040502), Town of Roann (HUC – 051201040509), and Washonis Creek (HUC – 051201040603) were included due to their listing on IDEMs 303(d) Listing.

Figures 5-2 through 5-7 provide the water monitoring results for each parameter of concern for each testing tributary for 2009 and 2010 and demonstrate the impairments throughout the Middle Eel River Watershed in all the testing tributaries.

Table 5-4. Middle Eel River Watershed – Critical Area - High Priority Subwatersheds with parameters of concern.

Middle Eel River High Priority Critical Areas		
12 Digit HUC	**HUC Name**	**Parameter of Concern**
051201040501	Silver Creek	IDEM 303(d) List for high phosphorus and *E. coli*, and PCBs in Fish Tissue ***Low*** - IBI & QHEI ***High*** - *E. coli*, Ammonia, TSS, and total phosphorus
051201040503	Beargrass Creek	IDEM 303(d) List for high *E. coli* ***Low*** – IBI ***High*** - *E. coli*, TSS, nitrates and total phosphorus
051201040602	Little Weesau – Weesau Creek	***Low*** - IBI & QHEI ***High*** - *E. coli*, ammonia, nitrates and total phosphorus

Table 5-5. Middle Eel River Watershed – Critical Area - Secondary Priority Subwatersheds with parameters of concern.

Middle Eel River Secondary Priority Critical Areas		
12 Digit HUC	**HUC Name**	**Cause for Listing**
051201040601	Flowers Creek	IDEM 303 (d) List for low DO, impaired biotic community, nutrients, mercury and PCBs, ***High*** - *E. coli*, TSS, nitrates and total phosphorus
051201040502	Otter Creek	IDEM 303 (d) List for *E. coli* and PCBs ***High*** - *E. coli*, TSS and total phosphorus
051201040508	Oren Ditch – Paw Paw	IDEM 303 (d) List for *E. coli* ***High*** - *E. coli*, TSS and total phosphorus
051201040505	Squirrel Creek	IDEM 303 (d) List for *E. coli* ***High*** - *E. coli*, TSS, nitrates and total phosphorus
051201040509	Town of Roann	IDEM 303 (d) List for *E. coli* and PCBs ***High*** - *E. coli*, TSS and total phosphorus
051201040603	Washonis Creek	IDEM 303 (d) List for *E. coli*, mercury and PCBs ***High*** - *E. coli*, TSS and total phosphorus

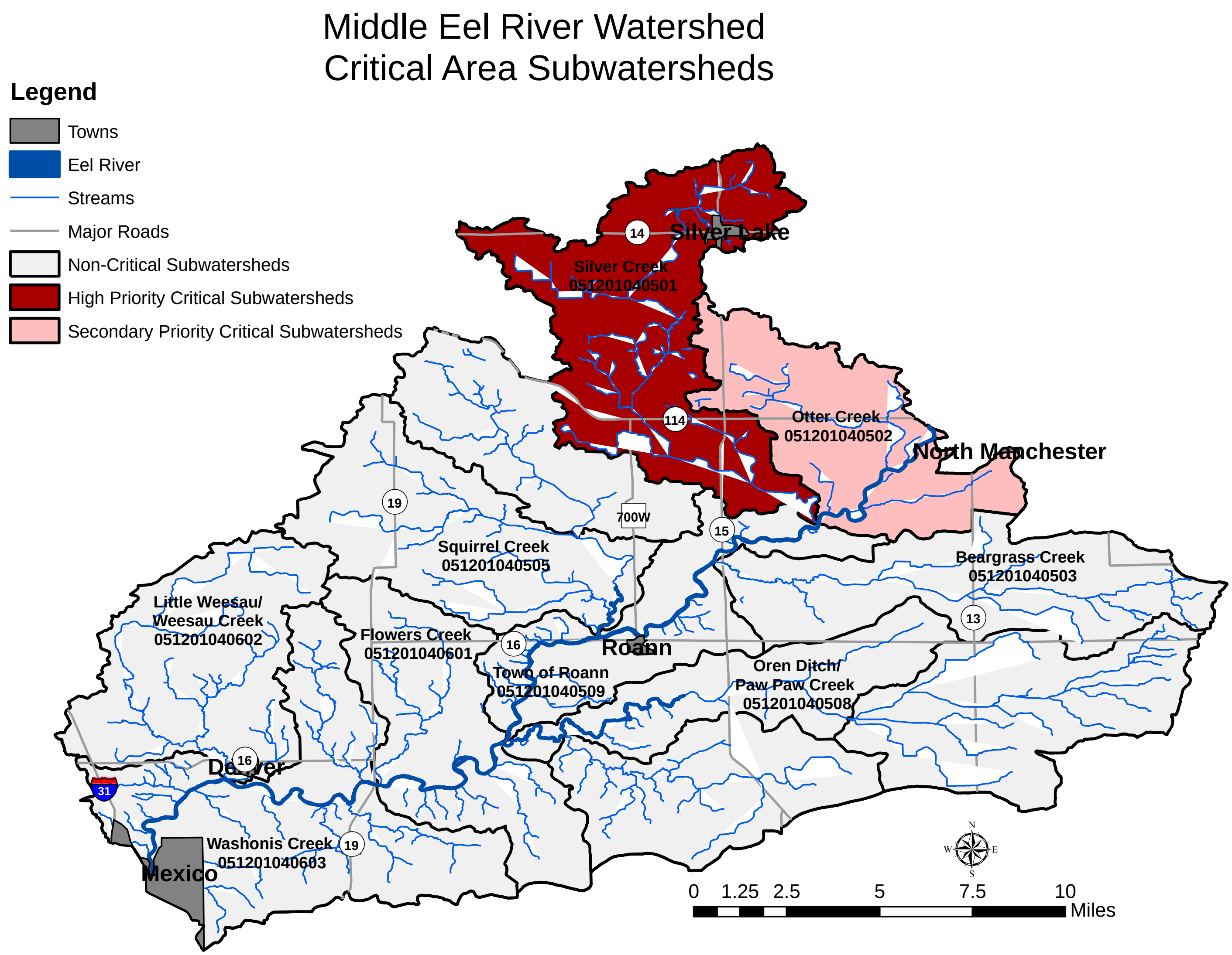


Figure 5-1. Middle Eel River Watershed, Critical Areas – High and Secondary Priority.

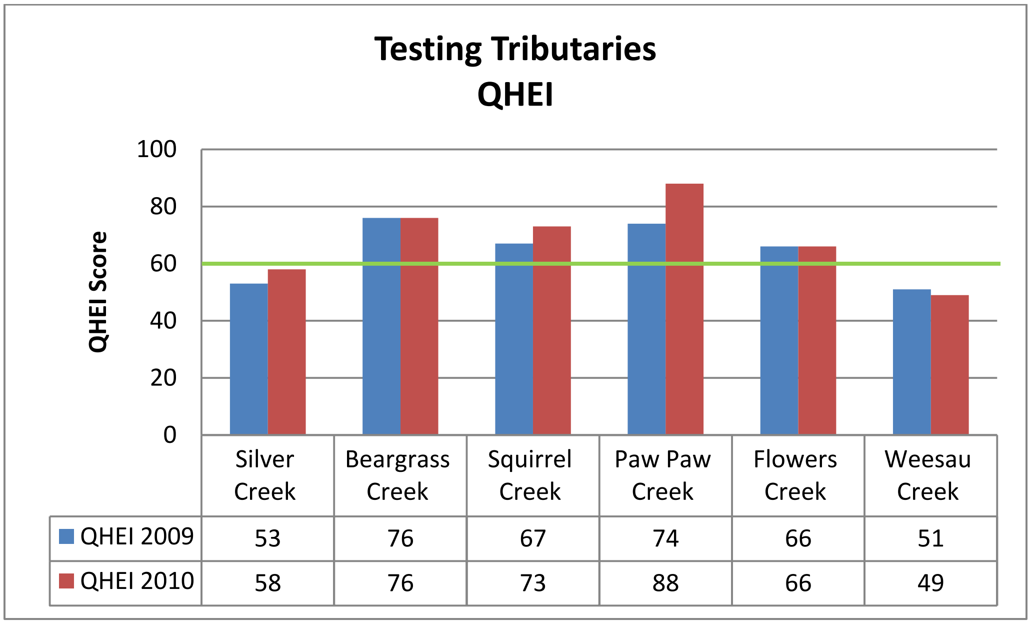


Figure 5-2. Middle Eel River Watershed - 2009 and 2010 QHEI scores for testing tributaries. The green line indicates a QHEI score of 60 which is the goal of this Watershed Management Plan.

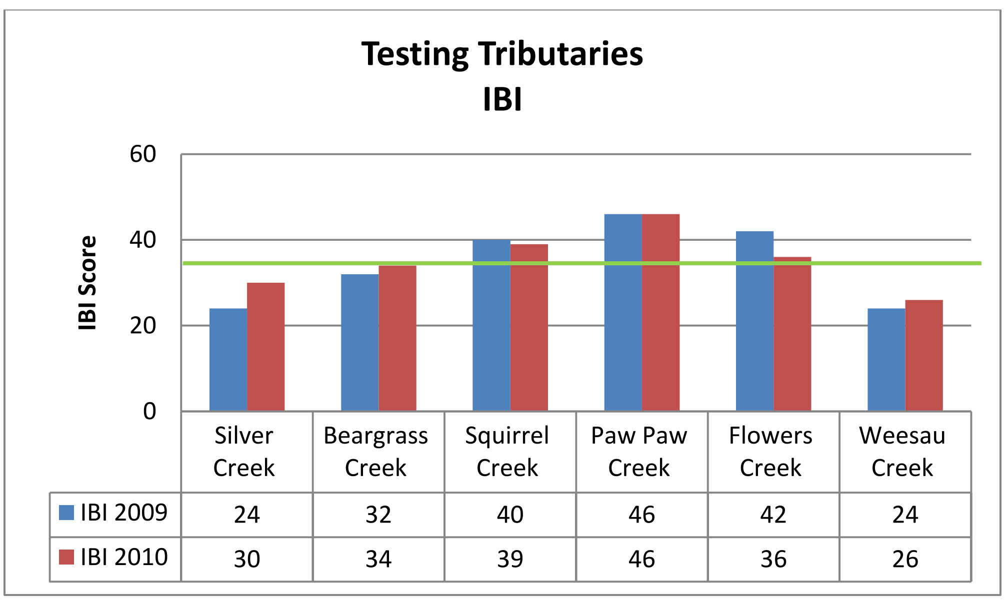
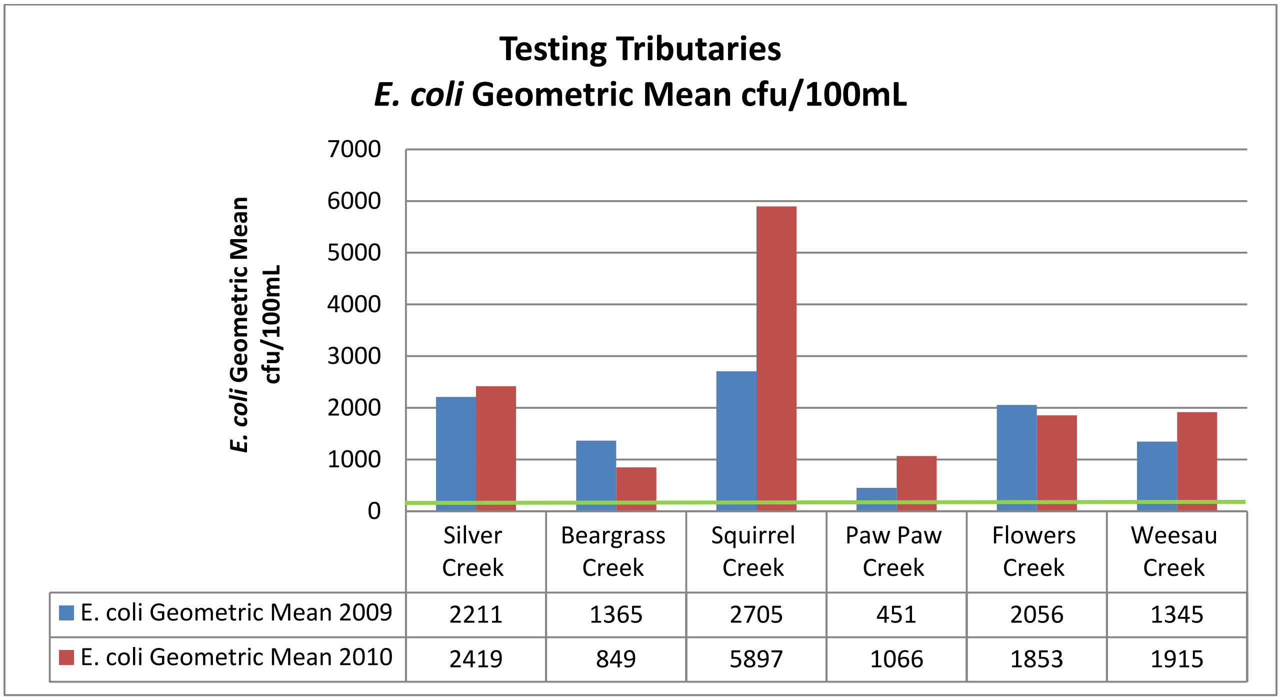
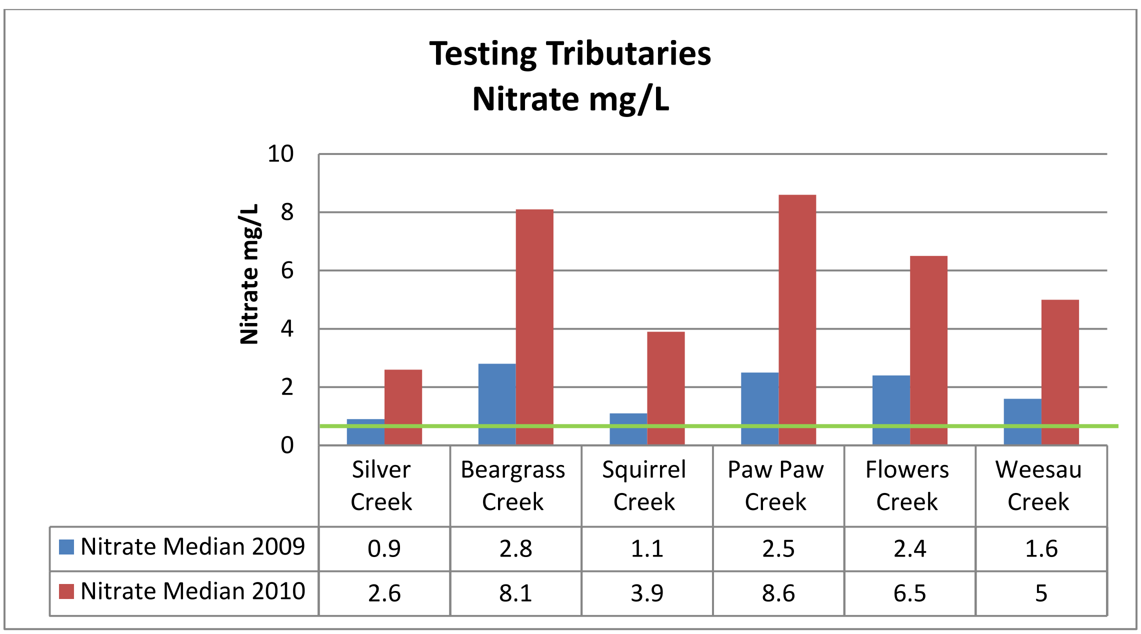


Figure 5-3. Middle Eel River Watershed - 2009 and 2010 IBI scores for testing tributaries. The green line indicates and IBI score of 35 which represents fair conditions within the tributary.



