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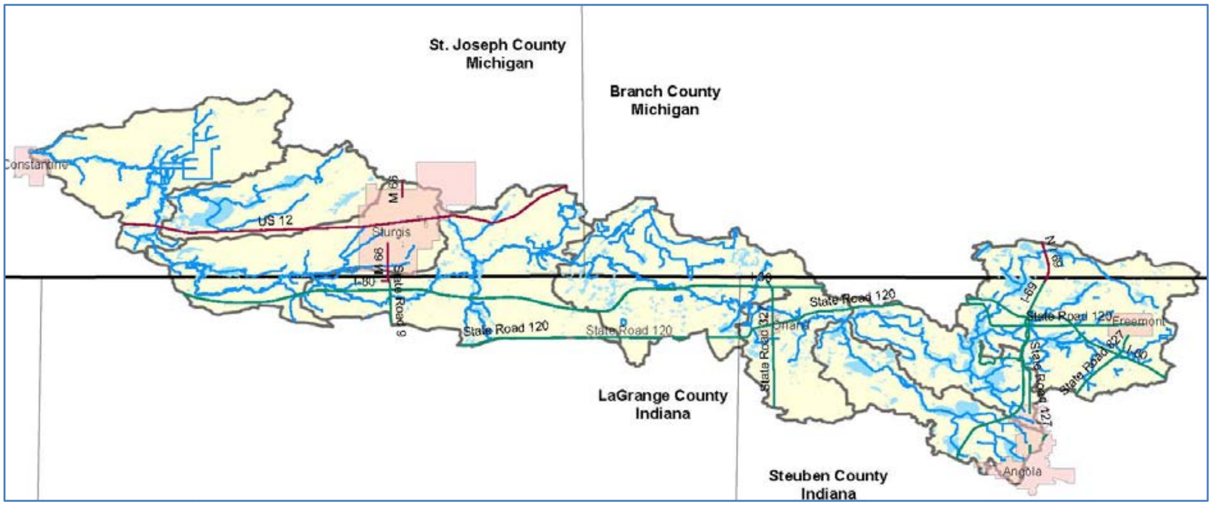

Prepared in Cooperation With:

LaGrange County Soil and Water Conservation District
910 S. Detroit Street
LaGrange, IN 46761
260-463-3471 ext. 3
www.lagrangeswcd.org

Prepared By:

SNRT, Inc
Natural Resource Associates

Principle Author: Kyle Quandt
5000 E 100 S
LaGrange, IN 46761

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Table of Contents

Table of Figures

Table of Tables

List of Acronyms

AFOs	Animal feeding operations
AU	Assessment Unit
BMPs	Best Management Practices
CAFF	Confined Animal Feeding Facility
CAFOs	Concentrated Animal Feeding Operations
CFOs	Confined Feeding Operations
cfu	Colony-Forming Unit
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DMR	Discharge Monitoring Report
DNR	Department of Natural Resources
DO	Dissolved oxygen
DRP	Dissolved Reactive Phosphorus
FRP	Fawn River Project
FCAs	Fish Consumption Advisory
HEL	Highly Erodible Land
HUC	Hydrologic Unit Codes
IDEM	Indiana Department of Environmental Management
IN	Indiana
INDOT	Indiana Department of Transportation
IR	Integrated Report
LTCP	Long Term Control Plan
LUSTs	Leaky underground storage tanks
MCL	Maximum Contaminant Level
MCM	Minimum Control Measures
MDEQ	Michigan Department of Environmental Quality
mg/L	Milligram per Liter
MGD	Million gallons per day
mIBI	Macroinvertebrate Index of Biotic Integrity
MS4	Municipal Separate Storm Sewer System
NFA	No Further Action
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resource Conservation Service
NPS	Nonpoint source pollution
NTUs	Nephelometric Turbidity Units
NWI	National Wetland Inventory
PCBs	Polychlorinated biphenyls
PHEL	Potentially Highly Erodible Land
ppb	Parts Per Billion

QAPP RC&D	Quality Assurance Project Plan Resource Conservation and Development
SWCD	Soil and Water Conservation District
SCLC	Steuben County Lakes Council
SWQMP	Storm Water Quality Management Plan
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
TP	Total Phosphorus
UDO	Unified Development Ordinance
US EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
USTs	Underground storage tanks
WHPP	Wellhead Protection Plan
WMP	Watershed Management Plan
WWTP	Waste Water Treatment Plant

1.0 Introduction

The LaGrange County Soil and Water Conservation District (SWCD) has been working with landowners and producers in LaGrange County to provide education on water quality issues and sustainable farming for the past 17 years. The relationship that has been formed between the SWCD and the farmers in the community has afforded the SWCD the ability to write comprehensive watershed management plans (WMP) for the Little Elkhart River, the Little Elkhart River Addendum, and Pigeon River and begin implementation of those WMPs with full support and help from the community. Monthly water testing in the Little Elkhart River system has shown improvements in water quality indicating that the SWCD's and local farmer's efforts to implement best management practices and improve water quality have made a difference in the watershed. It is anticipated as BMP implementation continues in the Pigeon River system, similar NPS pollution reductions will be achieved.

The success seen in previous watershed projects led the SWCD to look at surrounding watersheds to see if they could expand their efforts to include the Fawn River system. Steuben County SWCD had similar interests in this watershed resulting in a close partnership with the LaGrange County SWCD.

Agriculture is the major land usage for the entire drainage. Seed corn production is a major component along the drainage from western Steuben County, Indiana until it empties into the St. Joseph River. Other food production such as green beans, beets, and potatoes also play a significant role along the corridor. An important aspect in this type of agricultural landscape is the use of traditional practices which includes fall plowing that exposes fields to wind and sheet erosion. Evidence suggests traditional tillage practices may be having an influence on water quality in the watershed due to parts of the drainage being listed on the IDEM 303(d) list for impaired biotic communities. Big Otter Lake Inlet, Follette Creek, Walters Lake Inlet, Marsh Lake Outlet, and Green Lake Outlet are listed for impaired biotic communities in the draft 2012 Integrated Report.

Livestock operations are a growing commodity within the watershed. The Amish community is rather small along the Fawn River when compared to the Little Elkhart and Pigeon River drainages, but this community continues to grow resulting in an expansion of livestock based agriculture. Livestock related issues have been documented and are validated in water testing results with Crooked Creek, located in the Fawn River-Orland sub-watershed being listed as an impaired water body for *E.coli*.

Urban influences likely have an impact on the water quality throughout the watershed. Angola (p=8612) in Steuben County, is an Municipal Separate Storm Sewer System (MS4) city that currently affects Tamarack Lake (040500010802) and Lakes James-Crooked Creek (040500010803) sub-watersheds. It is anticipated that as the city grows north, the sub-watershed of Snow Lake (040500010801) will be included in the city's drainage area. Other urban influences include Fremont (p=2138), Howe (p=807), and Orland (p=434) in Indiana, and the majority of Sturgis, Michigan (p=10,994). The town of Constantine, Michigan (p=2076) primarily influences the St. Joseph River directly, but may contribute to the Fawn River along the northern edge of the watershed, in residential areas. In addition, the majority of lake systems within the river drainage have dense residential areas along the shorelines. These residential lake areas likely have an effect on the lake systems through use of lawn fertilizers, the increased use of seawalls rather than natural shorelines, and on lakes without centralized sewers, septic systems may be a significant problem.

After taking the above findings into consideration, both SWCDs met with several local organizations and agencies to present the above information and to collaborate on a project to write a WMP for the Fawn River watershed to develop an implementation plan to delist the impaired waterways from the IDEM 303(d) list outlined in the IDEM Integrated Report which is submitted to the US Environmental Protection Agency (EPA) every two years. A collaborative effort between the LaGrange County and Steuben County SWCDs, Branch County and St. Joseph County Conservation Districts, The Nature Conservancy, Pheasants Forever, LaGrange and Steuben County Lakes Councils, Indiana Department of Natural Resources (IN DNR), Friends of the St. Joe, the St. Joseph River Basin Commission, and many other organizations led to an application for funding to be submitted to IDEM through the CWA§319 grant program in September, 2011. The application was passed to the CWA§205(j) grant program and was approved for funding. The Fawn River Watershed project began in January, 2013.

Due to the high level of interest in all four counties it was decided to divide the area between east (Steuben and Branch Counties) and west (LaGrange and St. Joseph Counties). Steering Committees were developed for both locations which will allow a greater amount of participation in the planning process and not overwhelm meetings. This design gives every participant ample opportunity to voice their opinions. In April of 2013, steering committee meetings were held in Steuben and LaGrange Counties to kick off the project and begin listing stakeholder concerns for the Fawn River. The steering committee members were also charged with collecting additional concerns from their organizations and other concerned stakeholders. Tables 1.1 and 1.2 are lists of the two steering committee members and Table 1.3 lists current stakeholder concerns, as well as their relevance to this project.

Table 1.1: Steuben and Branch County Steering Committee Members

Name	Affiliation	Stakeholder Group
Kayleen Hart	Steuben County SWCD	Government/Conservation
Tom Green	Steuben County SWCD Supervisor	Government/ Coservation
Brian Musser	Natural Resource Conservation Service	Government/Conservation
Bill Schmidt	Steuben County Lakes Council	Lake Residents/Conservation
Eric Henion	Angola/Trine University MS4	Government/Stormwater
Anne Abernathy	Fremont Library and Fremont Parks	Government
Linda Hagerman	Lake George Conservancy	Lake Residents/Conservation
Renate Brenneke	Lake George Conservancy	Lake Residents/Conservation
Chris Snyder	Town of Fremont	Municipal Government
Beth Warner	The Nature Conservancy	Non-profit/Environment
Kathy Worst	Branch County Conservation District	Government/Conservation
Larry Gilbert	Steuben County Surveyor	Local Government
Neil Ledet	Indiana Department of Natural Resources	Environment

Table 1.2: LaGrange and St. Joseph County Steering Committee Members

Name	Affiliation	Stakeholder Group
Monroe Raber	Producer	Landowner
Neil Ledet	Indiana Department of Natural Resources	Environment
Jen Miller	St. Joseph County Conservation District	Government/Conservation
Leslie Raymer	LaGrange County Lakes Council	Lake Resident/Conservation
Rex Pranger	LaGrange County Surveyor	Government
Karen Mackowiak	St. Joseph River Basin Commission	Indiana State Government
Kevin Shide	LaGrange - Natural Resource Conservation Svc.	Government
Gary Heller	LaGrange County Commissioner	Government

Table 1.3: Stakeholder Concerns

Concerns	Relevance	Potential Problem
Livestock access to open water	It has been noted that livestock often have regular access to open water for drinking or to move between adjacent pastures	*E. coli* contamination, excess nutrients, erosion, sediment
Stormwater runoff from livestock operations	Stormwater will pick up pollutants from barnyards and pastures and carry them to open water if it is not properly contained or diverted from ditches, streams, rivers, and ponds	*E. coli* contamination, excess nutrients, and sediment
Increase in impervious surfaces	As the urban areas in the watershed expand, so does the impervious surfaces which increases stormwater runoff which can carry pollutants to open water	Oil and grease, Excess sediment, nutrients
Fertilizer used on urban lawns	As the urban centers and lakes in watershed expand so do the number of homes. Many homeowners are unaware of how to follow guidelines for lawn fertilizers and may over-apply fertilizer which has the potential to run over the land and into waterways	Excess nutrients and impaired biotic communities
Lakes in the area becoming more developed	Over fertilization of lawns around lakes in the area has been noted in the past. Also, as more homes are added the natural shoreline is often degraded, removed, or replaced with a seawall which may increase the chance for nutrients to reach open water and sediment from shoreline erosion.	Excess sediment, nutrients, impaired biotic communities, *E. coli*
Septic system discharge	Septic systems, if not properly maintained, can leak effluent into ground water or leach into surface waters. Many small lakes have concentrated residential areas still using septic systems.	Excess nutrients, sediment, *E. coli*
Lack of no-till and cover crop practices	Seed corn and other food crop field preparation does not include no-till or cover crop practices. In addition fall plowing that leave fields unprotected from erosion is a common practice throughout the drainage.	*E. coli* contamination, excess nutrients and sediments

Concerns	Relevance	Potential Problem
Wetland Conservation	Northeast Indiana has lost many of its historic wetlands which play a vital role in the ecosystem as they absorb floodwaters and pollution	Flooding, lack of wildlife and aquatic habitat, and impaired biotic communities
Stream Bank Erosion	An increase in surface runoff and stream channel modification can increase the potential for stream bank erosion	Sedimentation, turbidity, impaired biotic community
Sedimentation	Sedimentation of the surface water, especially within the Lake system is a concern expressed by stakeholders most anywhere surrounded by agricultural land. This concern has increased with the reduction of conservation tillage practices in the area over the past several years.	Sedimentation, turbidity, impaired biotic community

2.0 Physical Description of the Watershed

This Section will describe the Fawn River watershed in detail to provide a general understanding of the physical attributes of the area that led to its current landuse.

2.1 Watershed Location

A watershed is an area with defined boundaries such that all land and waterways drain into a particular point. Watersheds are given "addresses" called Hydrologic Unit Codes (HUC) that identify where they are located within the United States and into which point they drain. The largest HUC is two digits and defines a particular region. The more digits to a HUC the more specific the drainage area is. The Fawn River drainage is a 10 digit HUC (0405000108) located within the greater St. Joseph River – Lake Michigan watershed, an 8 digit HUC (04050001), shown in Figure 2. The Fawn River watershed is divided into nine, 12 digit HUCs; Snow Lake (040500010801), Tamarack Lake (040500010802), Lake James-Crooked Creek (040500010803), Town of Orland-Fawn River (040500010804), Himebaugh Drain–Fawn River (040500010805), Clear Lake-Fawn River (040500010806), Wegner Ditch-Fawn River (040500010807), Sherman Mill Creek (040500010808), and Fawn River Drain-Fawn River (040500010809). Each of the sub-watersheds will be discussed in detail in Section 3 of the WMP.

The Fawn River watershed, located in Steuben and LaGrange County, Indiana, and Branch and St. Joseph County, Michigan encompasses 165,361 acres of land including over 70 lakes. The Fawn River drainage begins in Steuben County, Indiana at Fish Lake north of the town of Fremont and flows northwest for a short distance before entering Branch County, Michigan where it encompasses several large lake systems. The drainage then turns south reentering Steuben County, Indiana where it encompasses many large and small lake systems north and northwest of the city of Angola. This portion of the river system involves the bulk of the county's largest lakes that are a significant economic base for the region. From this point the river flows west by northwest and enters LaGrange County, Indiana in the northeast corner and continues for a short distance before reentering Branch County, Michigan. The river flows west by northwest and enters St. Joseph County, Michigan southeast of the town of Sturgis where it turns southwest reentering LaGrange County, Indiana north of the town of Howe. This portion of the river encompasses many large and small lake systems in both Michigan Counties. The river flows west from Howe paralleling Interstate 80/90 to the northwest corner of LaGrange County, Indiana before turning north flowing into St. Joseph County, Michigan. The river drainage continues north encompassing several large and small lake systems before turning west where it empties into the St. Joseph River-Lake Michigan north of the town of Constantine, Michigan. The percent of the Fawn River watershed located within each of the four counties is depicted in Figure 2.1 and the Fawn River watershed is depicted in Figure 2.3.

Figure 2.1: Fawn River Watershed Percentage of Area per County

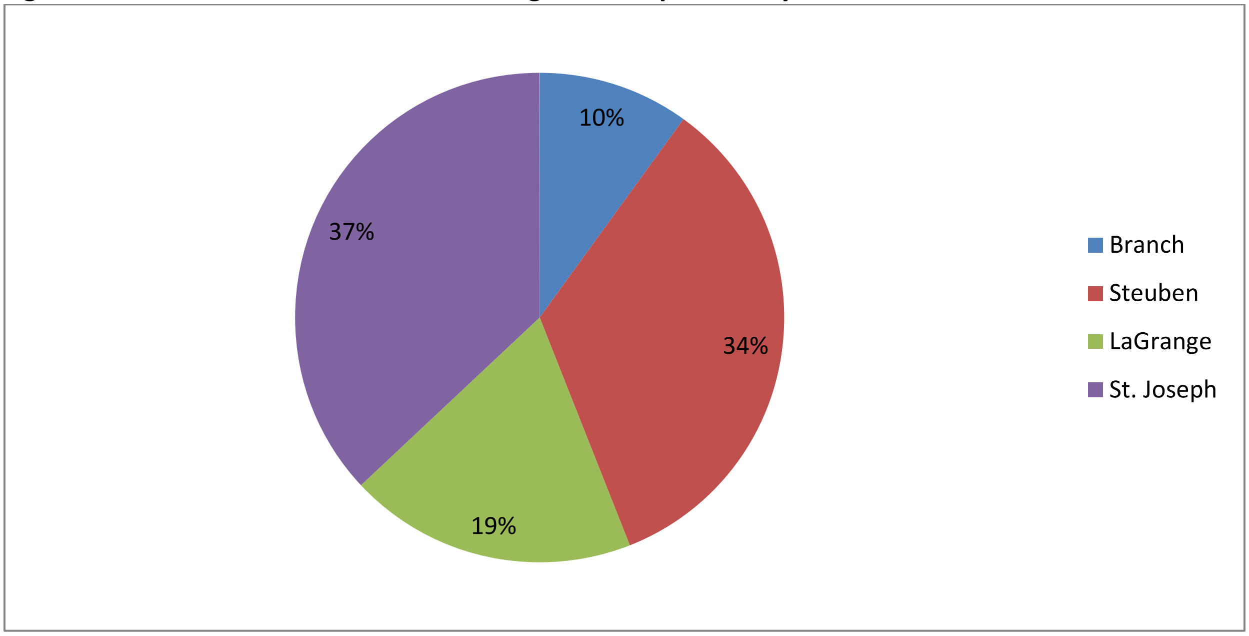


Figure 2.2: Fawn River Watershed Location

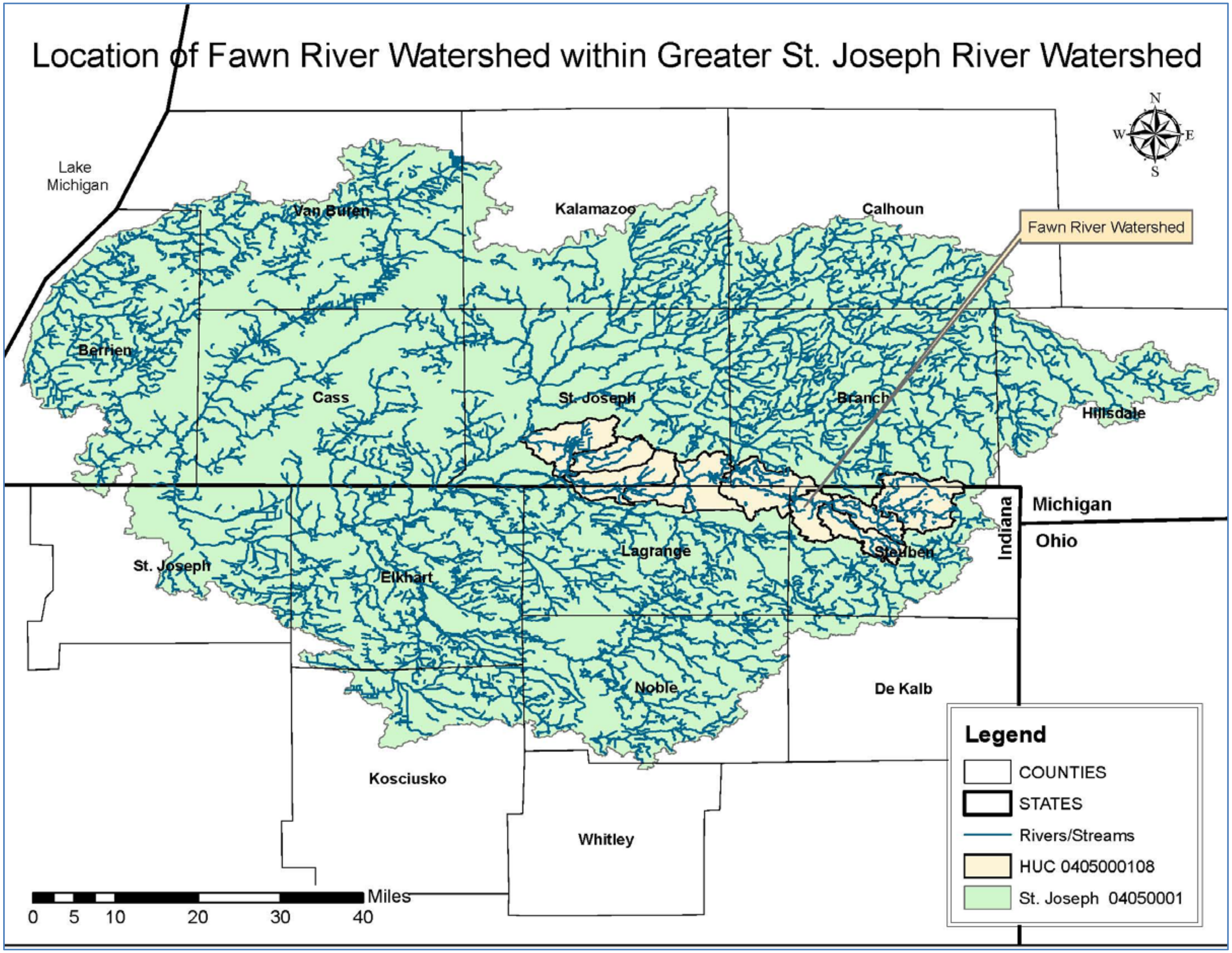
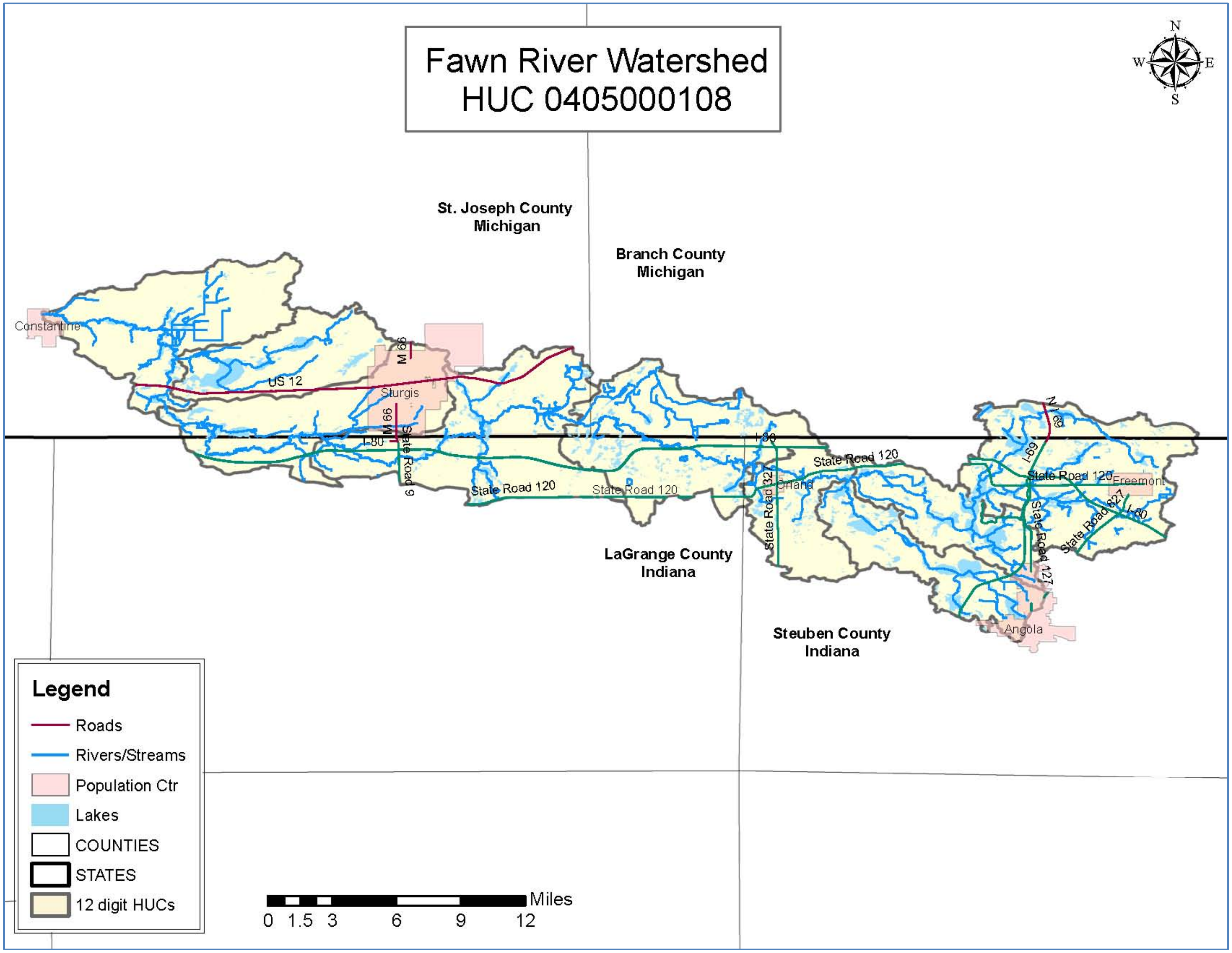


Figure 2.3: Fawn River Watershed



2.2 Geology, Topography, and Soils

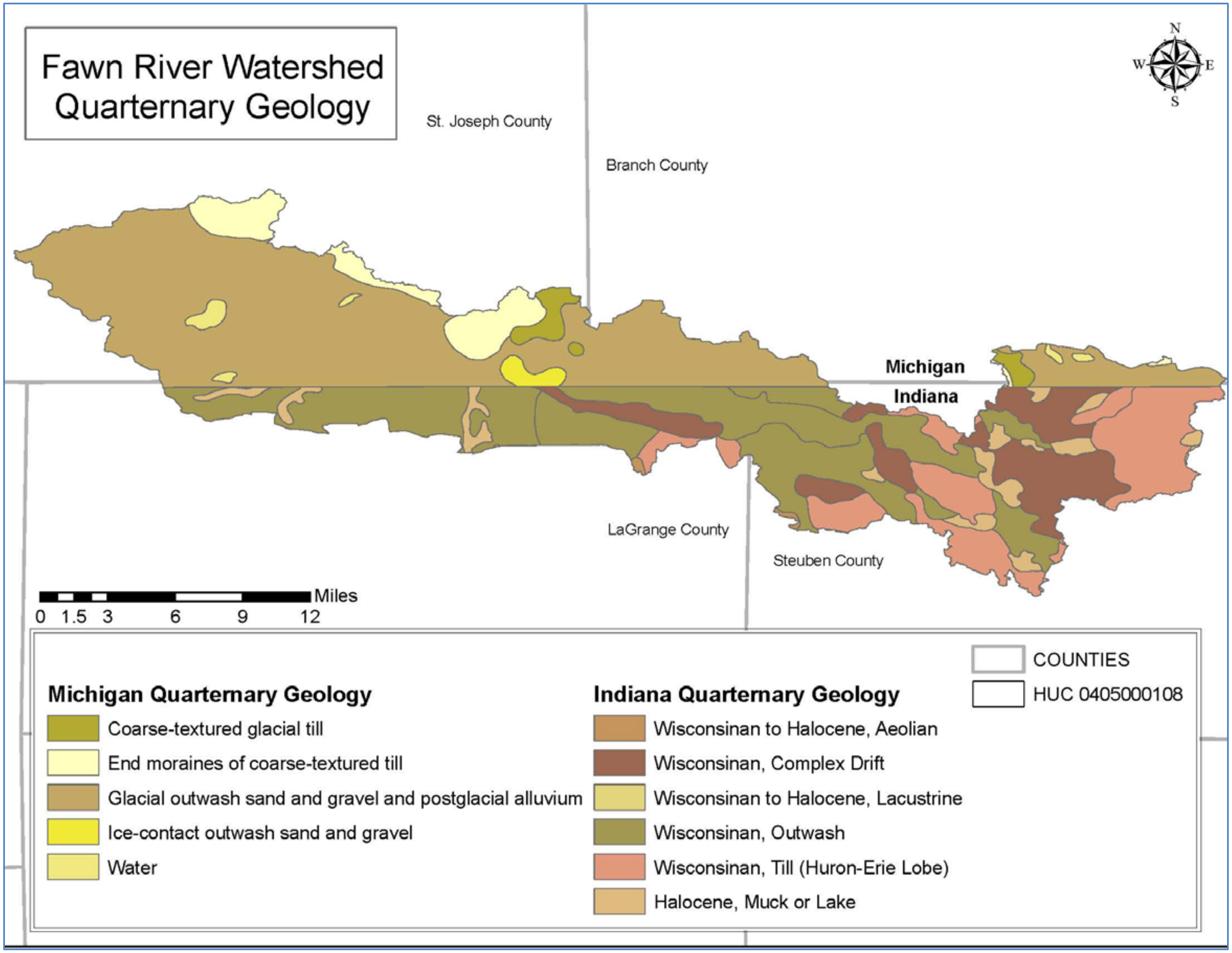
This Section describes the landscape of the area including the formation of the soils and topography present today, which makes the area a prime location for agriculture and the recreational destination it is.

2.2.1 Geology

The landscape of northern Indiana and southern Michigan is directly influenced by the last great glaciation which occurred over 10,000 years ago; the Lake Michigan Lobe of the Wisconsinan glaciation. The glaciers significantly changed the landscape of the project area, filling and damming rivers which created the present day Great Lakes. Prior to the glaciers sweeping over the land, the entire project area's landscape was comprised of rolling hills separated by broad valleys that were dominated by oak-hickory forests, and swamp and marsh lowlands. All of Indiana had the same characteristic rolling hills present in southern Indiana, as the limits of the Wisconsinan glaciation follows the line connecting Terre Haute, Edinburgh, and Richmond, Indiana. As the glaciers advanced and retreated, the massive structures flattened the land surface and wiped out whole forests. As the glaciers melted they formed the many kettle lakes that give northern Indiana and southern Michigan the nickname of "Lake Country". The melting glaciers also deposited rock, dirt and sand that they had picked up while traveling across the landscape. In the project area of northern Indiana and southern Michigan, where the glaciers melted relatively rapidly, glacial till ridges, called moraines, were left. However, the landscape is still much more level than pre-Wisconsinan times but presents a low hilly and rolling landscape.

The bedrock of the project area was deposited during the Mississippian Age, some 300 million years ago. The rocks deposited during the Mississippian Age are called the Borden Group and in the Fawn River watershed, consist primarily of shale and limestone in Indiana, and shale in Michigan. The type of bedrock present within the project area accounts for the ground water wells that supply drinking water to the population centers in the watershed including Sturgis, MI and Fremont and Angola, IN, as well as, the many wells that supply drinking water to the rural communities throughout the project area. The unconsolidated deposits, above the bedrock, are typically between 200 and 350 feet thick throughout the St. Joseph River – Lake Michigan watershed, however there are areas in extreme northeastern Steuben County with a thickness nearing 900 feet in thickness. The project area is covered in glaciofluvial material over the deeper clay deposits. The glaciofluvial material consists of mostly sand and gravel or loamy till and range in thickness from 5 to 25 feet in thickness. Figure 2.4 presents a map showing the geologic characteristics of the watershed.

Figure 2.4: Quarternary Geology of the Fawn River Watershed



2.2.2 Topography

The Fawn River watershed is located within the general physiographic province of the Central Lowlands, which can be broken down further to include the Southern Lower Peninsula Hills and Plains and Three River Lowlands physiographic regions in Michigan (Michigan State University), and the St. Joseph Drainageways and Warsaw Moraines and Drainageways in Indiana (IN DNR). The topography of the watershed is not drastically different from one end to the other with elevations ranging from 1070 feet above sea level at the headwaters to 800 feet above sea level where the Fawn outlets to the St. Joseph River. However, the landscape presents with low, rolling hills throughout the watershed with some flat plains between topographic peaks.

2.2.3 Soils

The project area is comprised of 15 general soil associations. Table 2.1 is a list of the soil associations present in the project area and a description of each association. Soil association descriptions were obtained from the Steuben, LaGrange, Branch, and St. Joseph county United States Department of Agriculture (USDA) soil surveys. The soil associations found throughout much of the Fawn River watershed are exceptionally productive soils, when properly drained and managed, which accounts for the heavy agriculture production present within the watershed. It should also be noted, that several of the soils associations in the watershed are ideal for wetlands, though many wetlands have been drained and converted to agriculture land.

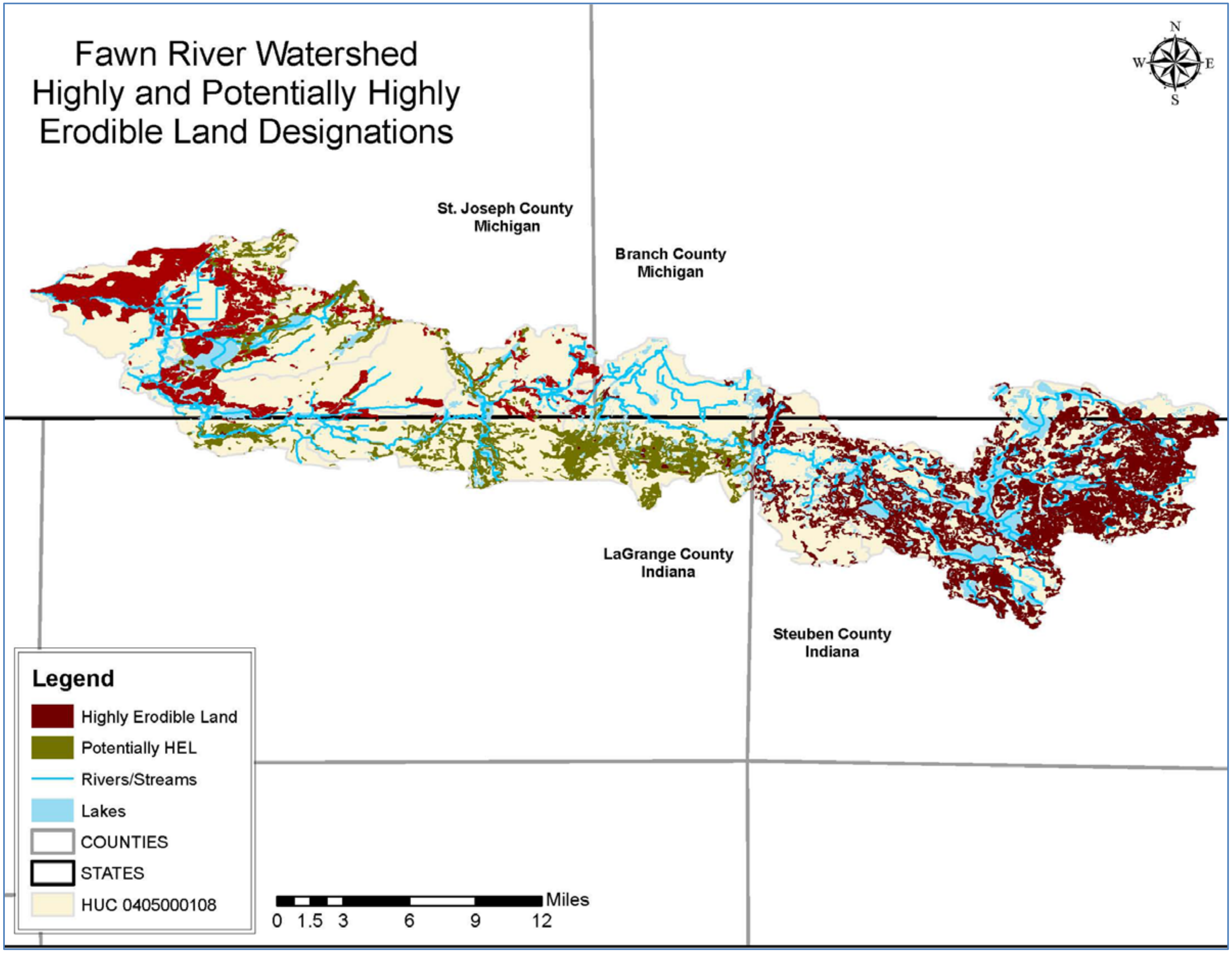
Table 2.1: General Soil Associations

County	Soil Association	Association Description
Steuben	Kosciusko-Ormas-Boyer	Nearly level to strongly sloping, well drained, loamy and sandy soils that are moderately deep or deep over sand and gravel; on outwash plains and moraines
	Riddles-Miami-Brookston	Deep, nearly level to moderately steep, well drained and very poorly drained, loamy soils on till plains
	Glynwood-Morely-Blount	Deep, nearly level to moderately steep, well drained to somewhat poorly drained, silty soils on till plains and moraines
	Houghton-Rensselaer-Milford	Deep, nearly level, very poorly drained, mucky, loamy, and silty soils in depressions on outwash plains and lake plains
LaGrange	Wawasee-Hillsdale-Conover	Nearly level to strongly sloping, well drained and somewhat poorly drained, moderately coarse textured and medium textured soils on till plains and moraines
	Boyer-Oshtemo	Nearly level to moderately steep, well drained, coarse textured soils on outwash plains, valley trains, moraines, and kames
	Shipshe-Parr	Nearly level to moderately sloping, well drained, moderately coarse textured and medium textured soils on outwash plains and till plains
	Houghton-Adrian	Nearly level, very poorly drained muck soils in depressional areas on outwash plains, till plains, and moraines

County	Soil Association	Association Description
Branch	Fox-Oshtemo-Ormas	Nearly level to moderately steep, well drained, loamy and sandy soils on outwash plains and moraines
	Fox-Houghton-Edwards	Nearly level to moderately sloping, well drained, loamy soils on outwash plains and moraines and level, very poorly drained, mucky soils in swamps, depressions, and drainageways
	Locke-Barry-Hillsdale	Level to moderately sloping, somewhat poorly drained, poorly drained, and well drained, loamy soils on till plains and moraines
St. Joseph	Adrian-Granby	Nearly level, very poorly drained and poorly drained mucky and loamy soils; in bogs and depressions and on outwash plains and lake plains
	Oshtemo-Spinks	Nearly level to gently rolling, well drained loamy and sandy soils; on outwash plains and moraines
	Hillsdale-Elmdale	Nearly level to gently rolling, well drained and moderately well drained loamy soils; on till plains and moraines
	Elston	Nearly level, well drained loamy soils; on outwash plains

The Fawn River steering committee and stakeholders expressed concern about soil erosion and sedimentation of streams, rivers, and lakes. The erosion issues present in the watershed may be due to unsustainable farming practices on land that is considered to be highly or potentially highly erodible. The Natural Resource Conservation Service (NRCS) maintains a database of highly erodible (HEL), potentially highly erodible land (PHEL), and hydric soils for each county. The soils that have been determined to be highly erodible are so designated by dividing their average rate of erosion by the soil loss tolerance, which is the maximum amount of soil loss that can occur before a long term reduction in productivity will be seen. Soils are determined potentially highly erodible based on the slope and length of the slope. The presence of HEL and PHEL in farmland can contribute significantly to nonpoint source pollution (NPS) by increasing the amount of sediment carrying other pollutants such as, nutrients and pesticides, to open water. Slightly over 26% of the soils present within the Fawn River watershed are considered to be HEL (20.17%) or PHEL (6.05%). Figure 2.5 is a map of the project area showing the location of HEL and PHEL in the watershed.

Figure 2.5: Highly and Potentially Highly Erodible Soil

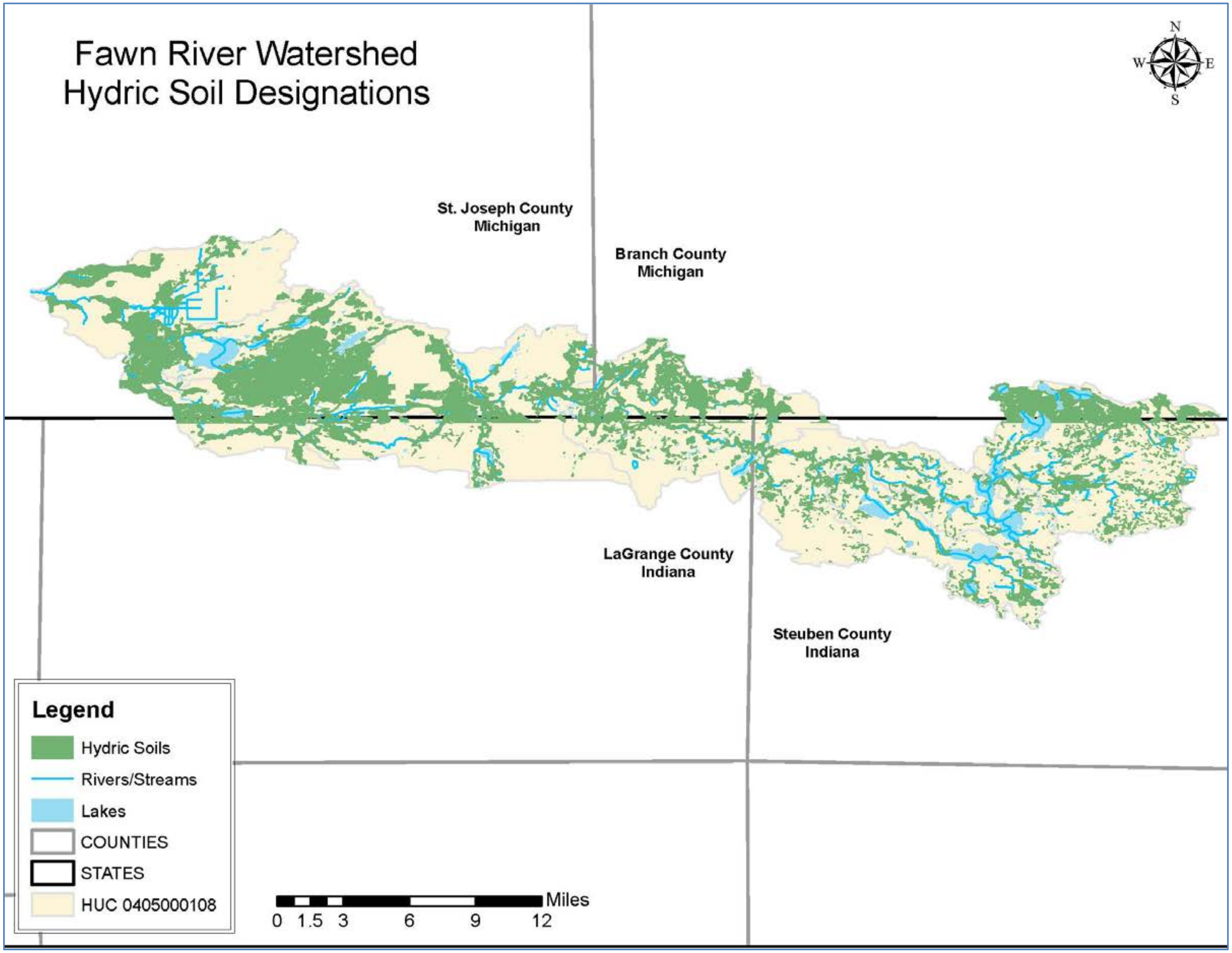


Hydric soils are present where wetlands are, or were. Several soils present within the project area are classified by the local NRCS as hydric as can be seen in Figure 2.6. The NRCS is in the process of standardizing soil classifications throughout the country; however Indiana and Michigan currently classify their soils differently. MI classifies all their major soil types as either hydric or not hydric while IN classifies their soils as hydric based on the dominant soil type and its associations. Hydric soils can pose threats to surface water when farmed due to excessive runoff of fertilizers, pesticides, and manure. Farmland located on hydric soils often requires the installation of field tiles to keep the fields from flooding or ponding. Field tiles can provide a direct conduit for water polluted with fertilizer, land applied manure, and sediment to reach surface waters. Hydric soils are also not suitable soils for septic usage as they do not allow for proper filtration of the septic leachate and may result in surface and/or groundwater contamination. Soils that are considered hydric are so classified for several reasons. The following explanation of hydric soils was taken from the NRCS, Field Office Technical Guide.

1) All Histols except for Folistels, and Histosols except for Folists.
2) Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that.
    a) Are somewhat poorly drained and have a water table at the surface (0.0 feet) during the growing season, or
    b) Are poorly drained or very poorly drained and have either:
        i) Water table at the surface (0.0 feet) during the growing season if textures are coarse sand, sand, or fine sand in all layers within a depth of 20 inches, or
        ii) Water table at a depth of 0.5 feet or less during the growing season if permeability is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches, or
        iii) Water table at a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 in/hr in any layer within a depth of 20 inches.
    c) Soils that are frequently ponded for long/very long duration at the growing season.
    d) Soils that are frequesntly flooded for long/very long duration at the growing season.

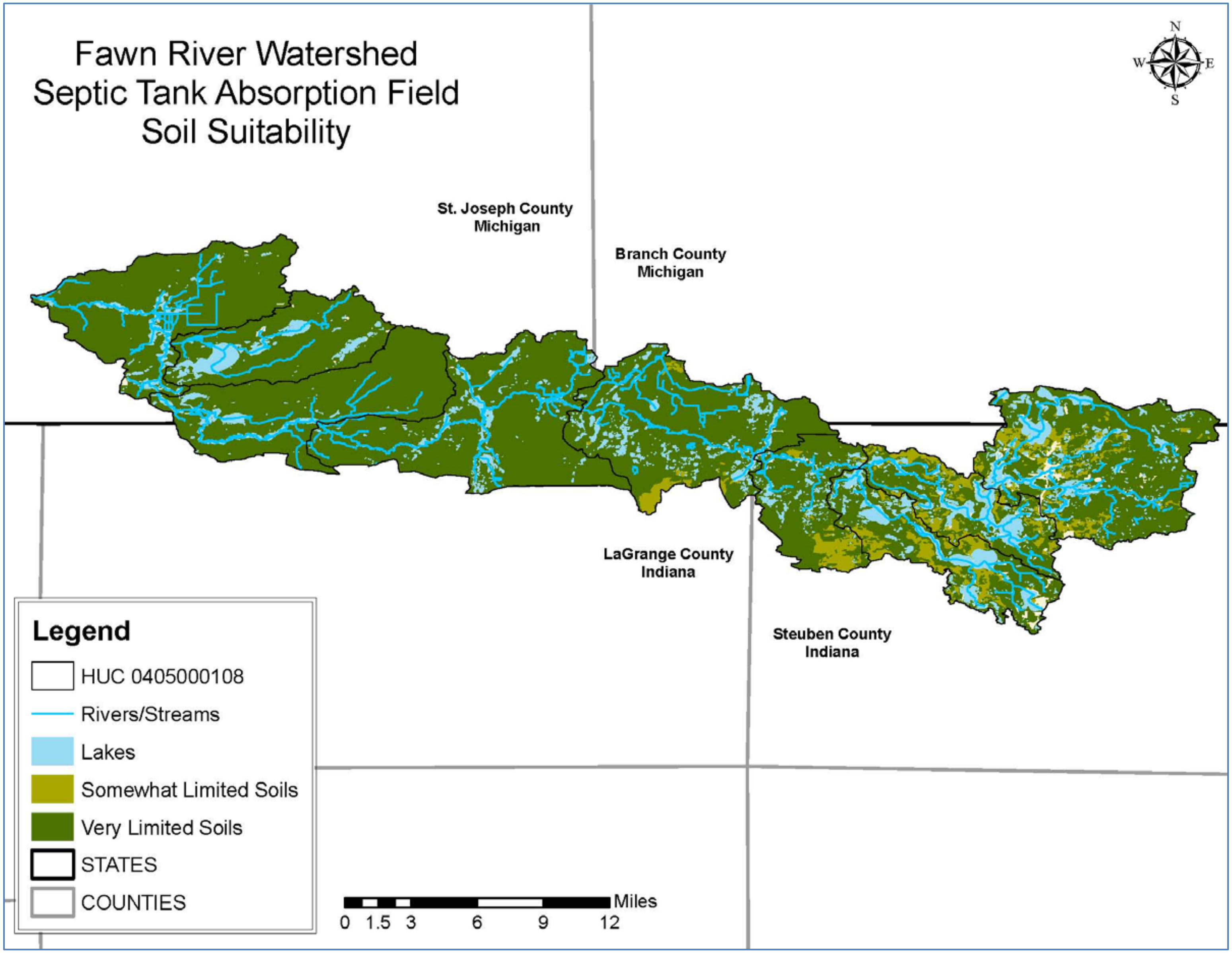
Hydric soils, while posing a significant problem when farmed, also are quite beneficial as they are prime locations to create or restore wetlands, which is a concern for the Fawn River steering committee and stakeholders. The Fawn River watershed is located where the many historic swamps once existed which were drained and converted to prime farmland in the late 19^{th} century which may account for the presence of hydric soils as over 27.46% of the soil in the watershed is classified as hydric. Wetlands are great resources as they supply many ecological benefits and could help prevent polluted runoff from reaching open water.

Figure 2.6: Hydric Soils



Soil type is important to consider when installing an onsite sewage disposal system as traditional septic tanks utilize the soil to absorb effluent discharged from the tank into absorption fields. Septic tank absorption fields are subsurface systems of French drains that distribute septic liquid waste evenly throughout the designated area and into the natural soil. Soil properties and landscape features that affect the ability of the soil to properly absorb and filter the effluent should be considered when designing a septic system. Most of the rural population within the Fawn River project area uses septic systems to process their wastewater, as do several lake populations in the area. All incorporated population centers utilize a centralized sewer system to handle household effluent. The Fawn River steering committee expressed concern regarding failing on-site waste disposal systems and since the majority of the watershed is rural and using on-site waste disposal, it is important to note that most of the soils (84.67%) located within the project area are rated as “very limited” for septic usage according to the NRCS. The NRCS has classified 6.8% of the soils as “somewhat limited” for the installation of an on-site sewage processing. Somewhat limited means that modifications can be made to either the site of septic installation or to the system itself to overcome any potential problems. A designation of “Very limited” means that modifications to the septic system site, or septic system itself, are either impractical or impossible. However, since less than 9% of the project area can safely handle a septic system (Figure 2.7), the ideal situation would be to not install any septic systems and revert to an above ground mound system, a constructed wetland to process wastewater, hook up to a centralized sewer system, or utilize another innovative means to safely process wastewater.

Figure 2.7: Soil Septic Suitability in the Fawn River Watershed



2.3 Climate

The climate in the project area is considered temperate with warm summers and cold winters. The warmest month of the year is July with an average high of 83^{o}F and average low of 61^{o}F. The coldest month of the year is January with an average high of 30^{o}F and low of 16^{o}F. There is an average of 38.5 inches of precipitation each year. Figure 2.8 graphically illustrates the average temperature range per month and Figure 2.9 illustrates the average precipitation per month within the project area.

Figure 2.8: Average Monthly Temperatures within Fawn River Watershed

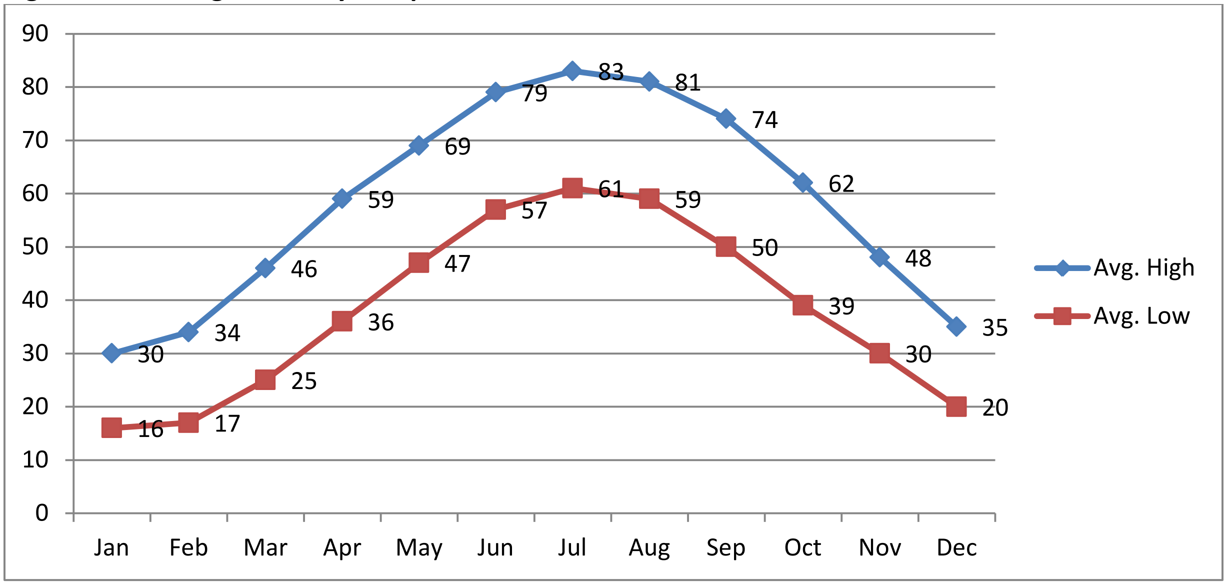
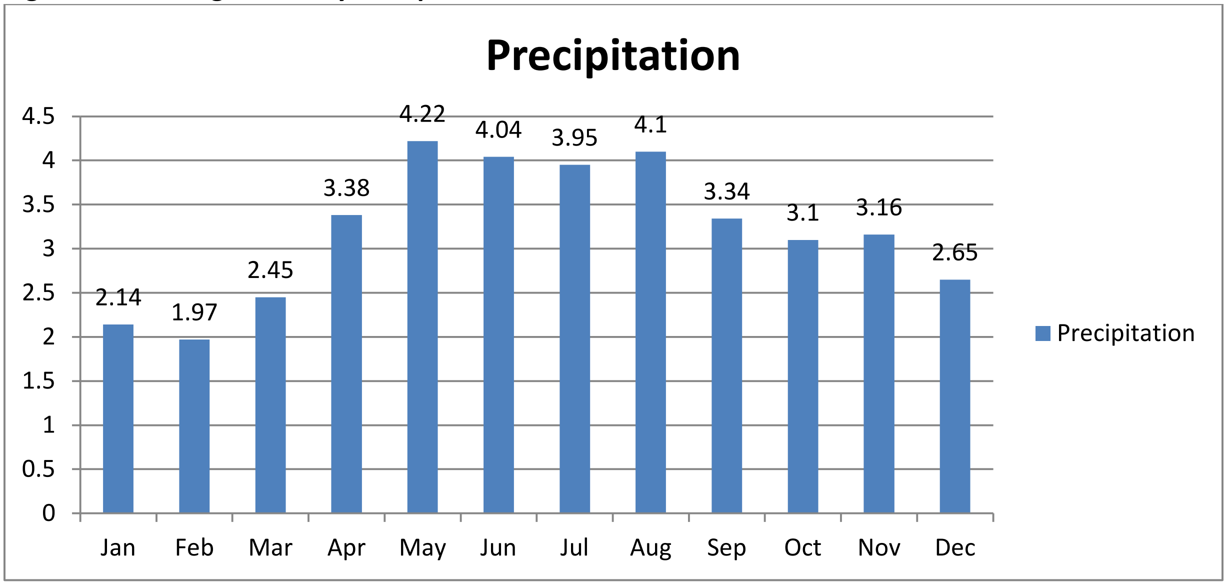


Figure 2.9: Average Monthly Precipitation within the Fawn River Watershed



2.4 Hydrology

There are 299.53 miles of streams, rivers, ditches, and canals located within the Fawn River Watershed according to the National Hydrography Dataset (NHD) which is released by the US Geological Survey (USGS). The Fawn River itself begins on the north edge of the town of Orland at the Indiana Department of Natural Resources (INDNR) Fawn River Fish Hatchery where Crooked Creek feeds into the hatchery and the Fawn exits the hatchery. The Fawn River measures 55.44 miles total between the hatchery and its confluence with the St. Joseph River – Lake Michigan. The Fawn River is listed by the Division of Recreation of the INDNR as "Outstanding" due to it being identified by the state natural heritage program, or similar program, as having outstanding ecological importance and because it is a state designated canoe route. Michigan does not have the Fawn River listed for any significance. Table 2.2 and Figure 2.10 represent the various types of flowing water in the Fawn River Watershed and a description of those various types is listed below.

- Stream/River – A body of flowing water.
- Artificial Path – A feature that represents flow through a two-dimensional feature, such as a lake or a double-banked stream.
- Connector Path – Establishes a known, but non-specific connection between two non-adjacent network segments that each has flow.
- Canal/Ditch – An artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft.

Table 2.2: Stream Miles in the Fawn River Watershed

Stream/River	Artificial Path	Connector Path	Canal/Ditch	Unit
143.36	113.45	0.04	42.68	Miles
230.71	182.57	0.07	68.69	Kilometers
			Total = 299.53	Miles

It should be noted that since the flowing water types are determined through aerial photography, that they may not be classified correctly. As will be discussed in Section 2.4.2, there are more maintained ditches located within the Fawn River watershed than is described in the NHD.

2.4.1 Lakes

There are over 2000 lakes located within the Fawn River Watershed, with 70 of those lakes having given names, most of which are also populated and are, or are becoming built-up. The sizes of the lakes vary from as small as less than a quarter of an acre to as large as 1,842 acres (the Lake James chain). The high number of lakes account for 16,792.54 acres (6,795.7 hectares) of surface area within the watershed. Figure 2.11 shows the location of the lakes within the Fawn River Watershed.

Figure 2.10: Rivers and Streams in the Fawn River Watershed

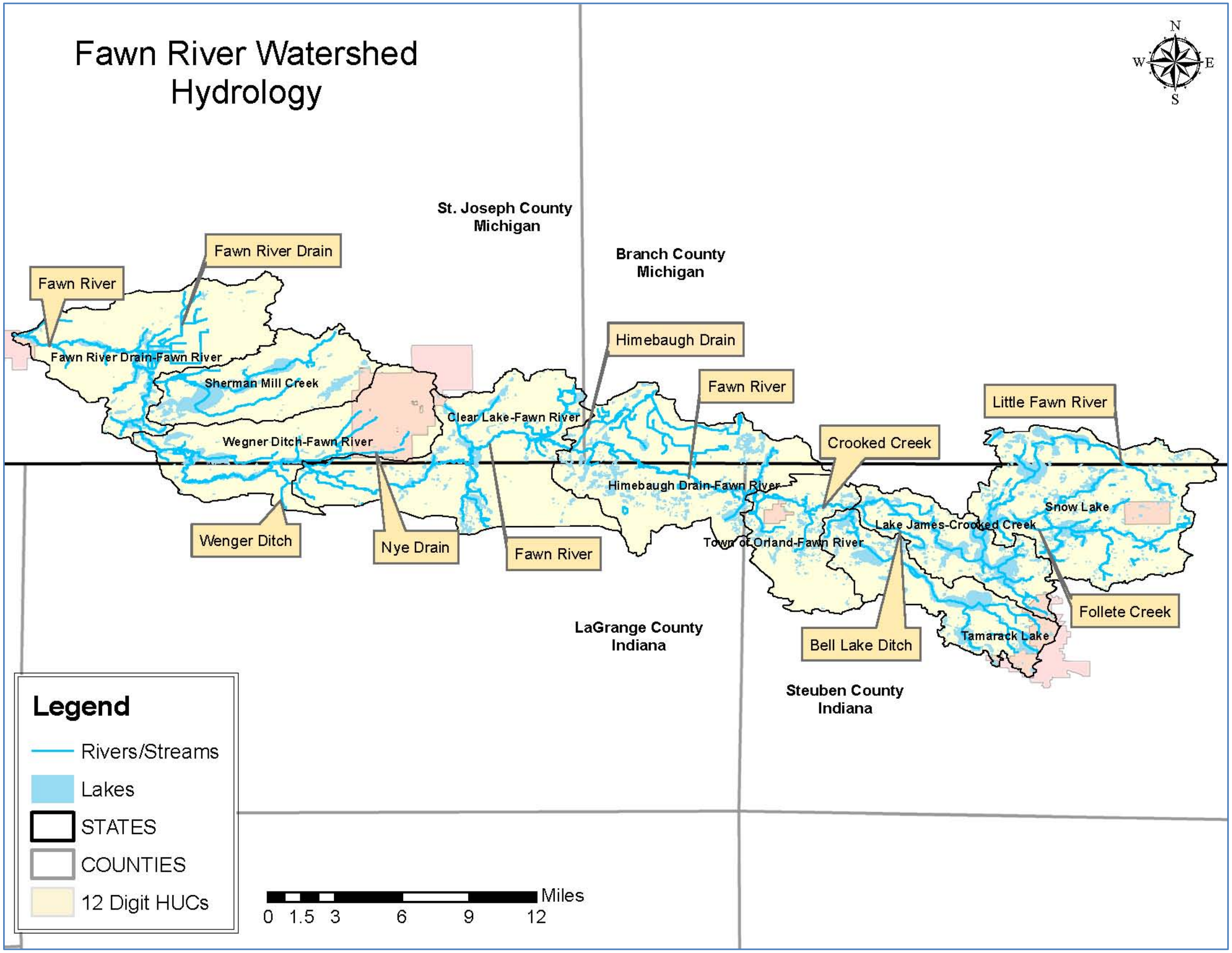
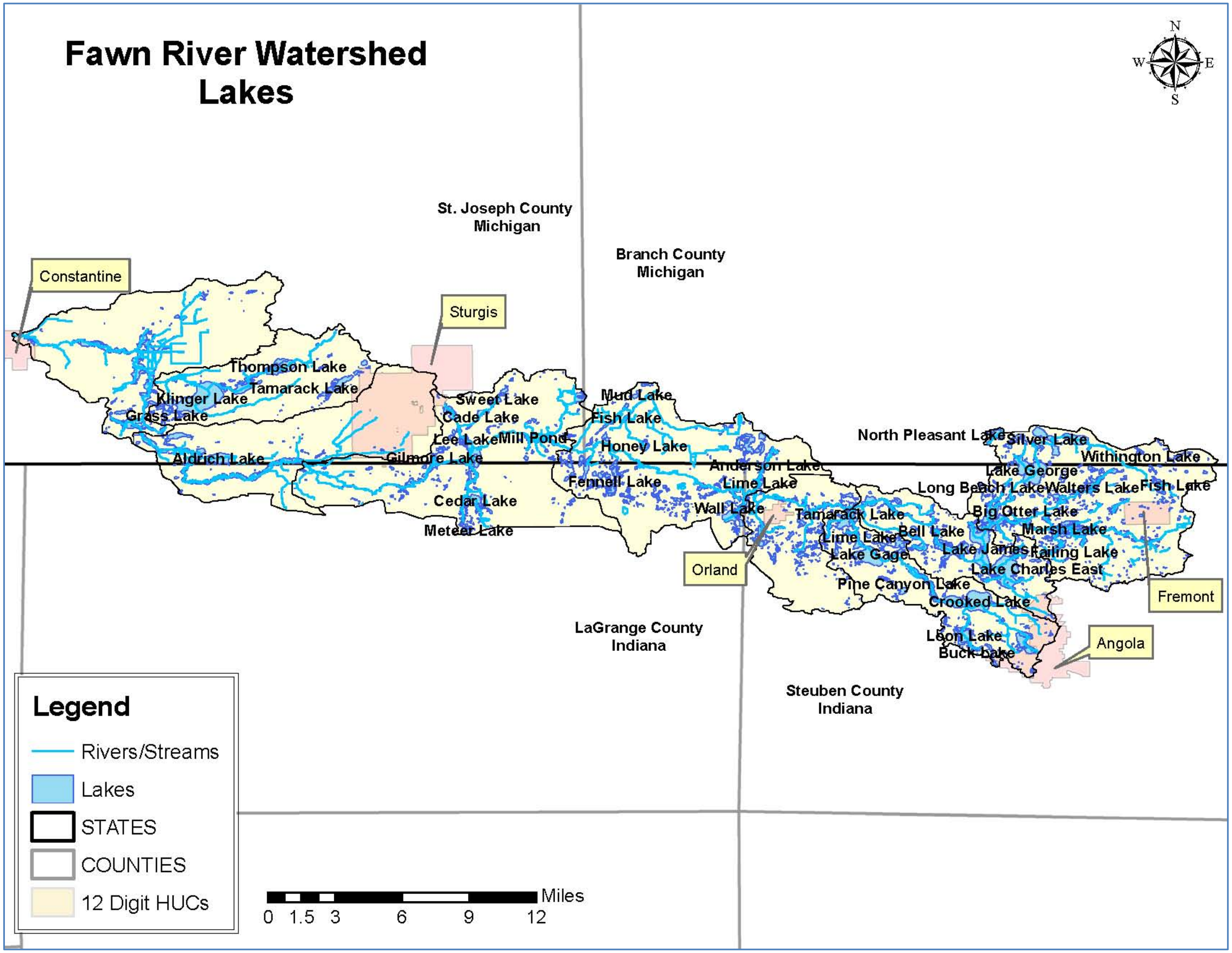


Figure 2.11: Lakes in the Fawn River Watershed



The lakes located in the Fawn River Watershed, specifically Steuben and LaGrange counties, are a major attraction to northeastern Indiana, bringing tourists in from around the tri-state area. Many residents of Fort Wayne, the second largest city in Indiana, have summer homes "at the lake" in northeast Indiana and it is estimated that the population of Angola nearly doubles during the warmer recreational months. Nearly all lakes of substantial size in the Fawn River Watershed are built-up now, and homes and businesses continue to be built in the area. Some struggles of this continues growth include the fact that the Regional Sewer Districts are struggling to ensure all new homes and facilities are hooked up to the centralized sewer system and the shorelines of the lakes are being turned into hardscapes which disrupts the natural aquatic ecosystem.

2.4.2 Legal Drains

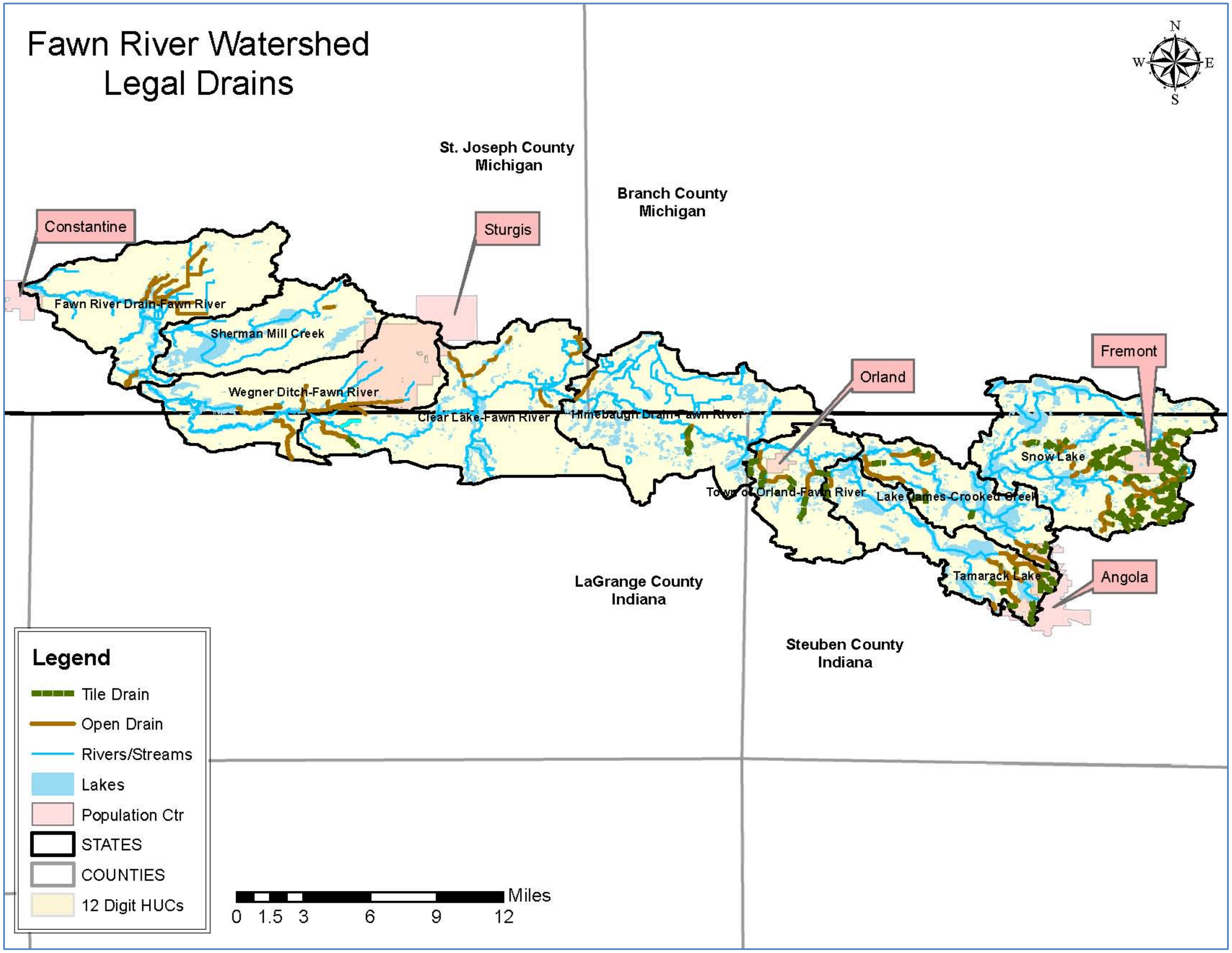
The natural streams, as well as legal drains, within the project area are used as a means to carry excess water from the land so that it may be used for agriculture, commerce, industry, and many other uses. However, due to flooding or ponding issues, many of the tributaries have been channelized to increase the velocity of water flowing downstream and decrease the risk of ponding and flooding. As can be seen in the Figure 2.10, above, many tributaries, specifically those located in St. Joseph County, have been channelized and straightened to aid in the draining of those heavily farmed areas.

Local drainage boards and County Surveyors are charged with maintaining many of the streams and ditches so that they may continue to function properly for their designed use. These maintained waterways are often referred to as legal drains. There are approximately 61.86 miles of legal surface drains and 44.18 miles of legal tile drains maintained by the county government within the Fawn River Watershed. St. Joseph County does not maintain records on any tile drains throughout the entire county, though they do assist with maintenance of tile drains, and Branch County does not have any regulated drains located within the project area. LaGrange County does not presently have the legal drains digitized, so paper maps were provided by the LaGrange County Surveyor Office and the drains were digitized by SNRT, Inc from the paper maps. Therefore, the total miles of legal drains located within LaGrange County may not be accurate. Table 2.3 provides a breakdown of legal drain miles within the project area for each county and Figure 2.12 shows the location of the legal drains.

Table 2.3: Legal Drains by County in the Fawn River Watershed

County	Steuben	LaGrange	St. Joseph	Branch	Total
Miles Open Drain	28.72	4.76	28.38	0	61.86
Miles Tiled Drain	42.33	1.85	0	0	44.18

Figure 2.12: Legal Drains in the Fawn River Watershed



2.4.3 Wetlands

Wetlands play an integral role in our lives. Wetlands are important habitat to many species of plants and animals, some of which are on the endangered species list. They provide recreational areas for wildlife and bird watching, fishing, and many other recreational past-times. Wetlands also help to lessen the impact of flooding and act as pollution sinks to absorb many pollutants prior to being released to open water. However, there are few wetlands still present in the Fawn River watershed compared to pre-settlement time. It was estimated by Friends of the St. Joseph River Association – Wetland Partnership, that the Fawn River Watershed has lost 39% of the wetlands present before settlement of the area. There are currently 26,798.56 acres of wetlands in the Fawn River watershed according to the National Wetland Inventory (NWI) which is based on 1979 data. The wetland land cover according to the NWI accounts for approximately 16% of the watershed area. The loss of wetlands has increased flooding and drought damage, as well as initiated the major decline in fish, bird, and wildlife species in the watershed.

There are several types of wetlands each providing different degrees of eco-services. The approximate area containing each type of wetland is outlined in Table 2.4 and described below.

- Freshwater Emergent Wetland – Palustrine; Herbaceous marsh, fen, swale, and wet meadow.
- Freshwater Forested/Shrub Wetland – Palustrine; Forested swamp or wetland shrub bog
- Freshwater Pond – Palustrine unconsolidated bottom or aquatic bed; pond
- Lake – Lacustrine wetland and deepwater; Lake or reservoir basin
- Riverine – Riverine wetland and deepwater; River or stream channel

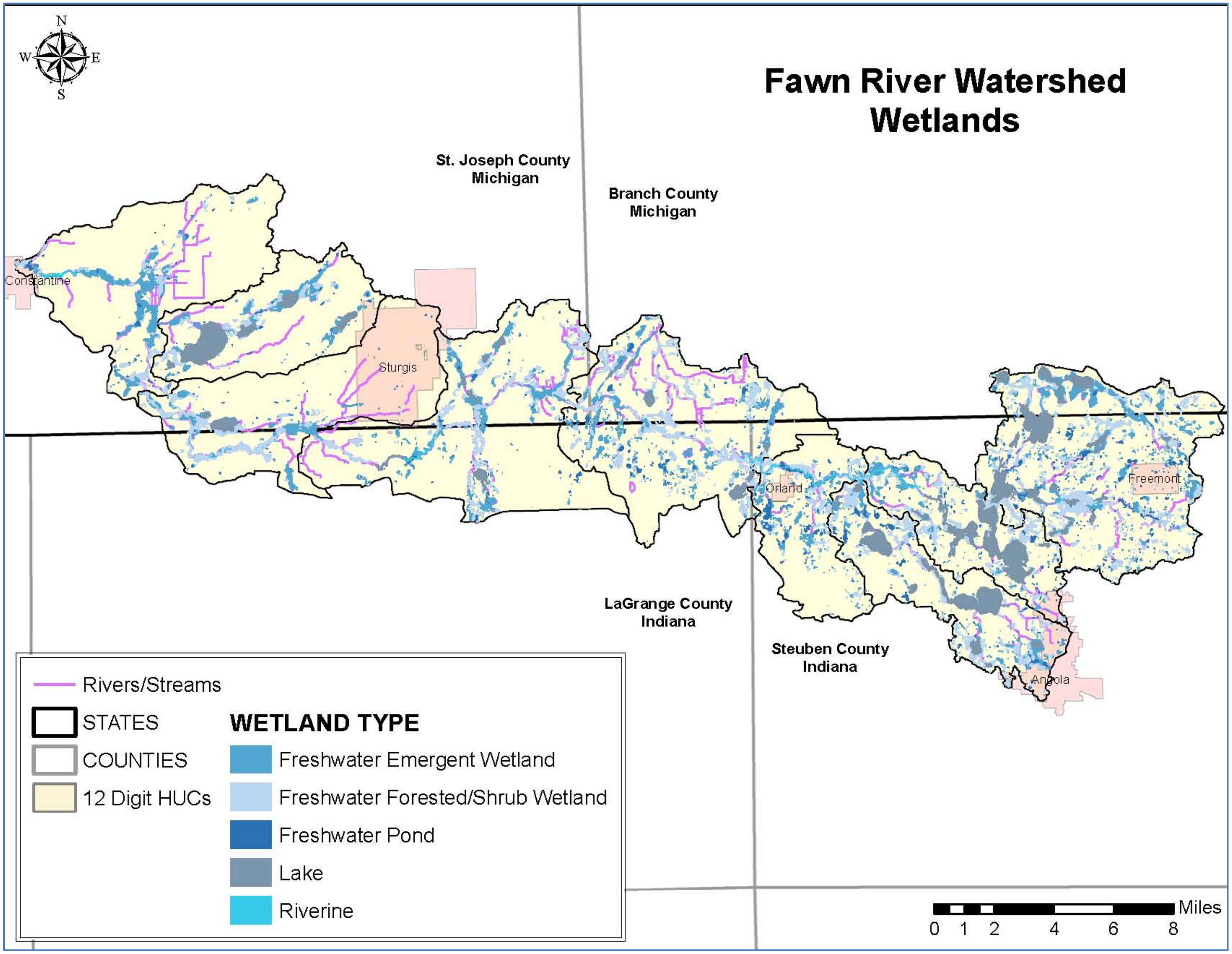
Table 2.4: Wetland Classification within the Fawn River Watershed

Wetland Type	Emergent	Forested/Shrub	Pond	Lake	Riverine
Acres	7487.75	9868.48	1440.34	7742.24	259.75
					Total = 26,798.56

It should be noted that an update to the 1979 NWI has been completed though it has not been made available to the public at this time. Matt Meersman of the Friends of the St. Joseph River Association was a part of a project involving the Michigan Department of Environmental Quality (MDEQ) that looked at the functional use of each wetland present in 2005, as well as that of pre-settlement wetlands to evaluate the functional use loss of wetlands in the entire St. Joseph River – Lake Michigan Watershed. That data has been supplied to this project by Matt Meersman. According to the wetland functional use study, the Fawn River watershed has lost 40% of its floodwater functional use, 36% of shoreline stabilization functional use, and a combined water quality functional use loss of 36% and habitat loss of 44%. It was also estimated that the Fawn River watershed has lost 61% of the ability to retain pathogens. These results suggest that the 39% loss in overall wetlands has had a greater impact on the quality of various aspects of the watershed. The wetland inventory conducted in 2005 shows approximately 616 acres of wetland has been lost between 1979 and 2005 (currently estimated at 26,182.4 acres) and nearly 11,000 acres of wetland has been lost since pre-settlement times. The publicly available, National Wetland Inventory, data was used for the analysis of acres per wetland type here to keep consistent with other published data, studies, and reports. However, the wetland functional use study, conducted by the Friends of the St. Joseph River Association – Wetland Partnership, will be used to evaluate wetland loss at the Sub-watershed level in Section 3.

Figure 2.13 shows where the wetlands within the Fawn River watershed have been delineated by the US Fish and Wildlife Service's, NWI. The wetlands in Figure 2.12 were not verified by a ground survey so should not be considered definitive wetland boundaries but rather estimates only.

Figure 2.13: Current Wetlands in the Fawn River Watershed



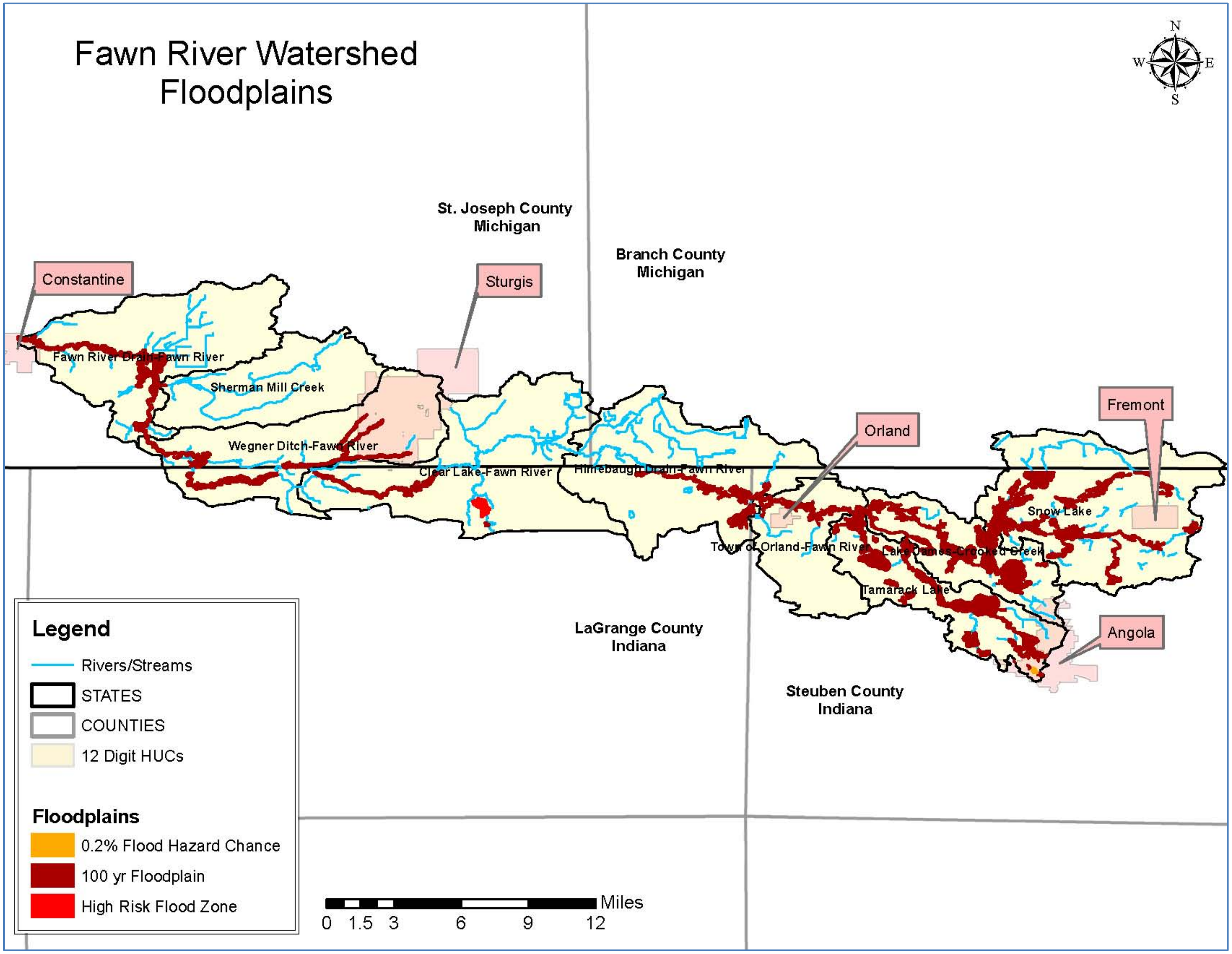
2.4.4 Floodplains and Levees

The Fawn River is not known to flood regularly largely because the river is fed by glacial lakes and is interconnected with a large aquifer system. However, flooding in general can be linked to economic hardship, water impairment, and the destruction of key wildlife habitat. There are three historic gage stations located within the Fawn River watershed, though none of them have been in use since the mid-1980s, the flood stage was set at 10 feet.

Floodplains are important to protect for environmental and economic reasons, as mentioned above. As was explained in Section 2.4.2, many open waterways in the Fawn River Watershed are under regular maintenance by the regulating offices in each county and as waterways are straightened and dredged, nature fights the banks to restore the natural sinuosity of the waterway and reestablish the streambank shelves to allow for floodwater to settle. Flooding can also be exacerbated by an increase in impervious surfaces such as those in and around Angola and Fremont, IN, and Sturgis, MI, as well as the many built-up lakes in the watershed. It should be noted that portions of Angola and Sturgis are located within the 100 year floodplain and are at risk of property and environmental damage from flooding according to the Federal Emergency Management Agency (FEMA). Imperviousness adds to the amount of water within the river, as well as the velocity and erosive power of the river. Indiana has made available floodplain maps to the public. Indiana agencies have designated Crooked Creek and much of the Fawn River, as well as most lake communities to be within a 100 year flood plain (approximately 9,505 acres) which means there is a 1% annual chance of the area becoming flooded. Indiana agencies have also deemed Cedar Lake, located in the Clear Lake – Fawn River sub-watershed, to be at high risk of flooding (approximately 149 acres) as well as approximately 13 acres located in Angola to be at a 0.2% risk of flooding. Michigan has only just begun to digitize their floodplain maps; therefore the entire watershed is not represented by flood risk maps in MI. The only portions of the watershed available for MI are located in St. Joseph County. A map showing the designated flood plains in the Fawn River is shown in Figure 2.14. Please note that GIS files are not available for MI and the flood risk areas on the map were digitized based on hard maps, and is an approximation only.

Due to the potential of flood damage to residences and businesses located within the floodplain, many areas will install levees as an urban flood protection measure. There are no levees located in the Fawn River watershed.

Figure 2.14: Floodplains Located within the Fawn River Watershed



2.4.5 Dams

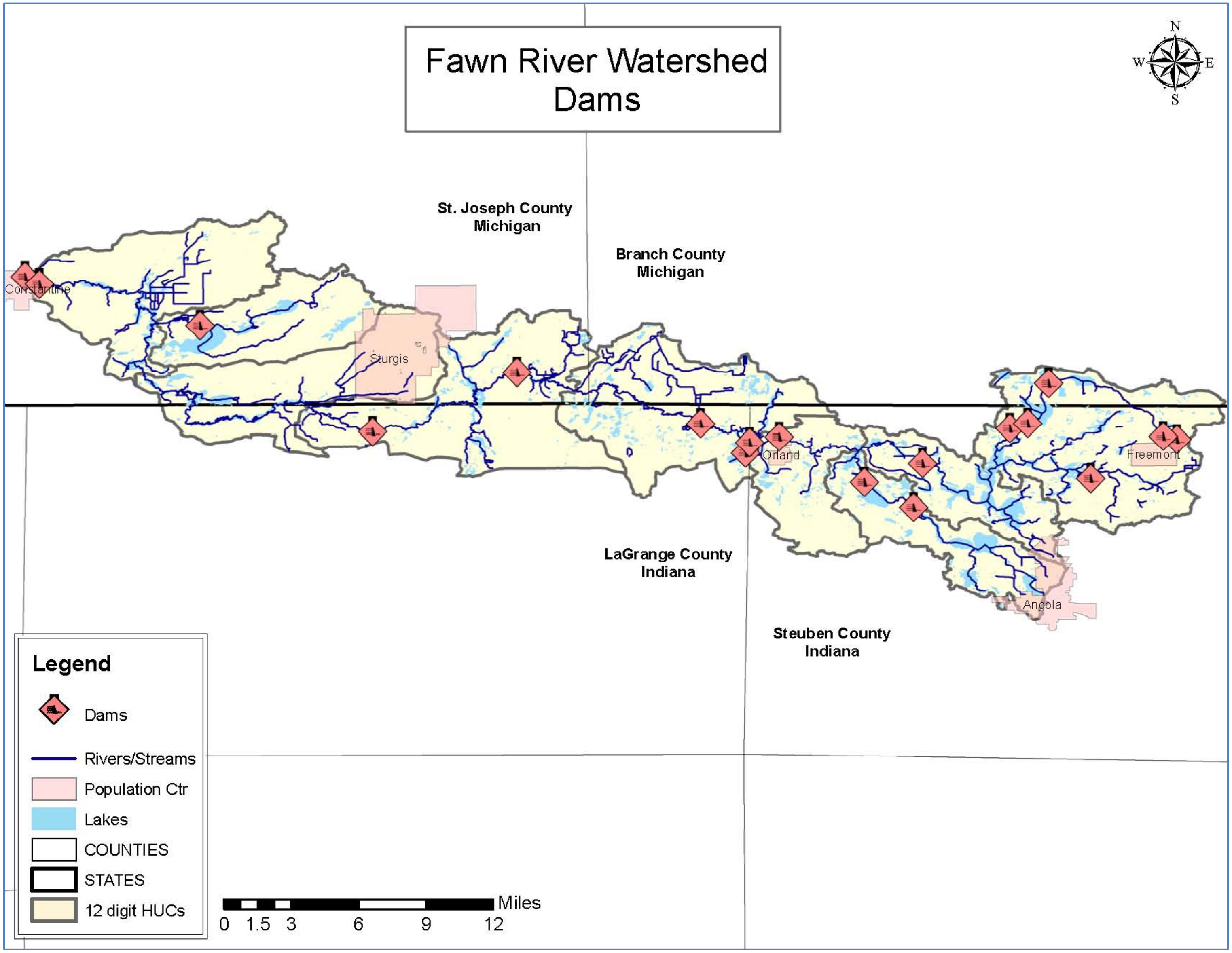
There are eleven dams located within the Fawn River Watershed. Five dams are located in St. Joseph County Michigan, and the remaining six dams are located in Steuben and LaGrange County, IN. Those dams are listed in Table 2.5, below. While dams can be beneficial to communities to supply recreational opportunities, drinking water reservoirs, hydroelectric power, and help control flood waters, they can also be detrimental to the natural hydrology and aquatic ecosystem. Some of the dangers of dams include blocking fish migration (discussed further in Section 2.6), slowing the natural flow of a river, altering the water temperature, decreasing oxygen levels, and causing silt, debris, and nutrients to collect in the waters behind the dam. Also, dams have an expected life span of about 50 years at which point their intended purpose may become compromised. A map of the dams and levees located within the project area can be seen in Figure 2.15.

Table 2.5: Dams Located in the Fawn River Watershed

Dam Name	Yr Completed	River Name	Pond Name	Pond Area	Sub-watershed
Fawn River Mill Dam	1830	Fawn River	Mill Pond	29.0	Fawn River Drain
Fawn River Power Company	1830	Fawn River	N/A	100.0	Clear Lake
Klinger Lake Level Control Structure	1969	Sherman Mill Creek	Klinger Lake	830.0	Sherman Mill Creek
Silver Lake Level Control Structure	N/A	Crooked Creek	Silver Lake	206.0	Snow Lake
Upper Constantine Dam	1948	Fawn River	N/A	90.0	Fawn River Drain
Minifenokee Lake Dam	1960	Unnamed Tributary	Lake Minfenokee	33.9	Snow Lake
Jimmerson Lake Dam	1945	Crooked Creek	Jimmerson Lake	305.3	Lake James
Fawn River Fishery Dam	N/A	Crooked Creek/ Fawn River	N/A	1.5	Town of Orland
Greenfield Mills Dam	1835	Fawn River	N/A	27.4	Himebaugh Drain
Long Beach Lake Dam	N/A	Little Fawn River	Long Beach Lake	16.6	Snow Lake
Lake George Dam	1927	Little Fawn River	Lake George	542.6	Snow Lake
Swaggers Plug Control Structure	N/A	Little Fawn River	Swaggers Lake	4.7	Snow Lake
Fish Lake Control Structure	N/A	Little Fawn River	Fish Lake	42	Snow Lake
Crooked Lake Control Structure	N/A	Carpenter Drain	Crooked Lake	785.3	Tamarack Lake
Lake Gage Control Structure	N/A	Carpenter Drain	Lake Gage	323.5	Tamarack Lake

Dam Name	Yr Completed	River Name	Pond Name	Pond Area	Sub-watershed
Mud Lake Control Structure	N/A	Unnamed Tributary	Mud Lake	37.6	Himebaugh Drain
Wall Lake Control Structure	N/A	Unnamed Tributary	Wall Lake	134.9	Himebaugh Drain
Star Mill Dam	1929	Fawn River	N/A	0	Clear Lake

Figure 2.15: Dams Located in the Fawn River Watershed



2.4.6 Drinking Water and Ground Water Resources

The Fawn River Watershed is located over three unconsolidated aquifer systems; the Howe Outwash Subsystem, Howe Outwash System, and Kendalville System. An unconsolidated aquifer means that the groundwater present within the Fawn River watershed is readily available for uptake and use to drinking and irrigation; however, it also means that the groundwater is more susceptible to contamination than consolidated aquifers. The thickness of the substrate over the aquifers varies from only 30 feet in depth at the southern edge of the Clear Lake sub-watershed, to 145 feet in depth throughout the majority of the rest of the watershed.

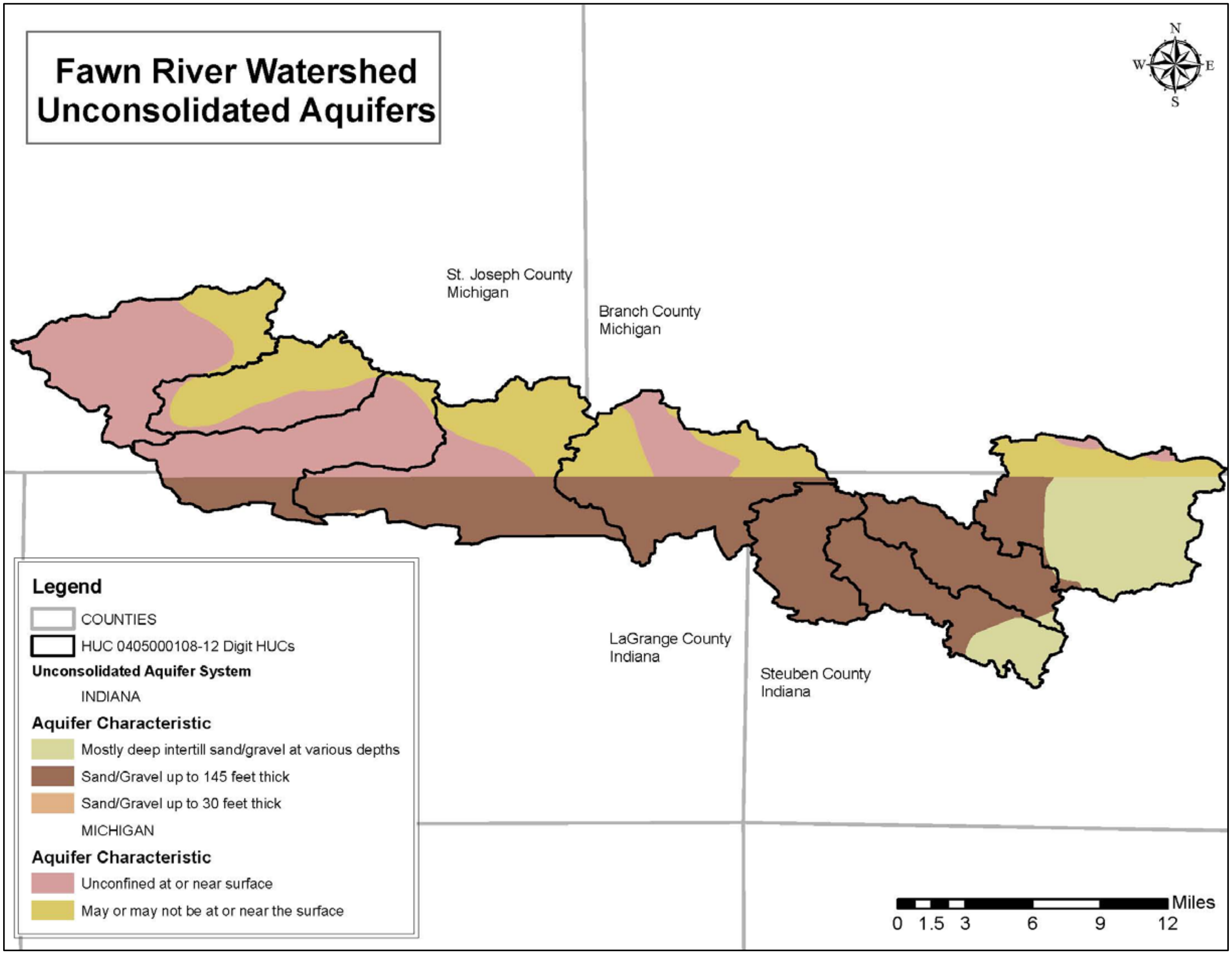
All residents in the watershed acquire their drinking water through wells. The incorporated areas of Fremont, Angola, Orland, Sturgis and Constantine supply drinking water to their residents through groundwater wells from one of the various aquifer systems located in the watershed and have some sort of protection plan in place to protect the groundwater from contamination, which will be discussed in Section 2.8. The other residents in the watershed have private water wells in which they obtain their drinking and irrigation water. The county health departments are responsible for the safety of the groundwater for private water wells and test the water before a new well can be installed. The wells are typically deemed inadequate for drinking if they test positive for the presence of fecal coliforms.

A survey of water withdrawals completed by the USGS in 2005 showed that Indiana and Michigan withdrew approximately 616 million gallons of water a day from ground water resources. Table 2.6 shows the total water withdrawals for Indiana and Michigan according to the 2005 USGS study. Figure 2.16 shows the aquifer system within the Fawn River watershed.

Table 2.6: Water Withdrawals in Indiana and Michigan (2005)

State	% of Population	Ground-water (Mgal/day)	Surface water (Mgal/day)	Total (Mgal/day)
Indiana	74	356	320	676
Michigan	71	260	883	1140
Total (Mgal/day)		616	1203	1816

Figure 2.16: Unconsolidated Aquifer System within the Fawn River Watershed



2.5 Land Use

Land use in the project area greatly influences the quality of the water resources. Land in agricultural production has the potential to erode, especially if over worked or if it is conventionally tilled annually. Thus soil particles carrying high levels of nutrients and pesticides have the potential to reach open water sources and effect aquatic plants and animals and cause the water to become non-potable. Livestock operations often can lead to high levels of bacteria in open water from manure storage areas that are not properly maintained or from livestock having direct access to open water sources. These two activities can also lead to high levels of sedimentation and nutrients in surface water. Industrial areas and urban centers can pose a threat to water quality due to the increased imperviousness of the landscape and industrial waste outfalls. For the reasons listed above, it is very important to investigate land use activities in the project area so as to determine the best method of remediating the pollution coming from the various land uses in the project area. Below is a general description of land uses in the project area. Section 3 of this WMP will provide an in depth look at the land use in the watershed by breaking it down to HUC 12 sub-watersheds.

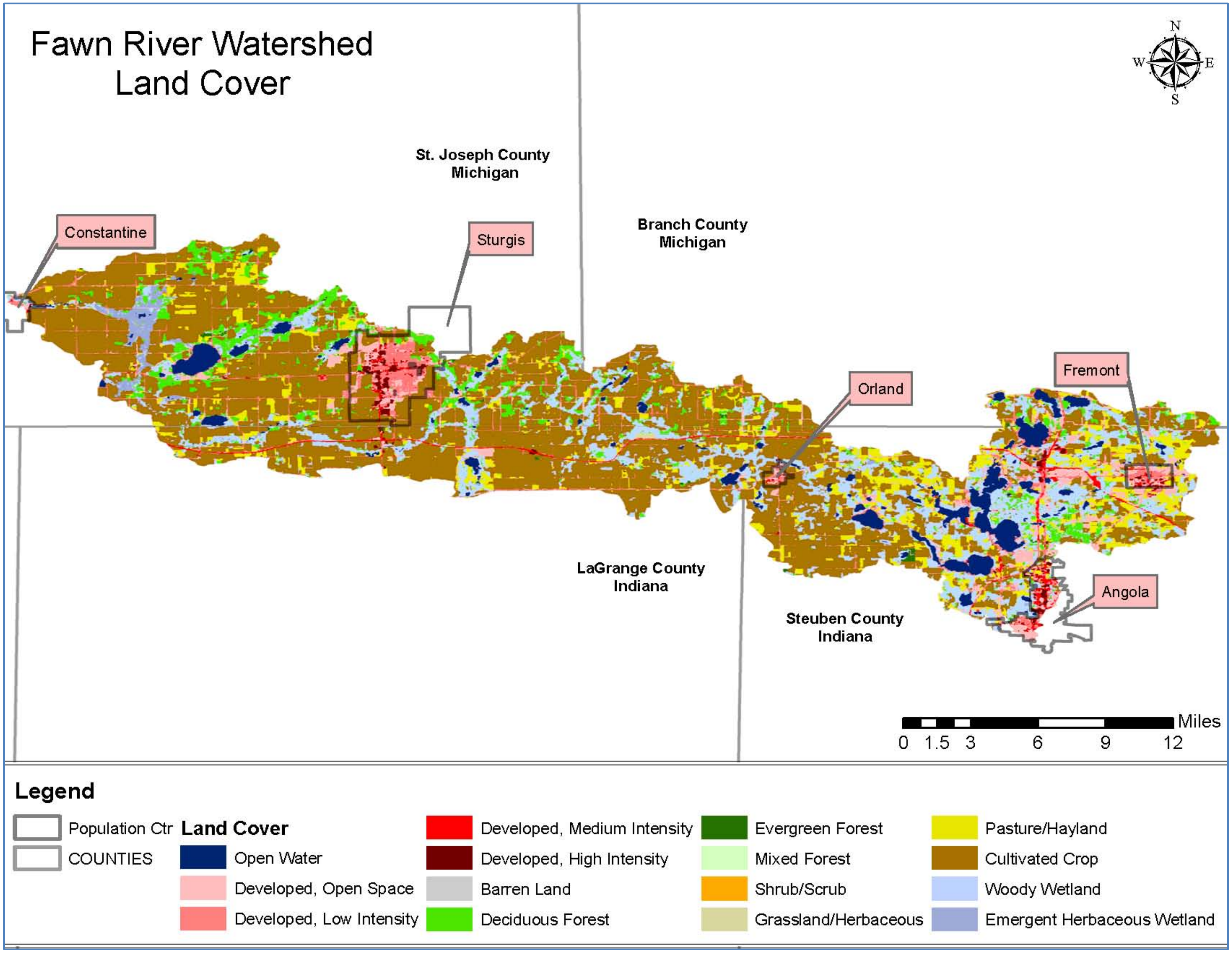
The predominant land use in the watershed is agriculture, specifically cultivated crops, as can be seen in Figure 2.17. It is important to note however, that wetlands take up nearly 16% of the land cover in the Fawn River watershed. There are few urban settings including Fremont, IN (Pop.=2,135), Orland, IN (Pop.=432), Sturgis, MI (Pop.=10,884), and part of Angola, IN (Pop.=8,591) and Constantine, MI (Pop.=2,057). Table 2.7 below shows the number of acres of land in each type of land use per state.