	Silver Creek	Beargrass Creek	Squirrel Creek	Paw Paw Creek	Flowers Creek	Weesau Creek
E. coli Geometric Mean 2009	2211	1365	2705	451	2056	1345
E. coli Geometric Mean 2010	2419	849	5897	1066	1853	1915

Figure 5-4. Middle Eel River Watershed - 2009 and 2010 *E. coli* geometric mean (cfu/100mL) water monitoring results for testing tributaries. The green line represents 125 cfu/100mL which is the Indiana State Standard and the target of this Watershed Management Plan.



	Silver Creek	Beargrass Creek	Squirrel Creek	Paw Paw Creek	Flowers Creek	Weesau Creek
Nitrate Median 2009	0.9	2.8	1.1	2.5	2.4	1.6
Nitrate Median 2010	2.6	8.1	3.9	8.6	6.5	5

Figure 5-5. Middle Eel River Watershed - 2009 and 2010 Median Nitrate (mg/L) water monitoring results for testing tributaries. The green line represents the USEPA Recommendation of 0.633 mg/L which is the target of this Watershed Management Plan.

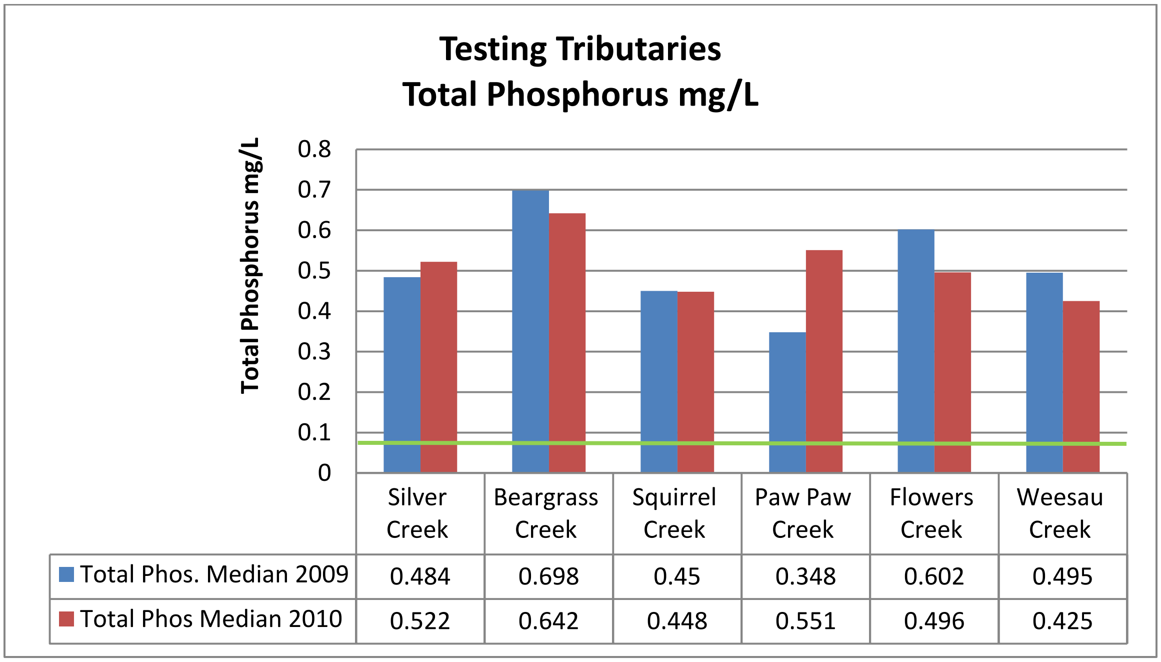


Figure 5-6. Middle Eel River Watershed - 2009 and 2010 Median Total Phosphorus (mg/L) water monitoring results for testing tributaries. The green line represents the US EPA Recommendation of 0.076 mg/L which is the target of this Watershed Management Plan.

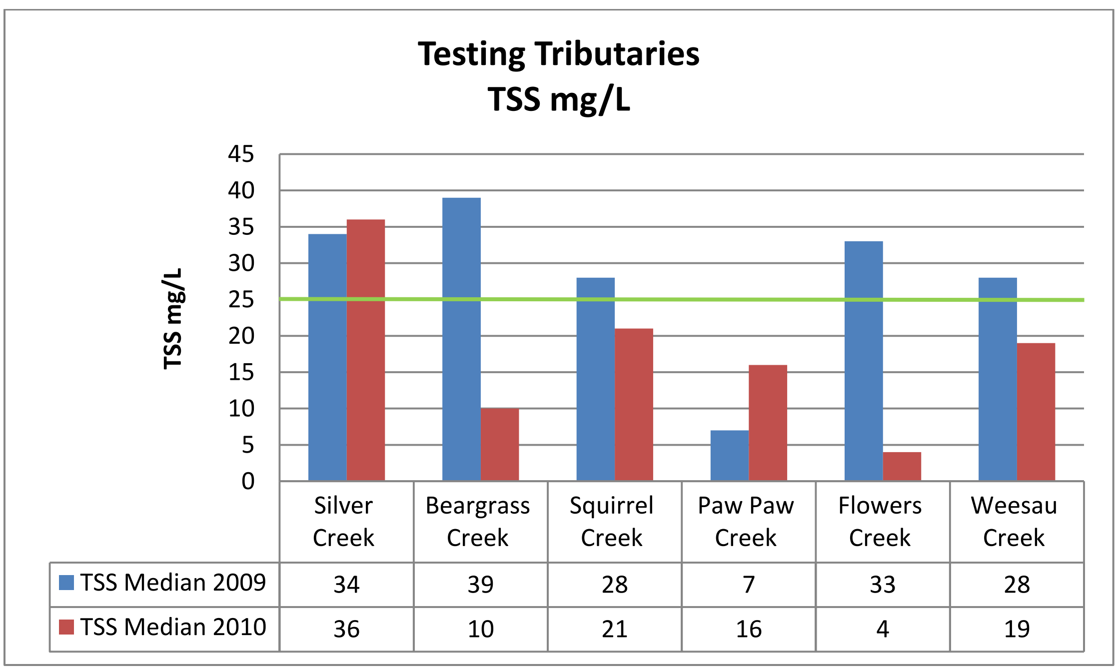


Figure 5-7. Middle Eel River Watershed - 2009 and 2010 Median TSS (mg/L) water monitoring results for testing tributaries. The green line represents 25 mg/L which is the target of this Watershed Management Plan.

Middle Eel River

Watershed Management Plan

SECTION 6

LOADS, GOALS, OBJECTIVES AND RESOURCES

1/14/11

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6.0 Key Issues and Concerns

The Steering Committee identified 3 key issues as top priority concerns in the watershed:

1) Degraded water quality that has concentrations above state standards in:
    a. Total Suspended Solids
    b. Nutrients: Nitrogen and Total Phosphorus
    c. *E. coli*
2) Degraded habitat for the biological community
3) Impaired biotic comminuties

This is a data driven plan, the magnitude of the water quality concerns within the watershed are a reflection of the water monitoring program. It is important to note that there is no one practice that can solve the concerns within the watershed. It will be necessary to implement a variety of practices throughout the watershed for improvement in water quality, biological community, and habitat. BMPs targeting the above mentioned parameters of concern are listed in Figure 6-1. Current load calculation are listed in Tables 6-1 through 6-8 and load reductions necessary to meet the goals are listed in Tables 6-9 through 6-14.

6.1 Load Calculations for Testing Tributaries

Daily and annual loads for ammonia, nitrate and total phosphorus (Lbs/day/year) for 2010 were calculated for each of the six testing tributaries and are shown below. TSS loads are calculated in tons per day/year. Load estimations are based on data collected during the 2010 field season. The field season runs from May 1 – June 31 and includes the time when the agricultural community is most active and represents the highest loading of the year. Consequently, when extrapolated to an annual load, the daily loads will be somewhat skewed as the parameters of concern will be the highest during the field season.

Table 6-1. Middle Eel River Watershed testing tributaries ammonia (lbs/day/year) median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Ammonia Pounds per Day/Year 2010 Field Season (May-July)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median (lbs/day)	13	11	8	2	12	8
Annual Load (lbs/yr)	4,745	4,015	2,920	730	4,380	2,920
Maximum	93	125	78	28	205	366
Minimum	2	0	0	0	1	0
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 6-2. Middle Eel River Watershed testing tributaries nitrate (lbs/day/year) median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Nitrate Pounds per Day/Year 2010 Field Season (May-July)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median (lbs/day)	489	558	669	244	1,765	1,077
Annual Load (lbs/yr)	178,485	203,670	244,185	89,060	644,225	393,105
Maximum	1,651	3,530	2,713	1,417	5,715	8,467
Minimum	58	0	0	0	17	0
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 6-3. Middle Eel River Watershed testing tributaries total phosphorus (lbs/day/year) median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Total Phosphorus Pounds per Day/Year 2010 Field Season (May-July)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median (lb/day)	102	76	55	18	99	71
Annual Load (lbs/yr)	37,230	27,740	20,075	6,570	36,135	25,915
Maximum	571	576	862	214	1,776	1,955
Minimum	0	0	0	0	5	0
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

Table 6-4. Middle Eel River Watershed testing tributaries TSS (lbs/day/year) median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

TSS Tons per Day/Year 2010 Field Season (May-July)						
	Silver Creek	Squirrel Creek	Weesau Creek	Flowers Creek	Paw Paw Creek	Beargrass Creek
Median (tons/day)	3.7	1.4	1.0	.05	1.2	0.6
Annual Load (tons/yr)	1,359	525	402	182	424	215
Maximum	31	36	53	10	120	159
Minimum	163	0	0	0	0	0
Acreage	20,163	15,192	14,853	13,581	35,118	14,793

6.2 Load Calculations for Mainstem Gage Stations

Daily and annual loads of ammonia, nitrate and total phosphorus (Lbs/day/year) for 2010 were calculated for each of the gage stations and are shown below. TSS loads are calculated in tons per day/year. Load estimations are based on data collected during the 2010 field season. The field season runs from May 1 – June 31 and includes the time when the agricultural community is most active and represents the highest loading of the year. Consequently, when extrapolated to an annual load, the daily loads will be somewhat skewed as the parameters of concern will be the highest during the field season. It is important to note that ammonia, total phosphorus and TSS decrease as they move through the Middle Eel River Watershed indicating the need to focus on the upper reaches of the Eel River Watershed. In order to decrease the loads of ammonia, total phosphorus, and TSS, watershed management plans will need to be written and implemented within the upper reaches of the Eel River Watershed.

Table 6-5. Middle Eel River Watershed mainstem gage stations ammonia (lbs/day/year) median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Ammonia Pounds per Day/Year 2010 Field Season (May-July)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median (lbs/day)	231	228	225
Annual Load (lbs/yr)	84,315	83,220	82,125
Maximum	9,602	4,879	5,121
Minimum	0	37	37
Acreage	92,442	120,179.5	49,192.8

Table 6-6. Middle Eel River Watershed mainstem gage stations nitrate (lbs/day/year) median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Nitrate Pounds per Day/Year 2010 Field Season (May-July)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median (lbs/day)	10,244	11,906	12,802
Annual Load (lbs/yr)	3,739,060	4,345,690	4,672,730
Maximum	91,743	74,303	75,923
Minimum	578	248	330
Acreage	92,442	120,179.5	49,192.8

Table 6-7. Middle Eel River Watershed mainstem gage stations total phosphorus (lbs/day/year) median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

Total Phosphorus Pounds per Day/Year 2010 Field Season (May-July)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median (lbs/day)	2,085	2,287	1,947
Annual Load (lbs/yr)	761,025	834,755	710,655
Maximum	82,071	47,823	38,952
Minimum	288	233	165
Acreage	92,442	120,179.5	49,192.8

Table 6-8. Middle Eel River Watershed mainstem gage stations TSS (lbs/day/year) median, maximum, minimum and subwatershed acreage, May 7-July 29, 2010.

TSS Tons per Day/Year 2010 Field Season (May-July)			
	Blocher Gage	Paw Paw Gage	Mexico Gage
Median (tons/day)	72	71	68
Annual Load (tons/yr)	26,249	25,761	24,688
Maximum	1.2	1.9	2.9
Minimum	0	1.2	1.3
Acreage	92,442	120,179.5	49,192.8

6.3 Goals The Steering Committee determined the following goals:

Problem Statement: High levels of nitrogen and phosphorus are present in the Watershed.

Goal 1: Reduce nitrogen and total phosphorus in the Middle Eel River Watershed Short term goals: 1-3 years					
Goal/Objective	**Action Item**	**Responsibility**	**Schedule**	**Indicators of Success**	**Cost Estimate**
Decrease nitrogen and total phosphorus in mainstem and tributaries	Develop and implement a cost-share program to assist with implementation of best management practices.	**Watershed Coordinator**	Complete development of cost-share program for IDEM approval by December 31, 2010	Cost-share program approval by IDEM	$60,000
	Implement BMPs targeted to reduce nitrogen and phosphorus including: nutrient management plans, variable rate technology, soil testing, conservation tillage, cover crops, grassed waterways, stream buffers and riparian corridor enhancement.	**NRCS, SWCDs** **Watershed Coordinator**	Contacts and agreements in by 2011, implementation of BMPs by December 31, 2012 Continue water monitoring as outlined in the QAPP	Number of agreements entered into with land owners. Document downward trend in nitrogen and total phosphorus in tributaries and mainstem	$212,000 $50,000 Annually
Foster interest in and educate the public on nonpoint sources of nutrients in the Middle Eel River Watershed	Encourage BMP's through educational events targeting the agricultural and urban community, focusing on BMPs that reduce nitrogen and phosphorus use.	**Watershed Coordinator, NRCS, SWCDs**	Hold 3 field days focusing on nonpoint source nutrients targeting the agricultural and urban community.	Number of field days and number of participants	Approx $750.00 Annually
Foster interest in and educate the public regarding the national impact of excessive nutrients	Hold public meetings to share water monitoring results with the public and progress in terms of BMPs installed or scheduled. Discussion will include local and national concerns regarding nutrient loading.	**Watershed Coordinator**	Annual meeting to educate and inform the public 2011 & 2012	Number of people attending the annual meeting	Approx $200 Annually

Goal #1: Reduce Nitrogen and Phosphorus in the Middle Eel River Watershed.

Short Term Goal: 1-3 years:

Document downward trend in Nitrogen and Total Phosphorus levels in critical areas (priority and secondary) (Figure 5-1).

Intermediate Term Goal: 3-15 years:

Reduce nitrogen, total phosphorus and to 50% of USEPA Recommended targets, nitrate maximum of 1.266 mg/L and total phosphorus maximum of 0.152 mg/L in the critical areas (Figure 5-1).

Action:

Continue implementation of BMPs throughout the watershed by partnering with the Mississippi River Basin Initiative ($2.9M)

Develop watershed management plans to include the entire Eel River Watershed (See page 3-54) (HUC - 05120104). Approx cost: $3M

Continue water monitoring in the Middle Eel River to determine effectiveness of BMPs. Approx. cost: $50,000 annually

Long Term Goal: 16-30 years:

Reduce nitrogen and total phosphorus to meet USEPA Recommended targets of nitrate maximum of 0.633 mg/L and total phosphorus maximum of 0.076 mg/L in the water as it exists the Middle Eel River Watershed (Figure 5-1).

Action:

Implementation of watershed management plans upstream of the Middle Eel River Watershed (HUC – 05120104).

Approximate cost: $5-10M

Continue implementation of BMPs that will be identified in additional watershed management plans.

Continue water monitoring in the Middle Eel River to determine effectiveness of BMPs. Approx. cost: $50,000 annually

Problem Statement: Elevated *E. coli* levels are present in the Watershed.

Goal 2: Reduce *E. coli* in the Middle Eel River Watershed
Short Term Goals: 1-3 years

Goal/Objective	Action Item	Responsibility	Schedule	Indicators of Success	Cost Estimate
Reduce *E. coli* in the tributaries and mainstem	Develop and implement a cost-share program to assist with implementation of best management practices that reduce *E. coli*.	**Watershed Coordinator**	Complete development of cost-share program for approval by IDEM by December 31, 2010	Cost-share program approval by IDEM	$60,000
Foster interest in and educate the public on nonpoint sources of *E. coli* in the Middle Eel River Watershed	Implement BMPs targeted to reduce *E. coli*	**NRCS, SWCDs**	Contacts and agreements in by 2011, implementation of BMPs by December 31, 2012	Number of agreements entered into with landowners.	$212,000 (Cost-Share Funds from current 319.)
	Encourage BMP's through educational events targeting the agricultural and urban community, focusing on nutrient management, soil testing, conservation tillage, cover crops, grassed waterways, stream buffers, prescribed grazing, livestock exclusion from waterways, waste storage facilities, composting facilities, equipment modification and anaerobic digesters.	**Watershed Coordinator, NRCS, SWCDs**	Hold1 field day targeting the agricultural community and BMPS that reduce *E. coli* in 2011.	Number of field days and number of participants	$750.00 Annually
		Watershed Coordinator	Continue water monitoring as outlined in the QAPP	Demonstrate downward trend of *E. coli* in the testing tributaries and mainstem	$50,000.00 Annually
	Hold public meetings to share water monitoring results with the public and progress in terms of BMPs installed or scheduled. Encourage proper septic system care and maintenance through education and outreach	**Local or state Board of Health and IDEM**	Annual meeting to educate and inform the public 2011 & 2012	Number of people attending the annual meeting	$250.00 Annually
	Support Laketon in pursuing Waste Water Treatment Facility	**Watershed Coordinator**	Watershed Coordinator to continue to work with the Laketon group throughout the process of implementing waste water treatment facility.	Installation of waste water treatment facility in Laketon	N/A

Goal #2: Reduce *E. coli* in the critical areas (Figure 5-1).

Short Term Goal: 1-3 years

Document downward trend in *E. coli* in critical areas (priority and secondary)(Figure 5-1).

Intermediate Goal: 3 – 15 years

Reduce *E. coli* to 50% of Indiana State Standard, Single Sample 470 CFU/100mL, or geometric mean of 250 CFU/100mL in the critical areas (Figure 5-1).

Action:

Continue implementation of BMPs throughout the watershed by partnering with the Mississippi River Basin Initiative ($2.9M)

Develop watershed management plans to include the entire Eel River Watershed (See page 3-54) (HUC - 05120104). Approx cost: $3M

Continue water monitoring in the Middle Eel River to determine effectiveness of BMPs. Approx. cost: $50,000 annually

Long Term Goal: 15-30 Years

Meet Indiana Sate Standard for *E. coli* Single Sample 235 CFU/100mL, or geometric mean of 125 CFU/100mL in the water leaving the Middle Eel River Watershed.

Action:

Implementation of watershed management plans upstream of the Middle Eel River Watershed (HUC – 05120104).

Approximate cost: $5-10M

Continue implementation of BMPs that will be identified in additional watershed management plans.

Continue water monitoring in the Middle Eel River to determine effectiveness of BMPs. Approx. cost: $50,000 annually

Problem Statement: There are very high levels of Total Suspended Solids (TSS) within the Watershed.

Goal 3: Reduce total suspended sediment (TSS) in the Middle Eel River Watershed. Short Term Goals: 1-3 years					
Goal/Objective	**Action Item**	**Responsibility**	**Schedule**	**Indicators of Success**	**Cost Estimate**
Reduce total suspended sediment in tributaries and mainstem	Develop and implement a cost-share program to assist with implementation of best management practices that reduce TSS.	**Watershed Coordinator**	Complete development of cost-share program for approval by IDEM by December 31, 2010	Cost-share program approval by IDEM	$60,000
	Implement BMPs targeted to reduce TSS such as cover crops, conservation tillage, filter strips, grassed waterways, pasture and hay planting and critical area planting.	**NRCS, SWCDs**	Contacts and agreements in by 2011, implementation of BMPs by December 31, 2012	Enter into agreements with 15 land owners to install BMPS targeting TSS	$212,000(Cost-Share Funds from current 319.)
Foster interest in and educate the public on the damage TSS can do to stream ecosystem health.	Encourage BMP's through educational events targeting the agricultural community, focusing on suspended sediment.	**Watershed Coordinator, NRCS, SWCDs**	Hold 3 field days targeting the agricultural community and BMPS that reduce TSS.	Number of field days and number of participants	$750.00 Annually
	Hold public meetings to share water monitoring results with the public and progress in terms of BMPs installed or scheduled.	**Watershed Coordinator**	Continue water monitoring as outlined in the QAPP Annual meeting to educate and inform the public 2011 & 2012	Demonstrate downward trend of TSS in the testing tributaries and mainstem Number of people attending the annual meeting	$50,000.00 Annually $200.00 Annually

Goal #3: Reduce Total Suspended Solids in the critical areas (priority and secondary)(Figure 5-1).

Short Term Goal: 1-3 years

Document downward trend in TSS in critical areas (priority and secondary) (Figure 5-1).

Intermediate goal: 3-15 years

Reduce TSS to maximum 50 mg/L in the critical areas (Figure 5-1).

Action:

Continue implementation of BMPs throughout the watershed by partnering with the Mississippi River Basin Initiative ($2.9M)

Develop watershed management plans to include the entire Eel River Watershed (See page 3-54) (HUC - 05120104). Approx cost: $3M

Continue water monitoring in the Middle Eel River to determine effectiveness of BMPs. Approx. cost: $50,000 annually

Long Term Goal: 15-30 years

Reduce TSS to maximum of 25 mg/L of Total Suspended Solids in the water leaving the Middle Eel River Watershed.

Action:

Implementation of watershed management plans upstream of the Middle Eel River Watershed (HUC – 05120104).

Approximate cost: $5-10M

Continue implementation of BMPs that will be identified in additional watershed management plans.

Continue water monitoring in the Middle Eel River to determine effectiveness of BMPs. Approx. cost: $50,000 annually

Problem Statement: There are impaired biotic communities and degraded habitat in the watershed.

Goal 4: Improve biotic habitat and fish communities in the Middle Eel River Watershed.
Short Term Goals: 1-3 Years

Goal/Objective	Action Item	Responsibility	Schedule	Indicator of Success	Cost Estimate
Improve biotic habitat and fish communities in tributaries and the mainstem	Develop and implement a cost-share program to assist with implementation of best management practices that improve biotic habitat and fish communities.	**Watershed Coordinator**	Complete development of cost-share program for approval by IDEM by December 31, 2010	Cost-share program approval by IDEM	$60,000
	Implement BMPs targeted to improve the biotic habitat and fish communities such as cover crops, conservation tillage, filter strips, grassed waterways, pasture and hay planting, critical area planting, nutrient management, stream buffers, prescribed grazing, and livestock exclusion from waterways	**NRCS, SWCDs**	Contacts and agreements in by 2011, implementation of BMPs by December 31, 2012	Enter into agreements with 5 land owners to install BMPS targeting improved biotic habitat	$212,000(Cost-Share Funds from current 319.)
	Encourage BMP's through educational events targeting the agricultural and urban community, focusing impaired biotic communities and habitat availability	**Watershed Coordinator, NRCS, SWCDs**	Hold 3 field days targeting the agricultural community and BMPS that improve biotic community and/or habitat by Dec. 31, 2012.	Number of field days and number of participants	$750.00 Annually
	Hold public meetings to share water monitoring results with the public and progress in terms of BMPs installed or scheduled.	**Watershed Coordinator**	Continue water monitoring as outlined in the QAPP Annual meeting to educate and inform the public 2011 & 2012	Demonstrate improved biotic community and habitat through QHEI and IBI scores in the critical subwatersheds. Number of meetings and participants attending the annual meeting	$35,000.00 Annually $200.00 Annually

Goal #4: Improve biotic habitat and fish communities in the tributaries and mainstem.

Sort Term Goals: 1-3 years

Document upward trend in IBI and QHEI scores in critical areas (priority and secondary) (Figure 5-1).

Intermediate Goal: 3-15 years

Improve IBI scores to the good category (range of 48-52) and QHEI scores to 55 in critical areas (Figure 5-1).

Action:

Continue implementation of BMPs throughout the watershed by partnering with the Mississippi River Basin Initiative ($2.9M)

Develop watershed management plans to include the entire Eel River Watershed (See page 3-54) (HUC - 05120104). Approx cost: $3M

Continue water monitoring in the Middle Eel River to determine effectiveness of BMPs. Approx. cost: $50,000 annually

Long Term Goal: 15-30 years

Attain IBI scores in the good to excellent category: total IBI score within the range of 48-60

Attain QHEI scores in the range providing suitable habitat for warm water aquatic life: total QHEI score within the range of 60 to 100

Action:

Implementation of watershed management plans upstream of the Middle Eel River Watershed (HUC – 05120104).

Approximate cost: $5-10M

Continue implementation of BMPs that will be identified in additional watershed management plans.

Continue water monitoring in the Middle Eel River to determine effectiveness of BMPs. Approx. cost: $50,000 annually

Problem Statement: There is a lack of public awareness of the impact of nonpoint source pollution and the watershed concept.

Goal 5: Increase public awareness of impacts of nonpoint source pollution and the watershed concept. Short Term Goals: 1-3 years					
Goal/Objective	**Action Item**	**Responsibility**	**Schedule**	**Indicators of Success**	**Cost Estimate**
Increase the public's understanding of nonpoint source pollution and the watershed concept.	Hold public meetings to educate the public	**Watershed Coordinator**	Annual meeting to educate and inform the public 2011 & 2012	Number of people attending the annual meeting	$200.00 Annually
	Create brochures to handout at fairs and various other locations	**Watershed Coordinator**	Create two new brochures for distribution by December 31, 2012	Brochures finished and distributed	Approx $200.00
	Update and maintain education opportunities at the North Manchester Center for History and the Stockdale Mill.	**Watershed Coordinator**	Maintain educational outreach materials through Dec. 31, 2012	Presence of displays	N/A
	Bi-annual newsletter	**Watershed Coordinator**	Create 2 newsletters annually	Number of newsletters published	Approx $200.00
	Website updates and management	**Watershed Coordinator**	Maintain website through Dec. 31, 2012	Website availability	N/A

Goal #5: Increase public awareness of the impacts nonpoint source pollution and the watershed concept.

Short Term Goal: 1-3 years

Educate landowners within the watershed about nonpoint source water quality concerns and solutions through newsletters, public meetings and outreach events.

A copy of the Watershed Management Plan will be sent to the County Commissioners and Planning Commissions in Wabash, Miami and Kosciusko counties.

A copy of the Watershed Management Plan will be sent to all libraries in Wabash, Miami and Kosciusko counties.

Intermediate Goal: 3-15 years

Educate landowners throughout the entire Eel River Watershed (HUC - 05120104) about nonpoint source water quality concerns and solutions through newsletters, public meetings and outreach events.

Action:

Continue implementation of BMPs throughout the watershed by partnering with the Mississippi River Basin Initiative ($2.9M)

Develop watershed management plans to include the entire Eel River Watershed (HUC - 05120104). Approx cost: $3M

Continue education and outreach at the same level as the short term goals.

Long term goals: 15-30 years

Educate landowners throughout the entire Eel River Watershed (HUC - 05120104) about nonpoint source water quality concerns and solutions through newsletters, public meetings and outreach events.

Action:

Implementation of watershed management plans upstream of the Middle Eel River Watershed (HUC – 05120104).

Approximate cost: $5-10M

Continue implementation of BMPs that will be identified in additional watershed management plans.

Continue water monitoring in the Middle Eel River to determine effectiveness of BMPs. Approx. cost: $50,000 annually

Continue education and outreach at the same level as the short term goals.

6.4 Estimated Load Reductions necessary to meet goals and BMP estimated effeciencies.

Data was analyzed for the Middle Eel River Watershed by determining the actual average loading per day (lbs/day/year) and comparing that to the average loading that would occur at the targets chosen for the Watershed Management Plan, this varies by parameter. The target, in mg/L, was inserted in place of the actual water monitoring data to determine loading at the target; TSS is calculated in tons/day/year. The result is the load reduction necessary to reach the target. **The Mexico Gage Station, which is the last monitoring location before the Eel River leaves the Middle Eel River Watershed, was used because it includes the accumulation of pollutants from the entire Watershed.**

The Steering Committee determined BMPs eligible for the Cost-Share Program that focus on reducing TSS, nitrates, phosphorus, and *E. coli*, with additional points granted for a systems approach that would include a combination of cover crops, low or no-till, and precision application of nutrients.

The estimated pollutant load reduction for Streambank Stabilization and Fencing, Filter Strips, Reduced Tillage and Waste Management BMPs are displayed in Table 6-9 through 6-14. Load reductions for all of the BMPs chosen by the Steering Committee are not available. Estimated load reductions were calculated using the Spreadsheet Tool for Estimating Pollutant Load.

> "STEPL**Spreadsheet Tool for Estimating Pollutant Load** (STEPL) employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs).STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It computes watershed surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies." (U.S. Environmental Protection Agency - STEPL - Spreadsheet Tool for Estimating Pollutant Load Region 5 Load Estimation Model).

STEPL does not provide modeling for all BMPs chosen by the Steering Committee.

Cover Crop efficiencies were calculated using the USEPA Region 5 Model for load reductions.

> "Region 5 Model is an Excel workbook that provides a gross estimate of sediment and nutrient load reductions from the implementation of agricultural and urban BMPs. The algorithms for non-urban BMPs are based on the "Pollutants controlled: Calculation and documentation for Section 319 watersheds training manual" (Michigan Department of Environmental Quality, June 1999)" (U.S. Environmental Protection Agency - STEPL - Spreadsheet Tool for Estimating Pollutant Load Region 5 Load Estimation Model).

It is very important to understand that these are only estimates for BMP effectiveness and that the results will vary by field within the watershed. However by combining several BMPs within the watershed an increase in effectiveness will be realized. The actual number and types of BMPs implemented and associated removal efficiencies and costs will depend upon several factors including site specific conditions, identification of willing land owners and available resources.

Load reduction calculations for BMPs other than those listed in Tables6-9 through 6-14 are not available using the Region 5 Model or STEPL, however, it is known that all of the BMPs chosen for this Watershed Management Plan target nonpoint sources of nutrients, sediment and/or *E. coli*. For instance using precision nutrient application would potentially reduce *E. coli*, nitrogen, and total phosphorus run-off by 100% on any field it was applied to, however load reductions are not available using the models for this practice.

As stated previously in this plan (Page 3-54), the Middle Eel River is receiving water from the upper reaches of the Eel River Watershed high in nutrients, E. coli and TSS. In order to meet the goals of this plan, it will be necessary to combine BMPs and to expand this project to the upper reaches of the Eel River Watershed.

Table 6-9. Middle Eel River Watershed Nitrate 2010 Loads and reductions necessary to reach intermediate and long-term goals at the Mexico Gage Station.

Middle Eel River Subwatershed at Mexico 169,480 Acres	Actual Nitrate 2010 Average Load	Intermediate Average Target Load at 1.266 mg/L	Load Reduction to meet Intermediate Goal	Long-Term Average Target Load at 0.633 mg/L	Load Reduction to meet long-term goal from Intermediate Goal
Daily Load Lbs/Day	18,082	5,133	12,949	2,567	2,566
Annual Load Lbs/Year	6,599,930	1,873,545	4,726,385	936,955	936,590

Table 6-10. Middle Eel River Watershed Nitrate load reductions estimated for Best Management Practices applied to a one acre area in the Middle Eel River Watershed.