It should be noted here that while irrigation is used for row crops throughout the project area, it is predominately used in St. Joseph County. Jennifer Miller, Administrator for the St. Joseph County Soil and Water Conservation District, explained that St. Joseph County uses the most irrigation for agriculture between all the counties in the state of Michigan. The St. Joseph County Master Plan states that 44% of all crop land in the county is irrigated which accounts for 23% of all irrigated land in Michigan. Irrigation use must be monitored to ensure the aquifer system can support the amount of irrigation taking place, and that the use of irrigation does not promote soil and fertilizer runoff from fields to open water.

Table 2.7: Land Use/Land Cover in Fawn River Watershed

NLCD Land Use Designation	Acres	%
Open Water	9405.65	4.76%
Developed Open Space	11265.96	5.70%
Developed Low Intensity	8639.33	4.37%
Developed Medium Insensity	2436.08	1.23%
Developed High Intensity	1097.74	0.56%
Barren Land	241.39	0.12%
Deciduous Forest	13048.83	6.61%
Evergreen Forest	549.27	0.28%
Shrub/Scrub	68.62	0.03%
Mixed Forest	223.64	0.11%
Grassland Herbaceous	845.62	0.43%
Pasture Hayland	17197.4	8.71%
Row Crops	102,147.47	51.73%
Woody Wetland	27101.87	13.72%
Emergent Herbaceous Wetlands	3207.28	1.62%
Total	197,476.11	100.00%

Figure 2.17: Land Use/ Land Cover in Fawn River Watershed



2.5.1 Tillage Transect Data

Tillage transects are a method of data collection concerning the use of various tillage practices used within the agricultural community. They are typically performed to gage the adoption of various conservation tillage practices and to get an accurate count of crop acreage. The amount of land utilizing cover crops is often collected during tillage transects as well. Indiana counties typically perform tillage transects on a biennial basis due to the high percentage of agricultural land use in the State. Michigan counties do not regularly perform any farm field transect data and the State has not performed a tillage transect since 1993. Jerry Grigar, the MI NRCS State Agronomist, believes there are more beans and small grains in no-till currently than when the data was last collected. The St. Joseph County NRCS District Conservationist has not noted a change in tillage over the past several years; however the Branch County SWCD believes that no-till is on the rise in their county. Steuben County has been very successful at encouraging and implementing conservation tillage practices with 80% of all corn fields and 96% of all soybean fields being in some form of conservation tillage. However, LaGrange County has been more successful at implementing cover crops as a management technique. This may be due to the high number of Amish farmers located within LaGrange County who have a harder time implementing no-till due to equipment constraints. Table 2.8 shows the number of acres in conservation tillage in St. Joseph and Branch counties, and Table 2.9 shows the percentage of fields utilizing conservation tillage and those utilizing cover crops in Steuben and LaGrange counties.

Table 2.8: Tillage Transect Data for Michigan Counties in 1993

County	Year Data Collected	No-Till		Ridge Till (All fields)	Mulch Till (All fields)
		Corn	Soybeans		
St. Joseph	1993	20000	14000	430	41800
Branch	1993	10600	11750	330	21018

Acreage is conventional tillage is not available for MI counties.

Table 2.9: Tillage Transect and Cover Crop Data for Indiana Counties in 2013

Tillage Type	Crops	Steuben	LaGrange
No-Till	Corn	31%	31%
Strip Till		0%	0%
Ridge Till		0%	0%
Mulch Till		23%	7%
Reduced Till		26%	8%
Cover Crops		1%	7%
Conventional Tillage		20%	54%
No-Till	Beans	68%	63%
Strip Till		0%	0%
Ridge Till		0%	0%
Mulch Till		18%	4%
Reduced Till		10%	10%
Cover Crops		1%	12%
Conventional Tillage		4%	24%

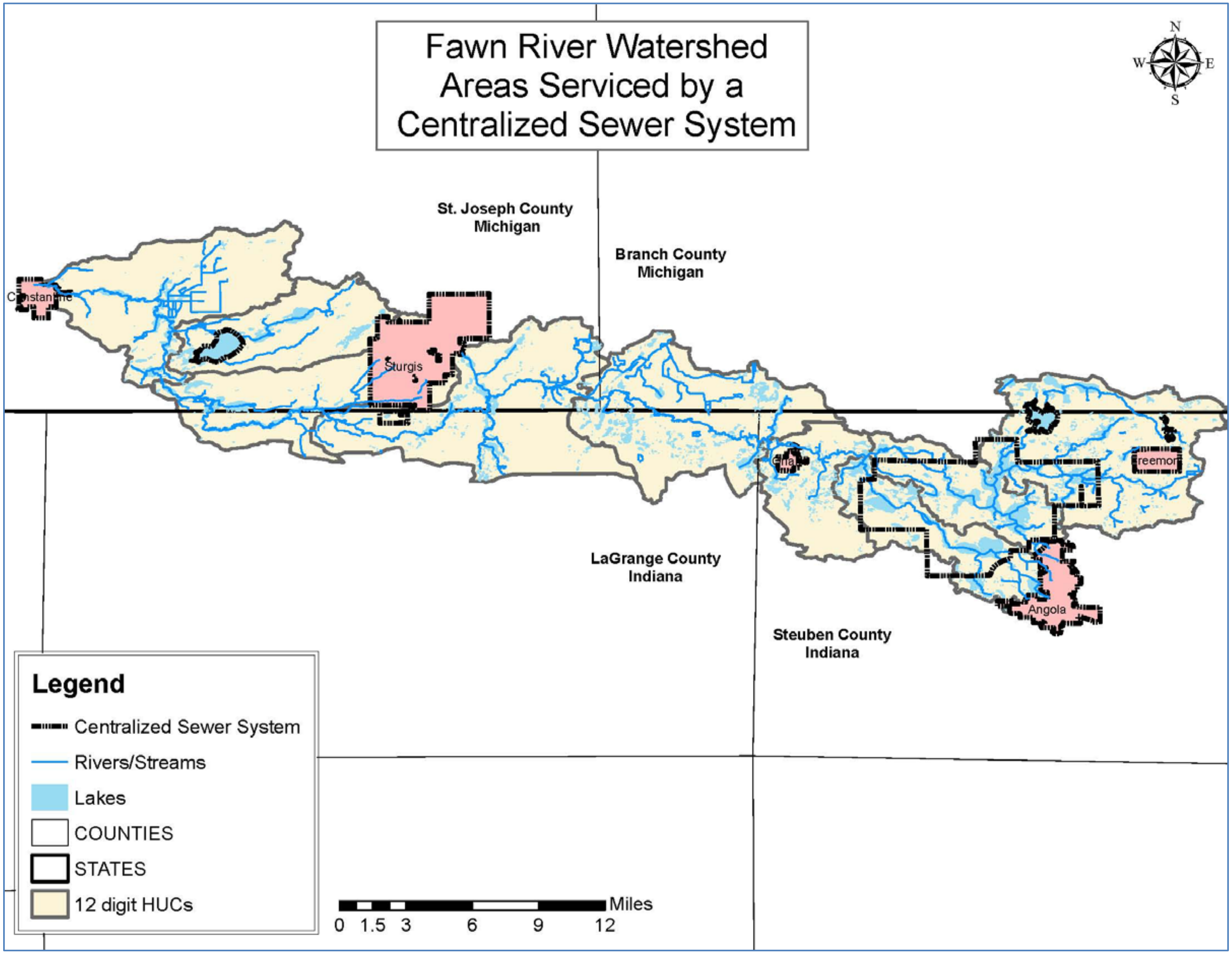
2.5.2 Septic System Usage

There are 10 populated areas that are served by a centralized sewer system. Most of the built-up lakes in the watershed are serviced by the Regional Sewer District with the exception of some homes along Lake George, Long Beach Lake, Barton Lake (both south west of Lake George), and Lime Lake which is located just northeast of Orland. The populated area of Waldon Woods, north of Lake Gage is also not serviced at this time. The Steuben Lakes Regional Waste District (SLRWD) is working to supply sewers to all the populated areas within the near future, including Snow Lake, Big Otter and Little Otter Lake, Lake Charles East and West. The SLRWD does currently supply sewers to some homes surrounding Lake Pleasant, and are in the planning process of running sewers to more of the Lake Pleasant homes. Also, all towns and cities located within the watershed are currently serviced by a sewer system. Figure 2.18 below, outlines all the areas where a centralized sewer system is currently being used. However, it is important to note that all rural areas located within the Fawn River watershed rely on on-site sewage disposal. It should also be noted that many of the smaller, built-up lakes are not currently serviced by a sewer system.

Much of the population in the Fawn River watershed currently relies on on-site waste disposal which can cause a contamination problem of surface and groundwater if the system is not properly installed and/or maintained. The number of failing or leaking septic systems is hard to estimate, as many of the systems are not on record with the local health departments. The county Health Departments located in the Fawn River Watershed were unable to provide an accurate estimate of leaking, failed or straight-piped septic systems for their counties. However, according to the US EPA, about 25% of households in the United States utilize on-site sewage disposal and anywhere from 1% - 5% of those systems are failing. Another study conducted by the National Environmental Service Center in 1992 and 1998 estimated that approximately 25% to 30% of on-site sewage treatment systems in Ohio, a similar landscape to that found in Indiana and Michigan, are failing. Though, due to the majority of the population in the Fawn River watershed being located within the rural community, it is expected that higher than 25% to 30% of the population within the watershed utilize on-site waste disposal systems. Septic system leachate may increase nutrient levels, as well as, fecal coliform, including the harmful *E. coli* bacteria, in both surface water and ground water, which is the sole source of drinking water within the project area.

It should also be noted that failing or leaking septic systems within the Fawn River Watershed are likely due to them being placed in areas where the soil in deemed as not suitable for a septic system. The soil located within the project area is predominantly sandy and/or gravelly which allows for rapid permeation of septic effluent.

Figure 2.18: Communities Served by a Centralized Sewer System



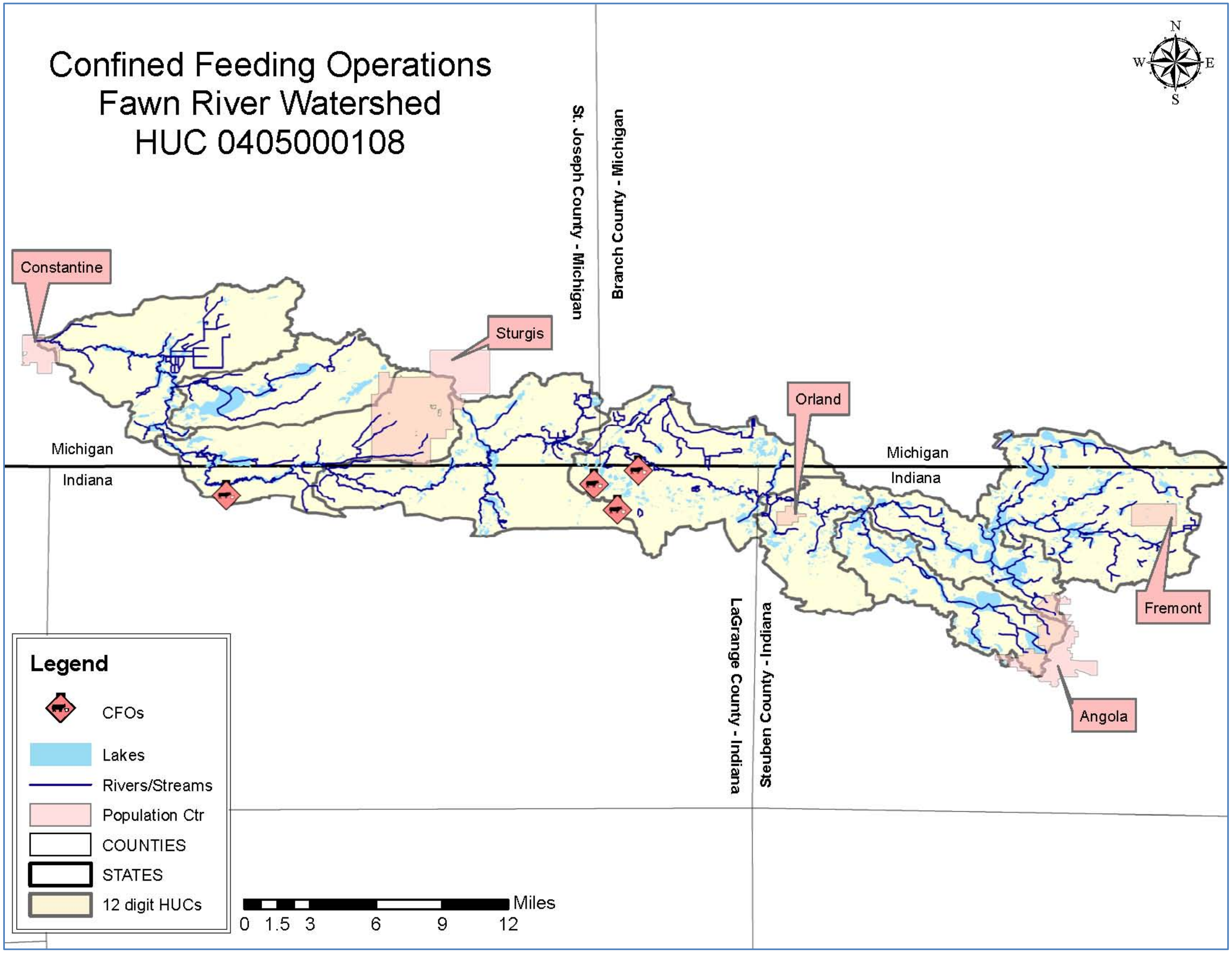
2.5.3 Confined Feeding Operations

Stakeholders voiced concern about stormwater runoff from livestock operations located within the project area as they can present a significant pollution problem if animal waste is not properly managed, such as proper storage of the manure and application of the manure as fertilizer on crop fields. There are four permitted confined feeding operations (CFOs) located within the project area; one in Wegner Ditch and three in Himebaugh Drain sub-watershed, all in Indiana. The four CFOs have a combined animal count of nearly 250,000. A confined feeding operation is so designated if there are 300 cattle, 500 horses, 600 swine or sheep, or 30,000 fowl present on the property and confined for at least 45 days during the year where there is no ground cover or vegetation present over at least half of the animals' confinement area. If the size of the operation is very large, or there have been compliance issues with an operation in the past, the CFO may be designated as a Concentrated Animal Feeding Operation (CAFO), and will be required to obtain a National Pollution Discharge Elimination System (NPDES) permit. The Steering Committee voiced concern regarding animal feeding operations, both regulated and non-regulated facilities. There are several smaller livestock operations located within the project area. Though, most are not located directly adjacent to a stream and therefore, were not inventoried during the WMP planning process. Those that were identified as a potential pollution problem in the watershed are listed as such in the respective sub-watershed Section. Table 2.10 below is a list of all CFOs in the project area and Figure 2.19 shows their location.

Table 2.10: Confined Feeding Operations in the Fawn River Watershed

Operation Name	County	Sub-watershed	Program	Animal Type	Animal #
Laurent D Jennings	Lagrange	Himebaugh Drain	CFO	Swine/Beef Cattle	2300/25
Contract Pork	Lagrange	Himebaugh Drain	CFO	Swine	6000
Michael Fanning Farms	Lagrange	Himebaugh Drain	CFO	Swine	1430
N & M Incorporated Fawn River Farm	Lagrange	Wegner Ditch	CFO	Broilers	240,000

Figure 2.19: Confined Feeding Operations in the Fawn River Watershed



2.5.4: Windshield Survey

A windshield survey was conducted throughout the watershed to identify areas where nonpoint source pollution (NPS) may be an issue. The survey was conducted in May 2014, with two people per vehicle, driving each road within each sub-watershed, and making note of any areas of significant soil loss, lack of riparian buffer, livestock access to open water, or other potential pollution sources. The notes taken during the windshield survey were then verified via a “desktop survey” of the watershed using 2011 aerial photography. The most significant potential NPS source identified during the windshield survey was a lack of riparian buffer along open water. However, other issues were also noted including conventionally tilled fields, sea walls and fetilized turf grass directly along the shoreline of built-up lakes, and some livestock issues, including one site where livestock have direct access to open water. It was also observed that many row crop farmers in the watershed are using irrigation on their fields. The windshield survey will be discussed in further detail, at the sub-watershed level, in Section three of this WMP.

2.5.5 National Pollution Discharge Elimination System

Facilities that discharge directly into a water body are required to obtain an National Pollution Discharge Elimination System (NPDES) permit from the overseeing state agency (IDEM and MDEQ). The permit regulates the amount of contaminants a facility can discharge into surface water and requires the facility to conduct regular water quality monitoring (typically monthly). While these facilities are regulated by the State, there is the potential that they may have accidental discharges above permit limits, or in some cases, the facilities may release a substance that they are not required to report to the State which may pose a threat to water quality; phosphorus is a common parameter not required to be reported. There are 11 NPDES permitted facilities located within the Fawn River. The NPDES facilities were obtained from the US EPA’s Enforcement and Compliance History Online (ECHO) website. ECHO allows the user to search for various permitted facilities by HUC 12 and will supply myriad data. Table 2.9 lists each facility, their permit number and address, the number of quarters the facility was in non-compliance over the past three years, as well as the reason for the violation. Pollutants in bold in Table 2.11 are those pollutants that caused a significant violation. Figure 2.17 is a map showing the location of each of the permitted facilities. The NPDES permitted facilities will also be mapped in their respective sub-watershed in Section 3 of this WMP.

It should be noted that there are two facilities located within the Fawn River watershed, with discharge points in the neighboring Pigeon River/Pigeon Creek watershed. Those facilities are listed in Table 2.11 and are highlighted in yellow.

Table 2.11: NPDES Permitted Facilities in the Fawn River Watershed

Permit Name	Permit #	County Name	Address	City	HUC 12	Lat.	Long.	Receiving Water Body Name	Qrts in Non-compliance (3 yrs)	Pollutant
Fremont WWTP	IN 0022942	Steuben	1715 SR 120	Fremont	040500010801	41.729681	-85.023148	Crooked Creek via Marsh Lake via Trib	5	BOD, E. coli, N, P, and TSS
Pokagon State Park	IN 0030309	Steuben	450 Lane 100 Lake James	Angola	040500010803	41.718028	-85.03667	Crooked Creek via Snow Lake	4	BOD, E. coli, P, and TSS **T Ammonia**
Angola Travelers Mall Mobil	IN 0032891	Steuben	7265 N Baker Rd	Fremont	040500010801	41.746056	-84.991417	St. Joseph via Big Otter Lake/ Walters Lake/ unnamed trib	10	**Chlorine**, E. coli, **T Ammonia**, **P**
Western Con-solidated Technologies	IN 0054011	Steuben	700 W Swagger Dr	Fremont	040500010801	41.712017	-84.979955	Unnamed Trib to Marsh Pond	4	**Chlorine**, Oil and Grease
Meridian Automotive Systems	IN G250062	Steuben	3000 Woodhull Dr	Angola	040500010803	41.6713	-85.0039	Pigeon Creek via Croxton Ditch	5	Temp
Sturgis-Big Hill Rd LF	MI 0047716	St. Joseph	US 12 and Big Hill Rd	Sturgis	040500010806	41.801944	-85.387778	Moe Drain	0	N/A
Travel Plaza - Ernie Pyle	IN 0050300	LaGrange	5000 E 750 N	Howe	040500010806	41.745194	-85.329083	Pigeon River via Unnamed Trib	2	non-RNCV
City of Sturgis WWTP	MI 0020451	St. Joseph	70250 Treatment Plant Rd	Surgis	040500010807	41.773611	-85.432778	Fawn River	1	non-RNCV/C

Permit Name	Permit #	County Name	Address	City	HUC 12	Lat.	Long.	Receiving Water Body Name	Qrts in Non-compliance (3 yrs)	Pollutant
Abbott Nutrition	MI 0025313	St. Joseph	901 N Centerville Rd	Sturgis	040500010807	41.8095	-85.426	Nye Drain	1 (RCRA) 0 (CWA)	Sulfuryl Flouride
Sturgis Well Field - SF	MI 0053465	St. Joseph	309 N Prospect St	Sturgis	040500010807	41.804444	-85.414722	Fawn River via Nye Drain	0	N/A
MI Milk Producers Assoc.	MI 0001414	St. Joseph	125 Depot St	Constantine	040500010809	41.843611	-85.665278	St. Joseph River	1	pH

2.5.6 Brownfields

Brownfields are defined by the USEPA as "real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant". Examining these sites in closer detail to determine potential future uses for the sites by cleaning up environmental hazards present, will help to protect the environment, can improve the local economy, and reduces pressure on currently undeveloped lands for future development. The EPA, States, and local municipalities often offer assistance in the form of grants and low interest rate loans for the cleanup and redevelopment of identified and potential brownfield sites.

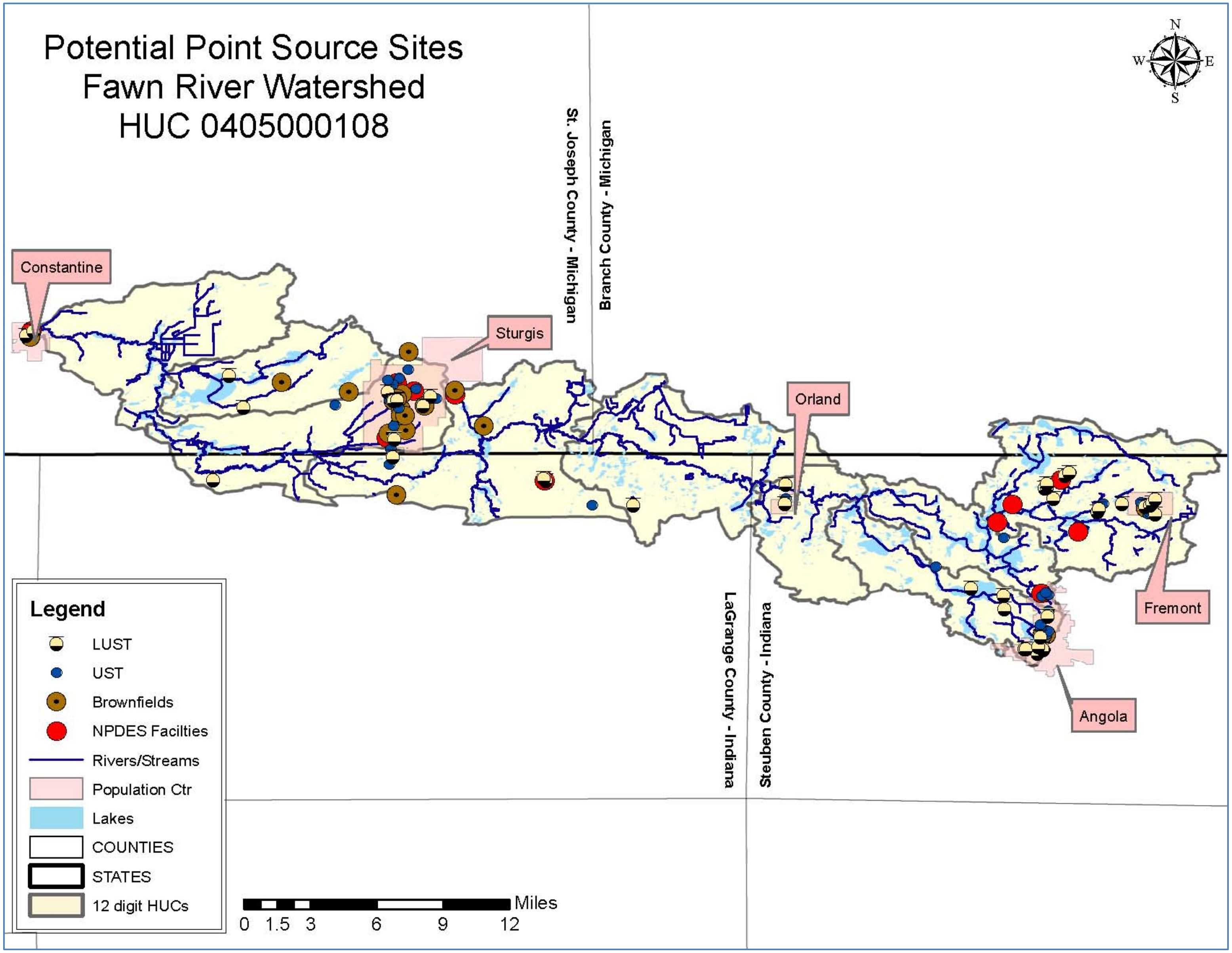
There are no brownfield sites that have a Brownfield Redevelopment Plan or that have received funding according to the state Brownfield district offices located within the Fawn River watershed. However, IDEM and MI DEQ have lists of potentially contaminated sites. There are four sites listed by IDEM as being a Brownfield and MI DEQ has listed 16 sites that are considered potentially contaminated within the Fawn River watershed. Figure 2.20 is a map delineating each specific brownfield site. The specific brownfield sites will be discussed in further detail in Section 3 of this WMP.

2.5.10 Underground Storage Tanks

An underground storage tank (UST) is a container placed under ground to store chemicals necessary to run a business or provide a service. Most USTs store gasoline, diesel, kerosene, or dry cleaner chemicals, though USTs are not limited to those chemicals alone. USTs pose a risk to the surrounding environment as they have the potential to leak (LUSTs) their contents into the soil which can leach into groundwater or surface water and contaminate them or leach into surrounding soils.

USTs are managed by the IDEM Office of Land Quality's Underground Storage Tank program and the MI Department of Licensing and Regulatory Affairs. The states are charged with insuring all USTs meet state and federal regulations so as to not contaminate surrounding land and/or water resources. The states are also responsible for making sure those tanks that do not meet requirements are properly closed or upgraded. There are currently 125 USTs located in the project area, 94 of which are currently leaking. All USTs and LUSTs located within the Fawn River Watershed are identified on the map of potential point sources of pollution in Figure 2.20. LUSTs will be discussed further in Section 3 under the respective sub-watershed.

Figure 2.20: Potential Point Sources of Pollution in the Fawn River Watershed



2.5.11: Parks

Thirty-eight parks and preserves are located within the project area totaling over 3,356 acres of land. Many of the parks are small municipal parks which are predominantly used by local residents and are supplied with playground equipment and picnic tables for the public to enjoy. However, there are a few larger trails, parks and nature preserves of note including the 1,260 acre Pokagon State Park, a large forested area along the shores of Lake James managed by the Indiana DNR, the 120 acre Fawn River Fen which provides prime habitat to many wetland animals, managed by The Nature Conservancy, the 135.2 acre Fawn River Nature Preserve managed by Acres Land Trust, and many other large preserves which provide habitat to many rare, threatened, or endangered species. The Fawn River is noted as one of the cleanest navigable rivers in Indiana by recreational enthusiasts, likely due to the amount of natural land surrounding the river and areas lakes, so preservation of these pristine properties is vital to the area's flora and fauna. Table 2.12 lists all parks located within the project area, how many acres or miles they encompass, who manages them and what type of activities are available at each site. Figure 2.21 is a map showing the location of each of the parks.

Table 2.12: Parks and Nature Preserves in the Fawn River Watershed

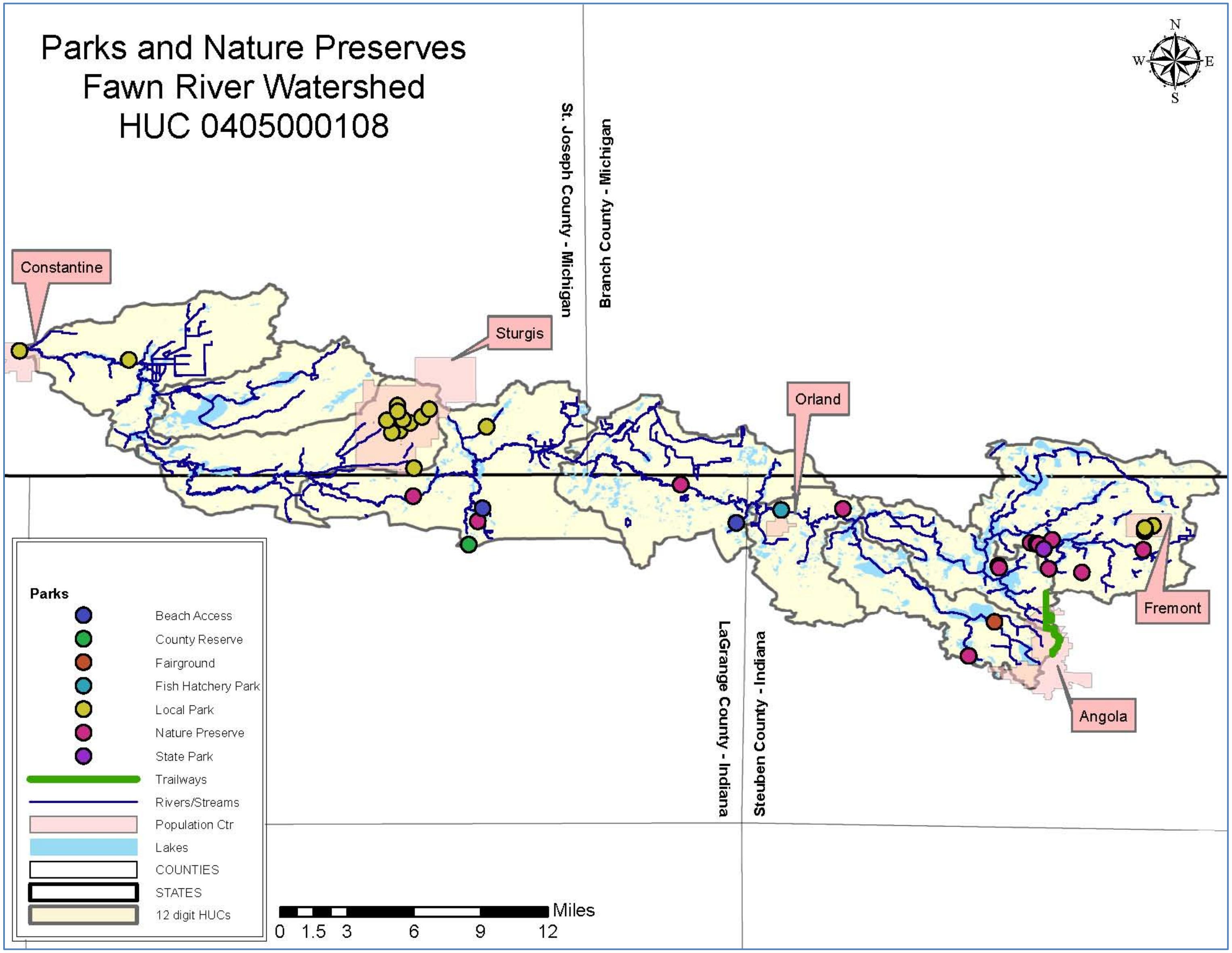
Name	Area	Ownership	Facilities/Activities
Cade Lake County Park	98 acres	St. Joseph County	Camping, hiking, beach on Cade Lake, fishing, boating, picnic area, playground
Jim Timm County Park	95 acres	St. Joseph County	Natural Area (woodland and wetland) hiking trail (more trails and boardwalk planned)
Riverview Park	Unknown	Constantine Township	Wooded Area, playground, basketball courts
Oaklawn Terrace Park	26 acres	City of Sturgis	Tree canopy, ice skating/roller skating, ampitheater, playground, picnic shelters
Arthur Carls Park	1.9 acres	City of Sturgis	playground, basketball court, picnic area
Franks Park	19.5 acres	City of Sturgis	sports complex, playground, restrooms
Free Church Park	0.6 acres	City of Sturgis	benches and floral display
Shadowlawn Park	0.5 acres	City of Sturgis	open green space
Memorial Park	3.7 acres	City of Sturgis	open green space, tree canopy, playground
Pioneer Park	0.5 acres	City of Sturgis	Marker for Judge John Sturgis, flower beds, green space
Thurston Woods	27 acres	City of Sturgis	paved trail, picnic areas, open green space, picnic shelters, wooded area, and playground

Name	Area	Ownership	Facilities/Activities
Old Depot Park	2.3 acres	City of Sturgis	Museum, gazebo, picnic area, and playground
Langrick Park	1.8 acres	City of Sturgis	Playground, basketball, sand volleyball, tennis, and handball courts
Cedar Lake Beach	Unspecified	LaGrange County	Unstaffed lake swimming access
Wall Lake Beach	Unspecified	LaGrange County	Unstaffed lake swimming access
Duff Nature Preserve	Unspecified	LaGrange County/Acres Land Trust	Wetland Nature Preserve on Cedar Lake
Pine Knob Park	99 Acres	LaGrange County	Hunting and fishing, archery targets, hiking, fishing, picnic area, wetlands
McClue Nature Preserve	80 acres	Steuben County Commissioners/ Acres Land Trust	30 acres of old growth forest, nature trails, parking lot
Steuben 4-H and Campground	Approx. 60 acres	Steuben County	Buildings and facilities for the annual Steuben County 4-H Fair and seasonal recreation/education. Horse and Pony arenas, managed turf grass/green space. Large oak trees along shore of Crooked Lake.
Fremont Town Park	Unspecified	Town of Fremont	Baseball diamonds, open green space, playground, and pavilion
Fremont Moose Skate Park	Unspecified	Town of Fremont	Open green space, skateboarding facility
Fremont Vistula Park	Unspecified	Fremont Schools	Baseball diamonds, tree cover, walking trails, playground
Broad Street Youth Park (proposed)	Unspecified	Town of Fremont	Open green space, tree canopy, pond, paved walking trail, semi-natural setting, pavilion, ball diamond, (connects to Moose Skate Park)
Angola Recreational Trailway	Approximately 1.5 miles (add. 1.3 mi. proposed)	City of Angola	Paved walking/biking trail
Fawn River Nature Preserve	135.2 acres	Acres Land Trust	Old growth and 2nd growth forest, Fawn River, 1.5 mile walking trails, wildlife and bird watching, parking lot
Beechwood Nature Preserve	89.8 acres	Acres Land Trust	Forest and meadow, 1.7 mile walking trail, wildlife and bird watching, parking lot

Name	Area	Ownership	Facilities/Activities
Foster Nature Preserve	2.7 acres	Acres Land Trust	Little Otter Lake, forest, access from Beechwood NP, 0.1 mile walking trail, wildlife and bird watching
Manjeri Nature Preserve	0.8 acres	Acres Land Trust	Little Otter Lake, forest access from Beechwood NP, 0.1 mile walking trail, wildlife and bird watching
Ropchan Wildlife Refuge and Nature Preserve	184 acres	Acres Land Trust/ INDNR Division of Fish and Wildlife	Cemetary Lake, adjacent to INDNR wetland conservation area, old and new growth forest, wetlands, 4.7 mile walking trail, platform at lake for wildlife and bird watching, parking lot
Ropchan Memorial Nature Preserve	79 acres	Acres Land Trust	Forest, wetland, wildlife and bird watching, wildlife viewing, 1.3 mile walking trail, parking lot
Wing Haven Nature Preserve	262.5 acres	Acres Land Trust	Seven Sisters Lake, 19th century log buildings, 1.9 mile walking trail, wetland fens, forest, meadows, wildlife and bird watching, wildlife viewing, parking lot
Fawn River Fen	120 acres	The Nature Conservancy	Fawn River, grass sedge fen, wildlife and bird watching
Pokagon State Park	1,260 acres	IN Dept. of Natural Resources	Lake James and Snow Lake access, Lake James beach, 1.6 mile bike trail, 11 mile walking trail, boat rental, camping, fishing, inn/lodge, nature center, picnic areas, saddle horses and 2 mile trail, Tobaggan Run, cross country sking, sledding, ice skating, wetlands and forest
Trine State Recreation Area	186 acres	IN Dept. of Natural Resources/ 101 Lakes Trust	Forest, 3.5 mile walking trail, sledding, Gentian Lake access and canoe rental, lodge and cabins
Loon Lake Nature Preserve	99 acres	INDNR, Division of Nature Preserves	North shore of Loon Lake, parking lot, walking trail, forest, meadow, and wetland areas (home to several threatened and endangered plant species), wildlife and bird watching
Potawatomi Nature Preserve	256 acres	INDNR, State Parks and Reservoirs	Located within Pokagon State Park, old growth forest, marsh and wetland areas, forest, Pokagon hiking trails pass through the preserve

Name	Area	Ownership	Facilities/Activities
Marsh Lake Nature Preserve	103 acres	INDNR, Division of Fish and Wildlife	Parking lot, no hiking trails, hunting in season, wetland habitats, old growth forest
Fawn River Fish Hatchery	Unspecified	INDNR	Fish rearing ponds, green space, access to Fawn River and fishing along property from the River, self-guided tour of facility and informational signs at each pond

Figure 2.21: Parks and Nature Preserves in the Fawn River Watershed



2.6 Previous Watershed Planning Efforts

The Fawn River watershed is a unique watershed due to the many lakes and natural setting of the Fawn River. The hydrologic features of the watershed are used extensively by local residents and tourists, which puts additional stress of the water resources. For these reasons, the Fawn River and its tributaries, as well as the lake system are important to understand and protect. There have been many studies conducted on the lakes of the area to control invasive aquatic plant species and sedimentation, but few studies of the river system and the surrounding land uses have been conducted. There are also few city and county master plans that have been written to outline problems and threats to our natural resources, and propose ways of protecting those resources in the watershed. This section provides a description of each of the previous studies and watershed planning efforts that have been conducted over the past decade. Figure 2.23 delineates the jurisdiction of each of the studies or plans that have been conducted in the watershed.

2.6.1 City and County Management Plans

The purpose of Municipal Management Plans is to identify potential issues in the area and determine a means of addressing those issues. All counties within the Fawn River Watershed have comprehensive or master plans, however not all populated areas do; Orland and Constantine do not have Plans.

Branch County Master Land Use Plan

The Branch County Master Plan was first written in 1974 and updated in 1997 by the Branch County Planning Commission in cooperation with the South-central Michigan Planning Council. The Master Plan outlines two concerns that can be connected to this project including prime agricultural land being utilized for development and the lack of tourism opportunities in the county relating to the many lakes located within the county. The Master Plan identified several potential opportunities to address the concerns, which are listed below.

- Encourage cooperation between agriculture and lake property owners with regard to water issues, where water quality is the most important issue for the future.
- Land that is not suited for agriculture should be developed for recreation.
- Work with Tourism Bureau to promote advantages of the county including the great fishing opportunities in the many lakes of the county.
- Provide recreation facilities to preserve and enhance the County's natural features by encouraging:
    - Control lakeshore and stream bank development
    - Encourage conservation and protection of natural areas
    - Prohibit floodplain development except for recreational purposes

The objectives outline in the Branch County Master Plan will help to address identified stakeholder concerns including an increase in impervious surfaces, lakes in the area becoming more developed, wetland conservation and streambank erosion.

St. Joseph County Michigan Master Plan

The St Joseph County Planning Commission, recognizing the fertile soil and abundance of ground water for irrigation, developed a County Master Plan in 1997 focusing on the protection of prime farmland within the county, while also taking into account the natural resources of the area. Several of the goals established during the development of the Master Plan are directly related to concerns expressed by the Fawn River Project Steering Committee. Those goals are listed below.

- "Provide for the development of sanitary sewers, improved sanitary disposal systems…"
- "…encourage long-term commitments to environmentally sound agricultural activities…"
- "Encourage intensive livestock operations …to locate away from areas prone to flooding."
- "Do not over-plan or over-zone for commercial (or industrial) development."
- "Establish a minimum setback for vegetative buffer along lakeshore or stream (and septic tanks and drainfields)."
- "Direct animal grazing landward of the vegetative buffer strip (along lakeshores and streams)."

The St. Joseph County Planning Commission has been updating their Master Plan regularly. The last update was completed in 2007 and it had a stronger focus on environmental conservation and preservation including such goals as maintaining a 1:1 ratio of "built-up" area and open and/or green space. The 2007 update also included a map of areas where increased sewer system capacity is necessary to maintain the integrity of the surrounding natural resources. Figure 2.20 is a map, taken from the 2007 Master Plan update, showing where the current wastewater treatment plants are and where new or expanded systems should be constructed to meet the projected population growth. The blue oval drawn on the map represents the approximate area of St. Joseph County located within the Fawn River project area.

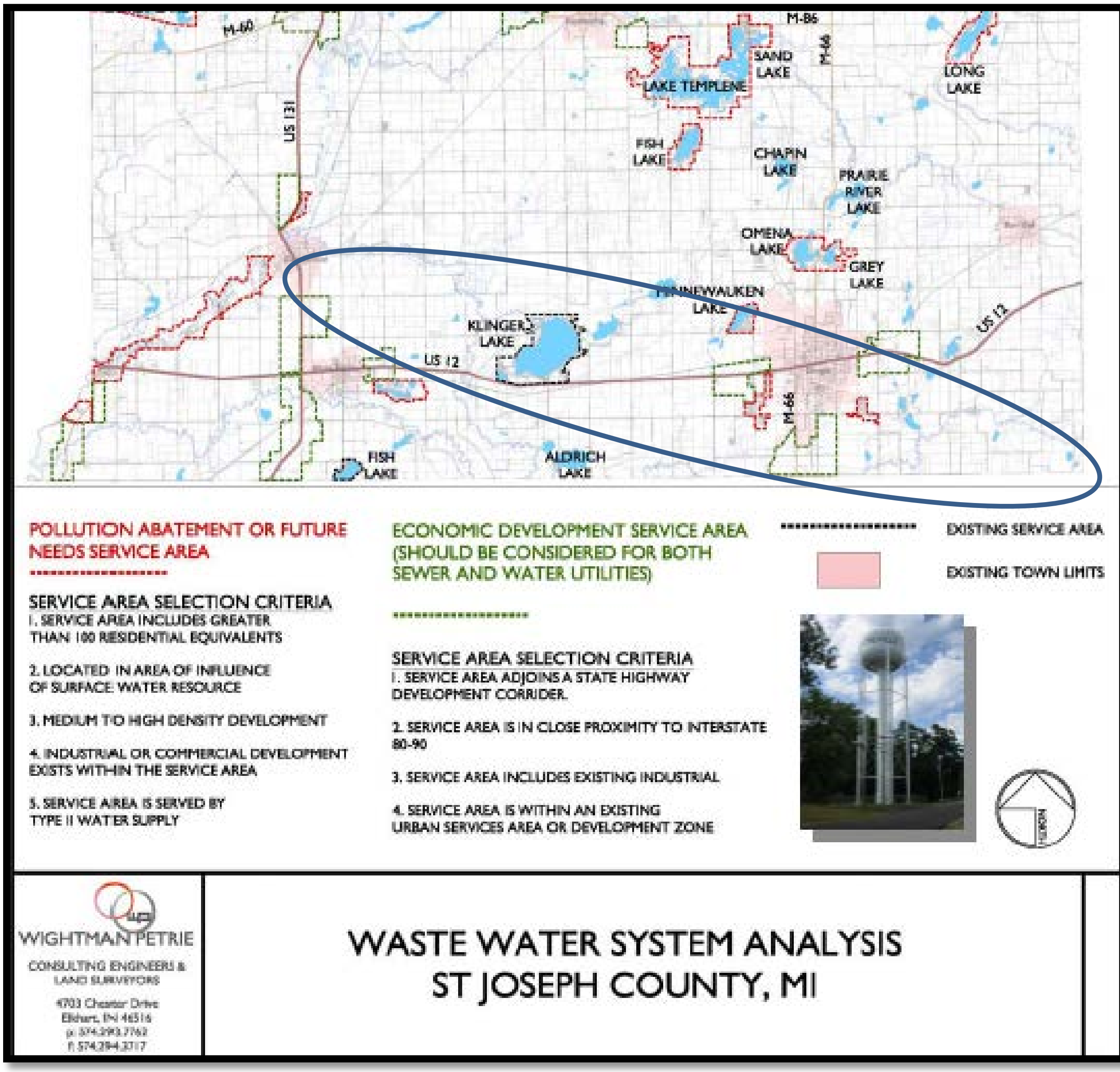
LaGrange County Comprehensive Plan

On December 6, 2010, the LaGrange County released their Comprehensive Plan. The Plan consists of two major subsections; the Planning Foundation and the Land Use Plan. The Planning Foundation takes natural resources into account, recognizing the uniqueness of the landscape of the county, where the Land Use Plan outlines strategies to limit the impact of urban sprawl and other construction activities on the natural environment. Goals and concerns outlined in the Plan that relate to the concerns of stakeholders in the watershed are:

- "New development will be built in a manner that maintains the integrity of the natural environment"
- "Water and water quality are valuable resources to the county both as a source of recreation and lifestyle but also as a life necessity"
- "…Urban sprawl will be minimized"
- "…poorly installed groundwater wells, placement of waste removal systems, improper manure management, or uncontrolled storm water runoff can create safety hazards…"
- "Encourage commercial uses, which are not associated with homes or farms, to locate on paved roadways"
- "Development of residential uses should be permitted at densities not to exceed two units per acre where adequate sanitary sewer services are available…housing units that have no access to sanitary sewer services should be restricted to one unit per acre…"

LaGrange County recognizes the value of the lake system and natural resources they have available in the county and have planned for their preservation to the best of their ability in the County Comprehensive Plan.

Figure 2.22: Existing and Planned Waste Water Treatment Services in St. Joseph County



Steuben County Comprehensive Plan

The Steuben County government saw a need to update the Old County Master Plan in 2005 as the area continued to grow due to the high quality of life, lakes, and other natural resources in the county. The Steuben County Comprehensive Plan was completed and adopted by the county government in 2006. Two aspects of the county Plan are relevant to the Fawn River

Watershed planning project, those are to manage growth of the county and nurture environmental quality.

Several objectives and actions in the Plan address issues described by the Fawn River stakeholders. Those objectives and/or actions are as follows:

- Require cluster designed residential development and allow incentives to developers who do so while protecting and enhancing environmental features
- Establish policies that require new residential properties to connect to centralized sewer systems when developed within a reasonable proximity to infrastructure
- Discourage residential sprawl
- Update the Zoning Ordinance to aid in the preservation of natural areas
- Create a visioning audit to identify ecological resources, open spaces, agricultural districts, buffer zones, green ways, and wildlife areas
- Buffer sensitive land uses from new commercial and industrial developments.
- Protect the water quality in the streams, lakes, and their watersheds
- Encourage the planting of native shade trees and evergreen trees to soften the impact of noise (which will also aid in stormwater uptake)
- Minimize conflicts between growth and the environment
- Conserve existing natural areas including woodlots, wildlife habitat, riparian corridors, littoral corridors, open spaces, wetlands, and floodplains

Steuben County Ordinance for Storm Drainage and Erosion Control

Under Ordinance number 673, Steuben County was responsible for the development of a plan to manage storm water runoff in the county. As stated in the ordinance the purpose of the ordinance is to "reduce the hazard to public health and safety caused by excessive stormwater runoff, to enhance economic objectives, and to protect, conserve and promote the orderly development of land and water resources within the regulatory area". The regulatory area of the ordinance includes all of Steuben County.

The ordinance outlines regulations regarding open channel design, stormwater detention, and erosion and sediment control. All activities in the ordinance will not only meet the objectives outlined above, but will also improve water quality by limiting the amount of stormwater which can carry pollutants to open water sources.

Angola Indiana Comprehensive Plan

Recognizing the importance of strategic planning to a vital and thriving city, Angola Planning Commission worked with consultants to devise a comprehensive plan for the City of Angola. The Plan was adopted by the Angola City Council in October, 2012. Part Two of the Plan outlines concerns and objectives, some of which relate to Fawn River stakeholder concerns including:

- Requiring all new structures to connect to public waste disposal system
- Encourage use of abandoned and under-utilized buildings prior to permitting new construction for businesses
- Require setbacks of development from environmentally sensitive areas
- Incentivize for conservation and preservation of environmentally sensitive areas
- Maintain stormwater management and erosion control ordinances

- Encourage development that reduces the city's environmental footprint

Fawn River Watershed stakeholder concerns, such as the increase in impervious surfaces, septic system discharge, wetland conservation, and streambank erosion will be partially addressed in the City of Angola if the objectives outlined in the Comprehensive Plan are met.

Angola Parks and Recreation 5-Year Master Plan

The City of Angola Parks and Recreation Master Plan was adopted in 2013 and is due to be updated in 2017. The Master Plan addresses several concerns of the Fawn River watershed stakeholders including:

- Preventing development on floodplains and in wetlands
- Maintaining their "Tree City USA" program
- Acquisition of the "center Lakes" area on the northwest edge of the city to add it to the city's park system as a nature preserve.

While the Angola Parks Department has some plans to maintain existing environemental projects and possibly acquire additional natural areas, it does not seem to take full advantage of the potential of the environmental resources of the area including prime wetland locations and other green spaces.

Fremont Comprehensive Plan

The Town of Fremont developed a draft Comprehensive Plan in 2013 with input from the Town of Fremont government and over 200 residents of the town. The Plan recommends a thorough review of the Comprehensive Plan by the Fremont Plan Commission and Town Council before 2024. There are several recommendations in the Comprehensive Plan that are in line with concerns expressed by the Fawn River stakeholders including:

- Require all new construction within the Town limits be hooked up to a centralized sewer system
- Protect conservation areas and provide incentives to preserve environmentally sensitive areas
- Establish stormwater management and erosion control ordinances
- Encourage development practices that reduce the town's footprint on the environment
- Encourage the use of native plants for new developments

If the above objectives in the Comprehensive Plan are met some of the stakeholder concerns will be addressed including wetland conservation, streambank erosion, increase in impervious surfaces, and septic system discharge.

(Sturgis) Master Plan of Future Land Use

The city of Sturgis, Michigan developed a landuse master plan to address concerns of residents, as well as, maintain and improve existing conditions of the city. The Master Plan addresses two if the Fawn River Watershed's stakeholder's concerns including an increase in impervious surfaces and wetland conservation by listing the following objectives within the Master Plan;

- "Preserve, protect, and improve historic, natural, scenic, or environmentally sensitive areas for appropriate public use and enjoyment and habitat protection."
- "Upgrade and maintain existing industrial areas" with the intention of utilizing existing structures prior to construction of new industrial facilities.

2.6.2 Watershed Management Plans

St. Joseph River Watershed Management Plan

There is only one watershed management plan that includes any of the Fawn River; the St. Joseph River Watershed Management Plan. The Friends of the Saint Joe River Association, a 501(c)3 organization, completed a watershed management plan for the entire St. Joseph River watershed (HUC 04050001) in 2005. The watershed is 4,685 square miles and includes 15 counties in Michigan and Indiana. Because of the large size of the watershed, the WMP is vague in its description of the Fawn River watershed and the water quality problems in the watershed. However, the plan noted the Fawn River watershed as being critical for agricultural practices that degrade water quality. Using a SWAT model, it was determined that the most effective BMPs to limit NPS pollution from entering the Fawn River are no-till practices, and edge of field filter strips. The WMP also recognizes the LaGrange County SWCD for its efforts to reduce sediment, nutrient, and pathogen contamination of surface water by implementing a livestock management program.

Michigan Great Lakes Plan

The Great Lakes provide vast opportunities to Michigan and are the driving force to its economy. Due to the importance of the Great Lakes to the economy and health of the state of Michigan, the Michigan Office of the Great Lakes prepared the MI Great Lakes Plan (MiGLP) which was completed in January, 2009. Many problems outlined in the MiGLP are in line with concerns voiced by Fawn River stakeholders such as controlling NPS, protecting and restoring wetlands, sustainable living (including development), and excluding phosphorus from lawn fertilizers. The MiGLP outlines specific objectives and recommendations to accomplish the goal of protecting the overall health of the Great Lakes, including reducing pollution discharging into the Great Lakes via their tributaries. The MiGLP also describes potential partners and funding sources to accomplish the goals.

2.6.3 Lake Management Plans

There are eleven lakes located within the Fawn River watershed that have had studies and/or management plans written for them. Most of the plans involve sediment control and/or removal, and aquatic vegetation management. A brief description of those plans is below. A

Crooked Lake

- Crooked Lake Monitoring Study
    - JF New, an environmental consulting firm, was hired by the Crooked Lake Association to conduct water quality analysis at three sample sites in 2003. One on a Loon lake tributary, on Carpenter Drain, and on Palfreyman Drain. Parameters collected included pH, Dissolved Oxygen, Temperature, Nitrogen, Phosphorus, Total Suspended Solids, and *E. coli*. The water quality analysis indicated that the water feeding into Crooked Lake is in full support of aquatic life as the parameters tested measured below the recommended target limits.

- Crooked Lake Engineering Feasibility Study
    - Based on a previous monitoring study of Crooked Lake, the Crooked Lake Engineering Feasibility Study looked at five potential projects to address sedimentation issues in Crooked Creek. These included streambank stabilization of Carpenter Drain, stormwater management at the 4-H Park, stream reconstruction at Palfreyman Drain at the Highway Department, facility, and eight potential wetland restoration projects. The study concluded that all projects were feasible except for the wetland restoration due to the lack of landowner participation. Completed projects are described below.
- Carpenter Drain Design/Build Report
    - In 2005, JF New, an environmental consulting firm, stabilized approximately 200 lineal feet of eroded bank and removed large pieces of debris in the channel which were the major sources of the erosion problem. JF New recommended monitoring of the site for the next five years. A follow-up report was not completed for this site.
- Steuben County 4-H Park, Stormwater and Sediment Reduction Design Project
    - JF New, an environmental consulting firm installed four raingardens, 462 linear feet of french drains which empty into the raingardens, adjacent to two service roads, 200 feet of eroding roads were paved including the addition of a curb to direct stormwater runoff, two catch basins (dry wells were installed, the project also called for the installation of a woodland berm for stormwater storage. Construction of most of the features was completed by November 2006.
- Crooked Lake Aquatic Vegetation Management Plan (AVMPs)
    - Crooked Lake Association began hiring a consultant to write AVMPs in 2007 when the DNR first identified nuisance plants within the Lake, specifically the invasive species including Starry Stonewart, Eurasion Watermilfoil, and Curly Pondweed. The latest AVMP for Crooked Lake was written in 2013. It is estimated that approximately 10% of Crooked Lake has been invaded by these three invasive plant species. The AVMP provides suggestions on the best use of funds and treatment areas to control the spread of the nuisance aquatic plants.

Lake George

- Aquatic Vegetation Management Plan Update 2013; Lake George
    - The Lake George Cottagers Association hired a contractor in 2006 to develop an AVMP for Eurasion watermilfoil. Most of the areas of concentrated watermilfoil have been treated annually since 2007. However, in 2009 Starry stonewart, another invasive plant species was discovered on Lake George. The AVMP was then updated to include the new plant species. The AVMP provides suggestions on the best use of funds and treatment areas to control the spread of the nuisance aquatic plants.

Lake James Chain

- Lake Diagnostic Study; Lake James, Snow Lake, Big Otter Lake, and Little otter Lakes
    - A diagnostic study was conducted on four lakes in the Lake James chain of lakes in 2006 to measure water quality and assess land use in the watershed that may impact water quality. Water quality and land use results indicated a need to control nutrient loading and invasive aquatic plant species in the lakes. Several recommendations were made to help improve water quality including;
        - Control invasive wetland and aquatic plant species
        - Network with Lake associations to improve overall water quality
        - Investigate the possibility to conduct a monitoring study to determine the impact of wastewater effluent

        - Avoid the redirection of stormwater drainage from other watersheds to the Lake James watershed
        - Implement a Lake resident education program about proper land and shoreline management
        - Work with NRCS and SWCD to implement best management practices on highly erodible land
        - Increase water quality sampling on the Lakes
    - Other more specific recommendations were also provided in the study including the following, a map of priority areas can be found on page 176 of the Study;
        - Stabilize the shore of Lake James, Croxton Ditch, Walter's Lake Drain, Follet Creek, and Crooked Creek watersheds.
        - Restore wetlands in Croxton Ditch and Walter's Lakes Drain watersheds
        - Protect wetlands and insure the practice of proper erosion control on disturbed lands
- Phase II – Engineering Feasibility Study and Engineering Design
    - The Middle Croxton Ditch running through the Lake James Golf Club properties has a lot of sediment due to streambank erosion. This study was conducted to learn the feasibility of reducing sediment loading into the Croxton Ditch, thus into the Lake James Chain. A engineering design was developed to restore approximately 840 linear feet of Croxton Ditch within the Golf Club property. The Steuben County Surveyor was granted funds to implement the design in 2014. The Study also determined that it would be feasible to conduct four dredging projects at an irrigation pond and sediment trap at the Gold Club.

Jimmerson Lake

- Jimmerson Lake Diagnostic Study
    - The Jimmerson Lake Association received a IN DNR grant to conduct a diagnostic study to learn the potential problems in the Lake and hired Commonwealth Biomonitoring to conduct the study. Problems identified within the Jimmerson Lake watershed and potential solutions include;
        - High percentage of highly erodible land surrounding the land which accounts for excessive erosion of land surrounding the lake and may contribute to the sediment loading in the lake
        - Stormwater runoff from Buena Vista area on the north shores of the lake contributing high nutrient and sediment loadings
        - More speed boats are used on Jimmerson Lake when compared to other Indiana lakes which may disrupt native emergent aquatic vegetation in the lake.
        - Concrete seawalls contribute to shoreline erosion and loss of aquatic plant and animal diversity
        - The many wetland and forested areas surrounding the lake should be purchased by the Jimmerson Lake association and be managed as conservation areas
        - Over 90% of the watershed upstream of Jimmerson Lake does not have any landuse planning. All lakes in the watershed should implement a lake management plan, including surrounding landuse management.

- Lake and River Enhancement Engineering Feasibility Study for Jimmerson Lake
    - Donan Engineering, Inc was contracted by the Jimmerson Lake Association to conduct and engineering feasibility study to install management practices that would prolong the life of the lake. The proposed practices to mitigate pollution problems in Jimmerson Lake include;
        - Sediment basins to capture sediment from the highly erodible land used for agriculture in the watershed in Section 5 of Pleasant Township
        - Conserve the many valuable wetlands surrounding Jimmerson Lake by purchasing a conservation easement for wetland areas that are slated for development
        - Install "No Wake" buoys at key locations to protect aquatic vegetation beds and the lake's shoreline
        - Implement an education and outreach program to educate the public about stormwater discharges and their impacts on water quality
        - Develop and enforce construction site ordinances to prevent erosion and ensure sediment does not discharge into open waters
- 2013 Aquatic Plant Management Plan Update for Jimmerson Lake
    - The first AVMP written for Jimmerson Lake was in 2005 and an update was written in 2006, 2008, 2012, and 2013. According to the 2013 update, Jimmerson Lake is oligotrophic, which indicated relatively good water quality. The lake has been colonized by the invasive species of Eurasion watermilfoil, curlyleaf pondweed, and starry stonewort. Another, non-native plant has been identified in the lake, spiny naiad, however it does not appear to be a prolific grower and does not appear to be a threat. Over 20% of the lake was noted as having starry stonewort. Eurasion watermilfoil and curlyleaf pondweed are prolific growers, though do not cover as much of the lake as does starry stonewort. The Jimmerson Lake Association has received IN DNR funding since 2005 to treat invasive aquatic vegetation in the lake. The 2013 update provides recommendations of where the most effective area of the lake is to treat invasive species.

<u>West Otter Lake</u>

- West Otter Lake Aquatic vegetation Management Plan Update 2013
    - The West Otter Lake Association acquired IN DNR funding to complete an AVMP, which was completed in 2005. An update to the AVMP was completed in 2006, 2012 and 2014. The invasive species of Eurasion watermilfoil and curlyleaf pondweed have colonized in West Otter Lake. Spiny naiad, another non-native aquatic plant species, is present in the Lake but does not pose a threat to the integrity of the lake. The 2013 update recognizes that in areas of dense growth of the lake, surface mats of the invasive species exist and impede recreational activities, specifically in the northwest portion of the lake near the public access site and on lake channels. The AVMP update provides recommendations of areas to treat the invasive species that would make the greatest impact to controlling the spread of the plants.

<u>Lake Gage and Lime Lake</u>

- Lake Gage and Lime Lake Engineering Feasibility Study
    - The Lake Gage and Lime Lake Association received an IN DNR grant to conduct an engineering feasibility study to determine the most effective means of reducing sedimentation of the two lakes in 2004. The study was conducted in three parts; 1) Habitat restoration of Concorde Creek, the main tributary to Lime Lake, 2) Wetland

integrity scoring and how the Concorde Creek project would affect the wetlands, 3) Restoration of a natural watercourse which was dredged and straightened that flows through a natural wetland area at the southeast end of Lake Gage. It was determined that streambank restoration of Concorde Creek would reduce sedimentation of Lime lake and improve the quality of surrounding wetlands and that restoring the natural watercourse would also reduce erosion and sedimentation of Lake Gage.

- Concorde Creek Channel Restoration Project Design Report
  - Following design specifications outlined in a 2008 Design project for Concorde Creek by JF New for the Lake Gage and Lime Lake Association, approximately 578 feet of channel in Concorde Creek was restored to its historic meander. To accomplish this, three earthen dams and reconstruction of the channel took place. The restored stream has better access to the natural floodplain which will allow for nutrients and sediment to settle out prior to being discharged into the lake. Also, nearly 400 feet of eroding channel was filled and native vegetation was planted to eliminate sedimentation from that area. It is expected that native flora and fauna habitat has been restored in this section of Concorde Creek and that nutrient and sediment loading to Lake Gage will be significantly reduced.
- Lake Gage and Lime Lake Aquatic Vegetation Management Plan
  - The Lake Gage and Lime Lake Association contracted Aquatic Weed Control to conduct a vegetation survey and propose a management plan to address any invasive species colonies found during the survey in 2012. Eurasian watermilfoil was found in the two lakes, mainly in areas with depths less than 10 feet and curlyleaf pondweed was found in Lime Lake. The frequency of Eurasian watermilfoil was up to 11.4% in Lake Gage and 30% in Lime Lake. The frequency of the plant in the two lakes is relatively low when compared to other Indiana lakes, so recommendations were made to monitor the growth of the plant only, and not spend funds to treat it at this point. However, specific recommendations were provided in the AVMP to maintain the lakes' integrity.
    - Reduce Eurasian watermilfoil to 10% or less in Lime Lake
    - Maintain Eurasian watermilfoil below 10% in Lake Gage
    - Maintain 8 native plant species in Lime Lake
    - Maintain 6 native plant species in Lake Gage

<u>Wall Lake</u>

- Lake Diagnostic Study
  - The Wall Lake Fisherman's Association, in conjunction with the IN DNR Division of Fish and Wildlife, contracted Aquatic Enhancement and Survey, Inc in 2005 to conduct a study of the lake's biological and chemical integrity. Based on findings during the water quality and landuse investigation the following recommendations were given;
    - Seek long term, legal protection of surrounding wetlands and woodlands
    - Begin a program to control purple loosestrife and prevent the spread of invasive plants into wetlands
    - Continue fish management activities and assess the 2005 walleye stocking of Wall Lake
    - Seek to connect Wall Lake residents to a central sewer system
    - Enhance wetland habitat in the watershed
    - Work with NRCS and SWCD staff to install best management practices on agricultural land in the watershed
- Aquatic Vegetation management Plan Update 2014

- Wall Lake Fisherman's Association first acquired grant funds from the IN DNR in 2005 to write an AVMP, which was completed in 2006. Since the first AVMP, an update has been completed in 2007, 2008, 2009, 2012, and 2014. Eurasion watermilfoil, starry stonewort, and curlyleaf pondweed have all been introduced to Wall Lake. Starry stonewort is a relatively new species in Wall Lake and treatment for this species first began in 2010. A terrestrial invasive plant species, purple loosestrife, has also begun to establish itself in surrounding wetland areas. Recommended treatment areas and rates of application are outlined in the AVMP. Specific recommendations to control the growth of invasive plant species in Wall Lake include;
    - Limit the occurrence of curlyleaf pondweed and Eurasian watermilfoil in late season sampling to 5% or less
    - Maintain a minimum of 10 native plant species with a diversity rate of 0.80

Cedar Lake

- Cedar Lake Diagnostic Study
    - The IN DNR Lake and River Enhancement staff performed a diagnostic study of Cedar Lake in 2009 and 2010, with the final report being released in 2010. The study found that the water quality is generally good and clear. There is little diversity in aquatic vegetation, and presents few recreational barriers, except for a few midsummer algae blooms. There is a diverse group of fish species found in Cedar Lake, which keeps the fishery at a satisfactory level. The study state's that the lake is only 70% built-up, which is far less built up than surrounding lakes and the Lake is surrounded by pristine wetlands which may filter many pollutants out prior to stormflow reaching Cedar Lake. The study suggests several steps to take to maintain the high quality of Cedar Lake including:
        - Promotion of BMPs to Lake residents such as;
            - Phosphorus free fertilizer
            - Shoreline habitat improvement
            - Installation of rain gardens and rain barrels to capture stormflow
            - And preventative maintenance of septic systems
        - Take precautions to avoid spreading aquatic invasive species
        - Maintain a volunteer base to take regular water quality samples through Hoosier Riverwatch
        - Protect and promote the importance of surrounding wetlands
        - Partner with LaGrange county SWCD and surveyor to promote BMPs to limit erosion of nutrients and sediment from agriculture, timber harvest, and construction projects.

      Following the above recommendations, not only in the Cedar Lake watershed but throughout the lake community, will help to address Fawn River stakeholder concerns such as wetland conservation, lack of no-till and cover crop practices, septic system discharge, and urban fertilizer use .

2.6.4 Other Studies

St. Joseph River Watershed Fish Migration Barrier Inventory

The Potawatomi Resource Conservation and Development Council (RC&D) conducted a study, which was published in 2011, of culvert, dams, and bridges located within the St. Joseph, Lake Michigan watershed to determine if the structures posed a problem for the necessary migration of aquatic life. The study used a scoring method on the impact the structures had on aquatic habitat, whether or not a partner agency or organization put priority on a particular structure, the cost of removal or modification to the structure, and a social score to determine the purpose of the structure. Then the scores were used to determine the priority of removal or modification to the structure.

Results from the study indicated that one hydroelectric dam, the Star Mill Dam, located on the Fawn River in LaGrange County was a high priority for removal or modification. The results of the study also indicated that there were four culverts located on the Fawn River that did not allow the passage of some aquatic species (three in LaGrange County and one in St. Joseph County) and one culvert that became a barrier at high flows in LaGrange County. The study suggests further investigation of these sites to determine the best means of modifying them to allow for the safe passage of aquatic life.

Fawn River Restoration

It has been estimated that approximately 100,000 cubic yards of sediment was released in 1998 from the Fawn River Fish Hatchery when their fish pond dams needed to be lowered to allow for repairs. The sediment covered what was a gravel floor, and filled a deep thalweg, which buried prime aquatic habitat. Landowners adjacent to the Fawn River sought funding for restoration efforts, which was awarded to the landowners in 2011. The funds were put into the Fawn River Restoration and Conservation Charitable Trust (Trust).

The Trust hired an environmental consulting firm to do the restoration. Sediment was removed and the thalweg was restored. Additionally, large woody debris structures were installed to restore the sinuosity of the stream. The restoration work looks to be effective and the Trust plans to expand restoration efforts to other areas of the Fawn River.

2.6.5 Wellhead Protection Plans

The majority of the rural community utilizes private water wells located on their property. Smaller incorporated areas and villages also acquire their drinking water from groundwater wells; however those wells are overseen by the State environmental regulating agency. Those communities are commonly known as community public water supply systems (CPWSS). A CPWSS is designated as such if it has 15 service connections or supplies drinking water to at least 25 people, according to the federal Safe Drinking Water Act. The entity controlling the system is required to develop a Wellhead Protection Plan (WHPP). A WHPP must contain five elements; 1) Establishment of a local planning team, 2) Wellhead Protection Area Delineation of where ground water is being drawn from, 3) Inventory of existing and potential sources of contamination to identify known and potential areas of contamination within the wellhead protection area, 4) Wellhead Protection Area Management to provide ways to reduce the risks found in step three, and 5) Contingency Plan in case of a water supply emergency. It is also important to identify areas for new wells to meet existing and future water supply needs. There are two phases of wellhead protection. Phase I is the development of the WHPP which involves delineating the protection area and determining sources of potential contamination. Phase II is the implementation of the WHPP. Table 2.13 identifies those CPWSSs located within the project area and which phase they are currently in. A map of well head protection areas in Indiana is not available since the delineation of such areas is not made public; however an approximate location of the WHPP was used and is delineated on a map which can be found in Figure 2.23. Michigan has made available the delineation of wellhead protection plans which are also outlined in the below figure.

Table 2.13: Wellhead Protection Plans in the Fawn River Watershed

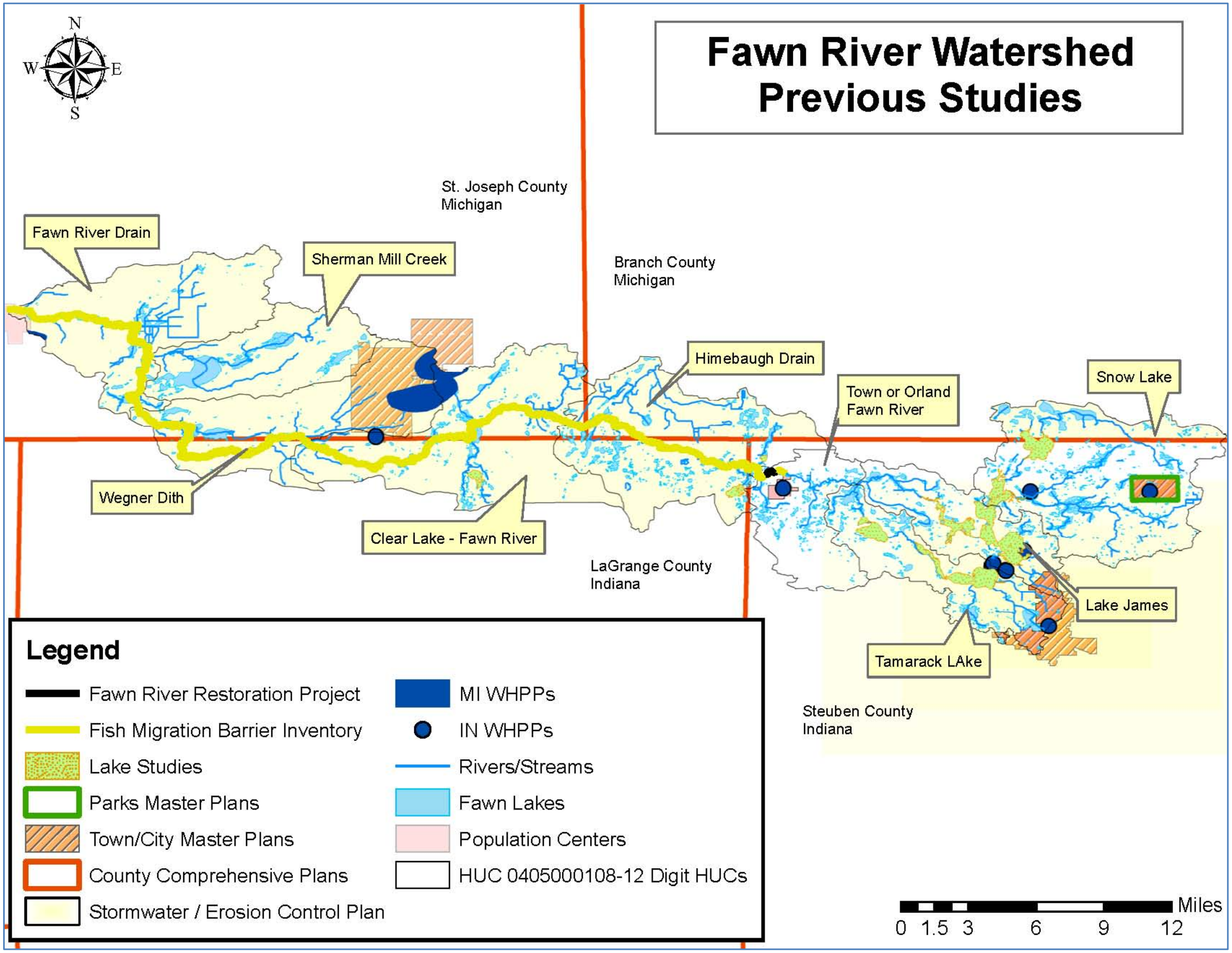
System Name	Population Served	Source	Phase	Watershed
Constantine	2095	GW	Unknown	Fawn River Drain
Sturgis	11920	GW	Unknown	Wegner Ditch
Memory Lane Mobile Home Park	568	GW	Unknown	Wegner Ditch
Fawn River Crossing	587	GW	Phase II	Wegner Ditch
Angola Water Department	8276	GW	5 yr update	Tamarack Lake
Fremont Water Department	1697	GW	Phase II	Snow Lake
Mobil-Rama	30	GW	Phase II	Snow Lake
Or-An Tc/Cleveland Tr. S.	46	GW	Phase II	Lake James
Linda Ann Mobile Home Court	30	GW	Phase II	Tamarack Lake
Leisure Lakes Mobile Home Court	27	GW	Phase II	Lake James
Orland Water Works	341	GW	Phase II	Town of Orland-Fawn River
Coachlight Mobile Home Court (Lots 1-18)	48	GW	Phase II	Lake James
Glen Eden Association	35	GW	Phase II	Lake James

2.6.6 Municipal Separate Storm Sewer System

The federal Clean Water Act requires storm water discharges from larger urbanized areas to be permitted under the National Pollutant Discharge Elimination System (NPDES) program. These communities are referred to as Municipal Separate Storm Sewer System (MS4) Communities and are required to develop a Storm Water Quality Management Plan.

The City of Angola and Trine University are co-permitted and is the only entity located within the project area designated as an MS4 community. IDEM describes a MS4 as “a conveyance or system of conveyances owned by a state, city, town, or other public entity that discharges to waters of the United States and is designed or used for collecting or conveying storm water.” The reason that MS4s are required is that urban storm water runoff has one of highest potentials for carrying pollutants to our waterways and as such, the Federal Clean Water Act requires that certain storm water dischargers acquire a National Pollutant Discharge Elimination System (NPDES) permit. Being an MS4 community, Angola was required to develop a Storm Water Quality Management Plan (SWQMP). The SWQMP must include six management techniques, referred to as “minimum control measures” (MCMs) including; 1) Public education and outreach; 2) Public participation and involvement; 3) Illicit discharge, detection and elimination; 4) Construction site runoff control; 5) Post-construction site runoff control; and 6) Pollution prevention and good housekeeping. Essentially, the MCMs list several management practices to limit the amount of storm water entering the sewers on a regular basis. Only about half of the City of Angola is located in Fawn River watershed, and the sewer conveyance system discharges storm water to the Pigeon Creek watershed. However, since the Pigeon Creek is also part of the larger St. Joseph River watershed, promotion of the MCMs outlined in the SWQMP should be promoted through this project for the portion of the MS4 community located within the project area, at a minimum.

Figure 2.23: Historic and Existing Studies in the Fawn River Watershed



2.7 Endangered Species

The Fawn River watershed is home to many federally and state listed endangered and threatened species. The US Fish and Wildlife Service (USFWS) maintains a database of those species that are either endangered, threatened, or candidates to become endangered on the federal level which can be seen in Table 2.14. There are several species of significance located within the Fawn River watershed which rely on wetland and upland forested areas for habitat, including the three mussel species, two butterflies, two snakes, an important plant species and the Indiana Bat.

According to the USFWS, the Indiana Bat population has decreased by over half since it was originally listed as endangered in 1967. This decrease in population can be attributed to human activities disturbing the Indiana Bat's habitat. Indiana Bats are very vulnerable to disturbances in their hibernation grounds as they hibernate in mass numbers (20,000 to 50,000) in caves in southern Indiana. The reason the bats population has declined in northern Indiana is mainly due to their breeding and feeding grounds, riparian and upland forests, being cleared for agricultural land and expanding urbanization. The Eastern Massasauga Rattlesnake lives in wetland areas, many of which have been drained to be used for agriculture. With much of the Eastern Massasauga's habitat being converted for other uses, the snakes numbers have declined dramatically. Many of the species listed as endangered at the federal level rely on wetland habitat for survival, and the clearing of that key land feature has caused the decline in those species numbers. State's Fish and Wildlife Agencies have listed several additional species not found on the federal list as endangered or threatened. The protection of the habitat in which all the species listed in Table 2.12 live is essential to their survival.

Table 2.14: Federally Listed Endangered Species

County	Species	Common Name	Status	Habitat	Image
Mammal					
St. Joseph, Branch, LaGrange	*Myotis sodalis*	Indiana Bat	Endangered	Hibernation in caves, swarming in wooded areas and stream riparian corridors	
Mussels					
Steuben	*Pleurobema clava*	Clubshell	Endangered	Fresh water, Rivers	
LaGrange	*Epioblasma triquetra*	Snuffbox	Endangered	Small to medium sized creeks with swift current and sand, gravel or cobble substrate (can be found in Lake Erie and some larger rivers)	
LaGrange	*Villosa fabalis*	Rayed Bean	Endangered	Smaller headwater creeks, sometimes larger rivers	

County	Species	Common Name	Status	Habitat	Image
Insects					
St. Joseph, Branch, Steuben, LaGrange	*Neonympha mitchellii mitchellii*	Mitchell's Satyr	Endangered	Fens	
LaGrange	*Lycaeides melissa samuelis*	Karner Blue	Endangered	Pine and oak savanna/barrens supporting wild lupine and nectar plants	
Reptiles					
St. Joseph, Branch, Steuben, LaGrange	*Sistrurus catenatus catenatus*	Eastern Massasauga	Candidate	Wetlands and adjacent uplands	
St. Joseph, Branch, Steuben, LaGrange	*Nerodia erythrogaster neglacta*	Copperbelly Watersnake	Threatened	Wooded and permanently wet areas such as oxbows, sloughs, brushy ditches, and floodplain woods	
Birds					
LaGrange	*Haliaeetus leucocephalus*	Bald Eagle	Threatened, Proposed for Delisting	Near water with old trees	

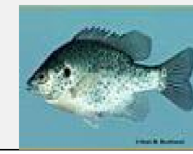
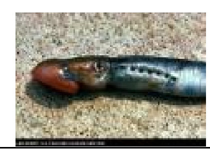
County	Species	Common Name	Status	Habitat	Image
Plants					
St. Joseph, Steuben, LaGrange	*Platanthera leucophaea*	Prairie White-fringed Orchid (Eastern Prairie Fringed Orchid)	Threatened	Mesic praire to wetlands, grassy habitat with little to no woody encroachment	

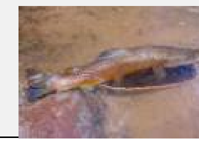
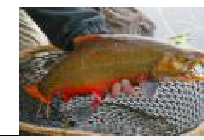
2.11 Invasive Species

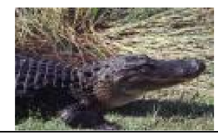
Invasive species are those organisms that do not naturally occur in a specific area and when introduced will cause deleterious effects on the ecology of the area. Invasive species may be one of the greatest threats to the natural areas within the Fawn River Watershed. Due to the fact that the newly introduced organism does not have natural predators, the organism can spread through an area quickly and can out compete native organisms that make an ecosystem thrive. Invasive species are of particular concern to the lake communities as invasive plants and aquatic organisms have already caused a decline in native plants and fish. Invasive species are also easily transported through the lake community as seeds, eggs, and actual organisms will attach themselves to boats which are then used in multiple different lakes, essentially transporting the organisms between different lakes. Table 2.15 is a list of invasive species that are located throughout the greater St. Joseph – Lake Michigan watershed, and can likely be found within the Fawn River watershed. That list of invasive species was obtained from the USDA-NRCS electronic Field Office Technical Guide (eFOTG). Table 2.16 is a list of invasive plant species that can be found in one or more of the four counties in which the Fawn River watershed is located. The eFOTG does not have the invasive plants listed for Indiana; therefore, the invasive plants list for Indiana was obtained from the Purdue University Extension website.

Table 2.15: Invasive Species in the St. Joseph-Lake Michigan Watershed

Common Name	Scientific Name	Habitat	Exotic / Native / Transplant	Source of Species	Image
Coelenterates					
Freshwater jellyfish	*Craspedacusta sowerbyi*	Freshwater	Exotic	Tranported with ornamental aquatic plants from China	
Crustacean					
scud	*Echinogammarus ischnus*	Freshwater- Marine	Exotic	Ballast water from Black Sea and Caspian Sea drainage	
Fish					
American shad	*Alosa sapidissima*	Freshwater - Marine	Native	Stocking in non-native waters	
Oscar	*Astronotus ocellatus*	Freshwater	Exotic	Stocking in non-native waters	
unidentified pacu	*Colossoma or Piaractus sp.*	Freshwater	Exotic	Aquarium releases or escapes from fish farms	
Grass carp	*Ctenopharyngodon idella*	Freshwater	Exotic	Stocking in non-native waters	

Common Name	Scientific Name	Habitat	Exotic / Native / Transplant	Source of Species	Image
Common carp	*Cyprinus carpio*	Freshwater	Exotic	Unauthorized stocking in non-native waters in 1800s	
Redear Sunfish	*Lepomis microlophus*	Freshwater	Native	Stocking in non-native waters	
Round goby	*Neogobius melanostomus*	Freshwater	Exotic	Ballast water from Black Sea	
Rainbow trout	*Oncorhynchus mykiss*	Freshwater - Marine	Native	Stocking in non-native waters	
Chinook Salmon	*Oncorhynchus tshawytscha*	Freshwater - Marine	Native	Stocking in non-native waters	
Coastal rainbow trout	*Oncorhynchus mykiss irideus*	Freshwater - Marine	Native	Stocking in non-native waters	
Sea Lamprey	*Petromyzon marinus*	Freshwater - Marine	Non-native to freshwater	Possibly introduced through the Erie Canal	

Common Name	Scientific Name	Habitat	Exotic / Native / Transplant	Source of Species	Image
pirapatinga, red-bellied pacu	*Piaractus brachypomus*	Freshwater	Exotic	Aquarium releases	
Atlantic Salmon	*Salmo salar*	Freshwater - Marine	Native	Stocking in non-native waters	
Brown trout	*Salmo trutta*	Freshwater	Exotic	Imported from Germany for sportfishing stock	
Brook Trout	*Salvelinus fontinalis*	Freshwater	Native	Stocking in non-native waters	
Lake Trout	*Salvelinus namaycush*	Freshwater	Native	Stocking in non-native waters	
Saugeye	*Sander canadensis x vitreus*	Freshwater	Native hybrid	Unknown	
Mullusks					
zebra mussel	*Dreissena polymorpha*	Freshwater	Exotic	Ballast water from Black Sea ship to Great Lakes	

Common Name	Scientific Name	Habitat	Exotic / Native / Transplant	Source of Species	Image
quagga mussel	*Dreissena rostriformis bugensis*	Freshwater	Exotic	Ballast water from Dneiper River drainage of Unkrain and Caspian Sea	
Chinese mysterysnail	*Cipangopaludina chinensis malleata*	Freshwater	Exotic	Sold in Chinese food markets in 1800s, possible aquarium release	
Reptiles					
American Alligator	*Alligator mississippiensis*	Freshwater	Native	Escaped or released pets	
Alligator Snapping Turtle	*Macrochelys temminckii*	Freshwater	Native	Released pets	
Insects					
Common Pine Shoot Beetle	*Tomicus piniperda*	Pine trees	Exotic	Native to Europe. Discovered in Ohio in 1992	

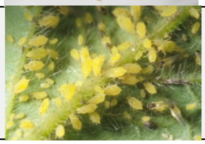
Common Name	Scientific Name	Habitat	Exotic / Native / Transplant	Source of Species	Image
Emerald Ash Borer	*Agrilus planipennis*	Ash Trees	Exotic	Likely cargo ships from eastern Russia, northern China, Japan or Korea. Discovered in 2002	
European Gypsy Moth	*Lymantria dispar dispar*	Temperate Forests	Exotic	Native to temperate forest of western Europe. Discovered in US in 1869	
Soybean Aphid	*Aphis glycines*	Underside of Soybean leaves	Exotic	Native to Asia. Discovered in 2000	

Table 2.16: List of Invasive Plant Species per County

Counties	Common Name	Scientific Name	Habitat
St. Joseph, Branch, Steuben, LaGrange	Asian Bush Honeysuckle(s)	*Includes many Lonicera*	Forest
	Autumn Olive	*Elaeagnus umbellata*	Openland
	Black Locust	*Robinia pseudoacacia*	Openland
	Canada Thistle	*Cirsium arvense*	Openland
	Common Reed; Phragmites	*Phragmites australis*	Wetland
	Curly-Leaf Pondweed	*Potamofeton crispus*	Wetland
	Eurasian Watermilfoil	*Myriophyllum spicatum*	Wetland
	Garlic Mustard	*Alliaria periolata*	Forest
	Japanese Knotweed	*Polygonum cuspidatum*	Forest
	Multiflora Rose	*Rosa multiflora*	Forest, Openland
	Norway Maple	*Acer platanoides*	Forest
	Purple Loosestrife	*Lythrum salicaria*	Wetland
	Reed Canary Grass	*Phalaris arundinacea*	Wetland
	Tree of Heaven	*Ailanthus altissima*	Forest

Counties	Common Name	Scientific Name	Habitat
St. Joseph, Branch, Steuben	Japanese Honeysuckle	*Lonicera japonica*	Forest
St. Joseph, Branch, LaGrange	Oriental Bittersweet	*Celastrus orbiculatus*	Forest
St. Joseph, Branch	amur cork-tree	*Phellodendron amurense*	Forest and Openland
	Baby's breath	*Gypsophila scorzonerifolia*	alkaline or limestone shores
	Bell's honeysuckle	*Lonicera x bella*	Forests, Openland
	Black jetbead	*Rhodotypos scandens*	Forest, Openland
	Black swallowwort	*Cynanchum louiseae*	Forest and open land
	Common buckthorn	*Rhamnus cathartica*	Forest, wetlands, Openland
	European fly honeysuckle	*Lonicera xylosteum*	Forest and Openland
	European frog-bit	*Hydrocharis morsus-ranae*	Wetland
	Flowering rush	*Butomus umbellatus*	Wetland
	Giant hogweed	*Heracleum mantegassianum*	Openland
	Giant knotweed	*Fallopia sachalinensis*	Floodplain forests, Openland
	Glossy buckthorn	*Rhamnus frangula*	wetlands, prairie, forests
	Hydrilla	*Hydrilla verticillata*	Wetland
	Japanese barberry	*Berberbis thunbergii*	Forest, Openland
	Japanese silt grass	*Microstegium vimineum*	Forests, riparian cooridor, openland
	kudzu	*Pueraria montana*	Openland
	Leafy spurge	*Euphorbia esula*	Openland and riparian areas
	Morrow's honeysuckle	*Lonicera morrowii*	Forest

Counties	Common Name	Scientific Name	Habitat
	pale swallowwort	*Cynanchum rossicum*	Upland forests and openland
	Reed mannagrass	*Glyceria maxima*	Wetland
	Russian Olive	*Elaegnus angustifolia*	Riparian areas, fields, openland
	Scotch pine	*Pinus sylvestris*	Openland
	Spotted knapweed	*Centaurea maculosa*	Openland
	Tartarian honeysuckle	*Lonicera ttatarica*	Forest
	Variable-leaf watermilfoil	*Myriophyllum heterophyllum*	Wetland
	water-hyacinth	*Eichornia crassipes*	Wetland
Steuben	Creeping Jenny	*Lysimachia nummularia*	Forest, Wetland
Steuben, LaGrange	Buckthorn(s)	*Rhamnus (frngula) cathartica)*	Wetland, openland
	Crown Vetch	*Securigera varia*	Openland
	Dame's Rocket	*Hesperis matronalis*	Forest, Openland
	Periwinkle	*Littorina littorea*	Forest
	Privet(s)	*Ligustrum obtusifolium*	Forest
	Purple Winter Creeper	*Euonymus fortunei*	Forest
	Siberian Elm	*Ulmus pumila*	Forest
	Smooth Brome	*Bromus inermis*	Forest, Openland
	Star-of-Bethlehem	*Ornithogalum nutans and O. umbelatum*	Wetland and riparian areas
	Sweet Clover(s)	*Melilotus officinalis*	Openland
	Tall Fescue	*Festuca arundinacea*	Openland
	White Mulberry	*Morus alba*	Openland

2.12 Summary of Watershed Inventory

All of the elements described above, when combined, can provide a larger picture of how the watershed functions and what activities may pose a greater threat to our water resources. This section will summarize the characteristics of the project area and describe how they relate to each other. This will be examined more closely in subsequent sections.

The predominant land use in the Fawn River watershed is agriculture due to the fertile soils, much of which used to be wetlands as can be seen by the amount of hydric soil present within the watershed (Figure 2.6). Hydric soils are not ideal for agricultural use due to the frequency of ponding and/or flooding. When soils are over saturated, excess nutrients and animal waste often wash off the field and may discharge directly into surface waters. Many landowners install field tiles or petition to convert open water to legal drains to be maintained by the county surveyor or engineer to prevent crop land from becoming over saturated. As can be seen in Figure 2.12, many streams and ditches have been converted to be on regular maintenance by the County, especially in Steuben County; 66.86 miles of open drain and 44.18 miles of tiled drains. However, this practice provides a direct means for nutrients, sediment, and bacteria to enter surface water, or depending on the depth to the water table, to groundwater resources used for crop irrigation or drinking water. For these reasons best management practices should be implemented on agricultural land with hydric soils, especially those using field tiles to drain the crop land.

Although only a little more than 7% of the watershed is considered developed, it is important to focus water quality improvement efforts in the urban areas specifically surrounding developed lakes. Fertilizer used on urban lawns can exacerbate aquatic plant growth which can alter the aquatic ecosystem, as well as inhibit regular recreational activities on the lakes. Many lakes in the watershed have begun to implement a “no phosphorus” fertilizer program as phosphorus is considered the limiting agent to algae growth. Also, many residents on the lakes have installed concrete sea walls at their property’s shoreline. The hard surface sea walls often destroys the gradual transition from shallow to deep water, and the crashing of the waves on the wall causes bottom sediments to stir up which increases turbidity. The use of sea walls can destroy habitat for many fish species, including their spawning areas, and block access to and from the water for turtles, frogs and other creatures that need access to land for feedings, resting and nesting.

There are several populated areas located within the Fawn River watershed including Fremont and Angola, IN and Sturgis, MI. While only Angola is required to have education and outreach regarding stormwater control due to it being an MS 4 community, stormwater management should be promoted in all populated areas, as urban stormwater has the greatest potential to carry many pollutants to open water including oil, grease, lawn fertilizer, salts, sediment, and other pollutants that can be harmful to the aquatic ecosystem.

Nearly ¼ of all soils in the watershed are considered HEL or PHEL, as can be seen in Figure 2.45. Since so much of the farmed land in the watershed is considered to be erodible, special precautions should be taken by those producers working HEL and PHEL land to limit the amount of soil erosion. As soil erodes, it can increase stream and lake sedimentation. The eroding soil particles often carry nutrients that bind to the particles to open water sources as well. This may cause an increase in phosphorus and nitrogen levels within the water system, leading to unsuitable water quality.

Since the majority of the land use in the Fawn River watershed is agriculture, specifically row crops (greater than 48% of the watershed); sedimentation can have a major effect on water quality and biota. Tillage data collected by each county (except those in MI in which a transect has not been conducted in decades) in the watershed indicates a relatively fair adoption of conservation tillage practices, especially in Steuben County with 80% of corn and 96% of beans utilizing conservation tillage. Conservation tillage requires a minimum of 30% residue cover on the land. This type of tillage decreases the potential for soil erosion, decreases soil compaction, and can save the producer time and money by minimizing the number of passes made on each field while preparing for the next planting season.

It was noted during the windshield survey that many producers are utilizing field irrigation sprinklers to water their crops, and also that many fields lack an adequate buffer to slow stormwater and absorb fertilizer and other pollutants prior to reaching open water. As mentioned above, conventional tillage increases erosion of farm fields, and irrigations, without proper management can do the same, as well as wash off nutrients meant for plant uptake. For these reasons, it is important to install adequate riparian buffers adjacent to crop fields.

There are 10 populated areas that are currently served by a centralized sewer system including all towns and cities located in the watershed, as well as some of the built up lakes. However, much of the watershed, approximately 82% is rural and therefore, many homes utilize on-site sewage treatment for their household effluent. While accurate estimates of the number of failing or failed septic systems could not be obtained for the project area, the US EPA estimates that up to 5% of all septic systems are currently failing. The USDA soil survey for Steuben, LaGrange, St. Joseph and Branch counties lists less than 10% of the soil in the project area as being suitable for septic system treatment as can be seen in Figure 2.7 on page 17. These two facts may lead one to believe that bacteria contamination, and excessive nutrients found within the water samples may be partly due to improperly sited septic systems and/or failing systems.

The entire population of the Fawn River watershed obtains their drinking water from groundwater, including the major population centers of Angola, Fremont, Orland, Sturgis, and Constantine from wells. Field tiles and improperly placed or faulty septic systems can seriously affect the integrity of the groundwater aquifer to be used for drinking water as the contaminated effluent may not be entirely filtered as it percolates through the soil. Leaking underground storage tanks can also pollute groundwater, contaminating drinking water with various harmful chemicals. For this reason, special precautions must be taken to ensure that the watershed’s populations drinking water source in not polluted.

As stated earlier, the majority of the land within the project area is used for agriculture and many of the wetlands that were once present have been drained for pasture land or row crops.

As mentioned in Section 2.4.3, it is estimated that the entire St. Joseph River Watershed has lost 53% of its historic wetlands. Wetlands play an important role in our ecosystem, not only as flood water traps and pollution sinks, but also as prime habitat for many of the species listed as endangered or threatened. For instance, the Indiana Bat, Copperbelly Water Snake, and Massasauga Rattlesnake all prefer the habitat provided by wetlands. Forest land, much of which has been cleared for agriculture, is also a vital habitat for endangered species, such as the Indiana Bat. Leaving some agricultural land fallow and replanting the fields with native vegetation to allow the landscape to return to forest or wetland will provide more vital habitat for those endangered and threatened species. Many of the strategic and comprehensive planning efforts by local governments and interest groups have made goals for conserving and protecting natural areas including LaGrange and Steuben County Master Plans, the Fremont and Angola Comprehensive Plans, the Angola Parks and Recreation Master Plan, and the City of Sturgis Master Plan.

Table 2.16, below, links those concerns that stakeholders from the public meetings had regarding the project area and water resources, to evidence found during the initial project area inventory. More evidence will be provided in subsequent sections at the 12 digit HUC level.

Table 2.16: Stakeholder Concerns and Relevant Evidence for Concern

Concerns	Evidence	Potential Problem
Livestock access to open water	One site was noted during the windshield survey that allowed for livestock to have direct access to open water.	*E. coli* contamination, excess nutrients, erosion, sediment
Stormwater runoff from livestock operations	A few livestock issues were noted during the windshield survey (discussed in more detail in subsequent Sections). There are four CFOs located within the watershed. Nearly 10% of the watershed land use is considered to be pasture/hayland which would indicate the presence of livestock in those areas. Gently rolling hills of the watershed and the lack of riparian buffers allow for runoff to reach open water easily.	*E. coli* contamination, excess nutrients, and sediment
Increase in impervious surfaces	70 built-up lakes located within the watershed which increases the number of driveways, patios, and access roads.	Oil and grease, Excess sediment, nutrients

Concerns	Evidence	Potential Problem
Fertilizer used on urban lawns	70 built-up lakes in the project area. Many lake residences have lush and green lawns which indicate the use of commercial fertilizers. The same situation can be seen in many naighborhoods and residential areas in Angola, Fremont, and Sturgis.	Excess nutrients and impaired biotic communities
Lakes in the area becoming more developed	Lakes within the area continue to allow for construction of new homes as well as there already being 70 built-up lakes in the watershed.	Excess sediment, nutrients, impaired biotic communities, *E. coli*
Septic system discharge	There are 10 populated areas in the watershed that are serviced by a centralized sewer system. Many built-up lakes located throughout the watershed are utilizing on-site waste disposal systems and the entire rural population utilizes on-site waste disposal. It is estimated that nearly 5% of all septic systems in the US are currently failing.	Excess nutrients, sediment, *E. coli*
Lack of no-till and cover crop practices	MI counties has not performed a tillage transect since 1993 and District Conservationist could not provide an estimate of current tillage usage but only 2% of all crops in Steuben County and 19% of all crops in LaGrange County use cover crops. 31% of corn in Steuben and LaGrange counties are in no-till and 68% and 63% of beans in Steuben and LaGrange counties, respectively, are in no-till.	*E. coli* contamination, excess nutrients and sediments
Wetland Conservation	According to the NWI, approximately 16% of the watershed is considered to be wetland. The Friends of the St. Joseph River Association - Wetland Partnership estimates nearly a 53% decrease in wetlands and comparing 1979 wetland data to 2005 data, the Fawn River watershed has lost approximately 616 acres of wetlands within that time.	Flooding, lack of wildlife and aquatic habitat and pollution sequestration, and impaired biotic communities
Stream Bank Erosion	The windshield survey revealed a lack of riparian buffer throughout the watershed which may increase streambank erosion.	Sedimentation, turbidity, impaired biotic community

3.0 Watershed Inventory by Sub-watershed

This Section reviews water quality and land use data at the HUC 12 level to provide a more detailed look at the overall watershed and to help identify key locations to focus efforts to improve the water quality in the watershed.

3.1 Water Quality Data

An important aspect of the watershed planning process is to examine current water quality data, as well as historic data to understand the issues present in the watershed. The historic data, some of which has been collected for decades, though only data collected since 2003 will be presented in this WMP, will provide a baseline in which to compare the data collected by the Fawn River project in 2013 and 2014. The historical data of consequence was combined with the watershed assessment that was done as part of this project to characterize water quality problems and their sources and tie them to stakeholder concerns. A Quality Assurance Project Plan (QAPP) was developed for this project and all protocols outlined in the QAPP were followed during water quality sampling. The QAPP can be found in Appendix A. The following sections will provide a detailed description of all water quality data that has been collected in the watershed to date.

3.1.1 Water Quality Parameters

The IDEM and Steuben County Lakes Council have collected water quality information in the Fawn River Watershed over the past decade for a myriad of different parameters including sediment, nutrients, and bacteria. The Fawn River project began water quality sampling in 2013 of those same parameters. The effects of various parameters on water quality are presented below.

Ammonia - Ammonia is common in the water system as it is released in the waste of living mammals. It is also released into the water system via farmland runoff as ammonium hydroxide is used as a fertilizer for row crops. Ammonia is important to measure for two reasons: the free form of ammonia, NH_3, is toxic to fish and can lower reproduction and growth of aquatic organism, or even result in death, and the nitrification of ammonia removes dissolved oxygen from the water. Measuring the amount of ammonia in the water is also a good indicator for other pollutants that may be reaching the water as well. Due to the toxic nature of too much ammonia in the water, the state of Indiana has set a standard of between 0 and 0.21 mg/L, dependent on temperature.