Best Management Practice	Estimated Nitrogen Load Reduction	Nitrate Lbs/year reduction when applying to a one acre area within the watershed	Estimated acres to reach Nitrate Intermediate Goal of 1.266 mg/L	Estimated acres to reach Nitrate long-term Goal of 0.633 mg/L from Intermediate Goal
Filter Strip	70%	12.2	387,408	76,770
Reduced Tillage	55%	12.6	375,122	74,332
Streambank Stabilization	75%	13.7	344,992	68,364
Waste Management	80-100%	967	4,888	968
Cover Crop	n/a	200	23,632	4,683
Cover Crop with Filter Strip	n/a	427	11,069	2,193

Table 6-11. Middle Eel River Watershed Total Phosphorus 2010 Loads and reductions necessary to reach intermediate and long-term goals at the Mexico Gage Station.

Middle Eel River Subwatershed at Mexico 169,480 Acres	Actual Total Phosphorus 2010 Average Load	Intermediate Average Target Load at 0.152 mg/L	Load Reduction to meet Intermediate Goal	Long-Term Average Target Load at 0.076 mg/L	Load Reduction to meet long-term goal
Daily Load Lbs/Day	4,278	616	3,662	308	3,970
Annual Load Lbs/Year	1,561,470	224,840	1,336,630	112,420	1,449,050

Table 6-12. Middle Eel River Watershed Total Phosphorus load reductions estimated for Best Management Practices applied to a one acre area in the Middle Eel River Watershed.

Best Management Practice	Estimated Total Phosphorus Load Reduction	Total Phosphorus Lbs/year reduction when applying to a one acre area within the watershed	Estimated acres to reach Total Phosphorus Intermediate Goal of 0.152 mg/L	Estimated acres to reach Total Phosphorus long-term Goal of 0.076 mg/L from Intermediate Goal
Filter Strip	75%	3.7	361,251	30,384
Reduced Tillage	45%	4.0	334,157	28,105
Streambank Stabilization	75%	4.1	326,007	27,419
Waste Management	90%	339.4	3,938	331
Cover Crop	n/a	100	13,366	1,124
Cover Crop with Filter Strip	n/a	214	6,246	525

Table 6-13. Middle Eel River Watershed TSS 2010 Loads and reductions necessary to reach intermediate and long-term goals at the Mexico Gage Station.

Middle Eel River Subwatershed at Mexico 169,480 Acres	Actual TSS 2010 Average Load	Intermediate Average Target Load at 50 mg/L	Load Reduction to meet Intermediate Goal	Long-Term Average Target Load at 25 mg/L	Load Reduction to meet long-term goal
Daily Load Tons/Day	241	101	140	51	190
Annual Load Tons/Year	87,965	36,865	51,100	18,615	69,350

Table 6-14. Middle Eel River Watershed TSS load reductions estimated for Best Management Practices applied to a one acre area in the Middle Eel River Watershed.

Best Management Practice	Estimated TSS Load Reduction	TSS Tons/year reduction when applying to a one acre area within the watershed	Estimated acres to reach TSS Intermediate Goal of 50 mg/L	Estimated acres to reach TSS long-term Goal of 25 mg/L from Intermediate Goal
Filter Strip	65%	2.6	19,654	7,019
Reduced Tillage	75%	3.0	17,033	6,083
Streambank Stabilization	75%	3.0	17,033	6,083
Waste Management	0%	0	n/a	n/a
Cover Crop	n/a	85	601	215
Cover Crop with Filter Strip	n/a	177	289	103

6.5 Best Management Practices chosen by the Steering Committee for Cost-Share Program

In order to meet the above mentioned reductions in nutrients, sediment, and *E. coli* the best management practices (BMPs) listed in Figure 6-1 have been chosen by the Steering Committee to be included in the Cost-Share Program. Cost-share participants will be encouraged to use a systems approach which is anticipated to provide the most significant decreases in the parameters of concern.

Practice Code	Conservation Practice	Target Pollutant	Unit	Ave. Cost per Unit	75% Cost-Share
472	Access Control	*E. coli*, nutrients	Ac.	75.00	56.25
316	Animal Mortality Facility	*E. coli*	Animal Unit	1013.00	760.00-Cap $22,000.00
342	Critical Area Planting	Sediment	Ac.	862.00	646.50
340	Cover Crops	Sediment, nutrients	Ac.	41.33	31.00
	Equipment Modification (Conservation Tillage, Cover Crops, and /or Precision Nutrient Application)	Sediment, *E. coli*, nutrients	No.		Cap $10,000.00
382	Fence	*E. coli*, nutrients	Ft.	1.00	.75
393	Filter Strip	Sediment, nutrients	Ac.	150.00	112.50
410	Grade Stabilization Structure	Sediment	No.	4,455.00	3,341.25
412	Grassed Waterway (with Erosion Control Blanket)	Sediment, nutrients	Ac.	8,400.00	6,300.00
561	Heavy Use Area Protection	Sediment	Sq. Ft.	1.00	0.75
468	Lined Waterway Outlet	Sediment, nutrients	Ft.	43.00	32.25
590	Nutrient Management	Nutrients	Ac.	22.00	16.50
582	Open Channel (2-Stage Ditch)	Sediment, nutrients	Ft.	21.33	16.00
512	Pasture & Hay Planting	Sediment, nutrients	Ac.	246.66	185.00
516	Pipeline	Sediment	Ft.	2.00	1.50
528	Prescribed Grazing	Sediment, nutrients	Ac.	25.00	18.75
329/345	Residue Mngt. No Till	Sediment, nutrients	Ac.	21.00	15.75
329/345	Residue Mngt. Mulch Till	Sediment, nutrients	Ac.	8.00	6.00
290	Riparian Herbaceous Cover	Sediment, nutrients	Ac.	321.00	240.75
578	Stream Crossing	*E. coli*, nutrients	No.	4,043.00	3,032.50
585	Strip Cropping	Sediment, nutrients	Ac.	4.00	3.00
587	Structure for Water Control	Nutrients	No.	1,191.00	893.25
612	Tree & Shrub Establishment	Sediment, nutrients	Ac.	523.00	392.25
620	Underground Outlet	Sediment	Ft.	5.00	3.75
313	Waste Storage Facility	*E. coli*, nutrients	Sq. Ft.	Varies	Varies
633	Waste Utilization	*E. coli*, nutrients	Ac.	42.00	31.50

638	Waste & Sediment Control Basin	Sediment, nutrients	No.	2,011.00	1,508.25
614	Watering Facility	*E. coli*, nutrients	No.	923.00	692.25
657	Wetland Restoration	Sediment, nutrients	Ac.	2,231.00	1,673.25

Figure 6-1. Best Management Practices (BMPs) chosen by the Steering Committee to address parameters of concern (nutrients, TSS an *E. coli*) within the Middle Eel River Watershed.

6.6 Monitoring Effectiveness

Progress and success of this Watershed Management Plan will be monitored through indicators. These indicators may be administrative such as the tracking of best management practices acreage, or programmatic such as the number of educational events and the number of participants attending these events. The timeline and specific indicators of success are outlined in the goals on pages 6-9 through 6-18. By monitoring these indicators it will be possible to determine the level of success of this plan. Monitoring progress can be general or very specific such as increasing the number of participants at events or through improvements observed in biological and/or chemical measurements. Maintaining a list of successful programs and tracking the number and acreage of best management practices as a result of this plan will help keep the momentum of the planning effort moving forward.

6.6.1 Goal Monitoring

For each goal, it is suggested that progress toward meeting each indicator listed on pages 6-9 through 6-18 be documented on a biannual (twice a year) basis by the Steering Committee of the Middle Eel River Watershed Initiative. Tracking the progress for each milestone will help to maintain focus on goal objectives and progress, in addition identify tasks that may need to be adjusted or modified to achieve the goal objective.

6.6.2 Plan Evaluation

The Middle Eel River Watershed Initiative Steering Committee will be responsible for the regular review and update of the Watershed Management Plan. The Plan should be evaluated on a biannual basis to document progress; assess effectiveness; modify activities; and keep implementation of the plan on schedule. The plan should be revised as needed by the Steering Committee to better meet the needs of the stakeholders and to meet water quality goals.

6.6.3 Water Monitoring

Water monitoring will be carried out according to the QAPP for the duration of the Grant period (2009-2012) by Manchester College. Additional grant funding will be requested in order to continue the water monitoring program (approximately $50,000/year) and document the effectiveness of BMPs and the Watershed Management Plan.

6.6.4 Contact Information

Questions regarding the Watershed Management Plan should be directed to:

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or

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Middle Eel River

Watershed Management Plan

APPENDICES

1/19/11

APPENDIX A

Middle Eel River Watershed Initiative – 319 Grant In-Kind Partners

Manchester College
Miami County SWCD
Wabash County SWCD
Waterborne Environmental, Inc.
Friends of Miami County's Bridges
Miami County Council
Indiana Department of Natural Resources
Wabash County Highway Department
Stockdale Mill Foundation
North Manchester Center for History
North Miami High School
Indiana Smallmouth Alliance
Wabash County Surveyor
North Manchester High School
Arrow Head Country RC & D
Tippecanoe Audubon Society
Wabash County Solid Waste District
Miller's Canoe Rental
Steve and Sandy Jarvis
Manchester College Faculty

APPENDIX B

Middle Eel River Watershed Initiative – Steering Committee Members

Ed Braun – IDNR Fish and Wildlife Division
Penny Collins – Wabash County SWCD
Kevin Cordes – Landowner/Farmer
Jim Dale – Landoowner/Farmer
Morris Day – Landowner/Farmer
Rick Duff – Miami County NRCS
Rod Edgell – IDNR Fish and Wildlife Division
Troy Hattery – Miami County SWCD
Robert Hettmansperger – Wabash County SWCD
Dave Kreps – Manchester College Faculty
Terri Michaelis – Watershed Coordinator
Jon Reese – Landowner/Farmer
Sam St. Clair – Koskiusko County NRCS
Jan Stout – Miami County SWCD
Jerry Sweeten – Manchester College Faculty
Joe Updike – Wabash County NRCS
Darci Zolman – Koskiusko County SWCD

Technical Sub-Committee

Jerry Sweeten – Manchester College Faculty
Dave Kreps – Manchester College Faculty
Ed Braun – IDNR – Division of Fish and Wildlide
Rod Edgell – IDNR Division of Fish and Wildlife

Education and Outreach Sub-Committee

Penny Collins – Wabash County SWCD
Jan Stout – Miami County SWCD
Jeri Kornegay – Manchester College – Director of Media and Public Relations
Melinda Sweeten – Wabash County Solid Waste District
Jabin Burnworth – North Manchester High School

APPENDIX C

Middle Eel River Watershed Initiative - List of Media Outlets Used for Press Releases

- Wabash Plain Dealer
- Peru Tribune
- Logansport Pharos Tribune
- Manchester News-Journal
- The Paper of Wabash County
- Churubusco News
- Columbia City Post & Mail
- Warsaw Times-Union (weekly North Manchester page)
- Fort Wayne Journal Gazette
- Huntington Herald-Press
- WKUZ-FM (Wabash)
- Northeast Indianan Public Radio
- Indiana's News Center (ABC Channel 21, Fort Wayne)
- WANE-TV (CBS Channel 15, Fort Wayne)
- Indiana Public Radio
- Associated Press (Indiana bureau)
- Indiana Association of Soil & Water Conservation Districts
- Indiana Audubon Society
- Indiana State Department of Agriculture
- Indiana Wildlife Federation
- National Wild Turkey Federation
- Purdue Cooperative Extension Service (ANR)
- Natural Resources Conservation Service (Indiana)
- The Nature Conservancy
- The Nature Conservancy of Indiana
- NM Chamber of Commerce
- Wabash Area Chamber of Commerce
- Wabash Carnegie Public Library

Public Meeting Notice for local media calendars

- Columbia City Post & Mail
- Fort Wayne Journal-Gazette calendar
- Peru Tribune
- Wabash Plain Dealer
- Manchester News-Journal
- Logansport Pharos Tribune
- Fort Wayne News-Sentinel calendar

APPENDIX D

Quality Assurance Project Plan

for

Middle Eel River Initiative

ARN # 9-90

Prepared by:

Jerry Sweeten
Associate Professor of Biology
Manchester College

Prepared for:

Indiana Department of Environmental Management
Office of Water Management
NPS/TMDL Section

March 2009

Approved By:

Eel River Watershed Coordinator:	______________________ Terri Michaelis	________ Date
NPS/TMDL QA Manager:	______________________ Betty Ratcliff	________ Date
NPS/TMDL Section Chief:	______________________ Andrew Pelloso	________ Date
Watershed Branch Chief:	______________________ Marylou Renshaw	________ Date

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Appendix D-2

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List of Tables

Distribution List

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North Manchester, IN 46962

Section 1: Study Description
Historical Information

Freshwater constitutes less than 2% of all water on earth yet freshwater ecosystems contain over 40% of fish species. In fact stream ecosystems are among the oldest geologic features on earth and contain a wide diversity of vertebrate and invertebrate species that have evolved to exist in these naturally dynamic systems. While there are no scientific investigations that provide insight into the flora and fauna or the temporal and spatial variability of stream systems prior to European settlement in North America, the change in land use has been well studied. For example, Indiana is composed of 23 million acres. Of this land area, presettlement Indiana was about a 20 million acre deciduous forest with the remaining acreage being streams, lakes, prairies, and wetlands. Today, Indiana has only about four million acres of forest. Of this, 75% is in the southern part of the state with the remainder in the north being fragmented woodlots dotted across an agricultural landscape (Jackson 1997). The majority of wetlands have been drained and the prairies are virtually nonexistant (Jackson 1997). These huge landscape level changes have resulted in terrestrial and aquatic ecosystem alterations that have not been well documented as a result of the lack of historical records. Research however does suggest that stream ecosystems are degraded proportionally more than terrestrial counterparts. For example Karr (1998) suggests that 34% of fishes, 75% of uniodid mussels, and 65% of crayfish are classified as rare to extinct compared to 11-14% for birds, mammals, and reptiles. This is perhaps a reflection of natural diffferences in ecosystem diversity or perhaps it is an indication that society is more disconnected from aquatic systems. It is easier and more convenient to watch and monitor birds than to watch and monitor fish or benthic macroinvertebrates. Over the recent past researchers and society in general have become more aware of the degraded nature of streams and lake ecosystems. Research has shed a great deal of light on the structure and function of these systems. While some of this is basic ecological research, there is also a significant body of knowledge regarding applied research that has attempted to connect anthropogenic disturbances and ecosystem health. This scientific approach has done a good job of shedding light on the degradation of ecosystems, but it has not been able to develop sufficient ways by which stream restoration and watershed best management practices can be effectively translated into improved water quality and improved biotic communities particularly for nonpoint sources of pollution. Stressors may be manifest at various levels of biological and chemical organization and when assessing streams it is important to have long-term data sets that analyze a variety of biological responses(Adams et. al 2002). In other words describing water quality problems has proved to be much easier than to assess stream ecosystem recovery. After decades of water quality legislation and the elimination of many significant pointsource pollution issues, particularly human and confined animal wastes, there appears to be some improvement (Gammon 1991).

While pointsource discharge is still a concern, the challenges now are focused on nonpoint source pollution, how to remediate them,and the best approach to quantify a change water quality or biotic communities. In this arena and of particular interest are excess nutrients, biological pathogens, mercury, and inorganic sediment (suspended and settled).
The Eel River watershed in northcentral Indiana is a major tributary to the upper wabash river. It spans six Counties and is the boundary between the Eastern Cornbelt Plains ecoregion to the

south and the Southern Michigan/Northern Indiana Drift Plains to the north. With a watershed area of just over 800 square miles, the Eelis about 110 miles long and originates in Allen County. The stream flows in a southwesterly direction and decends about two feet/mile and empties into the Wabash River near Logansport (Gammon 1990). The Eel has rich historical significance to both the Native Americans and the early European settlers who occupied the land in and around the Eel River watershed. To the Indians, the river served as a transportation route, and as a source of food and clean water. To the earler settlers, the river provdied transportation, a source of energy through the construction of mill dams, and as a source of food and water. In the more recent past, the river has served as a conduit for waste and some recreation. Before the construction of sewage treatment facilities in the 1970s and 80s effluent from humans and farm animals was typically dumped directly into the river. There are no scietific data regarding the impact of this era on the river. After the passage of the clean water act, all states were required to develop a list of impaired waterbodies each two years as outlined in the legislation under Sections 305(b) and 303(d). The results of this assessment published in 2008 lists 22 tributaries of the Eel River in Hydrologic Unit Codes (HUC) 05120104050 and 05120104060 and the HUCs for this study as impaired from *E. coli*, biotic communities, nutrients, (IDEM 2008). The Eel River fishes have been investigated, mostly as presences/absences, by Jordan (1890), Ulrey (1893), Gerking (1945), Aderkas (1962), Taylor (1972), Braun (1982 and 1988), and Gammon (1990). These surveys found 71 species of fishes in the river and tributaries (Braun 1982). Historically the Eel River has been well known as an outstanding smallmouth bass stream and people traveled from across the country to fish for Eel River bass. The river was even the destination for one of the first televised fishing shows produced by Gaddabout Gaddis the "flying fisherman". However in Braun (1982) conducted a survey of the Eel and documented a 97% decline in smallmouth bass. The decline of smallmouth continues to be a mystery with no conclusive evidence of what was responsible for the disappearance. It is also unclear that whatever was responsible for the disappearance of this top predator may have had catestrophic effects on nongame species of fish as well as the Uniodid mussels. During this investigation, 22 stations were sampled from Logansport to Columbia City that covered about 80 river miles (Braun 1982). From 1983 to 1986 the Department of Natural Resources released over 17,000 smallmouth bass fingerlings into the river in an effort to speed the recovery of native stocks. The results from this initiative suggests that smallmouth bass survival stocked in the spring was significantly better than smallmouth bass stocked in the fall and that the native fish recolonized the river. Since this work the Department of Natural resources has sampled the river through the 1990s as well as Jim Gammon (1990).

In 1990 Gammon surveyed each of the historic 22 sampling stations and included in his research not only presences/absences, but also he evaluated habitats and assessed the overall fish community through the use of the Index of Biotic Integrity (IBI). Gammon (1990) concluded that fish fauna resembled closely that found by Taylor in 1972. The exception was mottled sculpin (*cotus gbgairdi*), blacknose dace (*Rhinichthys atratulus*), madtom (Noturus sp.), suckermouth minnow (*Phenacobius mirabilis*), largemouth bass (*Micropterus salmoindes*) and carp (*Cyprinus carpio*). Each of these species were found in greater numbers during the 1972 survey than in 1990. It appears there was some kind of catastrophic event during the 1970s that changed the fish community structure. This event was perhaps the "defining moment" in the ecological health of the Eel River however this hypothosis is based on extrapolation of the current trends in biological data. More recently, Manchester College completed a three year study on a 1.5 mile stream reach of the Eel in the town of North Manchester. The Manchester College study documented smallmouth bass nesting locations, habitat, and nest success from 2006-2008. Data from this study strongly suggests that the year class strength for smallmouth bass is closely associated with low flow conditions during the spawning season from May-June. During wet years nesting success was significantly lower than success during dry years. This study also clearly demonstrated the influence stream habitat and fish community structure and function as measured by the Qualitative Habitat Evaluation Index (QHEI) and the Index of Biotic Integrity (IBI) near a low head dam in the study reach.

Study Goals

<u>Overall Goal:</u> Conduct a stream water quality monitoring program that will assess the middle portion of the Eel River ecosystem based on biological, chemical, and physical parameters prior to and after the implementation of best management practices as prescribed through the watershed management plan for the middle portion of the Eel River.

Goal 1: Monitor fish community structure and function as it relates to nonpoint source pollution through the use of the index of biotic integrity (IBI) at three mainstem sites and six tributaries prior to and after the implementation of best management practices as prescribed by the watershed management plan.

Goal 2: Assess stream habitat using the qualitative habitat evaluation index (QHEI) at three mainstem sites and six tributaries.

Goal 3: Quantify the presences and/or absences of freshwater mussels at three mainstem sites and six tributaries.

Goal 4: Quantify *Escherichia coli* at three mainstem sites and six tributaries prior to and after the implementation of best management practices as prescribed by the watershed management plan.

Goal 5: Evaluate spawning habitat, year class strength, and population of smallmouth bass (*Micropterus dolomeiu*) in the mainstem of the study reach.

Goal 6: Examine water chemistry including water temperature, dissolved oxygen, conductivity, total phosphorus, nitrate nitrogen, pH, and total suspended solids. These chemical constituents will be measured throughout selected rain events prior to and after the implementation of best management practices as prescribed by the watershed management plan.

Study Site

The study site includes two 11 digit hydrologic unit codes(HUC) of 05120104060 (downstream) and 05120104050 (upstream) of the Eel River in north central Indiana (figure 1). These two sub watersheds represent approximately 30 miles of the middle portion of the Eel River and about 300 square miles of the watershed. The land use within the study site is predominantly row crop agriculture with numerous concentrated animal feed operations (CAFO). Most if not all of the tributaries of this portion of the Eel have been deemed legal drains and have been significantly modified to facilitate drainage (at least in the upper portions of the streams). The riparian forest along the mainstem and the tributaries is restricted in most areas to less than 100 feet and most of the wetlands have been drained. While there are many rural dwellings scattered across the watershed, the only towns include Laketon, Roann, Denver, and Chili. These are small communities with populations of only a few hundred people, but lack adequate waste treatment of domestic sewage.

The three primary monitoring sites on the mainstem Eel River will include stream discharge gage and automatic water sampling equipment at the most upstream site, at the watershed break between the two 11 digit HUCs and one at the most downstream portion of the 30 mile reach. The upstream site is located just downstream from the town of North Manchester at river mile 49 or 85^o 48' 34.5" and 40^o 59' 45.1". The middle site is just downstream from the confluence of Pawpaw Creek at river mile 32.4 or 85o 58' 38.7" and 40^o 52' 23.9". The most downstream site is near the town of Mexico, Indiana near old U.S. 31 or river mile 18.26 or 80^o 06' 42.1" and 40^o 48' 49.4". These sites were strategically sited in order to more precisely determine the contribution nonpoint source pollution (NPS) from each sub watershed. In addition, six major tributaries were selected as sampling sites because of their major contribution to the mainstem. These six tributaries include: Beargrass Creek, Pawpaw Creek, Squirrel Creek, Otter Creek, Silver Creek, and Flower's Creek (figure 1). While money available from this grant limits the ability of this study to gage and place an automatic water samplers at each of the six tributaries, monitoring will consist of grab sample data along with biological and physical habitat data (figure 1).

Sampling Design

The sampling approach for this project is a targeted design that will focus on the assessment and quantification of the chemical, physical, and biological attrbutes of the stream reach. The procedures for each goal are well documented in the literature and are well suited to establish conditions as they presently exist and perhaps will be adequate to detct change in water quality as a result of the installation of best management practices as prescribed by the watershed management plan. The sampling design for this project will provide results that are "data rich" compared to other sampling efforts used to detect change in water quality over time.

Goal 1: Monitor fish community structure and function as it relates to nonpoint source pollution through the use of the index of biotic integrity (IBI) at three mainstem sites and six tributaries prior to and after the implementation of best management practices as prescribed by the watershed management plan.

The structure and function of fish communities has been widely used by biologists to provide and indication of stream ecosystem health. Over the recent past, the most commonly used tool is the Index of Biotic Integrity (IBI) (Karr 1981 and Simon 1995). The IBI assesses the fish community based on 12 indices that reflect fish species richness and composition, number and abundance of sensative species, trophic organization and function, reproductive guilds, abundance, and individual fish condition. Scores range from 0 (no fish present) to 60. A score of 60 represents an excellent fish community as compared to the best reference site for a particular ecoregion. Research from across the United States has clearly demonstrated the effectiveness and reliability of using the IBI as a stream monitoring tool. ThIBI will be calculated for each of the three mainstem sites and each of the six tributaries once each year over the course of the grant periord (4-years) beginning in the summer of 2009. Fish will be identified to species and scoring will be based on IBI calibration for the eastern cornbelt ecoregion (Simon 1995).

Goal 2: Assess stream habitat using the qualitative habitat evaluation index (QHEI) at three mainstem sites and six tributaries.
Stream habitat will be quantified for each of the three mainstem monitoring sites and for each of the six tributaries. Habitat scores will be based on the Qualitative Habitat Evaluation Index (QHEI) (Rankin 1989). The QHEI provides an assessment tool used widely by stream biologists to quantify the physical parameters that provide habitat for fish and benthic macroinvertebrates. Research has clearly shown positive correlations between QHEI scores and biological-base indices like the IBI (Rankin 1989). It is very important to connect land use and habitat availability or degradation. There are six variables used to calculate the QHEI and scores range from 0-100. QHEI scores greater than 60 suggest the stream reach is a suitable for warmwater habitat without use impairment. Scores of 45 to 60 may meet warmwater habitat in some circumstances, but it may show some level degradation suggests a classification as a modified warmwater habitat. A QHEI score between 32 and 45 meets modified warmwater habitat. A score of less than 32 may be suitable for modified warmwater habitat only if the watershed is greater than three square miles. Where modified warmwater habitat is not possible, the stream reach is classified as a limited resource stream (Rankin 1989 ,Cain 2008 and IDEM/ SOP 2002).

Goal 3: The presences and/or absences of freshwater mussels will be documented at three mainstem sites and six tributaries.
Freshwater mussels are some of the most imperiled organisms in North America. The Eel River fauna is represented by 29 species (Fisher personal communication). Of these 29 species, 24 species have been documented alive and 5 species have only been documented as weather dead shells. Within the middle Eel River, there are two federally endangered species that have been documented only as weather dead shells and one state endangered species that has been found alive only in the lower reaches of the river with only weathered dead speciemen in the upper portion of the river. Once during the 4-year study a survey of mussel species will be documented at each of the three mainstem monitoring sites and at each of the monitoring sites. A standard one hour roving survey will be used to document location of mussel species and mussel beds. These areas will be documented on GIS. Species verification will be provided by Brant Fisher, Aquatic nongame biologist for the Indiana Department of Natural Resources.

Goal 4: *Escherichia coli* will be quantified prior to and after the implementation of best management practices as prescribed by the watershed management plan.
Escherichia coli quantification is routinely used in stream water quality monitoring as an indicator of “safe conditions”. In Indiana all waters are designated for full body contact recreational use between April and October. In Indiana the water quality standard for E.coli is 125 colony forming units (CFU)/ 100 mL as a geometric mean based on not less than 5 samples equally spaced over 30-d or 235 CFU/100mL in any one sample in a 30-d period. *E. coli* will be strtegically sampled and measured once each two weeks at each of the sites as grab samples and for selected rain events from the three primary monitoring sites.

Goal 5: Evaluate spawning habitat, year class strength, and population of smallmouth bass (*Micropterus dolomeiu*) in the mainstem of the study reach.
Smallmouth bass is the top predator found in the Eel River and a very popular species of fish for fishermen. To assess the status of smallmouth bass in the middle Eel River a two kilometer section of the river upstream from the location of each of the three monitoring sites will be evaluated. Water temperature, stream velocity, water depth, nest diameter, distance from shore, distance from cover, and latitude/longitude will be documented for each nest. Number of eggs present in 10% of the nests located will be quantified. The zippin depletion method of population estimation will be used to estimate the smallmouth bass population in three one kilometer sections of the river upstream from the mainstem monitoring sites once in 2009 and once in 2011.

Goal 6: Examine water chemistry including water temperature, dissolved oxygen, conductivity, total phosphorus, nitrate nitrogen, pH, and total suspended solids. These chemical constituents will be measured throughout selected rain events prior to and after the implementation of best management practices as prescribed by the watershed management plan.
While it is well known that water chemistry is important in any water quality monitoring initiative, most often selected parameters are measured as grab samples and are taken daily, weekly, or at somewhat random intervals without knowledge of stream discharge. These data give only a small glimse into the dynamic nature of streams and may not provide a clear representation of organismal exposure or loadings of any of the constiuents being analyzed. This monitoring initiative will include three sample sites on the mainstem of the river that will be equiped with Isco automatic water samplers that will allow water samples to be taken from the river throughout storm events and multiple times daily during baseflow conditions. The sampler will be connected to a pressure transducer and a datalogger that will record continually stream discharge and water temperature. The data loggers will also be programmed to communicate with the water sampler. The sampling regime will involve six 1-Liter samples to be taken daily at baseflow condition. These samples will be analyzed daily as a composite sample by thoroughly mixing all six liters of water. From this a one liter aloquot will be taken for analysis. During storm events when the stage height increases 0.5 feet or about 100 cubic feet per second (cfs), the sampler will collect one sample of water each 6-hours. This sampling frequency will continue until the stage height returns to the median discharge. Whether the stream is at baseflow or there is a storm event, the samples will be collected daily. The samples will be taken to the laboratory at Manchester College and either preserved for analysis at a later time or analyzed immediately. This sampling design will allow quatification of exposure rates and data that can be used to calculate stream loadings. Sampling will take place from 1 May-31 June. These dates coincide well with planting times of agricutural crops and with the spawning activity of most fish.
Parameters that will be measured on-site daily include: water and air temperature (^{o}C), pH, Conductivity (microsiemens/cm), Dissolved Oxygen (mg/L), and stream dishcharge (cubic feet per second). Total Phoshporus (mg/L), Nitrate (mg/L), Total Suspended Solids (mg/L and NTU) will be taken back to the laboratory for analysis.

Study Schedule

Table 1. Study Schedule for monitoring activities.

Activity	Start Date	End Date
Goal 1: Fish Community Assessment	July/August 2009	July 2012
Goal 2: QHEI	July/August 2009,	July 2012
Goal 3: Freshwater mussel survey	July/August 2010	July/August 2010
Goal 4: *Escherichia coli* monitoring	May 2009	July 2012
Goal 5: smallmouth bass assessment	May-June 2009	June 2012
Goal 6: Water chemistry	May-June 2009	June 2012

Section 2: Study Organization and Responsibility

Key Personnel

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Project Organization

- Terri Michaelis is the watershed coordinator and is responsible to the Steering Committee.
- Jerry Sweeten is responsible for the water quality monitoring and reports to the watershed coordinator and the steering committee.
- Five Manchester College students will be hired as laboratory and field technicians. These students will report to Jerry Sweeten.