Dissolved Oxygen - Dissolved oxygen (DO) is the measure of oxygen in the water available for uptake by aquatic life. Typically, streams with a DO level greater than 8 mg/L are considered very healthy and streams with DO levels less than 2 mg/L are very unhealthy as there is not enough oxygen to sustain aquatic life. DO is affected by many factors including; temperature - the warmer the water the harder it is for oxygen to dissolve, flow –more oxygen can enter a stream where the water is moving faster and turning more, and aquatic plants – an influx of plant growth will use more oxygen than normal which does not leave enough available DO for other aquatic life, however photosynthesis will add oxygen to the water during the day. Thus, DO levels may change frequently when there is excessive aquatic plant growth. Excessive amounts of suspended or dissolved solids will decrease the amount of DO in the water. The state of Indiana has set a standard of at least an average of 5 mg/L per calendar day, but not less than 4 mg/L of DO for warm water streams. The US EPA recommends that DO not exceed 9 mg/L so as to avoid super-saturation of DO in the water system.

Temperature - As mentioned above, temperature can affect many aspects of the health of the water system. Water temperature is a controlling factor for aquatic organisms. If there are too many swings in water temperature, metabolic activities of aquatic organisms may slow, speed up, or even stop. Many things can affect water temperature including stream canopy, dams, and industrial discharges. The state of Indiana has set a standard for water temperature (which may be found in 327 IAC 2-1-6) depending on if the waterbody is a cold or warm water system.

Escherichia coli - *E. coli* is a bacteria found in all animal and human waste. *E. coli* testing is used as an indicator of fecal contamination in the water. While not all *E. coli* is harmful, there are certain strains that can cause serious illness in humans. *E. coli* may be present in the water system due to faulty septic systems, CSO overflows, wildlife; particularly geese, and from contaminated stormwater runoff from animal feeding operations. Due to the serious health risks from certain forms of *E. coli*, and other bacteria that may be present in water, the state of Indiana has developed the full body contact standard of less than 235 CFU/100 ml of *E. coli* in any one water sample and less than 125 CFU/100 ml for the geometric mean of five equally spaced samples over a 30 day period.

Total Kjeldahl Nitrogen - TKN is the sum of organic nitrogen, ammonia, and ammonium. High levels of TKN found in water is typically indicative of manure runoff from farmland or sludge discharging to the water from failing or inadequate septic systems. The level of TKN in the water is a good indicator of other pollutants that may be reaching the water. The US EPA recommends a target level not to exceed 0.076 mg/L.

Turbidity -Turbidity is the measure of the cloudiness of the water which may be caused by sediment or an overgrowth of aquatic plants or animals. High levels of turbidity can block out essential sunlight for submerged plants and animals and may raise water temperatures, which then can decrease DO. Sediment in the water causing it to be turbid can clog fish gills and smother nests when it settles, thus effecting the overall health of the aquatic biota. Turbid water may be caused from farm field erosion, feedlot or urban stormwater runoff, eroding stream banks, and excessive aquatic plant growth. The US EPA recommends that the turbidity in the water measure less than 10.4 NTUs.

pH - pH is the measure of a substance's acidity or alkalinity and is an important factor in the health of a water system because if a stream is too acidic or basic it will affect the aquatic organisms' biological functions. A healthy stream typically has a pH between 6 and 9, depending on soil type and substances that come from dissolved bedrock. pH can also change the water's chemistry. For example, a higher pH means that a smaller amount of ammonia in the water may make it harmful to aquatic organisms and a lower pH may increase the amount of metal present in the water as it will not dissolve as easily. For these reasons, the state of Indiana has set a standard for pH of between 6 and 9.

Total Suspended Solids – Total suspended solids (TSS) is a measure of all particulate matter (organic and inorganic) in a water sample. TSS is measured by passing a water sample through a series of sieves of differing sizes, drying the particulate, and weighing the dried matter. The amount of Total Suspended Solids (TSS) in the water system will have the same type of deleterious effect on water quality as mentioned above under turbidity including, debilitating aquatic habitat and life, and carrying other pollutants to the water such as fertilizers and pathogens. To maintain a healthy fishery Indiana recommends TSS levels remain at or below 25 mg/L; however, Michigan's Dept. of Environmental Equality recommends TSS levels remain at or below 20 mg/L.

Total Dissolved Solids - Total dissolved solids are all dissolved organic or inorganic molecules that are found in the water. The difference between TDS and TSS is that TSS cannot pass through a sieve of 2 micrometers or smaller. So, the lower the TDS measurement in the water sample the purer the water is. TDS is a measurement of any pollutant in the water including salt, metal, and other minerals. The IN state code has a standard of <750 mg/L to maintain a healthy aquatic ecosystem.

Phosphorus - Phosphorus is an essential nutrient for aquatic plants however, too much phosphorus can create an over growth of plants which can lower the DO in a water system and decrease the amount of light that penetrates the surface thus killing other aquatic life that depends on these for survival. Some types of aquatic plants that thrive when phosphorus levels are high, such as blue-green algae, which can be toxic when consumed by humans and wildlife. Excessive amounts of phosphorus have also been found in ground water thus increasing the bacteria growth in underground water systems. Phosphorus can reach surface and ground water through contaminated runoff from row crop fields, and urban lawns where fertilizer has been applied, animal feeding operations, faulty septic tanks, and the disposal of cleaning supplies containing phosphorus in landfills or down the drain. Unique to built-up lakes, "legacy phosphorus" found in benthic sediment can be an issue when disturbed due to increased wave action from hard surface sea walls or from heavy motorized boat traffic. The state of Indiana has set a target of 0.3 mg/L of total phosphorus in a water sample to list a waterbody as impaired on the state's impaired water list as required by the CWA § 303(d), often referred to as the 303(d) list. Though, the Ohio EPA (OEPA) has set a standard of 0.08 mg/L in warm water headwater streams and a standard of 0.3 mg/Lfor large rivers. The Fawn River Watershed steering committee decided to use OEPA's target of 0.08 mg/L for all tributaries and 0.3 mg/L for samples taken from the mainstem and lakes.

Dissolved Reactive Phosphorus (DRP)/Ortho-Phosphate – DRP is a form of phosphorus that is readily available for plant uptake once it reaches open water as it does not bind to soil particles. It is often considered the limiting factor to algae growth, which is a major concern throughout the natural resources world for lakes. There has been an increase in algal blooms in lakes. DRP can come from a variety of sources including point source dischargers and non-point sources.

The North Carolina State University recommends concentrations of DRP be less than 0.05 mg/L in water samples to maintain a viable aquatic ecosystem.

Nitrite - Nitrites are highly toxic to aquatic life and also toxic to humans, especially babies, if consumed in excessive amounts. Nitrites can cause shortness of breath and blue baby syndrome, which can lead to death in babies which is of great concern to those individuals who acquire their drinking water from wells. Nitrites are commonly found in the water system in trace amounts because nitrite is quickly oxidized to nitrate. However nitrites can be introduced in excessive amounts from sewage treatment plants if the oxidation process is interrupted, from farm field runoff, animal feeding lot runoff, and faulty septic systems. For the harmful health effects mentioned above, the state of Indiana adopted the US EPA MCL standard of less than 1 mg/L of nitrite in drinking water which can be found in 327 IAC 2-1-6.

Nitrate - Nitrates can have the same effect on the water system as phosphorus, only to a much lesser degree. Nitrates can be found at levels up to 30mg/L in some waters before detrimental effects on aquatic life occur. However, due to the fact that infants who consume water with nitrate levels exceeding the US EPA MCL of 10 mg/L can become ill, nitrates in drinking water should be of particular concern to people who use wells as their drinking water source. The most common sources of nitrates are from fertilizer runoff from row crop fields, faulty septic systems, and sewage. The Fawn River Watershed steering committee has decided to use the US EPA reference level for nitrates in the water system, which is set at 1.5 mg/L.

Pollution Tolerance Index for Macroinvertebrates - The Pollution Tolerance Index (PTI) is used as an indicator of water quality. Macroinvertebrates are collected from the waterway and classified into four groups depending on how tolerant they are of pollution in the water, from intolerant to very pollution tolerant species. The number and type of macroinverbrates found show the overall health of the water. The Fawn River watershed steering committee set a target of the index ranking to be greater than 23 based on the Hoosier Riverwatch method of collecting and ranking samples. Hoosier Riverwatch ranks macroinvertebrates as follows; >23 = excellent, 17-22 = good, 11-16 = fair, <10 = poor.

Citizens Qualitative Habitat Evaluation Index - The Citizens Qualitative Habitat Evaluation Index (CQHEI) is another method used to determine the quality of a waterway. Various aspects of aquatic habitat are evaluated including in-stream habitat and the surrounding land use, to determine the waterways ability to support aquatic life such as fish and macroinvertebrates. A score greater than 61 is considered to be a stream that fully supports aquatic life, and a score between 51 and 61 is considered a stream that partially supports aquatic life.

3.1.2 Water Quality Targets

When the above parameters are combined a greater picture of the overall quality of the waterway can be gleaned. For the purpose of interpreting inventory data and defining problems, target values were identified for water quality parameters of concern by the Fawn River watershed steering committee (Table 3.1). It is important to note that the same parameters were not analyzed by each entity that collected water quality samples.

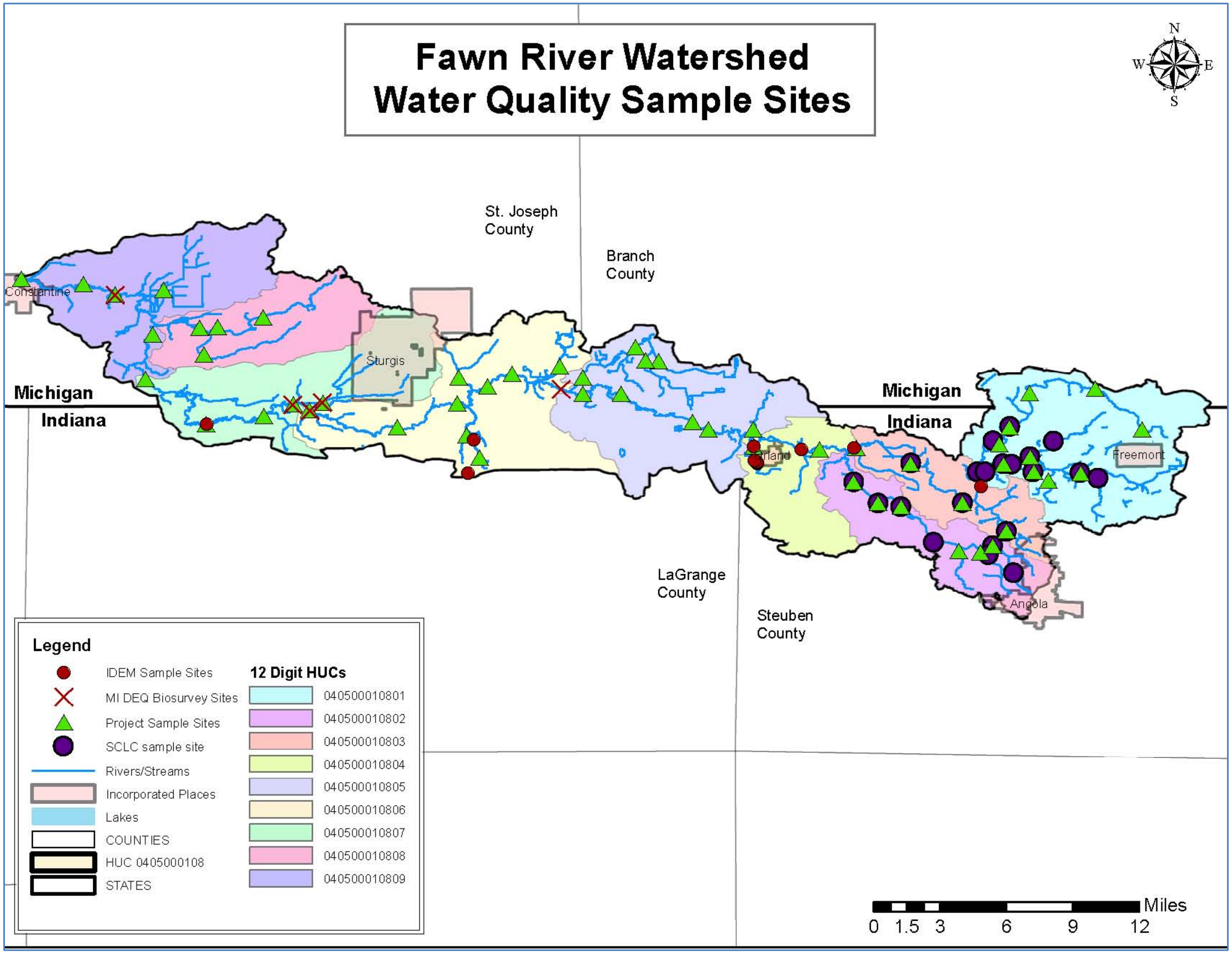
Table 3.1: Water Quality Targets

Parameter	Target	Source
Dissolved Oxygen	> 4 mg/L and not > 12 mg/L	327 IAC 2-1-6
Temperature	4.44 - 29.44 degrees C	327 IAC 2-1-6
Escherichia Coli	235 CFU/100 ml (single sample) or 125 CFU/100 ml (geo mean-5 equally spaced samples over a 30 day period)	327 IAC 2-1.5-8
Turbidity	< 10.4 NTU	US EPA recommendation (2000)
pH	> 6 or < 9	327 IAC 2-1-6
Total Suspended Solids	< 20 mg/L	Rule 50 of MI Water Quality Standards (Part 4 of Act 451)
Total Dissolved Solids	< 750 mg/L	327 IAC 2-1-6
Total Phosphorus	< 0.08 mg/L – Tributaries < 0.30 – Mainstem/Lakes	Ohio State Standard 327 IAC 2-1.5-8
Dissolved Reactive Phosphorus	< 0.05 mg/L – streams / <0.005 mg/L for Lake Systems	North Carolina State University Recommendation / Wawasee Area Conservancy Foundation Rec.
Total Ammonia	< 0.21 mg/L depending on temperature	327 IAC 2-1-6
Nitrate	< 1.5 mg/L	US EPA reference level (2000)
Nitrate + Nitrite	< 1.5 mg/L	US EPA reference level (2000)
Total Kjeldahl Nitrogen (TKN)	0.076 mg/L	US EPA recommendation (2000)
Pollution Tolerance Index for Macroinvertebrates	>23 points	Hoosier Riverwatch (2011)
Citizen's Qualitative Habitat Evaluation index	> 61 pts	Hoosier Riverwatch (2011)

3.2 Water Quality Sampling Efforts

A variety of water quality assessment projects have been completed within the Fawn River Watershed. These include the Indiana and Michigan, Integrated Reports, the IDEM Watershed Assessment and Planning Branch studies, MI DEQ studies, water quality analysis by the Steuben County Lakes Council (SCLC), and the Fawn River Project (FRP) sampling program. A summary of each study's methodology and general results are discussed below. Subsequent sections detail specific study information as it relates to each HUC 12 sub-watershed. Figure 3.1 displays all the sampling efforts that have taken place in the Fawn River watershed.

Figure 3.1: Water Quality Sample Sites in the Fawn River Watershed



3.2.1 IDEM and MI DEQ Integrated Reports

Each state is required to perform water quality analysis of its surface waters and report their findings to EPA in a report called the "Integrated Report" (IR) on a biannual basis, as mandated by the CWA§305(b). Prior to compiling the IR, a list of water bodies that do not meet state standards is developed as mandated by the Clean Water Act section 303(d). This has become commonly known as the 303(d) list. Many stream segments located within the Fawn River watershed are listed on the 2012 IDEM 303(d) list of impaired waters for *E. coli,* impaired biotic community, and PCBs in fish tissue. IDEM's 2012 IR can be found at http://www.in.gov/idem/nps/2639.htm, as well as IDEM's draft 2014 IR. Michigan's 2012 IR has also been approved by the US EPA and shows that the entire portion of the Fawn River Watershed project area located within Michigan is impaired for PCB or Mercury in fish tissue or the water column. The MI DEQ's Integrated Report can be found at http://www.michigan.gov/deq/0,4561,7-135-3313-12711--,00.html. A full list of those waters impaired within the Fawn River Watershed, as designated by each State, can be found in Table 3.2 and Table 3.3, and a map of those listed waters can be seen in Figure 3.2.

As part of the IDEM monitoring process, water samples are analyzed for numerous substances. Those relative to this WMP include: nitrogen as ammonia, nitrate+nitrite, total phosphorus, TKN, pH, TDS, TSS, DO, turbidity, temperature, and *E. coli*. Data collected by IDEM since 2003 was analyzed and sorted for the purpose of this project.

MI DEQ collected water quality samples from the Fawn River watershed at five sites in 2000 and one site in 2005. The entire St. Joseph River Watershed is on a five year rotating schedule for water sampling and was slated to be sampled in 2000, 2005, and 2010. None of the samples collected in 2010 were taken from the Fawn River Watershed. As part of the MI DEQ monitoring process, water samples are analyzed for numerous parameters. Those relative to this WMP include: nitrite, nitrate+nitrite, total phosphorus, Ortho-phosphorus, TKN, pH, TDS, and habitat. A Total Maximum Daily Load (TMDL) report was scheduled to begin for the Fawn River Watershed in 2013 to address the issue of PCBs and Mercury found in fish tissue and the water column. In January, 2013 a MI statewide TMDL report was released to address PCBs found in fish tissue and the water column from air deposition. The TMDL report can be found at http://www.michigan.gov/documents/deq/wrd-swas-tmdl-draftpcb_408124_7.pdf.

The consolidated list of waters in the IR by IDEM and MI DEQ are outlined in the following Tables 3.2 and 3.3, respectively.

Table 3.2: IDEM Consolidated List of Waters in the Fawn River Watershed

HUC12	2012 AUID	Assessment Unit Name	Recreation	Human Health / Fish Tissue	Aquatic Life Use	E COLI	IBC	PCBS (FISH TISSUE)	TOTAL MERCURY (FISH TISSUE)
40500010801	INJ0181_01	MARSH LAKE INLET	3	3	3				
	INJ0181_01 A	MARSH LAKE INLET - UNNAMED TRIBUTARY	3	3	3				
	INJ0181_01 B	MARSH LAKE INLET - UNNAMED TRIBUTARY	3	3	3				
	INJ0181_01 C	MARSH LAKE INLET - UNNAMED TRIBUTARY	3	3	3				
	INJ0181_P1 003	WALTERS LAKE - ARTIFICIAL PATH	NA	NA	NA		5A		
	INJ0181_P1 004	BIG OTTER LAKE - ARTIFICIAL PATH	NA	NA	NA		5A		
	INJ0181_P1 005	LITTLE OTTER LAKE - ARTIFICIAL PATH	NA	NA	NA		5A		
	INJ0181_P1 012	GREEN LAKE - ARTIFICIAL PATH	NA	NA	NA		5A		
	INJ0181_T1 001	BIG OTTER LAKE INLET	3	3	5A		5A		
	INJ0181_T1 001A	BIG OTTER LAKE INLET - UNNAMED TRIBUTARY	3	3	3				
	INJ0181_T1 002	FOLLETTE CREEK	3	3	5A		5A		
	INJ0181_T1 003	CROOKED CREEK	3	3	3				
	INJ0181_T1 004	WALTERS LAKE INLET	3	3	5A		5A		
	INJ0181_T1 004A	WALLTERS LAKE INLET - UNNAMED TRIBUTARY	3	3	3				
	INJ0181_T1 005	MARSH LAKE INLET	3	3	3				

HUC12	2012 AUID	Assessment Unit Name	Recreation	Human Health / Fish Tissue	Aquatic Life Use	E COLI	IBC	PCBS (FISH TISSUE)	TOTAL MERCURY (FISH TISSUE)
	INJ0181_T1 006	MARSH LAKE INLET	3	3	3				
	INJ0181_T1 006A	MARSH LAKE INLET - UNNAMED TRIBUTARY	3	3	3				
	INJ0181_T1 007	MARSH LAKE OUTLET	3	3	5A		5A		
	INJ0181_T1 008	GREEN LAKE OUTLET	3	3	5A		5A		
	INJ0181_T1 009	FAWN RIVER	3	3	3				
	INJ0181_T1 010	SNOW LAKE INLET	3	3	3				
	INJ0181_T1 011	MARSH LAKE INLET	3	3	3				
	INJ0181_T1 012	SEVEN SISTERS LAKES INLET	3	3	3				
	INJ01P1036 _00	SNOW LAKE	3	3	5A		5A		
	INJ01P1037 _00	MARSH LAKE	3	5B	5A		5A		5B
	INJ01P1041 _00	FISH LAKE	3	3	3				
	INJ01P1043 _00	WALTERS LAKE	3	3	3				
	INJ01P1044 _00	GEORGE, LAKE	3	2	3				
	INJ01P1045 _00	LONG BEACH LAKE	3	3	3				
	INJ01P1046 _00	LONE HICKORY (MUD) LAKE	3	3	3				

HUC12	2012 AUID	Assessment Unit Name	Recreation	Human Health / Fish Tissue	Aquatic Life Use	E COLI	IBC	PCBS (FISH TISSUE)	TOTAL MERCURY (FISH TISSUE)
	INJ01P1047_00	EATON LAKE	3	3	3				
	INJ01P1048_00	GREEN LAKE	3	3	2				
	INJ01P1049_00	MINIFENOKEE, LAKE	3	3	3				
	INJ01P1050_00	BIG OTTER LAKE	3	2	5A		5A		
	INJ01P1051_00	LITTLE OTTER LAKE	3	3	3				
	INJ01P1052_00	FAILING LAKE	3	3	2				
	INJ01P1053_00	SEVEN SISTERS LAKES	3	3	5A		5A		
40500010802	INJ0182_01	TAMARACK LAKE INLET	3	3	3				
	INJ0182_T1001	CROOKED LAKE INLET	3	3	3				
	INJ0182_T1002	CROOKED LAKE INLET	3	3	3				
	INJ0182_T1003	CROOKED LAKE INLET	3	3	3				
	INJ0182_T1004	GAGE LAKE INLET	3	3	3				
	INJ0182_T1005	TAMARACK LAKE INLET	3	3	3				
	INJ0182_T1006	WARNER LAKE INLET	3	3	3				
	INJ01P1057_00	TAMARACK LAKE	3	3	3				

HUC12	2012 AUID	Assessment Unit Name	Recreation	Human Health / Fish Tissue	Aquatic Life Use	E COLI	IBC	PCBS (FISH TISSUE)	TOTAL MERCURY (FISH TISSUE)
	INJ01P1058_00	WARNER LAKE	3	3	3				
	INJ01P1059_00	RHODES LAKE	3	3	3				
	INJ01P1060_00	CHAIR FACTORY LAKE	3	3	3				
	INJ01P1061_00	PERCH LAKE	3	3	3				
	INJ01P1062_00	LIME LAKE	3	3	3				
	INJ01P1063_00	SALLY OWEN LAKE	3	3	3				
	INJ01P1064_00	SYL-VAN, LAKE	3	3	3				
	INJ01P1065_00	GAGE, LAKE	3	3	2				
	INJ01P1066_00	CROOKED LAKE	3	2	3				
	INJ01P1067_00	PINE CANYON LAKE	3	3	3				
	INJ01P1068_00	LOON LAKE	3	3	3				
	INJ01P1069_00	CENTER LAKE	3	3	3				
	INJ01P1070_00	MIDDLE CENTER LAKE	3	3	3				
	INJ01P1071_00	LITTLE CENTER LAKE	3	3	3				
	INJ01P1072_00	BUCK LAKE	3	3	3				

HUC12	2012 AUID	Assessment Unit Name	Recreation	Human Health / Fish Tissue	Aquatic Life Use	E COLI	IBC	PCBS (FISH TISSUE)	TOTAL MERCURY (FISH TISSUE)
40500010803	INJ0183_01	CROOKED CREEK	3	2	2				
	INJ0183_T1 001	JIMMERSON LAKE INLET	3	2	2				
	INJ0183_T1 002	JIMMERSON LAKE INLET	3	3	3				
	INJ0183_T1 003	JIMMERSON LAKE INLET	3	3	3				
	INJ0183_T1 004	BELL LAKE DITCH	3	2	2				
	INJ01P1038 _00	JAMES, LAKE	3	5B	5A		5A	5B	
	INJ01P1039 _00	JIMMERSON LAKE	3	5B	5A		5A		5B
	INJ01P1054 _00	CHARLES EAST, LAKE	3	3	3				
	INJ01P1055 _00	CHARLES WEST, LAKE	3	3	3				
	INJ01P1056 _00	BELL LAKE	3	3	3				
40500010804	INJ0184_01	CROOKED CREEK	5A	3	3	5A			
	INJ0184_T1 001	CROOKED CREEK - UNNAMED TRIBUTARY	3	3	3				
	INJ0184_T1 002	CROOKED CREEK - UNNAMED TRIBUTARY	3	3	3				
	INJ0195_T1 040	ORLAND TRIB	3	3	2				
40500010805	INJ0185_02	FAWN RIVER	3	3	3				
	INJ0185_02 A	FAWN RIVER - UNNAMED DITCHES	3	3	3				

HUC12	2012 AUID	Assessment Unit Name	Recreation	Human Health / Fish Tissue	Aquatic Life Use	E COLI	IBC	PCBS (FISH TISSUE)	TOTAL MERCURY (FISH TISSUE)
	INJ0185_02B	FAWN RIVER - UNNAMED DITCHES	3	3	3				
	INJ01P1140_00	WALL LAKE	3	3	3				
	INJ01P1142_00	FENNELL LAKE	3	3	3				
	INJ01P1143_00	GREENFIELD MILLS LAKE	3	3	3				
	INJ0185_01	FAWN RIVER	3	3	3				
	INJ01P1141_00	BROWN LAKE	3	3	3				
	INJ01P1144_00	LIME LAKE	3	3	5A		5A		
40500010806	INJ0186_01	FAWN RIVER	3	3	3				
	INJ0186_01A	FAWN RIVER - UNNAMED DITCHES	3	3	3				
	INJ0186_02	FAWN RIVER	3	3	3				
	INJ0186_T1001	WENGER DITCH	3	3	3				
	INJ01P1148_00	CEDAR LAKE	3	3	3				
	INJ01P1149_00	DUFF LAKE	3	3	3				
	INJ01P1150_00	METEER LAKE	3	3	3				
40500010807	INJ0187_01	FAWN RIVER	2	3	3				
	INJ0187_T1001	WENGER DITCH	2	3	3				

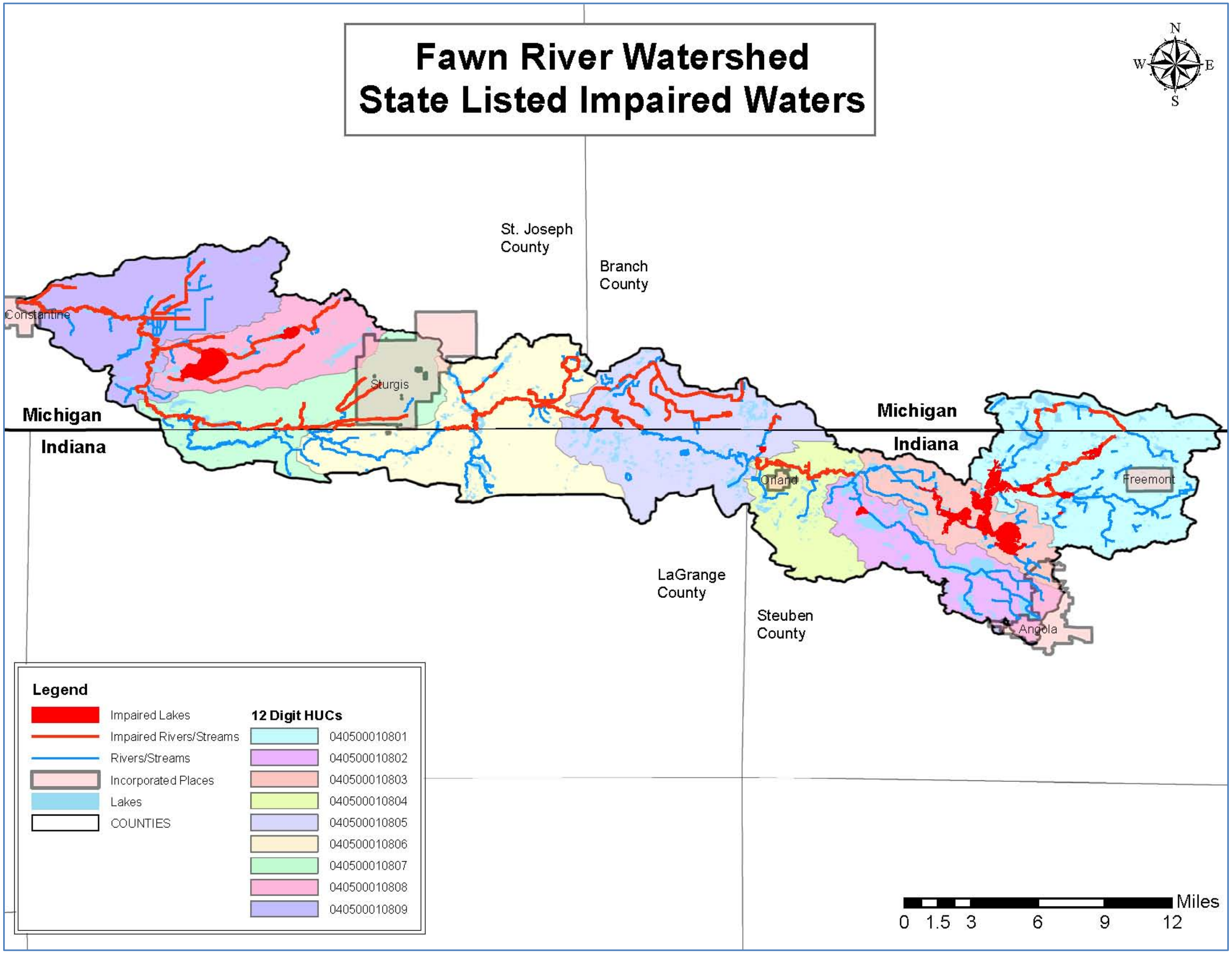
Category Description		Sub-Category
Category 1	Water Quality attainment for all designated uses and no use is threatened.	
Category 2	Water Quality attainment for some designated uses and no use is threatened; and insufficient data and information is available to determine if the remaining uses are attained or threatened.	
Category 3	Insufficient data and information are available to determine if any designated use is attained.	
Category 4	Waterway is impaired or threatened for one or more designated uses but does not require the development of a TMDL.	
	A TMDL has been completed that will result in the attainment of all applicable water quality standards.	A
	Other pollution control requirements are reasonably expected to result in the attainment of the water quality standard.	B
	Impairment is not caused by a pollutant for which a TMDL can be calculated.	C
Category 5	The Water quality standard in not attained. Waters may be listed in both 5A and 5B depending on the parameters causing the impairment.	
	The waters are impaired or threatened for one or more designated uses by a pollutant(s) and require a TMDL(s).	A
	The waterbody AU is impaired due to the presence of mercury or PCBs, or both in the edible tissue of fish collected from them at levels exceeding Indiana's human health criteria for these contaminants. The state believes that a conventional TMDL is not the appropriate approach to address these pollutants.	B

Table 3.3: MI DEQ Consolidated List of Waters in the Fawn River Watershed

HUC12	2012 AUID	2012 AU NAME	River Miles	Pollutant
40500010801	040500010801-01	Follette Creek and Little Fawn River	6.648671	PCB in Fish Tissue
				PCB in Water Column
40500010805	040500010805-01	UnNamed Tributary to Fawn River	1.352103	PCB in Fish Tissue
				PCB in Water Column
	040500010805-02	Fawn River and all tributaries from Himebaugh Drain upstream to IN line	31.938479	Mercury in Fish Tissue
				PCB in Fish Tissue
				PCB in Water Column
40500010806	040500010806-01	Indiana Waterbodies	11.42625	PCB in Fish Tissue
				PCB in Water Column
	040500010806-02	Fawn River	0.455465	PCB in Fish Tissue
				PCB in Water Column
	040500010806-03	UnNamed Tributary to Fawn River	0.227421	Mercury in Fish Tissue
				PCB in Fish Tissue
				PCB in Water Column
	040500010806-04	Fawn River and all tributaries in MI in this AUID south and east of Sturgis	27.769078	PCB in Fish Tissue
				PCB in Water Column
40500010807	040500010807-01	Fawn River	4.580127	PCB in Fish Tissue
				PCB in Water Column
	040500010807-02	Fawn River and all tributaries in MI, including Nye Drain, in this AUID southwest of Sturgis	5.775023	PCB in Fish Tissue
				PCB in Water Column
	040500010807-03	Fawn River	13.009648	Mercury in Fish Tissue
				PCB in Fish Tissue
				PCB in Water Column

HUC12	2012 AUID	2012 AU NAME	River Miles	Pollutant
40500010808	040800010808-01	Sherman Mill Creek and all tributaries from Fawn River confluence upstream to headwaters	16.285517	PCB in Fish Tissue
				PCB in Water Column
	040800010808-02	Klinger Lake	813.4532 ac	Mercury in Fish Tissue
	040800010808-03	Thompson Lake	147.5187 ac	Mercury in Fish Tissue

Figure 3.2: State Listed Impaired Waters in the Fawn River



3.2.2 Fish Consumption Advisory (FCA)

The Indiana Department of Environmental Management, the Indiana Department of Natural Resources and the Indiana Department of Health have worked together since 1972 on a collaborative effort to compile the Indiana Fish consumption advisory. As of 2014, the Michigan Fish consumption Advisory has been replaced by the regional Michigan Department of Community Health's *Eat Safe Fish* Guides. It is important to note that a fish advisory on a body of water does not necessarily mean that the water is unsafe for other recreational activities.

Carp greater than 20 inches and Walleye greater than 26 inches are on the Do Not Consume list for all counties and water bodies located within Indiana. There are FCAs for several species of fish that can be found in the Fawn River watershed. Go to the Indiana State Department of Health's website for more information on Indiana's FCA. (http://www.in.gov/isdh/23650.htm). The Fawn River Watershed falls within the Southwest region of the Michigan Eat Safe Fish Guide which can be found at http://www.michigan.gov/documents/mdch/MDCH_EAT_SAFE_FISH_GUIDE_-_SOUTHWEST_MI_WEB_455360_7.pdf.

Table 3.4 lists all species of fish that are on the Indiana and Michigan FCA for the Fawn River Watershed. It should be noted that the guidelines listed in the following table are for the general, healthy population. More strict guidelines are recommended for those individuals who fall within the "sensitive population" including children under the age of six years old and pregnant or nursing women, and women that will become pregnant.

Table 3.4: Fish Consumption Advisory in the Fawn River Watershed

State	Waterbody	Fish Species	Size Limit	Frequency for Safe Consumption	Contaminant
Michigan	Fawn River	Largemouth Bass	< 16"	2/mo	Mercury
			>16"	1/mo	
		Carp	Any	4/mo	Mercury
		Rock Bass	<7"	12/mo	Mercury
			>7"	4/mo	
		Smallmouth Bass	<16"	2/mo	Mercury
			>16"	1/mo	
		Sucker	Any	12/mo	Mercury
	Thompson Lake	Bullhead	Any	16/mo	Mercury
	Statewide	Black Crappie	Any	4/mo	Mercury
		Bluegill	Any	8/mo	Mercury
		Carp	Any	2/mo	PCBs
		Catfish	Any	4/mo	PCBs and Mercury
		Largemouth Bass	< 18"	2/mo	Mercury
			>18"	1/mo	

State	Waterbody	Fish Species	Size Limit	Frequency for Safe Consumption	Contaminant
		Smallmouth Bass	<18"	2/mo	Mercury
			>18"	1/mo	
		Muskellunge	Any	1/mo	Mercury
		Northern Pike	<30"	1/mo	Mercury
			>30"	6/yr	
		Rock Bass	Any	4/mo	Mercury
		Suckers	Any	8/mo	Mercury
		Sunfish	Any	8/mo	Mercury
		Walleye	<20"	2/mo	Mercury
			>20"	1/mo	
			>26"	Do Not Consume	
		White Crappie	Any	4/mo	Mercury
		Yellow Perch	Any	4/mo	Mercury
Indiana	**Crooked Creek**	Common Carp	>23"	1/wk	PCB
	Lake James	Northern Pike	20-36"	1/mo	Mercury
			>36"	6/yr	
	Statewide	Black Bass (all)	any	1/wk	Mercury and/or PCBs
		Rock Bass	any	1/wk	
		Crappie species	Any	1/wk	
		Sunfish species	Any	1/wk	
		Sauger	Any	1/wk	
		Walleye	<25"	1/wk	
			>25"	1/mo	
		Catfish	Any	1/wk	
		Norther Pike	<41"	1/wk	
			>41"	1/mo	
		Freshwater drum	Any	1/wk	
		Buffalo species	Any	1/wk	
		White bass	Any	1/wk	
		Striped or hybrid bass	<33"	1/wk	
			>33"	1/mo	
		Carp	<15"	1/wk	
			15-20"	1/mo	
			>20"	6/yr	
			>25"	Do Not Consume	

3.2.3 Steuben County Lakes Council

The Steuben County Lakes Council (SCLC) began a monitoring program surrounding lake inlets and outlets within the county in 2008. Water quality sampling and analysis is contracted to an outside company and samples are collected monthly from May through August. Samples are analyzed for *E.coli*, TP, TSS, D.O., pH and temperature. The SCLC has 21 sampling sites that are located within the Fawn River Watershed and were analyzed for inclusion in this WMP.

3.2.4 LaGrange County Soil and Water Conservation District

The IDEM 205(j) grant provided to the LaGrange County SWCD has funds specifically allocated to sampling water within the Fawn River Watershed. Specifically, the SWCD was to collect monthly samples at 54 sites located in the watershed for the first two years of the grant (2013 and 2014). Monitoring began in June, 2013. Due to time constraints of the Fawn River project (FRP), only data through May, 2014 has been analyzed for this project. Sustainable Natural Resource Technologies (SNRT) was contracted to collect water samples for analysis of nitrate, phosphorus, TDS, TSS, turbidity, DO, *E. coli*, temperature, and flow (at select sites). SNRT, Inc. was also contracted by the SWCD to collect and analyze macroinvertebrates and perform an aquatic habitat assessment using the volunteer monitoring protocol designated by the IN DNR Hoosier Riverwatch program once during the first year of the grant. Biological data was collected at each of the 54 project sample sites between October 1 and October 3, 2014.

3.3 Water Quality Data per Sub-watershed

This Section discusses historic and current water quality data that has been collected within each HUC 12 sub-watersheds in the Fawn River Watershed to help provide a picture of the overall health of each of the sub-watersheds.

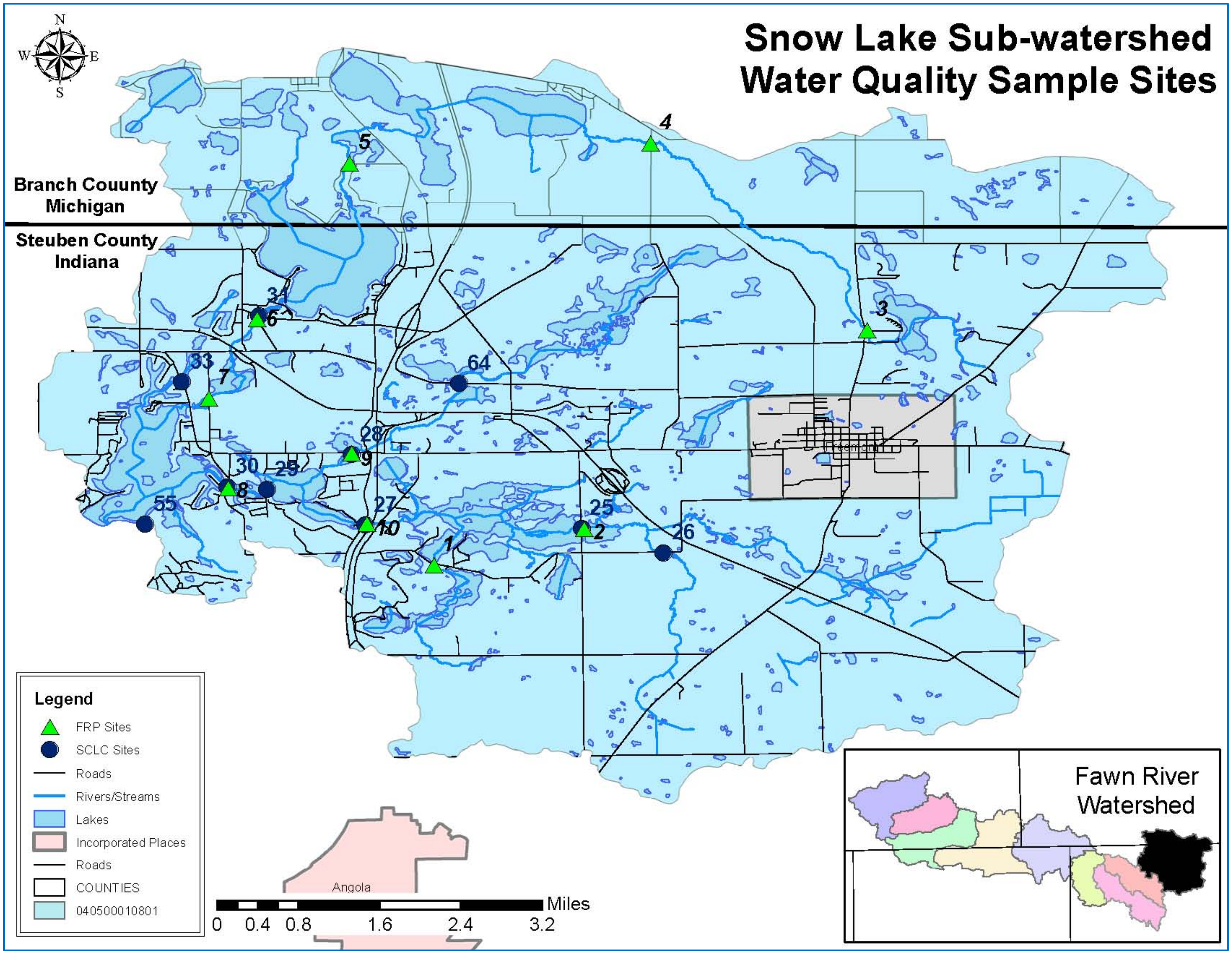
3.3.1 Snow Lake Sub-watershed Water Quality Analysis

Water quality in the Snow Lake sub-watershed was collected and analyzed at 10 sites by the SCLC and at 10 sites by the FRP. Five of the sampling sites were used by both the SCLC and the FRP. Results of the analysis of each site indicates the major parameters of concern in the Snow Lake sub-watershed are *E. coli* which exceeded the state standard in 22% of the samples analyzed in the watershed, phosphorus which exceeded the target level in 55% of the samples, nitrates which exceeded the target level in 30% of the samples, and to a lesser degree sediment as TSS exceeded the target level in 3% of the samples, and turbidity exceeded the state standard in 4% of the samples. Figure 3.3, below shows the location of each of the samples sites, and the following tables show the analysis of each sample site by each of the organizations that performed the sampling. Table 3.5, below, shows the average for the watershed as a whole; including all water quality samples in the watershed.

Table 3.5: Water Quality Analysis for all Sample Sites in the Snow Lake Sub-watershed

Snow Lake Sub-watershed			
Parameter	**Mean**	**Unit**	**% Does Not Meet Target**
E. coli	257.02	CFU	22%
TP	0.19	mg/L	55%
TSS	6.53	mg/L	3%
D.O.	6.99	mg/L	7%
Turbidity	2.4	NTU	4%
TDS	329.05	mg/L	15%
Nitrate	1.18	mg/L	30%

Figure 3.3: Snow Lake Water Quality Sample Sites



Both the SCLC and the FRP sampled water quality at the Crane Marsh outlet; sites 25 and 2, respectively. As can be seen in Tables 3.6 and 3.7 *E. coli* exceeded the state standard, on average, in 18% of the samples, TP exceeded the target of 0.08mg/L, on average, in 77% of the samples, and nitrates exceeded the target in 50% of the samples. Biological data collected by the FRP shows that pollution intolerant macroinvertebrates were not in high numbers at this site and the overall aquatic habitat was in poor condition. This may indicate that historic pollution issues may be present at this site.

Table 3.6: Steuben County Lakes Council Sampling at the Crane Marsh Outlet

SCLC, Site 25, Crane Marsh Outlet (tributary to Marsh Lake)				
Parameter	**Mean (Geomean)**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	71.83 (14.40)	CFU	2/19	11%
TP	0.25	mg/L	15/19	79%
TSS	12.94	mg/L	4/19	21%
D.O.	7.41	mg/L	0/19	0%
pH	7.82	SU	0/19	0%
Temp	20.47	^oC	0/19	0%

Table 3.7: Fawn River Project Sampling at the Crane Marsh Outlet

FRP, Marsh Lake Outlet; Site 2				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.97	SU	0/12	0%
Temp	11.38	^oC	0/12	0%
D.O.	9.17	mg/L	0/12	0%
TDS	418.8	mg/L	0/12	0%
Turbidity	3.92	NTU	1/12	8%
E. coli	116.67	CFU	3/12	25%
Nitrate	1.34	mg/L	6/12	50%
TP	0.24	mg/L	9/12	75%
TSS	7.67	mg/L	0/12	0%
Macroinvertebrates	18	Points	Fair	
CQHEI	53	Points	Partially Supporting	

The SCLC sampled at Deller Ditch, a tributary to Marsh Lake 15 times, between May, 2008 and August, 2012. The results indicate a problem with *E.coli* with an average CFU count of 285.47 CFU. Table 3.8 shows the results of the water quality analysis at Site 26.

Table 3.8: Steuben County Lakes Council Sampling at Deller Ditch

SCLC, Site 26, Deller Ditch (Tributary to Marsh Lake)				
Parameter	**Mean (Geomean)**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	285.47	CFU	6/15	40%
TP	0.04	mg/L	0/15	0%
TSS	9.87	mg/L	1/15	9%
D.O.	7.59	mg/L	0/15	0%
pH	7.82	SU	0/15	0%
Temp	18.71	^{o}C	0/15	0%

Both the SCLC and the FRP sampled water quality at the outlet of Little Otter Lake in Follett Creek; sites 27 and 10, respectively. The SCLC sampled at this location 19 times between 2008 and 2013 and the FRP sampled at this location 12 times between 2013 and 2014. Results of the analysis indicate an issue with TP, nitrates and E. coli at this site with average exceedances occurring 44%, 25% and 10% of the samples, respectively. Tables 3.9 and 3.10, below show the analysis by each organization at the Follett Creek sample site. Both the macroinvertebrate and habitat data collected at the FRP site 10 indicate that there may be an issue with historic pollution issues at this site as both scores were below the target level. It should be noted that the site was frozen during two sampling events, therefore only 10 water quality samples could be analyzed.

Table 3.9: Steuben County Lakes Council Sampling at Follet Creek

SCLC, Site 27, Follett Creek (Little Outer Lake Inlet)				
Parameter	**Mean (Geomean)**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	97.03 (59.02)	CFU	2/19	11%
TP	0.07	mg/L	4/19	21%
TSS	5.23	mg/L	0/19	0%
D.O.	6.85	mg/L	0/19	0%
pH	7.78	SU	0/19	0%
Temp	21.55	^{o}C	0/19	0%

Table 3.10: Fawn River Project Sampling at Follett Creek

FRP, Follet Creek; Site 10				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.02	SU	0/12	0%
Temp	12.56	ºC	0/12	0%
D.O.	7.37	mg/L	0/12	0%
TDS	353.85	mg/L	0/12	0%
Turbidity	1.67	NTU	0/12	0%
E. coli	70.83	CFU	1/12	8%
Nitrate	1.03	mg/L	3/12	25%
TP	0.13	mg/L	8/12	67%
TSS	2.92	mg/L	0/12	0%
Macroinvertebrates	18	Points	Fair	
CQHEI	57	Points	Poor	

Both the SCLC and the FRP sampled water quality at the Walter's Lake Drain, a tributary to Big Otter Lake; sites 28 and 9, respectively. As can be seen in Tables 3.11 and 3.12 *E. coli* exceeded the state standard, on average, in 39% of the samples, TP exceeded the target of 0.08mg/L, on average, in 36% of the samples, and nitrates exceeded the target in 10% of the samples. It should also be noted that D.O. fell below the state standard of 0.4 mg/L twice during the FRP sampling efforts between 2013 and 2014. Macroinvertebrate and habitat analysis at the FRP site 9 indicate that the water quality at this site is adequate to support a healthy aquatic ecosystem.

Table 3.11: Steuben County Lakes Council Sampling at Walter's Lake Drain

SCLC, Site 28, Walter's Lake Drain (Tributary to Big Otter Lake)				
Parameter	**Mean (Geomean)**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	430.76	CFU	8/14	57%
TP	0.05	mg/L	0/14	0%
TSS	6.02	mg/L	0/14	0%
D.O.	5.97	mg/L	2/14	14%
pH	7.48	SU	0/14	0%
Temp	19.99	ºC	0/14	0%

Table 3.12: Fawn River Project Sampling at Walter's Lake Drain

FRP, Walter's Lake Drain; Site 9				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.89	SU	0/10	0%
Temp	11.96	⁰C	0/10	0%
D.O.	6.62	mg/L	2/10 (<4mg/L)	20%
TDS	377.09	mg/L	0/10	0%
Turbidity	2.4	NTU	0/10	0%
E. coli	210	CFU	2/10	20%
Nitrate	1.03	mg/L	1/10	10%
TP	0.26	mg/L	8/10	80%
TSS	4.4	mg/L	0/10	0%
Macroinvertebrates	26	Points	Excellent	
CQHEI	64	Points	Good	

The SCLC sampled at the Big Otter Lake outlet, in Follett Creek 15 times between 2008 and 2012. An analysis of the samples indicate that this site is relatively unimpaired. However, when this site is compared with the analysis of Follett Creek prior to entering the Little and Big Otter Lake chain; SCLC site 27 and FRP site 10, one could assume that phosphorus, nitrates, and *E. coli* are settling out, or being diluted by the lake system. Table 3.13 shows the analysis of the water quality sampling effort at the Big Otter Lake outlet in Follett Creek.

Table 3.13: Steuben County Lakes Council Sampling in Follett Creek (Big Otter Lake Outlet)

SCLC, Site 29, Follet Creek (Big Otter Outlet)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	10.75	CFU	0/15	0%
TP	0.008	mg/L	0/15	0%
TSS	3.84	mg/L	0/15	0%
D.O.	8.39	mg/L	0/15	0%
pH	8.17	SU	0/15	0%
Temp	23.27	⁰C	0/15	0%

Both the SCLC and the FRP sampled water quality at the Follett Creek, Snow Lake inlet; sites 30 and 8, respectively. The SCLC sampled this location 15 times between 2008 and 2012, and the FRP sampled this location monthly between June 2013 and May 2014. As can be seen in Tables 3.14 and 3.15, the major water quality issue at this sample site is phosphorus, as TP exceeded the target level of 0.08 mg/L in 80% of the FRP's samples. Macroinvertebrate and habitat analysis at the FRP site 8 indicate that the water quality at this site is adequate to support a healthy aquatic ecosystem.

Table 3.14: Steuben County Lakes Council Sampling in Follett Creek (Snow Lake Inlet)

SCLC, Site 30, Follet Creek (Snow Lake Inlet)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	41.43	CFU	0/15	0%
TP	0.02	mg/L	0/15	0%
TSS	9.4	mg/L	0/15	0%
D.O.	7.5	mg/L	0/15	0%
pH	7.95	SU	0/15	0%
Temp	23.09	°C	0/15	0%

Table 3.15: Fawn River Project Sampling in Follett Creek (Snow Lake Inlet)

FRP, Snow Lake Inlet; Site 8				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.06	SU	0/10	0%
Temp	14.83	°C	0/10	0%
D.O.	8.29	mg/L	0/10	0%
TDS	329.05	mg/L	0/10	0%
Turbidity	2.4	NTU	0/10	0%
E. coli	40	CFU	0/10	0%
Nitrate	1.14	mg/L	1/10	10%
TP	0.17	mg/L	8/10	80%
TSS	4.3	mg/L	0/10	0%
Macroinvertebrates	23	Points	Excellent	
CQHEI	62	Points	Good	

Both the SCLC and the FRP sampled water quality at a tributary at the Lake George Outlet; sites 31 and 6, respectively. The SCLC sampled this location 18 times between 2008 and 2013, and the FRP sampled this location monthly between June 2013 and May 2014. As can be seen in Tables 3.16 and 3.17, the major water quality issue at this sample site is phosphorus, as TP exceeded the target level of 0.08 mg/L in 41% of the samples. The SCLC data also indicated an issue with D.O. as 39% of the SCLC samples for D.O. fell below the state standard. This may be due to algae growth which can be exacerbated by the high phosphorus levels found at this site.

Macroinvertebrate and habitat analysis at the FRP site 8 indicate that the water quality at this site is adequate to support a healthy aquatic ecosystem.

Table 3.16: Steuben County Lakes Council Sampling at the Lake George Outlet

SCLC, Site 31, Lake George Outlet				
Parameter	**Mean (Geomean)**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	211.11 (163.38)	CFU	7/18	39%
TP	0.14	mg/L	5/18	28%
TSS	5.04	mg/L	0/18	0%
D.O.	5.04	mg/L	7/18	39%
pH	7.49	SU	0/18	0%
Temp	21.66	^{o}C	0/18	0%

Table 3.17: Fawn River Project Sampling at the Lake George Outlet

FRP, Tributary from Lake George; Site 6				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.18	SU	0/11	0%
Temp	12.39	^{o}C	0/11	0%
D.O.	9.51	mg/L	0/11	0%
TDS	193.94	mg/L	0/11	0%
Turbidity	1.27	NTU	0/11	0%
E. coli	31.82	CFU	0/11	0%
Nitrate	1.06	mg/L	1/10	10%
TP	0.19	mg/L	7/11	64%
TSS	3	mg/L	0/11	0%
Macroinvertebrates	27	Points	Excellent	
CQHEI	89	Points	Good	

The SCLC sampled in Crooked Creek, a tributary leading to Snow Lake (Site 33) 19 times between 2008 and 2013. Analysis of the samples indicate an issue with E. coli as 21% of the samples exceeded the state standard of 235 CFU/100ml, phosphorus because TP also exceeded the target level in 21% of the samples, and D.O. which fell below the state standard of between 4 and 12 mg/L in 11% of the samples. Table 3.18 shows the water quality analysis for the SCLC site 33.

Table 3.18: Steuben County Lakes Council Sampling -Crooked Creek; Site 33

SCLC, Site 33, Crooked Creek (Tributary to Snow Lake)				
Parameter	**Mean (Geomean)**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	126.02 (41.19)	CFU	4/19	21%
TP	0.11	mg/L	4/19	21%
TSS	6.1	mg/L	0/19	0%
D.O.	6.29	mg/L	2/19	11%
pH	7.7	SU	0/19	0%
Temp	22.04	^oC	0/19	0%

The SCLC sampled in a tributary to Snow Lake (Site 55) in Pokagon State Park, 9 times between 2010 and 2012. Analysis of the samples indicate an issue with phosphorus because TP exceeded the target level of 0.08 mg/L in 89% of the samples with an average TP of 0.91 mg/L and readings from as low as 0.06 in July, 2011 and as high as 3.6 in July, 2010. Table 3.19 shows the water quality analysis for the SCLC site 55.

Table 3.19: Steuben County Lakes Council Sampling -Tributary to Snow Lake

SCLC, Site 55, Tributary to Snow Lake (Pokagon State Park)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	33	CFU	0/9	0%
TP	0.91	mg/L	8/9	89%
TSS	4.8	mg/L	0/9	0%
D.O.	7.86	mg/L	0/9	0%
pH	7.63	SU	0/9	0%
Temp	21.43	^oC	0/9	0%

The SCLC sampled at the Walter's Lake Drain (Site 64), 9 times between 2011 and 2013. Analysis of the samples indicates an issue with phosphorus because TP exceeded the target level of 0.08 mg/L in 56% of the samples with an average TP of 0.21 mg/L. Results also indicate an issue with *E. coli* which exceeded the state standard in 67% of the samples, and D.O. which fell below the state standard of between 4 and 12 mg/L in 13% of the samples. Table 3.20 shows the water quality analysis for the SCLC site 64.

Table 3.20: Steuben County Lakes Council Sampling at Walter's Lake Drain

SCLC, Site 64, Walter's Lake Drain (CR 660 N)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	1387.77	CFU	6/9	67%
TP	0.21	mg/L	5/9	56%
TSS	5.66	mg/L	0/9	0%
D.O.	6.16	mg/L	1/8	13%
pH	7.67	SU	0/9	0%
Temp	19.05	^{o}C	0/8	0%

The FRP sampled water quality at the Seven Sister's Lake Outlet (Site 1) seven times between 2013 and 2014. Only seven samples could be taken due to there being no flow three times and the stream being frozen twice during the sampling effort. Analysis of the samples indicates an issue with sediment as TSS and turbidity exceeded the target levels in one of the seven samples. The analysis also indicates an issue with nutrients as TP exceeded the target level in 100% of the samples and nitrates exceeded the target level in 29% of the samples. *E. coli* is also an issue at this site as readings exceeded the state standard of 235 CFU/100ml in 29% of the samples. Finally, DO readings were low in 14% of the samples which may be due to high sediment and nutrient levels that effect water temperatures and plant growth, respectively. Macroinvertebrate and habitat analysis at this site indicate that there may be historical pollution issues as macroinvertebrate scores were at the bottom of the scale for "fair" and habitat was scored very low at 24. Table 3.21 shows the analysis of water quality sampling at FRP site 1.

Table 3.21: Fawn River Project Sampling at Seven Sister's Lake Outlet

FRP, Seven Sisters Lake Outlet; Site 1				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.92	SU	0/7	0%
Temp	10.81	^{o}C	0/7	0%
D.O.	5.85	mg/L	1/7 (<0.4mg/L)	14%
TDS	290.48	mg/L	0/7	0%
Turbidity	.0.86	NTU	1/7	14%
E. coli	285.71	CFU	2/7	29%
Nitrate	0.82	mg/L	2/7	29%
TP	0.28	mg/L	7/7	100%
TSS	30.86	mg/L	1/7	14%
Macroinvertebrates	11	Points	Fair	
CQHEI	24	Points	Poor	

The FRP sampled water quality in the Little Fawn River (Site 3) four times between June 2013 and May, 2014. Only four samples could be taken due to there being no flow six times and the stream being frozen twice during the sampling effort. Analysis of the samples indicates an issue with nutrients as TP exceeded the target level of 0.08 mg/L in 100% of the samples and nitrates exceeding the target level in 50% of the samples. *E. coli* is also an issue at this site as readings exceeded the state standard of 235 CFU/100ml in one of the samples. Macroinvertebrate and habitat analysis at this site indicate that there may be historical pollution issues as macroinvertebrate scores were at the bottom of the scale for "fair" and habitat was scored very low at 23. Table 3.22 shows the analysis of water quality sampling at FRP site 3.

Table 3.22: Fawn River Project Sampling in the Little Fawn River: Site 3

FRP, Little Fawn River; Site 3				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.11	SU	0/4	0%
Temp	14.85	°C	0/4	0%
D.O.	7.08	mg/L	0/4	0%
TDS	168.43	mg/L	0/4	0%
Turbidity	4.75	NTU	0/4	0%
E. coli	125	CFU	1/4	25%
Nitrate	1.48	mg/L	2/4	50%
TP	0.38	mg/L	4/4	100%
TSS	9.5	mg/L	0/4	0%
Macroinvertebrates	11	Points	Fair	
CQHEI	23	Points	Poor	

The FRP sampled water quality in the Little Fawn River (Site 4) ten times between June 2013 and May, 2014. Only ten samples could be taken due to the stream being frozen twice during the sampling effort. Analysis of the samples indicates an issue with nutrients as TP exceeded the target level of 0.08 mg/L in 100% of the samples and nitrates exceeded the target level in 80% of the samples. *E. coli* is also an issue at this site as readings exceeded the state standard of 235 CFU/100ml in 60% of the samples. Finally, sediment may be an issue at this site as turbidity exceeded the state standard in 20% of the samples and TSS exceeded the target level in one sample. MAcroinvertebrate and habitat analysis at this site showed that pollution detected at this site in 2013-2014 either has not been present for an extended period of time, or that it does not affect the overall aquatic health surrounding FRP site 4. Table 3.23 shows the analysis of water quality sampling at FRP site 4.

Table 3.23: Fawn River Project Sampling in the Little Fawn River; Site 4

FRP, Little Fawn River; Site 4				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.33	SU	0/10	0%
Temp	11.8	ºC	0/10	0%
D.O.	9.49	mg/L	0/10	0%
TDS	296.11	mg/L	0/10	0%
Turbidity	7.1	NTU	2/10	20%
E. coli	270	CFU	6/10	60%
Nitrate	1.96	mg/L	8/10	80%
TP	0.32	mg/L	10/10	100%
TSS	12.5	mg/L	1/10	10%
Macroinvertebrates	21	Points	Good	
CQHEI	61	Points	Good	

The FRP sampled water quality in the Little Fawn River (Site 5) ten times between June 2013 and May, 2014. Only ten samples could be taken due to the stream being frozen twice during the sampling effort. Analysis of the samples indicates an issue with nutrients as TP exceeded the target level of 0.08 mg/L in 70% of the samples and nitrates exceeded the target level in one of the samples. *E. coli* may also be an issue as readings exceeded the state standard in one of the samples. D.O. measured lower than the state standard of 4mg/L in 30% of the samples which may be due to excessive algae growth exacerbated by the high phosphorus levels at this site. The macroinvertebrate score calculated in Oct. 2014 revealed a diverse group of pollution intolerant species present at FRP site 5 and that the habitat is good and can support a healthy aquatic ecosystem. Table 3.24 shows the analysis of water quality sampling at FRP site 5.

Table 3.24: Fawn River Project Sampling in Little Fawn River; Site 5

FRP, Little Fawn River; Site 5				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.96	SU	0/10	0%
Temp	13.3	ºC	0/10	0%
D.O.	6.68	mg/L	3/10 (<0.4 mg/L)	30%
TDS	197.93	mg/L	0/10	0%
Turbidity	1.3	NTU	0/10	0%
E. coli	120	CFU	1/10	10%
Nitrate	0.94	mg/L	1/10	10%
TP	0.22	mg/L	7/10	70%
TSS	2.8	mg/L	0/10	0%
Macroinvertebrates	23	Points	Excellent	
CQHEI	76	Points	Good	

The FRP sampled water quality in a tributary to Lake James (Site 7) 12 times between June 2013 and May, 2014. Analysis of the samples indicates an issue with nutrients as TP exceeded the target level of 0.08 mg/L in 75% of the samples and nitrates exceeded the target level in 25% of the samples. *E. coli* may also be an issue as readings exceeded the state standard of 235 CFU/100ml in one of the samples. D.O. measured lower than the state standard of 4 to 12 mg/L in one of the samples, as well. The macroinvertebrate score measured at FRP site 7 indicates a diverse assemblage of species and the habitat score indicates that a healthy aquatic ecosystem can survive at this site. Table 3.25 shows the analysis of water quality sampling at FRP site 7.

Table 3.25: Fawn River Project Sampling in a Tributary to Lake James; Site 7

FRP, Tributary to Lake James; Site 7				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.03	SU	0/12	0%
Temp	11.03	ºC	0/12	0%
D.O.	7.89	mg/L	1/12 (<4 mg/L)	8%
TDS	227.55	mg/L	0/12	0%
Turbidity	0.75	NTU	0/12	0%
E. coli	50	CFU	1/12	8%
Nitrate	1.04	mg/L	3/12	25%
TP	0.18	mg/L	9/12	75%
TSS	2.5	mg/L	0/12	0%
Macroinvertebrates	24	Points	Excellent	
CQHEI	82	Points	Good	

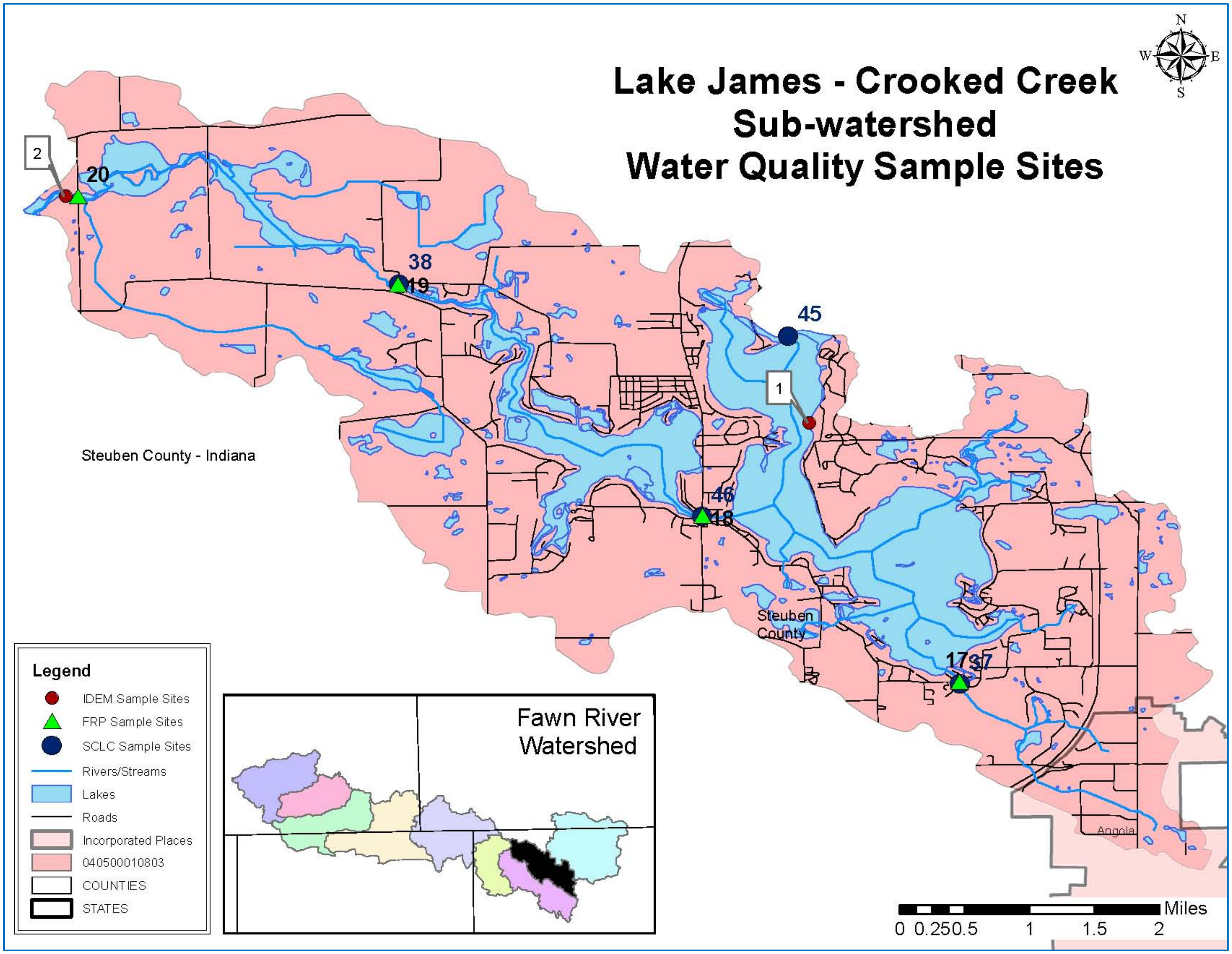
3.3.2 Lake James – Crooked Creek Sub-watershed Water Quality Analysis

Water quality in the Lake James – Crooked Creek sub-watershed was collected and analyzed at four sites by the SCLC and at four sites by the FRP. Three of the sites were used by both the SCLC and the FRP for sampling. IDEM also sampled in the Lake James-Crooked Creek Sub-watershed at two sites; Crooked Creek in 2000 and at the Pokagon State Park Beach in 2011-2013. Results of the analysis of each site indicates the major parameters of concern in the Lake James – Crooked Creek sub-watershed are *E. coli* which exceeded the target level in 16% of the samples analyzed in the watershed, phosphorus which exceeded the target level in 22% of the samples, nitrates which exceeded the target level in 21% of the samples, and to a lesser degree sediment as TSS exceeded the target level in <1% of the samples, and turbidity exceeded the state standard in 13% of the samples. Figure 3.4, below shows the location of each of the samples sites, and the following tables show the analysis of each sample site by each of the organizations that performed the sampling. Table 3.26, below, shows the average for the watershed as a whole; including all water quality samples in the watershed.

Table 3.26: Analysis of all Sample Sites in the Lake James-Crooked Creek Sub-watershed

Lake James - Crooked Creek Sub-watershed			
Parameter	**Mean**	**Unit**	**% Does Not Meet Target**
E. coli	193.01	CFU	16%
TP	0.2	mg/L	43%
TSS	5.61	mg/L	<1%
D.O.	8.68	mg/L	0%
Turbidity	4.78	NTU	13%
TDS	297.09	mg/L	0%
Nitrate	1.04	mg/L	21%

Figure 3.4: Water Quality Sample Sites in the Lake James – Crooked Creek Sub-watershed



The SCLC and the FRP both sampled at Croxton Ditch (Sites 37 and 17, respectively), a tributary to Lake James. The SCLC began sampling this site in May 2008, and sampled it monthly between May and September through 2013 and the FRP sampled the site monthly between June 2013 and May 2014. Sample analysis from this site indicates an issue with *E. coli*, phosphorus and nitrates. Macroinvertebrate and habitat scores collected by the FRP in October, 2014 at site 17 indicate that pollution runoff from the City of Angola may be having a negative impact on aquatic life as both scores were very low. Tables 3.27 and 3.28 show the analysis of the samples from each organization.

Table 3.27: Steuben County Lakes Council Sampling at Croxton Ditch (Site 37)

SCLC, Site 37, Croxton Ditch (tributary to Lk James at Lagoona Park)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	1063.85	CFU	10/13	77%
TP	0.13	mg/L	4/14	29%
TSS	5.26	mg/L	0/14	0%
D.O.	8.69	mg/L	0/14	0%
pH	7.95	SU	0/14	0%
Temp	18.46	^oC	0/14	0%

Table 3.28: Fawn River Project Sampling at Croxton Ditch (Site 17)

FRP, Croxton Ditch (Tributary to Lake James); Site 17				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.96	SU	0/12	0%
Temp	10.55	^oC	0/12	0%
D.O.	9.36	mg/L	0/12	0%
TDS	408.42	mg/L	0/12	0%
Turbidity	3.92	NTU	0/12	0%
E. coli	158.33	CFU	3/12	25%
Nitrate	1.09	mg/L	2/12	17%
TP	0.19	mg/L	8/12	67%
TSS	4.92	mg/L	0/12	0%
Macroinvertebrates	14	Points	Fair	
CQHEI	46	Points	Poor	

IDEM has a fixed sample location (Site 1) at the Pokagon State Park Beach as part of their Cyano Beach Project. Sampling takes place in June through August and began at this site began in 2011. Samples analyzed go through 2013. As can be seen in Table 3.29, TKN exceeded the target level in 71% of the samples, and turbidity exceeded the state standard in 11% of the samples.

Table 3.29: IDEM Sampling at Lake James in Pokagon State Park (Site 1)

IDEM - 2011-2013: Lake James (Lake James): Site 1				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
Ammonia	0	mg/L	0/7	0%
nitrate + nitrite	0	mg/L	0/7	0%
TKN	0.571	mg/L	5/7	71%
DRP	0.005	mg/L	0/3	0%
TP	0.005	mg/L	0/7	0%
Turbidity	6.13	NTU	1/9	11%
D.O.	8.659	mg/L	0/10	0%
pH	8.372	SU	0/10	0%
Temp	25.71	^oC	0/10	0%
Microcyctis	0.089	µg/L	0/10	0%

The SCLC sampled water quality in Crooked Creek at the Snow Lake outlet and Lake James inlet during the recreational season between 2008 and 2013. As can be seen in Table 3.30, none of the samples collected at this site exceeded the target level set by this project.

Table 3.30: Steuben County Lakes Council Sampling -Snow Lake to Lake James Inlet (Site 45)

SCLC, Site 45, Crooked Creek (Snow Lk outlet-Lk James Inlet)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	12.09	CFU	0/17	0%
TP	0.03	mg/L	0/17	0%
TSS	7.42	mg/L	0/17	0%
D.O.	8.03	mg/L	0/17	0%
pH	8.19	SU	0/17	0%
Temp	23.3	^oC	0/17	0%

Both the SCLC and the FRP sampled water quality in Crooked Creek at the Lake James Outlet (sites 46 and 18, respectively). The SCLC began sampling during the recreational season in May, 2008 and continued through Sept, 2013. The FRP sampled monthly between June, 2013 and May, 2014. As can be seen in Tables 3.31 and 3.32, phosphorus may be a significant issue at this site as the SCLC sampling effort for TP exceeded the target level of 0.08 mg/L in 28% of the samples and the FRP sampling effort for TP exceeded the target level for TP in 50% of the samples. It should be noted, that on August 17, 2012, TP levels were measured at 8.46 mg/L by the SCLC. All other sampling events after that were also above the target level, though the highest was 0.35 mg/L. Macroinvertebrate and habitat scores from the FRP site 18 were high indicating that a significant pollution issue is not present at this site.

Table 3.31: Steuben County Lakes Council Sampling -Crooked Creek (Lake James Outlet Site 46)

SCLC, Site 46, Crooked Creek (Lk James outlet-Jimmerson Lk Inlet @ 4 Corners)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	44.25	CFU	0/18	0%
TP	1.05	mg/L	5/18	28%
TSS	9.8	mg/L	1/18	6%
D.O.	8.06	mg/L	0/18	0%
pH	8.19	SU	0/18	0%
Temp	22.81	^oC	0/18	0%

Table 3.32: Fawn River Project Sampling in Crooked Creek- Lake James Outlet (Site 18)

FRP,Crooked Creek (Lake James Outlet); Site 18				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.1	SU	0/12	0%
Temp	13.26	^oC	0/12	0%
D.O.	9.24	mg/L	0/12	0%
TDS	261.84	mg/L	0/12	0%
Turbidity	1.17	NTU	0/12	0%
E. coli	8.33	CFU	0/12	0%
Nitrate	0.9	mg/L	1/12	8%
TP	0.14	mg/L	6/12	50%
TSS	2.5	mg/L	0/12	0%
Macroinvertebrates	35	Points	Excellent	
CQHEI	74	Points	Good	

Both the SCLC and the FRP sampled water quality in Crooked Creek at the Jimmerson Lake outlet at Nevada Mills (Sites 38 and 19, respectively). The SCLC began sampling monthly during the recreational season at this site in May, 2008 through Sept 2013 and the FRP sampled at this site monthly between June, 2013 and May, 2014. As can be seen in Tables 3.33 and 3.34, phosphorus and nitrates may be an issue at this site. TP exceeded the target level of 0.08 mg/L in 42% of the samples collected at this site, and nitrates exceeded the target level of 1.5 mg/L in 17% of the samples. *E. coli* exceeded the state standard once at this site in 2008. Macroinvertebrate and habitat scores from the FRP site 19 were high indicating that a significant, historic pollution issue is not present at this site.

Table 3.33: Steuben County Lakes Council Sampling -Crooked Creek (Jimmerson Lake outlet Site 38)

SCLC, Site 38, Crooked Creek (Jimmerson Lk outlet at Nevada Mills)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	69.73	CFU	1/19	5%
TP	0.07	mg/L	4/19	21%
TSS	5.71	mg/L	0/19	0%
D.O.	7.3	mg/L	0/19	0%
pH	7.89	SU	0/19	0%
Temp	23.73	^oC	0/19	0%

Table 3.34: Fawn River Project Sampling -Crooked Creek (Jimmerson Lake Outlet Site 19)

FRP, Crooked Creek (Jimmerson Lake Outlet); Site 19				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.16	SU	0/12	0%
Temp	13.54	^oC	0/12	0%
D.O.	9.4	mg/L	0/12	0%
TDS	250.41	mg/L	0/12	0%
Turbidity	1.25	NTU	0/12	0%
E. coli	16.67	CFU	0/12	0%
Nitrate	0.93	mg/L	2/12	17%
TP	0.14	mg/L	9/12	75%
TSS	2.33	mg/L	0/12	0%
Macroinvertebrates	31	Points	Excellent	
CQHEI	77	Points	Good	

Both IDEM and the FRP sampled water quality in Crooked Creek at the end of the chain of lakes through the Lake James – Crooked Creek sub-watershed (Sites 2 and 20, respectively). IDEM sampled this site in June, July and September, 2000 and the FRP sampled this site monthly from June, 2013 through May, 2014. Results from the sampling efforts are shown in Table 3.35 and 3.36. However, IDEM data is out of date. Analysis of the FRP indicates there may be an issue with phosphorus, and nitrate, and to a lesser degree *E. coli* loading at this site. However, macroinvertebrate and habitat scores do not indicate a historic pollution issue at this site.

Table 3.35: IDEM Sampling in Crooked Creek (Site 2)

IDEM - 2000: Crooked Creek (Lake James): Site 2				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
Ammonia	0.225	mg/L	1/2	50%
nitrate + nitrite	0.077	mg/L	0/3	0%
TKN	0.86	mg/L	3/3	100%
DRP	0.005	mg/L	0/3	0%
TP	0	mg/L	0/3	0%
TSS	5	mg/L	0/3	0%
TDS	300	mg/L	0/3	0%
Turbidity	12.43	NTU	2/3	67%
D.O.	8.757	mg/L	0/3	0%
pH	8.07	SU	0/3	0%
Temp	20.99	°C	0/3	0%

Table 3.36: Fawn River Project Sampling in Crooked Creek (Site 20)

FRP, Crooked Creek; Site 20				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.83	SU	0/12	0%
Temp	12.61	°C	0/12	0%
D.O.	9.27	mg/L	0/12	0%
TDS	267.66	mg/L	0/12	0%
Turbidity	3.75	NTU	0/12	0%
E. coli	170.83	CFU	2/12	17%
Nitrate	1.23	mg/L	5/12	42%
TP	0.17	mg/L	9/12	75%
TSS	7.58	mg/L	0/12	0%
Macroinvertebrates	34	Points	Excellent	
CQHEI	72	Points	Good	

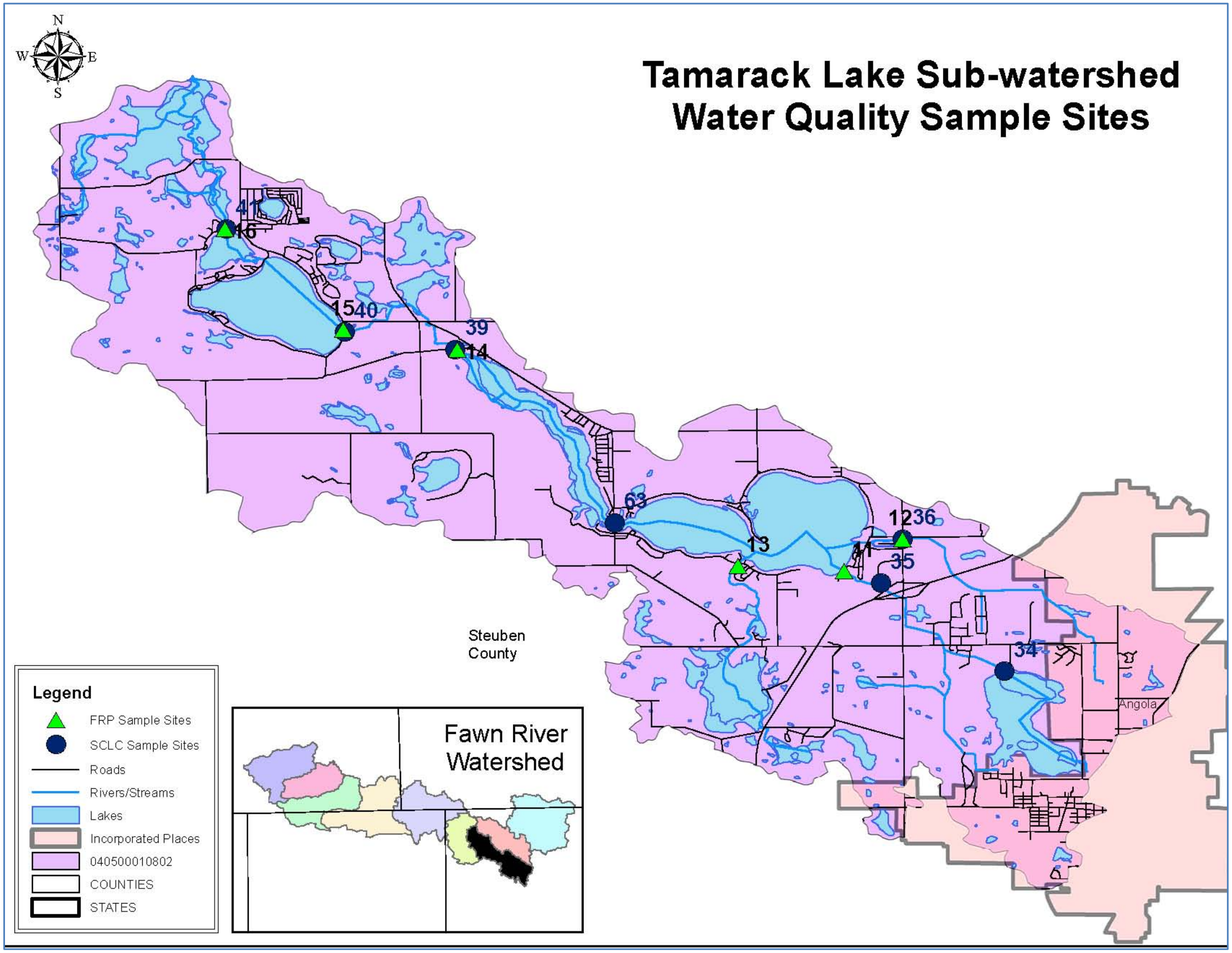
3.3.3 Tamarack Lake Sub-watershed Water Quality Analysis

Water quality in the Tamrack Lake sub-watershed was collected and analyzed at six sites by the SCLC and at seven sites by the FRP. Four of the sites were used by both the SCLC and the FRP for sampling. Results of the analysis of each site indicates the major parameters of concern in the Tamarack Lake sub-watershed are *E. coli* which exceeded the target level in 44% of the samples analyzed in the watershed, phosphorus which exceeded the target level in 39% of the samples, nitrates which exceeded the target level in 31% of the samples, and to a lesser degree sediment as TSS exceeded the target level in 6% of the samples, turbidity exceeded the state standard in 3% of the samples, and TDS exceeded the state standard in 1% of the samples. Figure 3.5, below shows the location of each of the samples sites, and the following tables show the analysis of each sample site by each of the organizations that performed the sampling. Table 3.37, below, shows the average for the watershed as a whole; including all water quality samples in the watershed.

Table 3.37: Analysis of all Sample Sites in the Tamarack Lake Sub-watershed

Lake James - Crooked Creek Sub-watershed			
Parameter	**Mean**	**Unit**	**% Does Not Meet Target**
E. coli	499.30	CFU	44%
TP	0.15	mg/L	39%
TSS	9.38	mg/L	6%
D.O.	7.83	mg/L	0%
Turbidity	3.00	NTU	3%
TDS	262.34	mg/L	0%
Nitrate	1.27	mg/L	31%

Figure 3.5: Water Quality Sample Site in Tamarack Lake Sub-watershed



The SCLC sampled in Carpenter Ditch, an outlet of Center Lake (Site 34) in May, July, and August from 2008 through 2012. Sample analysis from this site indicate an issue with E. coli, phosphorus and TSS as each parameter measured beyond the target level or state standard for that parameter. Table 3.38 shows the analysis of the samples taken from Site 34.

Table 3.38: Steuben County Lakes Council Sampling at Carpenter Ditch (Site 34)

SCLC, Site34, Carpenter Ditch (Outlet from Center Lake)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	834.31	CFU	11/14	79%
TP	0.072	mg/L	3/14	21%
TSS	18.15	mg/L	6/14	43%
D.O.	6.39	mg/L	0/14	0%
pH	7.78	SU	0/14	0%
Temp	20.72	^{o}C	0/14	0%

The SCLC sampled downstream of Site 34 in Carpenter Ditch (Site 35) four times annually during the recreational season between 2008 and 2013. Results of the analysis of this sample site indicate a significant issue with *E. coli* as the average CFU was 1704.16, with a geomean of 988.95, which far exceeds the state standard for both the single sample and geometric mean. E. coli exceeded the state standard in 95% of the samples. Phosphorus is also an issue at this site with measurements exceeded the target level in 37% of the samples. Sediment may also be an issue at Site 35 as 11% of the samples exceeded the state standard. Table 3.39 shows the analysis of the samples taken from Site 35.

Table 3.39: Steuben County Lakes Council Sampling at Carpenter Ditch (Site 35)

SCLC, Site 35, Carpenter Ditch (Tributary to Crooked Lake)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	1704.16	CFU	18/19	95%
TP	0.14	mg/L	7/19	37%
TSS	12.31	mg/L	2/19	11%
D.O.	7.92	mg/L	0/19	0%
pH	7.89	SU	0/19	0%
Temp	19.04	^{o}C	0/19	0%

The FRP sampled just downstream of the SCLC Site 35 in Carpenter Ditch at the inlet to Crooked Lake (Site 11) monthly between June 2013, and May 2014. Analysis of the samples indicates a significant issue with phosphorus as TP exceeded the target level of 0.08 mg/L in 75% of the samples. Analysis of the samples also indicated an issue with nitrates, which exceeded the target level in 42% of the samples, *E. coli*, which exceeded the state standard in 17% of the samples, and to a lesser degree sediment, as TSS and turbidity exceeded the state standard in one sample. Macroinvertebrate and habitat scores collected by the FRP in October, 2014 at site

11 indicate that pollution runoff from agriculture land and the City of Angola may be having a negative impact on aquatic life as both scores indicate poor diversity of macroinvertebrates and aquatic habitat. Table 3.40 shows the analysis of the samples taken at Site 11.

Table 3.40: Fawn River Project Sampling at Carpenter Ditch (Site 11)

FRP, Carpenter Ditch (Tributary to Crooked Lake); Site 11				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.78	SU	0/12	0%
Temp	11.68	ºC	0/12	0%
D.O.	9.16	mg/L	0/12	0%
TDS	322.36	mg/L	0/12	0%
Turbidity	5	NTU	1/12	8%
E. coli	79.17	CFU	2/12	17%
Nitrate	1.28	mg/L	5/12	42%
TP	0.22	mg/L	9/12	75%
TSS	9.33	mg/L	1/12	8%
Macroinvertebrates	6	Points	Poor	
CQHEI	21	Points	Poor	

The SCLC and the FRP both sampled water quality in Palfreyman Ditch, a tributary to Crooked Creek (Sites 36 and 12, respectively). The SCLC began sampling this site monthly during the recreational season in May, 2008 and continued through September, 2013. The FRP sampled at Site 12 monthly between June, 2013 and May 2014. Samples were not collected twice during that time frame do to the ditch being frozen during the winter months. Analysis of this site indicates a water quality issue with phosphorus and *E. coli* as TP exceeded the target level of 0.08 mg/L in 52% of the samples, and *E. coli* exceeded the state standard in 62% of the samples. The analysis also indicates that nitrates may be an issue at this site due to them exceeding the state standard in 40% of the FRP samples. Macroinvertebrates at the FRP site 12 are fair, however the habitat is considered to be poor. Again, this may be due to the influence the city of Angola has on the overall water quality at site 12. Tables 3.41 and 3.42, show the water quality analysis for each parameter by each of the sampling organizations.

Table 3.41: Steuben County Lakes Council Sampling at Palfreyman Ditch (Site 36)

SCLC, Site 36, Palfreyman Ditch (Tributary to Crooked Lake)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	976.83	CFU	12/19	63%
TP	0.15	mg/L	6/19	32%
TSS	16.15	mg/L	1/19	5%
D.O.	7.37	mg/L	0/19	0%
pH	7.79	SU	0/19	0%
Temp	20.36	ºC	0/19	0%

Table 3.42: Fawn River Project Sampling at Palfreyman Ditch (Site 12)

FRP, Palfreyman Ditch (Tributary to Crooked Lake); Site 12				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.78	SU	0/10	0%
Temp	12.47	^oC	0/10	0%
D.O.	8.47	mg/L	0/10	0%
TDS	280.4	mg/L	0/10	0%
Turbidity	3.8	NTU	0/10	0%
E. coli	555	CFU	6/10	60%
Nitrate	1.42	mg/L	4/10	40%
TP	0.25	mg/L	9/10	90%
TSS	7	mg/L	0/10	0%

The FRP sampled water quality in an unnamed tributary to Crooked Lake (Site 13) four times between June, 2013 and May, 2014. Samples were only taken twice due to the ditch being dry or frozen. An analysis of the samples taken at Site 13 indicate an issue with phosphorus as it exceeded the target level of 0.08 mg/L in 100% of the samples, and with *E. coli* as it exceeded the state standard in two of the four samples. Biological data could not be collected at this site due to the stream being dry at the time samples were being gathered. Table 3.43 shows the results of the water quality analysis at Site 13.

Table 3.43: Fawn River Project Sampling at an Unnamed tributary to Crooked Lake (Site 13)

FRP, Tributary to Crooked Lake; Site 13				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.87	SU	0/4	0%
Temp	14.13	^oC	0/4	0%
D.O.	8.58	mg/L	0/4	0%
TDS	221.98	mg/L	0/4	0%
Turbidity	1.75	NTU	0/4	0%
E. coli	575	CFU	2/4	50%
Nitrate	1.1	mg/L	0/4	0%
TP	0.22	mg/L	4/4	100%
TSS	3.25	mg/L	0/4	0%

The SCLC sampled water quality at the third basin of Crooked Lake (Site 63) three times in 2011. Results of the analysis indicate that there is not a water quality issue at this site. However, since only three samples were analyzed, more water quality samples should be evaluated to determine if there are, in fact, no water quality issues at this site. Table 3.44 shows the results of the water quality analysis at Site 63.

Table 3.44: Steuben County Lakes Council Sampling - Third Basin of Crooked Lake (Site 63)

SCLC, Site 63, Crooked Lake (Third Basin)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	24.2	CFU	0/3	0%
TP	0.02	mg/L	0/3	0%
TSS	12	mg/L	0/3	0%
D.O.	7.1	mg/L	0/3	0%
pH	7.99	SU	0/3	0%

Both the SCLC and the FRP sampled water quality from Concorde Creek, an outlet of Crooked Lake (Sites 39 and 14, respectively). The SCLC sampled at this location monthly during the recreational season between May, 2008 and August, 2013. The FRP sampled monthly between June, 2013 and May, 2014. Samples could not be taken once during that time frame due to there being no flow at the time. Results from the sampling efforts indicate there is an issue with *E. coli* at this site as it exceeded the state standard in 54% of the samples. There is also an issue with nutrients at this site as TP exceeded the target level of 0.08 mg/L in 37% of the samples, and nitrates exceeded the target level in 27% of the samples. There may also be an issue with sediment at TSS exceeded the state standard in 7% of the samples and turbidity exceeded the state standard in 9% of the samples. Biological data indicates there may be a historical water quality issue at this site as both macroinvertebrate and habitat scores were fairly low. Tables 3.45 and 3.46 show the results of the water quality analysis performed by each organization.

Table 3.45: Steuben County Lakes Council Sampling -Concorde Creek (Crooked Lake Outlet Site 39)

SCLC, Site 39, Concorde Creek (Outlet from Crooked Lake)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	689.09	CFU	11/17	65%
TP	0.06	mg/L	3/17	18%
TSS	9.81	mg/L	1/17	6%
D.O.	5.97	mg/L	0/17	0%
pH	7.59	SU	0/17	0%
Temp	22.7	^oC	0/17	0%

Table 3.46: Fawn River Project Sampling - Concorde Creek (Crooked Lake Outlet Site 14)

FRP, Concorde Creek (Outlet from Crooked Lake); Site 14				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.7	SU	0/11	0%
Temp	12.45	ºC	0/11	0%
D.O.	7.48	mg/L	0/11	0%
TDS	241.6	mg/L	0/11	0%
Turbidity	2.82	NTU	1/11	9%
E. coli	186.36	CFU	4/11	36%
Nitrate	0.93	mg/L	3/11	27%
TP	0.17	mg/L	7/11	64%
TSS	8.18	mg/L	1/11	9%
Macroinvertebrates	14	Points	Fair	
CQHEI	36	Points	Poor	

Both the SCLC and the FRP sampled water quality from Concorde Creek, at the inlet to Lake Gage (Sites 40 and 15, respectively). The SCLC sampled at this location monthly during the recreational season between May, 2008 and Sept, 2013. The FRP sampled monthly between June, 2013 and May, 2014. Samples could not be taken twice during that time frame due to the site being frozen at the time. Results from the sampling efforts indicate there is an issue with *E. coli* at this site as it exceeded the state standard in 48% of the samples. There is also an issue with nutrients at this site as TP exceeded the target level of 0.08 mg/L in 48% of the samples, and nitrates exceeded the target level in 50% of the samples. Macroinvertebrate and habitat data collected at FRP site 15 indicate that a historic pollution issue may be present at this site as both scored relatively low. Tables 3.47 and 3.48 show the results of the water quality analysis performed by each organization.

Table 3.47: Steuben County Lakes Council Sampling -Concorde Creek (Lake Gage Inlet Site 40)

SCLC, Site 40, Concorde Creek (Inlet to Lake Gage)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	480.1	CFU	11/19	58%
TP	0.13	mg/L	6/19	32%
TSS	9.61	mg/L	0/19	0%
D.O.	7.98	mg/L	0/19	0%
pH	7.92	SU	0/19	0%
Temp	20.59	ºC	0/19	0%

Table 3.48: Fawn River Project Sampling - Concorde Creek (Lake Gage Inlet Site 15)

FRP, Concorde Creek (Inlet to Lake Gage); Site 15				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.93	SU	0/10	0%
Temp	13.61	ºC	0/10	0%
D.O.	9.05	mg/L	0/10	0%
TDS	264.38	mg/L	0/10	0%
Turbidity	2.8	NTU	0/10	0%
E. coli	290	CFU	3/10	30%
Nitrate	1.83	mg/L	5/10	50%
TP	0.17	mg/L	8/10	80%
TSS	5.8	mg/L	0/10	0%
Macroinvertebrates	13	Points	Fair	
CQHEI	32	Points	Poor	

Both the SCLC and the FRP sampled water quality from Concorde Creek, at the outlet of Lime Lake (Sites 41 and 16, respectively). The SCLC sampled at this location monthly during the recreational season between May, 2008 and Sept, 2013. The FRP sampled monthly between June, 2013 and May, 2014. Results from the sampling efforts indicate there may be an issue with *E. coli* at this site as it exceeded the state standard in 6% of the samples; however the average CFU fell well below the state standard at 35.6 CFU/100ml. There is also an issue with nutrients at this site as TP exceeded the target level of 0.08 mg/L in 32% of the samples, and nitrates exceeded the target level in 25% of the samples. It should be noted that in July of 2012 the temperature reading of Site 41, by the SCLC was 30.1ºC, which is above the state standard. The air temperatures in the summer of 2012 reached record highs and it was a drought year which may have made the water level low and easier to heat. The high water temperature observed that year should not be considered a concern for this sample site. Biological data collected at FRP site 16 indicate a healthy aquatic ecosystem is present at this site. Tables 3.49 and 3.50 show the results of the water quality analysis performed by each organization.

Table 3.49: Steuben County Lakes Council Sampling -Concorde Creek (Lime Lake Outlet Site 41)

SCLC, Site 41, Concorde Creek (Outlet from Lime Lake)				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	63.34	CFU	1/19	5%
TP	0.1	mg/L	4/19	21%
TSS	6.33	mg/L	0/19	0%
D.O.	7.32	mg/L	0/18	0%
pH	8.02	SU	0/18	0%
Temp	23.01	ºC	1/14	7%

Table 3.50: Fawn River Project Sampling - Concorde Creek (Lime Lake Outlet Site 16)

FRP, Lime Lake Outlet; Site 16				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.91	SU	0/12	0%
Temp	13.27	°C	0/12	0%
D.O.	8.97	mg/L	0/12	0%
TDS	243.31	mg/L	0/12	0%
Turbidity	1.83	NTU	0/12	0%
E. coli	33.33	CFU	1/12	8%
Nitrate	1.03	mg/L	3/12	25%
TP	0.11	mg/L	6/12	50%
TSS	4.08	mg/L	0/12	0%
Macroinvertebrates	29	Points	Excellent	
CQHEI	74	Points	Good	

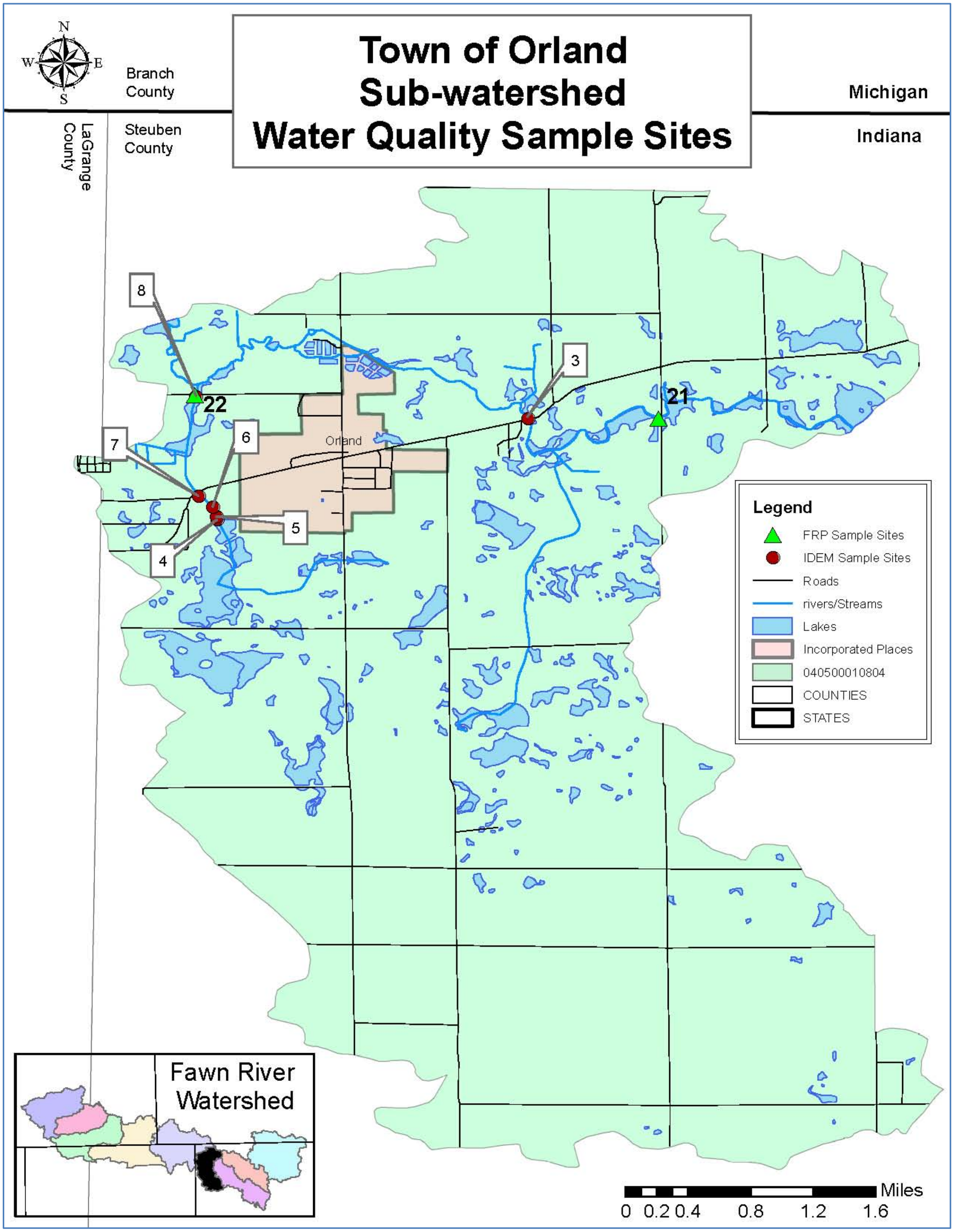
3.3.4 Town of Orland – Fawn River Sub-watershed Water Quality Analysis

Water quality in the Town of Orland sub-watershed was collected and analyzed at two sites by the FRP and at six sites by IDEM. All of IDEM's sampling took place over a decade ago, in the early 2000s. Therefore that data will not be used in the final water quality analysis of the watershed as a whole, but rather will be used as a historical reference of water quality within the Town of Orland sub-watershed. Results of the analysis of each site indicates the major parameters of concern in the Town of Orland sub-watershed are *E. coli* which exceeded the target level in 13% of the samples analyzed in the watershed, phosphorus which exceeded the target level in 88% of the samples, and nitrates which exceeded the target level in 29% of the samples analyzed. Figure 3.6, below shows the location of each of the samples sites, and the following tables show the analysis of each sample site by each of the organizations that performed the sampling. Table 3.51, below, shows the average for the watershed as a whole; including all water quality samples in the watershed performed by the FRP.

Table 3.51: Analysis of all Sample Sites in the Town of Orland Sub-watershed

Tamarack Lake Sub-watershed			
Parameter	**Mean**	**Unit**	**% Does Not Meet Target**
E. coli	77.15	CFU	13%
TP	0.20	mg/L	88%
TSS	4.42	mg/L	0%
D.O.	8.78	mg/L	0%
Turbidity	2.00	NTU	0%
TDS	308.14	mg/L	0%
Nitrate	1.30	mg/L	29%

Figure 3.6: Water Quality Sample Sites in Town of Orland – Fawn River Sub-watershed



The FRP sampled water quality in Crooked Creek (Site 21) monthly between June, 2013 and May, 2014. Results of the water quality analysis at this site indicate an issue with nutrients and *E. coli* as nitrates exceeded the target level in 25% of the samples, TP exceeded the target level of 0.08 mg/L in 75% of the samples, and E. coli exceeded the state standard in 17% of the samples. Biological data collected at this site indicate a healthy aquatic ecosystem. Table 3.52 shows the water quality analysis for the FRP Site 21.

Table 3.52: Fawn River Project Sampling in Crooked Creek (Site 21)

FRP, Crooked Creek; Site 21				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.85	SU	0/12	0%
Temp	12.61	°C	0/12	0%
D.O.	8.47	mg/L	0/12	0%
TDS	257.21	mg/L	0/12	0%
Turbidity	2.25	NTU	0/12	0%
E. coli	112.5	CFU	2/12	17%
Nitrate	1.18	mg/L	3/12	25%
TP	0.15	mg/L	9/12	75%
TSS	5.5	mg/L	0/12	0%
Macroinvertebrates	24	Points	Excellent	
CQHEI	73	Points	Good	

IDEM sampled water quality in Crooked Creek (Site 3) weekly between June and July, 2000. Results of the analysis at this site in 2000 indicate an issue with *E. coli* as the average CFU was 1233.46 and the geometric mean was 962.36 CFU; well above the state standards of 235 CFU/100ml and 125 CFU/100ml, respectively. There may also be a sediment issue at this site as the turbidity exceeded the state standard in one of the samples. Table 3.53 shows the water quality analysis for IDEM Site 3.

Table 3.53: IDEM Sampling in Crooked Creek (Site 3)

IDEM - 2000: Crooked Creek (Town of Orland): Site 3				
Parameter	**Mean (Geomean)**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	1233.456 (962.361)	CFU	4/5	80%
Turbidity	5.1	NTU	1/5	20%
D.O.	6.71	mg/L	0/5	0%
pH	7.654	SU	0/5	0%
Temp	24.66	°C	0/5	0%

IDEM sampled two sites (Sites 4 and 5) in Orland Ditch, in August, 2001. These sites are directly adjacent to each other. Results of the analysis of the water quality at these sites in 2001 show an issue with nitrogen, phosphorus, and sediment as all samples for these parameters exceeded the target levels in 100% of the samples. Site 5 also showed an exceedance of the target levels for nitrate+nitrite in 100% of the samples analyzed, with the average being nearly four times the target level at 5.65 mg/L. It should be noted that Site 5 is the first spot after the lake's overflow. Therefore, it may be assumed that the measured parameters measure high because of septic system leachate or fertilizer runoff from lake residences or surrounding agriculture fields. Table 3.54 and 3.55 show the individual results for sample sites 4 and 5.

Table 3.54: IDEM Sampling in Orland Ditch (Site 4)

IDEM - 2001: Orland Ditch (Town of Orland): Site 4				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
nitrate + nitrite	0.3	mg/L	0/1	0%
TKN	14	mg/L	1/1	100%
TP	1.91	mg/L	1/1	100%
TSS	165	mg/L	1/1	100%
TDS	263	mg/L	0/1	0%
Turbidity	40.7	NTU	2/2	100%
D.O.	5.82	mg/L	0/2	0%
pH	7.735	SU	0/2	0%
Temp	15.31	^{o}C	0/2	0%

Table 3.55: IDEM Sampling in Orland Ditch at Lake Outlet (Site 5)

IDEM - 2001: Orland Ditch (Town of Orland): Site 5				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
nitrate + nitrite	5.65	mg/L	2/2	100%
TKN	5.75	mg/L	2/2	100%
TP	1.795	mg/L	2/2	100%
TSS	1203.5	mg/L	2/2	100%
TDS	303	mg/L	0/2	0%
Turbidity	15.945	NTU	2/2	100%
D.O.	5.82	mg/L	0/2	0%
pH	7.53	SU	0/2	0%
Temp	17.585	^{o}C	0/2	0%

IDEM sampled water quality in Orland Ditch a little further downstream from the lake outlet (Site 6) twice in 2001. Results indicate there is still an issue with TKN, even after further dilution in the ditch as it exceeded the target level in both samples. Table 3.56 shows the results of water quality sampling at IDEM Site 6.

Table 3.56: IDEM Sampling in Orland Ditch (Site 6)

IDEM - 2001: Orland Ditch (Town of Orland): Site 6				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
nitrate + nitrite	1.1	mg/L	0/2	0%
TKN	0.8	mg/L	2/2	100%
TP	0.03	mg/L	0/2	0%
TSS	7.5	mg/L	0/2	0%
TDS	346.5	mg/L	0/2	0%
Turbidity	3.5	NTU	0/2	0%
D.O.	5.82	mg/L	0/2	0%
pH	7.245	SU	0/2	0%
Temp	15.67	^{o}C	0/2	0%

IDEM sampled water quality in Orland Ditch approximately ¼ mile from the initial sample site 5 at the lake outlet (Site 7) in Aug, Oct, and Nov, 2000 and in July and Aug, 2001. Results of the water quality analysis at Site 7 indicate an issue with nitrogen and TKN, Nitrate, and ammonia all exceeded target levels, with phosphorus as it exceeded the target of 0.08 mg/L in 67% of the samples, and with sediment as TSS exceeded the target level in 60% of the samples and turbidity exceeded the target level in 64% of the samples. D.O. also fell below the state standard threshold of 4 mg/L in 45% of the samples, which may be due to excessive plant growth as a result of high nutrient levels at this site. Table 3.57 shows the results of the water quality sampling at IDEM Site 7.

Table 3.57: IDEM Sampling in Orland Ditch (Site 7)

IDEM - 2000-2002: Orland Ditch (Town of Orland): Site 7				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
nitrate + nitrite	1.07	mg/L	1/6	17%
TKN	5.27	mg/L	4/6	67%
Ammonia	0.66	mg/L	3/5	60%
TP	0.87	mg/L	4/6	67%
TSS	2116.2	mg/L	3/5	60%
TDS	357.67	mg/L	0/3	0%
Turbidity	27.869	NTU	7/11	64%
D.O.	4.846	mg/L	5/11 (<4mg/L)	45%
pH	7.386	SU	0/11	0%
Temp	14.06	^{o}C	0/11	0%

Both IDEM and the FRP sampled in Orland Ditch (Sites 8 and 22 respectively). IDEM sampled this site in Aug, Oct, and Nov, 2000 and the FRP sampled this site monthly between June, 2013 and May, 2014. Comparing the historic sampling effort of IDEM in 2000 and the sampling effort of the FRP over the past year, while the parameters that were measured by each entity are not all the same, it is clear that the water quality at this site has not changed over the years. Results of the analysis indicate a continual issue with nitrogen and phosphorus at this site. Macroinvertebrate data revealed that a relatively good set of macroinvertebrate species was observed at this site, however, the habitat scored poorly which may be a due to a recent activity or disturbance around this site. Tables 3.58 and 3.59 show the results of the water quality analysis for the IDEM Site 8 and the FRP Site 22, respectively.

Table 3.58: IDEM Sampling in Orland Ditch (Site 8)

IDEM - 2000: Orland Ditch (Town of Orland): Site 8				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
nitrate + nitrite	0.44	mg/L	0/6	0%
TKN	0.45	mg/L	0/2	0%
Ammonia	0.087	mg/L	1/3	33%
TP	0.029	mg/L	1/3	33%
TSS	4.5	mg/L	0/2	0%
Turbidity	3.83	NTU	0/6	0%
D.O.	7.665	mg/L	1/6 (<4mg/L)	17%
pH	7.56	SU	0/6	0%
Temp	13.34	^oC	0/6	0%

Table 3.59: Fawn River Project Sampling in Orland Ditch (Site 22)

FRP, Orland Ditch; Site 22				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.13	SU	0/12	0%
Temp	11.53	^oC	0/12	0%
D.O.	9.09	mg/L	0/12	0%
TDS	321.47	mg/L	0/12	0%
Turbidity	2	NTU	0/12	0%
E. coli	41.8	CFU	1/12	8%
Nitrate	1.44	mg/L	4/12	33%
TP	0.24	mg/L	12/12	100%
TSS	3.33	mg/L	0/12	0%
Macroinvertebrates	18	Points	Good	
CQHEI	52	Points	Poor	

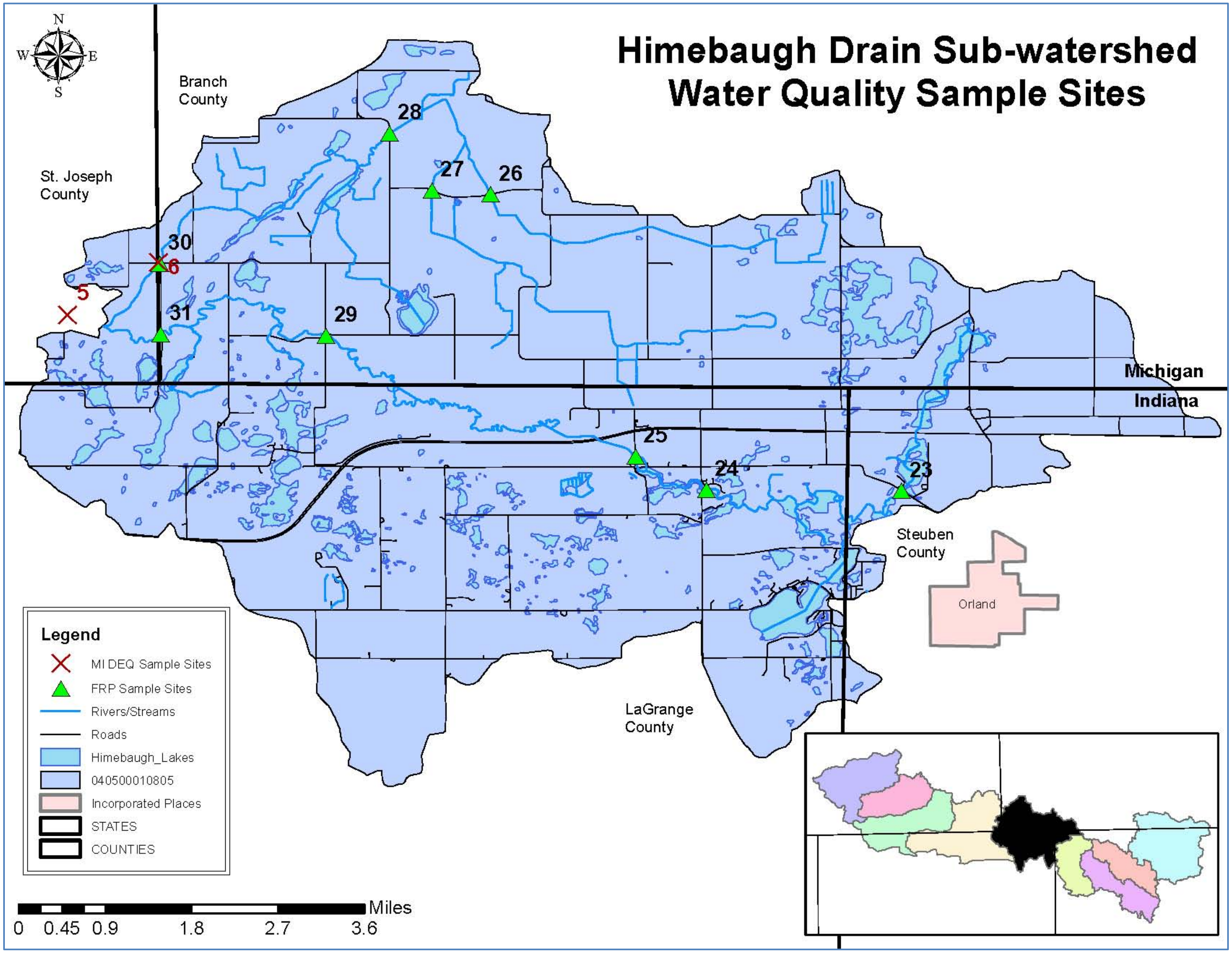
3.3.5 Himebaugh Drain Sub-watershed Water Quality Analysis

Water quality in the Himebaugh Drain sub-watershed was collected and analyzed at nine sites by the FRP and at one site by the MI DEQ. Mi DEQ only performed a habitat assessment and a macroinvertebrate analysis at this site (Site 6), and the assessment took place in 2010. The MI DEQ assessment will complement the water quality analysis done by the FRP, as biological data is a good indicator of long term water quality. Results of the analysis of each site indicates the significant issues in this watershed are phosphorus and nitrogen as TP exceeded the target level in 57% of all sampled in this watershed and nitrates exceeded the target level in 74% of all samples in this watershed. *E. coli* may also be an issue in the Himebaugh Drain sub-watershed as it exceeded the state standard in 13% of all the samples collected in this watershed. Table 3.60 shows the water quality analysis for all water quality samples collected from the Himebaugh Drain sub-watershed.

Table 3.60: Analysis of all Sample Sites in the HImebaugh Drain Sub-watershed

HImebaugh Drain Sub-watershed			
Parameter	**Mean**	**Unit**	**% Does Not Meet Target**
E. coli	115.50	CFU	13%
TP	0.20	mg/L	57%
TSS	6.30	mg/L	2%
D.O.	9.21	mg/L	0%
Turbidity	3.27	NTU	2%
TDS	310.94	mg/L	0%
Nitrate	2.19	mg/L	74%

Figure 3.7: Water Quality Sample Sites in the Himebaugh Drain Sub-watershed



The FRP sampled water quality in an unnamed tributary to the Fawn River (Site 23) monthly between June, 2013 and May, 2014. Analysis of the samples from this site indicate an issue with nutrients as TP exceeded the target level of 0.08 mg/L and nitrates exceeded the target level of 1.5 mg/L in 100% of the samples. Table 3.61 shows the results of the sampling effort at the FRP Site 23.

Table 3.61: Fawn River Project Sampling - Unnamed Tributary to the Fawn River (Site 23)

FRP, Tributary to Fawn River; Site 23				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.28	SU	0/12	0%
Temp	13.98	^oC	0/12	0%
D.O.	9.99	mg/L	0/12	0%
TDS	280.67	mg/L	0/12	0%
Turbidity	3.58	NTU	1/12	8%
E. coli	20.83	CFU	0/12	0%
Nitrate	3.08	mg/L	12/12	100%
TP	0.19	mg/L	12/12	100%
TSS	8.17	mg/L	1/12	8%

The FRP sampled water quality in the Fawn River (Site 24) monthly between June, 2013 and May, 2014. Samples could not be collected twice due to the stream being frozen during the winter months. Analysis of the samples from this site indicate an issue with nutrients as TP exceeded the target level of 0.3 mg/L and in one sample and nitrates exceeded the target level of 1.5 mg/L in 50% of the samples. E. coli may also be an issue at this site as it exceeded the state standard once during the sampling cycle. Table 3.62 shows the results of the sampling effort at the FRP Site 24.

Table 3.62: Fawn River Project Sampling - Fawn River (Site 24)

FRP, Fawn River; Site 24				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.1	SU	0/10	0%
Temp	14.52	^oC	0/10	0%
D.O.	8.34	mg/L	0/10	0%
TDS	272.29	mg/L	0/10	0%
Turbidity	2.5	NTU	0/10	0%
E. coli	60	CFU	1/10	10%
Nitrate	1.52	mg/L	5/10	50%
TP	0.2	mg/L	1/10	10%
TSS	5.9	mg/L	0/10	0%

The FRP sampled water quality in an unnamed tributary to the Himebaugh Drain (Site 26) monthly between June, 2013 and May, 2014. Analysis of the samples from this site indicate an issue with nutrients as TP exceeded the target level of 0.08 mg/L and nitrates exceeded the target level of 1.5 mg/L in 100% of the samples. Sediment may also be an issue at this site as TSS and turbidity exceeded the state standard once during the sampling cycle. However, both exceeded during the same sampling event, so the exceedance may be an anomaly. Table 3.63 shows the results of the sampling effort at the FRP Site 26.

Table 3.63: Fawn River Project Sampling - Unnamed Tributary to Himebaugh Drain (Site 26)

FRP, Unnamed Tributary to Himebaugh Drain; Site 26				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.11	SU	0/12	0%
Temp	10.93	⁰C	0/12	0%
D.O.	9.13	mg/L	0/12	0%
TDS	369.54	mg/L	0/12	0%
Turbidity	6.83	NTU	1/12	8%
E. coli	75	CFU	0/12	0%
Nitrate	3.78	mg/L	12/12	100%
TP	0.27	mg/L	12/12	100%
TSS	13.75	mg/L	1/12	8%

The FRP sampled water quality in another unnamed tributary to the Himebaugh Drain (Site 27) monthly between June, 2013 and May, 2014. Analysis of the samples from this site indicate an issue with nutrients as TP exceeded the target level of 0.08 mg/L in 83% of the samples and nitrates exceeded the target level of 1.5 mg/L in 100% of the samples. There may also be an issue with *E. coli* at this site as it exceeded the state standard in two of the samples collected. Table 3.64 shows the results of the sampling effort at the FRP Site 27.

Table 3.64: Fawn River Project Sampling - Unnamed Tributary to Himebaugh Drain (Site 27)

FRP, Unnamed Tributary to Himebaugh Drain; Site 27				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.17	SU	0/12	0%
Temp	10.78	⁰C	0/12	0%
D.O.	9.48	mg/L	0/12	0%
TDS	349.65	mg/L	0/12	0%
Turbidity	3.75	NTU	0/12	0%
E. coli	116.67	CFU	2/12	17%
Nitrate	2.08	mg/L	10/12	83%
TP	0.21	mg/L	12/12	100%
TSS	5.67	mg/L	0/12	0%

The FRP sampled water quality in Himebaugh Drain (Site 28) monthly between June, 2013 and May, 2014. Analysis of the samples from this site indicate an issue with nutrients as TP exceeded the target level of 0.08 mg/L in 100% of the samples and nitrates exceeded the target level of 1.5 mg/L in 75% of the samples. There is also an issue with *E. coli* at this site as it exceeded the state standard in 42% of the samples collected. Table 3.65 shows the results of the sampling effort at the FRP Site 28.

Table 3.65: Fawn River Project Sampling - Himebaugh Drain (Site 28)

FRP, Himebaugh Drain; Site 28				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.3	SU	0/12	0%
Temp	11.01	^oC	0/12	0%
D.O.	9.58	mg/L	0/12	0%
TDS	351.81	mg/L	0/12	0%
Turbidity	3.17	NTU	0/12	0%
E. coli	287.5	CFU	5/12	42%
Nitrate	2.21	mg/L	9/12	75%
TP	0.21	mg/L	12/12	100%
TSS	5.42	mg/L	0/12	0%

The FRP sampled water quality in the Fawn River (Site 29) monthly between June, 2013 and May, 2014. Samples could not be collected twice as the river was frozen during the winter months. Analysis of the samples from this site indicates an issue with nitrates which exceeded the target level of 1.5 mg/L in 70% of the samples. The average TP reading at this site was 0.2 mg/L which is below the target level of 0.3 mg/L for the mainstem of a river system. Table 3.66 shows the results of the sampling effort at the FRP Site 29.

Table 3.66: Fawn River Project Sampling - Fawn River (Site 29)

FRP, Fawn River; Site 29				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.25	SU	0/10	0%
Temp	14.25	^oC	0/10	0%
D.O.	9.28	mg/L	0/10	0%
TDS	282.59	mg/L	0/10	0%
Turbidity	2.5	NTU	0/10	0%
E. coli	105	CFU	0/10	0%
Nitrate	1.69	mg/L	7/10	70%
TP	0.2	mg/L	0/10	0%
TSS	4.1	mg/L	0/10	0%

The FRP and MI DEQ sampled in Himebaugh Drain (Sites 30 and 6, respectively). The FRP sampled the site monthly from June, 2013 through May, 2014. Samples were not able to be collected twice during the sampling period due to stream being frozen during the winter months. The MI DEQ sampled this site once in 2010 for macroinvertebrate and aquatic habitat only. Results of the analysis indicate an issue with nutrients as TP exceeded the target level of 0.08 mg/L in 90% of the samples and nitrates exceeded the target level in 80% of the samples. There may also be an issue with *E. coli* at this site as it exceeded the state standard in two samples. MI DEQ's biological analysis indicate that the high nutrient levels may be impairing the aquatic ecosystem as the number of macroinvertebrates that are not tolerant of pollution in the ecosystem found was only "acceptable" and the habitat was deemed to be "moderately impaired". Table 3.67 and 3.68 shows the results of the sampling efforts at this site.

Table 3.67: Fawn River Project Sampling - Himebaugh Drain (Site 30)

FRP, Himebaugh Drain; Site 30				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.22	SU	0/10	0%
Temp	15.24	°C	0/10	0%
D.O.	8.73	mg/L	0/10	0%
TDS	631.5	mg/L	0/10	0%
Turbidity	1.5	NTU	0/10	0%
E. coli	130	CFU	2/10	20%
Nitrate	1.94	mg/L	8/10	80%
TP	0.16	mg/L	9/10	90%
TSS	3.5	mg/L	0/10	0%

Table 3.68: MI DEQ Sampling - Himebaugh Drain (Site 6)

MI DEQ, Himebaugh Drain; Site 6			
Parameter	**Score / Rating**		
Habitat (2010)	Marginal (Moderately Impaired)		
IBI (2010)	0	Scale of 7 to -5	Acceptable

The FRP sampled water quality in the Fawn River (Site 31) monthly between June, 2013 and May, 2014. There were two instances when samples could not be taken due to the river being frozen during the winter months. Analysis of sample Site 31 indicates an issue with nitrates as it exceeded the target level in 60% of the samples. There may also be an issue with E. coli at this site as it exceeded the state standard in one sample. It should be noted that while the average TP reading was 0.19 mg/L, none of the samples exceeded the target level of 0.3 mg/L for mainstem sample sites. Table 3.69 shows the results of the analysis at Site 31.

Table 3.69: Fawn River Project Sampling -Fawn River (Site 31)

FRP, Fawn River; Site 31				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.19	SU	0/10	0%
Temp	14.24	°C	0/10	0%
D.O.	9.31	mg/L	0/10	0%
TDS	280.76	mg/L	0/10	0%
Turbidity	2.3	NTU	0/10	0%
E. coli	130	CFU	1/10	10%
Nitrate	1.57	mg/L	6/10	60%
TP	0.19	mg/L	0/10	0%
TSS	3.9	mg/L	0/10	0%

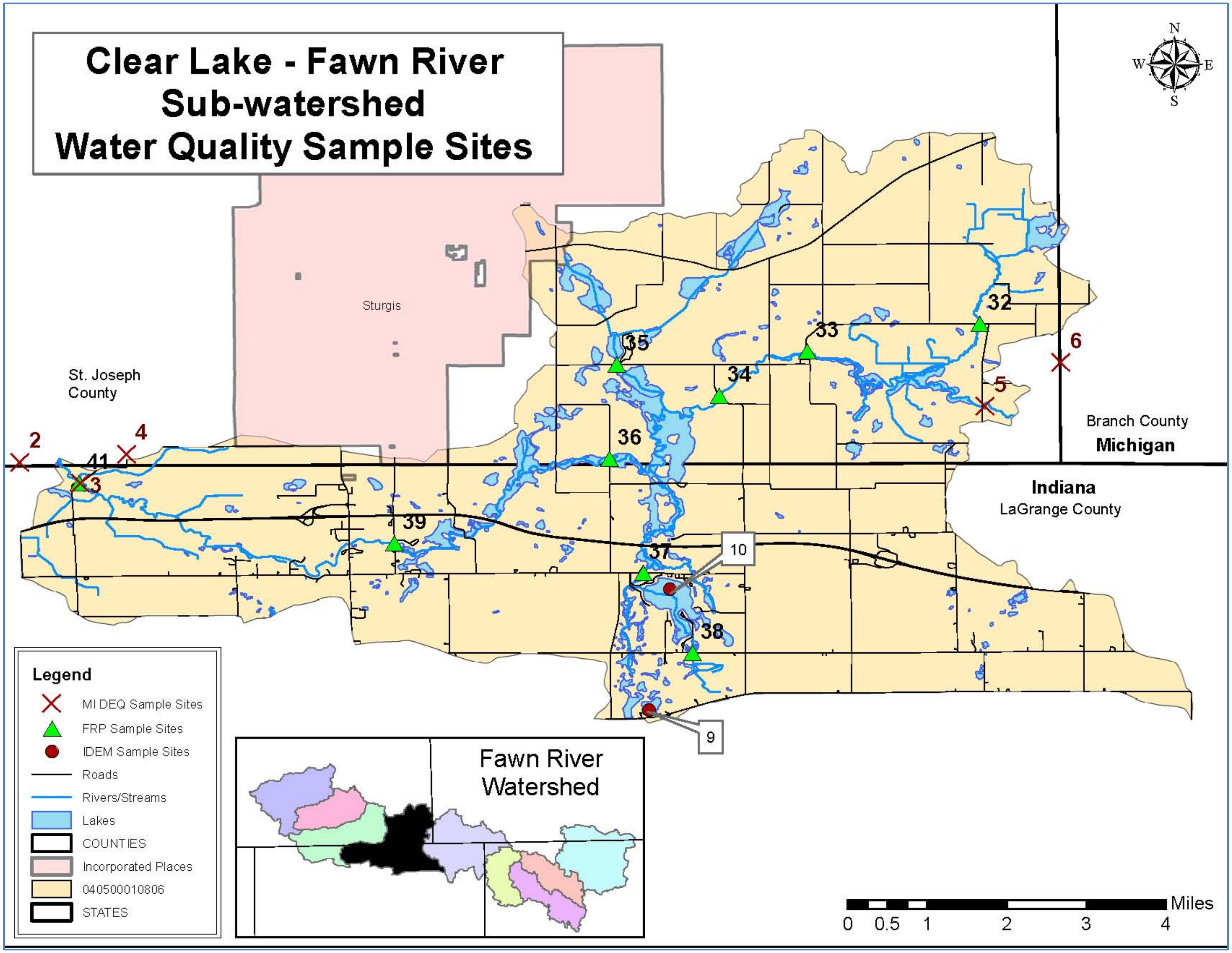
3.3.6 Clear Lake – Fawn River Sub-watershed Water Quality Analysis

Water quality in the Clear Lake sub-watershed was collected and analyzed at nine sites by the FRP, two sites by IDEM, and two sites by MI DEQ. All of MI DEQ and IDEM's sampling took place over a decade ago, in 2000. Therefore that data will not be used in the final water quality analysis of the watershed as a whole, but rather will be used as a historical reference of water quality within the Clear Lake sub-watershed. Results of the analysis of each of the FRP's sites indicate the major parameters of concern in the Clear Lake sub-watershed are *E. coli* which exceeded the target level in 19% of the FRP samples analyzed in the watershed, phosphorus which exceeded the target level in 54% of the samples, and nitrates which exceeded the target level in 49% of the FRP samples analyzed. Figure 3.8, below shows the location of each of the samples sites, and the following tables show the analysis of each sample site by each of the organizations that performed the sampling. Table 3.70, below, shows the average for the watershed as a whole; including all of the water quality samples in the watershed performed by the FRP.

Table 3.70: Analysis of all Sample Sites - Clear Lake Sub-watershed

Clear Lake – Fawn River Sub-watershed			
Parameter	**Mean**	**Unit**	**% Does Not Meet Target**
E. coli	146.35	CFU	19%
TP	0.22	mg/L	54%
TSS	5.98	mg/L	2%
D.O.	8.72	mg/L	1%
Turbidity	2.58	NTU	1%
TDS	291.79	mg/L	0%
Nitrate	1.71	mg/L	49%

Figure 3.8: Water Quality Sample Sites in the Clear Lake – Fawn River Sub-watershed



The MI DEQ sampled water quality and habitat in the Fawn River (Site 5) once in 2000. Results of the sampling indicate that while none of the water quality parameters exceeded the target level, the aquatic habitat at Site 5 was slightly impaired. This may be due to a lack of vegetative cover, riffles and pools, or sedimentation of the river bottom (MI DEQ did not sample for TSS, TDS, or turbidity at this site so this assumption cannot be verified by actual water quality data). Table 3.71 shows the results of the sampling effort by MI DEQ at Site 5.

Table 3.71: MI DEQ Sampling in the Fawn River (Site 5)

MI DEQ, Fawn River; Site 5				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
TDS	410	mg/L	0/1	0%
TKN	0.48	mg/L	0/1	0%
Nitrite	0.01	mg/L	0/1	0%
Nitrate + Nitrite	0.59	mg/L	0/1	0%
TP	0.02	mg/L	0/1	0%
DRP	0.02	mg/L	0/1	0%
Habitat	Good (Slightly Impaired)			

The FRP sampled water quality in an unnamed tributary to the Fawn River (Site 32) monthly from June, 2013 through May, 2014. Samples could not be taken twice during the sampling cycle due to the tributary being frozen during the winter months. Results of the analysis of Site 32 indicate there is an issue with nutrients and *E. coli*. TP exceeded the target level of 0.08 mg/L in 100% of the samples, and nitrates exceeded the target level in two of the samples. The high TP measurements may be why D.O. fell below the state standard threshold of not less than 4 mg/L as high P often increases algae and other aquatic plant growth which effects D.O. levels in the water. Results of the analysis also indicate an issue with *E.coli* due to it exceeding the state standard in 40% of the samples analyzed at Site 32. Macroinvertebrate and habitat scores were both in the range to indicate the aquatic habitat at Site 32 is generally good. Table 3.72 shows the results of the sampling effort by the FRP at sample Site 32.

Table 3.72: Fawn River Project Sampling -Unnamed Tributary to Fawn River (Site 32)

FRP, Unnamed Tributary to Fawn River; Site 32				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.09	SU	0/10	0%
Temp	13.48	°C	0/10	0%
D.O.	6.14	mg/L	1/10 (<4mg/L)	10%
TDS	208.74	mg/L	0/10	0%
Turbidity	4.2	NTU	0/10	0%
E. coli	275	CFU	4/10	40%
Nitrate	1.15	mg/L	2/10	20%
TP	0.38	mg/L	10/10	100%
TSS	11.6	mg/L	1/10	10%
Macroinvertebrates	21	Points	Good	
CQHEI	67	Points	Good	

The FRP sampled water quality in the Fawn River (Site 33) monthly from June, 2013 through May, 2014. Samples could not be taken twice during the sampling cycle due to the river being frozen during the winter months. Results of the analysis of Site 33 indicate there is an issue with nutrients as TP exceeded the target level of 0.3 mg/L for a mainstem river in one sample and nitrates exceeded the target level in 30% of the samples. It should be noted that pollutants are often diluted out in larger mainstem rivers, which may account for the parameter readings all being relatively low when compared to tributary sampling efforts. The macorinvertebrate score at Site 33 was 35 points indicating pollution intolerant macroinvertebrates were abundant at the site. However, the habitat score was not as good, though still indicating a relatively good aquatic habitat is present at the site. Table 3.73 shows the results of the sampling effort by the FRP at sample Site 33.

Table 3.73: Fawn River Project Sampling in the Fawn River (Site 33)

FRP, Fawn River; Site 33				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.28	SU	0/10	0%
Temp	14.17	°C	0/10	0%
D.O.	9.06	mg/L	0/10	0%
TDS	208.91	mg/L	0/10	0%
Turbidity	3.2	NTU	0/10	0%
E. coli	85	CFU	0/10	0%
Nitrate	1.36	mg/L	3/10	30%
TP	0.2	mg/L	1/10	10%
TSS	4.5	mg/L	0/10	0%
Macroinvertebrates	35	Points	Excellent	
CQHEI	86	Points	Good	

The FRP sampled water quality in the Fawn River (Site 34) monthly from June, 2013 through May, 2014. Samples could not be taken twice during the sampling cycle due to the river being frozen during the winter months. Results of the analysis of Site 34 indicate there is an issue with nutrients as TP exceeded the target level of 0.3 mg/L for a mainstem river in one sample and nitrates exceeded the target level in 50% of the samples. There may also be an issue with *E. coli* at Site 34 as it exceeded the state standard in one sample. Since the sample site is located within the mainstem of the Fawn River, it may be expected that water quality measurements be low, however, while they are low at Site 34 when compared to tributaries, measurements are slightly high for a mainstem, specifically nitrates. The macroinvertebrate score was excellent at Site 34 and the habitat score was on the high end of good at 92 points. Table 3.74 shows the results of the sampling effort by the FRP at sample Site 34.

Table 3.74: Fawn River Project Sampling in the Fawn River (Site 34)

FRP, Fawn River; Site 34				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.31	SU	0/10	0%
Temp	12.87	^oC	0/10	0%
D.O.	9.56	mg/L	0/10	0%
TDS	282.2	mg/L	0/10	0%
Turbidity	1.75	NTU	0/10	0%
E. coli	100	CFU	1/10	10%
Nitrate	1.36	mg/L	5/10	50%
TP	0.19	mg/L	1/10	10%
TSS	4.83	mg/L	0/10	0%
Macroinvertebrates	41	Points	Excellent	
CQHEI	92	Points	Good	

The FRP sampled water quality in an unnamed tributary to the Fawn River (Site 35) monthly from June, 2013 through May, 2014. Samples could not be taken twice during the sampling cycle due to the tributary being frozen during the winter months. Results of the analysis of Site 35 indicate there is an issue with phosphorus and possibly sediment. TP exceeded the target level of 0.08 mg/L in 100% of the samples, and TSS and turbidity exceeded the state standards in one of the samples. However, both turbidity and TSS exceedances took place in July, 2013 so it may have been the result of a rain event. The macroinvertebrate and habitat scores at Site 35 were not as good as at other sites with the macroinvertebrate score only at 12 and habitat score only at 37. Table 3.75 shows the results of the sampling effort by the FRP at sample Site 35.

Table 3.75: Fawn River Project Sampling -Unnamed Tributary to Fawn River (Site 35)

FRP, Tributary to Fawn River; Site 35				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.34	SU	0/10	0%
Temp	16.16	ºC	0/10	0%
D.O.	8.66	mg/L	0/10	0%
TDS	245.21	mg/L	0/10	0%
Turbidity	4.2	NTU	1/10	10%
E. coli	60	CFU	0/10	0%
Nitrate	0.89	mg/L	0/10	0%
TP	0.2	mg/L	10/10	100%
TSS	8.7	mg/L	1/10	10%
Macroinvertebrates	12	Points	Fair	
CQHEI	37	Points	Poor	

IDEM sampled water quality in Meteer Lake (Site 9) on July 5, 2000. Results of the analysis indicate an issue with nitrogen as TKN levels exceeded the target level of less than 0.591 mg/L in 100% of the samples. No other water quality issues were confirmed at Site 9. Table 3.76 shows the results of the water quality analysis for Site 9.

Table 3.76: IDEM Sampling in Meteer Lake (Site 9)

IDEM - 2000: Meteer Lake; Site 9				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
nitrate + nitrite	0.22	mg/L	0/2	0%
TKN	1.346	mg/L	2/2	100%
Ammonia	0.123	mg/L	0/2	0%
TP	0.0395	mg/L	0/2	0%
DRP	0.005	mg/L	0/2	0%
D.O.	7.67	mg/L	0/6	0%
Temp	26.62	ºC	0/6	0%

The FRP measured water quality at the inlet to Cedar Lake (Site 38) and the outlet to Cedar Lake (Site 37) monthly between June, 2013 and May, 2013 and IDEM sampled water quality in Cedar Lake in July, 2000. Comparing the results will allow a look into the function of the Lake and whether additional pollution is being produced at the lake. As can be seen by comparing tables 3.76, 3.77, and 3.78 more nitrogen is entering the lake than leaving, however phosphorus levels remain high going into, in, and out of the lake. It should also be noted that more *E. coli* is leaving the lake than entering. The water quality results may lead to the assumption that failing septic systems may be causing the pollution problems in the lake as nitrates and *E. coli* are an indicator of septic system effluent. Macroinvertebrate scores at Site 38, the inlet to Cedar Lake, were good and the habitat score was poor. Macroinvertebrate scores at Site 37, the outlet of Cedar Lake, were excellent and the habitat was good. The macorinvertebrate scores between the inlet and outlet of Cedar Lake indicate the lake provides a means for the water quality to improve enough to allow for a larger array of aquatic insects, including pollution intolerant macroinvertebrates. Tables 3.77, 3.78, and 3.79 show the results of sample sites 38, 10, and 37, respectively.

Table 3.77: Fawn River Project Sampling -Inlet to Cedar Lake (Site 38)

FRP, Inlet to Cedar Laker; Site 38				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.09	SU	0/12	0%
Temp	13.73	^oC	0/12	0%
D.O.	10.15	mg/L	0/12	0%
TDS	331.67	mg/L	0/12	0%
Turbidity	1.58	NTU	0/12	0%
E. coli	70.83	CFU	2/12	17%
Nitrate	3.92	mg/L	11/12	92%
TP	0.17	mg/L	12/12	100%
TSS	3.67	mg/L	0/12	0%
Macroinvertebrates	17	Points	Good	
CQHEI	59	Points	Poor	

Table 3.78: IDEM Sampling in Cedar Lake in 2000 (Site 10)

IDEM - 2000: Cedar Lake (Clear Lake-Fawn River): Site 10				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
nitrate + nitrite	0.438	mg/L	0/2	0%
TKN	0.533	mg/L	1/2	50%
Ammonia	0.5835	mg/L	2/2	100%
TP	0.0355	mg/L	0/2	0%
DRP	0.0325	mg/L	1/2	50%
D.O.	5.812	mg/L	3/11	27%
Temp	23.89	^oC	0/11	0%
pH	8.1	SU	0/2	0%

Table 3.79: Fawn River Project Sampling at Cedar Lake Outlet (Site 37)

FRP, Cedar Lake Outlet; Site 37				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.17	SU	0/12	0%
Temp	13.88	ºC	0/12	0%
D.O.	8.55	mg/L	0/12	0%
TDS	259.38	mg/L	0/12	0%
Turbidity	1.83	NTU	0/12	0%
E. coli	179.17	CFU	3/12	25%
Nitrate	1.44	mg/L	4/12	33%
TP	0.21	mg/L	12/12	100%
TSS	4.33	mg/L	0/12	0%
Macroinvertebrates	24	Points	Excellent	
CQHEI	77	Points	Good	

The FRP sampled water quality in the Fawn River at sample Site 36 monthly between June, 2013 and May, 2014. Samples could not be taken twice during the sampling period due to the river being frozen. Results of the analysis indicate an issue with nutrients and possibly E. coli at this site. TP exceeded the target level of 0.3 mg/L for a mainstem river in 30% of the samples, and nitrates exceeded the target level of 1.5 mg/L in 60% of the samples. *E. coli* also exceeded the state standard in one of the samples. Macroinvertebrate scores were excellent at habitat scores were good at Site 36, indicating a relatively healthy aquatic ecosystem. Table 3.80 shows the results of the water quality analysis for Site 36.

Table 3.80: Fawn River Project Sampling in Fawn River (Site 36)

FRP, Fawn River; Site 36				
Parameter	Mean	Unit	# Does Not Meet Target	% Does Not Meet Target
pH	8.23	SU	0/10	0%
Temp	14.24	ºC	0/10	0%
D.O.	8.35	mg/L	0/10	0%
TDS	280.91	mg/L	0/10	0%
Turbidity	2.4	NTU	0/10	0%
E. coli	70	CFU	1/10	10%
Nitrate	1.45	mg/L	6/10	60%
TP	0.24	mg/L	3/10	30%
TSS	5.5	mg/L	0/10	0%
Macroinvertebrates	26	Points	Excellent	
CQHEI	82	Points	Good	

The FRP sampled water quality in the Fawn River at sample Site 39 monthly between June, 2013 and May, 2014. Samples could not be collected twice during the sample cycle due to the river being frozen during the winter months. Results of the analysis indicate and issue with nutrients and E. coli at this sample site. TP exceeded the target level of 0.3 mg/L for mainstem rivers in one sample, and nitrates exceeded the target level in 80% of the samples. E. coli also exceeded the state standard in 40% of the samples indicating there may be a failing or leaking septic problem in the drainage area. The high nitrate and E. coli readings may also indicate livestock runoff problems in the drainage area. Biological data collected at Site 39 indicate a relatively healthy aquatic ecosystem as the macroinvertebrate and habitat scores were both good. Table 3.81 shows the water quality analysis for sample Site 39.

Table 3.81: Fawn River Project Sampling in the Fawn River (Site 39)

FRP, Fawn River; Site 39				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.14	SU	0/10	0%
Temp	15.22	ºC	0/10	0%
D.O.	8.54	mg/L	0/10	0%
TDS	289.07	mg/L	0/10	0%
Turbidity	2	NTU	0/10	0%
E. coli	265	CFU	4/10	40%
Nitrate	1.6	mg/L	8/10	80%
TP	0.17	mg/L	1/10	10%
TSS	4.8	mg/L	0/10	0%
Macroinvertebrates	20	Points	Good	
CQHEI	61	Points	Good	

The FRP and MI DEQ sampled in the Fawn River at the same location (FRP-Site 41 and MI DEQ-Site 3). The FRP sampled Site 41 monthly between June, 2013 and May, 2014 however, samples could not be collected twice during the sampling cycle due to the river being frozen. The MI DEQ sampled Site 3 once in 2000. Since MI DEQ sampled only once, the results of the sampling effort are of little comparative value. However, they did evaluate the aquatic habitat at Site 3, with the results indicating the habitat is slightly impaired. Results of the FRP sampling effort indicate an issue with nutrients and E. coli as TP exceeded the target level of 0.3 mg/L in 30% of the samples, nitrates exceeded the target level in 80% of the samples, and *E. coli* exceeded the state standard in 30% of the samples. The aquatic habitat at Site 41 is very good as the macroinvertebrate scores were excellent and the habitat scores were good. Tables 3.82 and 3.83 show the results of the MI DEQ and FRP sampling efforts, respectively.

Table 3.82: MI DEQ Sampling in the Fawn River (Site 3)

MI DEQ, Fawn River; Site 3				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
TDS	400	mg/L	0/1	0%
TKN	0.48	mg/L	0/1	0%
Nitrite	0.02	mg/L	0/1	0%
Nitrate + Nitrite	1	mg/L	0/1	0%
TP	0.02	mg/L	0/1	0%
DRP	0.02	mg/L	0/1	0%
pH	8.18	SU	0/1	0%
Habitat	Good (Slightly Impaired)			

Table 3.83: Fawn River Project Sampling in the Fawn River (Site 41)

FRP, Fawn River; Site 41				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.2	SU	0/10	0%
Temp	13.44	^oC	0/10	0%
D.O.	9.06	mg/L	0/10	0%
TDS	293.61	mg/L	0/10	0%
Turbidity	2.6	NTU	0/10	0%
E. coli	230	CFU	3/10	30%
Nitrate	1.93	mg/L	8/10	80%
TP	0.28	mg/L	3/10	30%
TSS	6.9	mg/L	0/10	0%
Macroinvertebrates	27	Points	Excellent	
CQHEI	79	Points	Good	

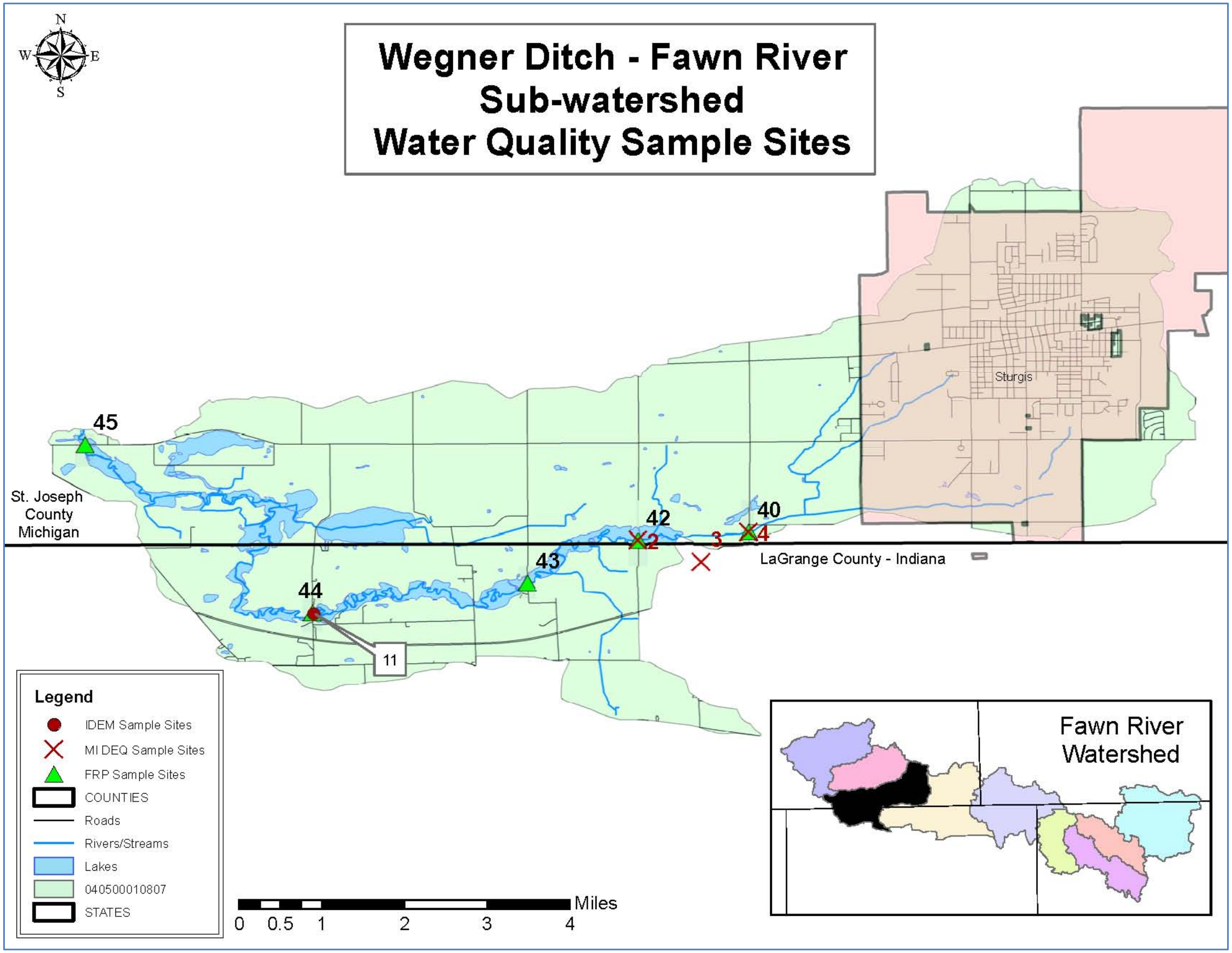
3.3.7 Wegner Ditch – Fawn River Sub-watershed Water Quality Analysis

Water quality in the Wegner Ditch – Fawn River sub-watershed was collected and analyzed at five sites by the FRP, one site by IDEM, and two sites by MI DEQ. All of MI DEQ and IDEM's sampling took place over a decade ago, in 2000. Therefore that data will not be used in the final water quality analysis of the watershed as a whole, but rather will be used as a historical reference of water quality within the Wegner Ditch sub-watershed. Results of the analysis of each of the FRP's sites indicate the major parameters of concern in the Wegner Ditch sub-watershed are *E. coli* which exceeded the target level in 26% of the FRP samples analyzed in the watershed, phosphorus which exceeded the target level in 37% of the samples, and nitrates which exceeded the target level in 86% of the FRP samples analyzed. Figure 3.9 shows the location of each of the samples sites, and the following tables show the analysis of each sample site by each of the organizations that performed the sampling. Table 3.84 shows the average for the watershed as a whole; including all of the water quality samples in the watershed collected by the FRP.

Table 3.84: Analysis of FRP Sample Sites in Wegner Ditch Sub-watershed

Wegner Dicth - Fawn River Sub-watershed			
Parameter	**Mean**	**Unit**	**% Does Not Meet Target**
E. coli	177.68	CFU	26%
TP	0.23	mg/L	37%
TSS	5.66	mg/L	0%
D.O.	9.05	mg/L	0%
Turbidity	2.95	NTU	0%
TDS	312.93	mg/L	0%
Nitrate	2.78	mg/L	86%

Figure 3.9: Water Quality Sample Sites in the Wegner Ditch Sub-watershed



The FRP and the MI DEQ sampled at the same location in Nye Drain, Sites 40 and 4, respectively. Samples were collected by the FRP monthly between June, 2013 and May, 2014 and the MI DEQ sampled one time in 2000 at Site 4. Results of the MI DEQ sampling effort indicate an issue with nitrogen, however the sample was held longer than recommended for sampling nitrates+nitrites so the results may not be accurate. The MI DEQ also evaluated the aquatic habitat at Site 4, and the results indicate a slight impairment. Analysis of the FRP sampling effort indicates an issue with nutrients and *E. coli*. Nitrate and TP both exceeded the target levels in 92% of the samples and *E. coli* exceeded the target level in 58% of the samples. The high number of exceedances may be due to urban runoff from the City of Sturgis, or from failing septic systems, or unsustainable farming techniques. Macroinvertebrae scores at Site 40 were excellent; however the habitat score was poor due to lack of vegetative buffer on the straightened Nye Drain. Tables 3.85 and 3.86 show the results of the water quality analysis at the FRP Site 40 and the MI DEQ Site 4.

Table 3.85: Fawn River Project Sampling in Nye Drain (Site 40)

FRP, Nye Drain; Site 40				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.05	SU	0/12	0%
Temp	11.35	ºC	0/12	0%
D.O.	9.33	mg/L	0/12	0%
TDS	364.86	mg/L	0/12	0%
Turbidity	2.58	NTU	0/12	0%
E. coli	412.5	CFU	7/12	58%
Nitrate	3.65	mg/L	11/12	92%
TP	0.28	mg/L	11/12	92%
TSS	3.83	mg/L	0/12	0%
Macroinvertebrates	18	Points	Good	
CQHEI	53	Points	Poor	

Table 3.86: MI DEQ Sampling in Nye Drain in 2000 (Site 4)

MI DEQ, Nye Drain; Site 4				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
TDS	520	mg/L	0/1	0%
TKN	0.24	mg/L	0/1	0%
Nitrite	0.03	mg/L	0/1	0%
Nitrate + Nitrite	2.6	mg/L	1/1	100%
TP	0.08	mg/L	0/1	0%
DRP	0.07	mg/L	0/1	0%
pH	8.07	SU	0/1	0%
Habitat	Good (Slightly Impaired)			

The FRP and the MI DEQ sampled at the same location in Fawn River, Sites 42 and 2, respectively. Samples were collected by the FRP monthly between June, 2013 and May, 2014 and the MI DEQ sampled one time in 2000 at Site 4. Results of the MI DEQ sampling effort indicate an issue with nitrogen, however the sample was held longer than recommended for sampling nitrates+nitrites so the results may not be accurate. The MI DEQ also evaluated the aquatic habitat at Site 2, and the results indicate a slight impairment. Analysis of the FRP sampling effort indicates an issue with nutrients, and *E. coli*. Nitrate exceeded the target level in 100% of the samples and TP exceeded the target level of 0.3 mg/L for mainstem streams in 33% of the samples. *E. coli* exceeded the target level in 25% of the samples. Biological data collected at Site 42 was very good with an excellent macroinvertebrate score and a good habitat score. Tables 3.87 and 3.88 show the results of the water quality analysis at the FRP Site 42 and the MI DEQ Site 2.

Table 3.87: Fawn River Project Sampling in the Fawn River (Site 42)

FRP, Fawn River; Site 42				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.94	SU	0/12	0%
Temp	11.58	°C	0/12	0%
D.O.	9.06	mg/L	0/12	0%
TDS	311.78	mg/L	0/12	0%
Turbidity	2.92	NTU	0/12	0%
E. coli	175	CFU	3/12	25%
Nitrate	3.31	mg/L	12/12	100%
TP	0.21	mg/L	4/12	33%
TSS	5.67	mg/L	0/12	0%
Macroinvertebrates	36	Points	Excellent	
CQHEI	87	Points	Good	

Table 3.88: MI DEQ Sampling in the Fawn River (Site 2)

MI DEQ, Fawn River; Site 2				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
TDS	460	mg/L	0/1	0%
TKN	0.5	mg/L	0/1	0%
Nitrite	0.01	mg/L	0/1	0%
Nitrate + Nitrite	1.7	mg/L	1/1	100%
TP	0.03	mg/L	0/1	0%
DRP	0.02	mg/L	0/1	0%
pH	8.3	SU	0/1	0%
Habitat	Good (Slightly Impaired)			

The FRP sampled water quality in the Fawn River at Site 43 monthly between June, 2013 and May, 2014. Results from the analysis of the samples taken at Site 43 indicate an issue with nutrients and E. coli as TP exceeded the target level of 0.3 mg/L in one sample, nitrates exceeded the target level in 67% of the samples, and E. coli exceeded the state standard in 25% of the samples. This site is further downstream than those listed above (approximately 3 river miles from Sturgis) and may have lower measurements of the various parameters as the urban runoff from Sturgis may have diluted enough in the mainstem of the Fawn River. Biological data collected at Site 43 was very good with an excellent macroinvertebrate score and a good habitat score. Table 3.89 shows the results of the water quality analysis at Site 43.

Table 3.89: Fawn River Project Sampling in Fawn River (Site 43)

FRP, Fawn River; Site 43				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	7.97	SU	0/12	0%
Temp	12.28	°C	0/12	0%
D.O.	9.02	mg/L	0/12	0%
TDS	308.38	mg/L	0/12	0%
Turbidity	3.67	NTU	0/12	0%
E. coli	137.5	CFU	3/12	25%
Nitrate	2.1	mg/L	8/12	67%
TP	0.21	mg/L	1/12	8%
TSS	7.33	mg/L	0/12	0%
Macroinvertebrates	33	Points	Excellent	
CQHEI	83	Points	Good	

The FRP and IDEM both sampled at the same location in the Fawn River (Sites 44 and 11, respectively). FRP sampled Site 44 monthly between June, 2013 and May, 2014. Samples could not be collected twice during the sampling cycle due to the river being frozen during the winter months. IDEM sampled Site 11 weekly for five weeks between Sept and Oct, 2000. IDEM did not sample for nutrients, however they did sample D.O. which was greater than the state standard of 12 mg/L in one of the samples and all samples were relatively high measuring above 10 mg/L. Samples collected by IDEM were typically done in the early evening, which may be why DO was high. An over growth in plants can produce a lot of oxygen in the water during photosynthesis. Since the analysis of the FRP samples indicate an issue with nutrients, that may increase aquatic plant growth, this assumption can be validated with further analysis. The FRP samples did not indicate any exceedances with DO, however four samples were greater than 9 mg/L. Macroinvertebrate samples at Site 44 were good,; however the habitat scores were low at only 54. Tables 3.90 and 3.91 show the results of the water quality sampling efforts at the FRP Site 44 and the IDEM Site 11.

Table 3.90: Fawn River Project Sampling in the Fawn River (Site 44)

FRP, Fawn River; Site 44				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.3	SU	0/10	0%
Temp	15.34	^oC	0/10	0%
D.O.	9.35	mg/L	0/10	0%
TDS	261.32	mg/L	0/10	0%
Turbidity	2	NTU	0/10	0%
E. coli	15	CFU	0/10	0%
Nitrate	2.09	mg/L	8/10	80%
TP	0.18	mg/L	2/10	20%
TSS	3.5	mg/L	0/10	0%
Macroinvertebrates	21	Points	Good	
CQHEI	54	Points	Poor	

Table 3.91: IDEM Sampling in the Fawn River (Site 11)

IDEM - 2000: Fawn River: Site 11				
Parameter	**Mean (Geomean)**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
E. coli	68.8 (67.33)	CFU	0/5	0%
Turbidity	0.8	NTU	0/5	0%
D.O.	10.87	mg/L	1/5 (>12mg/L)	20%
pH	8.208	SU	0/5	0%
Temp	14.822	^oC	0/5	0%

The FRP sampled water quality in Fawn River at Site 45, monthly between June, 2013 and May, 2014. Samples could not be collected twice during the sampling cycle due to the river being frozen during the winter months. Analysis of the samples indicate an issue with nutrients and *E. coli* at Site 45. TP exceeded the target level of 0.3 mg/L in 30% of the samples and nitrates exceeded the target level in 90% of the samples. *E. coli* exceeded the state standard of 235 CFU/100ml in two of the samples. Biological data collected at Site 45 was very good with an excellent macroinvertebrate score and a good habitat score. Table 3.92 shows the results of the water quality analysis at the FRP's Site 45.

Table 3.92: Fawn River Project Sampling in the Fawn River (Site 45)

FRP, Fawn River; Site 45				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.16	SU	0/10	0%
Temp	14.41	ºC	0/10	0%
D.O.	8.42	mg/L	0/10	0%
TDS	309.06	mg/L	0/10	0%
Turbidity	3.5	NTU	0/10	0%
E. coli	110	CFU	2/10	20%
Nitrate	2.6	mg/L	9/10	90%
TP	0.27	mg/L	3/10	30%
TSS	8	mg/L	0/10	0%
Macroinvertebrates	39	Points	Excellent	
CQHEI	88	Points	Good	

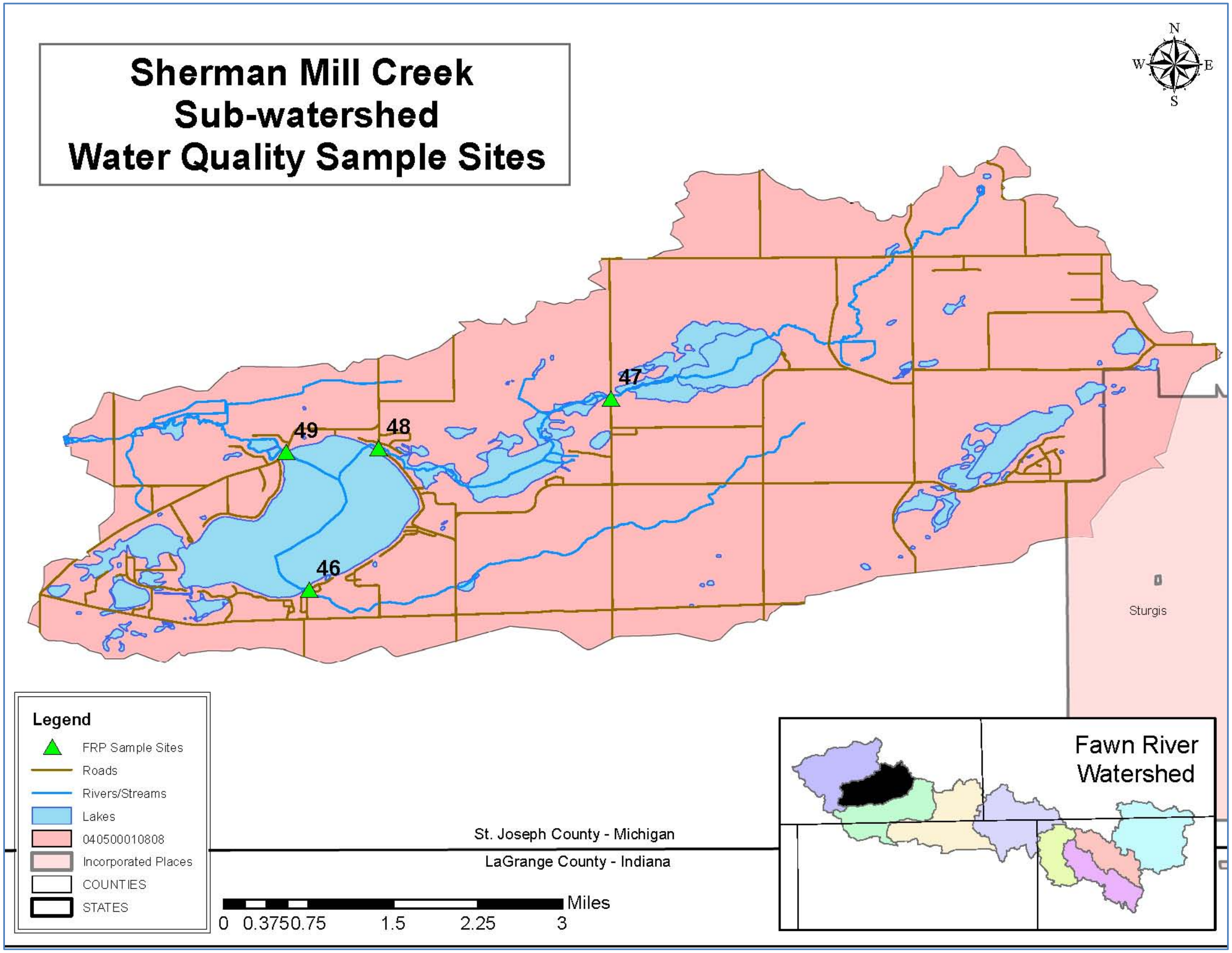
3.3.8 Sherman Mill Creek Sub-watershed Water Quality Analysis

Water quality in the Sherman Mill Creek sub-watershed was collected and analyzed at four sites by the FRP. Results of the analysis of each of the FRP's sites indicate the major parameters of concern in the Sherman Mill Creek sub-watershed are *E. coli* which exceeded the target level in 17% of the FRP samples analyzed in the watershed, phosphorus which exceeded the target level in 71% of the samples, and nitrates which exceeded the target level in 67% of the FRP samples analyzed. Figure 3.10 shows the location of each of the samples sites, and the following tables show the analysis of each sample site by each of the organizations that performed the sampling. Table 3.93 shows the average for the watershed as a whole; including all of the water quality samples in the watershed collected by the FRP.

Table 3.93: Analysis of FRP Sample Sites in the Sherman Mill Creek Sub-watershed

Sherman Mill Creek Sub-watershed			
Parameter	**Mean**	**Unit**	**% Does Not Meet Target**
E. coli	168.89	CFU	17%
TP	0.18	mg/L	79%
TSS	3.07	mg/L	0%
D.O.	9.35	mg/L	0%
Turbidity	1.18	NTU	0%
TDS	227.91	mg/L	0%
Nitrate	3.00	mg/L	67%

Figure 3.10: Water Quality Sample Sites in the Sherman Mill Creek Sub-watershed



The FRP collected water quality samples at an unnamed tributary to Sherman Mill Creek at the Klinger Lake inlet (Site 46). Samples were collected at this site monthly between June, 2013 and May, 2014. Samples could not be collected three times during the sampling cycle due to the stream being frozen during the winter months. Results of the analysis performed on samples collected from Site 46 indicate an issue with nutrients and *E. coli*. Phosphorus and nitrates exceeded the target level in 100% of the samples and E. coli exceeded the state standard in 33% of the samples. Biological data collected at Site 46 were poor as the macroinvertebrate score was only 12 and the habitat score was only 41, likely due to the surrounding agriculture land with very little vegetative buffer and the stream having very little sinuosity. Table 3.94 shows the results of the analysis performed for Site 46.

Table 3.94: Fawn River Project Sampling in Tributary to Sherman Mill Creek (Site 46)

FRP, Tributary to Sherman Mill Creek (Klinger Lake Inlet); Site 46				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.15	SU	0/9	0%
Temp	13.36	⁰C	0/9	0%
D.O.	9.27	mg/L	0/9	0%
TDS	304.58	mg/L	0/9	0%
Turbidity	1.44	NTU	0/9	0%
E. coli	138.89	CFU	3/9	33%
Nitrate	7.6	mg/L	9/9	100%
TP	0.26	mg/L	9/9	100%
TSS	2.67	mg/L	0/9	0%
Macroinvertebrates	12	Points	Fair	
CQHEI	41	Points	Poor	

The FRP sampled water quality in the Sherman Mill Creek at the Thompson Lake outlet monthly between June, 2013 and July, 2014. The results from the analysis of samples taken at this site indicate an issue with *E. coli*, and nutrients. *E. coli* exceeded the state standard in 25% of the samples, nitrates exceeded the target level in 100% of the samples, and phosphorus exceeded the target level of 0.08 mg/L in 83% of the samples. Biological data collected at Site 47 was very good with excellent macroinvertebrate scores and good habitat scores. Table 3.95 shows the results of the water quality analysis for samples from Site 47.

Table 3.95: Fawn River Project Sampling -Sherman Mill Creek (Thompson Lake Outlet Site 47)

FRP, Sherman Mill Creek (Thompson Lake outlet); Site 47				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.23	SU	0/12	0%
Temp	12.9	°C	0/12	0%
D.O.	9.37	mg/L	0/12	0%
TDS	228.9	mg/L	0/12	0%
Turbidity	1.33	NTU	0/12	0%
E. coli	441.67	CFU	3/12	25%
Nitrate	2.32	mg/L	12/12	100%
TP	0.18	mg/L	10/12	83%
TSS	3.67	mg/L	0/12	0%
Macroinvertebrates	25	Points	Excellent	
CQHEI	81	Points	Good	

The FRP sampled water quality in Sherman Mill Creek and the inlet to Klinger Lake (Site 48) monthly between June, 2013 and May, 2014. Results of the analysis indicate an issue with nutrients and E. coli at this site as E. coli exceeded the state standard in one of the samples, nitrates exceeded the target level in 50% of the samples, and phosphorus exceeded the target level of 0.08 mg/L in 83% of the samples. Biological data collected at Site 48 was very good with excellent macroinvertebrate scores and good habitat scores. Table 3.96 shows the results of the water quality analysis for Site 48.

Tale 3.96: Fawn River Project Sampling -Sherman Mill Creek (Klinger Lake Inlet Site 48)

FRP, Sherman Mill Creek (Klinger Lake Inlet); Site 48				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.29	SU	0/12	0%
Temp	13.2	°C	0/12	0%
D.O.	8.76	mg/L	0/12	0%
TDS	220.62	mg/L	0/12	0%
Turbidity	1.17	NTU	0/12	0%
E. coli	87.5	CFU	1/12	8%
Nitrate	1.96	mg/L	6/12	50%
TP	0.15	mg/L	10/12	83%
TSS	3.5	mg/L	0/12	0%
Macroinvertebrates	24	Points	Excellent	
CQHEI	67	Points	Good	

The FRP sampled water quality in the Sherman Mill Creek and the outlet of Klinger Lake (Site 49) monthly between June, 2013 and May, 2014. Results of the analysis of the samples taken at Site 49 indicate a possible issue with nutrients as both exceeded the target levels. However, when comparing sample Site 48 at the Klinger Lake inlet to Site 49 at the outlet of Klinger Lake, it is clear that the lake absorbed much of the nutrients that was being fed into the lake from Sherman Mill Creek. Biological data collected at Site 49 was very good with excellent macroinvertebrate scores and good habitat scores. Table 3.97 shows the results of the water quality analysis at Site 49.

Table 3.97: Fawn River Project Sampling - Sherman Mill Creek (Klinger Lake Outlet Site 49)

FRP, Sherman Mill Creek (Klinger Lake Outlet); Site 49				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.47	SU	0/12	0%
Temp	13.14	°C	0/12	0%
D.O.	9.97	mg/L	0/12	0%
TDS	176.72	mg/L	0/12	0%
Turbidity	0.83	NTU	0/12	0%
E. coli	0	CFU	0/12	0%
Nitrate	1.28	mg/L	2/12	17%
TP	0.13	mg/L	6/12	50%
TSS	2.33	mg/L	0/12	0%
Macroinvertebrates	31	Points	Excellent	
CQHEI	71	Points	Good	

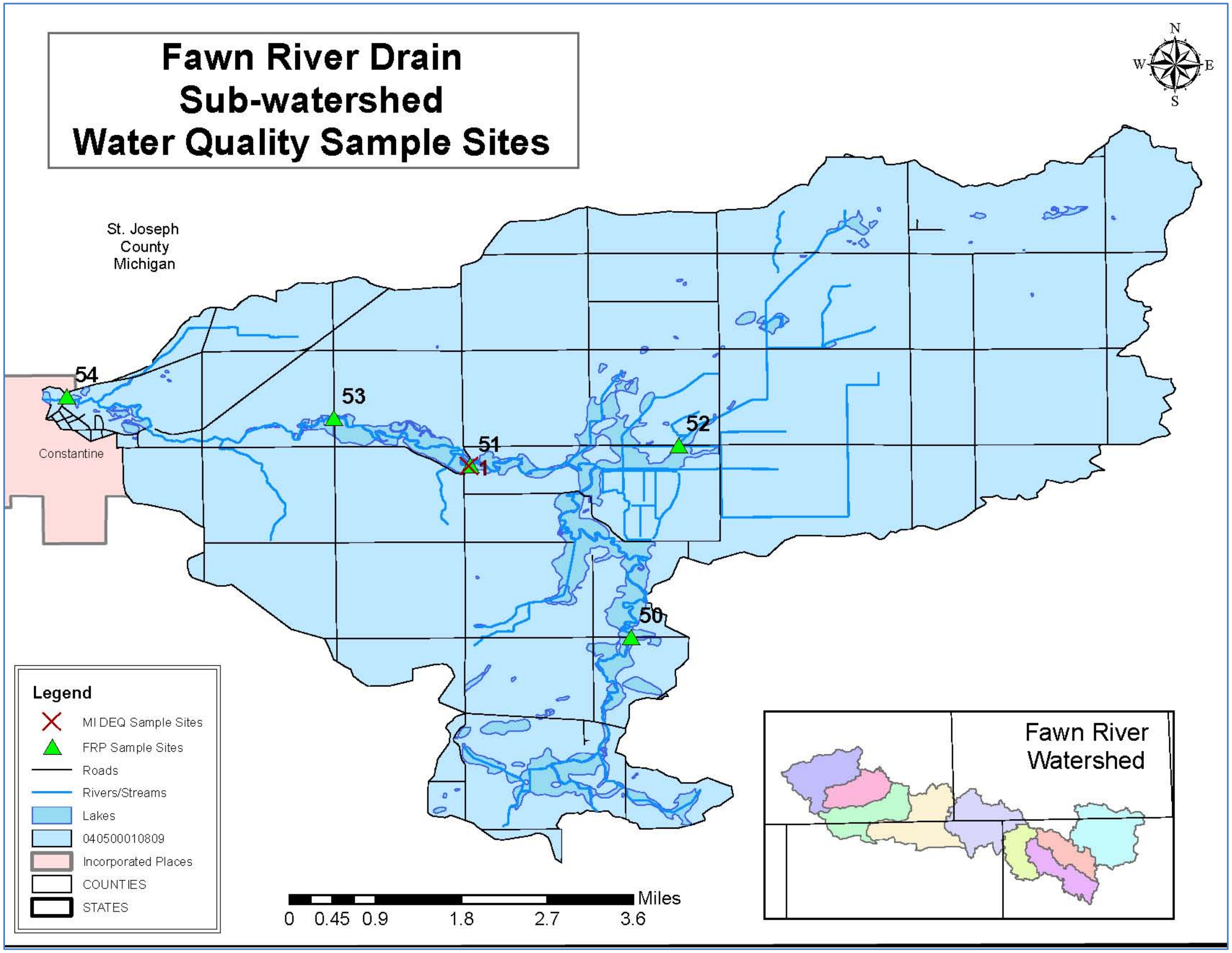
3.3.9 Fawn River Drain Sub-watershed Water Quality Analysis

Water quality in the Fawn River Drain sub-watershed was collected and analyzed at five sites by the FRP, and one site by MI DEQ. The MI DEQ's sampling took place over a decade ago, in 2000. Therefore that data will not be used in the final water quality analysis of the watershed as a whole, but rather will be used as a historical reference of water quality within the Fawn River Drain sub-watershed. Results of the analysis of each of the FRP's sites indicate the major parameters of concern in the Fawn River Drain sub-watershed are *E. coli*, phosphorus, and nitrates, and to a lesser degree sediment. Figure 3.11 shows the location of each of the sample sites, and the following tables show the analysis of each sample site by each of the organizations that performed the sampling. Table 3.98 shows the average for the watershed as a whole; including all of the water quality samples in the watershed collected by the FRP.

Table 3.98: Analysis of FRP Samples in the Fawn River Drain Sub-watershed

Fawn River Drain Sub-watershed			
Parameter	**Mean**	**Unit**	**% Does Not Meet Target**
E. coli	132.41	CFU	17%
TP	0.24	mg/L	39%
TSS	7.83	mg/L	4%
D.O.	8.40	mg/L	0%
Turbidity	3.35	NTU	4%
TDS	280.51	mg/L	0%
Nitrate	1.87	mg/L	71%

Figure 3.11: Water Quality Sample Sites in the Fawn River Drain Sub-watershed



The FRP sampled water quality in the Fawn River at Site 50 monthly between June, 2013 and May, 2014. Samples could not be collected twice during the sampling cycle due to the river being frozen during the winter months. The results of the analysis of the samples collected from Site 50 indicate an issue with nutrients, E. coli, and to a lesser degree sediment. Nitrates exceeded the target level in 90% of the samples, TP exceeded the target level of 0.03 mg/L in 30% of the samples, and E> coli exceeded the state standard in two of the samples. Turbidity and TSS each exceeded the state standards in one of the samples. Biological data collected at Site 50 was very good with excellent macroinvertebrate scores and good habitat scores. Table 3.99 shows the results of the analysis on water quality samples collected from Site 50.

Table 3.99: Fawn River Project Sampling in the Fawn River (Site 50)

FRP, Fawn River; Site 50				
Parameter	Mean	Unit	# Does Not Meet Target	% Does Not Meet Target
pH	8.02	SU	0/10	0%
Temp	14.21	^{o}C	0/10	0%
D.O.	8.44	mg/L	0/10	0%
TDS	304.93	mg/L	0/10	0%
Turbidity	3.9	NTU	1/10	10%
E. coli	100	CFU	2/10	20%
Nitrate	2.53	mg/L	9/10	90%
TP	0.24	mg/L	3/10	30%
TSS	7.9	mg/L	1/10	10%
Macroinvertebrates	36	Points	Excellent	
CQHEI	83	Points	Good	

The FRP sampled water quality from the Fawn River Drain, a tributary to the Fawn River (Site 52) monthly between June, 2013 and May, 2014. Results of the analysis of samples collected from Site 52 indicate an issue with nutrients and *E. coli* at this site. *E. coli* exceeded the state standard of 235 CFU/100ml in 25% of the samples, nitrates exceeded the target level in 50% of the samples, and TP exceeded the target level of 0.08 mg/L in 100% of the samples. The macroinvertebrate score was not as high as the rest of the sub-watershed at only 17 and the habitat score was poor at only 53, likely due to the surrounding agriculture land having an influence on the drain, lack of vegetative buffer, and the drain being largely straightened. Table 3.100 shows the results of the water quality analysis at Site 52.

Table 3.100: Fawn River Project Sampling in the Fawn River Drain (Site 52)

FRP, Fawn River Drain; Site 52				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.1	SU	0/12	0%
Temp	10.18	ºC	0/12	0%
D.O.	7.59	mg/L	0/12	0%
TDS	260.57	mg/L	0/12	0%
Turbidity	2.5	NTU	0/12	0%
E. coli	279.17	CFU	3/12	25%
Nitrate	1.14	mg/L	6/12	50%
TP	0.27	mg/L	12/12	100%
TSS	4.75	mg/L	0/12	0%
Macroinvertebrates	17	Points	Good	
CQHEI	53	Points	Poor	

Water quality is sampled by both the FRP and MI DEQ at the same location along the Fawn River (Sites 51 and 1, respectively). The FRP sampled water quality at Site 51 monthly between June, 2013 and May, 2014; however, samples could not be collected twice during the sampling cycle due to the river being frozen during the winter months. The MI DEQ sampled Site 1 one time in 2000 for various water quality parameters and aquatic habitat, and sampled fish species once in in 2005. Results of the analysis indicate an ongoing issue with nitrogen as the FRP sampling for nitrates exceeded the target level in 80% of the samples, and the MI DEQ sampling for nitrate+nitrite. However, the MI DEQ held the sample longer than the recommended amount for testing nitrate+nitrite levels. The FRP sampling also indicates an issue with phosphorus as TP levels exceeded the target of 0.3 mg/L in 30% of the samples and to a lesser degree, E. coli, turbidity and TSS, all of which exceeded the target levels once. Habitat analysis of the site in 2000 by the MI DEQ indicate that the aquatic habitat of the site is slightly impaired which may be due to sedimentation, which was not entirely tested for by the MI DEQ. Biological data collected at Site 51 was very good with an excellent macroinvertebrate score and good habitat score. Table 3.101 and 3.102 shows the results of the water quality analysis for FRP's Site 51 and the MI DEQ's Site 1.

Table 3.101: Fawn River Project Sampling in the Fawn River (Site 51)

FRP, Fawn River; Site 51				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.19	SU	0/10	0%
Temp	14.42	ºC	0/10	0%
D.O.	8.32	mg/L	0/10	0%
TDS	290.29	mg/L	0/10	0%
Turbidity	3.8	NTU	1/10	10%
E. coli	100	CFU	1/10	10%
Nitrate	1.86	mg/L	8/10	80%
TP	0.27	mg/L	3/10	30%
TSS	9.5	mg/L	1/10	10%
Macroinvertebrates	33	Points	Excellent	
CQHEI	84	Points	Good	

Table 3.102: MI DEQ Sampling in the Fawn River (Site 1)

MI DEQ, Fawn River; Site 1				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
TDS	400	mg/L	0/1	0%
TKN	0.48	mg/L	0/1	0%
Nitrite	0.02	mg/L	0/1	0%
Nitrate + Nitrite	1.6	mg/L	1/1	100%
TP	0.03	mg/L	0/1	0%
DRP	0.01	mg/L	0/1	0%
pH	8.3	SU	0/1	0%
Habitat (2000)	Good (Slightly Impaired)			
ICI (2005)	3	Acceptable		

The FRP sampled water quality from the Fawn River just downstream of a wetland area (Site 53) monthly between June, 2013 and May, 2014. Samples could not be collected twice during the sampling cycle due to the river being frozen during the winter months. Samples at this site indicate an issue with nitrates which exceeded the target level in 60% of the samples, phosphorus as TP exceeded the target level of 0.3 mg/L in 20% of the samples and *E. coli* which exceeded the state standard in 20% of the samples. Biological data collected at Site 53 was very good with an excellent macroinvertebrate score and good habitat score. Table 3.103 shows the results of the water quality analysis for Site 53.

Table 3.103: Fawn River Project Sampling in the Fawn River (Site 53)

FRP, Fawn River Drain; Site 53				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.22	SU	0/10	0%
Temp	14.28	ºC	0/10	0%
D.O.	8.14	mg/L	0/10	0%
TDS	284.17	mg/L	0/10	0%
Turbidity	3.8	NTU	0/10	0%
E. coli	85	CFU	2/10	20%
Nitrate	1.82	mg/L	6/10	60%
TP	0.23	mg/L	2/10	20%
TSS	10	mg/L	0/10	0%
Macroinvertebrates	29	Points	Excellent	
CQHEI	82	Points	Good	

The FRP sampled water quality from the Fawn River at the most downstream segment of the river prior to its confluence with the St. Joseph River in Constantine (Site 54) monthly between June, 2013 and May, 2014. Samples at this site indicate an issue with nitrates which exceeded the target level in 75% of the samples and phosphorus as TP exceeded the target level of 0.3 mg/L in 17% of the samples. *E. coli* may also be an issue at Site 54 as it exceeded the state standard in one of the samples. Biological data collected at Site 54 was very good with an excellent macroinvertebrate score and good habitat score. Table 3.104 shows the results of the water quality analysis for Site 54.

Table 3.104: Fawn River Project Sampling in Fawn River (Site 54)

FRP, Fawn River Drain; Site 54				
Parameter	**Mean**	**Unit**	**# Does Not Meet Target**	**% Does Not Meet Target**
pH	8.33	SU	0/12	0%
Temp	13.26	ºC	0/12	0%
D.O.	9.45	mg/L	0/12	0%
TDS	280.37	mg/L	0/12	0%
Turbidity	3	NTU	0/12	0%
E. coli	79.17	CFU	1/12	8%
Nitrate	2.09	mg/L	9/12	75%
TP	0.19	mg/L	2/12	17%
TSS	7.67	mg/L	0/12	0%
Macroinvertebrates	39	Points	Excellent	
CQHEI	87	Points	Good	

3.3.10 Summary of Water Quality Data in the Fawn River Watershed

As can be gleaned from the sections above and Table 3.105 below, the major water quality problems observed throughout the watershed are from nitrogen, phosphorus, and *E. coli*; Nitrates and TP had significant exceedances, while *E. coli* had a moderate amount of exceedances throughout the watershed. TSS and turbidity had a few exceedances of target levels in six of the sub-watersheds. All of these pollutants can discharge from faulty septic systems, barnyard or animal feeding operation runoff, improper application of manure and commercial fertilizer on crop land, conventional tillage on HEL and PHEL farmland, as well as from urban runoff from lawn fertilizer, and excess stormwater from impervious surfaces. However, high nutrient, and turbidity levels can also come directly from row crop fields either through surface runoff or tile discharge. Many best management practices that should be implemented to minimize the impact on water quality from nutrients will also minimize the impact from sediment runoff in the agricultural community. Urban best management practices are very different from agricultural practices, and often involve more education and outreach than agricultural BMPs. Biological data varied from excellent to poor throughout the watershed with low scores being present in areas that are largely built-up, urban areas, and in ditches that have been straightened and lack an adequate vegetative buffer. Sources of pollutants will be easier to identify after combining the water quality analysis results with land use data.

Table 3.105 shows the average of all water quality data collected over the past decade by the FRP and the SCLC, per parameter, per drainage area. Those values that are highlighted in pink exceed the target levels set by this project for that parameter. Since there are two targets for TP, depending on where the sample was taken, the average was not used to determine if TP exceeded the target level; the percent of exceedances was used. As can be seen in the table below, TP exceeded the target level in more than 30% of the samples in every sub-watershed. Therefore, the entire column for TP is highlighted pink, indicating that TP is an issue in every sub-watershed.

Table 3.105: Summary of Water Quality Data per Parameter and Percent Exceedance per Sub-watershed

Sub-watershed	Parameter													
	E. coli		TP		TSS		D.O.		Turbidity		TDS		Nitrate	
	CFU	%	mg/L	%	mg/L	%	mg/L	%	NTU	%	mg/L	%	mg/L	%
Snow Lake	257.02	22	0.19	55	6.53	3	6.99	7	2.4	4	329.05	0	1.18	30
Lake James	193.01	16	0.2	35	5.61	<1	8.68	0	4.78	13	297.09	0	1.04	21
Tamarack Lake	499.3	44	0.15	48	9.38	6	7.83	0	3	3	262.34	0	1.27	30
Town of Orland	77.15	13	0.2	50	4.42	0	8.78	0	2	0	289.34	0	1.3	29
Himebaugh Drain	115.5	13	0.2	57	6.3	2	9.21	0	3.27	2	310.94	0	2.19	74
Clear Lake	146.35	19	0.22	54	5.98	2	8.72	1	2.58	1	275.66	0	1.71	49
Wegner Ditch	177.68	26	0.23	37	5.66	0	9.05	0	2.95	0	312.93	0	2.78	86
Sherman Mill Drain	168.89	17	0.18	79	3.07	0	9.35	0	1.18	0	277.91	0	3	67
Fawn River Drain	132.41	17	0.24	39	7.83	4	8.4	0	3.35	4	283.06	0	1.87	71

3.4 Land Use per Sub-watershed

This section will provide information that was obtained through windshield and desktop surveys of each sub-watershed, as well as information that has been gathered via government agencies (i.e. IDEM and MI DEQ) and historic data found through research at the sub-watershed level. However it is important to note that there are particular trends that have been found watershed wide as described below.

The predominant land use in the project area is agriculture, as can be seen in Table 2.7, and Figure 2.17 in Section 2.5, encompassing nearly 58% of the total land use in the project area. Landowners using modern farming practices are scattered throughout the project area. The windshield survey conducted as part of this project, which took place in May, 2014, consisted of two people driving each road within the Fawn River Watershed and looking for potential pollution sources from land uses, farming techniques, or urbanized areas and lakes. The car was stopped at each bridge and observations were recorded about the surrounding land use, and any potential water quality problems. The windshield survey revealed that most row crop fields lack an adequate buffer, with some fields that are farmed all the way up to the streambank. Failing septic systems may be a significant contributor to surface and ground water pollution, as most of the rural community utilizes on-site sewage treatment. Many wetland areas were noted during the windshield survey, however many wetlands (over 50%) have been lost in the watershed, or they have been altered due to land conversion and therefore the natural pollution sinks that were once present in the watershed, are no longer providing their natural function. In most cases, erosion control, buffering ditch banks, septic system education, nutrient management, field drainage management, and wetland restoration/creation will be BMPs that will help to remediate the pollution issues in the Fawn River Watershed.

Although there are few urban areas in the project area contributing to less than 12% of the land use, it has been found that urban stakeholders do influence the water system in the project area, especially in the larger cities including Sturgis and Angola. Lake residence also influence water quality in the project area due to on-going construction, sea walls, and fertilizer use on their lawns. The water quality analysis performed as part of this project indicate that urban areas contribute significantly to TDS levels in the water. Education and outreach activities, as well as cost-share incentives and BMPs regarding septic tanks, proper fertilizer use, lake management, and stormwater management will be the most effective way of managing urban and lake NPS in the Fawn River Watershed. The utilization of small scale urban BMPs such as rain barrels and rain gardens will help with stormwater management in urban settings and provide a great resource for educational outreach. It will also be beneficial to work with the City and County Parks Departments on ways to improve water based recreation such as streambank stabilization projects, and installation of pervious walking paths and/or trails along the rivers. However, the quickest and most dramatic results in reducing nonpoint source pollutants in the Fawn River Watershed lie in utilizing BMP installation within the agricultural community, as well as with those homes utilizing on-site waste disposal systems.

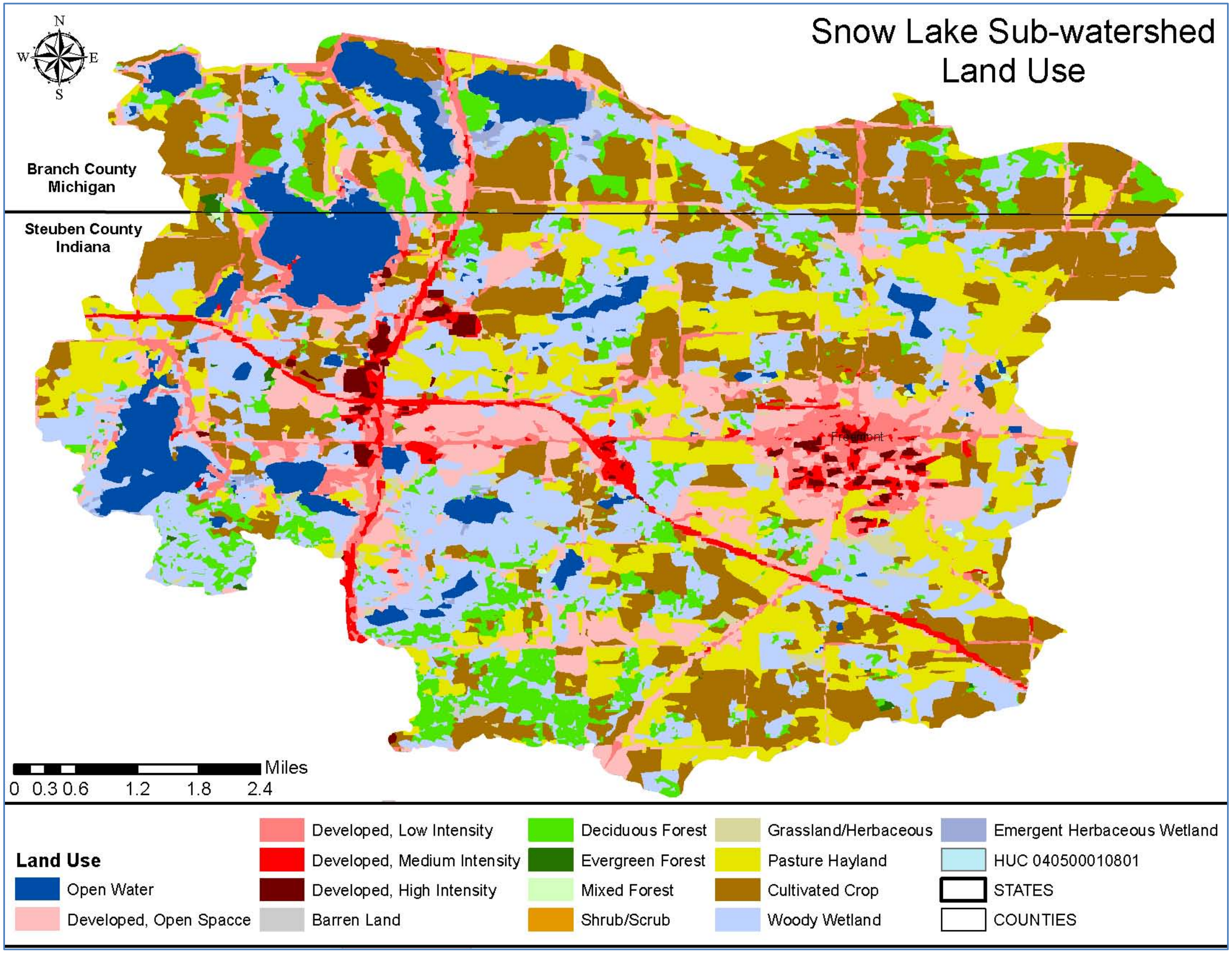
3.4.1 Snow Lake Sub-watershed Land Use

The primary influences on water quality in the Snow Lake Sub-watershed are agriculture as nearly 37% of the drainage area is in row crops or pasture and hayland, unsewered homes, and the lake communities. Over 19% of the Snow Lake sub-watershed is developed, which also impacts water quality in this sub-watershed. Table 3.4.1 shows the percentage of the Snow Lake Sub-watershed that is in each land use and Figure 3.12 is a map showing the delineation of land use in the sub-watershed. All landuse data presented was obtained from the National Land Cover Data from the USGS and analyzed in ArcGIS.

Table 3.4.1: Snow Lake Land Use Designations

NLCD Land Use Designation	Acres	%
Open Water	3278.51	11.38%
Developed Open Space	3215.77	11.16%
Developed Low Intensity	1491.78	5.18%
Developed Medium Intensity	617.08	2.14%
Developed High Intensity	256.89	0.89%
Barren Land	32.33	0.11%
Deciduous Forest	2268.19	7.87%
Evergreen Forest	60.74	0.21%
Shrub/Scrub	18.65	0.01%
Mixed Forest	21.85	0.08%
Grassland Herbaceous	306.99	1.07%
Pasture Hayland	4410.32	15.30%
Row Crops	6242.62	21.66%
Woody Wetland	6435.4	22.33%
Emergent Herbaceous Wetlands	164.85	0.57%
Total	28,821.93	100.00%

Figure 3.12: Snow Lake Sub-watershed Land Use Delineations



The windshield survey conducted as part of this project in May, 2014 revealed some common concerns scattered throughout the Snow Lake sub-watershed including agriculture land that lacks a riparian buffer along adjacent open water, sea walls constructed along the lakes in the watershed, and lush green lawns adjacent to open water, indicating fertilizer use in areas that lack adequate riparian and shoreline buffers. There was only one site that was noted during the survey, beyond the more common concerns listed above. A residential property adjacent to a tributary to Follett Creek lacked an adequate buffer for approximately 920 linear feet, which may contribute to sediment and nutrients to the stream. Figure 3.13 shows the location of that residential property, as well as the populated lakes where seawalls and excessive fertilizer application are used.

Another potential problem related to residential homes in the Snow Lake sub-watershed is the populated areas that are not currently serviced by a centralized sewer system. These homes most likely utilize an on-site waste disposal system that has the potential to leak or fail if not properly maintained. As is illustrated in Figure 3.14, over 80% of the sub-watershed's soils are designated as being very limited or somewhat limited for septic system placement and at least three of the built-up lakes including Huyck Lake, North Pleasant Lake, and Long Beach Lake are not currently serviced by a centralized sewer system, as well as not all homes on other built-up lakes are serviced by a centralized sewer system at this time. There are also homes scattered throughout the sub-watershed, in the rural areas, that are not currently serviced and are utilizing on-site waste disposal.

As stated above, much of the land in the Snow Lake sub-watershed is used for agriculture; either cultivated crops or pasture and hayland. Nearly 40% of the land in the sub-watershed is designated as highly erodible by the respective county's NRCS. Therefore, sediment, carrying nutrients attached to the soil particles, from HEL that is being conventionally tilled, or farmed directly up to the streambank have a direct path to deposit in to open water. Special precautions must be taken on farmland that is designated as HEL to prevent soil erosion, and sedimentation and nutrification of open water. Figure 3.15 shows the location of HEL in the watershed, overlaid on the agriculture land to paint a picture of where there is a risk of soil erosion.

As stated in Section 2.4, wetlands play a very important role in keeping our ecosystem in balance. According to the 2005 wetland inventory conducted by the MDEQ, and partners, the Snow Lake sub-watershed currently has 7,041 acres of wetland from the 9,408 acres of wetland present in pre-settlement times. That is a 25% loss of wetlands since settlement of the area. The loss in wetlands translates to a combined water quality functional use loss of 21% and a combined habitat functional use loss of 28%. Figure 3.16 shows the location of historic and current wetlands in the Snow Lake sub-watershed.