Section 3: Data Quality Indicators

Precision

All stream quaity parameters outlined in the six goals are divided by chemical, physical and biological paramters. During base-flow conditions, chemical parameters will be based on daily composite samples for three mainstem sites where six 1-liter samples will be collected daily and combined for a 1-L alliquot to be analyzed. These samples will be collected by 6712 Isco automatic water samplers. During storm events, a one liter discrete sample will be collected by the ISCO sampler each 6-h at each of the three mainstem sites. The water samples will be returned to the laboratory at Manchester College for analysis. The storm event samples will be collected daily until the stream gage height returns to the median level as determined by the USGS gage station in the town of North Manchester. For each water chemistry parameter (field and laboratory) duplicate samples or replicated readings will be taken after each ten samples or readings. The relative percent difference (RPD) will be used to calculate the precision of each not to exceed 20%. If a 20% difference is observed analysis test mentods will be reviewed and modified to bring the RPD within the stated 20%. This may require equipment to be recalibrated to the specifications provided by the manufacturer.

With two replicate samples taken, precision will be determined by calculating the Relative Percent Difference (RPD):

$$RPD = \frac{(C - C') \times 100\%}{(C + C')/2}$$

Where:
C = the larger of the two values
C' = the smaller of the two values

E.coli Testing

The filter membrane determination (SM 9222-B for *E. coli* colony forming units (CFU) will be used as described in the *Standard Methods for the Examination of Water and Wastewater*, 20th Ed and approved by Standard Methods Committee, 1997. Each batch of mTEC agar will be evaluated for consistency by inoculating test plates with known concentrations of *E. coli, and* each sampling period will include a field control involving sterile water added to one of the sample bottles.

1. Field and laboratory controls will be incorporated into the protocols.
2. All samples must be recorded in the field notebook.
3. All laboratory technicians will be required to follow "Standard Operating Procedures" listed in laboratory procedure manuals. Methods covered will include proper use of an autoclave, sample bottle preparation, field sampling, laboratory media and buffer preparation, membrane filtration techniques, data gathering, data interpretation, recording of data, and proper safety and hygiene practices in a microbiology laboratory.
4. Data will be recorded in both lab notebooks and computer spreadsheet.
5. Shaker water baths will be monitored for temperature stability.

Accuracy

All equipment will be calibrated according to manufacturer's instructions at the beginning of each field season and as necessary as determined by precision calculations. This will include the use of recommended methods, reagents, and frequencies. When possible sample blanks (deionized water) will be analyzed 5% of the time. If any data is questionable by falling outside the expected range of results, the data will be noted as questionable. The instrument(s) will subsequently be recalibrated. Please see specific procedures below.

Field Equipment:

Dissolved Oxygen meter/probe:

Hach luminescence probe and HQ40meter. Hach Method 10360 will be used to calibrate once at the beginning of each field season. New batteries will also be installed at the beginning of each field season and replaced as necessary. Duplicate readings will be made in the field every 10 readings to insure accuracy and precision.

Conductivity meter:

Hach Sension 5: Calibration will be completed in the laboratory using a known standard according to the manufactures instructions and batteries will be replaced as indicated by the meter.

Stream Discharge: Pressure Systems Series 500 pressure transducer and Campbell Scientific Data Logger will be used to calculate discharge in cubic feet per second (CFS). This equipment will be calibrated according to the specifications outlined by the manufacturer and a stream discharge rating curve will be calculated by the USGS using a hydroacoustic Doppler current profiler at each of the three sites. The ISCO water samplers will be installed with the assistance of engineers from Waterborne, Inc.

Laboratory Equipment

Hach DR 5000 UV-VIS spectrophotometer:
This spectrophotometer will be used to determined concentrations of nitrate and total phosphorus. Hach TNT plus method will be used for total phosphorus to reduce the chances for errors. The cadmium reduction method will be used for nitrate. The DR 5000 uses an internal calibration system. Spectrophotometer light source will be changed as needed.

Hach 2100 Turbidimeter:
A turbidity standards calibration kit ranging from 0.1 NTU-1,000 NTU will be used to calibrate at the beginning of each field season and the light source will be changed as needed.

Total Suspended Solids:
This parameter will be measured gravimetrically (mg/L) and recorded as NTU (above). Sterile 47 mm filters (0.45 micron) will be used. Deionized water will be used to calibrate TSS at 0. A Fisher M-220 analytical balance will be used to weigh the filters.

Standards: Standards will be used to assess the accuracy of laboratory equipment at the beginning of each field season for NTU, Nitrate, and Phosphorus. Standards accuracy will be determined by :

$$\%B = \frac{(x - T) \times 100}{T}$$

Where:
x = the mean of the results of duplicate analyses of the check standard
T = the concentration of the check standard

Biological Monitoring

Index of Biotic Integrity (IBI):
An appropriate stream reach will be sampled according to IDEM and EPA protocols for this index calculation. Electrofishing and seining will be used during periods when the water is low and clear enough to see fish clearly and to insure a valid representation of all fish species present will be sampled. Taxonomic keys will be used by trained personnel to identify species that are not readily identified in the field and all fish will be identified to species. Voucher specimen will be used as well.

Mussel Survey:
A roving survey during low flow conditions will be used to prepare a mussel species list for each of the sample sites. Taxonomic keys will be used by trained personnel to identify the mussels and Brant Fisher, Aquatic Nongame Biologist with IDNR will be used to verify identification.

Qualitative Habitat Evaluation Index (QHEI): This parameter will be conducted simultaneously by two trained personnel. Scores will be compared and averaged when or if there is disagreement. The QHEI will be conducted using procedures outlined by IDEM Office of Surface Water Quality.

E.coli testing

The filter membrane determination of *E. coli* colony forming units (CFU) will conform to protocols as described in USEPA 1603.

1. Field and laboratory controls will be incorporated into the protocols.
2. All samples must be recorded in the field notebook.
3. Each batch of mTEC agar will be evaluated for consistency by inoculating test plates with known concentrations of *E. coli.*
4. All laboratory technicians will be required to follow "Standard Operating Procedures" listed in laboratory procedure manuals. Methods covered will include proper use of an autoclave, sample bottle preparation, field sampling, laboratory media and buffer preparation, membrane filtration techniques, data gathering, data interpretation, recording of data, and proper safety and hygiene practices in a microbiology laboratory.
5. Data will be recorded in both lab notebooks and computer spreadsheet.
6. Shaker water baths will be monitored for temperature stability.

*All field and laboratory data will be entered into a laboratory notebook and then into an excel spreadsheet.

Completeness

Water chemistry and *E. coli* analysis is expected to be at least 95% completed each field season and all field data including biological data should be 100% unless the stream discharge is unusually high throughout the sampling period and would result in a safety risk to personnel.

Representativeness

Three gaged sites fitted with automatic water samplers, pressure tranducers, and data loggers will be positioned at the lower, middle and upper portions of the study reach (30 miles) (see Study Site Section). These sites are specifically located at the watershed breaks for each of the two 11digit HUCs. Stream discharge will be monitored continuously throughout the field season (May-August) and water samples will be collected daily during the months of May-June. Grab samples will be collected weekly at six tributaries. *E. coli* analysis will include biweekly samples of the sites and the three permanent monitoring sites through at least May and June as well as more frequent sampling during selected rain events. As a result of this sampling design, NPS contributions from each HUC can be calculated.

Comparability

All water chemical data will be collected using EPA approved methods through the use of equipment purchased from Hach Company, Campbell Scientific (data loggers) and Teledyne ISCO water samplers. All biological data will be collected using procedures used by IDEM and/or IDNR or EPA.

Section 4: Sampling Procedures

Table 2: Sampling procedures for three mainstem sites

Parameter	Sample Matrix	Sampling Frequency	Sampling Method	Sample Container	Sampl e Volu me	Holding Time
Total Phosphorus	**Lab**	**Daily**	**ISCO 6712 Composite and time integrated**	**polypropylen e**	**1-L**	**8-h unless preserved with acid**
Nitrate-Nitrite	**Lab**	**Daily**	**ISCO 6712 Composite and time integrated**	**polypropylen e**	**1-L**	**48-h cool at 4 C**
pH	**Lab**	**Daily**	**NA**	**NA**	**1-L**	**4-h**
Conductivity	**Field**	**Daily**	**NA**	**NA**	**NA**	
Temperature	**Field**	**Daily**	**NA**	**NA**	**NA**	
Total Suspended Solids	**Lab**	**Daily**	**Composite and time integrated Gravimetric and NTU**	**polypropylen e**	**1-L**	**7-d**
Stream Discharge	**Field**	**30-minutes**	**CFS**	**NA**	**NA**	**NA**
Dissolved Oxygen	**Field**	**Daily**	**NA**	**NA**	**NA**	**NA**
E. coli	**Lab**	**Bi-weekly**	**Composite**	**Sterile bottles**	**1-L**	**6-h**

Table 3: Sampling procedures for sites

Parameter	Sample Matrix	Sampling Frequency	Sampling Method	Sample Container	Sample Volume	Holding Time
E.coli	**Lab**	**Bi-weekly**	**Grab sample**	**sterile**	**1-L**	**6- h**
Total Phosphorus	**Lab**	**weekly**	**Grab Sample Persulfate digestion**	**polypropylene**	**1-L**	**8-h unless preserved with acid**
Nitrate-Nitrite	**Lab**	**weekly**	**Grab Sample Cadmium reduction**	**polypropylene**	**1-L**	**48-h cool at 4 C**
pH	**Lab**	**Weekly**	**NA**	**NA**	**1-L**	**4-h**
Conductivity	**Field**	**Weekly**	**NA**	**NA**	**NA**	**immediate**
Temperature	**Field**	**Weekly**	**NA**	**NA**	**NA**	**immediate**
Total Suspended Solids	**Lab**	**Weekly**	**Grab Sample Gravimetric and NTU**	**polypropylene**	**1-L**	**7-d**
Dissolved Oxygen	**Field**	**Weekly**	**NA**	**NA**	**NA**	**NA**

Table 4: Sampling procedures for biological data at three mainstem sites

Parameter	Sample Matrix	Sampling Frequency	Sampling Method	Sample Container	Sample Volume	Holding Time
IBI	**Field**	**Annually**	**EPA/IDEM**	**NA**	**NA**	**NA**
QHEI	**Field**	**Annually**	**EPA/IDEM**	**NA**	**NA**	**NA**
Mussel Survey	**Field**	**Once in 4-y**	**Roving survey IDNR**	**NA**	**NA**	**NA**

Section 5: Custody Procedures

Water samples will be collected daily from the ISCO water samplers at each of the three mainstem monitoring sites and weekly samples will be collected at each of the six tributaries. Trained personnel will place the water samplers in a crate for transportation to the laboratory at Manchester College. The samples will be analyzed either immediately or preserved with sulfuric acid and refrigerated for later analysis.

Calibration Procedures and Frequency

Please see the Accuracy Section.

Section 7: Sample Analysis Procedures

All water quality laboratory analysis will be completed using EPA approved procedures using Hach analytical equipment (table 6). Water samples will be collected daily from each of the three mainstem sites. The ISCO 6712 water samplers will be programmed to take six 1-L water samples daily at base flow conditions. These samples will be combined and for a daily composite analysis. If the stream rises 0.5 feet the samplers will collect one water sample every 4-h. These samples will be collected daily and analyzed separately to provide data that may be used to calculate mass loadings. One liter grab samples will be collected daily from each of the six tributaries. Dissolved oxygen (mg/L), temperature (^{o}C), and conductivity (µmhos/cm) will be measured daily at the three mainstem sites and weekly at the sites. Refer to Table 6 for details.

Table 5: Analytical Procedures

Parameter	Analytical Method	Performance Range or Detection Limits	Units
E.coli	USEPA 1603	1CFU/100 mL	CFU
Total Phosphorus	EPA 365.2	0.6-4.5 mg/L	mg/L
Nitrate nitrogen	SM 4500-NO3 (F)	0-30 mg/L	mg/L
pH	EPA 150.1	2-14	pH
Conductivity	EPA 120.1	0.01-19.99	(µmhos/cm)
Temperature	Hach HQ40	0.1 C^{o}	
Total Suspended Solids	SM 2540 D	0-4000 NTU	NTU and mg/L
Dissolved Oxygen	EPA 360.2	0.1-20 mg/L	mg/L
Weight/mass	Fisher M-220	0.01-220 g	g/mg

Section 8: Quality Control Procedures

All personnel will be adequately trained in:

- the use and calibration of all field and laboratory equipment.
- the application of IBI and QHEI.
- the DQIs and how to detect questionable data and what procedures to follow should it exist
- analytical procedures for each analysis
- keeping a well organized and accurate laboratory notebook
- properly entering data into Excel

Table 6: Quality Control Procedures

Quality Control Procedure	Field (Yes/No)	Laboratory (Yes/No)	Frequency
Duplicate water analysis	Yes	Yes	Every 10 readings or sample
Equipment calibration	No	Yes	At the beginning of each field season or if RPD>20%
Duplicate personnel to do QHEI	Yes	No	annually
Verify specimen identification	Yes	Yes	As needed
Blank	Yes	Yes	5%

Section 9: Data Reduction, Analysis, Review, and Reporting

Data Reduction

All data will be recorded into laboratory notebooks and later entered into an Excel spreadsheet. Data will be reviewed by Jerry Sweeten to check for any errors. Descriptive statistics and inferential statistics will be used to expose any patterns or trends that may appear in the data and all data will be compared to either previous studies in the case of biological data from IDEM and IDNR and chemical data will be compared against water quality standards. Tables and graphs will be created to facilitate the observations of patterns in the data. Data will be compared at each of the three subwatershed mainstem sites to determine what contribution of NPS is from above the study reach and from each of the two 11-digit HUCs. Data will be recorded in the appropriate units and mass loading calculations may be made. These calculations will be for nitrate, total Phosphorus, and suspended sediment. Since this is a 4-year project, data acquired prior to the implementation of best management plans as prescribed by the watershed management plan will be compared to data collected after implementation of the best management plans as prescribed by the watershed management plan. This will be in an attempt to detect any change in water quality that may result from best management practices. Results will be written in a final report (electronic and paper) and presented as oral presentations.

Data Reporting

All raw data and data analysis results generated as part of this grant project will be submitted in an electronic format with the Final Report to the IDEM Project Manager or Quality Assurance Manager. The format will be compatible with the software currently used by IDEM. PowerPoint presentations will be created using audience specific formats.

Section 10: Performance and System Audits

Faculty and student technicians will meet each week during the field season and review analytical procedures and data the collected. IDEM reserves the right to conduct external performance and/or systems audits of any component of this study.

Section 11: Preventative Maintenance

All field and laboratory equipment will be maintained through replacing batteries, lamps, pumps, or any other part necessary to the precision and accuracy of data collection. If a piece of equipment is breaks it will be replaced by the same or newer model from the same manufacturer. Preventive maintenance will occur prior to each field season or as necessary during the field season. Other than batteries, spare parts or equipment replacement can be expedited through overnight shipments.

Section 12: Data Quality Assessment
Precision

Described in Section 3. Outliers will be determined by statistical analysis and not be used in the overall data analysis. If the outliers are determined to be a result of equipment failure or personnel error, then corrective action (perhaps equipment repair or additional personnel training) will be taken immediately to alleviate the issue in the future.

Accuracy

Water Chemistry:
Should water chemistry data (field or laboratory) be determined to fall outside the "normal" expected value as a result of equipment or personnel error, it will not be used in the final analysis. Immediate action will be taken to repair or replace equipment and personnel will be retrained on procedures if necessary.

Biological Data:
Species identification will be verified by Jerry Sweeten or other experts if necessary to insure that all indices are calculated on valid data. No indices will be calculated based on student technician identification without verification from at least one professional level biologist. Relevant taxonomic keys and voucher specimen will be used. While procedures will prevent inaccurate data in this area, should accuracy goals be compromised the data will not be used in the analysis.

Completeness

The sampling strategies outlined in this study are "data rich". Having the capability to examine water samples throughout storm events, composite samples during base flow conditions, and grab samples will allow a more clear picture of how much NPS is moving down the stream as well as quantification of biotic exposure. These values will allow comparison of loadings and exposures before and after the implementation of best management practices and across years during the four years of the grant. The only reason biological data could not be collected is if it was an extremely wet year and the river remained muddy and discharge compromised the safety of personnel.

Section 13: Corrective Action

Whenever it is deemed that corrective action is needed, it will be completed as soon as possible. Corrective action may be spawned by data that are suspect. To avoid these situations preventive maintenance, adequate technician training, and equipment/reagent replacement will be monitored continuously.

Section 14: Quality Assurance Reports

Quality Assurance (QA) reports will be submitted to IDEM's Watershed Management Section every three months during the field season as part of the Quarterly Progress Report and/or Final Report.
Actions and procedures used to assess chemical, physical, and biological data in terms of its accuracy, precision and completeness
A record of equipment maintenance, calibrations, duplicate and replicate sampling.
A record of any data that was outside the RPD or appeared to be erroneous as a result of mechanical or personnel errors as well as the solutions to these problems. This discussion will also include any ways these errors might affect decision making in regards to patterns or trends in the data interpretation.

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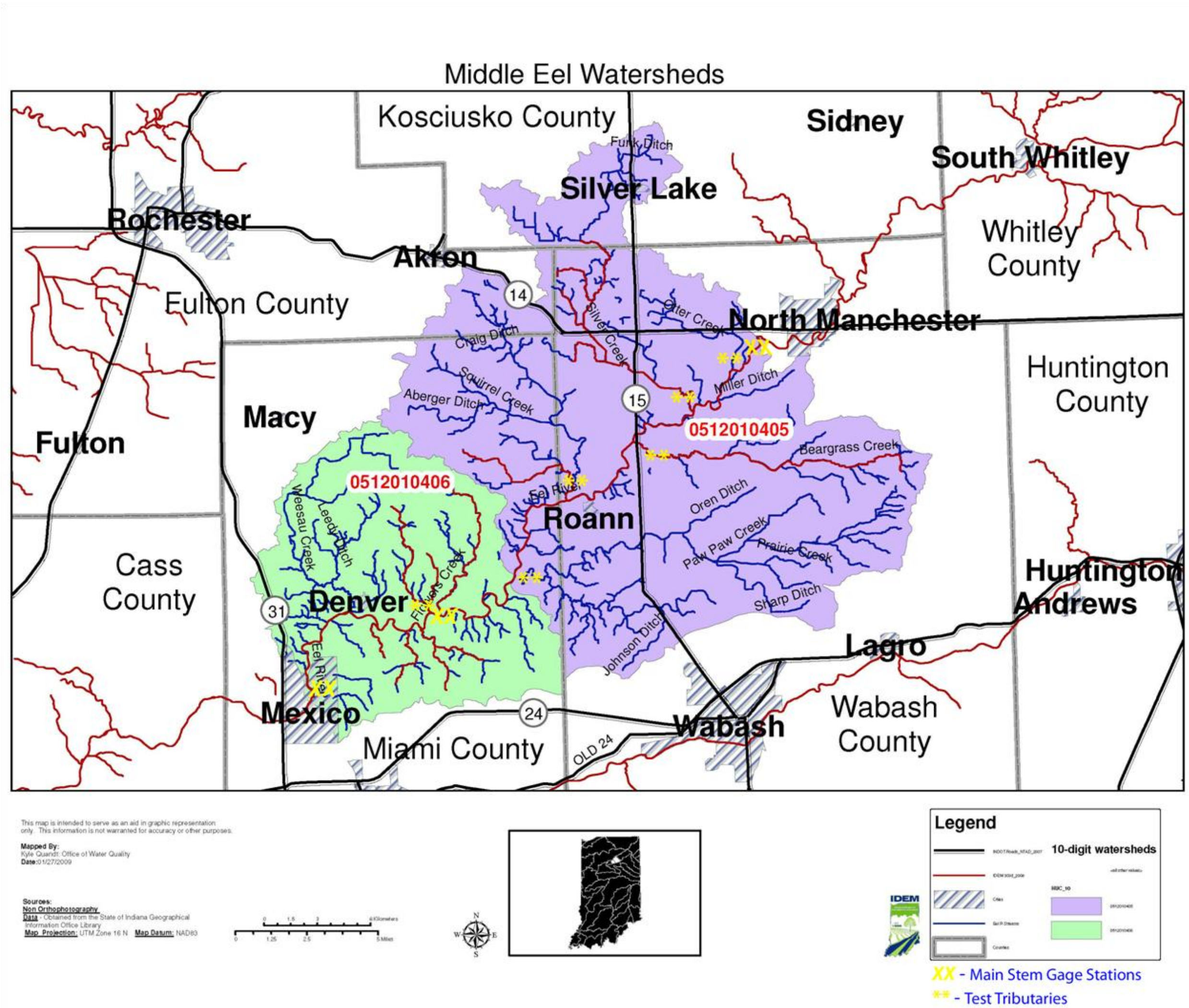
QAPP - Appendix A: Two 11-digit HUCs for the middle eel river initiative. Yellow XX indicates locations for the three permanent monitoring locations and the yellow * indicates the six tributaries that will monitored



Appendix D-27

APPENDIX E – Middle Eel River Watershed Initiative - Fish Survey 2009

2009 Number of individuals per species collected by use of a backpack Electrofisher at the Blocher Farm site (40^{o} 59’ 30.86”N and 85^{o} 48’ 30.35”W) for obtaining the IBI score

Scientific Name	Common name	Number of individual per species collected
Notropis rubellus	rosyface shiner	14
Semotilus atromaculatus	creek chub	41
Cottus bairdi	sculpin	26
Ericymba buccata	silverjaw minnow	9
Hybopsis amblops	bigeye chub	3
Etheostoma nigrum	johnny darter	7
Pimephales notatus	bluntnose minnow	4
Notropis stramineus	sand shiner	1
Ambloplites rupestris	rockbass	1
Campostoma anomalum	stoneroller	12
Etheostoma blenniodes	greenside darter	2
Lepomis macrochirus	bluegill	1
Percina maculata	blackside darter	3
	DELT	1

2009 Number of individuals per species collected by use of a boat shocker at the Blocher Farms (40^{o} 59’ 30.86”N and 85^{o} 48’ 30.35”W) for obtaining the IBI score

Scientific Name	Common name	Number of individuals per species collected
Micropterus dolomieui	smallmouth bass	7
Hypentelium nigricans	northern hogsucker	4
Catostomus commersoni	white sucker	30
Moxostoma erythrurum	golden redhorse	35
Cyprinus carpio	carp	1
Notropis spilopterus	spotfin shiner	6
Notropis photogenus	silver shiner	12
Ambloplites rupestris	rockbass	5
Nocomis micropogon	river chub	3
Luxilus chrysocephalus	striped shiner	19
Lepomis macrochirus	bluegill	4
Lepomis cyanellus	green sunfish	1
Notropis rubellus	rosyface shiner	3
	DELT	2

2009 Total number of individuals per species collected by use of both a boat shocker and a backpack Electroshocker at the Blocher Farms (40° 59' 30.86"N and 85° 48' 30.35"W) for obtaining the IBI score

Scientific Name	Common name	Number of individual per species collected
Notropis rubellus	rosyface shiner	19
Semotilus atromaculatus	creek chub	45
Cottus bairdi	sculpin	26
Ericymba buccata	silverjaw minnow	9
Hybopsis amblops	bigeye chub	3
Etheostoma nigrum	32ohnny darter	7
Pimephales notatus	bluntnose minnow	4
Notropis stramineus	sand shiner	2
Ambloplites rupestris	rockbass	6
Campostoma anomalum	stoneroller	12
Etheostoma blenniodes	greenside darter	2
Lepomis macrochirus	bluegill	4
Percina maculata	blackside darter	3
Micropterus dolomieui	smallmouth bass	7
Hypentelium nigricans	northern hogsucker	4
Moxostoma erythrurum	golden redhorse	35
Cyprinus carpio	carp	1
Notropis spilopterus	spotfin shiner	6
Luxilus chrysocephalus	striped shiner	19
Nocomis micropogon	river chub	3
Catostomus commersoni	white sucker	30
Lepomis cyanellus	green sunfish	1
Notropis photogenus	silver shiner	12
	TOTAL SPECIES = 22	TOTAL INDIVIDUALS = 260
	*DELT	3

Appendix E-3

2009 Number of individuals per species collected for use in obtaining the IBI score by use of a backpack Electrofisher slightly downstream from the convergence of Paw Paw Creek and the Eel River (40^{o} 52' 21.45" and 85^{o} 58' 49.48" W)

Scientific Name	Common name	Number of individuals per species collected
Lepomis cyanellus	green sunfish	2
Notropis rubellus	rosyface shiner	16
Notropis stramineus	sand shiner	2
Semotilus atromaculatus	creek chub	33
Notropis spilopterus	spotfin shiner	1
Ambloplites rupestris	rockbass	3
Etheostoma nigrum	33ohnny darter	4
Pimephales notatus	bluntnose minnow	5
Etheostoma blenniodes	greenside darter	1
Ericymba buccata	silverjaw minnow	1
Hybopsis amblops	bigeye chub	2
	DELT	3

2009 Number of individuals per species collected for use in obtaining the IBI score by use of a boat shocker slightly downstream from the convergence of Paw Paw Creek and the Eel River (40° 52’ 21.45” and 85° 58’ 49.48” W)

Scientific Name	Common name	Number of individuals per species collected
Moxostoma erythrurum	golden redhorse	86
Cyprinus carpio	carp	10
Carpiodes carpio	rivercarp sucker	11
Luxilus chrysocephalus	striped shiner	23
Catostomus commersoni	white sucker	11
Lepomis megalotis	longear sunfish	5
Notropis photogenus	silver shiner	16
Notropis spilopterus	spotfin shiner	5
Hypentelium nigricans	northern hogsucker	19
Nocomis micropogon	river chub	5
Ambloplites rupestris	rockbass	6
Dorosoma cepedianum	gizzard shad	1
Minytrema melanops	spotted sucker	1
Hybopsis amblops	bigeye chub	11
Notropis rubellus	rosyface shiner	23
Lepomis cyanellus	green sunfish	2
Etheostoma nigrum	34ohnny darter	1
Lepomis macrochirus	bluegill	2
Pimephales notatus	bluntnose minnow	4
Micropterus dolomieui	smallmouth bass	6
Lepomis microlophus	redear sunfish	1
Micropterus salmoides	largemouth bass	1
	DELT	4

2009 Total number of individuals per species collected for use in obtaining the IBI score by use of a boat shocker and a backpack Electroshocker slightly downstream from the convergence of Paw Paw Creek and the Eel River(40^{o} 52' 21.45" and 85^{o} 58' 49.48" W)

Scientific Name	Common name	Number of individual per species collected
Moxostoma erythrurum	golden redhorse	86
Cyprinus carpio	carp	10
Carpiodes carpio	rivercarp sucker	11
Luxilus chrysocephalus	striped shiner	23
Catostomus commersoni	white sucker	11
Lepomis megalotis	longear sunfish	5
Notropis photogenus	silver shiner	16
Notropis spilopterus	spotfin shiner	6
Hypentelium nigricans	northern hogsucker	19
Nocomis micropogon	river chub	5
Ambloplites rupestris	rockbass	9
Dorosoma cepedianum	gizzard shad	1
Minytrema melanops	spotted sucker	1
Hybopsis amblops	bigeye chub	13
Notropis rubellus	rosyface shiner	39
Lepomis cyanellus	green sunfish	4
Etheostoma nigrum	johnny darter	5
Lepomis macrochirus	bluegill	2
Pimephales notatus	bluntnose minnow	9
Micropterus dolomieui	smallmouth bass	6
Lepomis microlophus	redear sunfish	1
Micropterus salmoides	largemouth bass	1
Ericymba buccata	silverjaw minnow	1
Etheostoma blenniodes	greenside darter	1
Semotilus atromaculatus	creek chub	33
	TOTAL SPECIES = 25	TOTAL INDIVIDUALS = 318
	*DELT	7

Appendix E-6

2009 Number of individuals per species collected for use in obtaining the IBI score by use of backpack Electorshocker in Mexico, IN on the Eel River(40^{o} 48' 59.95"N and 86^{o} 06' 32.55"W)

Scientific Name	Common name	Number of individuals per species collected
Lepomis macrochirus	bluegill	10
Lepomis cyanellus	green sunfish	34
Etheostoma blenniodes	greenside darter	6
Etheostoma spectabile	orangethroat darter	5
Notropis rubellus	rosyface shiner	4
Notropis photogenus	silver shiner	2
Pimephales notatus	bluntnose minnow	75
Cottus Bairdi	sculpin	17
Semotilus atromaculatus	creek chub	20
Campostoma anomalum	stoneroller	32
Ambloplites rupestris	rockbass	5
Lepomis microlophus	redear sunfish	2
Micropterus salmoides	largemouth bass	2
Notropis stramineus	sand shiner	3
Etheostoma nigrum	36ohnny darter	6
Lepomis gibbosus	pumpkin seed	4
Hybopsis amblops	bigeye chub	2
Fundulus cingulatus	top minnow	4
Erimyzon oblongus	creek chubsucker	1
Percina maculata	blackside darter	1
Catostomus commersoni	white sucker	4
	DELT	0

2009 Number of individuals per species collected for use in obtaining the IBI score by use of a boat shocker in Mexico, IN on the Eel River(40° 48’ 59.95”N and 86° 06’ 32.55”W)

Scientific Name	Common name	Number of individuals per species collected
Moxostoma erythrurum	golden redhorse	38
Catostomus commersoni	white sucker	5
Notropis rubellus	rosyface shiner	66
Notropis photogenus	silver shiner	37
Hypentelium nigricans	northern hogsucker	40
Luxilus chrysocephalus	striped shiner	42
Notropis spilopterus	spotfin shiner	30
Lepomis macrochirus	bluegill	3
Lepomis megalotis	longear sunfish	8
Lepomis cyanellus	green sunfish	6
Hybopsis amblops	bigeye chub	14
Percina maculata	blackside darter	3
Micropterus dolomieui	smallmouth bass	24
Moxostoma valenciennesi	greater redhorse	6
Ambloplites rupestris	rockbass	2
Pimephales notatus	bluntnose minnow	15
Nocomis micropogon	river chub	8
Campostoma anomalum	stoneroller	14
Cyprinus carpio	carp	1
Carpiodes carpio	rivercarp sucker	1
Etheostoma blenniodes	greenside darter	2
Micropterus salmoides	largemouth bass	2
Ammocrypta pellucida	eastern sand darter	1
Notropis stramineus	sand shiner	5
	DELT	16