Figure 3.13: Windshield Survey Observations for Snow Lake Sub-watershed

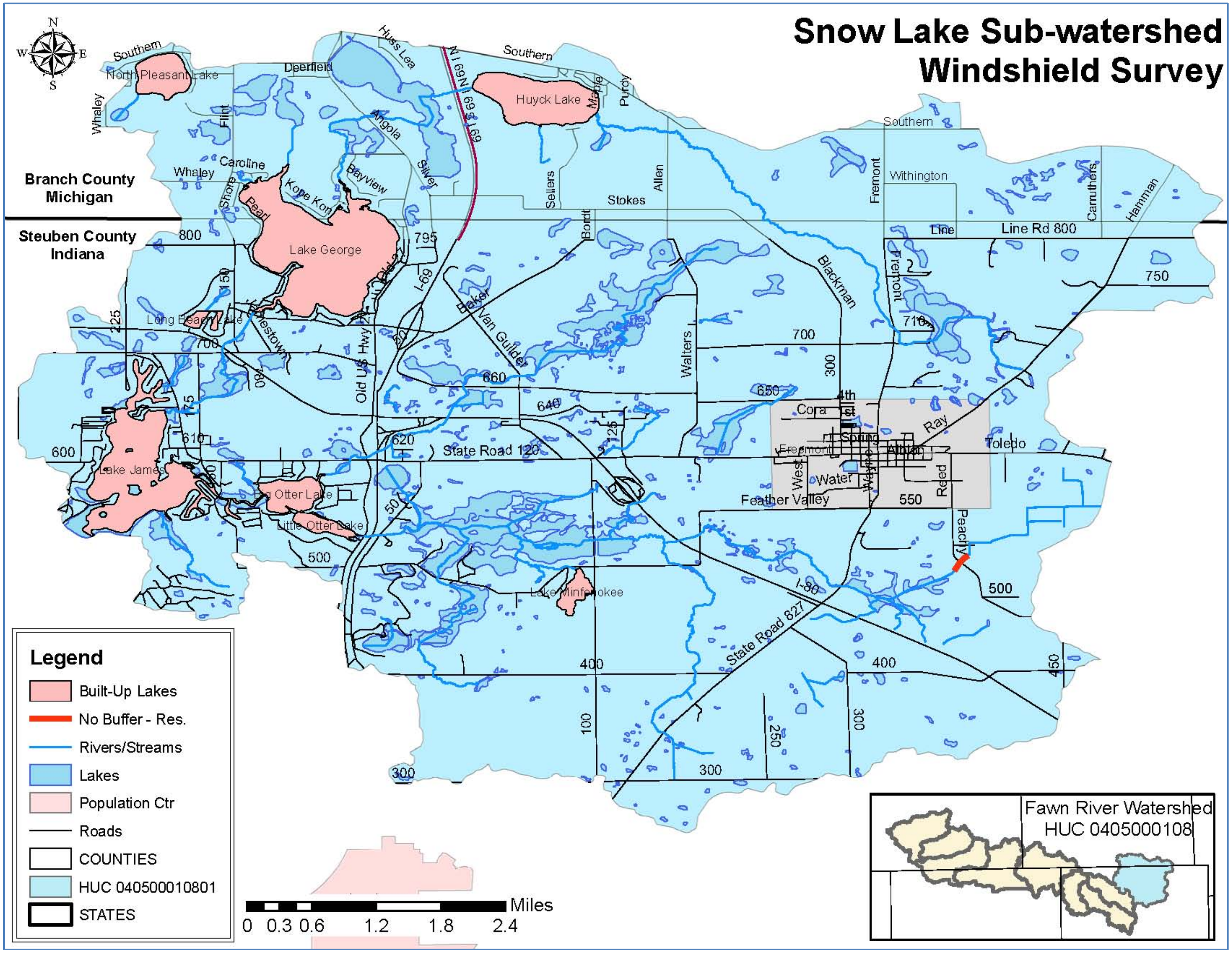


Figure 3.14: Septic Suitability in Snow Lake Sub-watershed

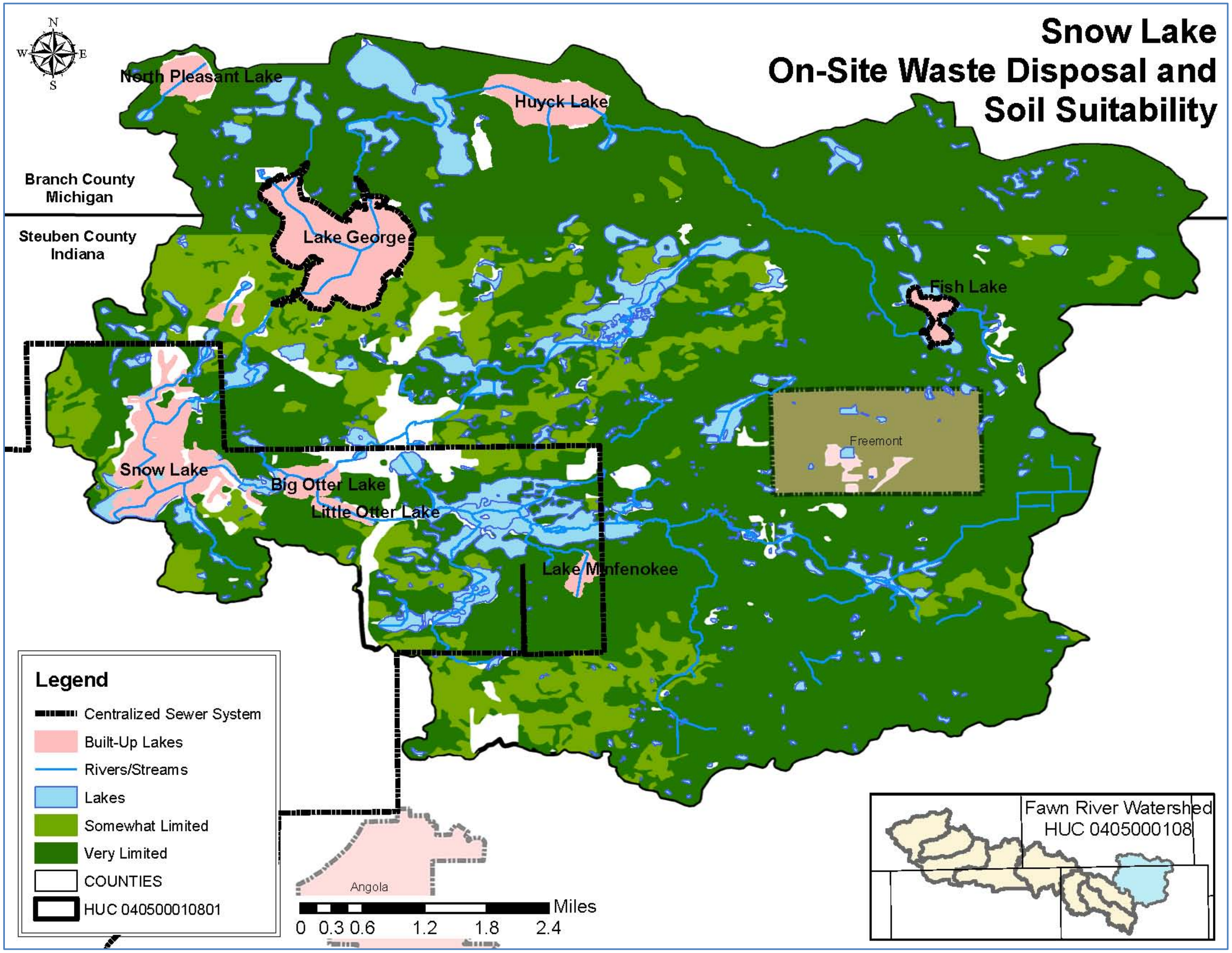


Figure 3.15: Highly Erodible Land in Agricultural Areas in the Snow Lake Sub-watershed

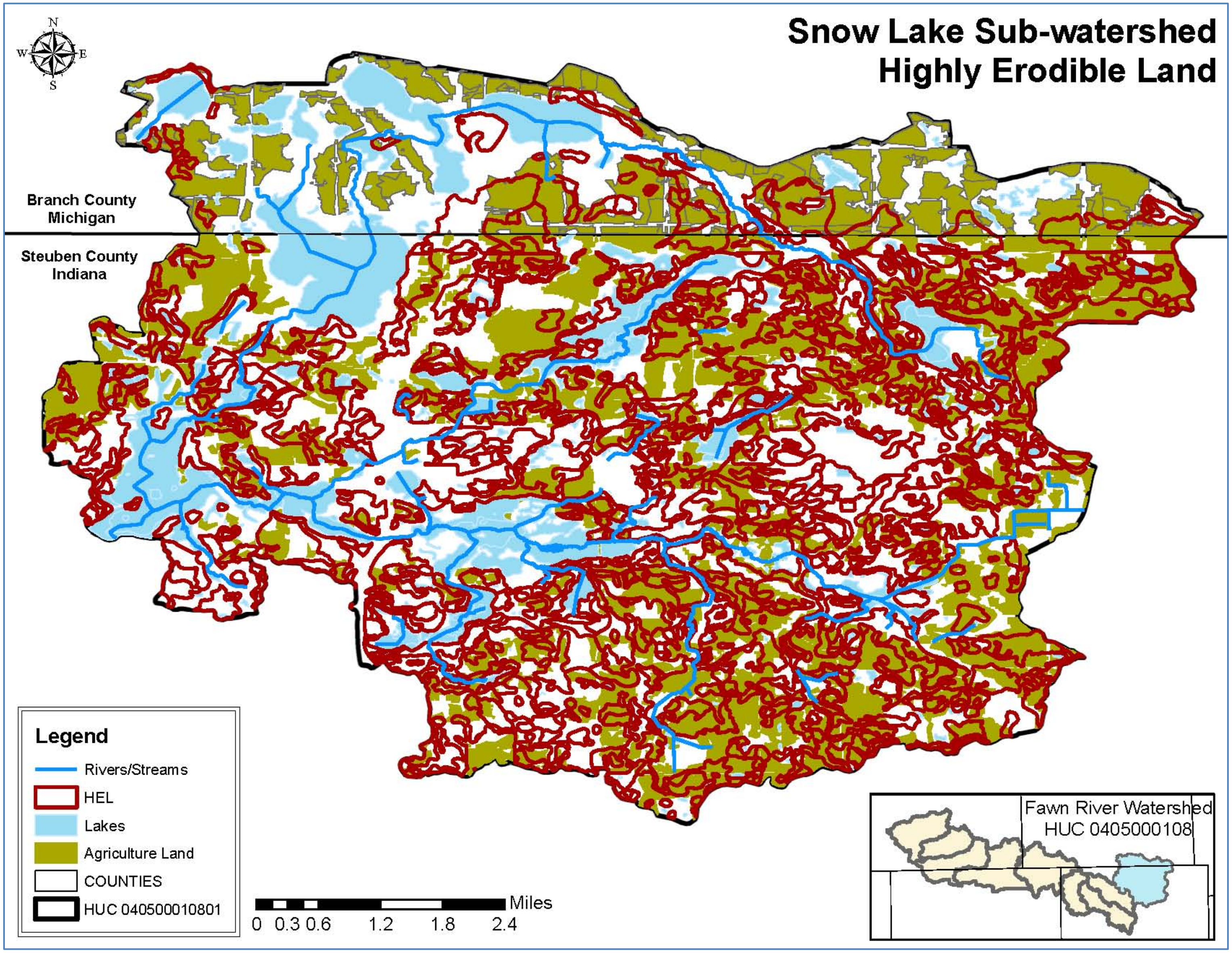
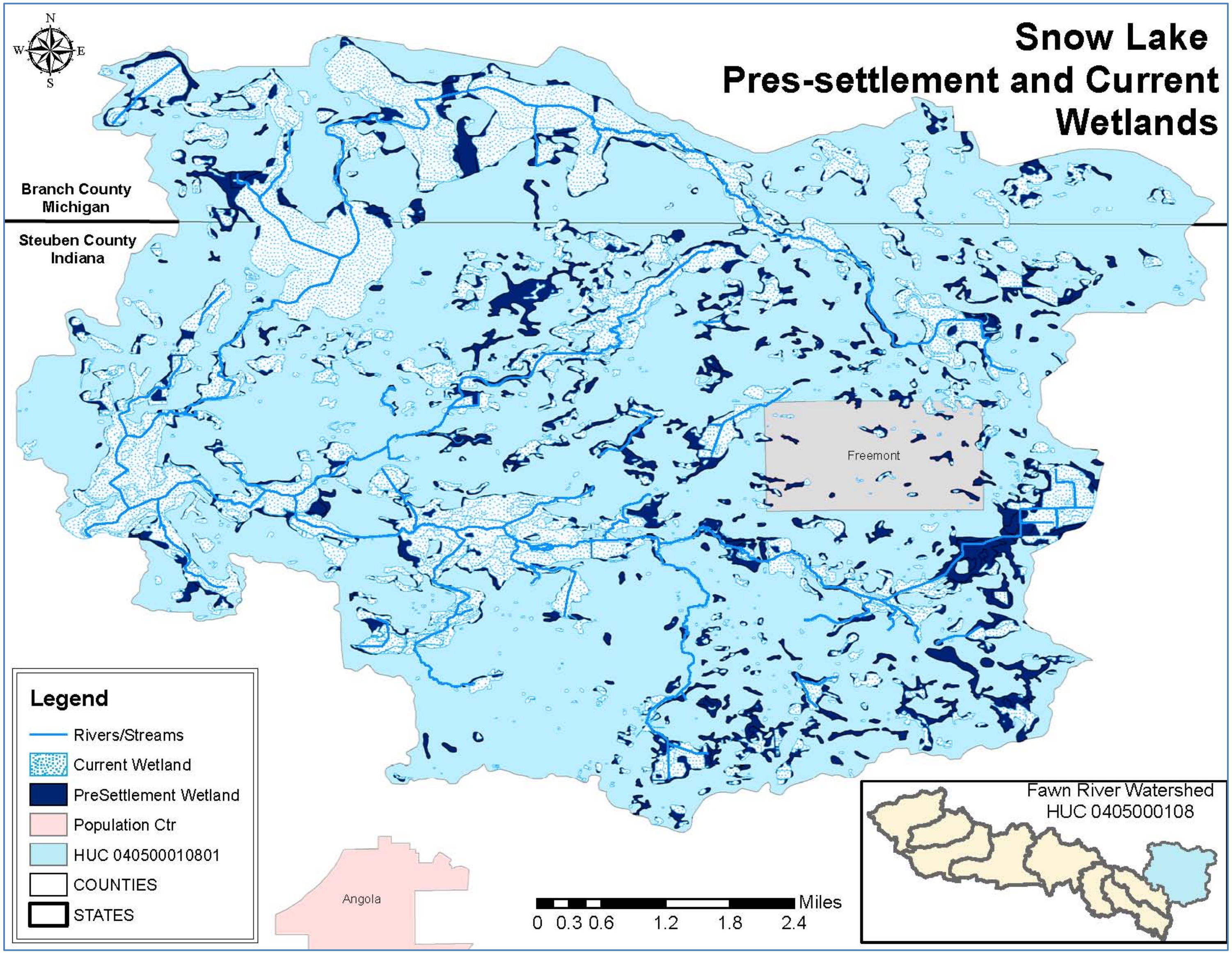


Figure 3.16: Current and Pre-settlement Wetlands in the Snow Lake Sub-watershed



A final threat to water quality found during the inventory of Snow Lake sub-watershed are potential point sources of pollution. There are three National Pollution Discharge Elimination System (NPDES) permitted facilities located within this sub-watershed. All of the facilities have been in no-compliance at least four times over the past three years and three of the facilities have been in significant non-compliance within that time period. However, none of them have formal enforcement actions taken against them. Table 3.4.2 lists the NPDES permitted facilities within the Snow Lake sub-watershed and the reason they were not in compliance.

Table 3.4.2: NPDES Permitted Facilities in the Snow Lake Sub-watershed

Permit Name	Permit #	Receiving Water Body Name	Qrts in Non-compliance (3 yrs)	Qtrs in Significant Non-compliance (3 yrs)	Pollutant Causing Non-compliance	Pollutant with Significant violations	Enforcement Actions (I=informal; F=formal) (5 yrs)
Fremont WWTP	IN0022942	Crooked Creek via Marsh Lake via Trib	5	0	BOD, E. coli, N, P, and TSS	N/A	I - 2
Angola Travelers Mall Mobil	IN0032891	St. Joseph via Big Otter Lake/Walters Lake/unnamed trib	10	6	Chlorine, E. coli, N, P	Chlorine, Total Ammonia, P	I - 3
Western Consolidated Technologies	IN0054011	Unnamed Trib to Marsh Pond	4	1	Chlorine, Oil and Grease	Chlorine	I - 2

There are also 27 underground storage tanks (USTs) located within the Snow Lake sub-watershed. While USTs do not pose an immediate threat to water resources, they do run the risk of leaking if not properly inspected and maintained. Of the 27 USTs located within this sub-watershed 14 of them are considered to be LUSTs by IDEM and seven of those are considered to be either a medium or high priority. Table 3.4.3 lists the LUSTs in the Snow Lake sub-watershed. Figure 3.17 shows the location of the NPDES permitted facilities and the LUSTs in the Snow Lake sub-watershed.

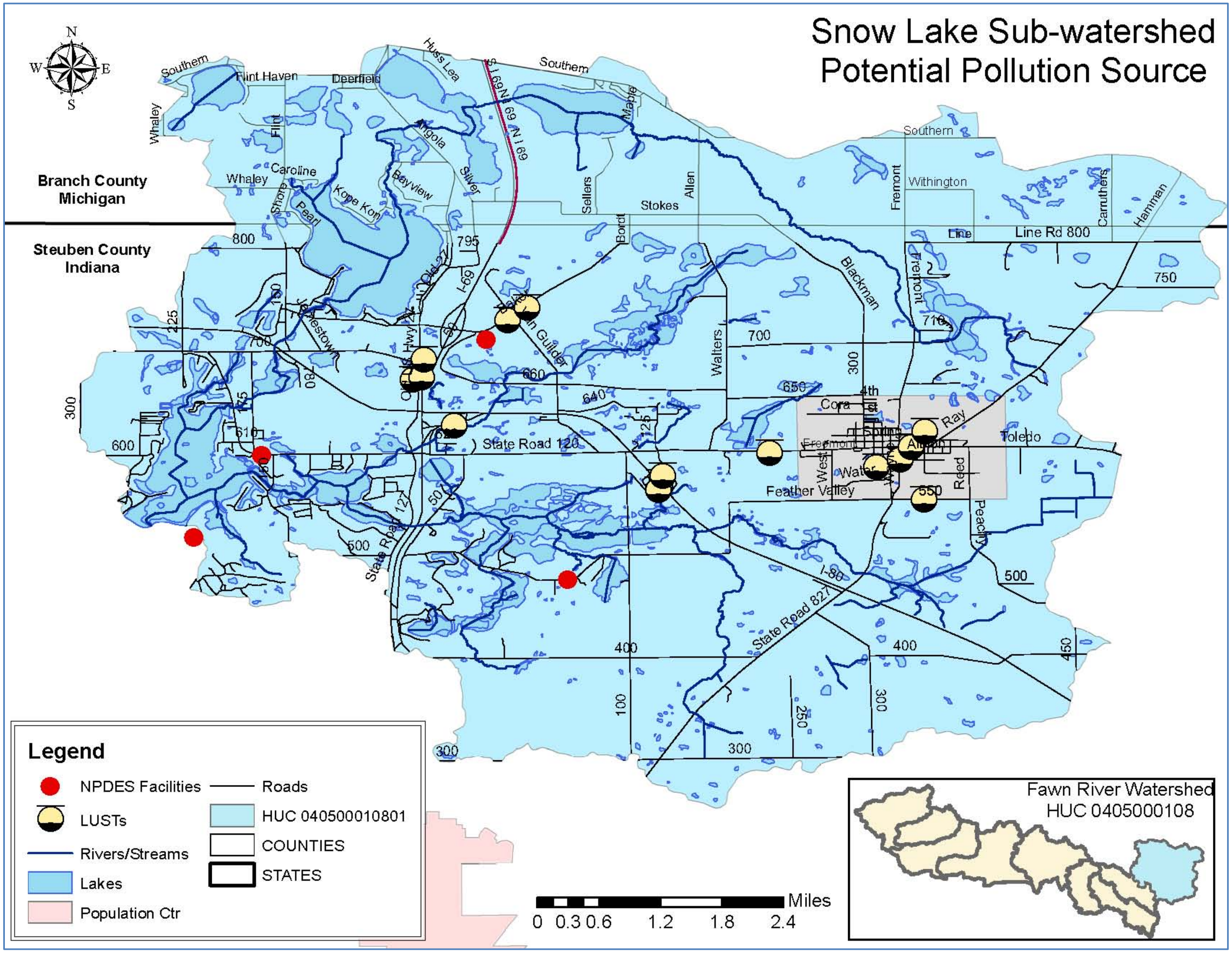
Table 3.4.3: Leaking Underground Storage Tanks in the Snow Lake Sub-watershed

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
3840	200210508	INDOT / Travel Plaza 8 South	Low	NFA-Conditional Closure	Soil
16142	198612010	Angola Toll Plaza	Low	NFA-Unconditional Closure	Soil
	199902543		Low	NFA-Unconditional Closure	Soil
10674	199707116	Fremont Schools	Low	Discontinued (active)	Soil
15887	199902507	Kennedy Oil Company (jacks)	Medium	NFA-Unconditional Closure	Well Head Protection
	199902507		Medium	NFA-Unconditional Closure	Soil
	199902507		Medium	NFA-Unconditional Closure	Groundwater
15386	199802500	Stuart A Zurcher	Low	NFA-Unconditional Closure	Soil
3841	200101502	Travel Plaza 8 North/ BP Booth Tarkington	Medium	Monitored natural attenuation (active)	Soil
	200101502		Medium	Monitored natural attenuation (active)	Groundwater
	200101502		Medium	Monitored natural attenuation (active)	Free Product
17239	199103539	Dexter Axle	Low	Discontinued (active)	Well Head Protection
	199103539		Low	Discontinued (active)	Soil
17423	200104504	Metalloy Corporation Fremont Casting Division	Low	NFA-Unconditional Closure	Soil
18022	199212508	Pioneer Auto/Truck Stop	High	Discontinued (active)	Drinking Water

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
6869	200112163	Petro Stopping Center	Medium	Active	Soil
	200112163		Medium	Active	MTBE
	200112163		Medium	Active	Groundwater
	200112163		Medium	Active	Free Product
5693	199405541	Pilot Travel Center NO 029	High	NFA-Conditional Closure	Soil
	199405541		High	NFA-Conditional Closure	MTBE
	199405541		High	NFA-Conditional Closure	Groundwater
	199405541		High	NFA-Conditional Closure	Free Product
	199405541		High	NFA-Conditional Closure	Drinking Water
	200811135		Spill	NFA-Unconditional Closure	Unknown
367	199401518	Simpson Industries Fremont Mfg / Metaldyne	Low	NFA-Unconditional Closure	Soil
	199007524		Low	NFA-Unconditional Closure	Soil
	199007524		Low	NFA-Unconditional Closure	MTBE
	199007524		Low	NFA-Unconditional Closure	Free Product
11312	199701523	Con Way Central Express	High	Active	Soil
	199701523		High	Active	MTBE
	199701523		High	Active	Groundwater
	199701523		High	Active	Free Product
	199302502		Low	Discontinued (active)	Soil
	199401532		Low	Discontinued (active)	Soil
	199410526		Low	Discontinued (active)	Soil

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
3216	199112539	Speedway #2701	Low	Discontinued (active)	Soil
	199307054		Medium	Discontinued (active)	Soil
	199510506		Medium	NFA-Unconditional Closure	Soil
	199510506		Medium	NFA-Unconditional Closure	Groundwater
	199307505		Medium	NFA-Unconditional Closure	Soil
	199307505		Medium	NFA-Unconditional Closure	MTBE
	199307505		Medium	NFA-Unconditional Closure	Groundwater

Figure 3.17: Potential Point Sources of Pollution in the Snow Lake Sub-watershed



Water quality data collected in the Snow Lake sub-watershed indicates a significant pollution issue with E. coli, phosphorus, and nitrates, and to a lesser degree sediment. The high nutrients and *E. coli* levels are likely from leaking septic systems as only 20% of the land is designated suitable for septic placement and the rural community is not serviced by a centralized sewer system. The high nutrients and *E. coli* levels may also be due to runoff of fertilizer from turf lawns around the built-up lakes and the Town of Fremont, and agriculture fields that do not utilize conservation tillage or riparian buffers. Finally, the destruction of wetlands that can efficiently filter pollutants from water may also be contributing to the high nutrient levels.

A variety of best management practices and management measures that could benefit the water quality in the Snow Lake sub-watershed are available. Some of those practices include conservation tillage, riparian and shoreline buffer installation adjacent to residential and agriculture land, nutrient management, cover crops, wetland restoration, septic system education and stormwater management measures.

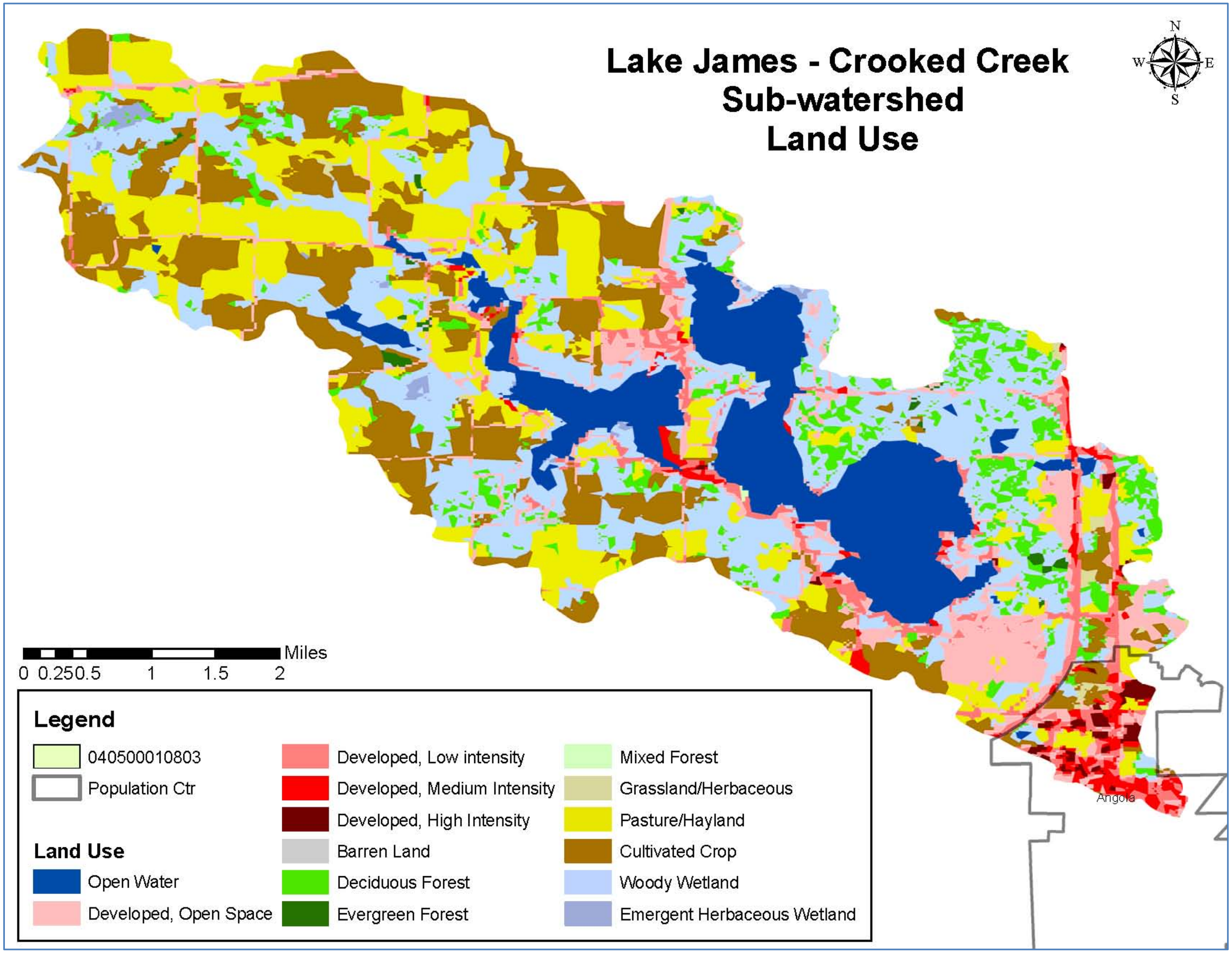
3.4.2 Lake James – Crooked Creek Sub-watershed Land Use

The primary influences on water quality in the Lake James-Crooked Creek Sub-watershed are agriculture as nearly 38% of the drainage area is in row crops or pasture and hayland. Unsewered homes and the lake communities also have a major influence on the water quality within the Lake James - Crooked Creek sub-watershed. Of significance in this sub-watershed is that over 25% of the watershed is covered by wetlands. This will be discussed in more detail later in this Section. Approximately 15% of this sub-watershed is developed due to the large lake system (Lake James is the most populated lake in Steuben County and the Fawn River watershed) and northwest section of the city of Angola is located within the drainage area. Table 3.4.4 shows the percentage of the Lake James – Crooked Creek Sub-watershed that is in each land use and Figure 3.18 is a map showing the delineation of land use in the sub-watershed. All landuse data presented was obtained from the National Land Cover Data from the USGS and analyzed in ArcGIS.

Table 3.4.4: Land Use in the Lake James – Crooked Creek Sub-watershed

NLCD Land Use Designation	Acres	%
Open Water	1887.43	15%
Developed Open Space	1054.16	8%
Developed Low Intensity	543.54	4%
Developed Medium Insensity	236.51	2%
Developed High Intensity	70.67	1%
Barren Land	7.57	<1%
Deciduous Forest	833.76	6%
Evergreen Forest	38.2	<1%
Shrub/Scrub	0	0%
Mixed Forest	3.75	<1%
Grassland Herbaceous	51.32	<1%
Pasture Hayland	2357.83	18%
Row Crops	2558.13	20%
Woody Wetland	3207.96	25%
Emergent Herbaceous Wetlands	59.35	<1%
Total	12,910.18	100%

Figure 3.18: Lake James – Crooked Creek Sub-watershed Land Use Designations



The windshield survey conducted as part of this project in May, 2014 revealed some common concerns scattered throughout the Lake James – Crooked Creek sub-watershed including agriculture land that lacks a riparian buffer along adjacent open water, sea walls constructed along the lakes in the watershed, and lush green lawns adjacent to open water, indicating fertilizer use in areas that lack adequate riparian and shoreline buffers. There were several sites noted during the survey as significant issues, beyond the more common concerns listed above. There were four locations noted during the survey where a significant lack of riparian buffer, adjacent to agriculture land, was noted; four locations where moderate to severe streambank erosion was noted, also adjacent to agriculture land, and one location where livestock had direct access to open water which contributes to streambank erosion, as well as allows for the direct deposit of animal waste into the stream. Table 3.4.5 lists the observations made during the survey, and the approximate length of the problem. Figure 3.19 shows the location of each of the issues discovered during the windshield survey, as well as the populated lakes where seawalls and excessive fertilizer application may be used.

Table 3.4.5: Windshield Survey Observations in Lake James–Crooked Creek Sub-watershed

Windshield Survey Observation	Potential Contaminant	Number or Length
Mod to Severe Streambank Erosion - Ag.	Sediment and Nutrients	3837 linear ft
Lack of Riparian Buffer	Sediment and Nutrients	3683 linear ft
Livestock Access to Open Water	Sediment, Nutrients, and *E. coli*	1

Another potential problem related to residential homes in the Lake James – Crooked Creek sub-watershed is the areas in the watershed that are not currently serviced by a centralized sewer system. These homes most likely utilize an on-site waste disposal system that has the potential to leak or fail if not properly maintained. As is illustrated in Figure 3.20, over75% of the sub-watershed's soils are designated as being very limited or somewhat limited for septic system placement. While all of the built-up lakes located within the Lake James sub-watershed are within the jurisdiction of the Steuben Lakes Regional Waste District, the homes on Lake Charles West and East are only just being connected to a sewer system. The northwest portion of the watershed is predominately agricultural land, and the homes located in that area are not serviced by a centralized sewer system and are currently utilizing an on-site waste disposal system, indicating that the homes in that area are at risk of leaking and potentially polluting surface and/or groundwater resources.

Figure 3.19: Windshield Survey Observations in Lake James –Crooked Creek Sub-watershed

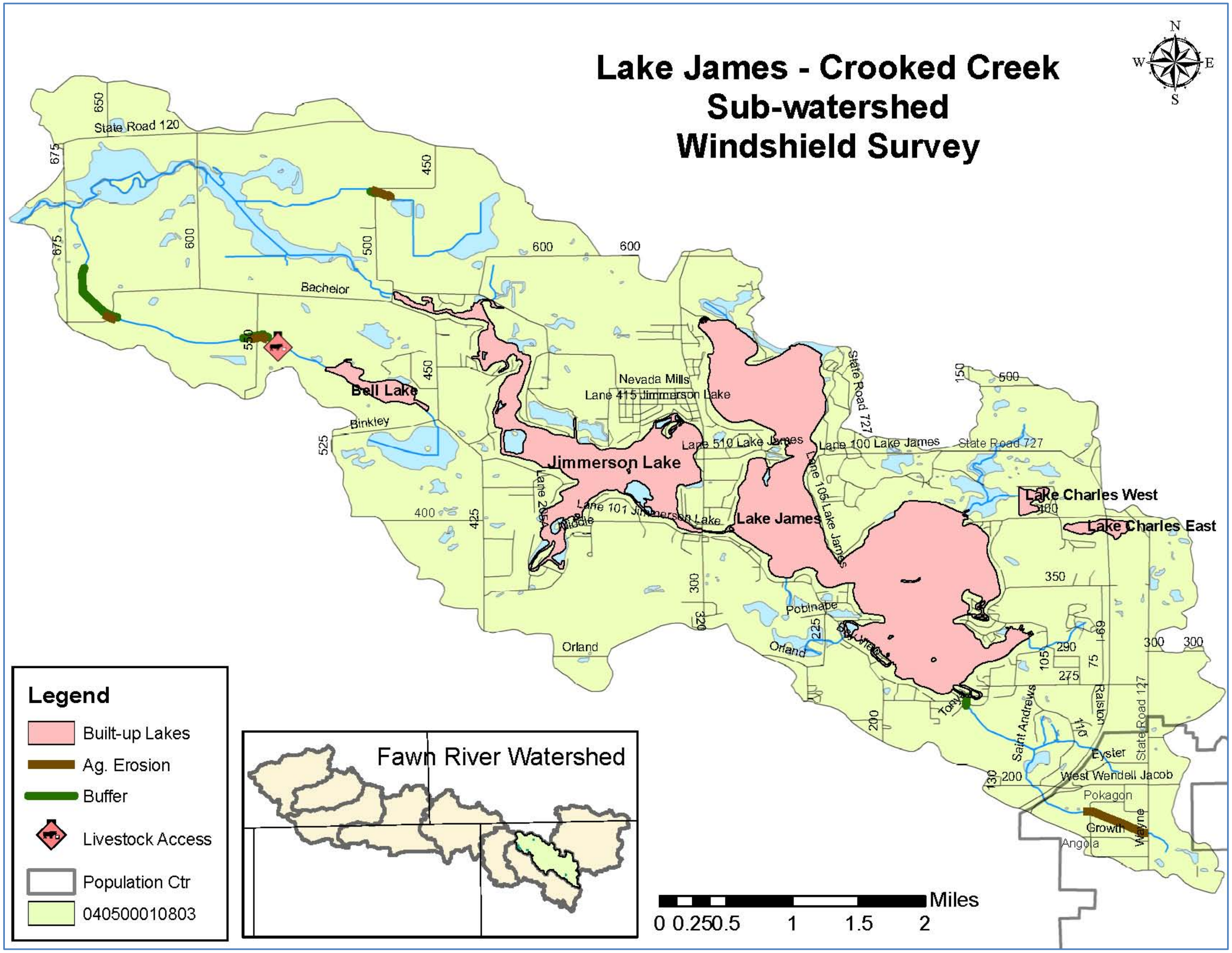
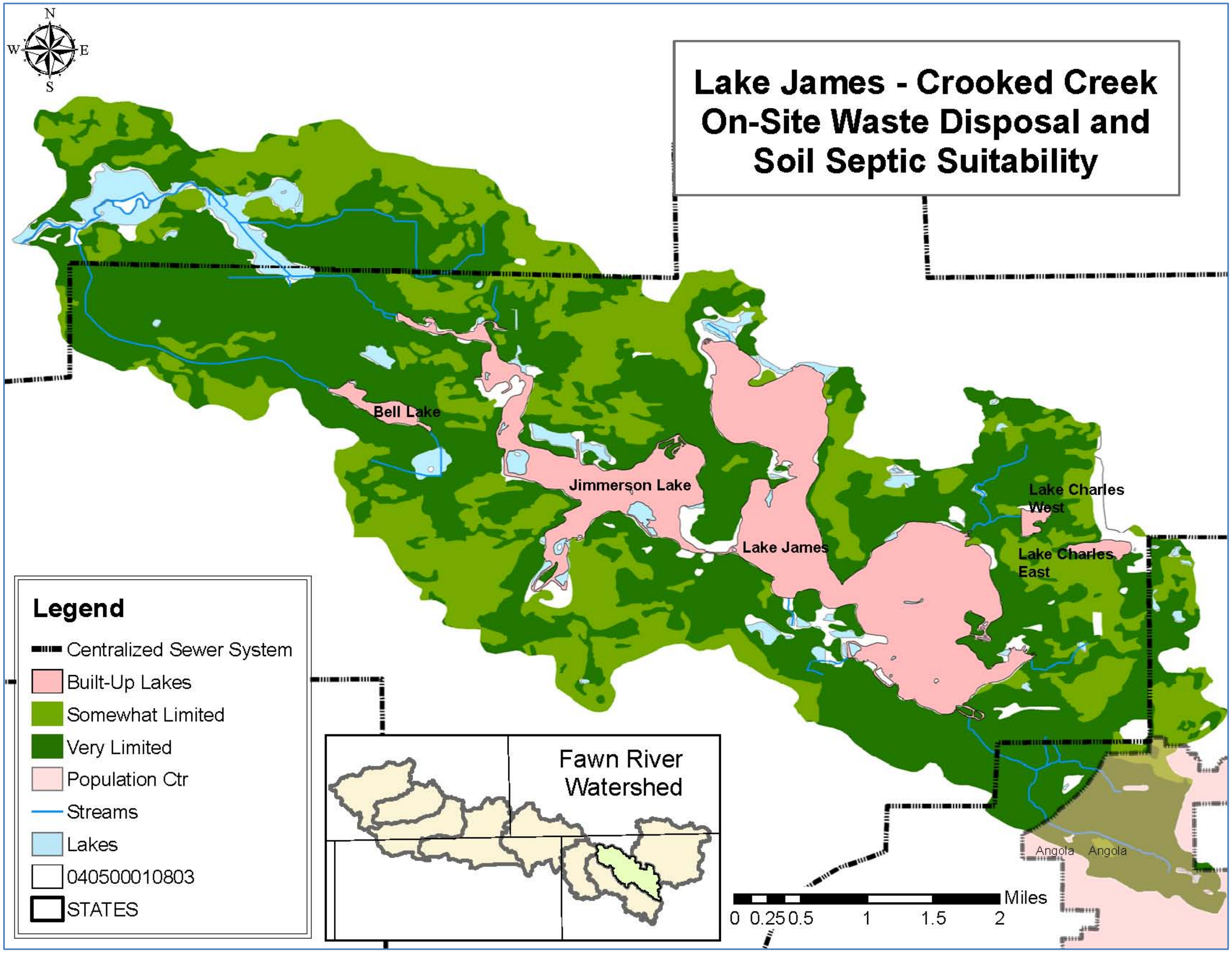


Figure 3.20: Septic Suitability in Lake James –Crooked Creek Sub-watershed



As stated above, much of the land in the Lake James – Crooked Creek sub-watershed is used for agriculture; either cultivated crops or pasture and hayland. Approximately 37% of the land in the sub-watershed is designated as highly erodible by the Steuben County NRCS. Therefore, sediment, carrying nutrients attached to the soil particles, from HEL that is being conventionally tilled, or farmed directly up to the streambank have a direct path to deposit in open water. An analysis of agriculture land and HEL revealed that nearly 4,500 acres of agriculture land in the Lake James – Crooked Creek sub-watershed is located on HEL. Therefore, special precautions must be taken on farmland in this sub-watershed that is designated as HEL to prevent soil erosion, and sedimentation and nutrification of open water. Figure 3.21 shows the location of HEL in the watershed, overlaid on the agriculture land to paint a picture of where there is a risk of soil erosion.

There is more land covered in wetlands than any other land cover in the Lake James – Crooked Creek sub-watershed. According to the 2005 wetland inventory conducted by the MDEQ, and partners, the Lake James – Crooked Creek sub-watershed currently has 3,447.7 acres of wetland from the 4,398.8 acres of wetland present in pre-settlement times. That is nearly a 22% loss of wetlands since settlement of the area. The loss in wetlands translates to a combined water quality functional use loss of 29% and a combined habitat functional use loss of 25%. Figure 3.22 shows the location of historic and current wetlands in the Lake James-Crooked Creek sub-watershed.

Figure 3.21: Highly Erodible Land in Lake James–Crooked Creek Sub-watershed

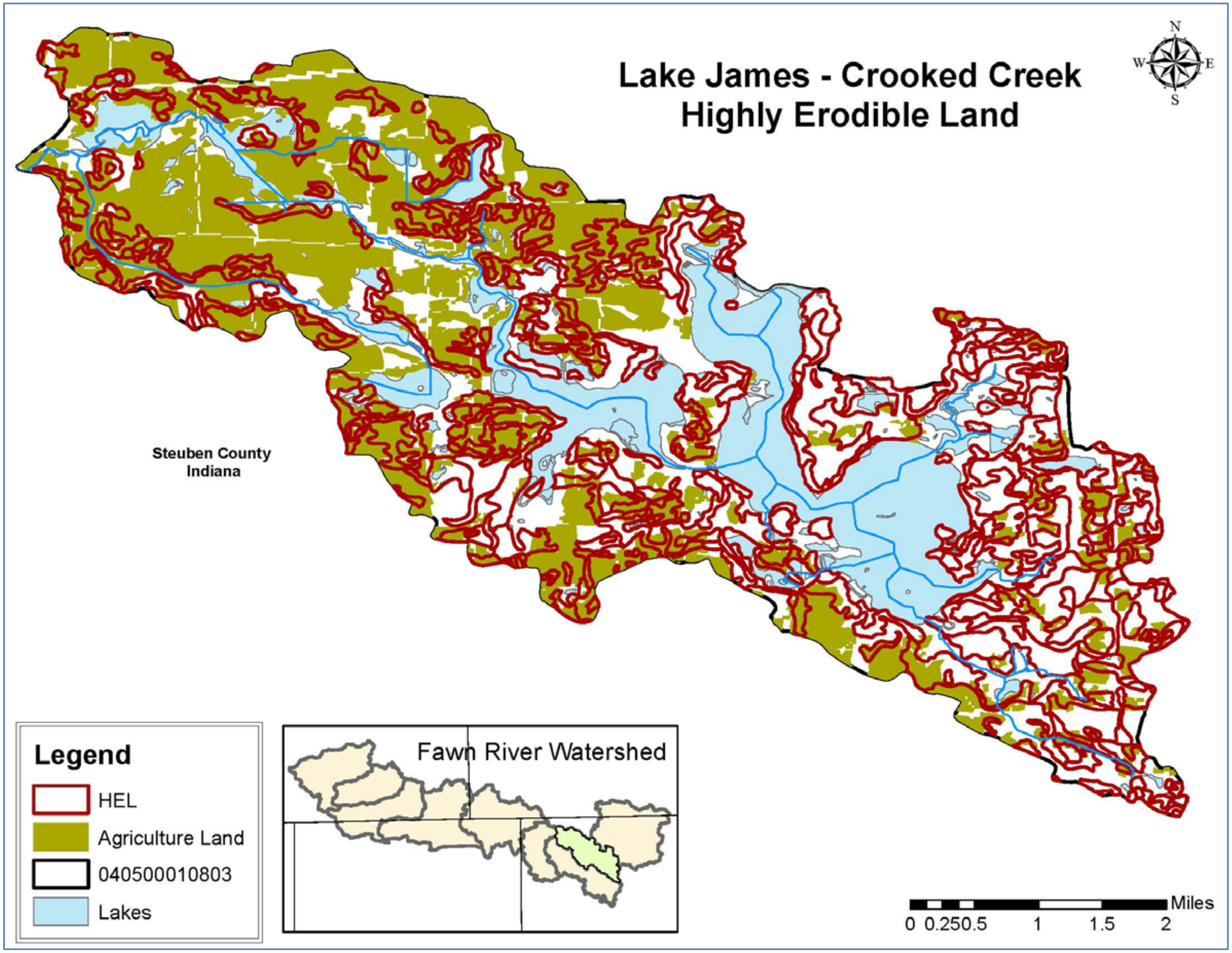
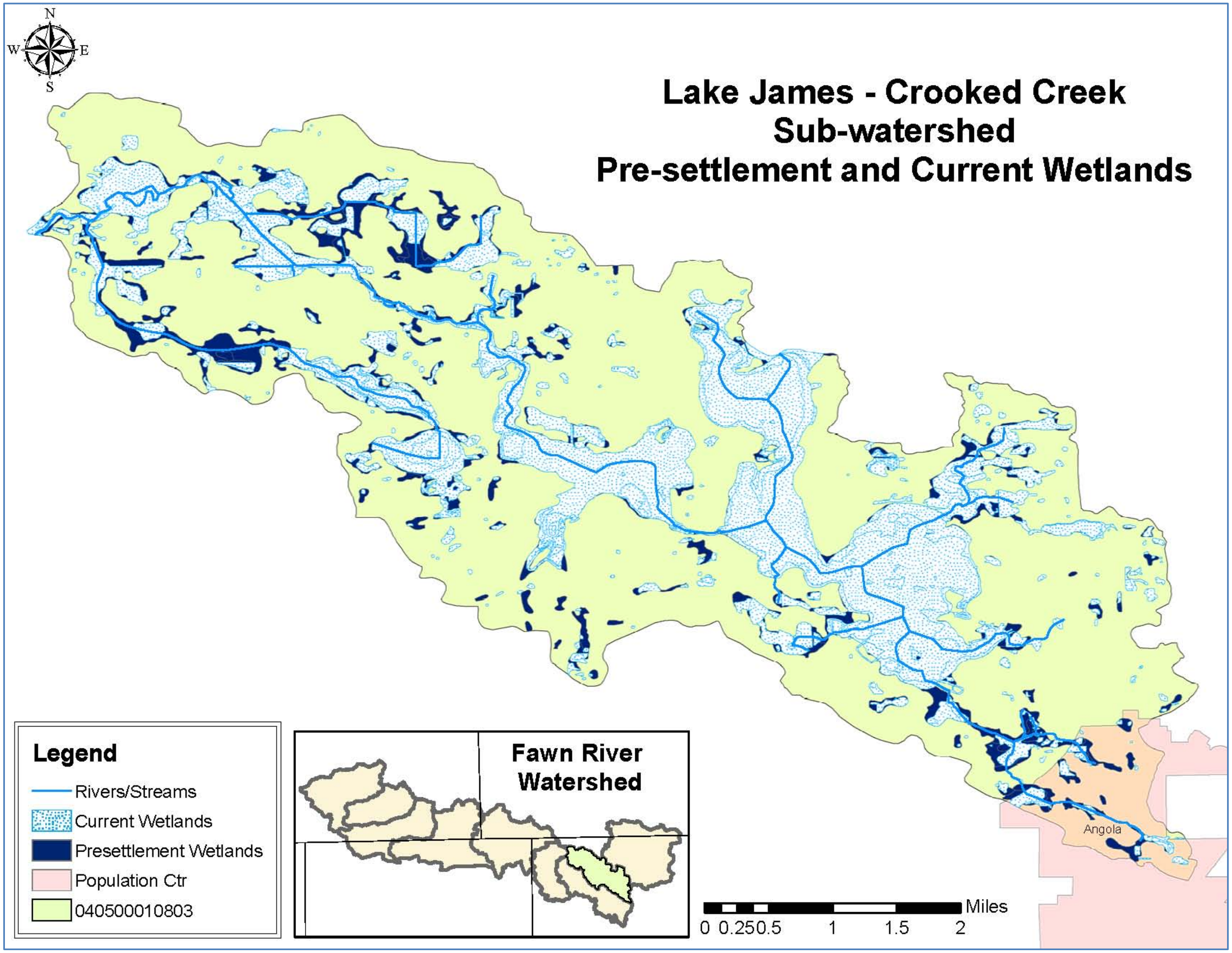


Figure 3.22: Wetlands in Lake James-Crooked Creek Sub-watershed



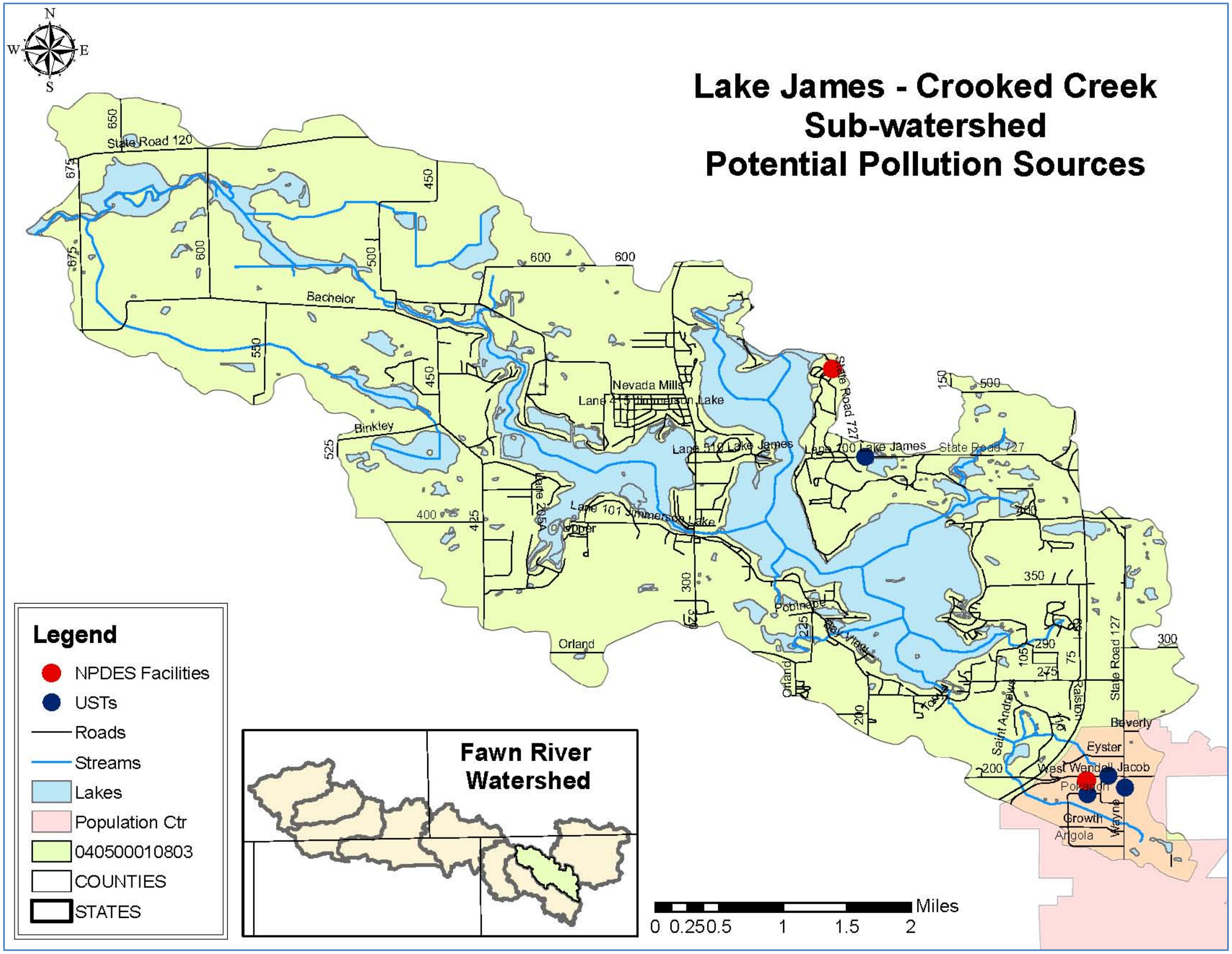
A final threat to water quality found during the inventory of Lake James – Crooked Creek sub-watershed is potential point sources of pollution. There are two NPDES permitted facilities located within this sub-watershed, however one of them, Meridian Automotive Systems, discharges outside the watershed to the Pigeon River. Both of the facilities have been in no-compliance at least four times over the past three years and Pokagon State Park has been in significant non-compliance for total ammonia within that time period. However, neither of them has had formal enforcement actions taken against them. Table 3.4.6 lists the NPDES permitted facilities within the Lake James – Crooked Creek sub-watershed and the reason they were not in compliance.

Table 3.4.6: NPDES Permitted Facilities in Lake James–Crooked Creek Sub-watershed

Permit Name	Permit #	Receiving Water Body Name	Qrts in Non-compliance (3 yrs)	Qtrs in Significant Non-compliance (3 yrs)	Pollutant Causing Non-compliance	Pollutant with Significant violations	Enforcement Actions (I=informal; F=formal) (5 yrs)
Pokagon State Park	IN0030309	Crooked Creek via Snow Lake	4	1	BOD, E. coli, N, P, and TSS	Total Ammonia	I - 1
Meridian Automotive Systems	ING250062	Pigeon Creek via Croxton Ditch	5	0	Temperature	N/A	I -1

There are four USTs located within the Lake James – Crooked Creek sub-watershed, though none of them are currently designated as a LUST, they do run the risk of leaking if not properly inspected and maintained. Figure 3.23 shows the location of the NPDES permitted facilities and the USTs in the Lake James – Crooked Creek sub-watershed.

Figure 3.23: Potential Point Sources of Pollution (Lake James–Crooked Lake Sub-watershed)



Water quality data collected in the Lake James – Crooked Creek sub-watershed indicates a significant pollution issue with phosphorus and nitrates, and to a lesser degree *E. coli* and turbidity. There were four sites observed during the windshield survey where streambank erosion was observed, and nearly 3700 linear feet of streambank lacking a riparian buffer.

The high nutrient levels found throughout the Lake James – Crooked Creek sub-watershed are likely from leaking septic systems as only 25% of the land is designated suitable for septic placement and most of the rural community is not serviced by a centralized sewer system. The high nutrients and E. coli levels may also be due to runoff of fertilizer from turf lawns around the built-up lakes and the City of Angola, and agriculture fields that do not utilize conservation tillage or riparian buffers. The fact that 4500 acres of farm land within this sub-watershed is situated on HEL also is a likely cause to the high nutrient and sediment levels found through the water quality testing. Nutrients often make their way to open water by sediment as the nutrients attach to the sediment particles. Finally, the destruction of wetlands that can efficiently filter pollutants from water may also be contributing to the high nutrient levels.

Finally, one site was noted during the windshield survey where livestock had direct access to open water in the Lake James – Crooked Lake sub-watershed. This type of practice can contribute to excess nutrients, sediment, and *E. coli* through the direct deposit of animal waste into the water and streambank erosion from the cattle passing through, or down to the stream.

A variety of best management practices and measures that could benefit the water quality in the Lake James – Crooked Creek sub-watershed are available. Some of those practices include conservation tillage, riparian and shoreline buffer installation adjacent to residential and agriculture land, cover crops, streambank stabilization, livestock exclusion, nutrient management, wetland restoration, septic system education and stormwater management measures.

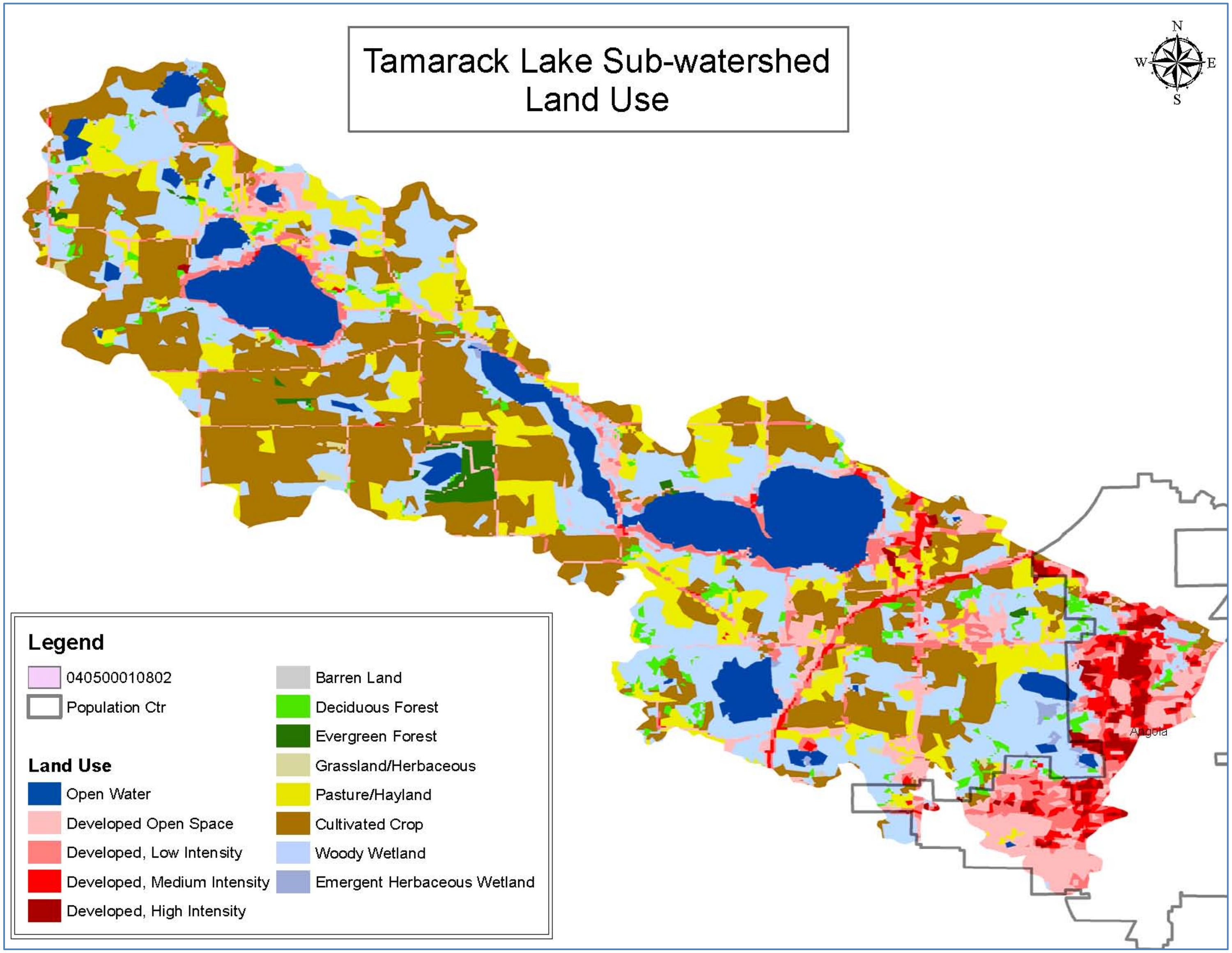
3.4.3 Tamarack Lake Sub-watershed Land Use

The primary influence on water quality in the Tamarack Lake Sub-watershed is agriculture as over 45% of the drainage area is in row crops or pasture and hayland. Unsewered homes and the lake communities also have a major influence on the water quality within the Tamarack Lake sub-watershed. Of significance in this sub-watershed is that nearly 25% of the watershed is covered by wetlands. This will be discussed in more detail later in this Section. Approximately 16% of this sub-watershed is developed due to the large lake system, most of which is built-up, and a large portion of the City of Angola. Table 3.4.7 shows the percentage of the Tamarack Lake Sub-watershed that is in each land use and Figure 3.24 is a map showing the delineation of land use in the sub-watershed. All landuse data presented was obtained from the National Land Cover Data from the USGS and analyzed in ArcGIS.

Table 3.4.7: Land Use in the Tamarack Lake Sub-watershed

NLCD Land Use Designation	Acres	%
Open Water	1547.26	9.55%
Developed Open Space	1183.04	7.30%
Developed Low Intensity	781.74	4.82%
Developed Medium Insensity	358.71	2.21%
Developed High Intensity	200.59	1.24%
Barren Land	2.73	0.02%
Deciduous Forest	329.16	2.03%
Evergreen Forest	134.61	0.83%
Grassland Herbaceous	41.15	0.25%
Pasture Hayland	1891.75	11.68%
Row Crops	5747.6	35.47%
Woody Wetland	3937.47	24.30%
Emergent Herbaceous Wetlands	46.91	0.29%
Total	16,202.72	100%

Figure 3.24: Tamarack Lake Sub-watershed Land Use Designations



The windshield survey conducted as part of this project in May, 2014 revealed some common concerns scattered throughout the Tamarack Lake sub-watershed including agriculture land that lacks a riparian buffer along adjacent open water, sea walls constructed along the lakes in the watershed, and lush green lawns adjacent to open water, indicating fertilizer use in areas that lack adequate riparian and shoreline buffers. There were three sites noted during the survey, beyond the more common concerns listed above. Two of the sites located in Angola, were commercial sites with the majority of the properties being impervious, that lack an adequate riparian buffer to slow storm flow and capture various urban pollutants. The third site was the Highway Departments storage site, which also lacked an adequate riparian buffer. In total, approximately 1618 linear feet of streambank lacked an adequate riparian buffer in the Tamarack Lake sub-watershed, and each site either already had slight streambank erosion, or has the potential to develop erosion. Figure 3.25 shows the location of the sites identified during the windshield survey as potential problems, as well as the populated lakes where seawalls and excessive fertilizer application are used.

It was discovered during the desktop survey that Warner Lake has two agriculture properties on it. It appears from the aerial photos from 2012, that one of the properties goes directly to the shoreline and lacks any buffer. While there is not water quality testing site near Warner Lake, the aerials show excessive algal growth indicating high nutrient levels in the lake.

Another potential problem related to residential homes in the Tamarack Lake sub-watershed is the populated areas that are not currently serviced by a centralized sewer system. These homes most likely utilize an on-site waste disposal system that has the potential to leak or fail if not properly maintained. As is illustrated in Figure 3.25, over 73% of the sub-watershed's soils are designated as being very limited or somewhat limited for septic system placement and at least two of the built-up lakes including Warner Lake and Pine Canyon Lake are not currently serviced by a centralized sewer system. There is also a neighborhood, Waldon Woods, just north of Lime Lake that is located within the boundaries of the Steuben Lakes Regional Waste District but is not currently serviced; however the SLRWD hopes to service all areas within its jurisdiction within the next decade. There are also homes scattered throughout the sub-watershed, in the rural areas, that are not currently serviced and are utilizing on-site waste disposal.

Figure 3.25: Windshield Observations in the Tamarack Lake Sub-watershed

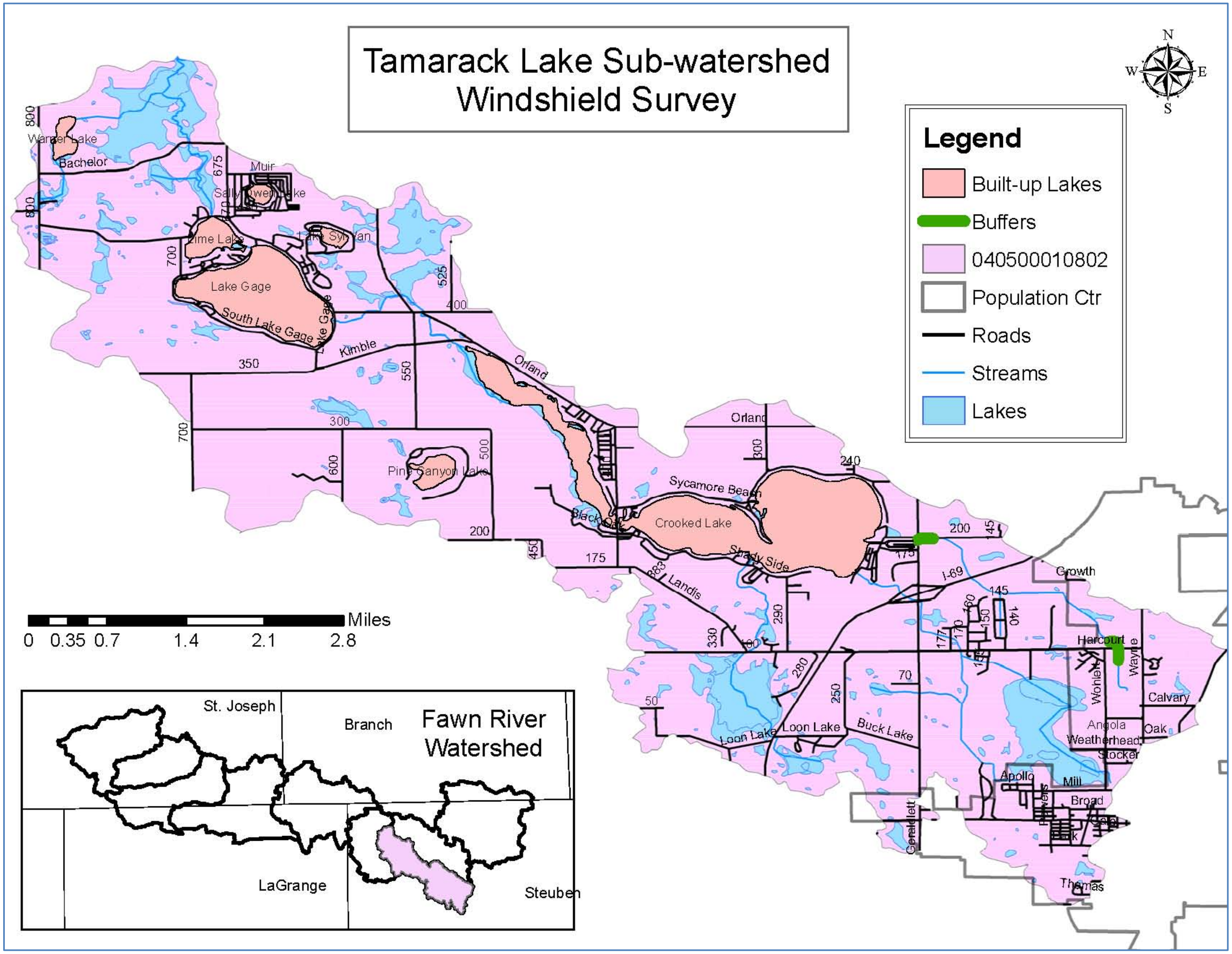
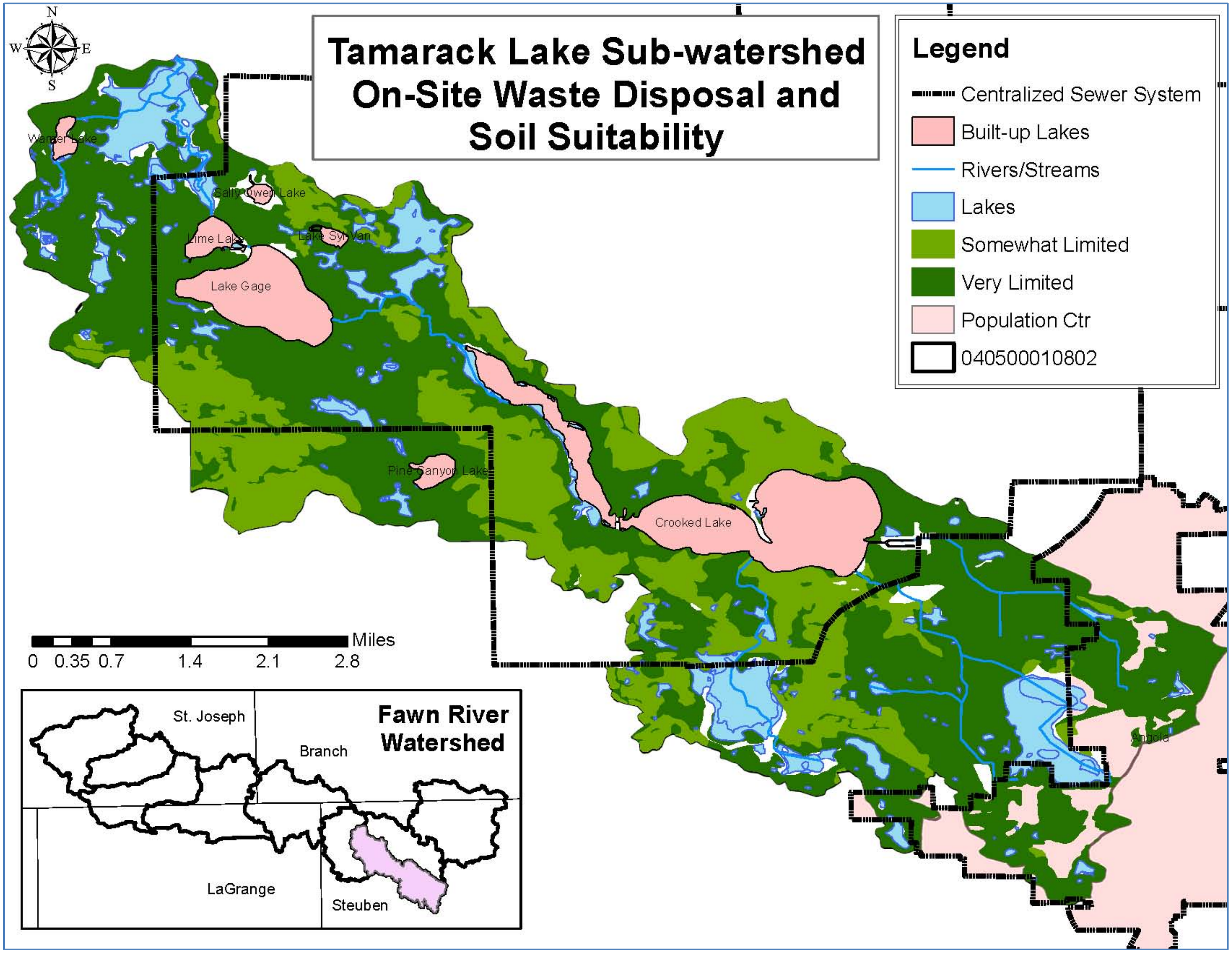


Figure 3.25: Septic Suitability in the Tamarack Lake Sub-watershed



As stated above, much of the land in the Tamarack Lake sub-watershed is used for agriculture; either cultivated crops or pasture and hayland. Approximately 47% of the land in the sub-watershed is designated as highly erodible by the Steuben County NRCS. Therefore, sediment, carrying nutrients attached to the soil particles, from HEL that is being conventionally tilled, or farmed directly up to the streambank have a direct path to deposit in open water. An analysis of agriculture land and HEL revealed that nearly 7,035 acres of agriculture land in the Tamarack Lake sub-watershed is located on HEL. Therefore, special precautions must be taken on farmland in this sub-watershed that is designated as HEL to prevent soil erosion, and sedimentation and nutrification of open water. Figure 3.26 shows the location of HEL in the watershed, overlaid on the agriculture land to paint a picture of where there is a risk of soil erosion.

The second most common land cover in the Tamarack Lake sub-watershed, next to agriculture, is wetlands with nearly 25% of the watershed being classified as a wetland. According to the 2005 wetland inventory conducted by the MDEQ and partners, the Tamarack Lake sub-watershed currently has 3,415.71 acres of wetland from the 4,286.03 acres of wetland present in pre-settlement times. This is over a 20% decline in the wetlands since settlement of the area. The loss in wetlands translates to a combined water quality functional use loss of 22% and a combined habitat functional use loss of 21%. Figure 3.27 show the location of the historic and current wetlands in the Tamarack Lake sub-watershed.

Figure 3.26: Highly Erodible Land in the Tamarack Lake Sub-watershed

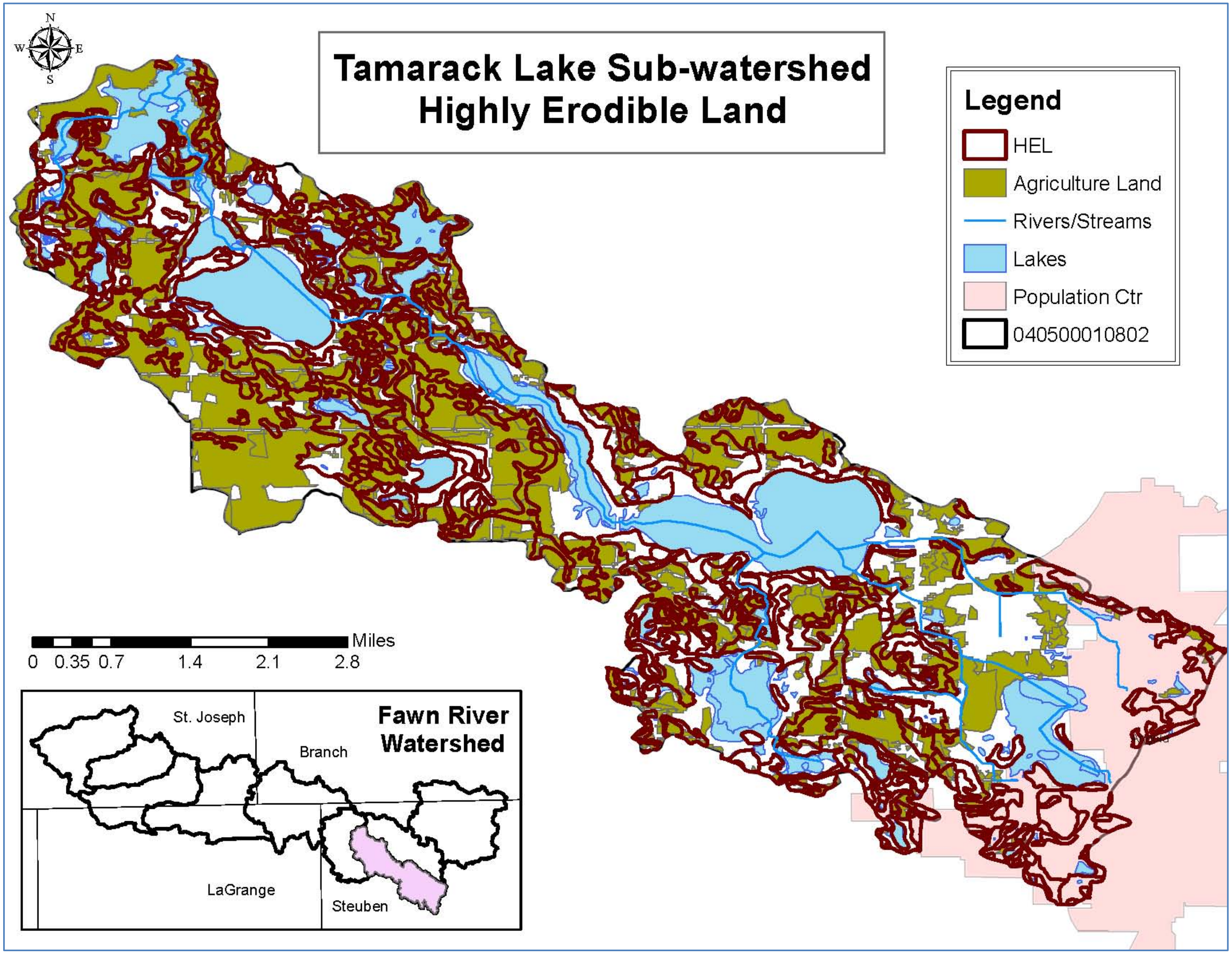
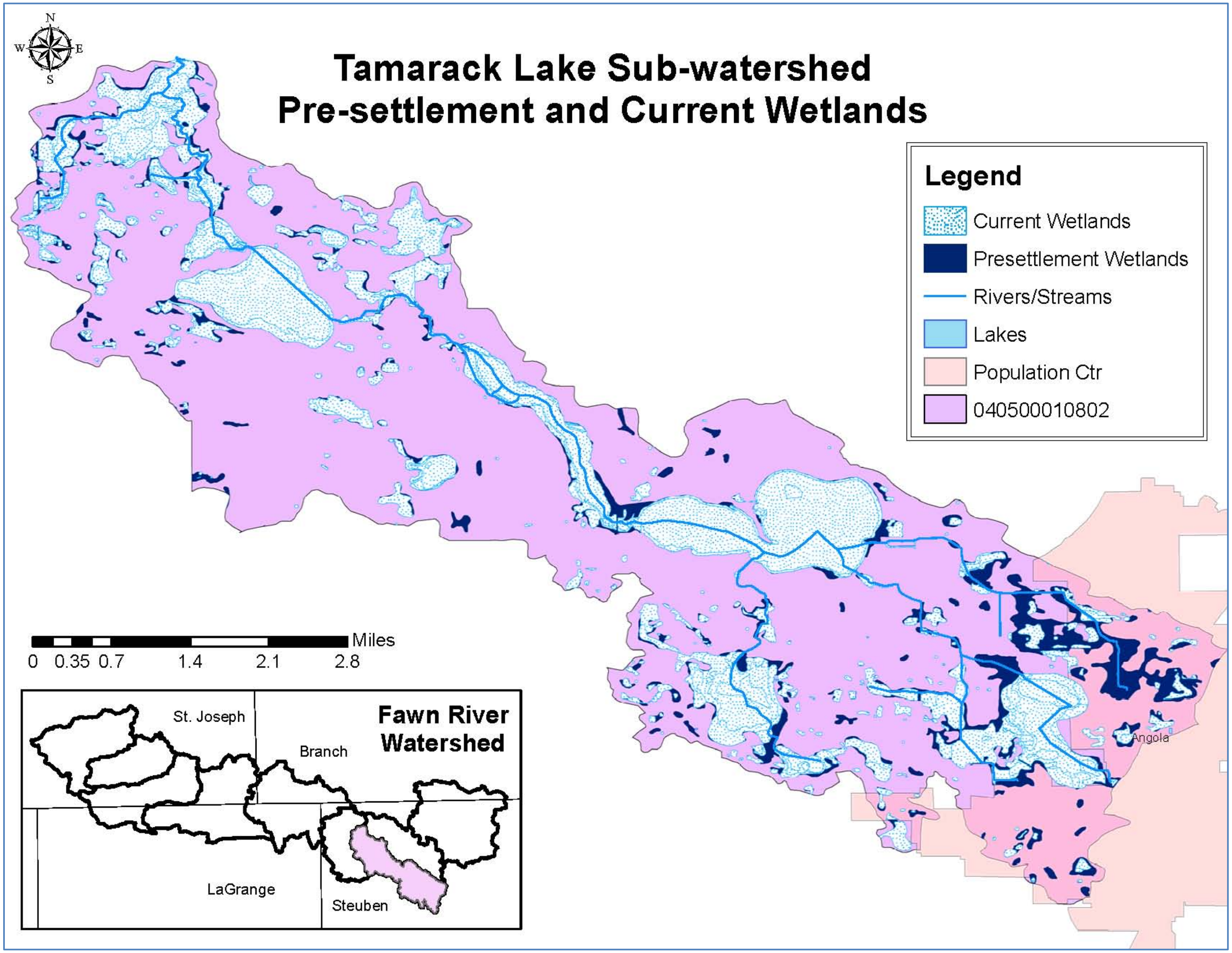


Figure 3.27: Current and Pre-settlement Wetlands in the Tamarack Lake Sub-watershed



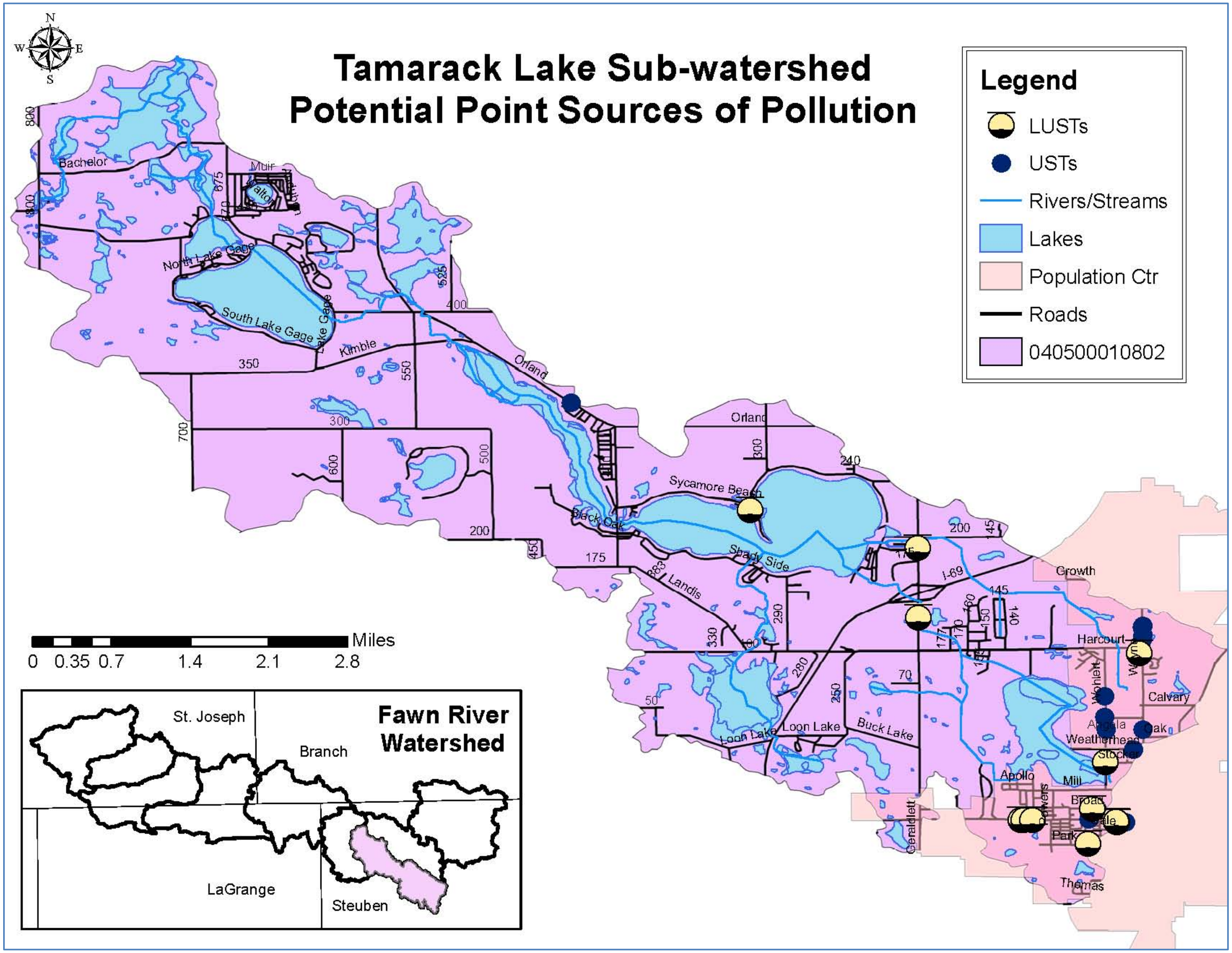
A final threat to water quality found during the inventory of Tamarack Lake sub-watershed are potential point sources of pollution. There are not any NPDES permitted facility located within this sub-watershed. However, there are 27 USTs located within the Tamarack Lake sub-watershed. While USTs do not pose an immediate threat to water resources, they do run the risk of leaking if not properly inspected and maintained. Of the 27 USTs located within this sub-watershed 12 of them are considered to be LUSTs by IDEM and seven of those are considered to be a medium priority for remediation. Table 3.4.8 lists the LUSTs in the Tamarack Lake sub-watershed. Figure 3.28 shows the location of the LUSTs in the sub-watershed.

Table 3.4.8: Leaking Underground Storage Tanks in Tamarack Lake Sub-watershed

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
7227	199901536	Wagner's Shell #844	Medium	NFA-Conditional Closure	Soil
	199901536		Medium	NFA-Conditional Closure	MTBE
	199901536		Medium	NFA-Conditional Closure	Groundwater
19384	199507529	Tri State University	Medium	Monitored natural attenuation (active)	Soil
	199507529		Medium	Monitored natural attenuation (active)	Groundwater
517	199902502	Jerry's Marathon	Medium	NFA-Conditional Closure	Soil
	199902502		Medium	NFA-Conditional Closure	Groundwater
11709	199403529	Emro Marketing Wake Up #6088	Medium	NFA-Unconditional Closure	Soil
	199403529		Medium	NFA-Unconditional Closure	Groundwater
	199403529		Medium	NFA-Unconditional Closure	Geologically Suscept
	199105501		Low	NFA-Unconditional Closure	Unknown
19649	199507225	Former Const Co Facility	Low	NFA-Unconditional Closure	Soil
18164	199208505	Owner Unknown Tanks	Low	NFA-Unconditional Closure	Soil
760	200008513	Steuben County Farm Bureau Coop	Medium	Monitored natural attenuation (active)	Soil
	200008513		Medium	Monitored natural attenuation (active)	Groundwater

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
24629	200205126	Complete Stop	Medium	NFA-Unconditional Closure	Soil
	200205126		Medium	NFA-Unconditional Closure	Groundwater
16293	199509523	Steuben County Highway Dept	Low	NFA-Unconditional Closure	Soil
16773	198910016	Crooked Lake Marina	Low	Discontinued (active)	Soil
6085	198910026	Nipsco Angola	Low	NFA-Unconditional Closure	Soil
24629	200205126	Complete Stop	Medium	NFA-Unconditional Closure	Soil
	200205126		Medium	NFA-Unconditional Closure	Groundwater

Figure 3.28: Potential Point Sources of Pollution in the Tamarack Lake Sub-watershed



Water quality data collected in the Tamarack Lake sub-watershed indicates a significant pollution issue with *E. coli*, which exceeded the state standard in a total of 44% of the samples, and nutrients which exceeded the target levels in less than 40% of the samples. The percent of *E. coli* samples taken from sites leading to Crooked Lake were all very high, as was the *E. coli* sample taken at Crooked Lake's outlet. These results indicate there is significant fecal material reaching open water prior to entering Crooked Lake, which could be from leaking septic systems as this rural area is not serviced by a centralized sewer system, or from wildlife or pet waste. The results also indicate that *E. coli* is being contributed to the lake from around that lake as well, since 36% of the samples from the lake's outlet also exceeded the state standard. Crooked Lake is serviced by a sewer system, so the *E. coli* is likely from wildlife or pet waste which enters the lake through stormflow and since much of the lake is lacking an adequate shoreline buffer, there is a direct path for polluted stormflow to enter the lake. This pattern is not duplicated for the sample points at the inlet and outlet of the Lake Gage-Lime Lake system. *E. coli* levels were much higher entering the lake than they were exiting the lake.

Nitrates and phosphorus measured high for all sample points in the watershed, though total phosphorus was higher for those sample sites upstream of Crooked Lake. Again, that may be due to leaking septic systems, wildlife and pet waste runoff, or from excessive fertilizer from farm fields or residential lawns in and around Angola. It should also be noted the majority of the wetlands that have been lost in the watershed from pre-settlement times is in the areas upstream of Crooked Lake.

Excess nutrients may also be a problem in this watershed because over 7,000 acres of farmland is located on highly erodible land, and if that land is not sustainably farmed and is conventionally tilled, sediment carrying nutrients from fertilizer may runoff the land and deposit in open water. Also, it was noted during the windshield survey that there is a lack of adequate riparian and shoreline buffer present in the sub-watershed, and that three sites not only lacked a riparian buffer, but that was possibly contributing to slight erosion.

A variety of best management practices and management measures that could benefit the water quality in the Tamarack Lake sub-watershed are available. Some of those practices include conservation tillage, cover crops, riparian and shoreline buffer installation adjacent to residential and agriculture land, nutrient management, wetland restoration, septic system education and stormwater management measures.

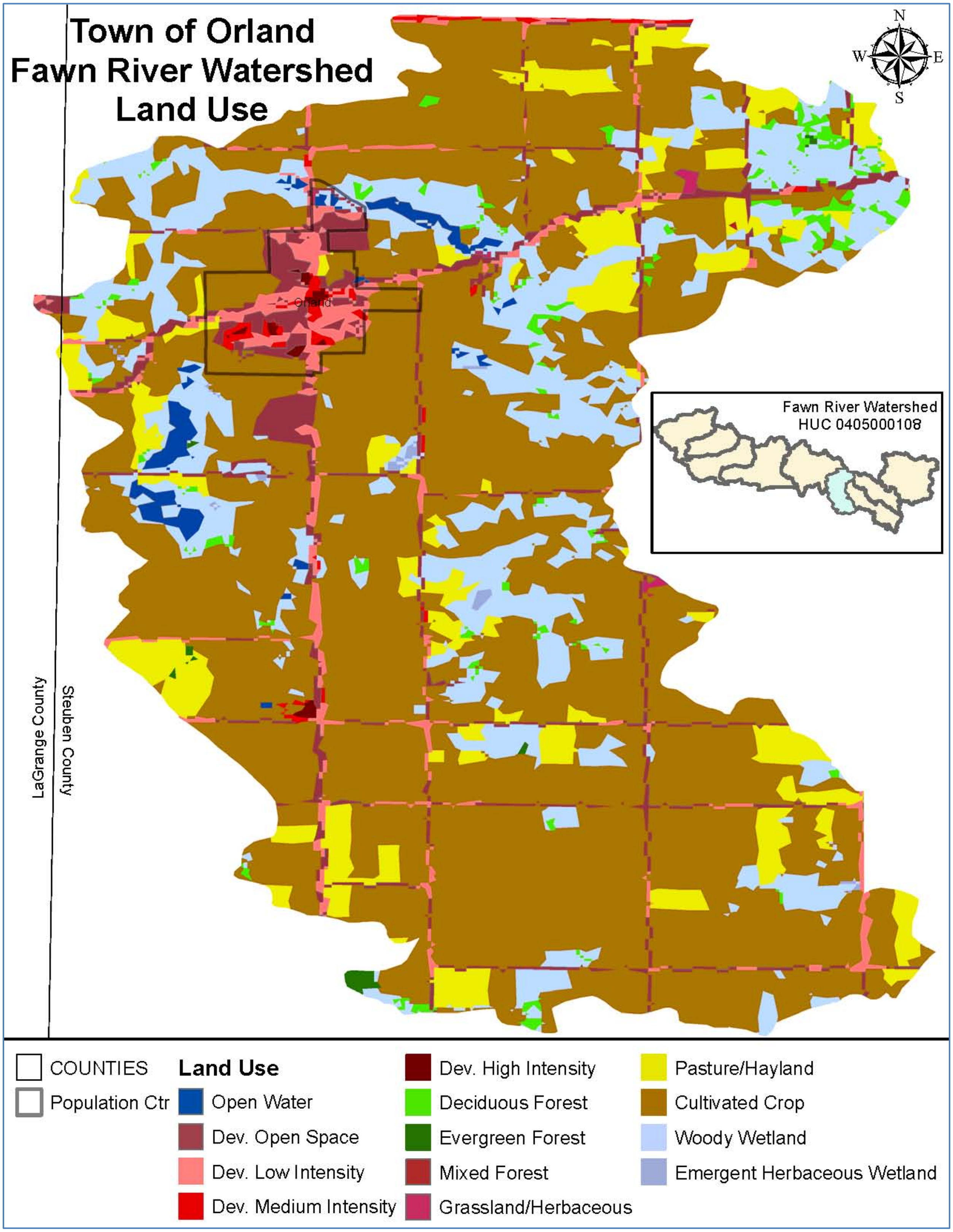
3.4.4 Town of Orland – Fawn River Sub-watershed Land Use

The primary influence on water quality in the Town of Orland – Fawn River Sub-watershed is agriculture as over 72% of the drainage area is in row crops or pasture and hayland. Unsewered homes in the rural areas of this sub-watershed also have a major influence on the water quality within the Town of Orland – Fawn River sub-watershed. Of significance in this sub-watershed is that over 17% of the sub-watershed is covered by wetlands. This will be discussed in more detail later in this Section. Nearly 8% of the Town of Orland sub-watershed is developed, most of which is from the Town of Orland itself, and State Roads 120 and 327. Table 3.4.9 shows the percentage of the Town of Orland – Fawn River Sub-watershed that is in each land use and Figure 3.29 is a map showing the delineation of land use in the sub-watershed. All landuse data presented was obtained from the National Land Cover Data from the USGS and analyzed in ArcGIS.

Table 3.4.9: Land Use in Town of Orland–Fawn River Sub-watershed

NLCD Land Use Designation	Acres	%
Open Water	109.81	0.89%
Developed Open Space	556.59	4.50%
Developed Low Intensity	343.18	2.77%
Developed Medium Insensity	65.93	0.53%
Developed High Intensity	17.49	0.14%
Deciduous Forest	155.47	1.26%
Evergreen Forest	17.02	0.14%
Mixed Forest	0.79	0.01%
Grassland Herbaceous	17.13	0.14%
Pasture Hayland	1039.71	8.40%
Row Crops	7941	64.16%
Woody Wetland	2095.42	16.93%
Emergent Herbaceous Wetlands	17.49	0.14%
Total	12,377.03	100.00%

Figure 3.29: Town of Orland – Fawn River Sub-watershed Land Use Designations



The windshield survey conducted as part of this project in May, 2014 revealed that a lack of riparian buffer along agriculture land was common practice throughout the watershed. However, there were two locations of significance where there was virtually no buffer present between a row crop field and stream. The total length of the sites needing a riparian buffer (verified through a desktop survey) is 5,929 linear feet. It should be noted that the Town of Orland sub-watershed houses the Fawn River Fish Hatchery, where the IN DNR raises various fish species for their restocking program. In the past, the lowering of the water level in the fish ponds has caused a significant sediment release, however, water quality sampling of FRP site 22, downstream of the hatchery did not reveal any sediment issues. There are no populated lakes located in the Town of Orland sub-watershed, as there is in the previous three sub-watersheds summarized in this report thus far. Figure 3.30 shows the location of the sites identified during the windshield survey as potential problems in the Town of Orland sub-watershed.

Another potential problem related to residential homes in the Town of Orland – Fawn River sub-watershed is the areas that are not currently serviced by a centralized sewer system. These homes most likely utilize an on-site waste disposal system that has the potential to leak or fail if not properly maintained. As is illustrated in Figure 3.31, over 93% of the sub-watershed's soils are designated as being very limited or somewhat limited for septic system placement and the majority of the sub-watershed is not serviced by a centralized sewer system. The most populated area of the Town of Orland is serviced and a small portion in the southeast portion of the watershed is also serviced; both by the Steuben Lakes Regional Sewer District.

Figure 3.30: Windshield Survey Observations in Town of Orland–Fawn River Sub-watershed

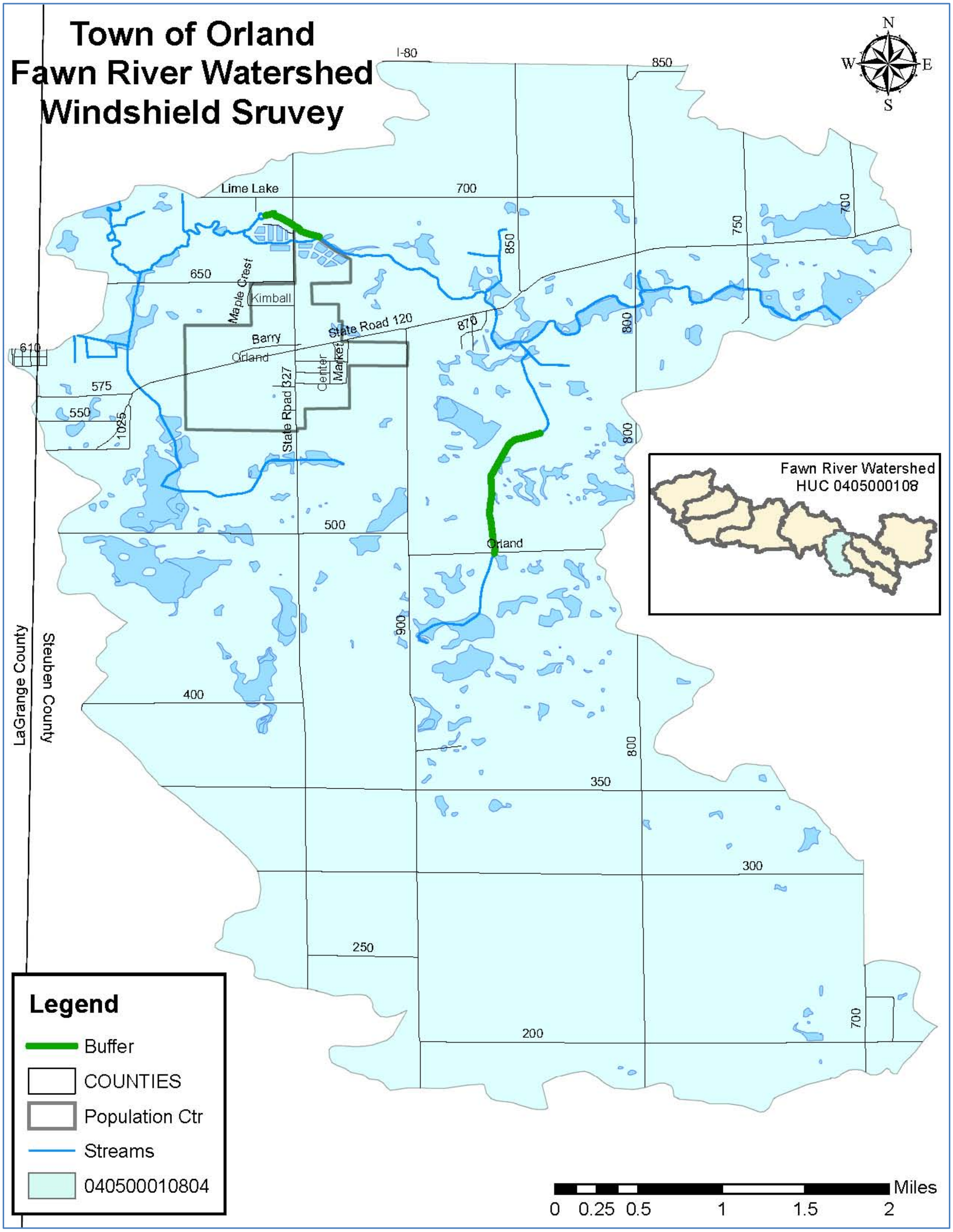
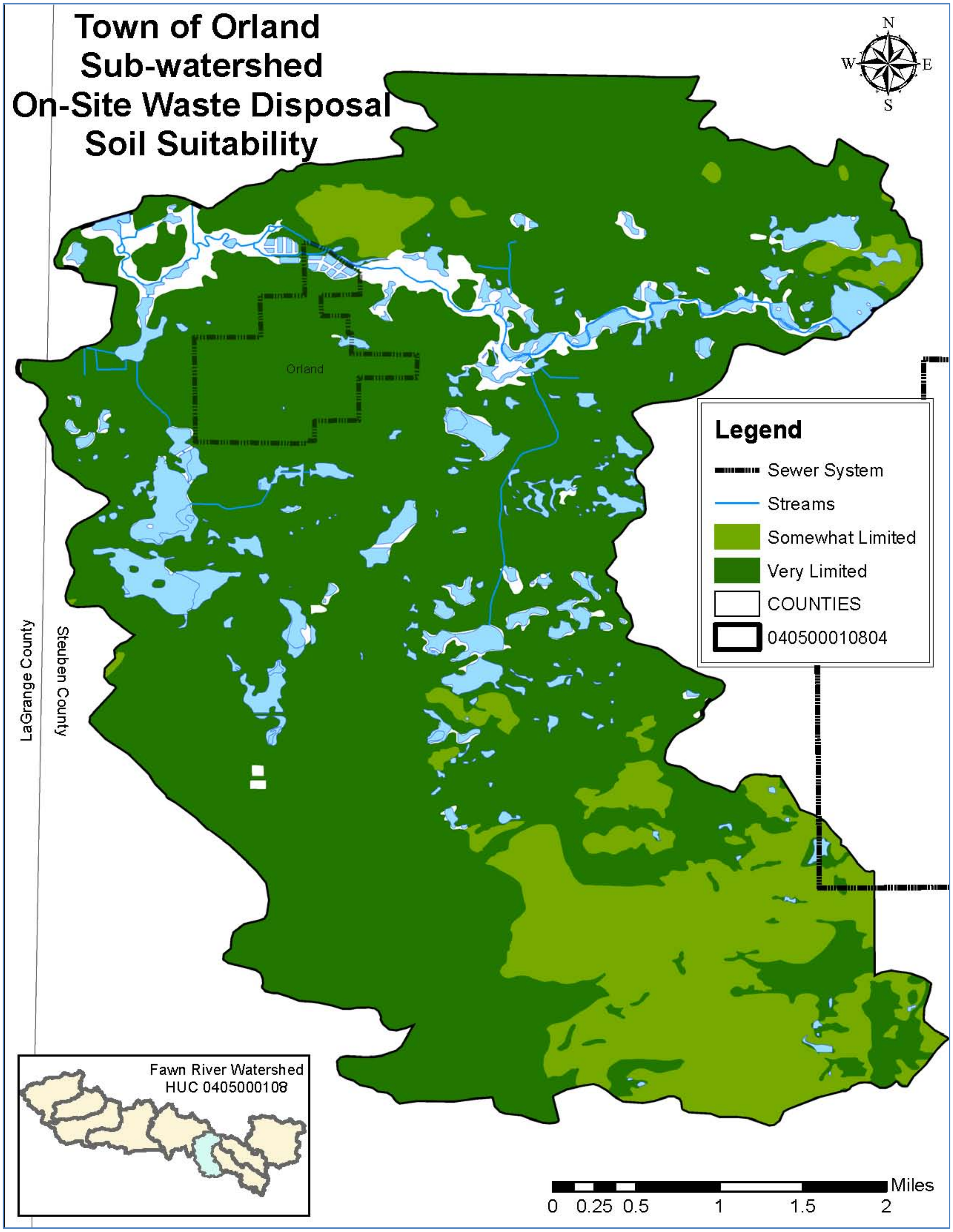


Figure 3.31: Septic Suitability in Town of Orland – Fawn River Sub-watershed



As stated above, most of the land in the Town of Orland – Fawn River sub-watershed is used for agriculture; either cultivated crops or pasture and hayland. Approximately 16% of the land in the sub-watershed is designated as highly erodible by the Steuben County NRCS. This percentage is not as significant as it is in other sub-watersheds. However, there is still potential for sediment, carrying nutrients attached to the soil particles, from HEL that is being conventionally tilled, or farmed directly up to the streambank to deposit in open water. Special precautions must be taken on farmland in this sub-watershed that is designated as HEL to prevent soil erosion, and sedimentation and nutrification of open water. Figure 3.32 shows the location of HEL in the watershed, overlaid on the agriculture land to paint a picture of where there is a risk of soil erosion.

The Town of Orland – Fawn River sub-watershed has a significant amount of land cover designated as wetland: over 17%. According to the 2005 wetland inventory conducted by MDEQ and partners, the Town of Orland – Fawn River sub-watershed currently has 1,520.29 acres of wetland from the 2,140.27 acres of wetland present in pre-settlement times. This is nearly a 29% decline in the wetlands since settlement of the area. The loss in wetlands translates to a huge loss in the ability of the wetlands to absorb pollutants prior to them being released into open water and in prime habitat for fauna that relies on wetlands for survival. According to data collected in 2005, there has been a water quality functional use loss of 32% and a habitat functional use loss of 36% in the Town of Orland sub-watershed. Figure 3.33 shows the wetland delineation for the historic and current wetlands in the Town of Orland sub-watershed.

Figure 3.32: Highly Erodible Land in Town of Orland – Fawn River Sub-watershed

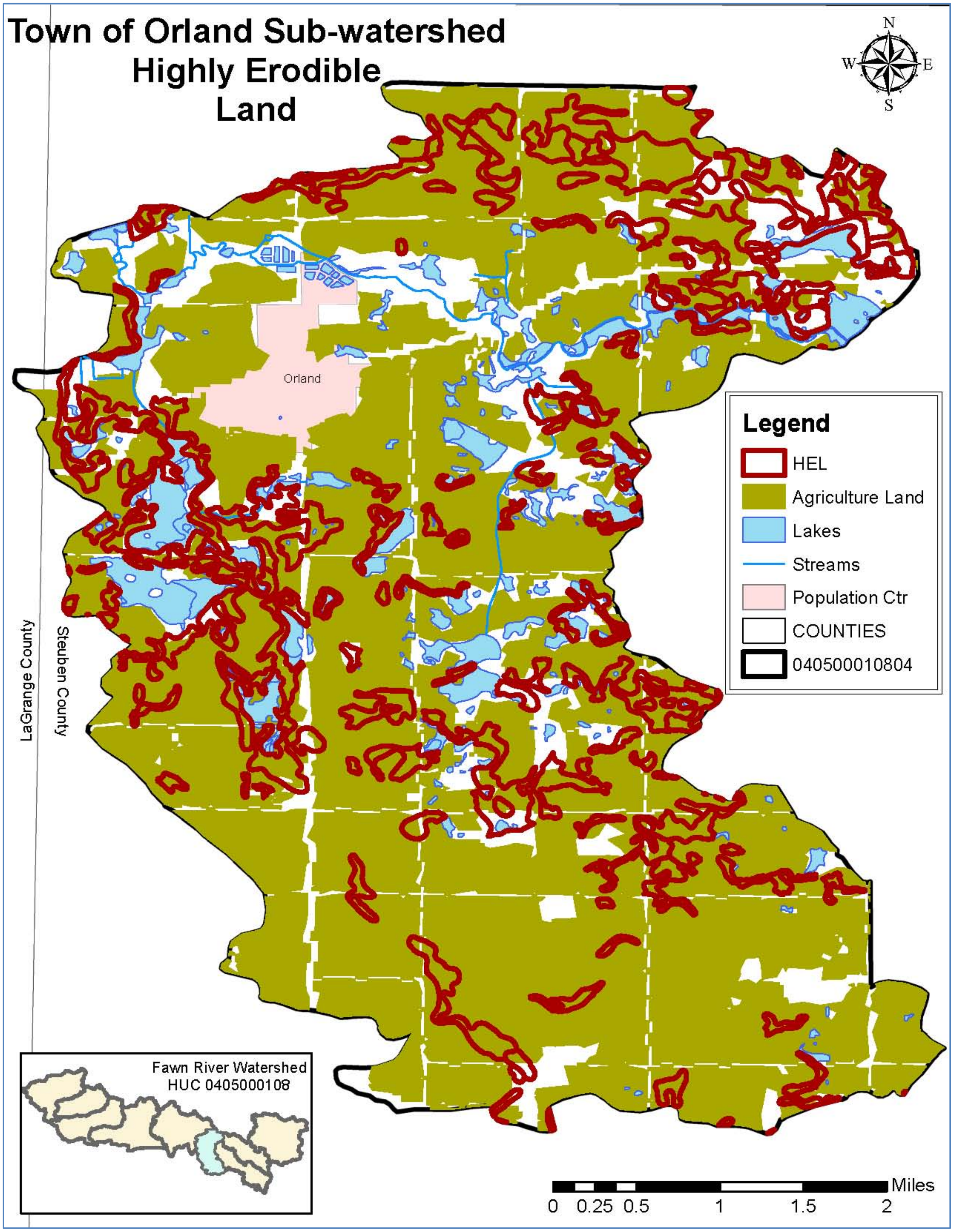
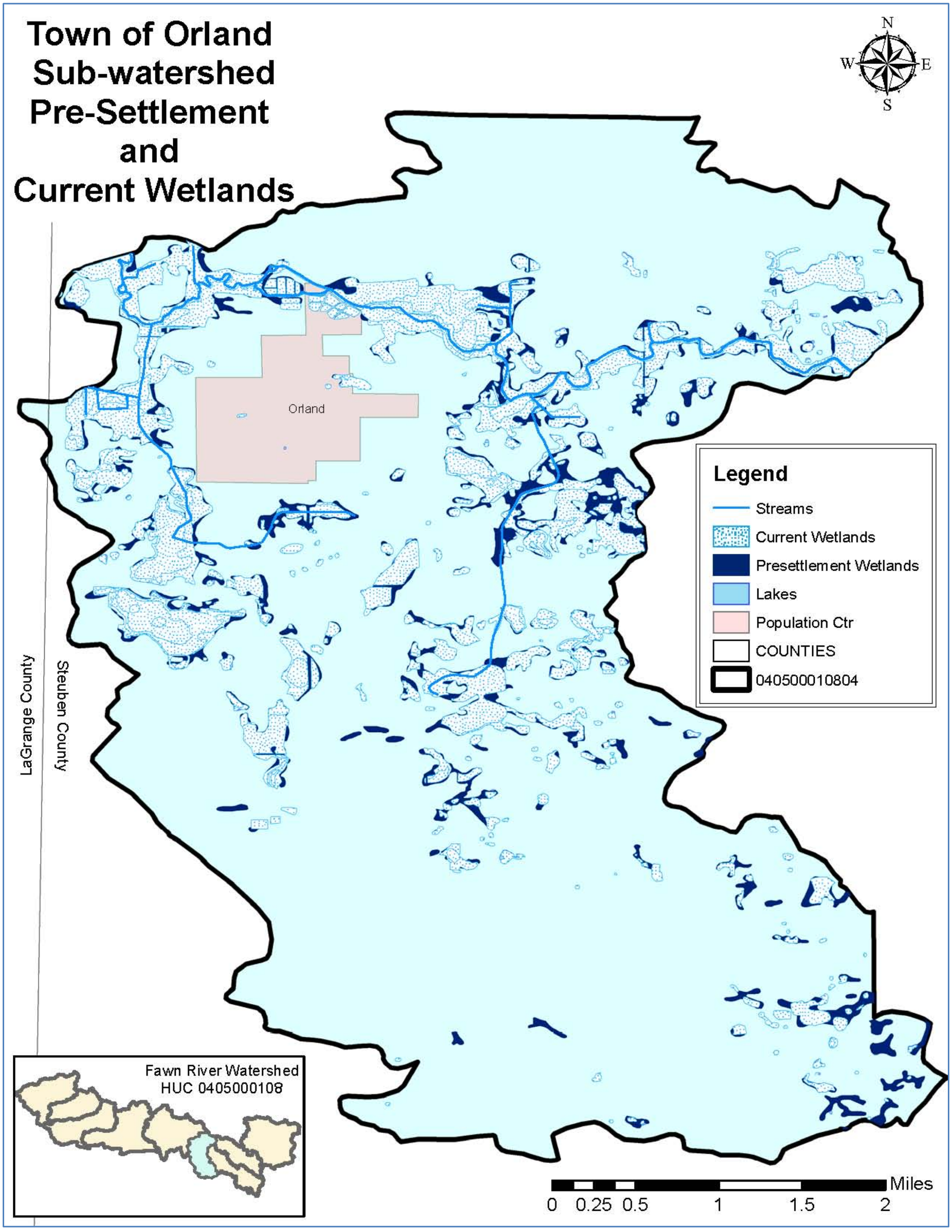


Figure 3.33: Wetlands in the Town of Orland – Fawn River Sub-watershed

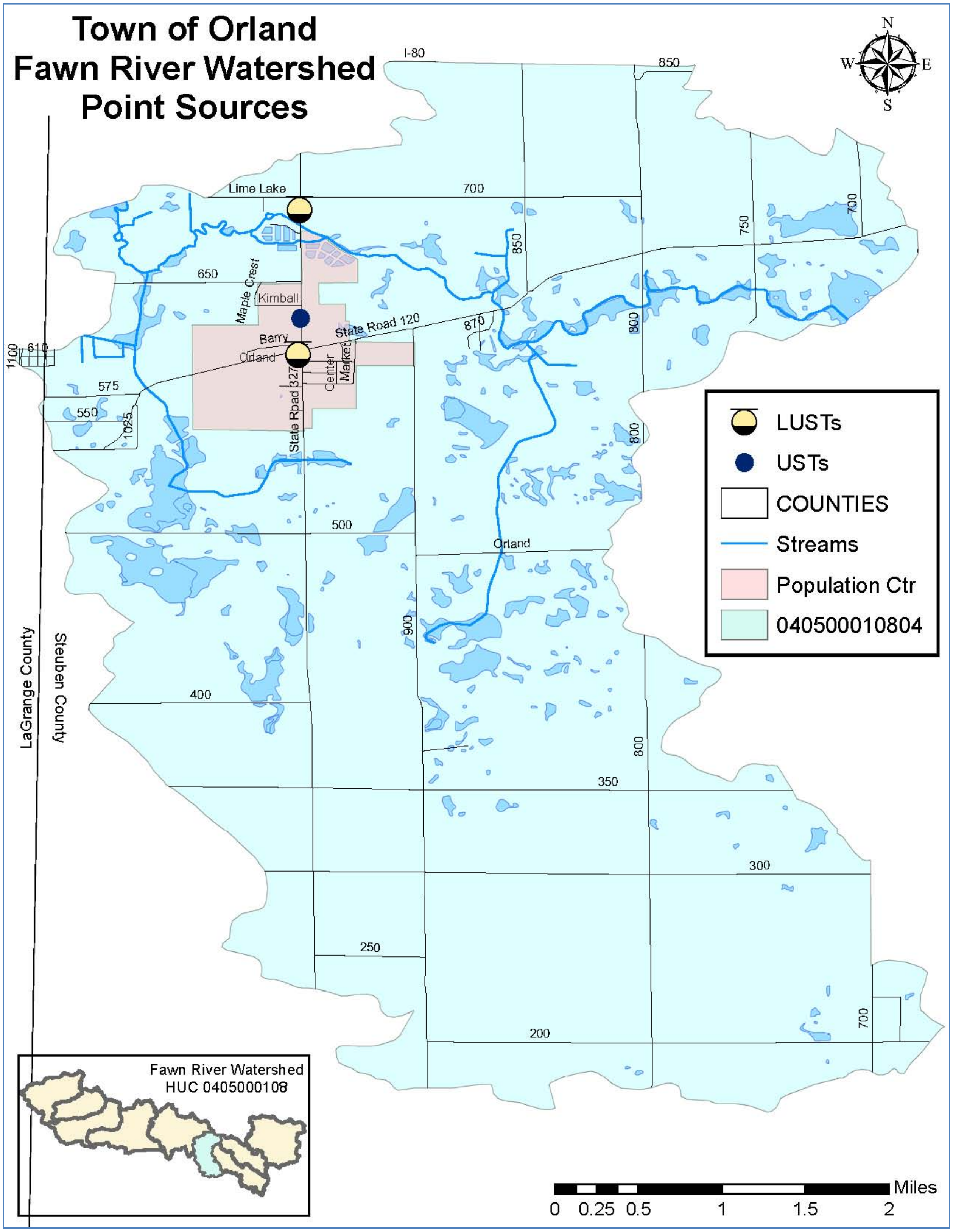


A final threat to water quality found during the inventory of Town of Orland – Fawn River sub-watershed is potential point sources of pollution. There are not any NPDES permitted facility located within this sub-watershed. However, there are three USTs located within the this sub-watershed. While USTs do not pose an immediate threat to water resources, they do run the risk of leaking if not properly inspected and maintained. Of the 3 USTs located within this sub-watershed 2 of them are considered to be LUSTs by IDEM and they are both considered to be a high or medium priority for remediation. Table 3.4.10 lists the LUSTs in the Town of Orland – Fawn River sub-watershed. Figure 3.34 shows the location of the LUSTs in the sub-watershed.

Table 3.4.10: Leaking Underground Storage Tanks in Town of Orland–Fawn River Sub-watershed

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
511	199902520	Bill's Orland Marathon	High	NFA-Conditional Closure	Soil
	199902520		High	NFA-Conditional Closure	MTBE
	199902520		High	NFA-Conditional Closure	Groundwater
	199902520		High	NFA-Conditional Closure	Free Product
	199902520		High	NFA-Conditional Closure	Drinking Water
4138	199410503	Fawn River State Fish Hatchery	Medium	NFA-Unconditional Closure	Soil
	199410503		Medium	NFA-Unconditional Closure	Groundwater

Figure 3.34: Potential Point Sources of Pollution in the Tamarack Lake Sub-watershed



Water quality data collected in the Town of Orland – Fawn River sub-watershed indicates a pollution issue with nutrients as the total of samples collected for nutrients exceeded the target level in 29% of the samples and those sampled for phosphorus exceeded the target level in 50% of the samples. *E. coli* is also a problem in this sub-watershed as all the samples collected *for E. coli* exceeded the state standard in 13% of the samples. The two sites sampled by the FRP showed phosphorus levels exceeded the target greater than 80% of the time. Due to the sub-watershed being mostly agriculture, the high phosphorus and nitrogen levels are likely a result of unsustainable farming techniques such as farming up to open water without an adequate riparian buffer, and using conventional tillage methods on HEL. Another potential cause of the high percentages of samples that exceeded target levels for E. coli, nitrates, and phosphorus may be the lack of a centralized sewer system in the sub-watershed since only Orland, and a fragment of the southeast portion of the watershed is serviced by one.

A final, potential cause of the high nutrient levels found through the water quality sampling efforts of the FRP, is the loss in wetlands in the Town of Orland – Fawn River sub-watershed. The watershed has lost 32% of the pollution filtering power of wetlands since pre-settlement times.

A variety of best management practices and management measures that could benefit the water quality in the Town of Orland – Fawn River sub-watershed are available. Some of those practices include conservation tillage, cover crops, riparian buffer installation adjacent to residential and agriculture land, nutrient management, wetland restoration, and septic system education.

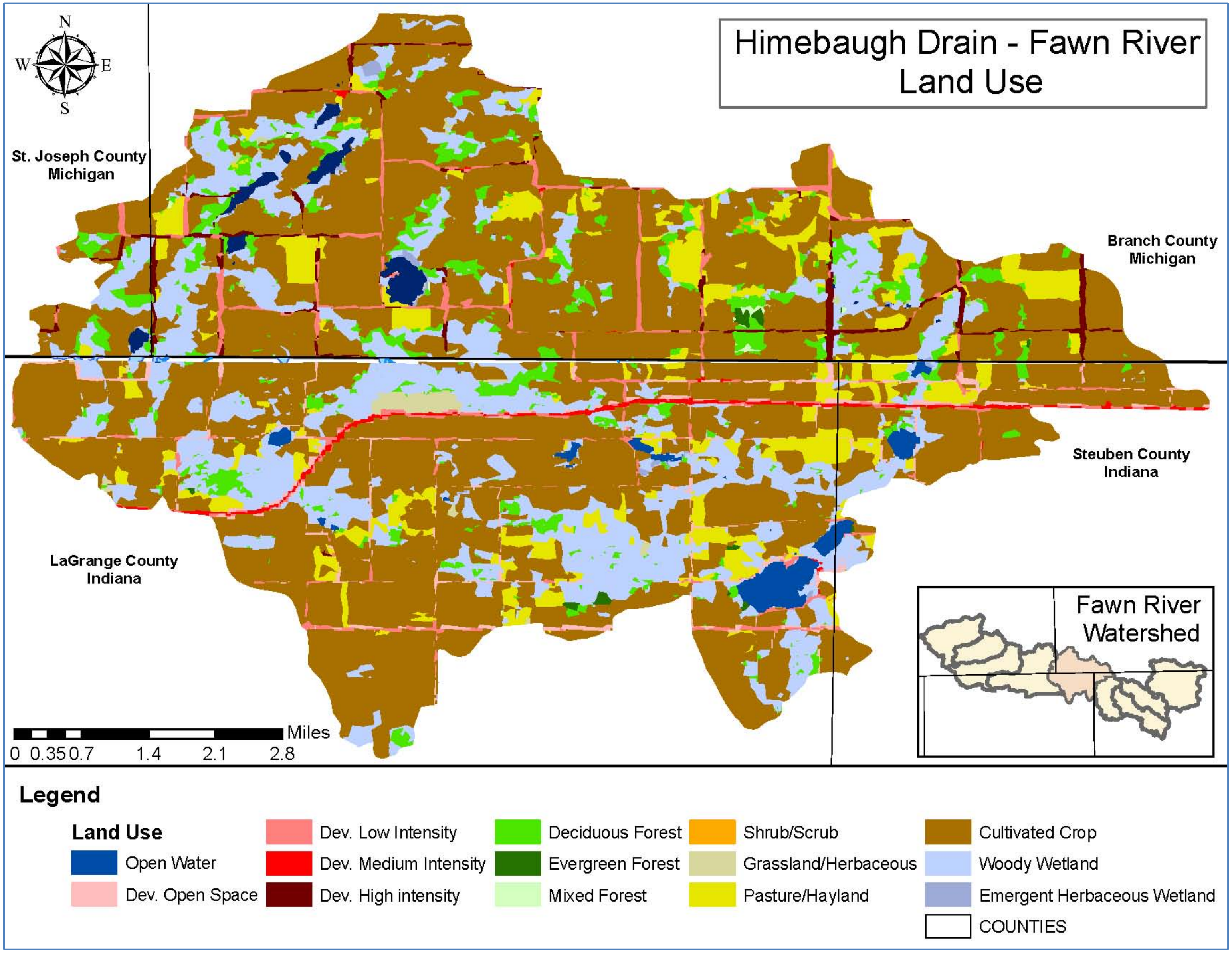
3.4.5 Himebaugh Drain – Fawn River Sub-watershed Land Use

The primary influence on water quality in the Himebaugh Drain Sub-watershed is agriculture as over 67% of the drainage area is in row crops or pasture and hayland. Unsewered homes in the rural areas of this sub-watershed also have a major influence on the water quality within the Himebaugh Drain sub-watershed. Of significance in this sub-watershed is that over 17% of the sub-watershed is covered by wetlands. This will be discussed in more detail later in this Section. Nearly 7% of the this sub-watershed is developed, most of which is from major roads, including Interstate 80 which is a four lane partial toll road that connects the west and east coasts, as there are no populated areas located within the drainage. Table 3.4.11 shows the percentage of the Himebaugh Drain Sub-watershed that is in each land use and Figure 3.35 is a map showing the delineation of land use in the sub-watershed. All landuse data presented was obtained from the National Land Cover Data from the USGS and analyzed in ArcGIS.

Table 3.4.11: Land Use in the Himebaugh Drain Sub-watershed

NLCD Land Use Designation	Acres	%
Open Water	471.99	1.71%
Developed Open Space	866.52	3.14%
Developed Low Intensity	739.08	2.68%
Developed Medium Insensity	168.56	0.61%
Developed High Intensity	1.74	0.01%
Barren Land	15.38	0.06%
Deciduous Forest	1629.07	5.91%
Evergreen Forest	50.46	0.18%
Shrub/Scrub	11.68	0.04%
Mixed Forest	27.49	0.10%
Grassland Herbaceous	173.26	0.63%
Pasture Hayland	1977.96	7.17%
Row Crops	16727.24	60.64%
Woody Wetland	4665.82	16.91%
Emergent Herbaceous Wetlands	59.54	0.22%
Total	27,585.79	100.00%

Figure 3.35: Himebaugh Drain Sub-watershed Land Use Designations



The windshield survey conducted as part of this project in May, 2014 revealed some common concerns scattered throughout the Himebaugh Drain sub-watershed including agriculture land that lacks a riparian buffer along open water, sea walls constructed along the lakes in the watershed, and lush green lawns adjacent to open water, indicating fertilizer use in areas that lack adequate riparian and shoreline buffers. However, there were several locations where more specific issues were observed. There were 11 sites where there was zero riparian buffer present adjacent to agriculture fields, and slight erosion of the streambank was observed at each of the 11 locations. The total length of the streambank needing a riparian buffer in the agriculture community (verified through a desktop survey) is 24,534 linear feet. One site was noted as having severe erosion, where the banks were sloughing into the stream due to a lack of riparian buffer adjacent to row crop fields. The total length of streambank needing stabilized is 628 linear feet. There were also two residential properties adjacent to a stream where there was no riparian buffer with lush green turf grass leading directly up to the streambank. The total length of those residential areas in need of a riparian buffer is 513 linear feet. One location was noted where livestock had direct access to open water which contributes to erosion along the streambanks that become denuded of vegetation from the livestock, and to nutrients and E. coli due to the livestock depositing waste directly into the stream. Finally, one bridge was noted as a fish barrier in the Fawn River where five culverts were placed under the road for the river to pass, though the culvert was not conducive to the passage of fish. Table 3.4.12 lists the observations made during the survey, and the approximate length of the problem. Figure 3.36 shows the location of each of the issues discovered during the windshield survey, as well as the populated lakes where seawalls and excessive fertilizer application may be used.

Table 3.4.12: Windshield Observations in the Himebaugh Drain Sub-watershed

Windshield Survey Observation	Potential Contaminant	Number or Length
Severe Streambank Erosion - Ag.	Sediment and Nutrients	628 linear ft
Lack of Riparian Buffer - Ag	Sediment and Nutrients	24,534 linear ft
Lack of Riparian Buffer - Residential	Sediment, Nutrients, and *E. coli*	513 linear ft
Livestock Access to Open Water	Sediment, Nutrients, and *E. coli*	1
Fish Barrier	Decline in Fish Species	1

Another potential problem related to residential homes in the Himebaugh Drain sub-watershed is the areas that are not currently serviced by a centralized sewer system. These homes most likely utilize an on-site waste disposal system that has the potential to leak or fail if not properly maintained. As is illustrated in Figure 3.37, over 96% of the sub-watershed's soils are designated as being very limited or somewhat limited for septic system placement and there are no areas of the sub-watershed that is serviced by a centralized sewer system, including the four populated lakes in the sub-watershed.

Figure 3.36: Windshield Observations in the Himebaugh Drain Sub-watershed

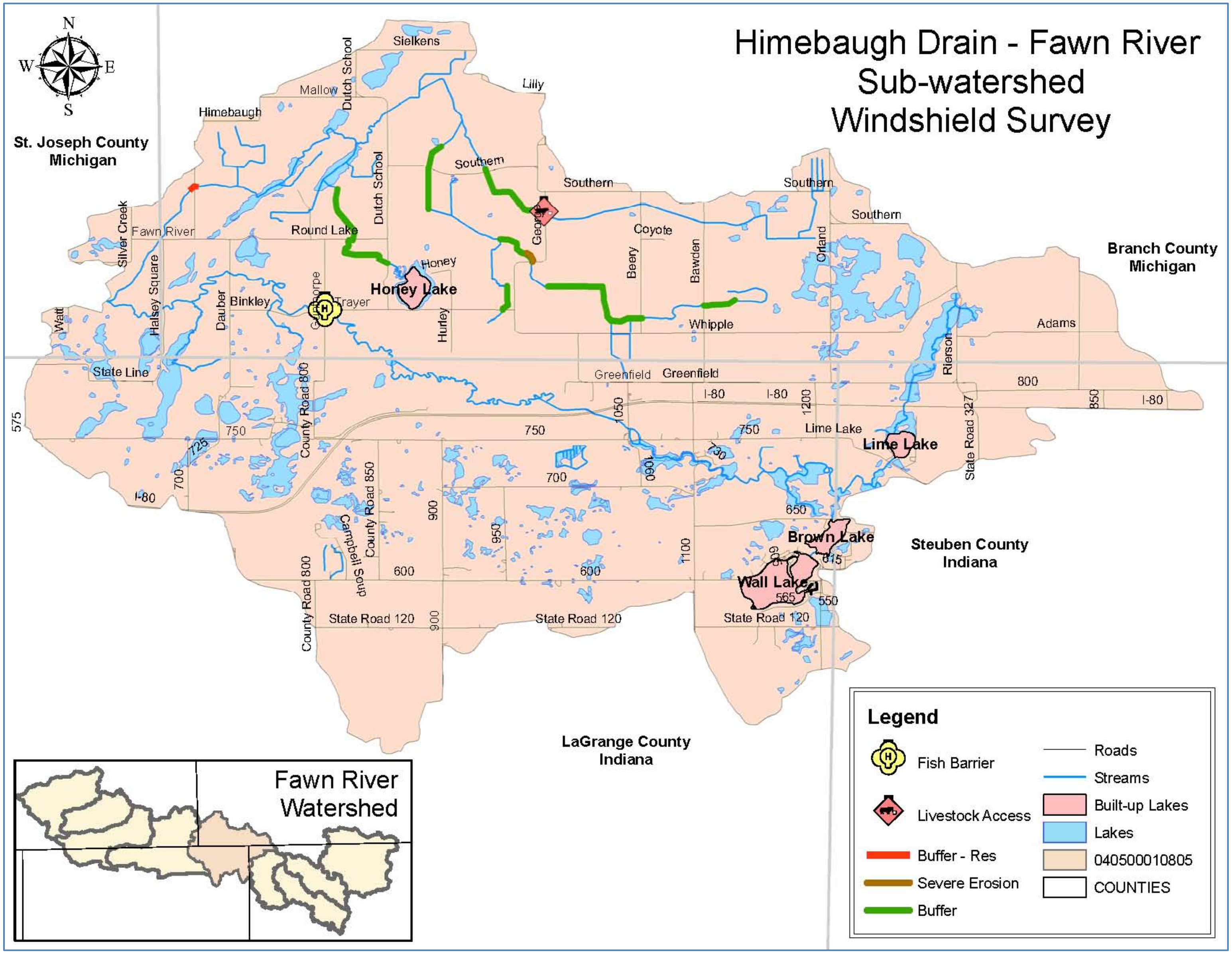
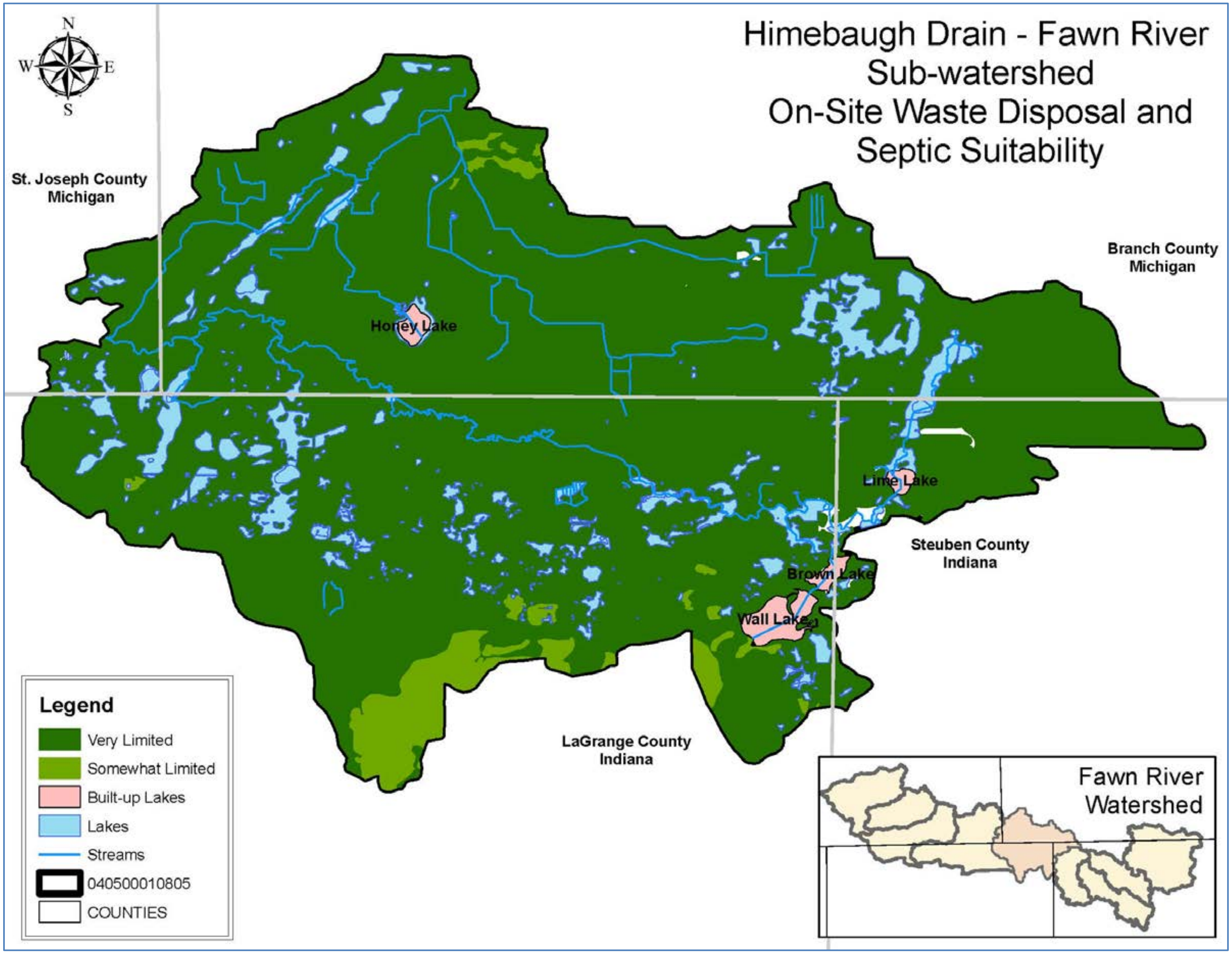


Figure 3.37: Septic Suitability in the Himebaugh Drain Sub-watershed



As stated above, most of the land in the Himebaugh Drain sub-watershed is used for agriculture; either cultivated crops or pasture and hayland. Approximately 17% of the land in the sub-watershed is designated as highly or potentially highly erodible by the respective county's NRCS. This percentage is not as significant as it is in other sub-watersheds. However, there is still potential for sediment, carrying nutrients attached to the soil particles, from HEL that is being conventionally tilled, or farmed directly up to the streambank to deposit in open water. Special precautions must be taken on farmland in this sub-watershed that is designated as HEL or PHEL to prevent soil erosion, and sedimentation and nutrification of open water. Figure 3.38 shows the location of HEL and PHEL in the watershed, overlaid on the agriculture land to paint a picture of where there is a risk of soil erosion.

The Himebaugh Drain sub-watershed has a significant amount of land cover designated as wetland: over 17%. According to the 2005 wetland inventory conducted by MDEQ and partners, the Himebaugh Drain sub-watershed currently has 3600.78 acres of wetland from the 5939.65 acres of wetland present in pre-settlement times. This is nearly a 39% decline in the wetlands since settlement of the area. The loss in wetlands translates to a huge loss in the ability of the wetlands to absorb pollutants prior to them being released into open water and in prime habitat for fauna that relies on wetlands for survival. According to data collected in 2005, there has been a water quality functional use loss of 42% and a habitat functional use loss of 44% in the HImebaugh Drain sub-watershed; much greater of a loss than the previous sub-watershed. Figure 3.39 shows the wetland delineation for the historic and current wetlands in the Himebaugh Drain sub-watershed.

Figure 3.38: Highly and Potentially Highly Erodible Land in Himebaugh Drain Sub-watershed

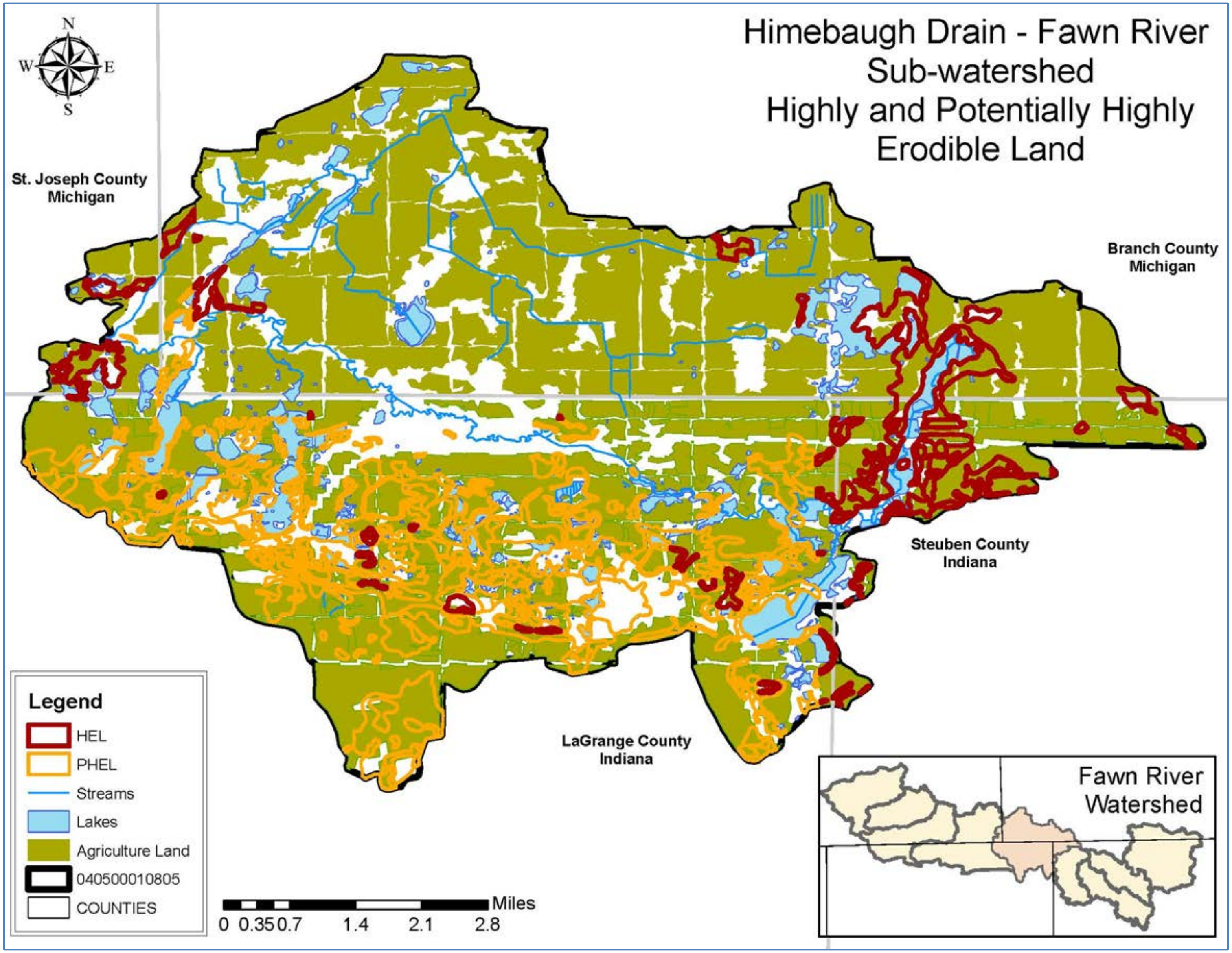
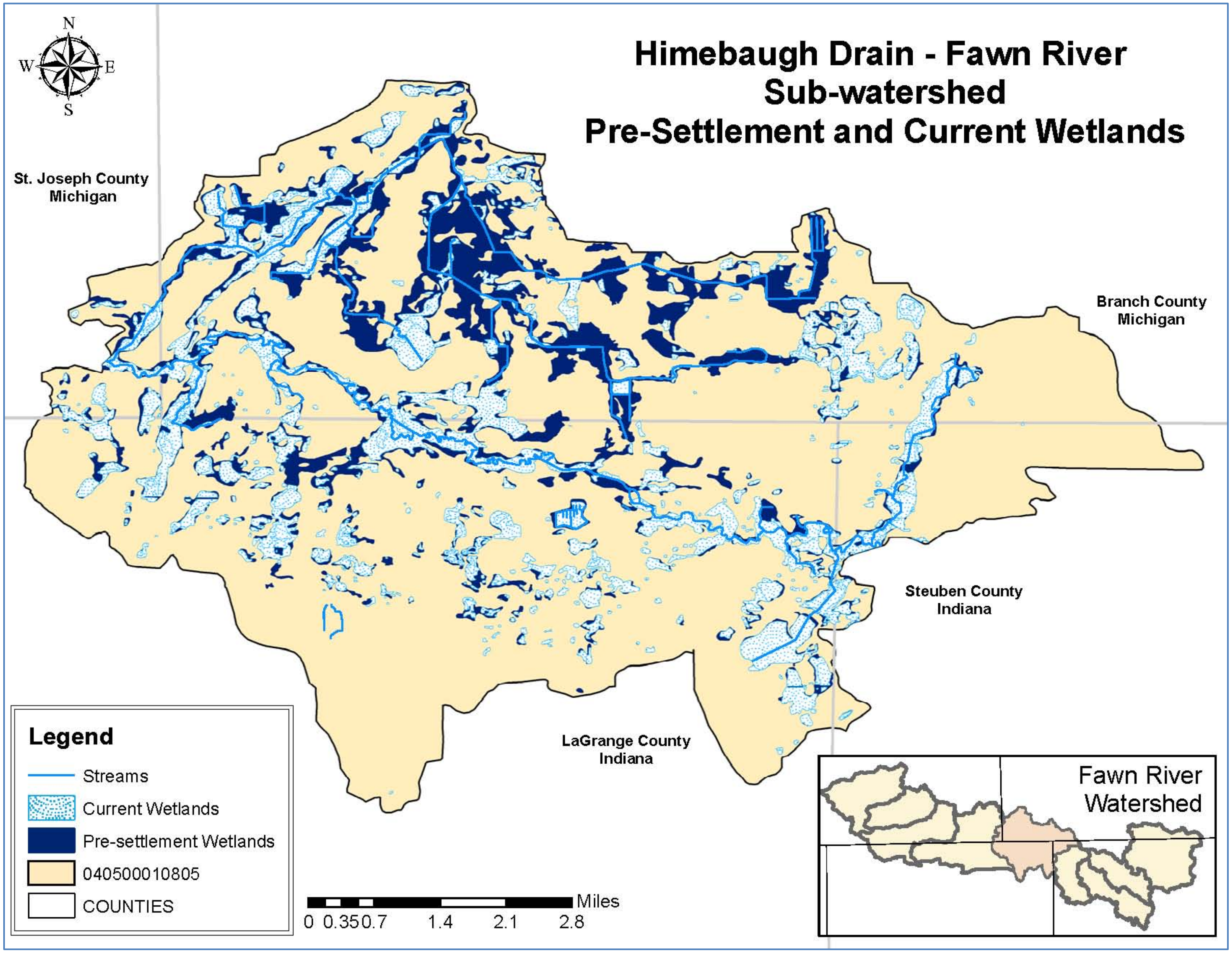


Figure 3.39: Wetlands in Himebaugh Drain Sub-watershed



A final threat to water quality found during the inventory of Himebaugh Drain sub-watershed is potential point sources of pollution. There are not any NPDES permitted facilities located within this sub-watershed. However, there are two USTs located within the Himebaugh Drain sub-watershed. While USTs do not pose an immediate threat to water resources, they do run the risk of leaking if not properly inspected and maintained. Of the two USTs located within this sub-watershed one of them is considered to be a LUST by IDEM and it is considered to be a medium priority for remediation. Table 3.4.13 lists the information about the LUST located in the Himebaugh Drain sub-watershed.

Table 3.4.13: Leaking Underground Storage Tank in the Himebaugh Drain Sub-waterhsed

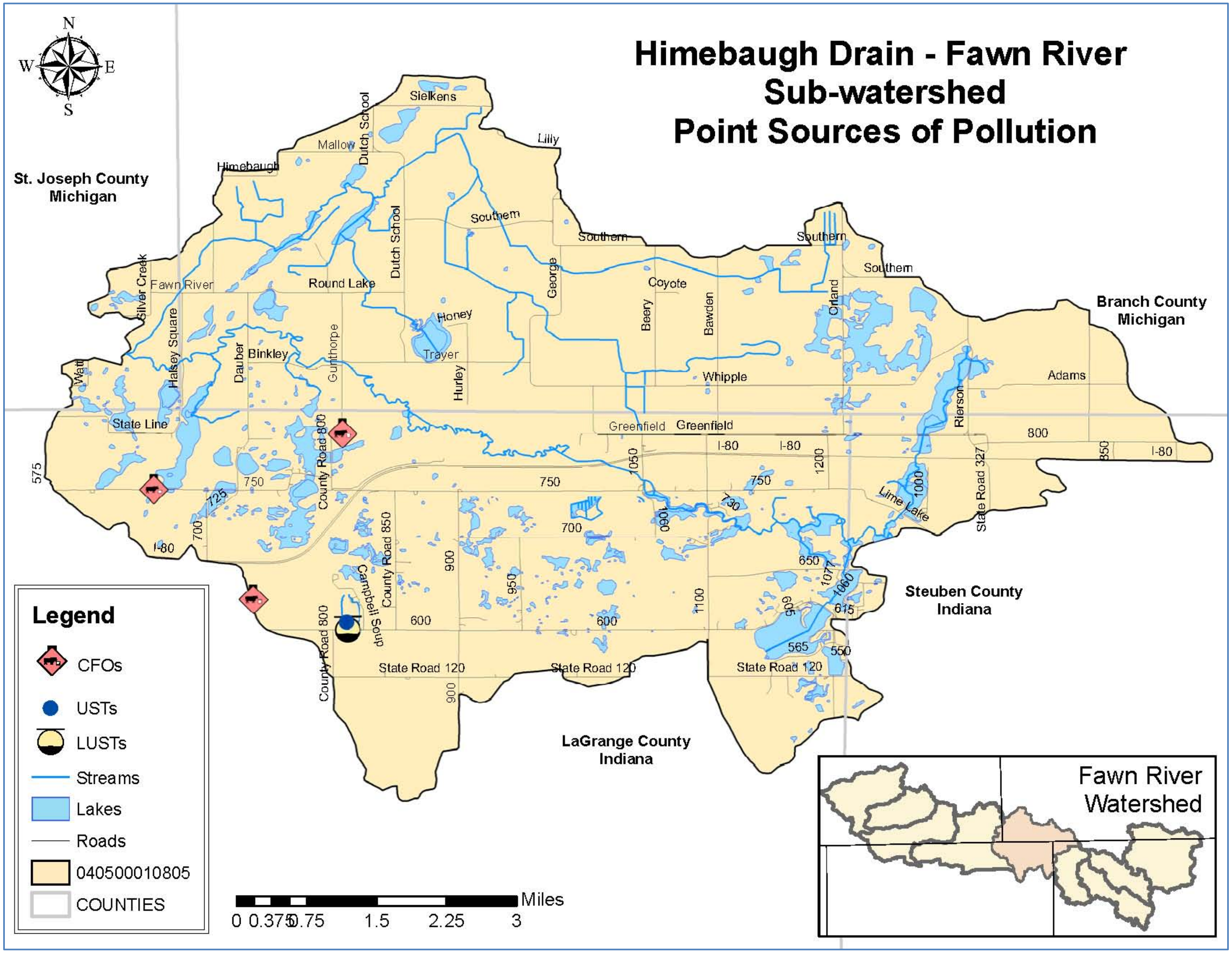
UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
16869	199004525	Campbell's Mushroom's, Inc.	Medium	Active	Soil
	199004525		Medium	Active	Groundwater

Three confined feeding operations can be found in the Himebaugh Drain Sub-watershed; all in LaGrange County, IN and all are swine operations. CFOs present a potential problem due to the volume of manure produced at the facility. If the manure holding facility is not large enough, or is not properly maintained, there is the potential for manure to discharge from the holding facility and potentially contaminate surface and/or groundwater. They also pose a threat if the manure is being land applied as fertilizer and soil tests to determine the proper amount of manure needed for plant uptake are not performed; manure may be applied to the land in excess. Two of the CFOs are relatively close to a wetland area. Michael Fanning Farms is located approximately 300 feet from a wetland that is connected to a tributary of the Fawn River and Contract Pork is located approximately 600 feet from a stand-alone wetland. Table 3.4.14 lists the three CFOs located within the Himebaugh Drain sub-watershed and Figure 3.40 shows the location of the potential point sources of pollution in the sub-watershed.

Table 3.4.14: Confined Feeding Operations in the Himebaugh Drain Sub-watershed

Operation Name	County	Sub-watershed	Program	Animal Type	Animal #
Laurent D Jennings	Lagrange	Himebaugh Drain	CFO	Swine/Beef Cattle	2300/25
Contract Pork	Lagrange	Himebaugh Drain	CFO	Swine	6000
Michael Fanning Farms	Lagrange	Himebaugh Drain	CFO	Swine	1430

Figure 3.40: Point Sources of Pollution in Himebaugh Drain Sub-watershed



Water quality data collected in the Himebaugh Drain sub-watershed indicates a significant pollution issue with phosphorus and nitrates, and to a lesser degree *E. coli*. An analysis of all the samples collected in the Himebaugh Drain sub-watershed shows that nitrates exceeded the target level in 74% of the samples, phosphorus in 57% of the samples, and *E. coli* exceeded the state standard in 13% of the samples collected. The high nutrients and *E. coli* levels may be due to leaking septic systems as only 4% of the land is designated suitable for septic placement and none of the residents in this sub-watershed have access to a centralized sewer system at this time. The high nutrients and *E. coli* levels may also be due to runoff of fertilizer from turf lawns around the built-up lakes, and agriculture fields that do not utilize conservation tillage, nutrient management, or riparian buffers. The windshield survey revealed that there is over 24,000 linear feet of streambank with no riparian buffer in place. There was also one site where livestock were seen in the stream during the windshield survey. The livestock at that site pose a significant risk to water quality by contributing sediment, bacteria, and nutrients directly to the stream. Finally, the destruction of wetlands that can efficiently filter pollutants from water may also be contributing to the high nutrient levels as the Himebaugh Drain sub-watershed has a wetland functional use loss for water quality benefits of 42%.

The biological data collected by the MDEQ at this site indicates that the habitat is moderately impaired, which may be due to the wetland functional use loss for habitat of 44%, and also the lack of riparian buffer used in the Himebaugh Drain sub-watershed.

Specific water quality problems that can be tied to the windshield survey are that the FRP's site 23 collects water that flows through Wall and Brown Lakes, both of which are built-up and the residents utilize on-site waste disposal. Site 23 samples exceeded the target level for nitrates and phosphorus in 100% of the samples. The FRP's site 28 exceeded the target level for phosphorus in 100% of the samples, nitrates exceeded the target level in 75% of the samples, and *E. coli* exceeded the state standard in 42% of the samples. This may be a results of the sites observed during the windshield survey, upstream of site 28 that lacked a riparian buffer, as well as the site where livestock have direct access to open water, also upstream of Site 28.

A variety of best management practices and management measures that could benefit the water quality in the Himebaugh sub-watershed are available. Some of those practices include conservation tillage, cover crops, riparian and shoreline buffer installation adjacent to residential and agriculture land, nutrient management, wetland restoration, septic system education and livestock exclusion from open water.

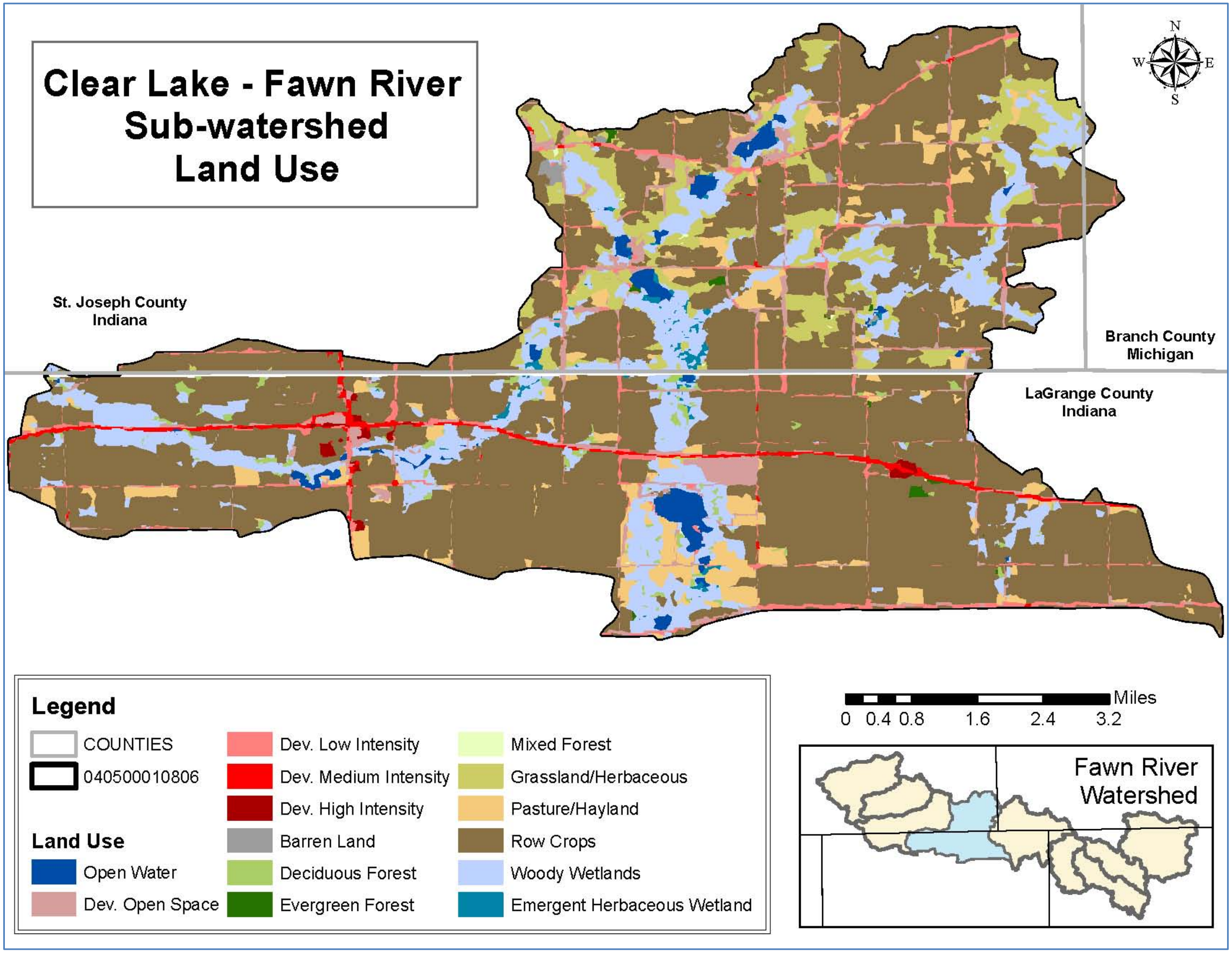
3.4.6 Clear Lake – Fawn River Sub-watershed Land Use

The primary influence on water quality in the Clear Lake Sub-watershed is agriculture as over 70% of the drainage area is in row crops or pasture and hayland. Unsewered homes in the rural areas of this sub-watershed also have a major influence on the water quality within the Clear Lake sub-watershed. There are no large populated areas located within the Clear Lake sub-watershed, however over 8% of the watershed is considered to be developed mainly because I-80 runs through this watershed, as well as the US-12 which is a major road, though less traveled than I-80. There are also three built-up lakes located in the Clear Lake sub-watershed, including Cedar Lake (the largest of the three), Williams Lake and Sweet Lake; none of which are connected to a centralized sewer system. Table 3.4.15 shows the percentage of the Clear Lake Sub-watershed that is in each land use and Figure 3.41 is a map showing the delineation of land use in the sub-watershed. All landuse data presented was obtained from the National Land Cover Data from the USGS and analyzed in ArcGIS.

Table 3.4.15: Land Use in the Clear Lake Sub-watershed

NLCD Land Use Designation	Acres	%
Open Water	413.74	1.28%
Developed Open Space	1204.93	3.73%
Developed Low Intensity	1110.84	3.44%
Developed Medium Insensity	315.58	0.98%
Developed High Intensity	79.11	0.24%
Barren Land	59.59	0.18%
Deciduous Forest	2018.14	6.25%
Evergreen Forest	55.96	0.17%
Shrub/Scrub	17.22	0.05%
Mixed Forest	21.19	0.07%
Grassland Herbaceous	78.62	0.24%
Pasture Hayland	1449.01	4.48%
Row Crops	21840.32	67.60%
Woody Wetland	3473.87	10.75%
Emergent Herbaceous Wetlands	171.31	0.53%
Total	32,309.43	100.00%

Figure 3.41: Clear Lake – Fawn River Sub-watershed Land Use Designations



The windshield survey conducted as part of this project in May, 2014 revealed some common concerns scattered throughout the Clear Lake sub-watershed including agriculture land that lacks a riparian buffer along open water, sea walls constructed along the lakes in the watershed, and lush green lawns adjacent to open water, indicating fertilizer use in areas that lack adequate riparian and shoreline buffers. However, there were three locations where more specific issues were observed. There was one site where there was zero riparian buffer present adjacent to a residential property, and slight erosion of the streambank was observed at the site as well. The total length of the streambank needing a riparian buffer in the (verified through a desktop survey) is 743 linear feet. Two sites were identified as possibly having pasture runoff. One site on CR 250 has livestock in a pasture that frequently floods allowing for animal waste to wash into the adjacent stream during the floodwater recession back into the stream banks. The other location is on CR 600 near Duff Lake where cattle are in pasture directly adjacent to tributaries to Duff Lake. It appears the livestock are fenced out of the stream, however there is a high potential that animal waste will run directly into the stream due to the pasture's proximity to the stream and the lack of riparian buffer. Table 3.4.16 lists the observations made during the survey, and the approximate length of the problem. Figure 3.42 shows the location of each of the issues discovered during the windshield survey, as well as the populated lakes where seawalls and excessive fertilizer application may be used.

Table 3.4.16: Windshield Survey Observations in the Clear Lake – Fawn River Sub-watershed

Windshield Survey Observation	Potential Contaminant	Number or Length
Pasture Runoff	*E. coli*, Sediment and Nutrients	2
Lack of Riparian Buffer - Res	Sediment and Nutrients	743 linear ft

Another potential problem related to residential homes in the Clear Lake sub-watershed is the areas that are not currently serviced by a centralized sewer system. These homes most likely utilize an on-site waste disposal system that has the potential to leak or fail if not properly maintained. As is illustrated in Figure 3.43, over 93% of the sub-watershed's soils are designated as being very limited for septic system placement and there are no areas of the sub-watershed that is serviced by a centralized sewer system, including the three populated lakes in the sub-watershed.

Figure 3.42: Windshield Survey Observations in the Clear Lake Sub-watershed

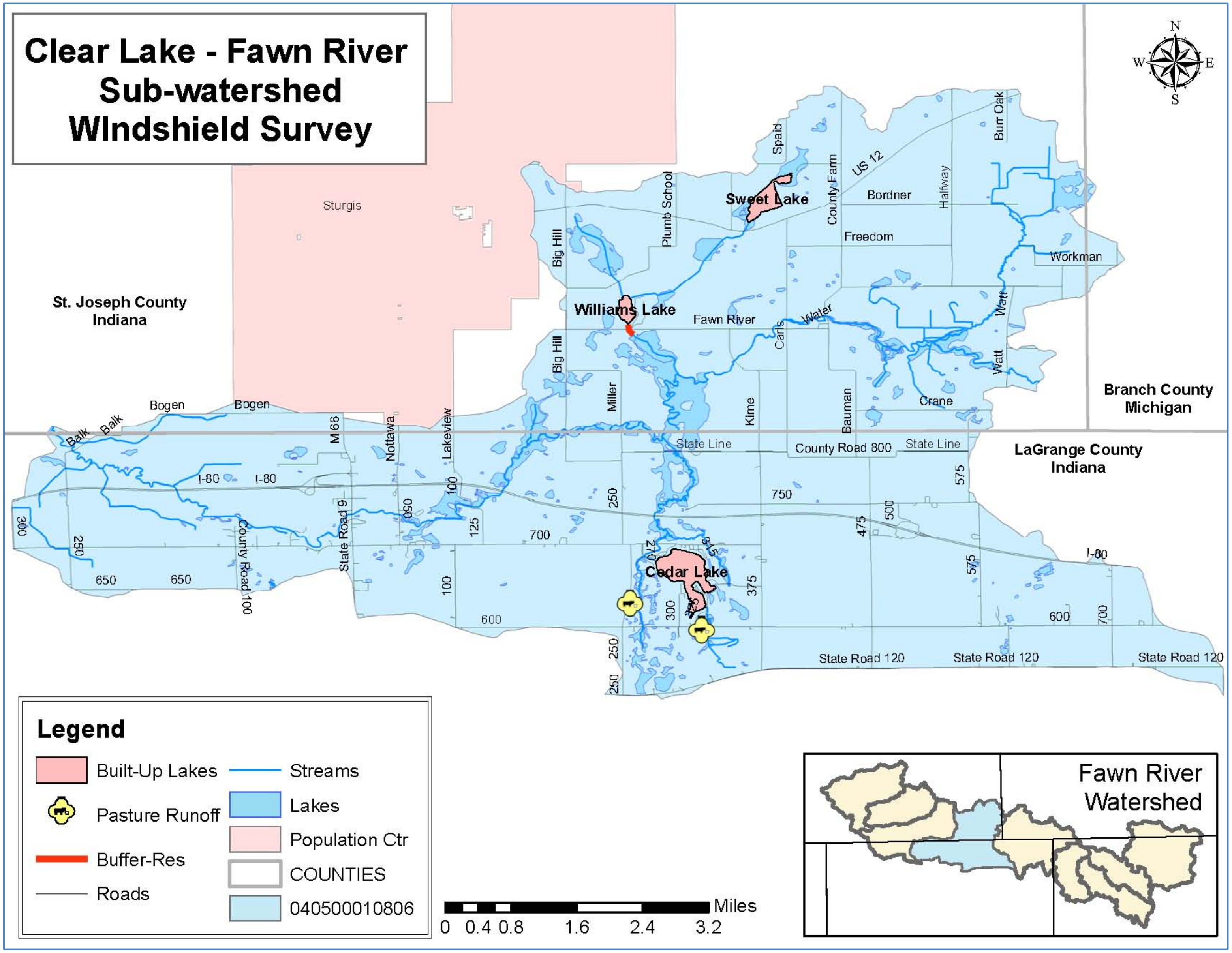
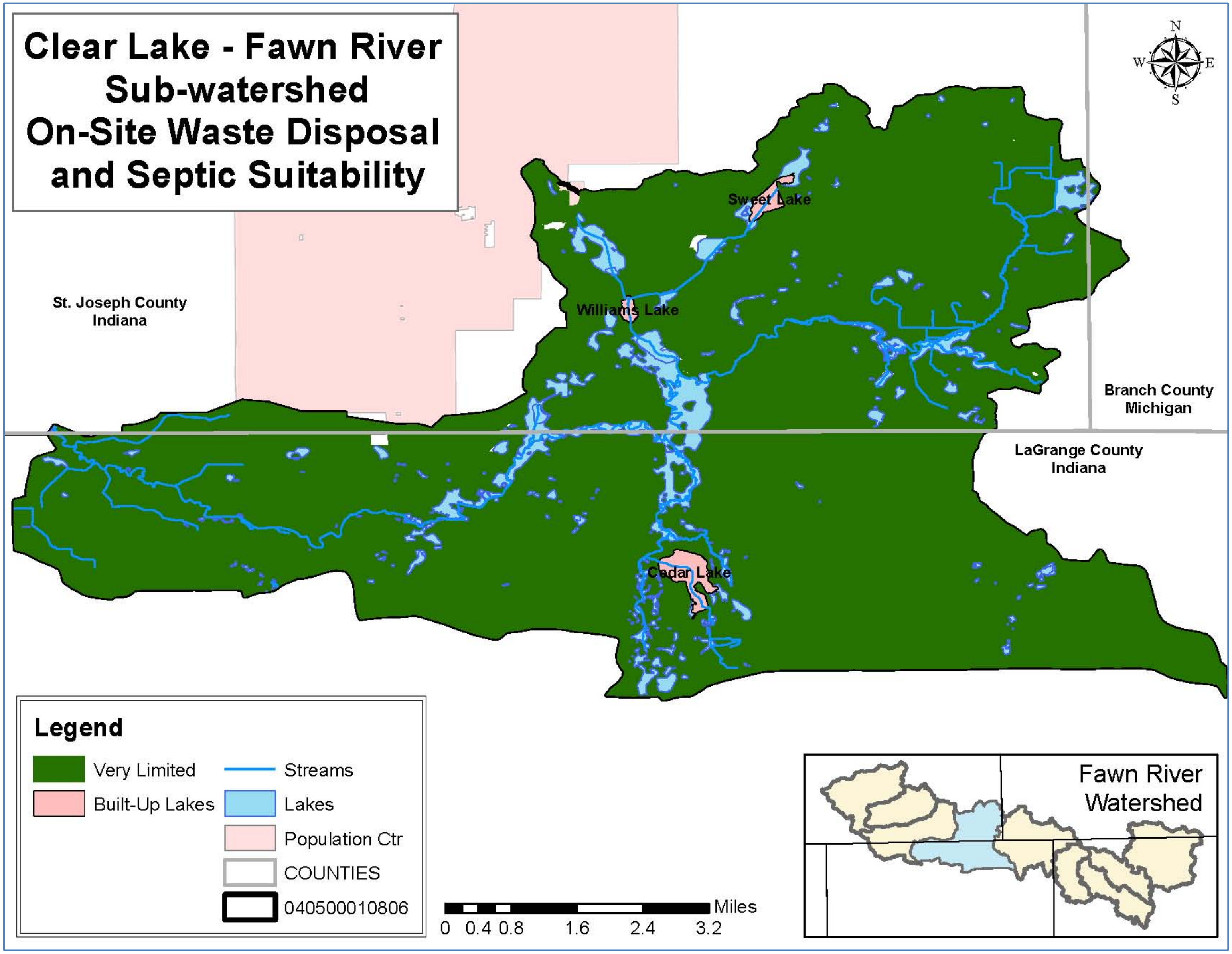


Figure 3.43: Septic Suitability in the Clear Lake Sub-watershed



As stated above, most of the land in the Clear Lake sub-watershed is used for agriculture; either cultivated crops or pasture and hayland. Approximately 16% of the land in the sub-watershed is designated as highly or potentially highly erodible by the respective county's NRCS. This percentage is not as significant as it is in other sub-watersheds. However, there is still potential for sediment, carrying nutrients attached to the soil particles, from HEL that is being conventionally tilled, or farmed directly up to the streambank to deposit in open water. Special precautions must be taken on farmland in this sub-watershed that is designated as HEL or PHEL to prevent soil erosion, and sedimentation and nutrification of open water. Figure 3.44 shows the location of HEL and PHEL in the watershed, overlaid on the agriculture land to paint a picture of where there is a risk of soil erosion.

The Clear Lake sub-watershed has approximately 11% of land cover designated as wetland. According to the 2005 wetland inventory conducted by MDEQ and partners, the Clear Lake sub-watershed currently has 3,080.12 acres of wetland from the 5840.12 acres of wetland present in pre-settlement times. This is over a 47% decline in the wetlands since settlement of the area. The loss in wetlands translates to a huge loss in the ability of the wetlands to absorb pollutants prior to them being released into open water and in prime habitat for fauna that relies on wetlands for survival. According to data collected in 2005, there has been a water quality functional use loss of 47% and a habitat functional use loss of 53% in the Clear Lake sub-watershed; much greater of a loss than the previous sub-watersheds. Since only 11% of the watershed is classified as wetland, it is important to protect the existing wetlands, to prevent further loss in the ability of the land cover to absorb pollutants and provide habitat to important flora and fauna. Figure 3.45 shows the wetland delineation for the historic and current wetlands in the Clear Lake sub-watershed.

Figure 3.44: Highly and Potentially Highly Erodible Land in the Clear Lake Sub-watershed

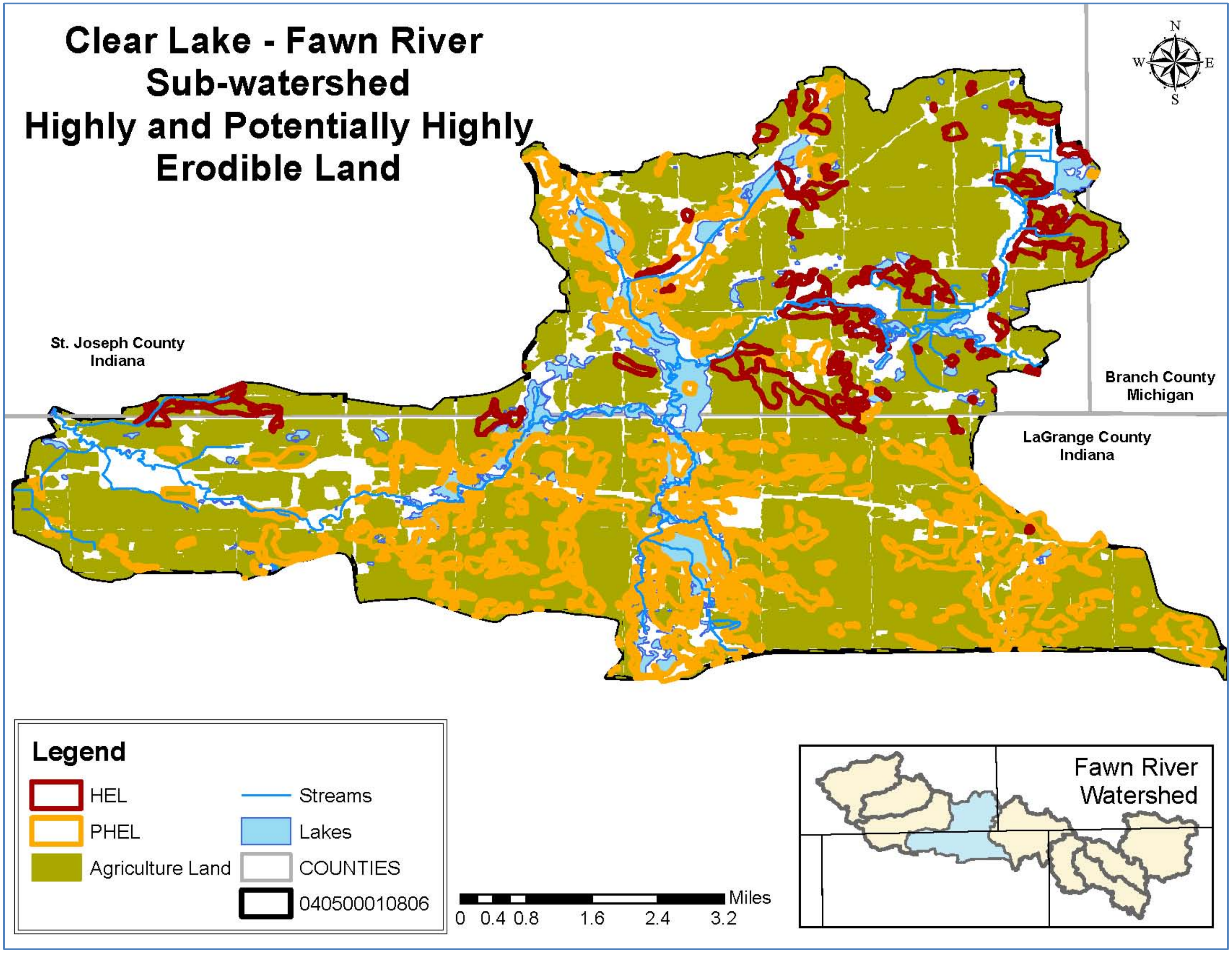
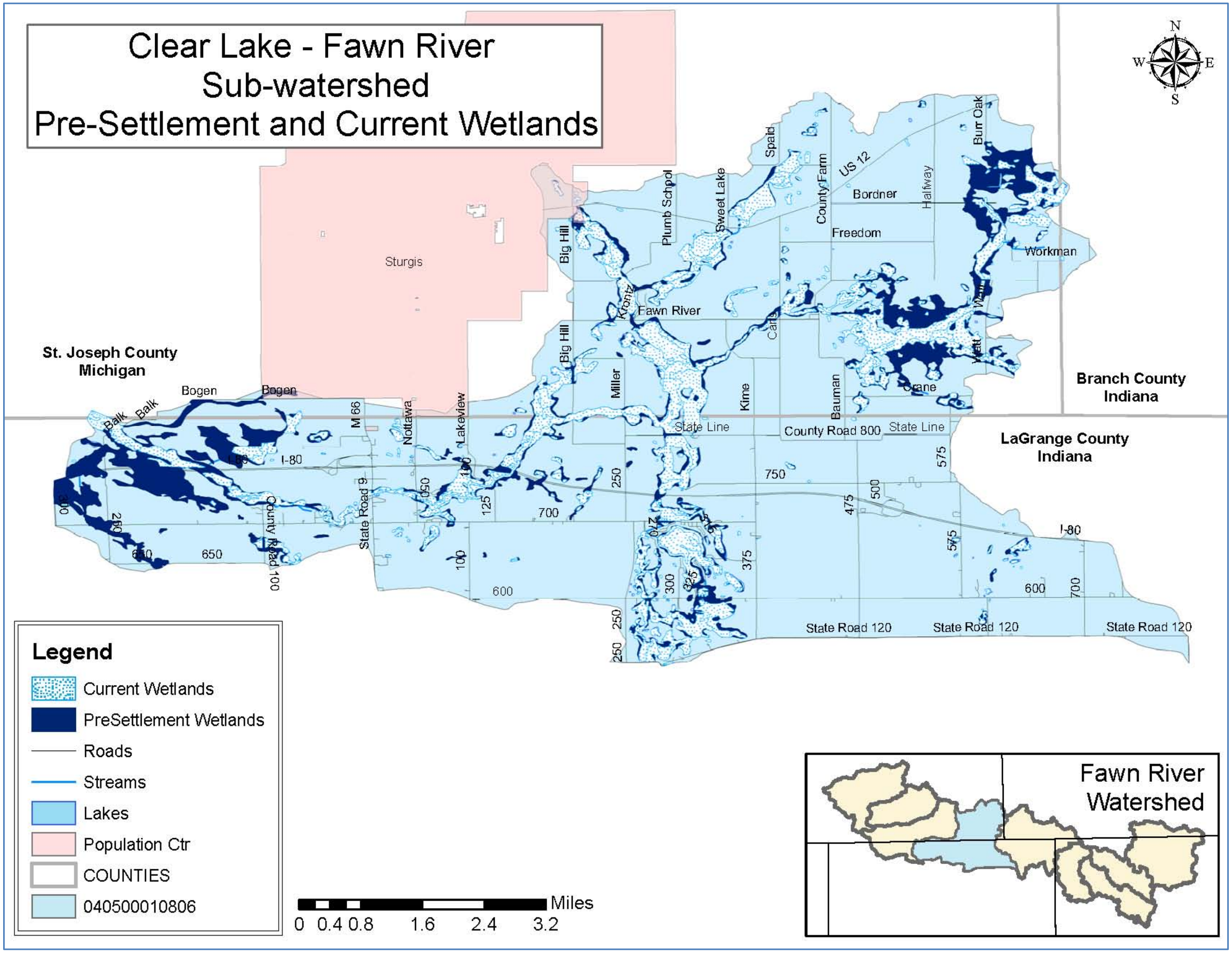


Figure 3.45: Current and Pre-Settlement Wetlands in the Clear Lake Sub-watershed



A final threat to water quality found during the inventory of Clear Lake sub-watershed is potential point sources of pollution. There are two NPDES permitted facilities located within this sub-watershed, however one of the facilities drains into the Pigeon River Watershed and is highlighted in yellow in Table 3.4.17 below. There are four USTs located within the Clear Lake sub-watershed. While USTs do not pose an immediate threat to water resources, they do run the risk of leaking if not properly inspected and maintained. Of the three USTs located within this sub-watershed three of them are considered to be a LUST by IDEM and while the one located in Michigan does not have its priority level listed, those located in Indiana are all considered to be a high priority for remediation. Table 3.4.18 lists the information about the LUSTs located in the Clear Lake sub-watershed.

Table 3.4.17: NPDES Permitted Facilities in the Clear Lake Sub-watershed

Permit Name	Permit #	Receiving Water Body Name	Qrts in Non-compliance (3 yrs)	Qtrs in Significant Non-compliance (3 yrs)	Pollutant Causing Non-compliance	Pollutant with Significant violations	Enforcement Actions (I=informal; F=formal) (5 yrs)
Sturgis-Big Hill Rd LF	MI0047716	Moe Drain	0	0	N/A	N/A	N/A
Travel Plaza - Ernie Pyle	IN0050300	Pigeon River via Unnamed Trib	2	0	non-RNCV		0

Table 3.4.18: Leaking Underground Storage Tanks in the Clear Lake Sub-watershed

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
3837	200204502	Amoco Ss 30969 / Travel Plaza 7 South	High	Active	Groundwater
	200204502		High	Active	Free Product
	200204502		High	Active	Soil
	200204502		High	Active	MTBE
3836	199912534	BP-Ernie Pyle/Travel Plaza 7 North	High	Active	Soil
	199912534		High	Active	MTBE
	199912534		High	Active	Groundwater
	199912534		High	Active	Free Product
	200411509		N/A	Deactivated (no release confirmed)	Unknown
000-08736	C-1152-98	J & M Service Center	Unknown	Unknown	Unknown

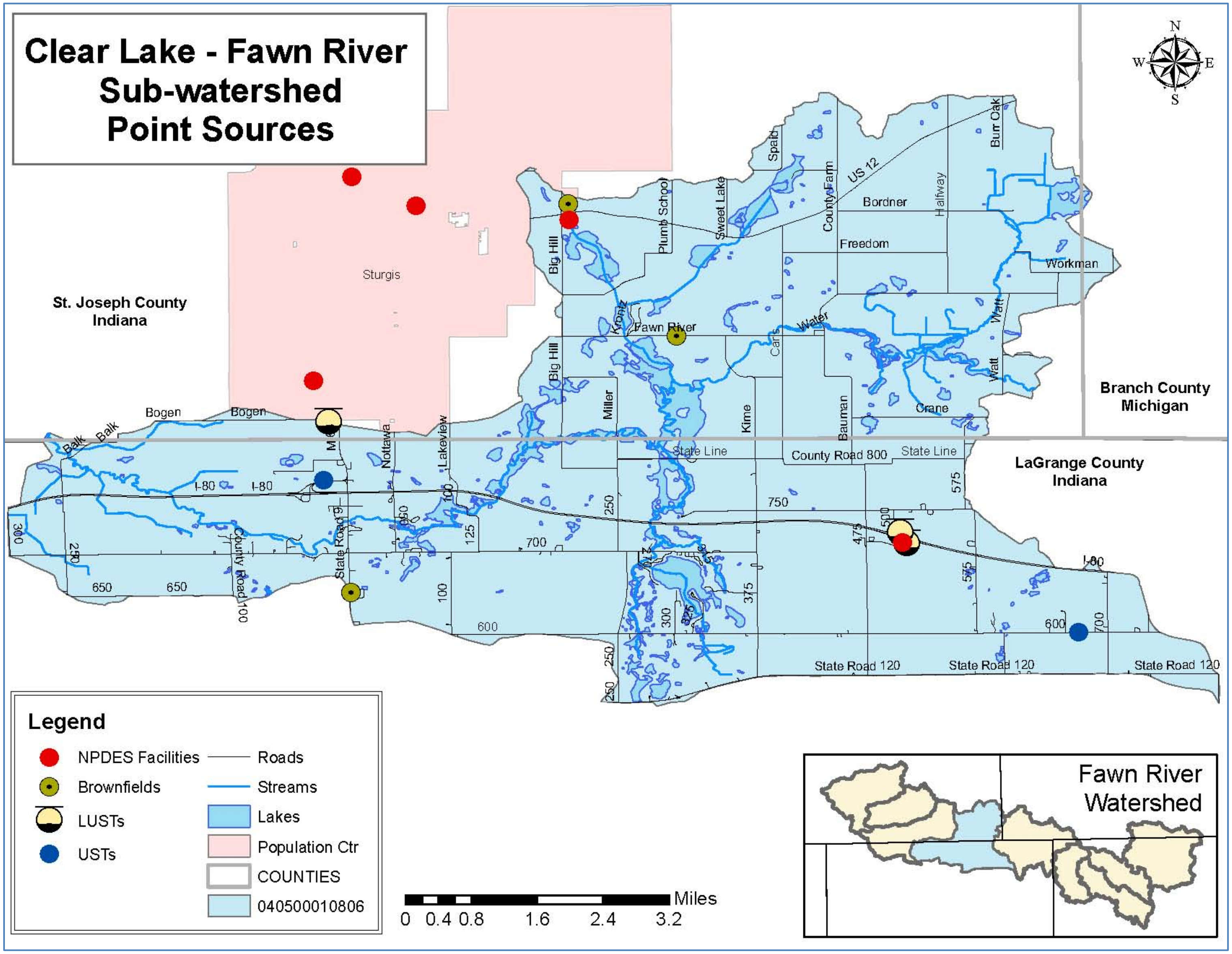
There are three sites in the Clear lake sub-watershed that are potential Brownfield sites and should be examined closer to determine if the sites are contaminated. Since these sites are listed as potential brownfields, they are eligible for funding to do further studies on the properties to determine the correct remediation work that needs to be completed to make the sites useful for other purposes while remediating any potential contamination from the site. Table 3.4.19 lists the three Brownfield sites located within the Clear Lake sub-watershed.

Figure 3.46 shows the location of all the potential point sources of pollution in the Clear lake sub-watershed.

Table 3.4.19: Brownfield Eligible Sites in the Clear Lake Sub-watershed

Name	Address	City	County
Fawn River Road Drums	30390 Fawn River Rd	Sturgis	St. Joseph
Sturgis City of LF (WWTP)	Big Hill Road 70250 S. Treatment Plant Rd	Sturgis	St. Joseph
Multiplex Incorporated	6505 N SR 9	Howe	LaGrange

Figure 3.46: Potential Point Sources of Pollution in the Clear Lake Sub-watershed



Water quality data collected in the Clear Lake sub-watershed indicates a significant pollution issue with phosphorus and nitrates, and to a lesser degree *E. coli*. An analysis of all the samples collected in the sub-watershed shows that nitrates exceeded the target level in 49% of the samples, phosphorus in 54% of the samples, and *E. coli* exceeded the state standard in 19% of the samples collected. The high nutrients and *E. coli* levels may be due to leaking septic systems as only 7% of the land is designated suitable for septic placement and none of the residents in this sub-watershed have access to a centralized sewer system at this time. The high nutrients and *E. coli* levels may also be due to runoff of fertilizer from turf lawns around the built-up lake (Cedar Lake), and agriculture fields that do not utilize conservation tillage, nutrient management, or riparian buffers.

The windshield survey revealed that there is over 740 linear feet of streambank with no riparian buffer in place adjacent to residential properties, though a small riparian buffer was noted throughout the sub-watershed adjacent to agriculture land as well. It should also be noted that St. Joseph County has the highest use of irrigation for crop fields in the entire state of Michigan. The reliance on irrigation in the county was observed during the windshield survey where over half of the crop fields had irrigation equipment in the field. Irrigating crop fields without an irrigation management plan in place may pose a threat to water quality due to over use or improper timing of the irrigation. There were also two sites where livestock pose a threat due to the proximity of their pastures to open water sources. The livestock pose a significant risk to water quality by contributing sediment, bacteria, and nutrients directly to the stream through storm flow or when the pasture becomes flooded and the flood water recedes. Finally, the destruction of wetlands that can efficiently filter pollutants from water may also be contributing to the high nutrient levels as the Clear Lake sub-watershed has a wetland functional use loss for water quality benefits of 47%, and 53% for habitat.

Specific water quality problems that can be tied to the land use survey are that the pasture runoff issues are a significant problem as FRPs sites 37 and 38 both had 100% of the samples that were tested for phosphorus exceed the target level. Site 38 is directly adjacent to one of the pastures and that site's samples exceeded targets for nitrate in 92% of the samples and *E. coli* in 17% of the samples. Many of the sample sites in the Clear Lake sub-watershed had higher exceedances for *E. coli* than in other sub-watersheds that were examined, specifically FRP's sites 32, 39, and 41 where each exceeded the state standard for *E. coli* in 40% of the samples. This may be due to the number of homes utilizing on-site waste management systems that are improperly placed or leaking, the heavy use of irrigation on land that has had manure fertilizer application, livestock operation runoff, or improper manure application.

A variety of best management practices and management measures that could benefit the water quality in the Clear Lake sub-watershed are available. Some of those practices include conservation tillage, riparian and shoreline buffer installation adjacent to residential and agriculture land, nutrient management, wetland restoration, septic system education pasture management, and irrigation management.

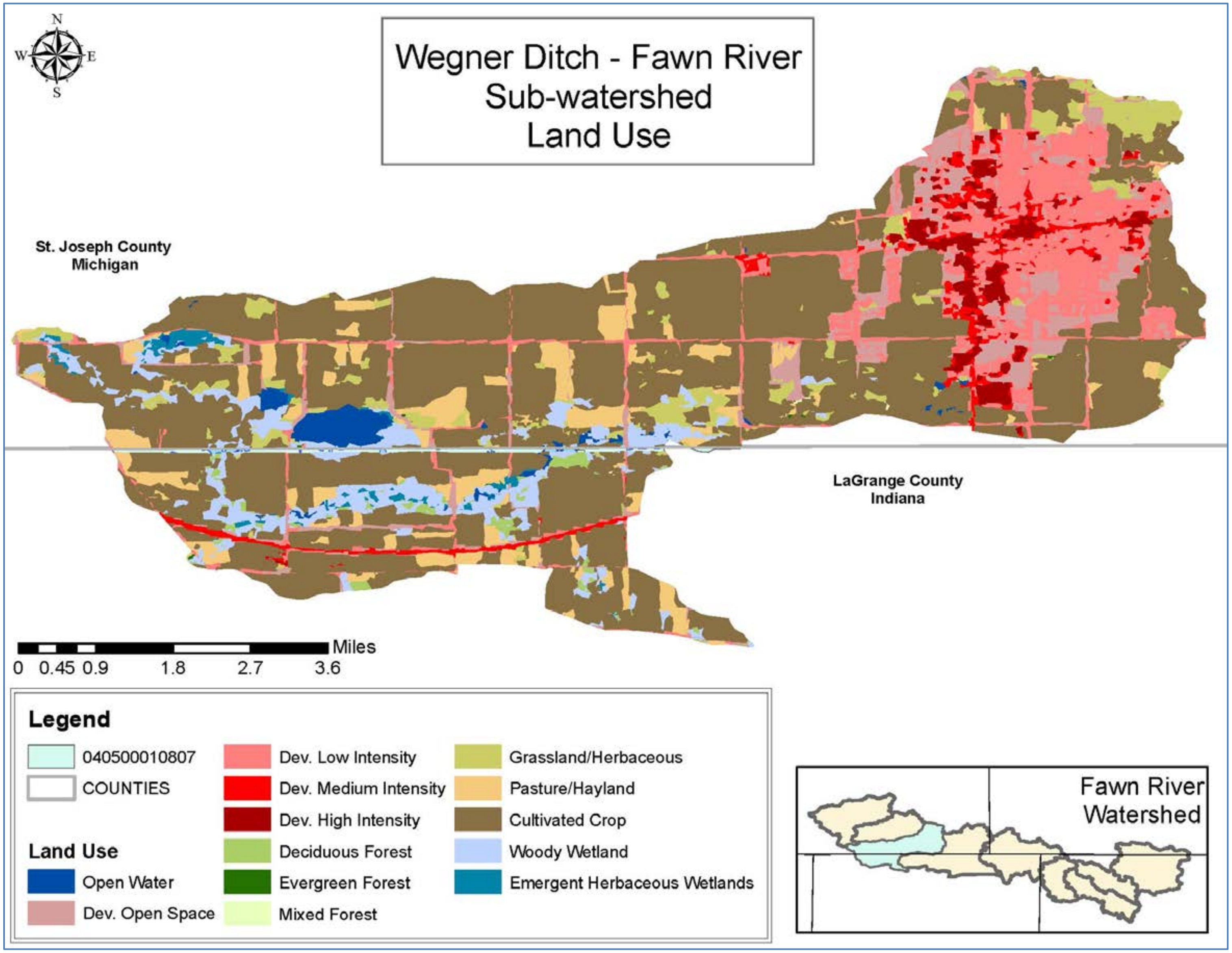
3.4.7 Wegner Ditch Sub-watershed Land Use

The primary influence on water quality in the Wegner Ditch Sub-watershed is agriculture as over 67% of the drainage area is in row crops or pasture and hayland. However, urban areas also have a significant influence on this sub-watershed as over 20% of the drainage area is considered to be developed, mostly as a result of the majority of the city of Sturgis being located within the sub-watershed boundaries, as well as the built-up Aldrich Lake. Unsewered homes in the rural areas of this sub-watershed have a major influence on the water quality within the Wegner Ditch sub-watershed as does the unsewered community of Aldrich Lake. Table 3.4.15 shows the percentage of the Clear Lake Sub-watershed that is in each land use and Figure 3.47 is a map showing the delineation of land use in the sub-watershed. All landuse data presented was obtained from the National Land Cover Data from the USGS and analyzed in ArcGIS.

Table 3.4.20: Land Use in the Wegner Ditch Sub-watershed

NLCD Land Use Designation	Acres	%
Open Water	281.37	1.13%
Developed Open Space	1588.84	6.39%
Developed Low Intensity	2340.95	9.42%
Developed Medium Insensity	612.48	2.46%
Developed High Intensity	451.97	1.82%
Barren Land	32.93	0.13%
Deciduous Forest	1236.37	4.98%
Evergreen Forest	10.84	0.04%
Shrub/Scrub	3.35	0.01%
Mixed Forest	6.64	0.03%
Grassland Herbaceous	62.63	0.25%
Pasture Hayland	1536.06	6.18%
Row Crops	15192.42	61.14%
Woody Wetland	1319.49	5.31%
Emergent Herbaceous Wetlands	171.07	0.69%
Total	24,847.41	100.00

Figure 3.47: Wegner Ditch Sub-watershed Land Use Designations



The windshield survey conducted as part of this project in May, 2014 revealed some common concerns scattered throughout the Wegner Ditch sub-watershed including agriculture land that lacks a riparian buffer along open water, sea walls constructed along the lakes in the watershed, and lush green lawns adjacent to open water, indicating fertilizer use in areas that lack adequate riparian and shoreline buffers. However, there were four locations where more specific issues were observed. There were three sites where there was zero riparian buffer present adjacent to agricultural land, and slight erosion of the streambank was observed at the sites as well. Two of the streams that lacked a buffer were also directly adjacent to I-80 so erosion may be more intense at those streams due to the runoff from the highway. The total length of the slightly eroded streambank needing a riparian buffer in the (verified through a desktop survey) is 3,177 linear feet. There were also two natural streams which run through the same agriculture field that have been tiled and no longer function as a natural stream. The tiled streams would benefit from daylighting as they are connected to a tributary of the Fawn River. The total length of the two streams that have been tiled is 10,977 linear feet. Table 3.4.21 lists the observations made during the survey, and the approximate length of the problem. Figure 3.48 shows the location of each of the issues discovered during the windshield survey, as well as the populated lake (Aldrich Lake) where seawalls and excessive fertilizer application may be used.

Table 3.4.21: Windshield Survey Observations in the Wegner Ditch Sub-watershed

Windshield Survey Observation	Potential Contaminant	Number or Length
Tiled Natural Stream in Row Crop Fields	Sediment and Nutrients	10,977 linear ft
Lack of Riparian Buffer - Ag.	Sediment and Nutrients	3,177 linear ft

Another potential problem related to residential homes in the Wegner Ditch sub-watershed is the areas that are not currently serviced by a centralized sewer system. These homes most likely utilize an on-site waste disposal system that has the potential to leak or fail if not properly maintained. As is illustrated in Figure 3.49, over 77% of the sub-watershed's soils are designated as being very limited for septic system placement. The City of Sturgis is serviced by a centralized sewer system, however the populated Aldrich Lake is not currently serviced and the residents most likely utilize on-site waste disposal systems

Figure 3.48: Windshield Survey Observations in the Wegner Ditch Sub-watershed

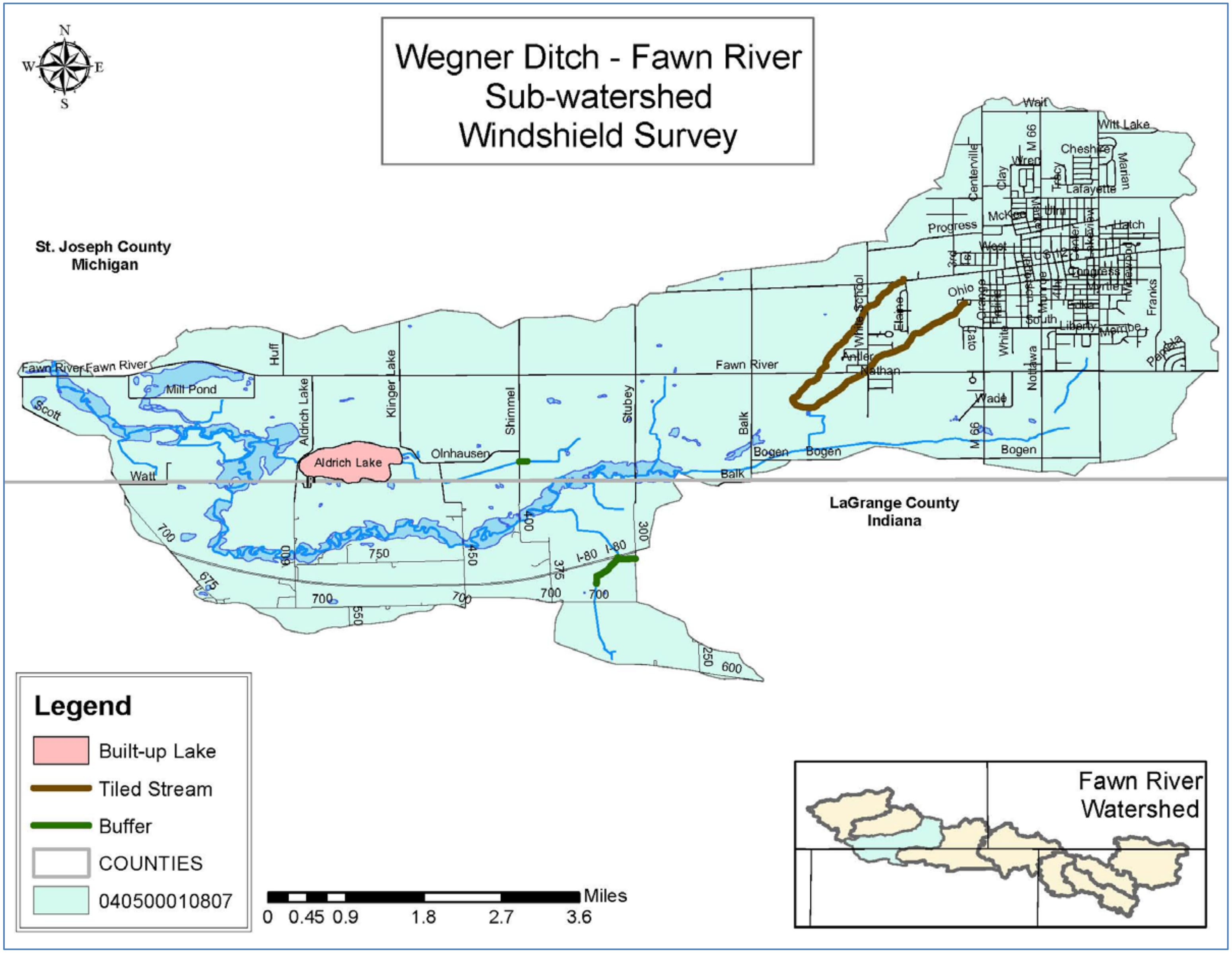
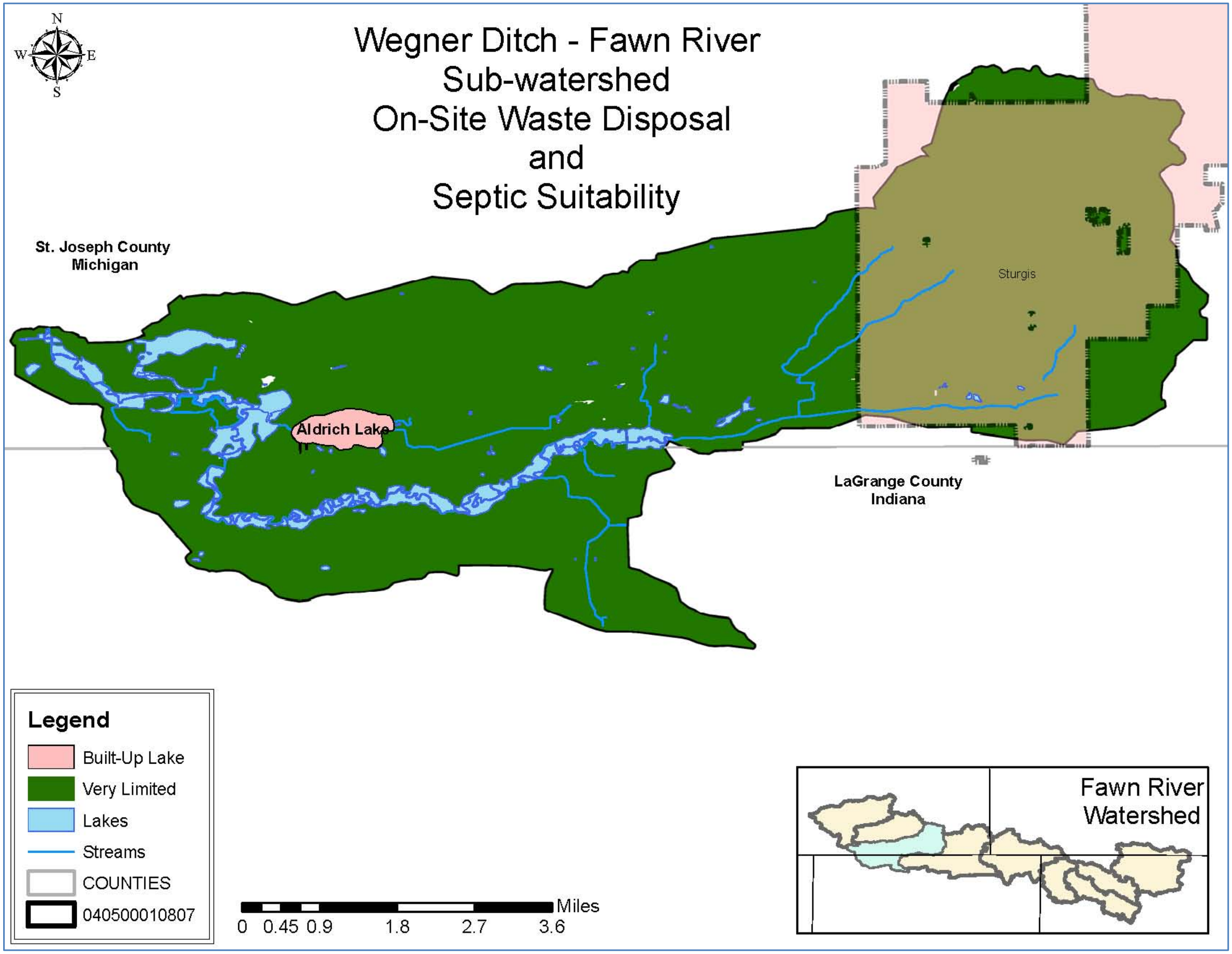


Figure 3.49: Septic Suitability in the Wegner Ditch Sub-watershed



As stated above, most of the land in the Wegner Ditch sub-watershed is used for agriculture; either cultivated crops or pasture and hayland. Approximately 12% of the land in the sub-watershed is designated as highly or potentially highly erodible by the respective county's NRCS. This percentage is not as significant as it is in other sub-watersheds. However, there is still potential for sediment, carrying nutrients attached to the soil particles, from HEL that is being conventionally tilled, or farmed directly up to the streambank to deposit in open water. Special precautions must be taken on farmland in this sub-watershed that is designated as HEL or PHEL to prevent soil erosion, and sedimentation and nutrification of open water. Figure 3.50 shows the location of HEL and PHEL in the watershed, overlaid on the agriculture land to paint a picture of where there is a risk of soil erosion.

The Wegner Ditch sub-watershed has approximately 6% of land cover designated as wetland. According to the 2005 wetland inventory conducted by MDEQ and partners, the Wegner Ditch sub-watershed currently has 1,876.82 acres of wetland from the 3,158.6 acres of wetland present in pre-settlement times. This is over a 40% decline in the wetlands since settlement of the area. The loss in wetlands translates to a huge loss in the ability of the wetlands to absorb pollutants prior to them being released into open water and in prime habitat for fauna that relies on wetlands for survival. According to data collected in 2005, there has been a water quality functional use loss of 43% and a habitat functional use loss of 47% in the Wegner Ditch sub-watershed. Since only 6% of the watershed is currently classified as wetland, it is important to protect the existing wetlands, to prevent further loss in the ability of the land cover to absorb pollutants and provide habitat to important flora and fauna. Figure 3.51 shows the wetland delineation for the historic and current wetlands in the Wegner Ditch sub-watershed.