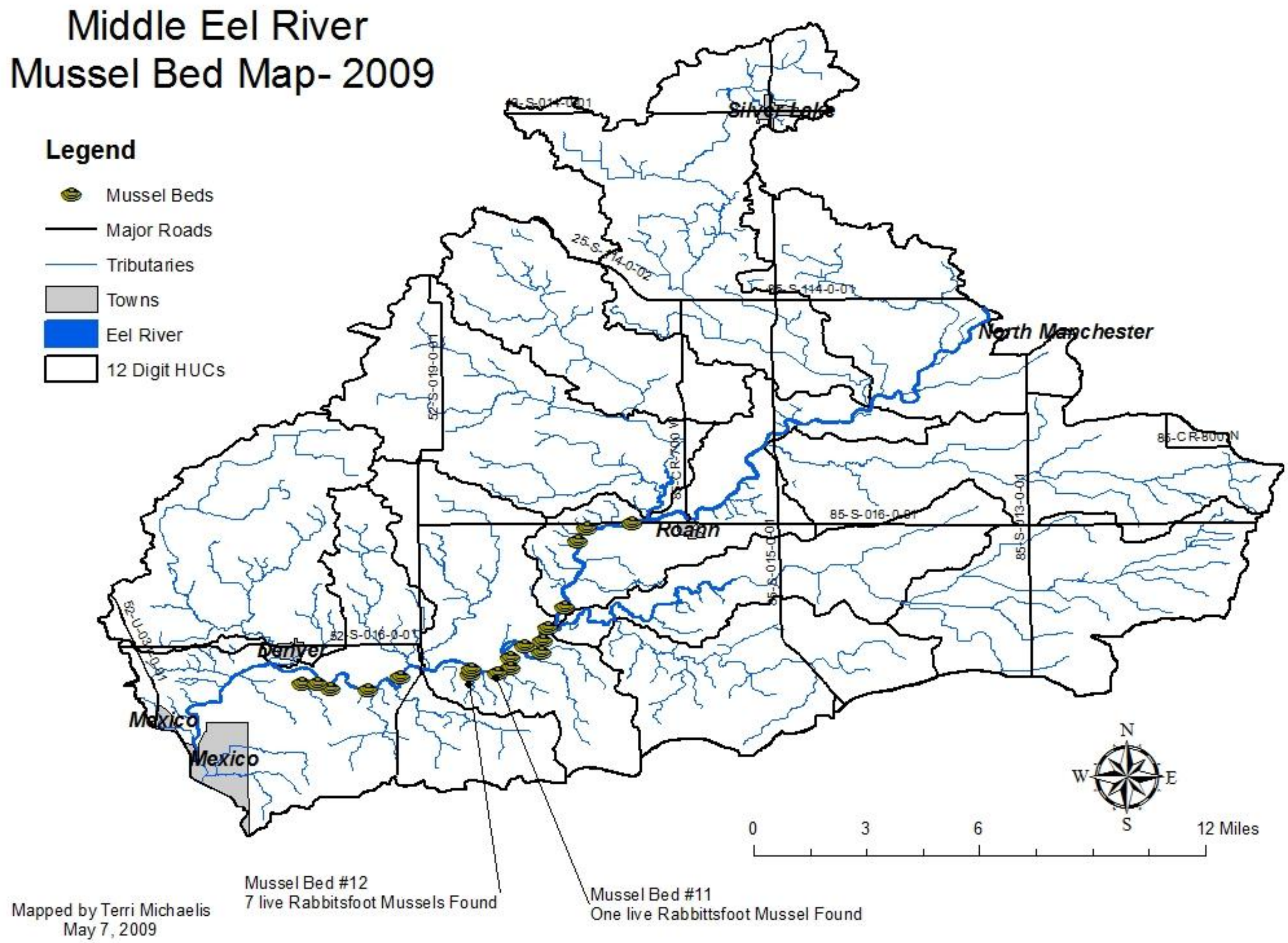
2009 Total number of individuals per species collected for use in obtaining the IBI score by use of a boat shocker and backpack Electrofisher in Mexico, IN on the Eel River (40° 48' 59.95"N and 86° 06' 32.55"W)

Scientific Name	Common name	Number of individuals per species collected
Lepomis macrochirus	bluegill	13
Lepomis cyanellus	green sunfish	40
Etheostoma blenniodes	greenside darter	8
Etheostoma spectabile	orangethroat darter	5
Notropis rubellus	rosyface shiner	70
Notropis photogenus	silver shiner	39
Pimephales notatus	bluntnose minnow	90
Cottus Bairdi	sculpin	17
Moxostoma erythrurum	golden redhorse	58
Semotilus atromaculatus	creek chub	74
Campostoma anomalum	stoneroller	46
Ambloplites rupestris	rockbass	7
Lepomis microlophus	redear sunfish	2
Micropterus salmoides	largemouth bass	4
Notropis stramineus	sand shiner	8
Etheostoma nigrum	johnny darter	6
Lepomis gibbosus	pumpkin seed	4
Hybopsis amblops	bigeye chub	16
Fundulus cingulatus	top minnow	4
Erimyzon oblongus	creek chubsucker	1
Percina maculata	blackside darter	3
Catostomus commersoni	white sucker	9
Moxostoma valenciennesi	greater redhorse	6
Hypentelium nigricans	northern hogsucker	40
Luxilus chrysocephalus	striped shiner	51
Notropis spilopterus	spotfin shiner	60
Lepomis megalotis	longear sunfish	8
Micropterus dolomieui	smallmouth bass	24

Nocomis micropogon	river chub	8
Carpiodes carpio	rivercarp sucker	1
Cyprinus carpio	carp	1
Ammocrypta pellucida	eastern sand darter	1
	TOTAL SPECIES = 32	TOTAL INDIVIDUALS = 724
	*DELT	16

APPENDIX F – Mussels Identified live in the Middle Eel River Watershed in 2009. Scientific name followed by common name.

Lampsilis siliquoidea - Fatmucket
Alasmidonta marginata - Elktoe
Amblema plicata - Three Ridge
Cyclonaias tuberculata - Purple Wartyback
Elliptio dilatata – Spike
Fusconaia flava - Wabash Pigtoe
Lampsilis cardium - Plain Pocketbook
Lasmigona costata - Fluted Shell
Corbicula fluminea - Asian Clam
Pleurobema sintoxia - Round Pigtoe
Ptychobranchus fasciolaris - Kidneyshell
Strophitus undulates - Creeper
Quadrula c. cylindrical - Rabbitsfoot



APPENDIX F-2
Mussel Beds Sampled 2009

Appendix G – IDEM Historical Water Monitoring Eel River

HUC to 14	County Name	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds	Sample Date	Alkalinity (as CaCO3) (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, Nitrate+Nitrite (mg/L)	Phosphorus, Total (mg/L)	TSS (mg/L)
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	4/3/2007 9:35	214 (fDJ)	< 0.1	3.1	0.1	32
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	5/1/2007 10:35	214	< 0.1	3.1	0.1	16
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	6/26/2007 9:45	264	< 0.1	1.6	0.1	6
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	7/10/2007 9:35	271	< 0.1	0.8	0.09	4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	8/1/2007 12:10	266	< 0.1	1.1	0.14	4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	9/10/2007 10:15	214	< 0.1	2.4	0.2	16
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	10/15/2007 10:45	296	< 0.1	0.7	0.05	< 4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	11/14/2007 9:10	201	< 0.1	5.4	0.28	15
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	12/4/2007 9:45	155	< 0.1	6.2	0.24	35
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	6/18/2008 11:00	214	0.053	4.54	0.236	60
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	7/23/2008 8:20	244	0.071	0.798	< 0.1	9.5
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	8/26/2008 11:30	270	0.023 (UJ)	1.72	< 0.1	9.5
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	7/16/2008 10:05					
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	7/23/2008 11:00					
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	7/30/2008 10:20					
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	8/6/2008 10:00					
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	8/13/2008 9:35					
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	1/14/2008 10:20	137	< 0.1	3.2	0.26	51
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	3/5/2008 9:35	97	0.4	2	0.38	59
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	4/9/2008 12:15	210	< 0.1	2.3	0.11	25
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	5/20/2008 9:40	256	< 0.1	2.8	0.1	6
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	6/17/2008 10:30	196 (Q)	< 0.1	4.4	0.32	124
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	7/22/2008 11:25	266	< 0.1	1	0.08	4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	8/20/2008 10:15	292	< 0.1	1	0.11	4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	9/17/2008 9:30	217	< 0.1	2	0.12	7
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	10/21/2008 11:15	249	< 0.1	0.6	0.06	< 4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	11/25/2008 9:30	293	< 0.1	1.5	0.05	< 4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	12/4/2008 9:25	285 (Q)	< 0.1	1.2	0.03	< 4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	2/24/2009 9:30	221	< 0.1	3.6	0.11	8
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	3/17/2009 10:45	130	< 0.1	3.1	0.21	106
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	4/14/2009 11:00	146	< 0.1	3.2	0.24	86
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	5/19/2009 10:10	186	< 0.1	3.6	0.18	42

5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	6/18/2009 11:40	249	< 0.1	2.9	0.1	13
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	7/23/2009 10:40	263	< 0.1	1.3	0.07	9
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	8/4/2009 11:00	286	< 0.1	1	0.06	< 4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	9/29/2009 9:30	306	< 0.1	1	0.09	< 4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	10/26/2009 10:00	204	< 0.1	5	0.18	21
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	11/16/2009 11:20	296	< 0.1	1.6	0.09	< 4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	12/29/2009 9:05	201	< 0.1	5.3	0.14	15
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	1/26/2010 10:45	128	< 0.1	5.8	0.29	48
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	2/8/2010 10:40	286	< 0.1	2.4	0.06	5

Appendix G – IDEM Historical Water Monitoring Eel River

HUC to 14	County Name	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds	Sample Date	Dissolved Oxygen (mg/L)	Water Temperature (C)	Saturation PerCent (%)	pH (SU)	Specific Conductance (uS/cm)	Turbidity (NTU)
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	6/18/2008	7.66	18.8	84.7	8.03	562	110
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	7/23/2008	7.71	22.46	91.4	8.06	622	8.1
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	8/26/2008	8.41	20.16	95.6	8.12	691	14.2
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	4/3/2007	9.04	12.33		8.17	592	57.8
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	5/1/2007	8.46	16.28		8.32	590	14
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	6/26/2007	3.97	21.3		7.95	713	1.8
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	7/10/2007	6.66	23.6		8.02	705	6.38
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	8/1/2007	7.8	23.25		7.15	730	5.2
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	9/10/2007	6.92	20.26		7.9	622	22.7
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	10/15/2007	9.06	13.95		8.43	765	4.29
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	11/14/2007	7.79	11.46		8.26	675	33.6
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	12/4/2007	9.8	3.69		8.02	570	81
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	1/14/2008	11	3.9		8.17	413	130
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	3/5/2008	12.86	0.65		8.19	335	85.6
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	4/9/2008	7.82	10.88		7.91	591	33.1
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	5/20/2008	8.43	13.38		7.84	636	15.6
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	6/17/2008	8.67	18.66		7.87	549	215
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	7/22/2008	7.73	22.44		8.09	715	6
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	8/20/2008	7.65	19.71		8.22	734	10
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	9/17/2008	7.75	16.52		7.97	625	11.1
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	10/21/2008	10.4	10.52		8.47	732	5.6
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	11/25/2008	13.55	2.21		8.69	771	3.2
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	12/4/2008	12.94	1.52		8.84	761	2.8
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	7/16/2008	9.15	23.56	108	8.11	720	10.9
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	7/23/2008	9.72	22.61	112.7	8.09	718	7.1
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	7/30/2008	7.53	23.94	89.2	8.05	768	15.3

5120104060040	Miami	40	49	32.47031	-86	6	48.13013	8/6/2008	6.63	22.83	77.2	7.93	734	9.5
5120104060040	Miami	40	49	32.47031	-86	6	48.13013	8/13/2008	7.63	20.51	84.9	8	778	22.8
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	2/24/2009	7.87	0.45		7.9	654	13
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	3/17/2009	5.05	8.18		8.02	419	99
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	4/14/2009	10.76	6.69		7.94	463	142
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	5/19/2009	8.61	14.05		7.91	514	48
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	6/18/2009	7.86	18.17		8.33	690	18.3
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	7/23/2009	7.42	19.44		8.15	700	7.92
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	8/4/2009	7.27	21.15		8.21	709	6.62
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	9/29/2009	8.02	13.74		8.37	703	3.8
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	10/26/2009	9.4	10.58		7.94	518	30.4
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	11/16/2009	10.29	9.16		8.35	622	4.1
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	12/29/2009	11.77	1.16		8.73	492	23
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	1/26/2010	12.58	1.57		8.87	386	81
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	2/8/2010	12.82	0.42		8.4	692	8
5120104050030	Wabash	40	56	52.52062	-85	53	26.71885	3/9/2010	11.52	6.13		8.24	601	16.6

APPENDIX H - Tippecanoe Audubon Society Breeding Bird Survey 2010.

Summary of Middle Eel River Watershed Breeding Bird Survey for June 2010					
Subwatershed:	Paw-Paw Crk	Paw-Paw Crk	Beargrass	Squirrel/	Lower Squirrel-
	Oren Ditch	Sharp Ditch	Creek	Berger Ditch	Roann
Date:	6/26/2010	6/26/2010	6/12/2010	6/5/2010	6/19/2010
Total species observed:	60	31	66	62	53
Canada Goose	X				
Mallard	X		X	X	
Blue-winged Teal				X	
Ring-necked Pheasant			X	X	
Northern Bobwhite	X		X	X	
Sora			X		
Great Blue Heron	X	X	X	X	
Green Heron				X	
Turkey Vulture	X	X	X	X	X
Sharp-shinned Hawk			X		X
Cooper's Hawk			X		
Red-tailed Hawk	X		X	X	X
American Kestrel	X	X		X	X
American Coot			X		
Killdeer	X	X	X	X	X
Rock Pigeon	X		X	X	
Mourning Dove	X	X	X	X	X
Yellow-billed Cuckoo	X			X	X
Chimney Swift			X	X	X
Ruby-throated Hummingbird	X			X	X
Belted Kingfisher	X			X	
Red-headed Woodpecker			X	X	X
Red-bellied Woodpecker	X		X	X	X
Downy Woodpecker		X	X	X	
Hairy Woodpecker	X				
Northern Flicker	X	X	X	X	X
Eastern Wood-Pewee	X	X	X	X	X
Acadian Flycatcher	X		X	X	X
Alder Flycatcher			X	X	
Willow Flycatcher			X	X	
Eastern Phoebe	X		X	X	X
Great Crested Flycatcher	X		X	X	
Eastern Kingbird	X		X	X	X
Yellow-throated Vireo	X				X
Warbling Vireo	X		X	X	

Red-eyed Vireo	X	X	X		
White-Eyed Vireo	X				X
Blue Jay	X		X		X
American Crow	X		X	X	X
Horned Lark			X		
Purple Martin		X	X		X
Tree Swallow	X	X	X	X	X
N. Rough-winged Swallow				X	X
Barn Swallow	X	X	X	X	X
Black-capped Chickadee			X	X	X
Tufted Titmouse	X	X	X	X	X
White-breasted Nuthatch	X		X	X	X
Carolina Wren	X		X	X	X
House Wren	X	X	X	X	X
Blue-gray Gnatcatcher	X		X		
Eastern Bluebird			X	X	X
Wood Thrush	X		X	X	X
American Robin	X	X	X	X	X
Gray Catbird	X	X	X	X	X
Northern Mockingbird	X			X	X
Brown Thrasher			X		X
European Starling	X	X	X	X	
Cedar Waxwing			X		
Northern Parula			X		X
Yellow Warbler	X		X	X	X
Yellow-throated Warbler	X				
Prothonotary Warbler	X				X
Common Yellowthroat		X	X	X	X
Yellow-breasted Chat	X				
Scarlet Tanager			X	X	
Eastern Towhee	X	X			
Chipping Sparrow	X	X	X	X	X
Field Sparrow	X	X	X	X	X
Vesper Sparrow			X		
Savannah Sparrow	X		X	X	
Grasshopper Sparrow				X	
Song Sparrow	X	X	X	X	X
Northern Cardinal	X	X	X	X	X
Rose-breasted Grosbeak	X				
Indigo Bunting	X	X	X	X	X
Dickcissel	X	X	X	X	X
Bobolink				X	
Red-winged Blackbird	X	X	X	X	X
Eastern Meadowlark	X	X	X	X	X
Common Grackle	X	X	X	X	X
Brown-headed Cowbird	X	X	X	X	X
Baltimore Oriole	X		X	X	X

House Finch	X		X		X
American Goldfinch	X	X	X	X	X
House Sparrow	X	X	X	X	X

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