Figure 3.50: Highly and Potentially Highly Erodible Land in Wegner Ditch Sub-watershed

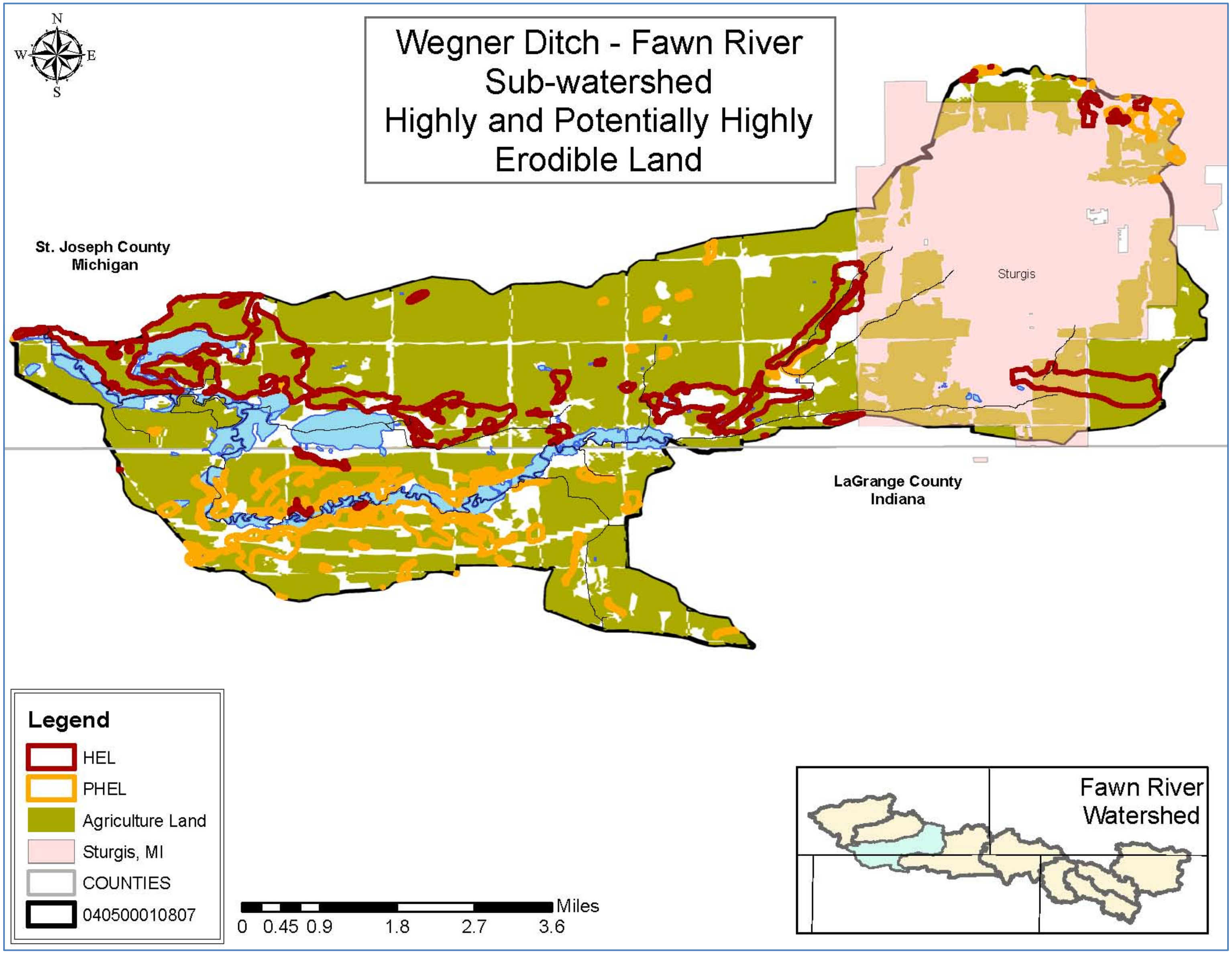
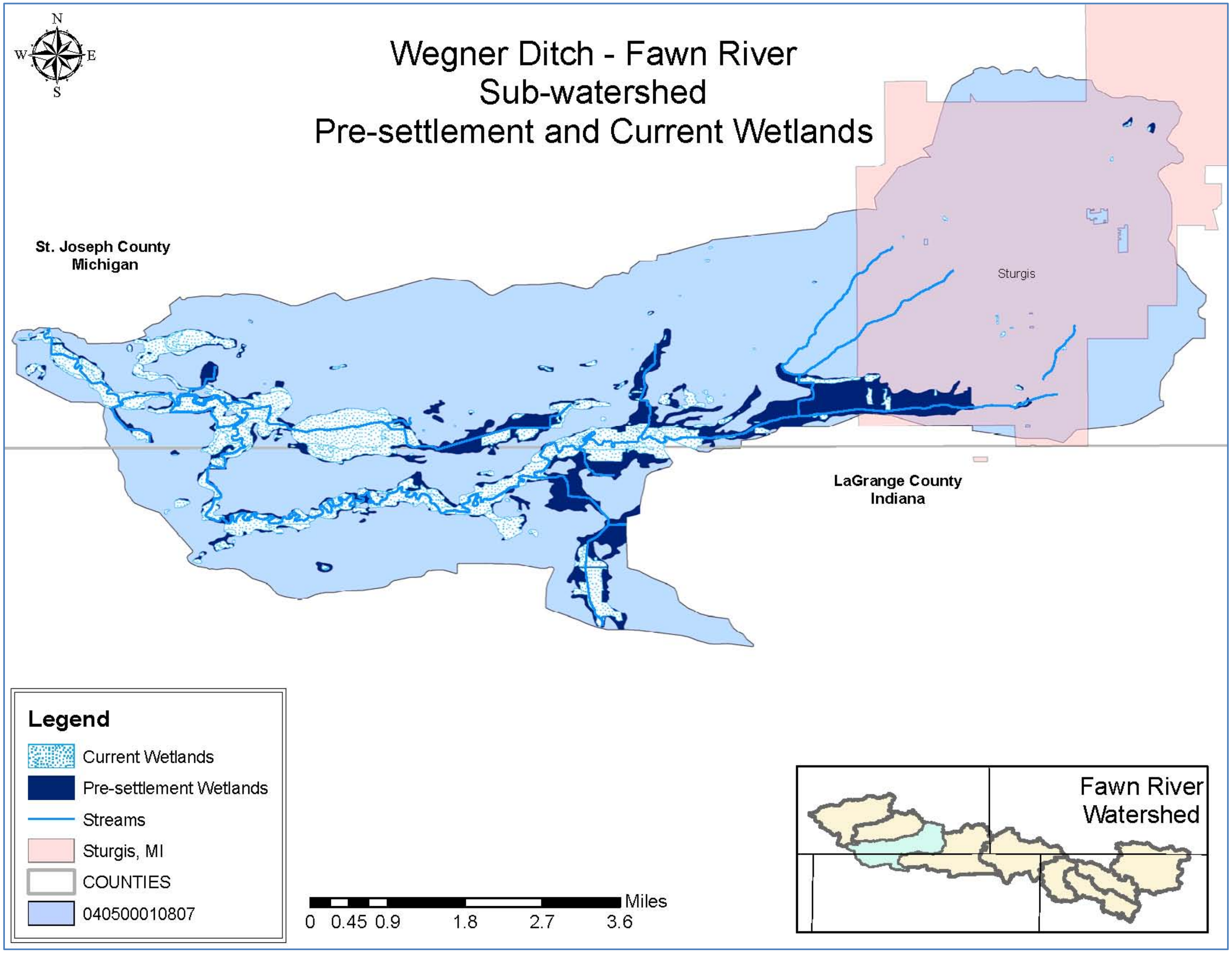


Figure 3.51: Current and Pre-Settlement Wetlands in the Wegner Ditch Sub-watershed



A final threat to water quality found during the inventory of Wegner Ditch sub-watershed is potential point sources of pollution. There are four NPDES permitted facilities located within this sub-watershed; three of which have been in non-compliance within the past 3 years, but none of them have been in significant con-compliance. Table 3.4.22 below lists the four NPDES permitted facilities.

Table 3.4.22: NPDES Permitted Facilities in the Wegner Ditch Sub-watershed

Permit Name	Permit #	Receiving Water Body Name	Qrts in Non-compliance (3 yrs)	Qtrs in Significant Non-compliance (3 yrs)	Pollutant Causing Non-compliance	Pollutant with Significant violations	Enforcement Actions (I=informal; F=formal) (5 yrs)
City of Sturgis WWTP	MI0020451	Fawn River	1	0	non-RNCV/C	N/A	0
Abbott Nutrition	MI0025313	Nye Drain	1 (RCRA) 0 (CWA)	0	Sulfuryl Flouride	N/A	I - 1
Sturgis Well Field - SF	MI0053465	Fawn River via Nye Drain	0	0	N/A	N/A	N/A
MI Milk Producers Assoc.	MI0001414	St. Joseph River	1	0	pH	N/A	0
non-RNCV = facility has effluent, compliance schedule, permit schedule, or single-event violations in the current quarter, however, is not considered to be in violation (https://echo.epa.gov/dfr_data_dictionary#compbyqtr); C = not considered in violation based on a manual review of data by State or EPA region.							

There are 48 USTs located within the Wegner Ditch sub-watershed. While USTs do not pose an immediate threat to water resources, they do run the risk of leaking if not properly inspected and maintained. Of the 48 USTs located within this sub-watershed seven of them are considered to be a LUST by IDEM and/or MDEQ. MDEQ does not prioritize the LUSTs as does IDEM, therefore only the one LUST located in Indiana is prioritized; it is considered to be a medium or low priority for remediation. Table 3.4.23 lists the information about the LUSTs located in the Clear Lake sub-watershed.

Table 3.4.23: Leaking Under Ground Storage Tanks in the Wegner Ditch Sub-watershed

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
3834	199105255	Lagrange Maintenance	Medium	NFA-Unconditional Closure	Soil
	199105255		Medium	NFA-Unconditional Closure	Groundwater
	199902544		Low	NFA-Unconditional Closure	Soil
000-13190	C-1285-98	Sturgis Iron and Metal Co. Inc./ Omni Source	Unknown	Unknown	Unknown
000-11932	C-0530-94	Consumers Concrete Corp.	Unknown	Unknown	Unknown
000-05286	C-0129-90	Sturgis Diesel Plant	Unknown	Unknown	Unknown
000-09958	C-0306-92	Annette's Shell	Unknown	Unknown	Unknown
000-16812	C-0069-94	Sturgis Hospital	Unknown	Unknown	Unknown
000-10085	C-0108-11	Admiral Petroleum #68	Unknown	Unknown	Unknown

One confined feeding operations can be found in the Wegner Ditch Sub-watershed. The CFO houses 240,000 broiler chickens, which is 210,000 more than is required to designate the farm as a CFO. CFOs present a potential problem due to the volume of manure produced at the facility. If the manure holding facility is not large enough, or properly maintained there is the potential for manure to discharge from the holding facility and potentially contaminate surface and/or groundwater. They also pose a threat if the manure is being land applied as fertilizer and soil tests to determine the proper amount of manure needed for plant uptake is not performed; manure may be applied to the land in excess. The CFO in Wegner Ditch is approximately 2,400 feet, (approximately ½ mile) from the Fawn River. Table 3.4.24 lists the CFO located within the Wegner Ditch sub-watershed.

Table 3.4.24: Confined Feeding Operations in the Wegner Ditch Sub-watershed

Operation Name	County	Sub-watershed	Program	Animal Type	Animal #
N & M Incorporated Fawn River Farm	Lagrange	Wegner Ditch	CFO	Broilers	240,000

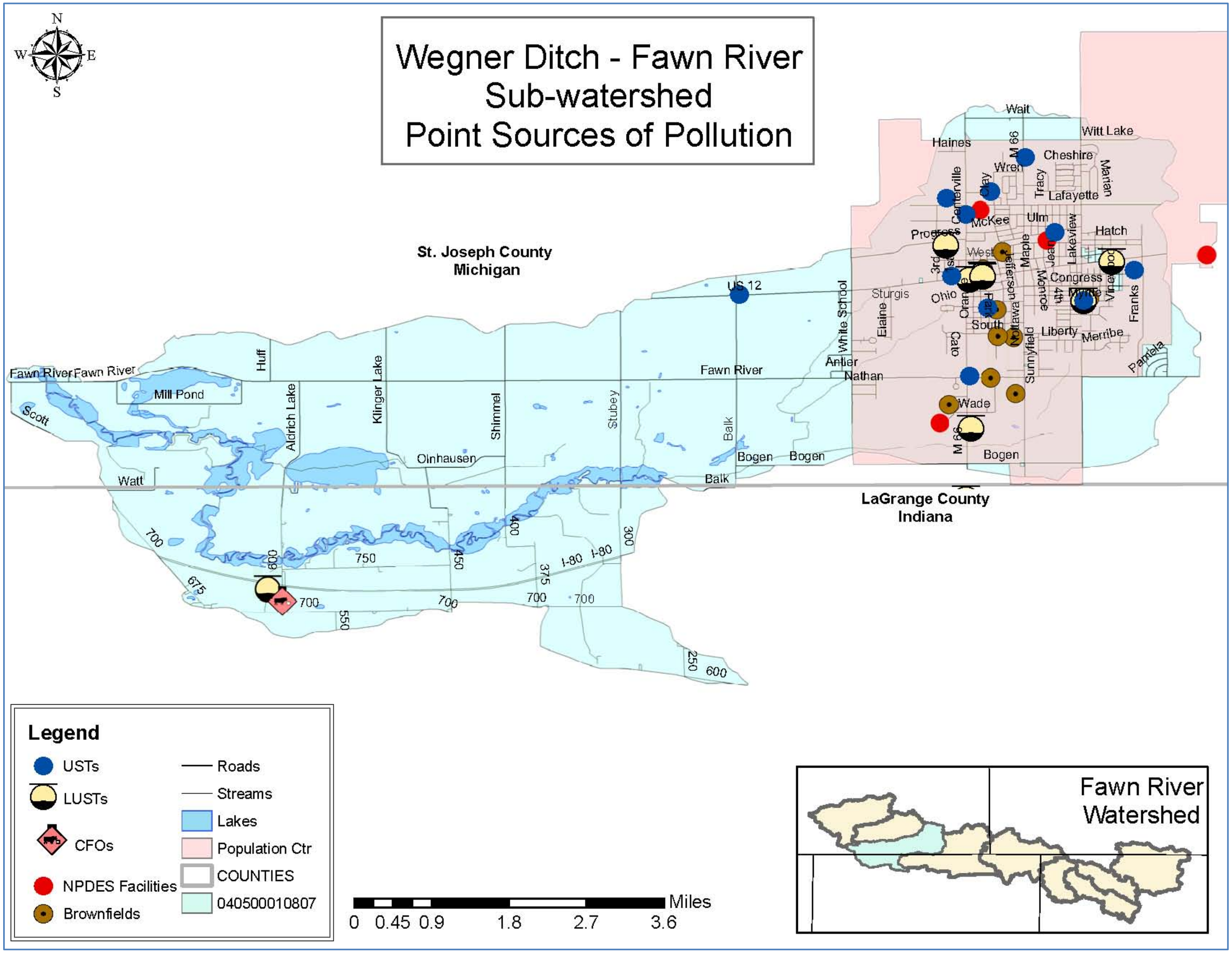
There are eight sites in the Wegner Ditch sub-watershed that are potential Brownfield sites and should be examined closer to determine if the sites are contaminated. Since these sites are listed as potential brownfields, they are eligible for funding to do further studies on the properties to determine the correct remediation work that needs to be completed to make the sites useful for other purposes, while remediating any potential contamination from the site. Table 3.4.25 lists the Brownfield sites located within the Wegner Ditch sub-watershed.

Figure 3.52 shows the location of all the potential point sources of pollution in the Wegner Ditch sub-watershed.

Table 3.4.25: Brownfield Eligible Sites in the Wegner Ditch Sub-watershed

Site #	Name	Address	City	County
75000120	Grumman Olson Industrial	1801 South Nottawa St (Plant 5)	Sturgis	St. Joseph
75000127	Grumman Olson Industrial, Inc - West	1861 S Centerville Rd. (Plants 1-4)	Sturgis	St. Joseph
00009958	Maruti Namah Inc	704 W Chicago Rd	Sturgis	St. Joseph
75000112	Paramount/ Berridge	303/401 St. Joseph Street	Sturgis	St. Joseph
75000036	Sturgis Hospital (Fuel Oil)	916 Myrtle Ave	Sturgis	St. Joseph
75000016	Sturgis Municipal Wells	309 N. Prospect	Sturgis	St. Joseph
75000119	SW Sturgis TCE	210 West South St	Sturgis	St. Joseph
75000109	Fawn River and Nattawa	Fawn River Rd/ Nattawa Rd	Sturgis	St. Joseph
75000067	Oak International	1160 White Street	Sturgis	St. Joseph
75000116	MGP - Sturgis - MGU	308 Florence St	Sturgis	St. Joseph

Figure 3.52: Potential Point Sources of Pollution in the Wegner Ditch Sub-watershed



Water quality data collected in the Wegner Ditch sub-watershed indicates a significant pollution issue with phosphorus, nitrates, and *E. coli*. TDS also appears to be an issue directly downstream of Sturgis. An analysis of all the samples collected in the sub-watershed shows that nitrates exceeded the target level in 86% of the samples, phosphorus in 37% of the samples, *E. coli* exceeded the state standard in 26% of the samples collected, and TDS exceeded the state standard in 13% of the samples. All exceedances for TDS were at FRP sites 40 and 42, the two samples sites directly downstream of Sturgis, indicating that urban stormwater runoff is the contributing factor causing the high TDS readings.

The high nutrients and *E. coli* levels found in Wegner Ditch may be due to leaking septic systems as only 23% of the land is designated suitable for septic placement and none of the residents in this sub-watershed, outside of those in Sturgis, have access to a centralized sewer system at this time. The high nutrients and *E. coli* levels may also be due to runoff of fertilizer from turf lawns around the built-up lake (Aldrich Lake) and Sturgis, and agriculture fields that do not utilize conservation tillage or cover, nutrient management, or riparian buffers.

It is notable that the samples from the Wegner Ditch sub-watershed measured so high for the nutrients and E. coli due to the fact that all samples (except Site 42) were collected directly from the Fawn River where more water and higher flow would typically dilute the samples.

As mentioned in the above Section, St. Joseph County has the highest use of irrigation for crop fields in the entire state of Michigan. Again, the reliance on irrigation in the county was observed during the windshield survey where nearly half of the crop fields had irrigation equipment in the field.

It appears that agriculture land and urban land both cause significant water quality impairment in the Wegner Ditch sub-watershed, and it would benefit from best management practices that focus on both land uses. The functional use loss of wetlands also appears to have a great impact on water quality in the Wegner Ditch sub-watershed; therefore, wetland restoration would be beneficial to the overall health of the sub-watershed.

A variety of best management practices and management measures that could benefit the water quality in the Wegner Ditch sub-watershed are available. Some of those practices include conservation tillage, cover crops, riparian and shoreline buffer installation adjacent to residential and agriculture land, nutrient management, wetland restoration, septic system education, irrigation management, and stormwater management measures.

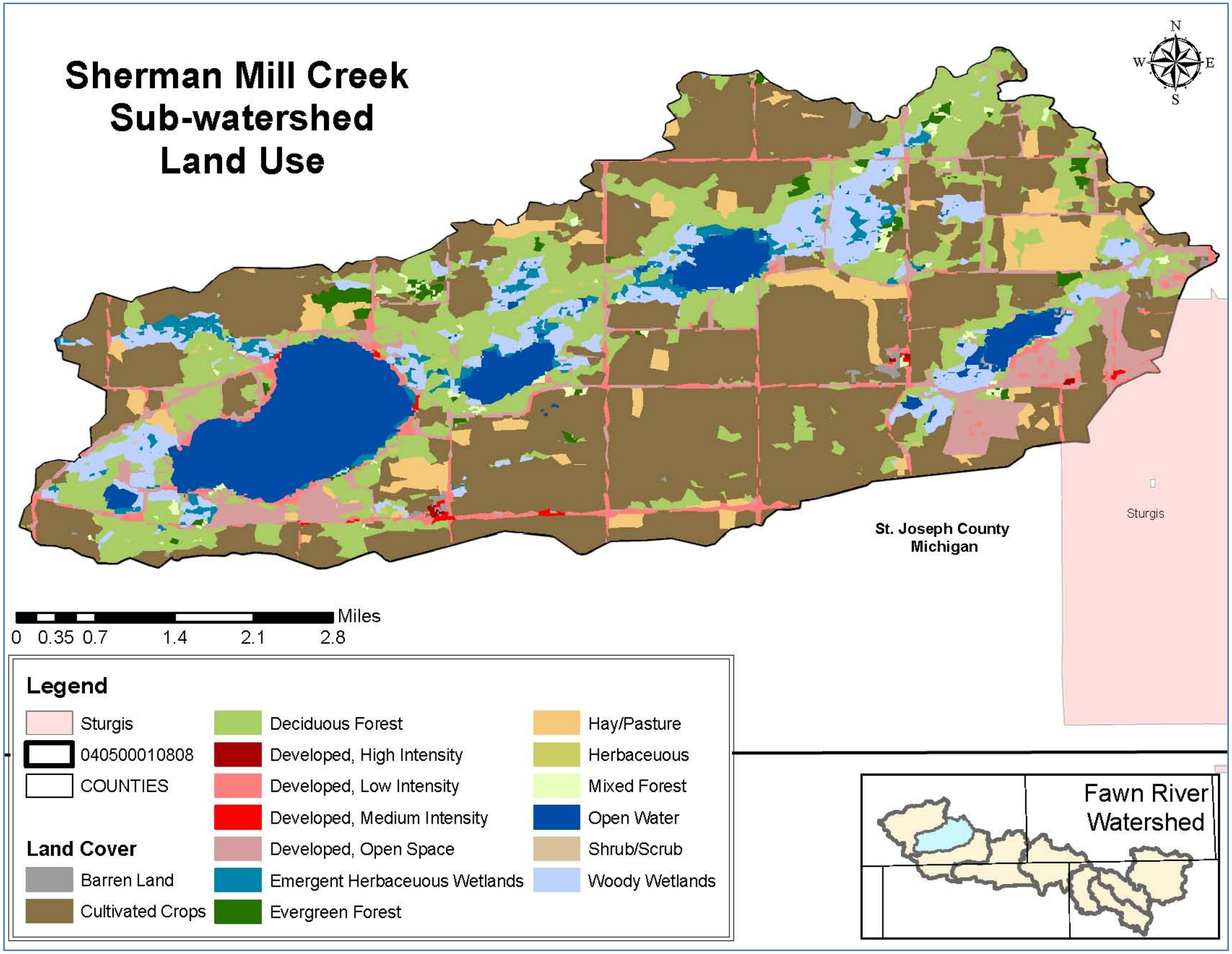
3.4.8 Sherman Mill Creek Sub-watershed Land Use

The primary influences on water quality in the Sherman Mill Creek Sub-watershed are agriculture as nearly 60% of the drainage area is in row crops or pasture and hayland, unsewered homes, and the lake communities. Slightly over 8% of the Sherman Mill Creek sub-watershed is developed from the northwest corner of Sturgis and Klinger Lake, mostly, which also impacts water quality in this sub-watershed. Table 3.4.26 shows the percentage of the Sherman Mill Creek sub-watershed that is in each land use and Figure 3.53 is a map showing the delineation of land use in the sub-watershed. All landuse data presented was obtained from the National Land Cover Data from the USGS and analyzed in ArcGIS.

Table 3.4.26: Land Use in the Sherman Mill Creek Sub-watershed

NLCD Land Use Designation	Acres	%
Open Water	1247.66	6.44%
Developed Open Space	1051.58	5.42%
Developed Low Intensity	545.52	2.81%
Developed Medium Insensity	24.15	0.12%
Developed High Intensity	7.57	0.04%
Barren Land	62.33	0.32%
Deciduous Forest	2639.47	13.61%
Evergreen Forest	159.66	0.82%
Shrub/Scrub	10.04	0.05%
Mixed Forest	118.66	0.61%
Grassland Herbaceous	62.25	0.32%
Pasture Hayland	924.78	4.77%
Row Crops	10,500.87	54.17%
Woody Wetland	987.6	5.09%
Emergent Herbaceous Wetlands	1044.35	5.39%
Total	19,386.49	100.00%

Figure 3.53: Land Use Designations in the Sherman Mill Creek Sub-watershed



The windshield survey conducted as part of this project in May, 2014 revealed that Sherman Mill Creek has few problems associated with inadequate riparian buffers, though it could benefit from cover crops and increased conservation tillage usage. A small and sparsely populated area of Sturgis is located in Sherman Mill Creek sub-watershed, though Klinger Lake is completely developed, and three smaller lakes are partially developed, indicating that future development may be a possibility. Lush green lawns on lake residences were observed during the windshield survey, indicating fertilizer use in areas that lack adequate riparian and shoreline buffers. There was one natural stream, a tributary to Klinger Lake, that has been tiled and no longer functions as a natural stream. The tiled stream would benefit from daylighting. The total length of the stream that has been tiled is approximately 21,637 linear feet. Figure 3.54 shows the location of each of the issues discovered during the windshield survey, as well as the populated lakes in the sub-watershed where seawalls and excessive fertilizer application may be used.

Another potential problem related to residential homes in the Sherman Mill Creek sub-watershed is the areas that are not currently serviced by a centralized sewer system. The city of Sturgis and Klinger Lake are the only areas in the sub-watershed that are currently serviced by a sewer system. All other homes most likely utilize an on-site waste disposal system that has the potential to leak or fail if not properly maintained. As is illustrated in Figure 3.55, over 62% of the sub-watershed's soils are designated as being very limited for septic system placement. Minnewaukan Lake is very close to the City of Sturgis, however the St. Joseph County Health Department expressed that Klinger Lake is the only built-up lake that is currently serviced by a sewage treatment plant, therefore, it can be assumed that Minnewauken Lake, Tamarack Lake, and Thompson Lake residents all utilize on-site waste disposal systems.

Figure 3.54: Windshield Survey Observations in the Sherman Mill Creek Sub-watershed

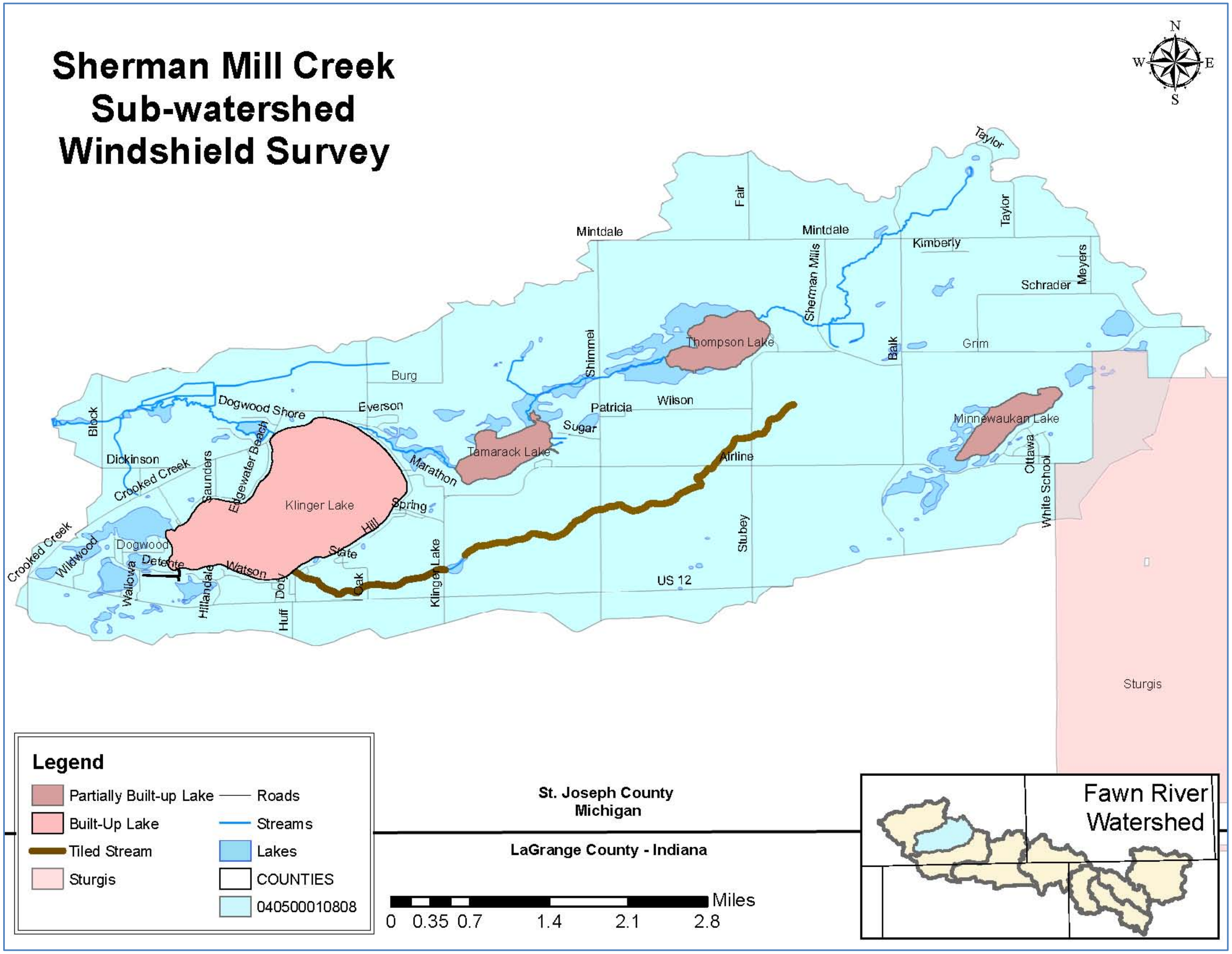
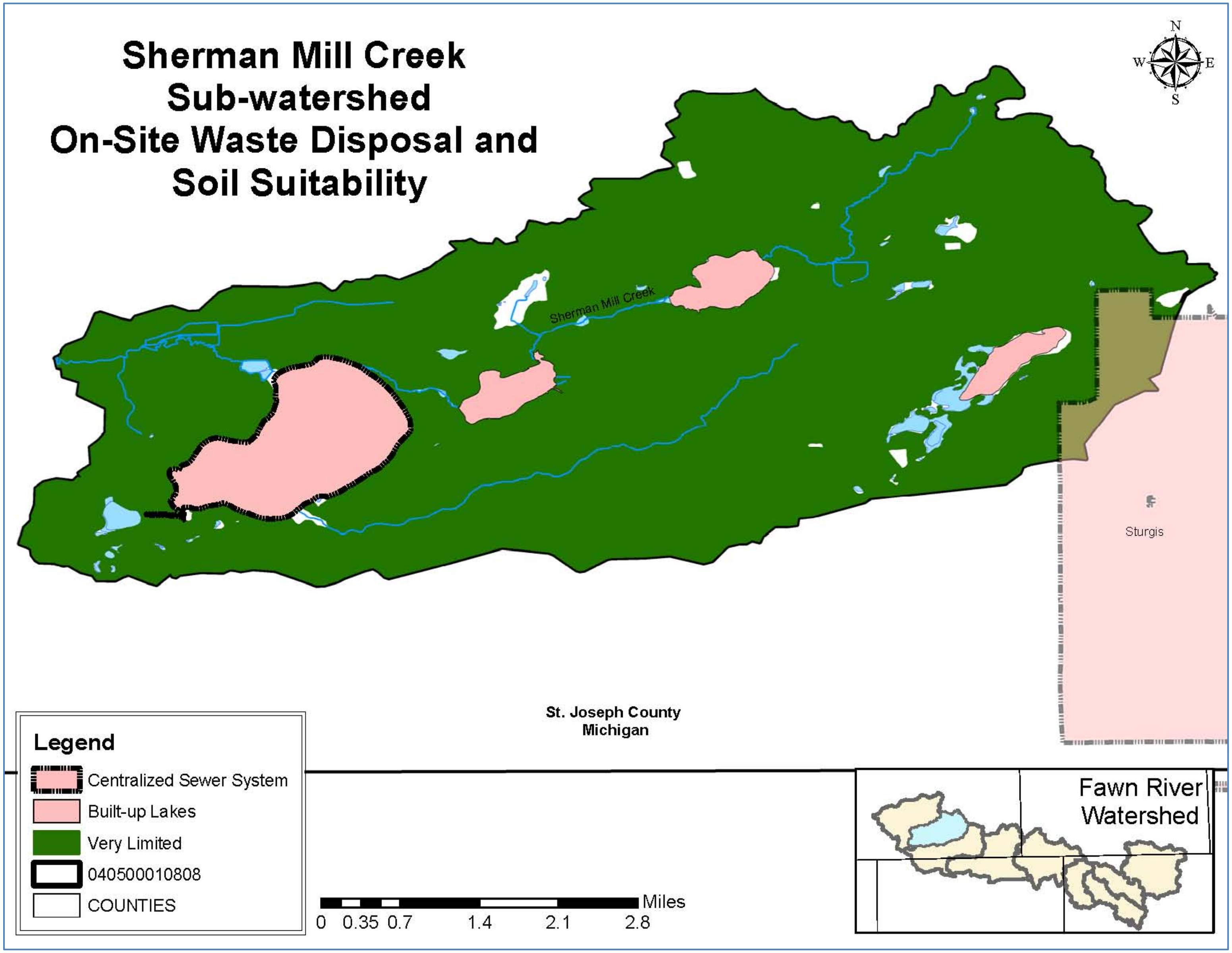


Figure 3.55: Septic Suitability in the Sherman Mill Creek Sub-watershed



As stated above, most of the land in the Sherman Mill Creek sub-watershed is used for agriculture; either cultivated crops or pasture and hayland. Approximately 18% of the land in the sub-watershed is designated as highly or potentially highly erodible by the St. Joseph County's NRCS. This percentage is not as high as it is in other sub-watersheds, though it is significant in the Sherman Mill Creek sub-watershed since just less than 60% of the drainage area is designated as agriculture land and the majority of the HEL and PHEL falls within the agriculture land. There is potential for sediment, carrying nutrients attached to the soil particles, from HEL and PHEL that is being conventionally tilled, or farmed directly up to the streambank to deposit in open water. Special precautions must be taken on farmland in this sub-watershed that is designated as HEL or PHEL to prevent soil erosion, and sedimentation and nutrification of open water. Figure 3.56 shows the location of HEL and PHEL in the watershed, overlaid on the agriculture land to paint a picture of where there is a risk of soil erosion.

The Sherman Mill Creek sub-watershed has approximately 10.5% of land cover designated as wetland. According to the 2005 wetland inventory conducted by MDEQ and partners, the Sherman Mill Creek sub-watershed currently has 2,472.85 acres of wetland from the 4,039.74 acres of wetland present in pre-settlement times. This is nearly a 39% decline in the wetlands since settlement of the area. The loss in wetlands translates to a huge loss in the ability of the wetlands to absorb pollutants prior to them being released into open water and, especially, in prime habitat for fauna that relies on wetlands for survival. According to data collected in 2005, there has been a water quality functional use loss of 47% and a habitat functional use loss of 61% in the Sherman Mill Creek sub-watershed. Since only 10% of the watershed is currently classified as wetland, it is important to protect the existing wetlands, to prevent further loss in the ability of the land cover to absorb pollutants and provide habitat to important flora and fauna. Figure 3.57 shows the wetland delineation for the historic and current wetlands in the Sherman Mill Creek sub-watershed.

Figure 3.56: Highly and Potentially Highly Erodible Land in Sherman Mill Creek Sub-watershed

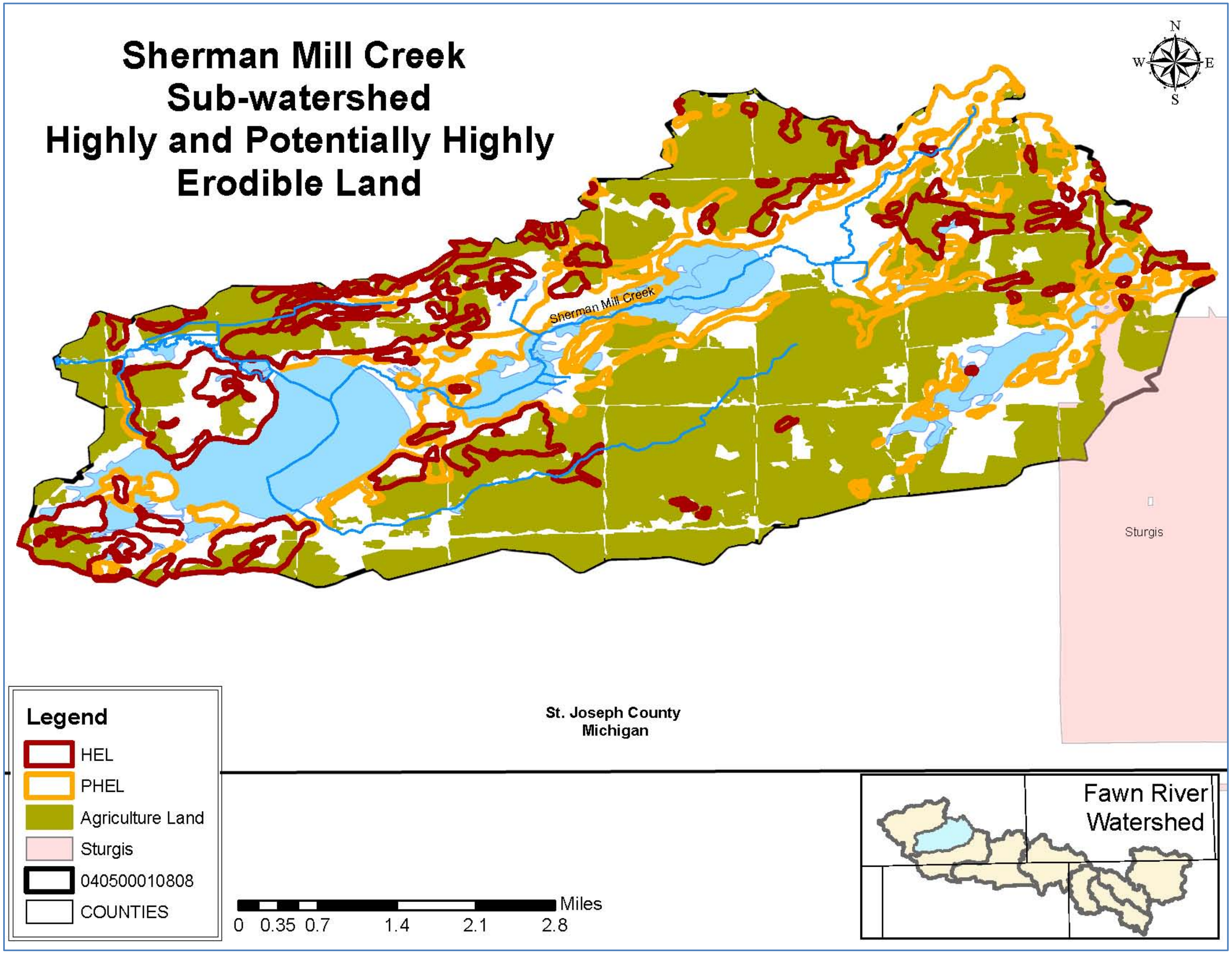
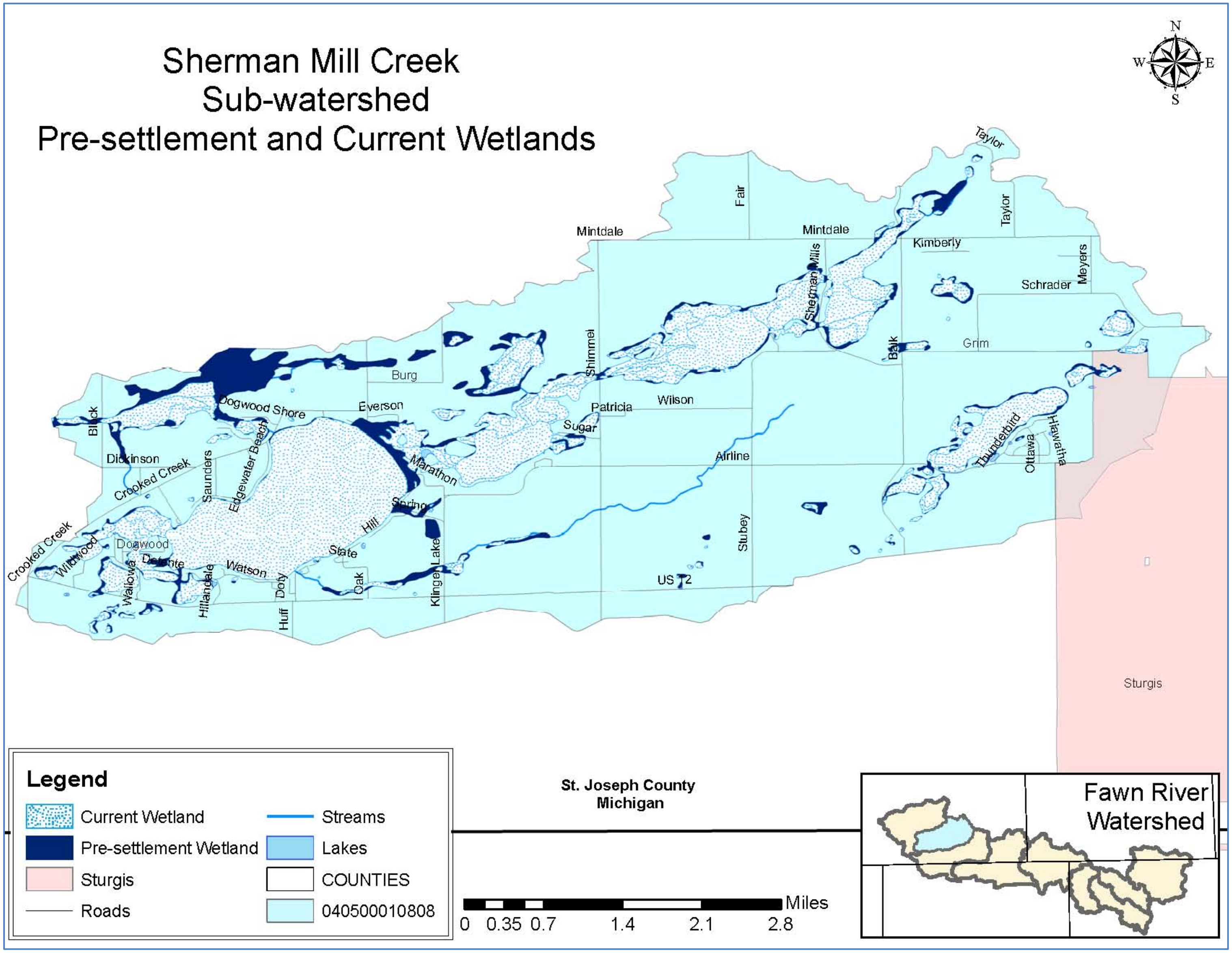


Figure 3.57: Wetlands in the Sherman Mill Creek Sub-watershed



A final threat to water quality found during the inventory of Sherman Mill Creek sub-watershed is potential point sources of pollution. There are not any NPDES permitted facilities located within this sub-watershed. However, there are two USTs both of which are leaking and therefore considered to be LUSTs. MDEQ does not prioritize the LUSTs as does IDEM, therefore the same information provided in previous Sections is not available for the Sherman Mill Creek sub-watershed. Table 3.4.27 lists the LUSTs located within the Sherman Mill Creek sub-watershed.

Table 3.4.27: Leaking Underground Storage Tanks in the Sherman Mill Creek Sub-watershed

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
000-33437	C-0074-97	Klinger Lake Marina	Unknown	Unknown	Unknown
000-17765	C-2709-91	Bart's Bait Shop	Unknown	Unknown	Unknown

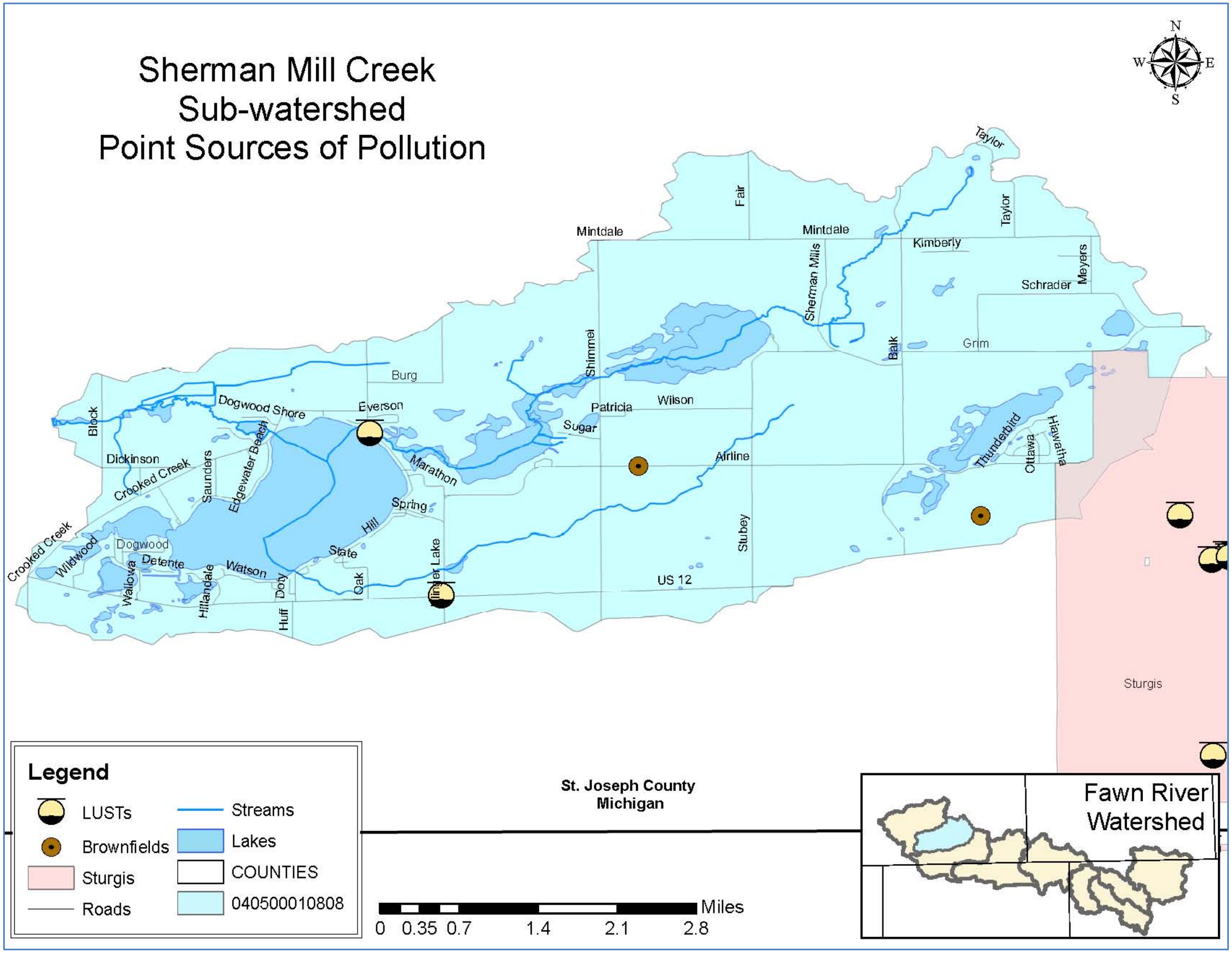
There are two sites in the Sherman Mill Creek sub-watershed that are potential Brownfield sites and should be examined closer to determine if the sites are contaminated. Since these sites are listed as potential brownfields, they are eligible for funding to do further studies on the properties to determine the correct remediation work that needs to be completed to make the sites useful for other purposes, while remediating any potential contamination from the site. Table 3.4.28 lists the Brownfield sites located within the Sherman Mill Creek sub-watershed.

Figure 3.58 shows the location of all the potential point sources of pollution in the Sherman Mill Creek sub-watershed.

Table 3.4.28 Brownfields Located in the Sherman Mill Creek Sub-watershed

Site #	Name	Address	City	County
75000130	Abbott Laboratories Ross Products Div.	White School Rd	Sturgis	St. Joseph
75000113	Carl Eaton Farm/Sturgis	23240 Airline Rd	Sturgis	St. Joseph

Figure 3.58: Potential Point Sources of Pollution in the Sherman Mill Creek Sub-watershed



Water quality data collected in the Sherman Mill Creek sub-watershed indicates a significant pollution issue with phosphorus, nitrates, and *E. coli*. An analysis of all the samples collected in the sub-watershed shows that nitrates exceeded the target level in 67% of the samples, phosphorus in 89% of the samples, *E. coli* exceeded the state standard in 17% of the samples collected, specifically *E. coli* was high at FRP sites 47 which is at the outlet from Thompson Lake, an unsewered community, and at FRP site 46, which is at Klinger Lake inlet from a tributary that has been mostly tiled and converted to farm land. Nitrates and phosphorus were high at every sample site though the highest readings were at FRP site 46, on the tributary that has been mostly tiled allowing for nutrients to have a direct conduit to open water.

The high nutrients and *E. coli* levels found in Sherman Mill Creek may be due to factors beyond those listed above. They may be a result of leaking septic systems as only 23% of the land is designated suitable for septic placement and none of the residents in this sub-watershed, outside of those in Sturgis and Klinger Lake, have access to a centralized sewer system at this time. This is evident from the high E. coli and nutrient levels at FRP site 47, which is at an outlet to Thompson Lake, an unsewered community. The high nutrients and *E. coli* levels may also be due to runoff of fertilizer from turf lawns around the built-up lakes and Sturgis, and agriculture fields that do not utilize conservation tillage or cover, nutrient management, or riparian buffers.

It should be noted that FRP Site 49, at Klinger Lake outlet, had no samples exceed the state standard for E. coli, though did exceed for nutrients, and phosphorus exceeded the target in 50% of the samples, again reinforcing the assumption that the high nutrients may be from fertilizer on turf grass. Phosphorus released from disturbed bottom sediment has been shown to be the source of high nutrient readings in other lakes in the region, and may be the source of the high nutrient levels in Klinger Lake as well. This phenomenon of “legacy phosphorus” found in benthic sediment is often exacerbated by the use of seawalls which are common practice on built-up lakes throughout the project area.

As mentioned in the above Section, St. Joseph County has the highest use of irrigation for crop fields in the entire state of Michigan. Again, the reliance on irrigation in the county was observed during the windshield survey where nearly half of the crop fields had irrigation equipment in the field.

Finally, the destruction of wetlands that can efficiently filter pollutants from water may also be contributing to the high nutrient levels as the Sherman Mill Creek sub-watershed has a wetland functional use loss for water quality benefits of 47%, and the highest functional use loss for habitat at 61%, therefore wetland preservation and restoration should be a high priority in the Sherman Mill Creek sub-watershed.

It appears that agriculture land and urban/residential land both cause significant water quality impairment in the Sherman Mill Creek sub-watershed, and it would benefit from best management practices that focus on both land uses.

A variety of best management practices and management measures that could benefit the water quality in the Sherman Mill Creek sub-watershed are available. Some of those practices include conservation tillage, cover crops, riparian and shoreline buffer installation adjacent to residential and agriculture land, nutrient management, wetland restoration, septic system education, irrigation management, and stormwater management measures.

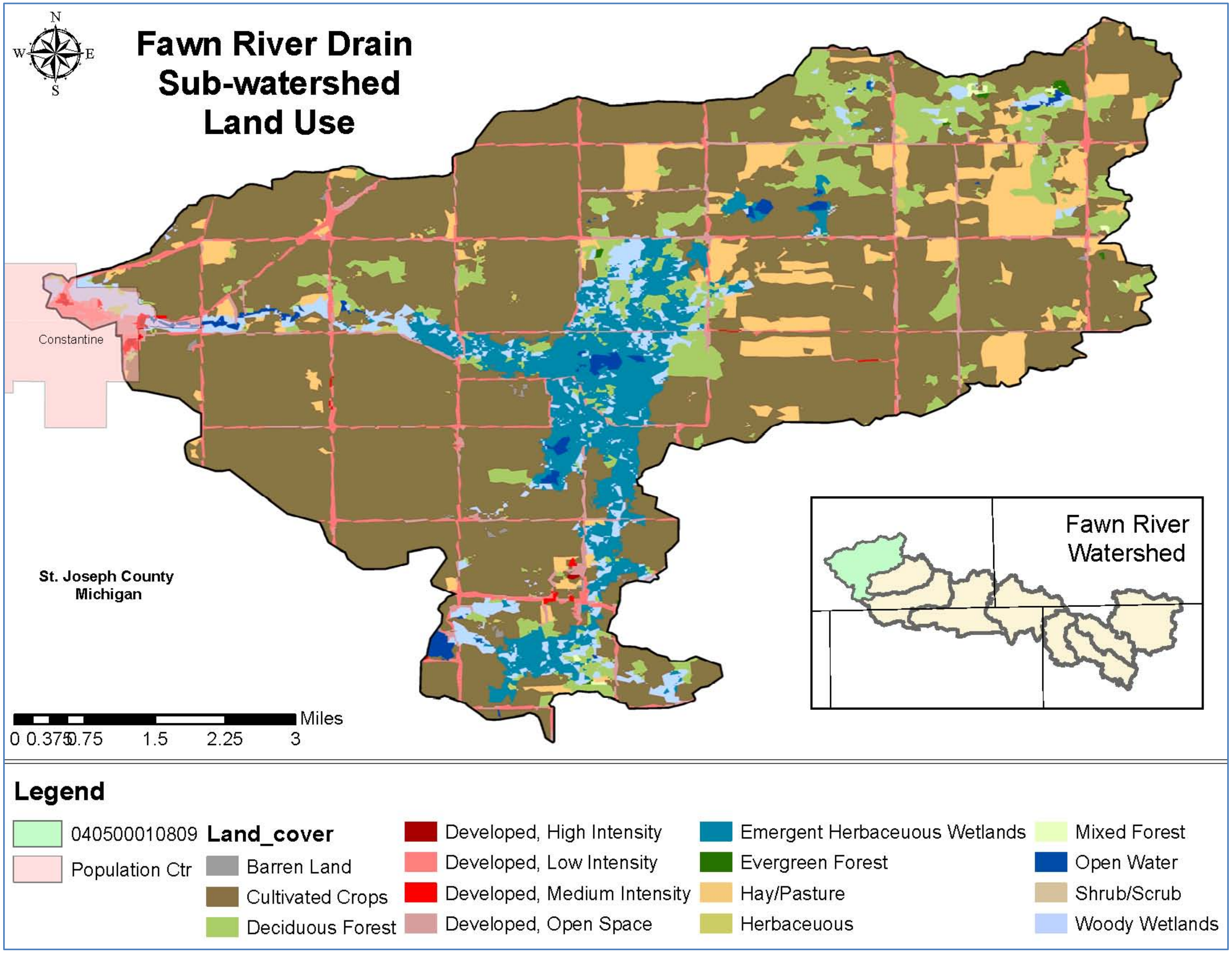
3.4.9 Fawn River Drain Sub-watershed Land Use

The primary influences on water quality in the Fawn River Drain Sub-watershed are agriculture as nearly 74% of the drainage area is in row crops or pasture and hayland and unsewered homes. Slightly under 6% of the Fawn River Drain sub-watershed is developed; primarily from the rural roads and the east side of the Village of Constantine, MI, which is located within the Fawn River Drain sub-watershed. Table 3.4.29 shows the percentage of the Fawn River Drain Sub-watershed that is in each land use and Figure 3.59 is a map showing the delineation of land use in the sub-watershed. All landuse data presented was obtained from the National Land Cover Data from the USGS and analyzed in ArcGIS.

Table 3.4.29: Land Use in the Fawn River Drain Sub-watershed

NLCD Land Use Designation	Acres	%
Open Water	167.88	0.73%
Developed Open Space	544.53	2.36%
Developed Low Intensity	742.7	3.22%
Developed Medium Insensity	37.08	0.16%
Developed High Intensity	11.71	0.05%
Barren Land	28.53	0.12%
Deciduous Forest	1939.2	8.42%
Evergreen Forest	21.78	0.09%
Shrub/Scrub	7.68	0.03%
Mixed Forest	23.27	0.10%
Grassland Herbaceous	52.27	0.23%
Pasture Hayland	1609.98	6.99%
Row Crops	15397.27	66.85%
Woody Wetland	978.84	4.25%
Emergent Herbaceous Wetlands	1472.41	6.39%
Total	23,035.13	100.00%

Figure 3.59: Land Use Designations in the Fawn River Drain Sub-watershed



The windshield survey conducted as part of this project in May, 2014 revealed that the Fawn River Drain has more areas than other sub-watershed where agriculture fields have an inadequate riparian buffer resulting in streambank erosion. Observations made during the windshield survey, and verified through a desk top survey, reveal that approximately 10,086 linear feet of open water is in need of a larger riparian buffer to protect water quality. The Fawn River Drain also has several natural streams that have been tiled and converted to farm land, approximately 14,182 linear feet. The Village of Constantine is partially located in the Fawn River Drain. Constantine is at the confluence of the Fawn River and the St. Joseph River; therefore, it is important to manage polluted stormwater in Constantine. Unlike the other sub-watersheds, there are not any populated lakes located in the Fawn River Drain. It was also noted during the windshield survey, that the Fawn River Drain has far more channelized ditches and streams than any of the other sub-watersheds within the Fawn River watershed. Table 3.4.30 shows the observations made during the windshield survey, and the approximate length of the problem (verified through a desktop survey of aerial photography). Figure 3.60 shows the location of each of the issues discovered during the windshield survey.

Table 3.4.30: Windshield Survey Observations for the Fawn River Drain Sub-watershed

Windshield Survey Observation	Potential Contaminant	Number or Length
Lack of Riparian Buffer - Ag	Sediment and Nutrients	10,086 linear ft
Tiled Natural Stream	Sediment, Nutrients, and *E. coli*	14,182 linear ft

Another potential problem related to residential homes in the fawn River Drain sub-watershed is the areas that are not currently serviced by a centralized sewer system. The Village of Constantine is the only area in the sub-watershed that is currently serviced by a sewer system. All other homes most likely utilize an on-site waste disposal system that has the potential to leak or fail if not properly maintained. As is illustrated in Figure 3.61, approximately 90% of the sub-watershed's soils are designated as being very limited for septic system placement.

Figure 3.60: Windshield Survey Observations in the Fawn River Drain Sub-watershed

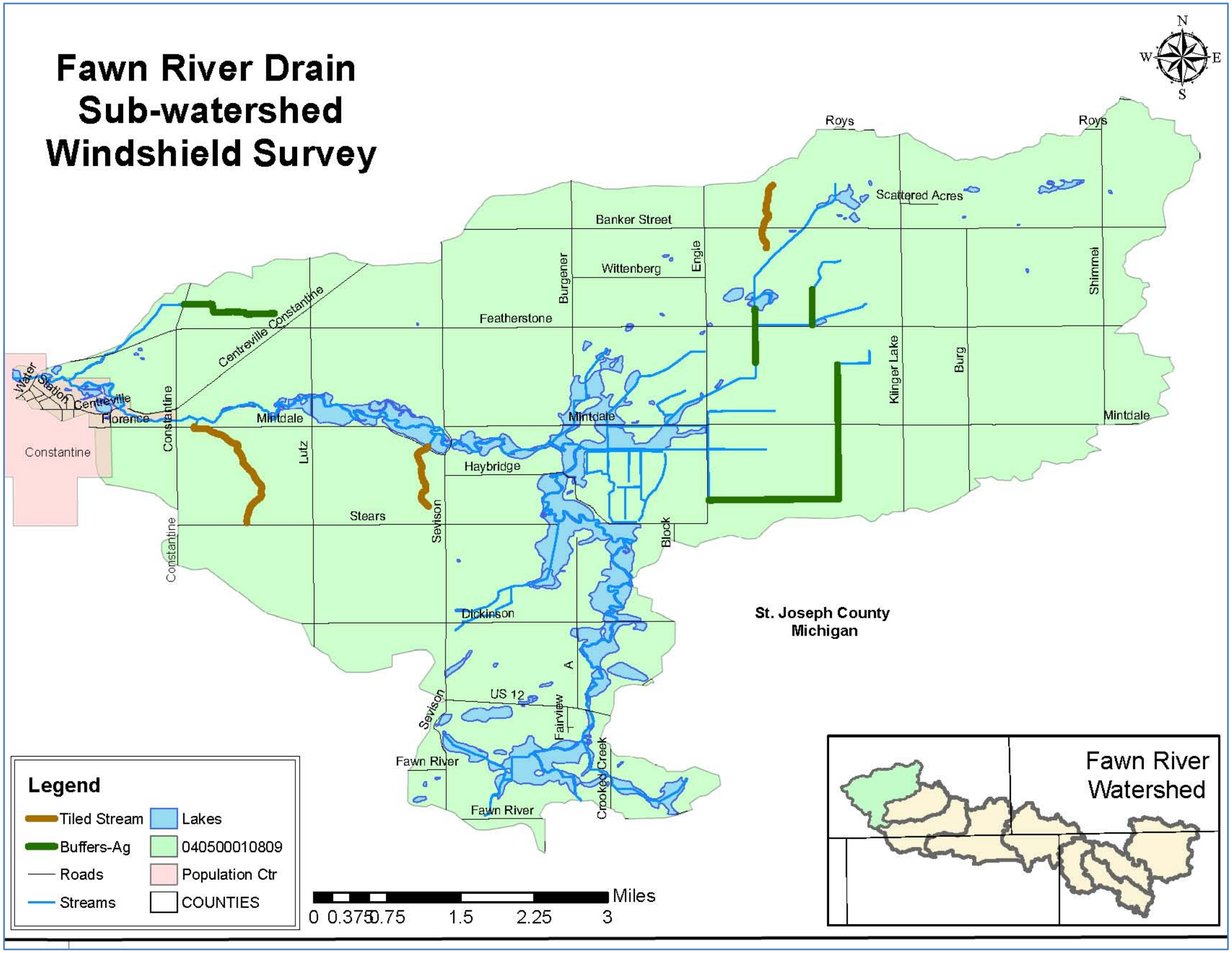
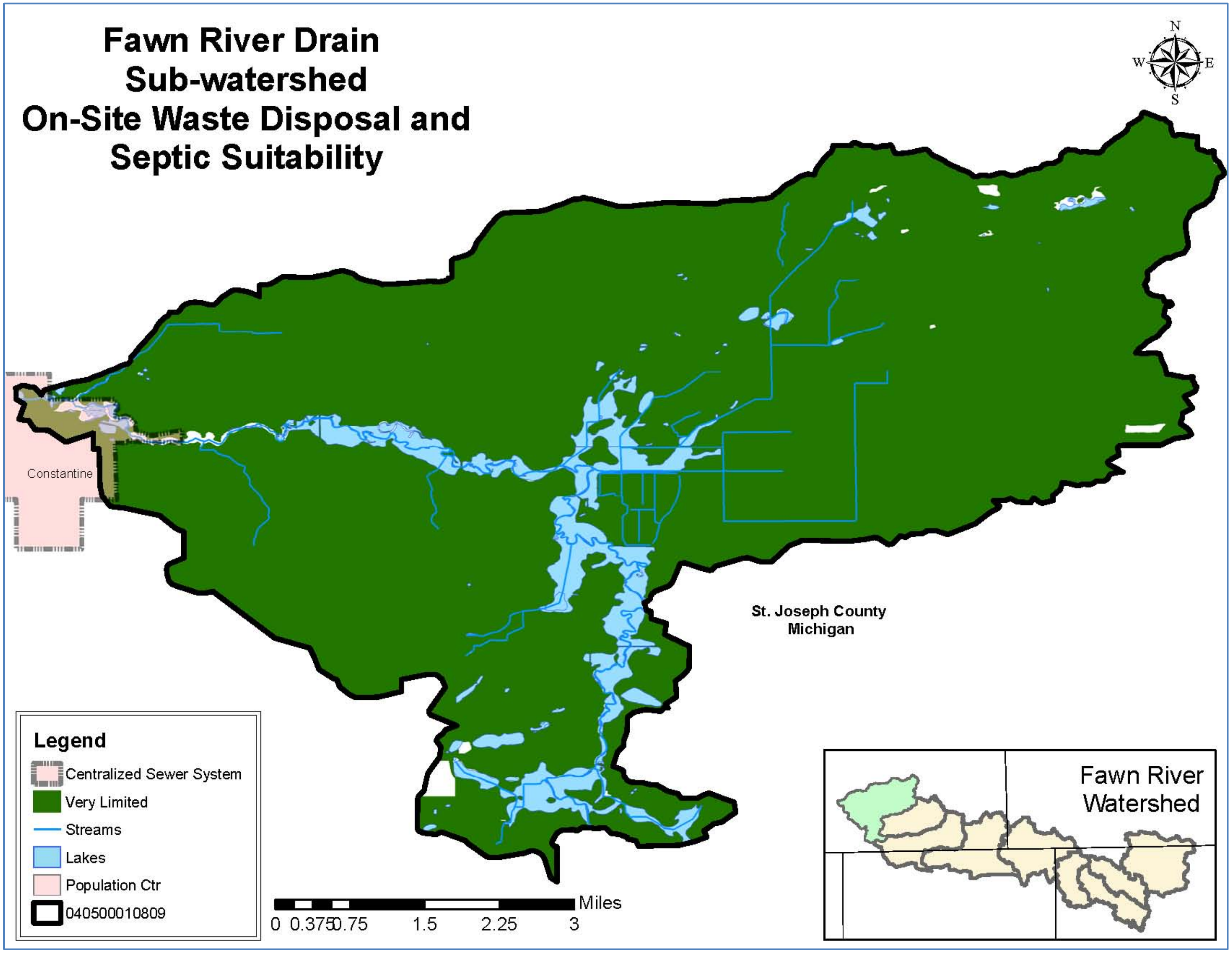


Figure 3.61: Septic Suitability in the Fawn River Drain Sub-watershed



As stated above, most of the land in the Fawn River Drain sub-watershed is used for agriculture; either cultivated crops or pasture and hayland. Approximately 15% of the land in the sub-watershed is designated as highly or potentially highly erodible by the St. Joseph County's NRCS. This percentage is not as high as it is in other sub-watersheds, though it is significant in the Fawn River Drain sub-watershed since most of the HEL and PHEL is agriculture land. There is potential for sediment, carrying nutrients attached to the soil particles, from HEL and PHEL that is being conventionally tilled, or farmed directly up to the streambank to deposit in open water. Special precautions must be taken on farmland in this sub-watershed that is designated as HEL or PHEL to prevent soil erosion, and sedimentation and nutrification of open water. Figure 3.62 shows the location of HEL and PHEL in the watershed, overlaid on the agriculture land to paint a picture of where there is a risk of soil erosion.

The Fawn River Drain sub-watershed has approximately 11% of land cover designated as wetland. According to the 2005 wetland inventory conducted by MDEQ and partners, the Fawn River Drain sub-watershed currently has 1,949.98 acres of wetland from the 4,567.92 acres of wetland present in pre-settlement times. This is over a 57% decline in the wetlands since settlement of the area; much more than in any other sub-watershed in the Fawn River watershed. The loss in wetlands translates to a huge loss in the ability of the wetlands to absorb pollutants prior to them being released into open water and, especially, in prime habitat for fauna that relies on wetlands for survival. According to data collected in 2005, there has been a water quality functional use loss of nearly 60% and a habitat functional use loss ofnearly 73% in the Fawn River Drain sub-watershed. Since only 10% of the watershed is currently classified as wetland, it is very important to protect the existing wetlands, to prevent further loss in the ability of the land cover to absorb pollutants and provide habitat to important flora and fauna. Figure 3.63 shows the wetland delineation for the historic and current wetlands in the Fawn River Drain sub-watershed.

Figure 3.62: Highly and Potentially Highly Erodible Land in Fawn River Drain Sub-watershed

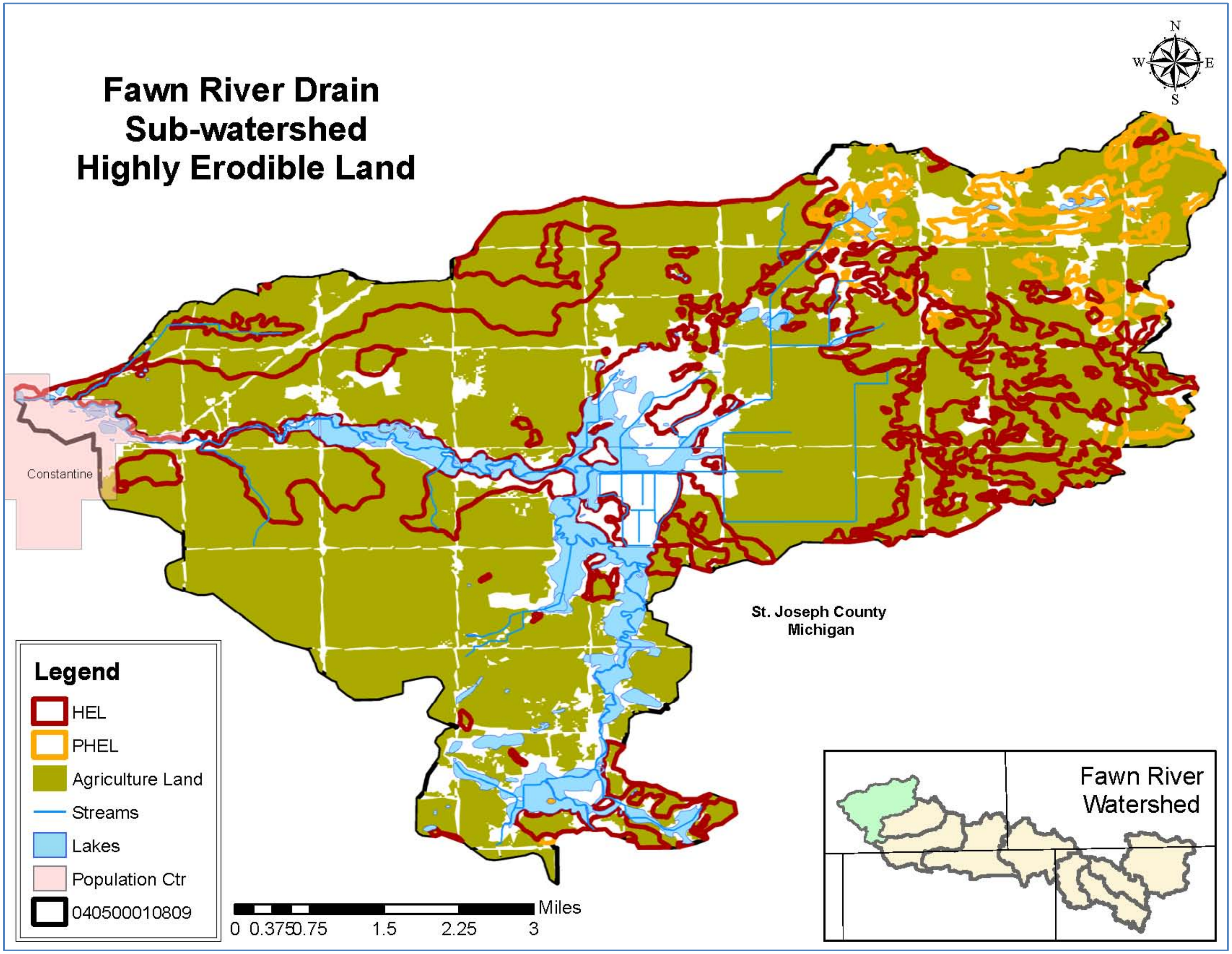
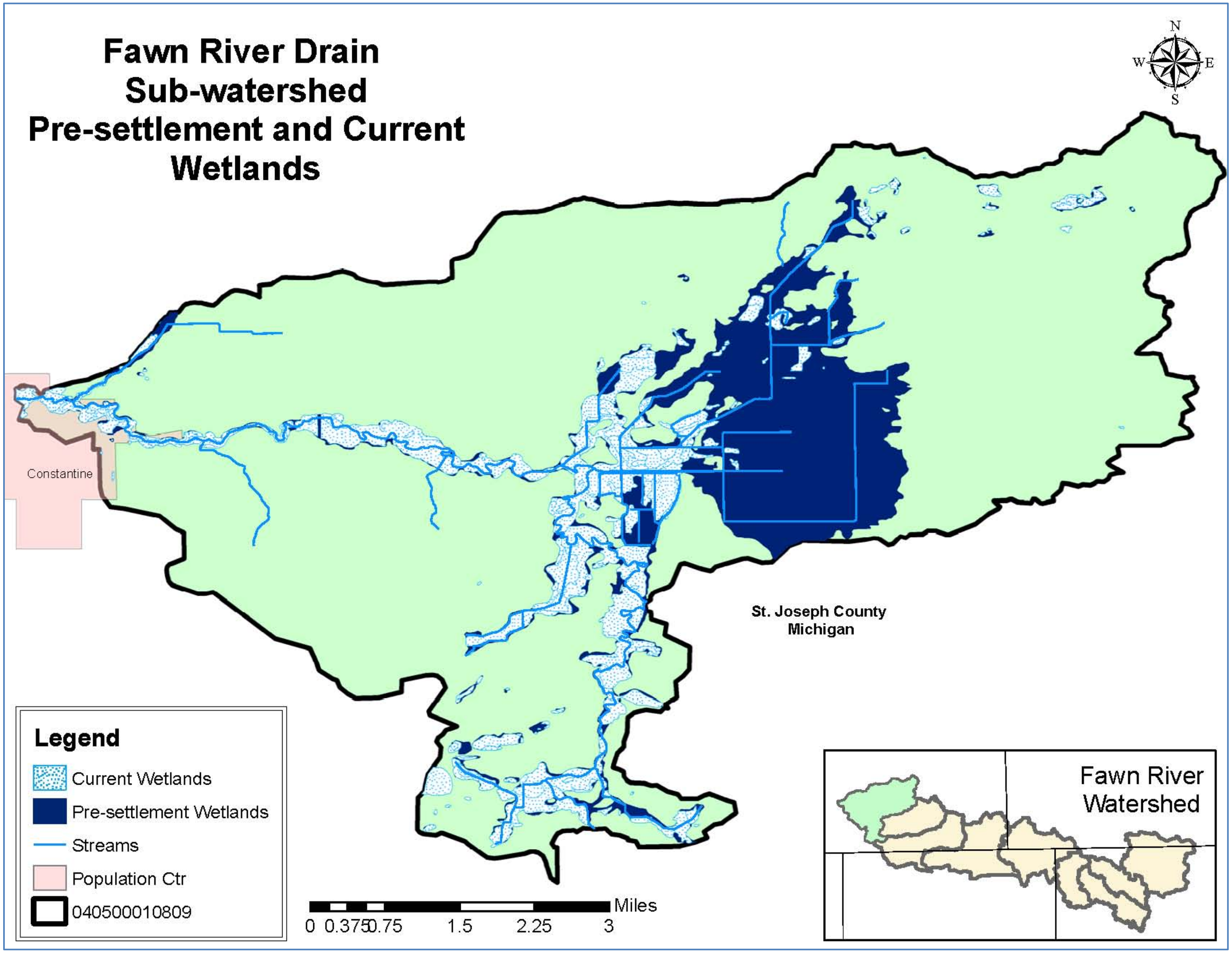


Figure 3.63: Wetlands in the Fawn River Drain Sub-watershed



A final threat to water quality found during the inventory of Fawn River Drain sub-watershed is potential point sources of pollution. There is one NPDES permitted facility located in Constantine within the Fawn River Drain sub-watershed. It was in violation of its permit once within the past three years for pH levels. Table 3.4.31 lists the information about the NPDES permitted facility in the Fawn River Drain sub-watershed.

Table 3.4.31: NPDES Permitted Facility in the Fawn River Drain Sub-watershed

Permit Name	Permit #	Receiving Water Body Name	Qrts in Non-compliance (3 yrs)	Qtrs in Significant Non-compliance (3 yrs)	Pollutant Causing Non-compliance	Pollutant with Significant violations	Enforcement Actions (I=informal; F=formal) (5 yrs)
MI Milk Producers Assoc.	MI0001414	St. Joseph River	1	0	pH	N/A	0

There is one UST located within the Fawn River Drain sub-watershed. The UST is leaking and is therefore considered to be a LUST by the MDEQ. MDEQ does not prioritize the LUSTs as does IDEM, therefore the same information provided in previous Sections is not available for the Fawn River Drain sub-watershed. Table 3.4.32 lists the information available regarding the LUST located within the Fawn River Drain sub-watershed.

Table 3.4.32: Leaking Underground Storage Tanks in the Fawn River Drain Sub-watershed

UST FACILITY ID	INCIDENT NUMBER	NAME	PRIORITY DESC	TANK STATUS DESCRIPTION	AFFECTED AREA NAME
000-10086	C-0159-12	Jit Food and Gas Inc/Shell Speedy Mart	Unknown	Unknown	Unknown

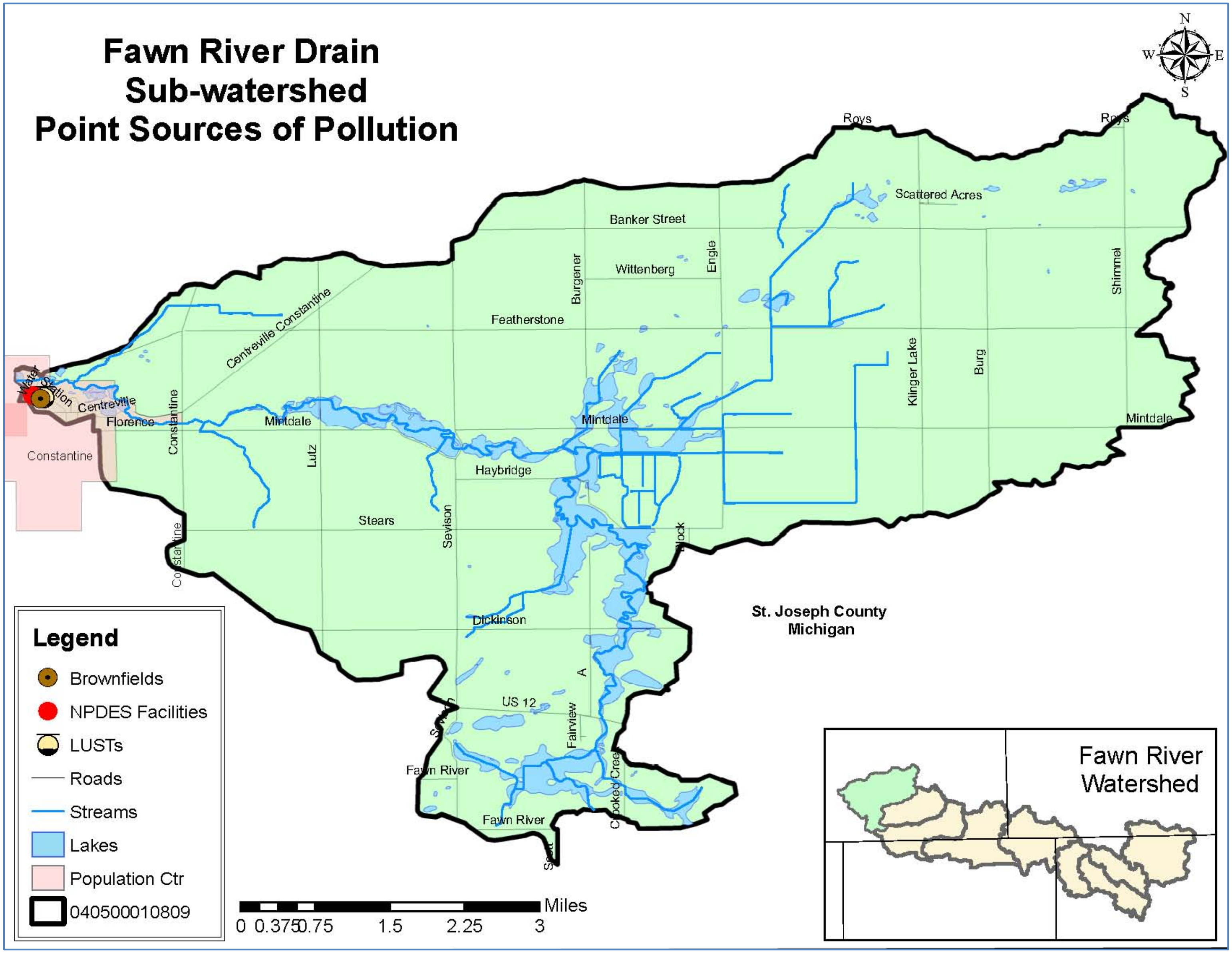
There is one site in the Fawn River drain sub-watershed that is a potential Brownfield site and should be examined closer to determine if the sites are contaminated. Since the site is listed as a potential brownfield, it is eligible for funding to do further studies on the property to determine the correct remediation work that needs to be completed to make the site useful for other purposes, while remediating any potential contamination from the site. Table 3.4.33 lists the Brownfield site located within the Fawn River Drain sub-watershed.

Figure 3.64 shows the location of all the potential point sources of pollution in the Fawn River Drain sub-watershed.

Table 3.4.33 Brownfields Located in the Fawn River Drain Sub-watershed

Site #	Name	Address	City	County
75000027	Constantine Residential Wells	Centerville/Dept/ White Pigeon Rd	Constantine	St. Joseph

Figure 3.64: Potential Point Sources of Pollution in the Fawn River Drain Sub-watershed



Water quality data collected in the Fawn River Drain sub-watershed indicates a significant pollution issue with phosphorus and nitrates, and to a lesser degree *E. coli* and sediment. An analysis of all the samples collected in the sub-watershed shows that nitrates exceeded the target level in 71% of the samples, phosphorus in 39% of the samples, *E. coli* exceeded the state standard in 17% of the samples collected, and TSS and turbidity both exceeded the target level in 4% of the samples.

Looking at specific water quality sampling sites; FRP Site 50 measured high for all parameters which may be partially due to Aldrich Lake which is directly upstream of this site, as well as extensive agriculture and septic system usage on land that is not suitable for either practice as a significant amount of HEL is present upstream from FRP Site 50, and only 10% of the land in the sub-watershed is suited for on-site waste disposal systems. FRP Site 52 is located downstream of the channelized streams in the drainage, which is where the majority of the 10,089 linear feet of riparian buffer is needed. Site 52 is also directly downstream of where the majority of the wetland loss is. The loss in wetlands limited the ability of the land to absorb pollutants prior to them entering the streams by nearly 59%. The remaining sample sites are all located on the Fawn River, and all exceeded targets for *E. coli*, phosphorus and nitrates. It can be assumed that the tiled streams, which provide a direct means of transporting pollutants to open water, lack of adequate riparian buffers, septic system leachate, the devastating loss in wetlands, and extensively farmed land contribute to the high pollutant levels at FRP Sites 51, 53, and 54.

As mentioned in the above Section, St. Joseph County has the highest use of irrigation for crop fields in the entire state of Michigan. Again, the reliance on irrigation in the county was observed during the windshield survey where nearly half of the crop fields had irrigation equipment in the field.

A variety of best management practices and management measures that could benefit the water quality in the Fawn River Drain sub-watershed are available. Some of those practices include conservation tillage, cover crops, riparian buffer installation adjacent to, nutrient management, wetland restoration, septic system education, irrigation management, and stormwater management measures.

3.5 Watershed Inventory Summary

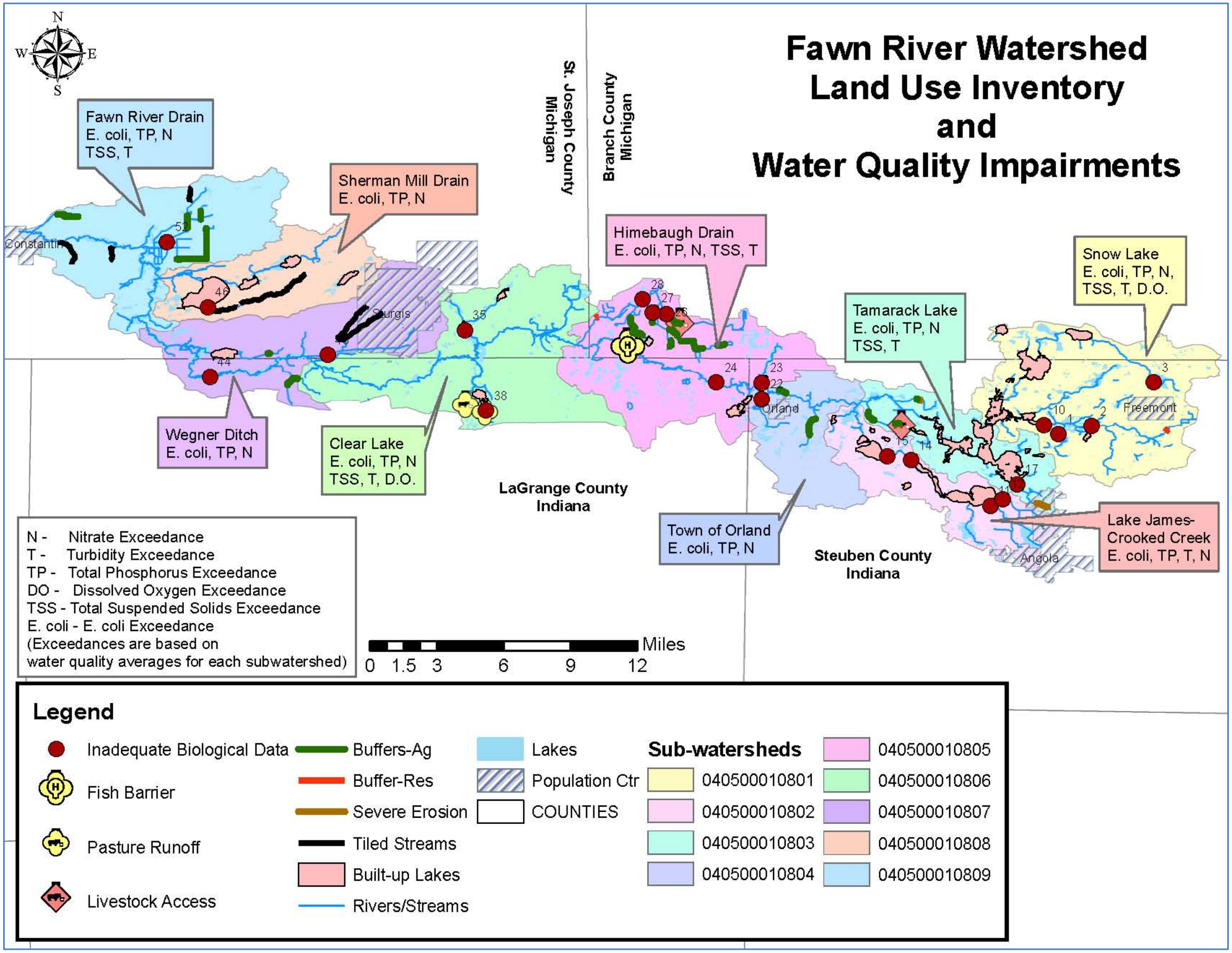
To better understand the water quality problems in the Fawn River Watershed and what influences may be contributing to those problems, a map was developed outlining the water quality issues in each sub-watershed, as well as showing the results of the land use inventory, specifically those sites that were identified during the windshield survey, where inadequate macroinvertebrate and/or habitat data was found as well as other points of interest that may be contributing to the degradation of water quality (Figure 3.65). As can be seen in the map below, *E. coli,* Nitrates, and Phosphorus levels were elevated in every sub-watershed and TSS and turbidity were elevated slightly in scattered sub-watersheds. It can also be seen in Figure 3.65 that biological data was poor at sample sites downstream of populated areas, as well as at sites located on streams or ditches that have been modified, or where livestock issues were noted during the windshield survey.

After examining water quality and land uses throughout the Fawn River watershed it can be determined that the problems and concerns contributing to water quality impairments within the watershed vary from sub-watershed to sub-watershed. As stated above, sub-watersheds with a populated area located within the boundaries show a higher concentration of *E. coli*, and TDS, than is typically found in the more rural sub-watersheds. Conversely, the more rural sub-watersheds typically show higher concentrations of phosphorus and nitrates (with the exception of Wegner Ditch where the nitrates exceeded the target in 86% of the samples). This indicates that each sub-watershed will need to be addressed individually to address the varying sources of water impairment across the Fawn River Watershed.

Land uses throughout the watershed are primarily row crops, and pasture fields. The soils within the project area are ideal for row crops as they are nutrient rich soils; however there is a significant amount of farm land that is still being conventionally tilled on HEL and/or PHEL. Most crop fields within the watershed do not have winter cover crops planted, are farmed directly up to the streambank which lack an adequate riparian buffer to prevent soil erosion and absorb polluted runoff. Since so much of the watershed is rural, it can be assumed that on-site sewage treatment is prevalent throughout the watershed. Though, there are 14 built-up lakes within the Fawn River Watershed that are not connected to a centralized sewer system and may be leaking directly into the lake. This poses a threat to water quality as over 91% of the soils in the watershed are classified as not suitable for septic placement.

The windshield survey revealed several possible contributors to the degradation of water quality in the Fawn River watershed including mowed residential lawns that have little to no riparian and/or shoreline buffer. Often times, stormwater runoff from urban areas can carry bacteria from pet waste and excess fertilizer and pesticides, as well as road salt, oil and grease and other pollutants. These urban issues transcend to the lake communities as well. However, lake residents can exacerbate the problems by installing hard surface seawalls which can increase erosion, as well as not provide the vegetation necessary to decrease the velocity of storm flow carrying nutrients, bacteria and other pollutants, prior to it discharging into the lake. Some more direct sources of pollution identified during the windshield and desktop survey are; two sites where livestock have direct access to open water and two sites with pasture runoff, 49,027 linear feet of riparian buffer needed where slight erosion is beginning to occur as well, 4,465 feet of streambank with severe erosion, 56,210.26 feet of stream that has been tiled and would benefit from being daylighted, a culvert under a bridge providing a barrier for fish migration, nearly 15,373 acres of wetland lost since pre-settlement times, and extensive irrigation use, especially in St. Joseph County. Each of these sites and observations made during the windshield survey provide a direct means for pollution to enter surface water and can be remediated with the implementation of BMPs.

Figure 3.65: Land Use and Water Quality Summary of the Fawn River Watershed



3.6 Analysis of Stakeholder Concerns

Stakeholders in the Fawn River Watershed expressed concerns regarding water quality and land uses during the public meeting held in 2013 and additional concerns were raised after performing the watershed inventory. These concerns are outlined in Table 3.6.1, as well as whether or not the concerns are supported by the collected data, quantifiable, outside the scope of this project, and whether or not the steering committee would like to focus on the concerns. The evidence found during the watershed inventory was presented to the steering committee at a meeting in August 2014. The steering committee expressed that focus should be placed on all the concerns outlined in the table, as each concern poses a threat to water quality.

Table 3.6.1: Analysis of Stakeholder Concerns

Concerns	Supported by Data?	Evidence	Able to Quantify?	Outside Scope?	Group Wants to Focus On?
Livestock access to open water	Yes	All sub-watersheds had sample sites that exceeded the target for E. coli, TP, and nitrates. Two sites were noted during the windshield survey where livestock have access to open water. More may be present in the watershed as the survey took place from the road only. (Himebaugh Drain and Tamarack Lake)	Yes	No	Yes
Stormwater runoff from livestock operations	Yes	All sub-watersheds had sample sites that exceeded the target for E. coli, TP, and nitrates. Four sites (including the two livestock access sites) were noted during the windshield survey where livestock operations had a direct influence on water quality through stormwater runoff from pastures and/or barnyards. (Clear Lake, Himebaugh Drain and Tamarack Lake) There are also four CFOs with the potential to have manure runoff. (Himebaugh Drain and Wegner Ditch)	Yes	No	Yes
Increase in impervious surfaces	Yes	While specifics were not able to be obtained to determine the increase in imperviousness within the Fawn River, stakeholder observations have concluded that there is an increase in impervious surface, especially around the lakes. Observations made during the windshield survey verify stakeholder claims, as many new homes were being erected around the lakes. Also, the Fawn River Crossing on SR 9, south of Sturgis is relatively new, and includes an industrial park, as well as truck stop and other businesses. Sub-watersheds with populated areas had increased TDS readings compared to less urbanized sub-watershed (Snow Lake, Lake James, and Wegner Ditch)	Yes	No	Yes

Concerns	Supported by Data?	Evidence	Able to Quantify?	Outside Scope?	Group Wants to Focus On?
Fertilizer used on urban lawns	Yes	All sub-watersheds had sample sites that exceeded the target for TP, and nitrates. Specific information regarding fertilizer use on urban lawns is unobtainable at this time, however, the lakes are surrounded by lush green turf grasses, and many residential properties also have lush turf grass lawns which indicate the use of fertilizer. Also, many homes were observed to have the flags in their lawns advertising a commercial fertilizer service, many of which routinely apply fertilizer six times annually without soil samples to determine the correct application amount for each individual lawn.	Yes	No	Yes
Lakes in the area becoming more developed	Yes	While specifics were not able to be obtained to determine the increase in imperviousness within the Fawn River, stakeholder observations have concluded that there is an increase in impervious surface, especially around the lakes. Observations made during the windshield survey verify stakeholder claims, as many new homes were being erected around the lakes.	Yes	No	Yes
Septic system discharge	Yes	All sub-watersheds had sample sites that exceeded the target for E. coli, TP, and nitrates. Nearly 85% of the soils are classified by the NRCS as being very limited for septic usage and nearly 7% are classified as somewhat limited for septic usage. US EPA estimates that 25% of households utilize on-site waste disposal systems with up to 5% of those failing. The National Environmental Service Center estimates up to 30% of all systems are failing.	Yes	No	Yes
Lack of no-till and cover crop practices	Yes	All sub-watersheds except Town of Orland, Wegner Ditch, and Sherman Mill Creek has water quality results for turbidity and TSS that were greater than the target level. Estimates for MI counties could not be obtained but only 2% of all crops in Steuben County and 19% of all crops in LaGrange County use cover crops. 31% of corn in Steuben and LaGrange counties are in no-till and 68% and 63% of beans in Steuben and LaGrange counties, respectively, are in no-till.	Yes	No	Yes

Concerns	Supported by Data?	Evidence	Able to Quantify?	Outside Scope?	Group Wants to Focus On?
Wetland Conservation	Yes	According to the NWI, approximately 16% of the watershed is considered to be wetland. The Friends of the St. Joseph River Association - Wetland Partnership estimates nearly a 53% decrease in wetlands since presettlement time. Comparing pre-settlement wetland data to 2005 data, the Fawn River watershed has lost approximately 11,000 acres of wetlands within that time. Four species that rely on wetlands for habitat are on the federal endangered species list. Functional use loss data shows that a WQ filtering functional use loss of between 21% in Snow Lake sub-watershed and 59% in the Fawn River Drain sub-watershed and a habitat functional use loss of between 21% in Tamarack Lake sub-watershed and 73% in the Fawn River Drain sub-watershed.	Yes	No	Yes
Stream Bank Erosion	Yes	All sub-watersheds had sample sites that exceeded the target levels for TSS and turbidity, except for Town of Orland, Wegner Ditch, and Sherman Mill Creek. The windshield and desktop surveys revealed a lack of riparian buffer which also exhibited slight erosion, including 2,176 linear feet in residential areas, and 49,027 linear feet in agriculture areas. 4,465 linear feet of moderate to severe bank erosion was also observed during the windshield survey.	Yes	No	Yes
Tiled Streams in Ag fields and un-buffered tile inlets	Yes	All sub-watersheds had sample sites that exceeded nitrate, TP, and E. coli targets and all sub-watersheds, except Town of Orland, Wegner Ditch, and Sherman Mill Creek, had sample sites that exceeded the targets for TSS, and turbidity. County surveyors in Steuben and LaGrange County manage 233,270.4 feet of tiled drains, and the windshield and desktop surveys revealed 46,796 feet of stream that has been tiled as it is no longer visible on the surface and the National Hydrologic Dataset has the streams marked as being present. An inventory of tile inlets has not been performed in the Fawn River watershed, however many un-buffered inlets were observed during the windshield survey.	Yes	No	Yes

4.0 Pollution Sources and Loads

4.1 Potential Causes of Water Quality Problems

In this section concerns identified by stakeholders in the watershed and through the watershed inventory will be linked to problems found through the watershed investigation. Additionally, potential causes for the problems identified will be expressed. Finally, potential sources will be identified. Table 4.1.1 shows the connection between those concerns the stakeholders have chosen to focus efforts on, problems found in the watershed, and the potential causes of those problems.

Table 4.1.1: Connection between Stakeholder Concerns, Problems, and Potential Causes

Concern(s)	Problem	Potential Cause(s)
- Livestock Access to open water - Stormwater runoff from livestock operations - Lakes in the area becoming more built-up - Septic system discharge - Tiled streams in ag. fields and un-buffered tiled inlets - Wetland Conservation	High levels of E. coli were discovered in areas streams after reviewing historic and current water quality data	- E. coli levels exceed the state standard - Area producers are unaware of the water quality threat of not having adequate manure storage and allowing livestock access to open water - There is a lack of education and outreach regarding septic management - There has been little effort to address urban issues in the watershed - There is a lack of education and outreach regarding urban stormwater issues
- Livestock Access to open water - Stormwater runoff from livestock operations - Lakes in the area becoming more built-up - Septic system discharge - Tiled streams in ag. fields and un-buffered tiled inlets - Increase in impervious surfaces - Fertilizer used on urban lawns - Lack of no-till and cover crop practices - Wetland Conservation	Area streams have nutrient levels exceeding the target level set by this project	- Nitrogen levels exceed the target set by this project - Phosphorus levels exceed the target set by this project - There is a lack of education and outreach regarding septic maintenance - There has been little effort to address urban issues in the watershed - Area producers are unaware of the cumulative effects of best management practices - Livestock operators are unaware of the effects to water quality from “traditional” management techniques used in the watershed

Concern(s)	Problem	Potential Cause(s)
- Septic system discharge	Historic design and lack of maintenance of septic systems is an issue in the watershed	- There is a lack of education and outreach regarding septic system maintenance
- Livestock access to open water - Stormwater runoff from livestock operations - Lack of no-till and cover crop practices - Wetland conservation - Streambank erosion - Tiled Streams in Ag. fields and un-buffered tile inlets	Best management practices to limit nonpoint source pollution are underutilized in the watershed	- There is a lack of education and outreach regarding the benefits of best management practices - Area producers are unaware of the cumulative effects of best management practices
- Streambank Erosion - Wetland Conservation - Lack of no-till and cover crop practices - Tiled streams in ag. fields and un-buffered tile inlets - Livestock access to open water - Stormwater runoff from livestock operations - Increase in impervious surfaces - Fertilizer used on urban lawns - Lakes in the area becoming more built-up - Septic system discharge	Sections of the Fawn River and its tributaries are listed as impaired on the IN or MI 303(d) list for IBC	- There has been little effort to address urban issues in the watershed - There is a lack of education and outreach regarding the benefits of best management practices - There is a lack of education and outreach regarding septic system maintenance - Area producers are unaware of the cumulative effects of best management practices - Livestock operators are unaware of the effects to water quality from “traditional” management techniques used in the watershed such as direct access to open water - Nutrient and *E. coli* levels exceed the targets set by this project - CQHEI scores were very low for several water quality sampling sites throughout the watershed - Lack of stream buffers/filter strips

Concern(s)	Problem	Potential Cause(s)
- Stream bank erosion - Wetland Conservation - Lakes in the area becoming more developed - Increase in impervious surfaces	Ten species in the watershed are on the Federal Endangered Species list	- Nitrates and phosphorus exceeded the target set by this project, thus lowering the quality of aquatic habitat - Lack of riparian buffer for adequate habitat - Land conversion / segmentation - CQHEI scores were very low for several water quality sampling sites throughout the watershed

4.2 Potential Sources Resulting in Water Quality Impairment

Now that stakeholder concerns have been linked to water quality problems and potential causes of those problems, and a thorough watershed inventory has been conducted, sources to the problems can be determined. Outlining the sources to the problems found in the watershed will help to narrow the land area of where to focus implementation efforts to have the greatest impact on improving water quality in the Fawn River Watershed. Table 4.2.1 lists the problems, potential cause(s), and potential source(s) of the problems.

Table 4.2.1: Problems, Causes, and Sources

Problem	Potential Cause(s)	Potential Source(s)
High levels of E. coli were discovered in areas streams after reviewing historic and current water quality data	- E. coli levels exceed the state standard - Area producers are unaware of the water quality threat of not having adequate manure storage and allowing livestock access to open water - There is a lack of education and outreach regarding septic management - There has been little effort to address urban issues in the watershed - There is a lack of education and outreach regarding urban stormwater issues	- Pet waste in urban areas including built-up lakes and Fremont, Angola, Sturgis, Constantine, and Orland - It is estimated that greater than 25% of the households in the watershed are utilizing on-site waste disposal and up to 5% of those are failing - Many built-up lakes utilize on-site waste disposal (Snow Lake sub-watershed-3 lakes, Tamarack Lake sub-watershed-2 lakes, Himebaugh Drain sub-watershed-4 lakes, Clear Lake sub-watershed-3 lakes, Wegner Ditch sub-watershed-1 lake, Sherman Mill Creek sub-watershed-3 lakes) - Over 84% of the soils in the watershed are considered to be very limited for septic system placement and over 6% is considered somewhat limited for septic placement - There are four CFOs located in the watershed totaling 250,000 animals (Wegner Ditch, and Himebaugh Drain) which produces multiple tons of manure each year that may be land applied in an unsustainable manner, during wet weather, on frozen ground, or in close proximity to open water - Livestock access to open water (Lake James-1, Himebaugh Drain-1) - Pasture runoff issues (Clear Lake-2)

Problem	Potential Cause(s)	Potential Source(s)
Area streams have nutrient levels exceeding the target level set by this project	- Nitrogen levels exceed the target set by this project - Phosphorus levels exceed the target set by this project - There is a lack of education and outreach regarding septic maintenance - There has been little effort to address urban issues in the watershed - Area producers are unaware of the cumulative effects of best management practices - Livestock operators are unaware of the effects to water quality from "traditional" management techniques used in the watershed	- Lack of proper management measures on ag. land on PHEL (6.05% of soils) and HEL (20.17% of soils) - It is estimated that greater than 25% of the households in the watershed are utilizing on-site waste disposal and up to 5% of those are failing - Many built-up lakes utilize on-site waste disposal (Snow Lake-3, Tamarack Lake-2, Himebaugh Drain-4, Clear Lake-3, Wegner Ditch-1, Sherman Mill Creek-3) - Over 84% of the soils in the watershed are very limited for septic system placement and over 6% is considered somewhat limited for septic placement - Pasture runoff issues (Clear Lake) - Livestock with direct access to open water (Lake James, Himebaugh Drain) - 49% of the watershed is in cultivated crops which are fertilized to promote plant growth. Unsustainable farming techniques increase fertilizer runoff - 13% of the watershed is developed. Over fertilization of turf grass leads to excess fertilizer runoff - Over fertilization of turf grass at lake properties on the 32 built-up lakes in the watershed (Snow Lake, Lake James, Tamarack Lake, Himebaugh Drain, Clear Lake, Wegner Ditch, and Sherman Mill Drain sub-watersheds) - Excessive use of irrigation without irrigation management plans in place throughout the watershed - Only 8% of corn and 13% of bean fields also utilize cover crops which aids in nutrient uptake and prevents soil erosion - 56,796 lf of natural streams have been tiled in ag fields which, if not properly managed and buffered, allow for nutrients to leach through the tiles - 20% of corn fields in Steuben and 54% in LaGrange are conventionally tilled (4% and 24%, respectively for beans).

Problem	Potential Cause(s)	Potential Source(s)
Historic design and lack of maintenance of septic systems is an issue in the watershed	- There is a lack of education and outreach regarding septic system maintenance	- There is a lack of education and outreach regarding septic system maintenance - Over 84% of the soils in the watershed are considered to be very limited for septic system placement and over 6% is considered somewhat limited for septic placement - It is estimated that greater than 25% of the households in the watershed are utilizing on-site waste disposal and up to 5% of those are failing - Many built-up lakes utilize on-site waste disposal (Snow Lake-3, Tamarack Lake-2, Himebaugh Drain-4, Clear Lake-3, Wegner Ditch-1, Sherman Mill Creek-3)
Best management practices to limit nonpoint source pollution are underutilized in the watershed	- There is a lack of education and outreach regarding the benefits of best management practices - Area producers are unaware of the cumulative effects of best management practices	- There is a lack of education and outreach regarding the benefits of best management practices - Federal and local funding for the implementation of agricultural management measures have been cut significantly over the past decade including Farm Bill programs such as CREP, CRP and WRP, Counties have lowered funding to SWCDs, LARE, 319, and GLRI and GLC funding is not consistent - There is limited education and outreach regarding urban best management practices and stormwater control
Sections of the Fawn River and its tributaries are listed as impaired on the IN or MI 303(d) list for IBC, Mercury and PCBs in Fish Tissue	- There has been little effort to address urban issues in the watershed - There is a lack of education and outreach regarding the benefits of best management practices - There is a lack of education and outreach regarding septic system maintenance - Area producers are unaware of the cumulative effects of	- Lack of proper management measures on agriculture land on PHEL (6.05% of soils) and HEL (20.17% of soils) in the watershed - It is estimated that greater than 25% of the households in the watershed are utilizing on-site waste disposal and up to 5% of those are failing - Many built-up lakes utilize on-site waste disposal (Snow Lake-3, Tamarack Lake-2, Himebaugh Drain-4, Clear Lake-3, Wegner Ditch-1, Sherman Mill Creek-3)

Problem	Potential Cause(s)	Potential Source(s)
Sections of the Fawn River and its tributaries are listed as impaired on the IN or MI 303(d) list	best management practices - CQHEI scores were very low for several water quality sampling sites throughout the watershed - Livestock operators are unaware of the effects to water quality from "traditional" management techniques used in the watershed direct access to open water - Nutrient and E. coli levels exceed the targets set by this project	- Over 84% of the soils in the watershed are considered to very limited for septic system placement and over 6% is considered somewhat limited for septic placement - Pasture runoff issues (Clear Lake -2) - Livestock with direct access to open water (Lake James - 1 and Himebaugh Drain - 1) - 49% of the watershed is in cultivated crops which are fertilized to promote plant growth. Unsustainable farming techniques increase fertilizer runoff - 13% of the watershed is developed. Over fertilization of turf grass leads to excess fertilizer runoff - Over fertilization of turf grass and extensive use of seawalls at lake properties on the 32 built-up lakes in the watershed (Snow Lake, Lake James, Tamarack Lake, Himebaugh Drain, Clear Lake, Wegner Ditch, and Sherman Mill Drain sub-watersheds) - Excessive use of irrigation without irrigation management plans in place throughout the watershed - Only 8% of corn and 13% of bean fields utilize cover crops which aids in nutrient uptake and prevents soil erosion - 56,796 lf of natural streams have been tiled in ag fields which, if not properly managed and buffered, allow for nutrients to escape the fields through the tiles - There are four CFOs located in the watershed totaling 250,000 animals (Wegner Ditch, and Himebaugh Drain) which produces multiple tons of manure each year that may be land applied in an unsustainable manner, during wet weather, on frozen ground, or to close to open water - There is a lack of riparian buffer on 49,027 lf of stream within the ag. community and 2,176 lf in the urban areas

Problem	Potential Cause(s)	Potential Source(s)
Sections of the Fawn River and its tributaries are listed as impaired on the IN or MI 303(d) list		- 74% of the corn fields and 28% of the bean fields between Steuben and LaGrange counties utilize conventional tillage techniques
Ten species in the watershed on the Federal Endangered Species list	- Nitrates and phosphorus exceeded the target set by this project, thus lowering the quality of aquatic habitat - Lack of riparian buffer for adequate habitat - Land conversion / segmentation	- The watershed has lost a 39% of the presettlement wetlands equaling a habitat functional use loss of 44%. - The windshield survey revealed 51,203 lf of stream lacking a riparian buffer, most of which also exhibited slight to moderate streambank erosion - Less than 9% of the watershed is considered to be forested

4.3 Pollution Loads and Necessary Load Reductions

After close review of historic water quality data from the IDEM, Steuben County Lakes Council, MI DEQ, and current water quality data collected by the Fawn River Project as part of the development of this WMP, for consistency of parameters measured in each of the sub-watersheds, as well as quality assurance techniques and weather conditions, pollution loads and subsequent load reductions would be based on data collected by the FRP only, which was funded through the 319 grant used for this project. Current pollution loads were determined for each HUC12 sub-watershed, and when compared to the water quality targets set by the Fawn River steering committee and outlined in Section 3, provides detail on how much pollution loads will need to be reduced to meet the targets set for the project area.

Water quality samples were taken by the FRP from 54 sites; several sites in each of the nine HUC12 sub-watersheds. Adequate water quality samples were taken to provide a baseline look at water quality in each of the sub-watersheds. Current pollution loads and load reductions were analyzed for nitrate, total phosphorus, TSS and TDS only, as turbidity and *E.coli* loads cannot be accurately determined, and loads determined for the other parameters measured by the Initiative as part of this project would not be useful to this project. However, it is important to note that both turbidity and *E. coli* are a concern of the Fawn River steering committee.

Loads were determined by using the following equation; (cfs * (X * 0.001) * 984.2589781), where cfs equals the average flow of the stream measured in cubic feet per second, X equals the average parameter measurement in mg/l, and 984.2589781 is the conversion factor used to make the outcome equal tons per year. Table 4.3.1 is a reminder of the target concentrations for each of the parameters of concern that were set by this project's steering committee. Table 4.3.2 through Table 4.3.5 show the current and target loads and load reductions needed for nitrate, total phosphorus, TDS, and TSS, respectively. Turbidity and E. coli, while loads cannot be determined, are important parameters to consider when evaluating the health of the watershed. Turbidity is an indicator of sediment, as well as other pollutants that can cause water to become murky and inhibit plant growth and effect aquatic habitat and *E. coli* is used as an indicator to determine the amount of fecal material making its way to open water. Therefore, Table 3.4.6 shows the average concentration of turbidity and *E. coli* for each sub-watershed as well as the percentage of target concentration exceedance per sub-watershed.

Table 4.3.1: Target Concentration for Parameters of Concern

Parameter of Concern	Target Concentration
Nitrate	< 1.5 mg/l
Total Phosphorus	< 0.08 mg/L (tributaries) and <0.3 mg/L (mainstem)
Total Dissolved Solids	< 750 mg/l
Total Suspended Solids	< 20 mg/l
Turbidity	< 10.4 NTU
E. coli	< 235 CFU/100ml

Table 4.3.2: Nitrate Pollution Load Reductions Needed to Meet Target Loads

Subwatershed		Mean Flow (ft^3/sec)	Nitrate (tons/year)		
HUC	Name		Current	Target	Reduction Needed
040500010801	Snow Lake	5.96	6.9	8.8	0
040500010803	Lake James	35.53	36.28	52.45	0
040500010802	Tamarack Lake	39.24	48.9	57.9	0
040500010804	Town of Orland	39.24	50.68	57.93	0
040500010805	Himebaugh Drain	10.76	23.14	15.89	7.25
040500010806	Clear Lake	123.78	208.64	182.75	25.89
040500010807	Wegner Ditch	156.91	429.12	231.66	197.46
040500010808	Sherman Mill Creek	111.51	329.51	164.63	164.87
040500010809	Fawn River Drain	247.02	454.3	364.69	89.6
		Total	**1587.47**	**1136.7**	**485.07**

Table 4.3.3: Phosphorus Pollution Load Reductions Needed to Meet Target Loads

Subwatershed		Mean Flow (ft^3/sec)	Total Phosphorus (tons/year)		
HUC	Name		Current	Target	Reduction Needed
040500010801	Snow Lake	5.96	1.4	0.5	0.9
040500010803	Lake James	35.53	5.59	2.79	2.79
040500010802	Tamarack Lake	39.24	7.3	3.09	4.21
040500010804	Town of Orland	39.24	7.52	3.09	4.43
040500010805	Himebaugh Drain	10.76	2.16	0.85	1.32
040500010806	Clear Lake	123.78	27.16	36.55	0
040500010807	Wegner Ditch	156.91	35.47	46.33	0
040500010808	Sherman Mill Creek	111.51	19.22	32.93	0
040500010809	Fawn River Drain	247.02	57.59	72.94	0
		Total	**163.41**	**199.07**	**13.65**

Table 4.3.4: Total Dissolved Solids Pollution Load Reductions Needed to Meet Target Loads

Subwatershed		Mean Flow (ft^3/sec)	Total Dissolved Solids (tons/year)		
HUC	Name		Current	Target	Reduction Needed
040500010801	Snow Lake	5.96	3282.14	4250	0
040500010803	Lake James	35.53	20371.17	26227.24	0
040500010802	Tamarack Lake	39.24	19866.94	28966.74	0
040500010804	Town of Orland	39.24	21911.73	28963.17	0
040500010805	Himebaugh Drain	10.76	6456.893	7946.292	0
040500010806	Clear Lake	123.78	65851.24	91377.07	0
040500010807	Wegner Ditch	156.91	94762.78	115830.1	0
040500010808	Sherman Mill Creek	111.51	49048.16	82317.37	0
040500010809	Fawn River Drain	247.02	134942.6	182346.1	0
		Total	**416493.653**	**568224.082**	**0**

Table 4.3.5: Total Suspended Solids Pollution Load Reductions Needed to Meet Target Loads

Subwatershed		Mean Flow (ft^3/sec)	Total Suspended Solids (tons/year)		
HUC	Name		Current	Target	Reduction Needed
040500010801	Snow Lake	5.96	47.2	117.3	0
040500010803	Lake James	35.53	151.54	699.39	0
040500010802	Tamarack Lake	39.24	242.3	772.45	0
040500010804	Town of Orland	39.24	170.58	772.35	0
040500010805	Himebaugh Drain	10.76	66.72	211.9	0
040500010806	Clear Lake	123.78	728.45	2436.63	0
040500010807	Wegner Ditch	156.91	874.24	3088.8	0
040500010808	Sherman Mill Creek	111.51	336.58	2195.13	0
040500010809	Fawn River Drain	247.02	1904.53	4862.56	0
		Total	**4522.14**	**15156.51**	**0**

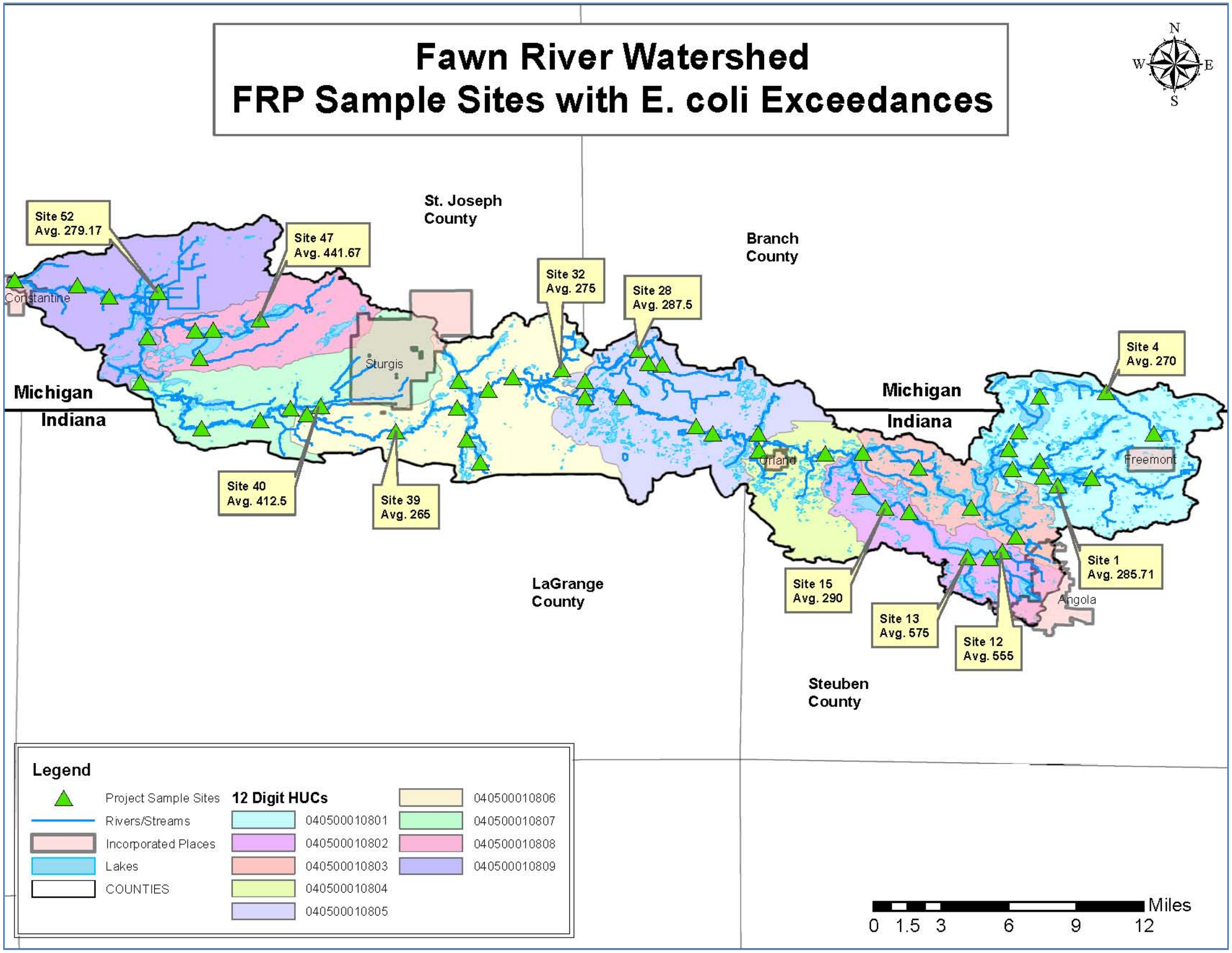
Table 3.4.6: E. coli and Turbidity Concentrations and Percent Exceedance per Sub-watershed

Sub-watershed	Parameter			
	E. coli		Turbidity	
	CFU	%	NTU	%
Snow Lake	257.02	22	2.4	4
Lake James	193.01	16	4.78	13
Tamarack Lake	499.3	44	3	3
Town of Orland	77.15	13	2	0
Himebaugh Drain	115.5	13	3.27	2
Clear Lake	146.35	19	2.58	1
Wegner Ditch	177.68	26	2.95	0
Sherman Mill Drain	168.89	17	1.18	0
Fawn River Drain	132.41	17	3.35	4

*The concentrations highlighted in pink either exceeded the target for that parameter or the percentage of exceedances was greater than 20%.

Examining the average *E. coli* levels for each sub-watershed does provide information about which sub-watersheds may have the most problem with *E. coli* contamination; however there are several Fawn River Project sample sites that also had average *E.coli* measurements that exceeded the state standard. The drainage area to those sample sites should be considered for the remediation of potential *E.coli* pollution sources. Figure 4.1 shows the location of the FRP sample sites, with the sites that had high *E.coli* measurements labeled with what the average *E. coli* measurements were for that site.

Figure 4.1: Fawn River Project Sample Sites with E.coli Exceedances



5.0 Critical Areas

Critical areas are defined by IDEM as those areas that have been identified through historical studies, land use information, and water quality data, in the project area as needing implementation efforts to improve current water quality or that will mitigate the impact of potential sources of NPS to protect water quality. This Section will identify the critical areas within the Fawn River Watershed and outline the reason why those areas are most important to focus implementation efforts.

5.1 Critical Areas to Focus Implementation Efforts.

Identifying critical areas and goals to address those critical areas will focus efforts in the watershed on the areas that will have the greatest impact on improving water quality in the Fawn River Watershed. Please note that if there are several areas that are considered critical for a particular practice or parameter, a "priority" may be assigned to those areas so that implementation efforts will be focused on the areas that will have the biggest impact on water quality first. Once all possible implementation efforts have been exhausted in Priority Area 1, efforts will be focused on Priority Area 2, and so on.

5.1.1 Pollutant Based Critical Areas

The Fawn River Watershed Steering Committee expressed concern regarding several problems, land uses and practices that can be observed throughout the watershed that may be contributing to the high nutrient and bacteria levels demonstrated by water quality data. These problems include runoff from livestock operations, increase in impervious surfaces, fertilizer used on urban lawns, increased development on built-up lakes, septic system discharge, lack of conservation tillage and cover crop practices, wetland conservation, streambank erosion and sedimentation. An additional issue was discovered during the windshield survey that may contribute to high nutrient levels; unbuffered tiled inlets and tiled ditches and streams through agriculture fields. Analysis of water quality data show that nitrate and phosphorus load reductions are needed throughout the project area. Additionally, there are several water quality sample sites spread throughout the watershed, except for in the Town of Orland and Lake James-Crooked Creek sub-watershed, whose *E. coli* averages exceed the state standard of 235 cfu/100ml.

The windshield survey conducted as part of this project revealed several areas of concern to help validate stakeholder concerns. It was also noted during the survey that many streams and ditches have been straightened and have lost their natural shelf and flood plain and much of the woody riparian area has been cleared, thus many area ditches and streams are lacking an adequate riparian buffer to reduce the pollutant loading to the stream. This practice does a great job to quickly move water away from farm fields; however it also increases stream flow causing bank erosion further downstream, increases water temperatures, and decreases aquatic and riparian habitat. In addition to those areas, 74% of the corn fields and 28% of the bean fields within Steuben and LaGrange counties utilize conventional tillage techniques, which allows for surface flow of sediment, fertilizers, and pesticides to discharge into open water.

The land cover of the Fawn River watershed is 13% urban due to the fact that Angola, Fremont, Orland, and Sturgis are all fully or mostly located within the watershed. Additionally, there are 37 built-up lakes within the watershed where heavy lawn fertilizer use is common practice. Sea walls are also common along the shorelines of the lakes, which allows for runoff from turf grass to run directly into the lakes, increases wave action which may contribute to more shoreline erosion, as well as stir up settled sediment carrying nutrients that then get released into open water.

There were only four livestock issues observed during the windshield survey which were located within the Lake James – Crooked Creek, Himebaugh Drain, and Clear Lake sub-watersheds. Therefore, it can be assumed that much of the high *E. coli* levels measured throughout the watershed are from leaking septic systems, wildlife, improperly applied manure as fertilizer, or pet waste runoff from urban lawns; however livestock are an obvious contributor of excessive nutrients and *E. coli* at the sample sites directly downstream of the four livestock issues that were observed in the project area.

For the reasons listed above, the FRP Steering Committee has decided to make certain sub-watersheds critical for implementation of BMPs to reduce nutrient loadings based on water quality data, necessary load reductions to meet water quality targets, and observations made during the windshield survey, as well as the likelihood that BMPs will be accepted by landowners within the sub-watershed. Table 5.1 lists each sub-watershed, the calculated load reduction for each, and the priority given to each sub-watershed for implementation efforts to mitigate the nutrient loads reaching open water. Priorities were determined based on the extent of the load reduction needed and the number of parameters that need to be addressed. Due to previous experience working with landowners within these subwatersheds by area conservation districts and NRCS offices, priorities were also based on the likelihood of being successful in implementation efforts in each sub-watershed. Each sub-watershed will be addressed differently, and implementation efforts for each sub-watershed will be discussed in Section 7.

Table 5.1: Implementation Prioritization for Nutrient Load Based Critical Areas

Sub-watershed	Load Reduction (Tons/year)		Implementation Priority
	Nitrates	TP	
Himebaugh Drain	7.25	1.32	1
Wegner Ditch	197.46	0	1
Sherman Mill Drain	164.87	0	1
Fawn River Drain	89.6	0	1
Tamarack Lake	0	4.21	2
Clear Lake	25.89	0	2
Town of Orland	0	4.43	2
Lake James	0	2.79	2
Snow Lake	0	0.9	[redacted]

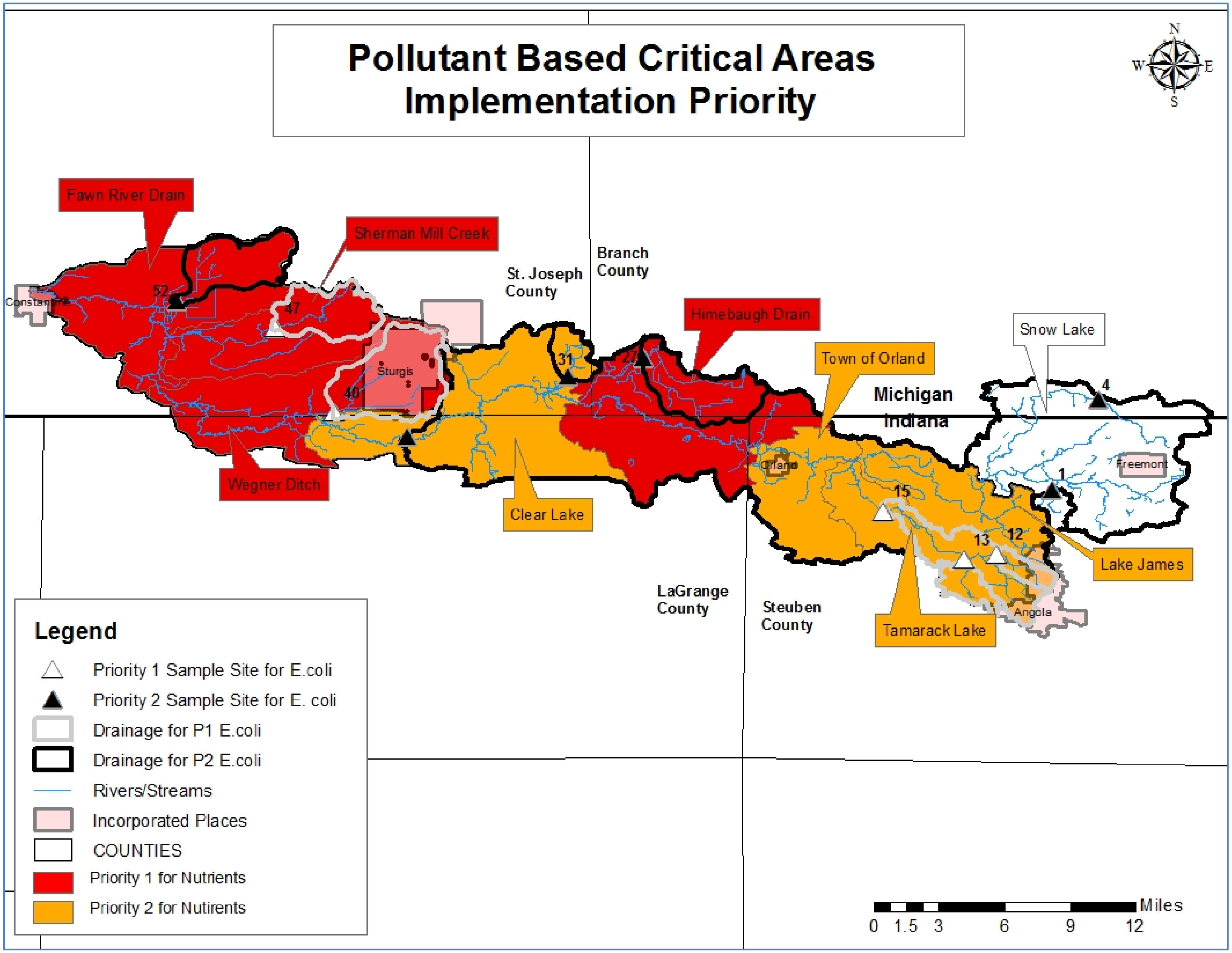
Critical areas for *E. coli* were determined based on those sub-watersheds that contained water quality samples sites whose average measurement was greater than the state standard of 235 cfu/100ml. The high *E. coli* measurements are likely due to leaking or failed septic systems, pet waste from urban lawns, or livestock. Table 5.2 lists the subwatersheds, as well as the sample site numbers within those sub-watersheds whose *E. coli* averages were greater than the state standard and whose drainage area is considered to be critical for education and outreach regarding septic system maintenance, pet waste disposal, and BMPs to lessen the impact of livestock operations and manure used as fertilizer. Priority of implementation efforts were determined based on the amount in which the sample averages exceeded the state standard and the likelihood of landowners to adopt various BMPs.

Table 5.2: Implementation Prioritization for E. coli Based Critical Areas

Sub-watershed	E. coli Averages Greater than Target by Site	Implementation Priority
Tamarack Lake	Site 12 - 555 cfu/100ml Site 13 - 575 cfu/100ml Site 15 - 290 cfu/100ml	1
Sherman Mill Drain	Site 47 - 441.67 cfu/100ml	1
Wegner Ditch	Site 40 - 412.5 cfu/100ml	1
Himebaugh Drain	Site 28 - 287.5 cfu/100ml	2
Snow Lake	Site 1 - 285.71 cfu/100ml Site 4 - 270 cfu/100ml	2
Fawn River Drain	Site 52 - 279.17 cfu/100ml	2
Clear Lake	Site 32 - 275 cfu/100ml Site 39 - 265 cfu/100ml	2
Town of Orland	0	[redacted]
Lake James	0	[redacted]

Figure 5.1, below, shows the location of critical sample sites for pollutants (nitrogen, phosphorus, and *E. coli*). Sub-watersheds in red are priority one for addressing nutrients, and those in orange are priority two. The USGS Stream Stats program is able to delineate drainage areas to a particular point for many states; however, it is not able to do so for points located in MI. Therefore, the following map has actual delineations for the drainage areas to the critical sample sites for *E. coli* in IN, and an approximate drainage area was drawn on the map for those critical sample sites for *E. coli* located in MI.

Figure 5.1: Implementation Priority for Pollutant Based Critical Areas



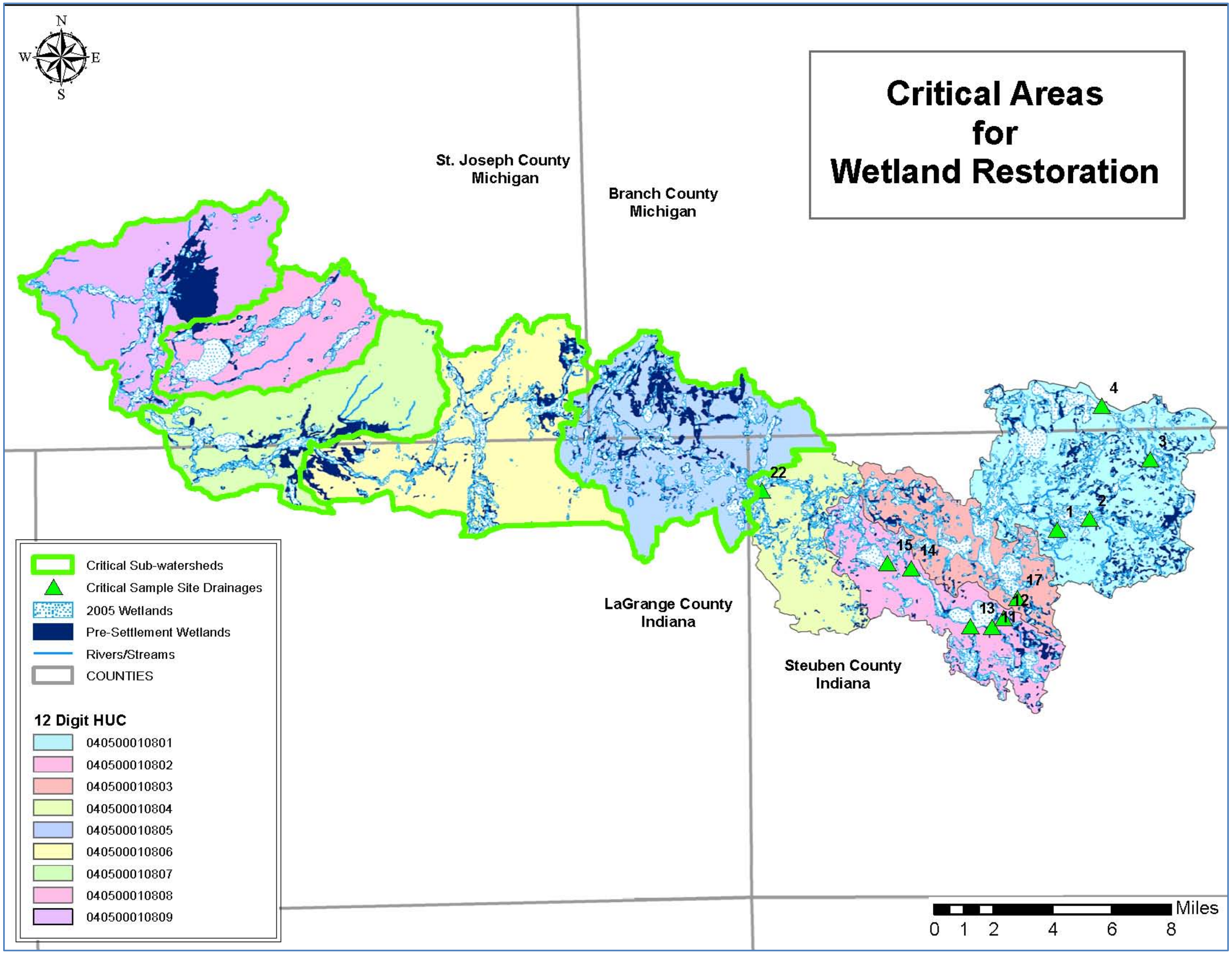
5.1.2 Wetland Based Critical Areas

Wetlands play an important role in the natural environment as they provide prime habitat for many species of flora and fauna, including eight of the ten endangered species listed in Section 2.7. Wetlands also act as sponges absorbing excess nutrients preventing its discharge into lakes and streams, as well as absorbing the impact of floodwaters which can prevent damage to homes and other structures. The wetland functional use study outlined in Section 2.4.3, and in each sub-watershed under Section 3.4, determined that the Fawn River Watershed has lost 40% of its floodwater control, 36% of its shoreline stabilization, 44% of its habitat, 36% of its combined water quality functional use, and 61% of its ability to retain harmful pathogens. Therefore, it is important to protect the remaining wetlands and restore wetlands that have disappeared since the last National Wetland Inventory was conducted in 1979. Protecting existing wetlands, especially in the more populated areas will help to mitigate any flooding issues as area lakes become more built-up and help to absorb nutrients and pathogens from leaking on-site waste disposal systems and fertilizer runoff. Restoring the wetlands present before settlement of the area will play an important role in improving water quality in the Fawn River Watershed's streams and lakes. Table 5.3 lists the sub-watersheds within the Fawn River Watershed and the percent of functional use loss since pre-settlement times for water quality and habitat in each sub-watershed. Note the last column in the Table shows the priority level given to each sub-watershed based on the functional use loss and the water quality data collected as part of this project. Figure 5.3 is a map depicting the 1979 NWI with the 2005 wetland inventory overlaid on top. The dark blue wetland areas visible in the map are critical for wetland restoration.

Table 5.3: Implementation Prioritization for Wetland Restoration Critical Areas

Sub-watershed	Wetland Functional Use Loss		Implementation Priority
	Water Quality	Habitat	
Clear Lake	47%	53%	1
Sherman Mill Creek	47%	61%	1
Fawn River Drain	59%	73%	1
Himebaugh Drain	42%	44%	1
Wegner Ditch	43%	43%	1
Town of Orland	32%	36%	2
Snow Lake	21%	28%	2
Lake James	29%	25%	2
Tamarack Lake	22%	21%	2

Figure 5.3: Critical Areas for Wetland Restoration



6.0 Goals, Management Measures, and Objectives

6.1 Goal Statements and Progress Indicators

The FRP steering committee used historic studies, land use, and water quality data, as well as current data, stakeholder input, problems found during the watershed investigation, and identified critical areas to determine overall goals for the watershed. The overarching goal of the project is to reduce pollutant loads and mitigate pollution sources so that water quality measurements will meet the project's target levels and/or state or federal water quality standards. However, to reach that principle goal of improving the quality of water in the Fawn River Watershed smaller, more attainable, goals were written. Each of the goal statements in the following Section is written to take small steps toward meeting the main goal of this project. It is also important to be able to measure the progress being made toward meeting each of the goals. Therefore, indicators were determined that will be used as a measurement tool and are listed in the following section as well.

6.1.1 Reduce Nitrogen Loading

The average historic nitrate levels measured in the Fawn River Watershed exceeded the target level in five of the nine sub-watersheds in the project area including Himebaugh Drain, Clear Lake, Wegner Ditch, Sherman mill Creek, and the Fawn River Drain sub-watersheds. The Nitrate loading calculations indicated that a combined 485.07 ton/year load reduction is needed in those sub-watershed mentioned above. To reach the target loading of 1136.7 tons/year or less, a 30.6% nitrate load reduction will need to be achieved. Much of the nitrate pollution may be coming from farm fields, urban fertilizer use, and leaking septic systems. Best management practices and an education and outreach program will need to be implemented in the critical areas identified for Nitrate loading to achieve the water quality goal for Nitrate.

<u>Goal Statement – Nitrate</u>

The goal of this project is for Nitrate levels in sampled water to be reduced by 15% within 5 years and 31% within 15 years.

<u>Indicator</u>

Water quality and administrative indicators will be used to show the progress toward meeting the goal for nitrogen levels in the Fawn River Watershed.

<u>Water Quality Indicator</u>

Nitrate will be measured at a minimum monthly throughout the year at the historic sample sites located within critical areas for nitrate. Sampling efforts will begin after three to five years of implementation. To determine if the milestones set for the nitrogen goal are being met, it would be expected to see that more water quality samples are meeting the target level for nitrate of 1.5 mg/L each year of sampling after three to five years of implementation.

Administrative Indicator
The load reductions as a result of best management practices that are installed in the watershed, as determined by the load reduction models, will be monitored to determine if the BMPs that are being installed are working adequately to reduce overall loadings of nitrate to reach the 30.6% reduction needed to meet the target load.

Administrative Indicator
The number of best management practices that can reduce nitrate levels that are installed in the watershed will be monitored. Annual goals for each of the various BMPs that can reduce nitrate levels are described in the Action register in Section 6.3.

6.1.2 Reduce Total Phosphorus Loading

The average historic total phosphorus levels measured in the Fawn River Watershed exceeded the target level in five of the nine sub-watersheds in the project area including Snow Lake, Lake James, Tamarack Lake, Town of Orland and Himebaugh Drain. The phosphorus loading calculations indicated that a combined 13.65 ton/year load reduction is needed in those sub-watersheds mentioned above. To reach the target loading of 72.94 tons/year or less, a 17.9% phosphorus load reduction will need to be achieved. Much of the phosphorus pollution may be coming from farm fields, urban fertilizer use, and leaking septic systems. Best management practices and an education and outreach program will need to be implemented in the critical areas identified for phosphorus loading to achieve the water quality goal for phosphorus.

Goal Statement – Total Phosphorus
The goal of this project is for phosphorus levels in sampled water to be reduced by 10% within 5 years and 18% within 15 years.

Indicator
Water quality and administrative indicators will be used to show the progress toward meeting the goal for total phosphorus levels in the Fawn River Watershed.

Water Quality Indicator
Phosphorus will be measured at a minimum monthly throughout the year at the historic sample sites located within critical areas for phosphorus. Sampling efforts will begin after three to five years of implementation. To determine if the milestones set for the phosphorus goal are being met, it would be expected to see that more water quality samples are meeting the target level for phsohphorus of 0.08 mg/L in tributaries and 0.3 mg/L in the mainstem of the Fawn River each year of sampling after three to five years of implementation.

Administrative Indicator

The load reductions as a result of best management practices that are installed in the watershed, as determined by the load reduction models, will be monitored to determine if the BMPs that are being installed are working adequately to reduce overall loading of total phosphorus to reach the 17.9% reduction necessary to meet the target load.

Administrative Indicator

The number of best management practices that can reduce total phosphorus levels (as described in Section 6.3) that are installed in the watershed will be monitored. Annual milestones for each of the various BMPs that can reduce phosphorus levels are described in the Action register in Section 6.3.

6.1.3 Reduce *E. coli* Loading

After analyzing both water quality data collected by this project and all historical water quality data, average *E. coli* levels exceeded the state standard of 235 CFU/100ml in three sub-watersheds located within the project area. Though, 11 of the 54 sample sites, in seven different sub-watersheds, including Tamarack Lake, Sherman Mill Drain, Wegner Ditch, Himebaugh Drain, Snow Lake, Fawn River Drain, and Clear Lake, exceeded the state standard. Excessive *E. coli* could be from wildlife, leaking failed or straight pipe on-site waste management, or animal operations located within the Fawn River Watershed.

Goal Statement – *E. coli*

The goal of this project is to have 30% of water quality samples meet the state standard of 235 CFU/100ml for *E. coli* within 5 years, and 50% of water quality samples meet the state standard within 15 years.

Indicator

Water quality and administrative indicators will be used to show the progress toward meeting the goal for *E. coli* levels in the Fawn River Watershed.

Water Quality Indicator

E. coli will be measured at a minimum monthly throughout the year at the historic sample sites located within critical areas for *E. coli*. Ideally weekly samples will be collected during the recreational season at the 11 sample sites where historically *E. coli* levels exceeded the state standard. Sampling efforts will begin after three to five years of implementation. To determine if the milestones set for the *E. coli* goal are being met, it would be expected to see that water quality samples are showing a decreasing trend in *E. coli* with more samples meeting the target level for *E. coli* of 235 CFU/100ml for a single sample each year of sampling after three to five years of implementation.

Administrative Indicator

The number of best management practices that can reduce *E. coli* levels that are installed in the watershed will be monitored. Annual milestones for each of the various BMPs that can reduce *E. coli* levels are described in the Action Register in Section 6.3.

6.1.4 Increase Wetland Acreage throughout the Watershed

The wetland functional use loss study that took place in 2005 revealed that the Fawn River Watershed has lost over 42% of its wetlands since pre-settlement times. With the loss in wetland acreage in the Fawn River Watershed also comes a functional use loss in excess of 35% for floodwater absorption, shoreline stabilization, water quality, and natural habitat. In a watershed dotted with lakes that are increasingly becoming built-up, and prime habitat for so many species of flora and fauna, including eight of the ten federally endangered species found within the project area, the protection and restoration of wetlands play a very important role in the health of the aquatic ecosystem in the Fawn River Watershed.

Goal Statement – Wetland Restoration and Protection

The goal of this project is to protect all existing wetlands immediately and increase the acreage of wetlands in the Fawn River Watershed by 500 acres within 5 years, and by 5,500 acres within 15 years.

Indicator

Administrative indicators will be used to show the progress toward meeting the goal for *E. coli* levels in the Fawn River Watershed.

Administrative Indicator

The acres of wetlands restored each year will be monitored. Annual milestones for wetland restoration are described in the Action Register in Section 6.3.

Administrative Indicator

The acres of wetlands that are protected will be monitored. It would be expected that no remaining wetlands in the Fawn River Watershed will be negatively altered or destroyed.

6.1.4 Reduce the Number of Faulty Septic Systems

Nearly 85% of the soils located within the Fawn River Watershed are considered to be very limited for the placement of septic systems, and another 6.8% of the soils are considered to be somewhat limited which means that significant alterations to the soil would need to be done in areas where a septic system is being installed to make it suitable. The rural community in the project area relies on on-site waste disposal systems, most of which were likely installed in soils that cannot support such a system. The majority of the urban and built-up areas are serviced by the Steuben Lakes Regional Sewer District (SLRSD) or municipal utilities; however not all homes located on populated lakes within the SLRSD's jurisdiction are currently serviced; there are still five populated areas in need of service from the SLRSD. There are also six other populated areas within the project area that are not currently serviced. High nitrate, phosphorus, and *E. coli* levels found in the watershed may be a result of leaking and faulty septic systems.

Goal Statement – Septic Systems

It is the goal of this project to reduce the number of failing and leaking septic systems in the Fawn River Watershed by working with area decision makers on a comprehensive septic system ordinance and developing and promoting an education and outreach program regarding septic system maintenance.

Indicator

Water Quality, social and administrative indicators will be used to show the progress toward meeting the goal for reducing the impact on water quality from septic systems in the Fawn River Watershed.

Water Quality Indicator

Nitrate, phosphorus, and *E. coli* will be measured at a minimum monthly throughout the year at the historic sample sites located within critical areas for nutrients and *E. coli*. Ideally weekly samples for *E. coli* will be collected during the recreational season at the 11 sample sites where historically *E. coli* levels exceeded the state standard. Sampling efforts will begin after three to five years of implementation. To determine if the milestones set for the septic system goal are being met, it would be expected to see that water quality samples are showing an increasing trend in water quality with more samples meeting the target levels each year of sampling after three to five years of implementation.

Social Indicator

A pre and post indicator survey regarding septic system functionality and maintenance will be conducted at workshops to determine individuals knowledge regarding septic systems and the amount in which that knowledge increases as a result of the workshop. It would be expected that 80% of the attendants of the workshops would have a better understanding of septic systems after the workshop.

Administrative Indicator

The number of people who attend septic system maintenance workshops will be monitored. It is a goal to have 25% of targeted households, including those located in populated areas known to still be using septic systems for their waste disposal and rural homeowners, show representation at the septic system outreach events.

Administrative Indicator

The number of failing, leaking, or straight pipe septic systems reported to the local health departments will be monitored. It is expected that the education and outreach program will increase the number of reported septic issues to the health departments.

Administrative Indicator

The number of households that enlist septic system companies to provide regular maintenance and/or repair leaking, failed, and straight-piped septic systems will be monitored. It is expected that the education and outreach program will increase the number of households performing regular septic maintenance and repairing improperly functioning systems. The goal is that at least 30% more maintenance and repairs occur after 3 to 5 years of implementation of the education program.

Administrative Indicator

A comprehensive septic system ordinance is passed within each county of the project area within five years of implementation.

6.2 Management Practices to Address Critical Areas and Accomplish Goals

In order to address the concerns leading to the designation of the above mentioned critical areas, best management practices and conservation measures will need to be taken. The Fawn River Watershed Steering Committee considered the plethora of management practices and measures available to address the critical area concerns and determined that certain practices will have the greatest impact on the water quality in the critical areas and will be the focus of phase two of the FRW project. In the table below, several practices and measures are outlined, and the predicted load reduction is presented for each BMP. Load reduction estimates were determined using either the Region 5, or STEP-L and assumptions that were used to determine the load reductions in each of the models is outlined in the table as well. A few of the load reductions were determined using the Soil and Water Assessment Tool (SWAT) that has recently been recalibrated by Purdue University. The reductions that are presented from the SWAT model were calculated for the Upper St. Joseph River Watershed – Maumee River Basin and were used for the Fawn River project due to the fact that variables are very similar between the two watersheds, and it is believed that the SWAT model is more accurate than the other two available load reduction models. The following list is not all inclusive and other practices and management measures may be added to the list in the future.

Table 6.1: Management measures to Address Critical Areas and Project Goals

BMP or Management Measure	Critical Area to be Addressed by BMP	Reason for Being Critical	Assumptions Used	Estimated Load Reduction per BMP		
				Sediment	Total Phosphorus	Nitrogen
Agriculture, Urban, and Septic System Education Program	All Critical Sub-watersheds	Nutrients, E. coli, and Wetlands		N/A	N/A	N/A
Lake resident education and outreach on their impact to lake water quality		Nutrients, E. coli, and Wetlands		***	***	***
Annual Ag. And Urban Workshops/Field Days		Nutrients, E. coli, and Wetlands		N/A	N/A	N/A
Wetland (Restoration/Creation)	Clear Lake, Sherman Mill Creek, Fawn River Drain, Himebaugh Drain, Wegner Ditch, Town of Orland, Snow Lake, Lake James, Tamarack Lake	Wetland	100 acres contributing area/BMP	5.93 ton/yr	8 lbs/yr	48 lbs/yr

BMP or Management Measure	Critical Area to be Addressed by BMP	Reason for Being Critical	Assumptions Used	Estimated Load Reduction per BMP		
				Sediment	Total Phosphorus	Nitrogen
Nutrient / Pesticide Management	Himebaugh Drain, Wegner Ditch, Sherman Mill Drain, Fawn River Drain, Tamarack Lake, Clear Lake, Town of Orland, Lake James	Nutrient	Estimated 20% reduction of fertilizer and pesticides provided by Purdue University ona per acre basis	0.614 ton/yr	1.10 lbs/yr	6.67 lbs/yr
Cover Crops[1]		Nutrient	Planted a day after harvest. Cover crop killed and left as residue on field, one week prior to next crop planting	11 ton/yr	12lbs/yr	22 lbs/yr
Two-stage ditch[1]		Nutrient	1000 linear foot with a depth of 10'	80 ton/yr	80 lbs/yr	160 lbs/yr
Conservation Tillage/Mulch Till[3]		Nutrient	Presented on a per acre basis	0.77 ton/yr	.12 lbs/yr	2.37 lbs/yr
Conservation Tillage/No-Till[3]		Nutrient	Presented on a per acre basis	0.36 ton/yr	0.08 lbs/yr	1.13 lbs/yr
Soil Ammendments (Gypsum)[5,6]		Nutrient	Presented on a per acre basis	0.47 ton/yr	1.49 lbs/yr	***
Native Vegetation Planting (Switch Grass)[3]		Nutrient	Continuously grown, with one time planting. 75% is harvested and urea is applied annually at 122 kg/ha	2.68 ton/yr	4.65 lbs/yr	26.72 lbs/yr
Streambank Stabilization[1]		Nutrient	1000 linear feet of stabilization on both banks	160 ton/yr	160 lbs/yr	320 lbs/yr
Replace Seawalls with Natural Shoreline		Nutrient		***	***	***
Rain Barrels[2]		Nutrient	1 Acre contributing area to a 50 gallon rain barrell	0.2 ton/yr	0.15 lbs/yr	0.81 lbs/yr
Rain Gardens (Residential)[2]		Nutrient	1 acre of contributing area/BMP	0.18 ton/yr	0.1 lbs/yr	2 lbs/yr
Rain Gardens (Commercial)[2]		Nutrient	10 acres of contributing	4.63	6 lbs/yr	42 lbs/yr

BMP or Management Measure	Critical Area to be Addressed by BMP	Reason for Being Critical	Assumptions Used	Estimated Load Reduction per BMP		
				Sediment	Total Phosphorus	Nitrogen
	Himebaugh Drain, Wegner Ditch, Sherman Mill Drain, Fawn River Drain, Tamarack Lake, Clear Lake, Town of Orland, Lake James		area/BMP	ton/yr		
Curb Cuts (In combination with other LID practices)		Nutrient		***	***	***
Bioswale[2]		Nutrient	10 acres of contributing area/BMP	0.1 ton/yr	0.3 lbs/yr	0.6 lbs/yr
Infiltration Trench[2]		Nutrient	10 acres of contributing area/BMP	0.2 ton/yr	0.7 lbs/yr	4.0 lbs/yr
Pervious Pavement[2] (Commercial)		Nutrient	10 acres of contributing area/BMP	1.13 ton/y	4.35 lbs/yr	56.9 lbs/yr
Pervious Pavement[2] (Residential)		Nutrient	1 acre of contributing area/BMP	1.68	7.54	79.86
Encourage the Sale of Phosphorus Free Fertilizers at Local Retailers		Nutrient		N/A	N/A	N/A
Urban Fertilizer Education Program		Nutrient		N/A	N/A	N/A
Tree Planting[4]		Nutrient		N/A	N/A	N/A
Wildlife Exclusion at Stormwater Basins	All Critical Sub-watersheds	Nutrient and E. coli		***	***	***
Pet Waste Disposal Receptacle		Nutrient and E. coli		***	***	***
Native Vegetation Planting		Nutrient and E. coli		***	***	***
Extended Wet Detention[2]		Nutrient and E. coli	10 acres of contributing area/BMP	0.12 ton/yr	0.59 lbs/yr	5.56 lbs/yr
Riparian Buffers[1]		Nutrient and E. coli	LR model for streambank protection was used for 1000 linear feet on both banks of the stream	190 ton/yr	190 lbs/yr	320 lbs/yr
Filter Strip[2]		Nutrient and E. coli	1 acre of contributing area/BMP	2.10 ton/yr	3.42 ton/yr	11.63 lbs/yr

BMP or Management Measure	Critical Area to be Addressed by BMP	Reason for Being Critical	Assumptions Used	Estimated Load Reduction per BMP		
				Sediment	Total Phosphorus	Nitrogen
Repair/replace Leaking On-Site Waste Disposal Systems	All Critical Sub-watersheds	Nutrient and E. coli	4 people per household who use 60 gallons of water per day	248.2 lbs/yr	6.5 lbs/yr	55 lbs/yr
Drainage Water Management		Nutrient and E. coli		***	***	***
Blind Inlets		Nutrient and E. coli		***	***	***
Septic System Workshop		Nutrient and E. coli		N/A	N/A	N/A
Education Program Geared Toward Livestock Operators		Nutrient and E. coli		N/A	N/A	N/A
Limited Access Stream Crossing/Exclusion Fencing (along with Streambank Erosion Practices and/or Alternative Watering Facility)[2]		Nutrient and E. coli	30 head of dairy and/or beef cattle and 10 horses present on 50 acres of agriculture land	9.7 ton/yr	24.1 lbs/yr	194.2 lbs/yr
Rotational Grazing		Nutrient and E. coli		***	***	***
Manure Holding Facilities / Dry Stack Areas[1]		Nutrient and E. coli	40 head of dairy cows, 10 young heifers, and 10 horses and <24% paved/BMP	***	129 lbs/yr	1,426 lbs/yr
Comprehensive Nutrient Management		Nutrient and E. coli		***	***	***
Runoff Management System[1]		Nutrient and E. coli	40 head of dairy cows, 10 young heifers, and 10 horses and <24% paved/BMP	***	284 lbs/yr	***
Repair/replace Leaking On-Site Waste Disposal Systems[8]		Nutrient and E. coli	4 people per household who use 60 gallons of water per day	248.2 lbs/yr	6.5 lbs/yr	55 lbs/yr

BMP or Management Measure	Critical Area to be Addressed by BMP	Reason for Being Critical	Assumptions Used	Estimated Load Reduction per BMP		
				Sediment	Total Phosphorus	Nitrogen
Septic System Education and Outreach	All Critical Sub-watersheds	Nutrient and E. coli		N/A	N/A	N/A
Work With Local Planners to Establish Rules for Proper Septic System Usage/Placement/Inspection		Nutrient and E. coli		N/A	N/A	N/A

[1]Region 5 Load Reduction Model; [2]STEP-L Load Reduction Model; ***Too many variables, too new of a technology to estimate, or a model does not exist to estimate load reductions; [3]SWAT Load Reduction Model, [4]A medium sized tree is estimated to uptake 2380 gallons of water annually (Center for Urban Forest Research, Pacific Southwest Research Station, USDA Forest Service, Davis, California. July 2002); [5]TP loss estimated to be cut by 57% according to a study in the periodical Agricultural and Food Science, [6]DRP loss is estimated to be cut by 66% and sediment by 56% compared to controls fields reported in the National Soil Erosion Research Laboratory, [7]Extensive Green Roofs have the capacity to absorb 50% of rainfall, [8]Estimates found in the Onsite Wastewater Treatment Systems Manual, US EPA, 2002.

6.3 Action Register to Accomplish Goals

The goals set by the Fawn River Watershed Steering Committee are ambitious; therefore the steering committee determined objectives to help the project reach the goals set by the steering committee. Each objective has milestones to reach within a certain timeframe to determine the progress toward achieving each of the goals. The following tables are Action Registers which outline the management measures that will need to be implemented in order to reach the goals set for this project. The first Table is a general Action Register for the project as a whole, identifying specific tasks that need to be accomplished to implement the entire WMP including hiring personnel and acquiring funding, providing education and outreach, acquiring necessary partnerships, and developing and promoting a cost-share program. The following Tables are Action Registers for each critical area to address the pollutants or management measures that are causing the areas to be impaired. The critical area Action Registers outline the number of BMPs that will need to be installed within critical area to reach the necessary load reductions to meet target levels. Milestones are set for each of the BMPs stating how many, and/or what size of BMP will be installed to meet the goals set by this project. BMPs are not determined per sub-watershed as it is unknown where implementation will be successful, but rather the total number, or size, or BMP needed to reach the total load reduction necessary to meet the target load is presented.

6.3.1 General Action Register for Implement

The following table consists of general objectives necessary to implement the Fawn River Watershed Management Plan and reach all goals outlined in Section 6.1 on this WMP including reducing nutrient and E. coli loading, and protect and restore wetlands within the critical areas.

Table 6.1: General Action Register for Personnel and Funding

Hire Personnel and Acquire Necessary Funding					
Objective	**Target Audience**	**Implementation Timeframe**	**Milestone**	**Estimated Cost**	**Partners (P) / Technical Assistance (TA)**
Implement the Fawn River Watershed Management Plan	Fawn River Watershed Stakeholders	Within the First Two Years after WMP Approval then ongoing	Hire personnel to implement the WMP (6 months)	$50,000/ year	County SWCD and NRCS offices, Friends of the St. Joe River Assoc., IDEM, IN DNR, MDEQ and MI DNR, OEPA (P and TA)
			Secure Funding to Implement the WMP including any office overhead and salaries (6 months)	$1,000	
			Secure funding to promote education and outreach programs (6 months)	***	
			Secure Funding to Begin Water Quality Sampling Efforts (2 years)	***	

*** Cost included in salary.

Table 6.2: General Action Register for Education and Outreach

Provide Education and Outreach in Critical Areas					
Objective	**Target Audience**	**Implementation Timeframe**	**Milestone**	**Estimated Cost**	**Partners (P) / Technical Assistance (TA)**
Develop and Implement an Agriculture Education and Outreach Program	Fawn River Watershed Stakeholders Located within Critical Areas	Within the First 12 Months after WMP Approval then ongoing	Compile an ag. Education/Outreach Plan (6 months)	***	County Lakes Councils, SWCD, FSA, and NRCS offices (P, TA) Friends of the St. Joe River Assoc. (P, TA), The Nature Conservancy (P, TA)
			Develop and/or Disseminate an Ag. Education Brochure (8 months)	$4,000	
			Hold First Annual Ag. BMP Workshop/Field Day (12 months)	$1,500 / year	
			Meet with Amish Bishops to Get "buy-in" for Education Programs Within the Amish Community (6 months)	***	
Develop and Implement an Agriculture Education and Outreach Program Specific to Livestock Operators	Fawn River Watershed Livestock Operators	Within the First 12 Months after WMP Approval then ongoing	Compile a livestock education/outreach plan (6 months)	***	County Lakes Councils, SWCD, FSA, and NRCS offices (P, TA) Friends of the St. Joe River Assoc. (P, TA)
			Develop and/or disseminate a livestock education brochure (8 months)	$2,000	
			Hold first annual pasture walk (12 months)	$500 / year	
			Meet with Amish Bishops to Get "buy-in" for Education Programs Within the Amish Community (6 months)	***	
Develop and Implement an Urban Education and Outreach Program	Fawn River Watershed Stakeholders in Critical Areas (Sturgis, Angola)	Within the First 24 Months after WMP Approval then ongoing	Compile an urban education and outreach plan (12 months)	***	County Planning Commissions (P) Angola, Fremont, Sturgis, Administrators, MS4 coordinators and Decision
			Develop and/or disseminate an urban education brochure (12 months)	$4,000	

Provide Education and Outreach in Critical Areas					
Objective	**Target Audience**	**Implementation Timeframe**	**Milestone**	**Estimated Cost**	**Partners (P) / Technical Assistance (TA)**
			Hold first Annual urban BMP Workshop (18 months)	$1,000 / year	Makers (P), County Lakes Councils and SWCDs (P, TA)
			Install a Demonstration Urban BMP that has not yet been utilized in that urban setting (18 months)	$2,000	
Develop and Implement a Septic System Educational Program	Fawn River Watershed Stakeholders who Utilize Septic Systems	Within the First 18 Months after WMP Approval then ongoing	Develop and/or Disseminate a Septic System Maintenance Brochure (18 months)	$4,000	County Health Departments and SWCDs (P,TA) Area Septic System Businesses (P, TA)
			Hold First Annual Septic System Workshop for homeowners (18 months)	$1,000/ year	
Develop and Implement a Wetland Educational Program	Fawn River Watershed Stakeholders	Within the First 12 Months after WMP Approval then ongoing	Compile a Wetland Education and Outreach Plan (6 months)	***	County SWCD and NRCS Offices (P, TA), IN DNR and MI DNR (P), The Nature Conservancy (P, TA), Friends of the St. Joe River Assoc. (P, TA), County Planning Offices (P)
			Develop and/or Disseminate a Brochure Discussing the Ecological and Environmental Services Offered by Wetlands (8 months)	$4,000	
			Hold First Annual Wetland Field Day to Promote Preservation and Construction of Wetlands. (12 months)	$500	

*** Cost included in salary.

Table 6.3: General Action Register for Partnerships

Partner with Key Organizations to Assist with WMP Implementation					
Objective	**Target Audience**	**Implementation Timeframe**	**Milestone**	**Estimated Cost**	**Partners (P) / Technical Assistance (TA)**
Partner with Organizations who are Providing Education/Outreach or cost assistance with Septic Issues	Fawn River Watershed Septic System Stakeholders	Within the First 18 Months after WMP Approval	Meet with County Health Departments Annually to Discuss Septic Issues (12 months)	***	County and State Health Departments and SWCDs (P,TA), EPA (TA), Local Septic System Businesses (P)
			Work with Local Septic System Businesses to offer discounts to stakeholders who sign up for regular septic maintenance including pump-outs and inspections. (12 months)	$500/ year	
Partner with Municipalities and other Organizations who are Providing Education and Outreach or Cost Assistance with Urban Stormwater Issues	Fawn River Watershed Urban Stormwater Stakeholders	Within the First 18 Months after WMP Approval	Make contact with City and County Planners / MS4 Coordinators (12 months)	***	County Planning Commissions and SWCDs (P) Angola, Fremont, and Sturgis Administrators, MS4 coordinators and Decision Makers (P)
			Meet with City and County Decision Makers Bi-annually (12 months)	***	
			Work with City and County Planners to Encourage Low Impact Design for New Developments (18 months)	***	
			Partner with organizations that currently provide urban education and outreach (12 months)	***	

Partner with Key Organizations to Assist with WMP Implementation					
Objective	**Target Audience**	**Implementation Timeframe**	**Milestone**	**Estimated Cost**	**Partners (P) / Technical Assistance (TA)**
Partner with County Lakes Councils	Fawn River Watershed Recreation Stakeholders	Within the First 12 Months after WMP approval then ongoing	Make contact with Lakes Councils and Lake Associations to discuss enforcing a phosphorus free fertilizer policy and replacement of seawalls with natural shorelines (6 months)	***	Steuben and LaGrange County Lake Councils (P), County SWCDs (P), All Private Lake Associations (P), IN DNR and MI DNR (P, TA)
			Meet with Organizations who have agreed to be partners bi-annually (12 months)	***	

*** Cost included in salary.

Table 6.4: General Action Register for Tracking Indicators

Milestones for Indicators of Reaching Goals (not covered elsewhere)					
Objective	**Target Audience**	**Implementation Timeframe**	**Milestone**	**Estimated Cost**	**Partners (P) / Technical Assistance (TA)**
Disseminate and Analyze Social Indicator Study for Septic Systems	Fawn River Watershed Stakehodlers who Utilize Septic Systems	Within 2 Years after WMP Approval	Social Indicator Study for Septic Systems Developed and Disseminated at Workshops (18 months)	$1,000	County SWCDs and Health Departments (P, TA)
			Social Indicator Study Analyzed (24 months)		
Water Quality Sampling	Fawn River Watershed Stakeholders	Within 5 Years after WMP Approval	Water Quality Sampling Begins at historic critical sites for Turbidity, TDS, TSS, Nitrate+Nitrite, TP, and *E. coli* at a minimum	$25,000/ year	County SWCDs (P), County Lakes Councils (P), Regional Sewer Districts and Cities of Angola and Sturgis (P)

Table 6.5: General Action Register for Cost-Share Program

Develop and Promote Cost-share Programs					
Objective	**Target Audience**	**Implementation Timeframe**	**Milestone**	**Estimated Cost**	**Partners (P) / Technical Assistance (TA)**
Develop, and Promote a Cost-share Program on BMPs to Reduce Pollutant Loadings	Fawn River Watershed Stakeholders	Within the First 18 Months after WMP Approval	Secure Funding to Implement the Cost-share Program (12 months)	***	County SWCD, FSA, and NRCS Offices (P) City and County Parks Departments (P) MS4 Coordinators and LTCP Implementers (P), The Nature Conservancy (P, TA), Purdue and Michigan State Extensions (P, TA), IDEM, IN DNR, MDEQ, MI DNR (P, TA)
			Program Developed for Agriculture Cost Share Opportunities (6 months)	***	
			Develop and disseminate an Ag. Cost-share Brochure (8 months)	$1,500 / year	
			Program Developed for Urban Cost Share Opportunities (12 months)	***	
			Develop and disseminate an Urban Cost-share Brochure (18 months)	$1,500/ year	
			Program Developed for Lake homeowner Cost Share Opportunities (8 months)	***	
			Develop and disseminate a Lake Cost-share Brochure (10 months)	$1,500/ year	
			Program Developed for Wetland Restoration Cost Share Opportunities (6 months)	***	
			Develop and disseminate a Wetland Cost-share Brochure (8 months)	$1,500/ year	

*** Cost included in salary.

6.3.2 Action Registers to Implement Cost-share Program in Each Sub-watershed

The following sub-sections include action registers for the implementation of a cost-share program in the critical areas outlined in Section 5 of this WMP. The Action Registers include information regarding the number of BMPs that will be installed annually, the total that will be installed over the next 15 years, the total cost of implementation over the 15 year period, as well as the total load reduction that will be achieved annually should all the BMPs be installed as outlined within the Action Register. It is important to note that the load reduction of each BMP often compounds year after year. For example, the annual load reduction from implementation of no-till will be greater in year three of no-till farming than it was during the initial year of implementation. Therefore, the overall load reduction may be greater than is projected from the models. Water quality testing after 3-5 years of implementation will aid in understanding what the actual load reduction is from BMP efforts. Additionally, not all the BMPs that will be implemented in the project area can be modeled in one of the available load reduction models, and therefore, not all BMPs listed in the following Action Registers will have load reductions associated with them.

Table 6.6: Implementation Action Register for Urban and Lake Residents

Nutrient and E. coli Critical Areas: Priority 1 - (Nutrients) Himebaugh Drain, Sherman mill Creek, Fawn River Drain (E. coli) Sample Sites 12, 13, 15, 40, 47; Priority 2 - (Nutrients) Lake James, Tamarack Lake, Clear Lake (E. coli) Sample Site 1, 4, 28, 32, 39, 52										
Objective	**Target Audience**	**Imple-mentation Timeframe**	**Action**	**Milestone**	**Quantity**		**Load Reduction**			**Estimated Total Cost**
					Annual	**Total**	**Sediment (tons/yr)**	**Phosphorus (lbs/yr)**	**Nitrogen (lbs/yr)**	
Implement Urban BMPs to Reduce Pollutant Loads in Critical Areas	Urban and Lake Home-owners	Within 15 Years of WMP Approval	Rain Barrels	Install 10 rain barrels/year	10	150	2	1.5	8.1	$7,500
			Rain Gardens (Residential)	Install 5 gardens/year	5	75	0.9	0.5	10	$15,000
			Rain Gardens (Commercial)	Install 2 garden/year	2	30	9.26	12	84	$30,000
			Curb Cuts (in combination with other LID practices)	1 project every 2 years	0.5	7	***	***	***	$55,000
			Bioswale	1 project every 2 years	0.5	7	0.05	0.15	0.3	$35,000

Nutrient and E. coli Critical Areas: Priority 1 - (Nutrients) Himebaugh Drain, Sherman mill Creek, Fawn River Drain (E. coli) Sample Sites 12, 13, 15, 40, 47; Priority 2 - (Nutrients) Lake James, Tamarack Lake, Clear Lake (E. coli) Sample Site 1, 4, 28, 32, 39, 52										
Objective	Target Audience	Imple-mentation Timeframe	Action	Milestone	Quantity		Load Reduction			Estimated Total Cost
					Annual	Total	Sediment (tons/yr)	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	
Implement Urban BMPs to Reduce Pollutant Loads in Critical Areas	Urban and Lake Home-owners	Within 15 Years of WMP Approval	Extended Wet Detention	1 project every 3 years	0.33	5	0.0396	0.1947	1.8348	$75,000
			Infiltration Trench	1 project every 3 years	0.33	5	0.066	0.231	1.32	$75,000
			Pervious Pavement (Residential)	Install 1 every 2 years	0.5	7	0.565	2.175	28.45	$55,000
			Pervious Pavement (Commercial)	Install 1 every 5 years	0.2	3	0.336	1.508	15.972	$30,000
			Native Vegetation Planting	Install 1 acre every 2 years	0.5	7	***	***	***	$35,000
			Pet Waste Disposal Receptacles	Install 2 in each urban park	2	20	***	***	***	$2,000
			Wildlife Exclusion at Stormwater Basins	Install 1 exclusion every 2 years	0.5	7	***	***	***	$35,000
			Encourage the sale of phosphorus free fertilizers at local retailers	Meet with all local retailers within 24 months of WMP approval						***

Nutrient and E. coli Critical Areas: Priority 1 - (Nutrients) Himebaugh Drain, Sherman mill Creek, Fawn River Drain (E. coli) Sample Sites 12, 13, 15, 40, 47; Priority 2 - (Nutrients) Lake James, Tamarack Lake, Clear Lake (E. coli) Sample Site 1, 4, 28, 32, 39, 52										
Objective	**Target Audience**	**Imple-mentation Timeframe**	**Action**	**Milestone**	**Quantity**		**Load Reduction**			**Estimated Total Cost**
					Annual	**Total**	**Sediment (tons/yr)**	**Phosphorus (lbs/yr)**	**Nitrogen (lbs/yr)**	
Implement Urban BMPs to Reduce Pollutant Loads in Critical Areas	Urban and Lake Home-owners	Within 15 Years of WMP Approval	Encourage Lake associations to institute a ban on the use of phosphorus fertilizers	Meet with all lake associations within 18 months of WMP approval						***
			Begin an urban tree planting program	Plant 10 trees annually	10	150				$15,000
			Replace sea walls with Natural Shoreline protection	Install 1 natural shoreline within 2 years and 1 annually thereafter	1	14				$100,000

Table 6.7: Implementation Action Register for Agriculture Producers

Objective	Target Audience	Imple-mentation Timeframe	Action	Milestone	Quantity		Load Reduction			Estimated Total Cost
Nutrient and E. coli Critical Areas: Priority 1 - (Nutrients) Himebaugh Drain, Sherman mill Creek, Fawn River Drain (E. coli) Sample Sites 12, 13, 15, 40, 47; Priority 2 - (Nutrients) Lake James, Tamarack Lake, Clear Lake (E. coli) Sample Site 1, 4, 28, 32, 39, 52										
					Annual	Total	Sediment (tons/yr)	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	
Implement Agricultural BMPs to Reduce Pollutant Loads	Agriculture Producers in Critical Areas	Within 15 Years of WMP Approval	Nutrient / Pesticide Management	1000 new acres annually	1000	15,000	614	1100	6670	$300,000
			Cover Crops	1500 new acres/yr	1500	22,500	16500	18000	33000	$700,000
			Two-stage Ditch	1 project every 2 years	1000 lf/ 2 years	7000 lf	80	80	160	$250,000
			Conservation Tillage	1000 acres annually	1000	15000	770	120	2370	$300,000
			Blind Inlets	2 annually	2	30				$30,000
			Drainage Water Management	2 annually	2	30				$60,000
			Soil amendments - Gypsum	500 new acres annually	500	7500	235	745	-	$300,000
			Native Vegetation Planting	200 new acres annually	200	3000	536	930	5344	$500,000
			Filter Strips	Install 2 annually with 150 acre contributing area	2 / 300 acres	30 / 4500 acres	63	102.6	348.9	$120,000

Nutrient and E. coli Critical Areas: Priority 1 - (Nutrients) Himebaugh Drain, Sherman mill Creek, Fawn River Drain (E. coli) Sample Sites 12, 13, 15, 40, 47; Priority 2 - (Nutrients) Lake James, Tamarack Lake, Clear Lake (E. coli) Sample Site 1, 4, 28, 32, 39, 52										
Objective	**Target Audience**	**Imple-mentation Timeframe**	**Action**	**Milestone**	**Quantity**		**Load Reduction**			**Estimated Total Cost**
					Annual	**Total**	**Sediment (tons/yr)**	**Phosphorus (lbs/yr)**	**Nitrogen (lbs/yr)**	
Implement Agricultural BMPs to Reduce Pollutant Loads	Agriculture Producers in Critical Areas	Within 15 Years of WMP Approval	Riparian Buffers	Install 1500 lf annually	1500	22,500	285	285	480	$400,000
			Streambank Stabilization	500 lf annually for 10 years	500	5000	80	80	160	$500,000
			Livestock Exclusion	2 annually until no access exists	2	2	19.4	48.2	388.4	$15,000
			Comp. Nutrient Management	2 annually	2	20				$60,000
			Runoff Management Systems	2 annually until no access exists	2	2				$15,000

Table 6.8: Implementation Action Register for Wetland Restoration

Wetland Restoration Critical Area: Priority 1 - Clear Lake, Sherman Mill Creek, Fawn River Drain, Himebaugh Drain, Wegner Ditch; Priority 2 - Town of Orland, Snow Lake, Lake James, Tamarack Lake										
Objective	Target Audience	Imple-mentation Timeframe	Action	Milestone	Quantity		Load Reduction			Estimated Total Cost
					Annual	Total	Sediment (tons/yr)	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	
Restore Pre-Settlement Wetlands	Stake-holders Located Within the Fawn River Watershed	Within 15 Years of WMP Approval	Wetland Restoration	Restore 100 acres of wetlands annually for 5 years, then 500 acres annually for 10 years	100	5,500	5.93	8	48	$1,000,000

7.0 Potential Annual Load Reductions after Implementation

Actions outlined in Section 6 were determined by taking a combination of aspects of watershed management including how likely it is that landowners will be willing to participate in a cost-share program to implement BMPs and the potential load reductions that would result from their implementation. Using the Spreadsheet Tool for Estimating Pollution Load (STEPL), the Region 5 load reduction model, which both can be found at http://it.tetratech-ffx.com/steplweb/, and the recalibrated SWAT model provided by Purdue University, potential load reductions were determined for nitrogen, phosphorus, and sediment on a per BMP basis.

The two load reduction models available for public use at this time do have some limitations in that not all BMPs can be modeled and as stated earlier in this WMP, estimates for *E. coli* cannot be determined accurately. Therefore, narrative assumptions for the benefit of certain BMPs and possible load reductions will be provided.

It is important to note that assumptions were made for the model inputs as exact acreage of implementation is dependent on the support for participation that is received by landowners in the critical areas as outlined in Section 5. The load reductions presented in this document are derived from a model and are best guess scenarios only, and only account for the BMPs which planned to be installed as part of this project, assuming that no BMPs were installed in the past, or are currently being used. It is understood throughout the conservation community that load reductions from BMPs have a cumulative effect and that the reductions in pollutant loads will increase exponentially as they are implemented year after year or in combination with other BMPs. Accurate load reductions will be determined when the water quality analysis is performed on historic sample sites in the Fawn River Watershed after three to five years of implementation. Table 7.1 shows the estimated load reduction after implementation of the Action Registers outlined in Section 6 for all critical areas. As can be seen in Table 7.1, according to estimated load reductions from various models the sediment, total phosphorus and nitrogen goals as outlined in Section 6.1 will not only be met, but likely exceeded by the end of the 15 year Fawn River Watershed Management Plan implementation.

Table 7.1: Estimated Load Reductions after Implementation

	Load Reduction			Estimated Total Cost
	Sediment (tons/yr)	**Phosphorus (lbs/yr)**	**Nitrogen (lbs/yr)**	
Estimated Total	19201.5466	21517.0587	49119.2768	$5,114,500
Necessary Annual Load Reduction	0	27300	970,140	
Annual Percent Reduction	-	78.82%	5.06%	
Estimated Load Reduction at Project End	288,023	322,756	736,789	
Percent Reduction at Project End	-	100.00%	75.95%	

8.0 Future Activities

After extensive research conducted over two and a half years in the Fawn River Watershed, the resulting Watershed Management Plan is full of valuable information regarding common land uses and practices, as well as historic and present day water quality issues found in each subwatershed located within the Fawn River watershed. However, this information is not common knowledge therefore; key findings in the WMP and the cost-share program will be introduced to the public through at least one annual public meeting held in Indiana and Michigan, within months of the final WMP approval by the IDEM, MDEQ, and US EPA. The meetings will be advertised through local media outlets including newspapers, Lake Associations, SWCD, NRCS, and FSA offices. Other means of advertisement will be pursued as well. Informing the Fawn River stakeholders on the extent of the water quality problems within the watershed will hopefully illicit concern as well as a willingness to change behaviors to have a positive impact on water quality.

Next steps in the Fawn River Watershed project is for the Steering Committee to develop a cost-share program that will include, at a minimum, those management measures outlined in the Action Register in Section 6.3 of this WMP, and the various incentive levels that will be used to encourage the adoption of those management measures. The Steering Committee will work closely with all Conservation Districts located within the project area, as well as the partners outlined in the Action Register to make sure their cost-share recommendations are realistic for the demographic of the area, and to utilize their help for promoting the program. A key component of the cost-share program's success is the education and outreach aspect of the Fawn River Watershed project. Field days and workshops regarding agricultural, lake and urban land uses and BMPs will be held annually, as part of this project, however, partnering with other organizations such as other county SWCD and NRCS offices, The Nature Conservancy, the IN and MI DNR, and smaller non-profit groups that focus on water quality and sustainable land uses, will prove to be integral in promoting practices to improve the health of the watershed.

It is anticipated and encouraged that this WMP be reviewed and utilized by other organizations within the Fawn River Watershed including the Friends of the St. Joe River Association, LaGrange and Steuben County Lake Associations, Steuben, LaGrange, and St. Joseph County SWCDs, The Nature Conservancy, County Drainage Boards, Surveyors and Engineers, City and County Planning Departments, and other organizations concerned about the water quality of the Fawn River Watershed. The Fawn River Watershed project's first priority will be to obtain funding to pursue the objectives outlined in the Action Register; however we hope to work with other organizations that plan to do the same. As the point of contact for this WMP, the LaGrange County SWCD will distribute the document to all stakeholder organizations (a distribution list is located at the end of this document), as well as have hard copies of the document available to borrow, or purchase at the SWCD office located at 910 S. Detroit St. LaGrange, IN.

A watershed is continually changing as land uses change, towns begin to expand, new businesses organize in the area, farmland is converted to other uses, or wetlands are drained or moved to accommodate development or farming. These changes in the Fawn River Watershed particularly have continued to have an enormous impact on water quality and the aquatic habitat in area lakes, and in the river itself. As the watershed continues to change so must the actions taken to maintain and/or improve the integrity of the water quality. Therefore, the Fawn River Watershed Management Plan must remain a 'living document' and goals, objectives, and actions outlined in the WMP must be revisited by the LaGrange SWCD, or its partners, at a minimum, every ten years. However, as area stakeholders including residents, conservation organizations and planners, City and Town governments, or others working on the implementation of the Fawn River Watershed Management Plan observe land uses and/or water quality changing, the WMP must be revised to meet the area conservation needs and provide a refocus of efforts if necessary, at that time.

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Appendix A

Quality Assurance Project Plan

Fawn River Watershed Management Plan

EDS # A305-3-3

Prepared by:

David P. Arrington, Ph.D.
Watershed Coordinator
LaGrange County SWCD

Prepared for:

Indiana Department of Environmental Management
Office of Water Quality
Watershed Planning & Restoration Section
June 2013

Approved By:

Project Manager:	______________________________ David P. Arrington	________ Date
TLSS QA Manager:	______________________________ Betty Ratcliff	________ Date
TLSS Section Chief:	______________________________ Chuck Bell	________ Date

2.0 **Table of Contents**

PROJECT MANAGEMENT

3.0 List of Appendices & Tables

3.1 List of Appendices & Tables

3.2 List of Tables

3.3 Distribution List

Betty Ratcliff, IDEM NPS Quality Assurance Manager
Technical and Logistical Services Section
Indiana Department of Environmental Management
100 North Senate Avenue
MC 65-44 IGCN 1255
Indianapolis, IN 46204-2251

Joseph Schmees, IDEM NPS Project Manager
Watershed Planning & Restoration Section
Indiana Department of Environmental Management
100 North Senate Avenue
MC 65-44 IGCN 1255
Indianapolis, IN 46204-2251

Martin Franke, LaGrange SWCD District Manager
910 S. Detroit Street
LaGrange, IN 46761

David P. Arrington, Watershed Coordinator
910 S. Detroit Street
LaGrange, IN 46761

Julie Diehm, Water Quality Field/Lab Technician
910 S. Detroit Street
LaGrange, IN 46761

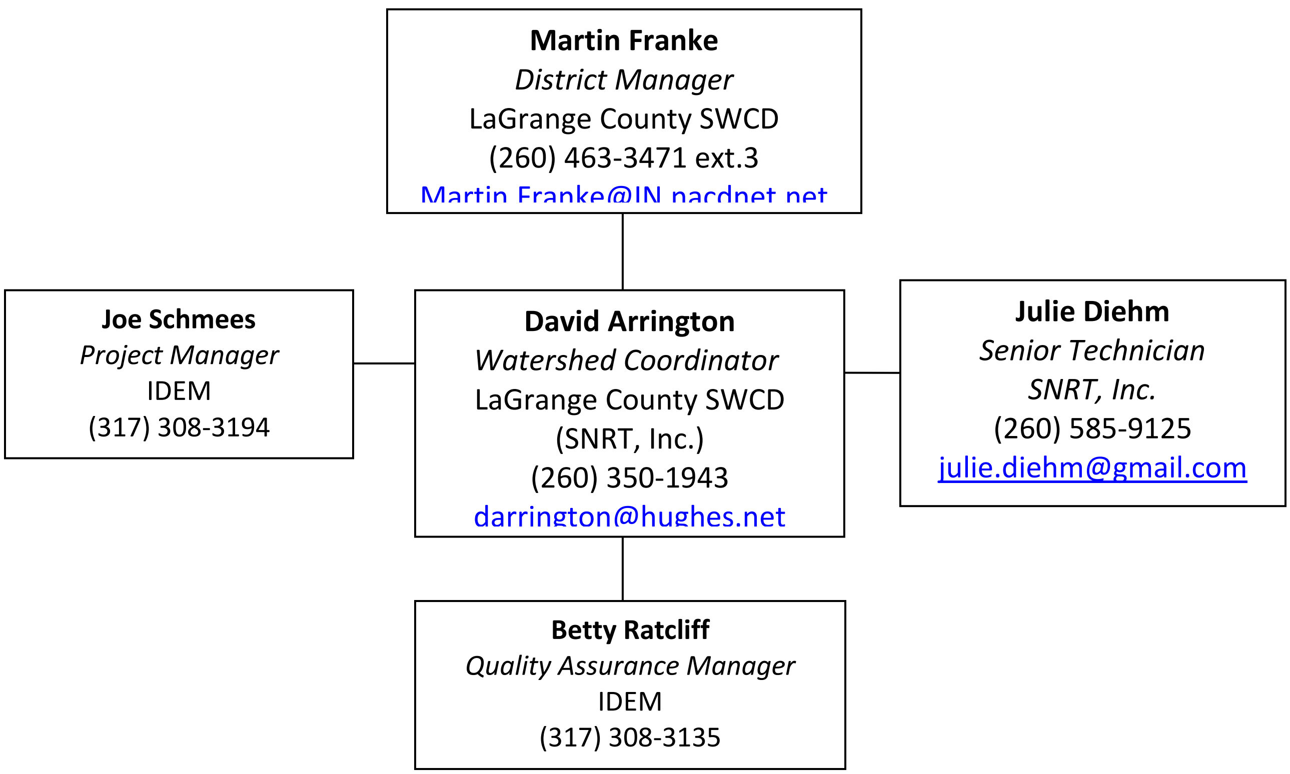
4.0 Project Task/or Organization

4.1 Key Personnel

David P. Arrington Ph. D., Watershed Coordinator
260-350-1943, darrington@hughes.net
Overall project responsibility, senior scientist and QA Officer

Julie Diehm, Senior Field Lab Technician
260-585-9125
Supervises field and lab personnel

4.2 Project Organization Chart



The Watershed Coordinator (also the project manager) reports directly to the SWCD District Manager. The Senior Technician reports directly to the Watershed Coordinator and oversees other Field/Lab Technicians. The Watershed Coordinator will coordinate with the IDEM Quality Assurance Manager and IDEM Project Manager. A minimum of two contracted individuals will conduct sampling and analysis.

5.0 Special Training Needs/Certification & Qualifications

N/A

6.0 Problem Definition/Background

6.1 Problem Statement

Seed corn production is the major component along the drainage from western Steuben County until it empties into the St. Joseph River. Other food production such as green beans, beets, and potatoes play a significant role along this corridor. An important aspect in this type of agricultural landscape is the use of traditional tillage practices which includes fall plowing that exposes fields to wind and sheet erosion. Observations carried out by the LaGrange County SWCD indicate an absence of ditch/stream bank buffering of fields using traditional tillage practices. Additional evidence suggesting traditional tillage practices may be having a major influence is reflected in the IDEM 303(d) list of impaired waters for this drainage. Snow lake, Lake James, Jimmerson Lake, Big Otter Lake and Seven Sisters Lakes are listed for impaired biotic communities. Water quality sampling conducted by the Steuben County Lakes Council indicates raised total suspended solids loading during Spring rain events before crop coverage had been established.

There is also a livestock influence in the watershed and that influence is growing. The Amish community is rather small along the Fawn River when compared to the Little Elkhart River and Pigeon River drainages but this community continues to grow resulting in an expansion of livestock based agriculture. Livestock related issues have been visually documented and are validated in water quality testing results with the Fawn River-Orland segment being listed as an impaired water body for E.coli. In addition, water quality testing has shown elevated levels of nitrates and phosphorus.

Urban influences likely have an impact on water quality throughout this drainage. Angola in Steuben County, is an MS4 city that currently influences 040500010802-Tamarack Lake and 040500010803-Lake James-Crooked Lake HUC 12 subwatersheds. It is anticipated, that as the city grows north, the HUC 12 subwatershed 040500010801-Snow Lake will be included into the city's area of drainage influence. Other urban influences include Fremont and Orland in Indiana, and the southern portion of Sturgis, Michigan. The town of Constantine, Michigan primarily influences the St. Joseph River directly, but may have an influence along the northern edge in residential areas. In addition the majority of moderate to large sized lakes within the river drainage have dense residential areas along the shorelines. These residential areas likely have a runoff influence on the lake systems through the use of lawn fertilizers.

Although long-term quantitative water quality studies do not exist, short duration studies conducted by both Michigan and Indiana environmental/natural resource departments have indicated a significant agricultural influence for nutrient, sediment, and E.coli loading. Both the Steuben and LaGrange County Lakes Councils have begun long-term water quality testing at many lakes to include both inlet and outlet systems. With three years of quantitive data collection in Steuben County and one year of collection in LaGrange County, the data clearly suggests a major agricultural input of non-point source pollutants reaching the lake systems. Hoosier River Watch Data, although not quantitative, indicates a non-point source pollutant contamination by nutrients, suspended solids, and E.coli. In addition, many of the smaller lake *systems do not have centralized sewers and rely on septic systems for waste treatment. There is a high probability that during wet seasons these septic systems play some role in surface water contamination.*

6.2 Historical & Background Information

See 6.1 and 7.1.

7.0 Process Design

7.1 Study Site Description

The Fawn River drainage begins in Steuben County, Indiana at Fish Lake north of the town of Fremont and flows northwest for a short distance before entering Branch County, Michigan where it encompasses several large lake systems. The drainage then turns south reentering Steuben County, Indiana where it encompasses many large and small lake systems north and northwest of the city of Angola. This portion of the river system involves the bulk of the county"s largest lakes that are a significant economic base for the region. From this point the river flows west by northwest and enters LaGrange County, Indiana in the northeast corner and continues for a short distance before reentering Branch County, Michigan. The drainage flows west by northwest and enters St. Joseph County, Michigan southeast of the town of Sturgis where it turns southwest reentering LaGrange County, Indiana north of the town of Howe. This portion of the river encompasses many large and small lake systems in both Michigan Counties. The river flows west from Howe paralleling Interstate 80 to the northwest corner of LaGrange County, Indiana before turning north flowing into St. Joseph County, Michigan. The river drainage continues north encompassing several large lake systems before turning west where it empties into the St. Joseph River north of the town of Constantine, Michigan. The Fawn River drainage as a whole includes slightly over 156,000 acres and over 70 lake systems. Agriculture is the major land usage for the entire drainage.

8.0 Quality Objectives & Criteria for Measurement Data

8. 1 Goal Statements & Objective Statements

The goals listed below are designed to provide a quantitative assessment of physical and chemical parameters within each HUC 12 of the Fawn River drainage. The watershed coordinator will use the results during the WMP development to prioritize future BMP implementation by subwatershed or HUC 12. Statistical procedures such as ANOVA and Regression Analysis will be employed in the prioritization process. Continued sampling during and after BMP implementation is essential in evaluating WMP goal success and for evaluation of land use change effects on water quality.

Macroinvertebrate and habitat evaluations will be conducted using Indiana River Watch methods. The data collected will be less quanitative than physical/chemical data but will provide trend data during long term monitoring.

Monitoring Goal 1: The primary goal is to establish a baseline in the 9 HUCs listed under EDS# A305-3-3.

Objective 1: Establish baseline data that is comparable at a quantitative level.

Objective 2: Isolate problematic segments for BMP installation prioritization.

Monitoring Goal 2: Demonstrate differences between subwatersheds.

Objective 1: Continue collecting baseline data before and after BMP installation.

Objective 2: Establish all BMPs in treatment watershed by Fall 2014.

8.2 Study Site

The project area is the entire drainage of the Fawn River consisting of 9 HUC12s (Appendix A). Water quality testing will be conducted in all subwatersheds. Under this study data will be collected in watersheds:

040500010801 – Snow Lake

040500010802 – Tamarack Lake

040500010803 – Lake James-Crooked Lake

040500010804 – Fawn River-Orland

040500010805 – Fawn River-Himebaugh Drain

040500010806 – Fawn River-Clear Lake

040500010807 – Fawn River-Wegner Ditch

040500010808 – Sherman Mill Creek

040500010809 – Fawn River-Fawn River Drain

An average of six sites per HUC12 have been selected and will be sampled monthly during the "ice-out" season (Appendix A). A total of 54 sites have been selected and are listed below and collected with a Megellan Vehicle GPS:

Site#	Latitude (N)	Longitude(E)	Site Description
1	41.7083	84.9753	Culvert-Marsh Lake Inlet

South side of culvert on 500N between Seven Sisters Lakes and Marsh lake.

2	41.7213	84.9727	Culvert-Marsh Lake Inlet

West side of culvert just north of 500N on 100E.

3	41.7387	84.9285	Culvert-Fish Lake Outlet

On Fremont Road just north of 700N.

4	41.7743	84.9568	Culvert-Huyck Lake Outlet

West side of culvert on Allen Road just south of Southern Road.

5	*41.7755*	*85.0010*	*Culvert Lake George Inlet*

South side of culvert on Kope Ken Road west of Angola Road.

6	*41.7393*	*84.0201*	*Culvert-Lake George Outlet*

South side of culvert on SW side of Lake George.

7	*41.7315*	*85.0260*	*Culvert-Snow Lake Inlet*

South side of culvert on SR 120 just west of Dave's Restaurant.

8	*41.7245*	*85.0232*	*Bridge-Snow Lake Inlet*

West side of bridge on 100W south of SR 120.

9	*41.7277*	*85.0023*	*Culvert-Big Otter Lake Inlet*

South side of culvert at west side of outlet mall parking lot, south of SR 120.

10	*41.7213*	*85.0015*	*Culvert-Little Otter Lake Inlet*

West side of culvert next to Bait Shop parking lot on Pokagon Road.

11	*41.6728*	*85.0273*	*Culvert-Crooked Lake Inlet*

West side of culvert on 200N just west of 100W.

12	*41.6700*	*85.0317*	*Culvert-Crooked Lake inlet*

West side of culvert approximately ¼ mile south of site 11.

13	*41.6707*	*85.0500*	*Culvert-Culver Crooked Lake Inlet*

North side of culvert just west of 200W.

14	*41.6882*	*85.0532*	*Culvert-Crooked Lake Outlet*

West side of culvert on 350N.

15	*41.6895*	*85.0822*	*Culvert-Lake Gage Inlet*

West side of culvert just south of 400N.

16	*41.7077*	*85.1212*	*Culvert-Lake Gage Outlet*

North side of culvert at north end of Lake George just west of 675W.

17	*41.6785*	*85.0215*	*Culvert-Lake James Inlet*

North side of culvert on south side of Lake James.

18	*41.6893*	*85.0390*	*Bridge-Lake James Outlet*

West side of bridge on 300N between Lake James and Jimmerson Lake.

19	*41.7253*	*85.0792*	*Bridge-Jimmerson Lake Outlet*

West side of bridge on 575N on NW corner of Jimmerson Lake.

20	*41.7307*	*85.1204*	*Bridge-Fawn River*

East side of bridge on 675W just south of SR 120.

21 41.7307 85.1352 Bridge-Fawn River

East side of bridge on 800W just south of SR 120.

22 41.7318 85.1812 Culvert-Wall Lake Ditch

South side of culvert on 650N ½ mile west of SR 327.

23 41.7383 85.1810 Culvert-Lime Lake Outlet

South side of culvert on 700N ½ mile west of SR 327.

24 41.7583 85.2088 Bridge-Fawn River

West side of bridge on 1100E just south of 750N.

25 41.7723 85.2225 Bridge-Fawn River

East side of bridge on 1125E just north 750N.

26 41.7852 85.2382 Culvert-Ditch to Fish Lake

South side of culvert on Southern Road.

27 41.7855 85.2535 Culvert Ditch to Fish Lake

South side of culvert on Southern Road.

28 41.7808 85.2573 Culvert-Fish Lake Inlet

West side of culvert on Dutch School Road just south of Mallow Road.

29 41.7725 85.2732 5 Culverts-Fawn River

East side of culverts at intersection of Trayer and Gunthorpe roads.

30 41.7728 85.2817 Bridge-Himebaugh Drain

North side of bridge on Round Lake Road west of Dauber Road.

31 41.7790 85.2882 Culvert-Fawn River

West side of culvert ½ mile south of Round Lake Road.

32 41.7833 85.3037 Culvert-Ditch

South side of culvert on Fawn River Road just west of Watt Road.

33 41.7800 85.3358 Bridge-Fawn River

West side of bridge on Fawn River Road.

34 41.7755 85.3557 Bridge-Fawn River

South side of bridge on Kene Drive.

35 41.7788 85.3743 Culvert-Lee Lake Inlet/Williams Lake Outlet

South side of culvert on Fawn River road.

36 41.7587 85.3775 Bridge-Fawn River

West side of bridge on Miller Road.

37 41.7360 85.3738 Culvert-Cedar lake Outlet

North side of culvert on 700N just west of golf course.

38 41.7293 85.3585 Culvert-Cedar Lake Inlet

North side of culvert on 600N west of 375E.

39 41.7393 85.4210 Bridge-Fawn River

West side of bridge on 050E.

40 41.7590 85.4702 Culvert-Nye Drain

West side of culvert on Balk Road.

41 41.7558 85.4755 Bridge-Fawn River

West side of bridge on south end of Balk Road.

42 41.7397 85.4818 I-80/90 Overpass-South End

East side of culvert on Stubey Road.

43 41.7535 85.5035 Bridge-Fawn River

West side of bridge on Shimmel Road.

44 41.7595 85.5357 Culvert-Aldrich Lake

West side of culvert on Aldrich Lake Road.

45 41.7782 85.5800 Bridge-Fawn River

West side of bridge on Fawn River road betweem Crooked Creek and Scott Roads.

46 41.7877 85.5368 Culvert-Klinger Lake Inlet at Golf Course

South side of culvert just north of golf course clubhouse.

47 41.8228 85.5037 Culvert-Ditch

West side of culvert on Shimmel Road between Thompson and Tamarack Lakes.

48 41.8090 85.5315 Culvert Klinger Lake Inlet

North side of culvert on NE corner of lake just south of Klinger Lake Road.

49 41.8085 85.5387 Bridge-Klinger Lake Inlet

West side of bridge on Klinger Lake Road, NW corner of Klinger Lake.

50 41.8050 85.5807 Bridge-Fawn River

North side of bridge on Dickinson Road west of Block Road.

51 41.8288 85.5817 Closed Bridge-Fawn River

East side of bridge on Haybridge Road, from south side.

52 41.8332 85.5807 Culvert-Fawn River Drain

South side of culvert on Mintdale Road 1 mile west of Engle Road.

53 41.8355 85.6240 Bridge-Fawn River

West side of bridge on Lutz Road.

54 41.8377 85.6583 Bridge-Fawn River Outlet into St. Joseph River East side of bridge on Featherstone Road.

8.3 Sampling Design

A synoptic approach was chosen to give a representative analysis of the 9 HUC 12s involved. The synoptic approach will provide data that isolates segments and "finger" tributaries revealing trends that may require intervention during future implementation of BMPs.

Electronic field instruments will be used to collect data at each site on dissolved oxygen, pH, temperature, total dissolved solids, and turbidity on a monthly basis. Total phosphorus, nitrates, total suspended solids and E.coli will be collected for lab analysis on a monthly basis..

Macroinvertebrates and habitat data will be collected during the first summer of the project using Hoosier River Watch procedures.

8.4 Study Timetable

Sampling under this QAPP will begin June 2013 and will continue through May 2015 (Table 1). Analysis of data will be on-going throughout the study to indentify and steer current implemetation programs to problematic locations. Macroinvertebrate sampling will be completed late summer 2013.

The major constraint during sampling will be during winter when many sites may be frozen. Every attempt will be made to sample as many sites as possible during winter.

Table1: Study Schedule

Activity	Start Date	End Date
Sample collection: DO, Temp, pH, TP, NO_3, Turb, TDS, TSS, *E. coli* and flow. (monthly) BOD (yearly)	June 2013	May 2015
Flow (monthly at sites: 5,7,12,21,22,34,40,41,55,60)	June 2013	May 2015
Macroinvertebrate/Habitat data collection (once)	Summer 2013	Summer 2013
Analysis (on-going)	June 2013	May 2015

9.0 Data Quality Indicators (*for Measurement Data)*

9.1 Precision

Field Chemistry Parameters

Field equipment will be calibrated in accordance with manufacturer's specifications. Replicate/field blank samples will be taken with the following field equipment: Hach instruments sensION 156 (DO, pH, Temp, TDS), 2100 Turbidmeter, 2000-11 Flo-Mate Portable Velocity Sensor. Three replicate samples and three field blanks will be taken during each sampling cycle or 1 replicate/blank per 20 samples. Precision will be calculated using the RPD method:

$$RPD = \frac{(C-C')x100\%}{(C+C')/2}$$

Where:

C=the larger of two values

C'=the smaller of two values

Laboratory Water Chemistry Parameters

Grab samples will be collected for, total phorsphorus, nitrates, and total suspended solids at each site for analysis with the Hach DR2500 or DR 3800 Spectrophotometer. Three duplicate samples and three field blanks will be taken per sampling cycle or 1 duplicate/blank per 20 samples. Standards will be used in accordance with manufacturer's guidelines. E. coli samples will be collected using sterile containers with duplicates of each sample analyzed using the Easy Gel method with incubator set at 35°C for 24 hours. Precision will measured using the RPD method. The laboratory is located at the Par Gil Natural Resources Learning Center, 250 North SR9, LaGrange, IN 46761. The phone number is 260-463-8822.

The electronic field instruments will be calibrated before each sampling cycle to insure accuracy within the limits of each device. In the laboratory, strict adherence to procedures and consistant calibration of the Hach DR2500/DR3800 in accordance with manufacturer's specifications employed.

Macroinvertibrates Parameters - Both technicians are fully trained with 16 years experience in collection and data analysis. To ensure precision the watershed coordinator will participate in the sampling.

9.2 Accuracy and or Bias

The majority of parameters will be collected using precision instruments that have specific +/- accuracies associated with each parameter. Equipment will be calibrated prior to each sampling cycle in order to maintain manual accuracy specifications. Field protocol procedures will be strictly adhered to ensuring site sampling accuracy is maintained.

To reduce bias, additional samples will be collected and analyzed. To further reduce bias, the same technicians that have worked on similar projects for 16 years will be employed. Familiarity with protocols will reduce bias.

9.3 Completeness

Field and Laboratory Chemistry Parameters

The sampling schedule is aggressive to allow room for missed measurements. In this study quantitative and qualitative analysis will be achieved if 75% of measurements are taken for each site and for each parameter (Table 2). All sites have been surveyed for access and proper sampling hydrology. However, during extreme climatic events acquiring samples at some locations may become impossible. The most plausable constraint will be during winter months when ice conditions may make sampling difficult at best. In addition, during drought conditions flow may stop on several "finger" drainages.

$$\% \text{ completeness} = \frac{\text{(number of valid measurements)}}{\text{(number of valid measurements expected)}} \times 100\% = \frac{1296}{1728} \times 100\% = 75\%$$

Macroinvertebrate Parameters

In order to achieve the desired level of completeness for this study 100% of macroinvertibrate analysis must be completed (Table 2). This should be attainable since there is flexibilty in selecting sampling dates that are conducive to achieve 100% collection.

Table 2: Data Quality Objectives

Parameter	Precision	Accuracy	Completeness
DO, pH, Turb, Temp, TDS, TSS	RPD<5%	Instrument limits See Table 4	75%
TP, NO_3	RPD<5%	Instrument limits See Table 4	75%
E. coli	RPD<10%	High	75%
Flow	RPD<5%	$\pm$3% + zero stability zs=$\pm$0.1m/sec	75%
Macroinvertebrate	High	High	100%
Habitat	High	High	100%

9.4 Representativeness

In using the synoptic approach, a relatively even representation of water quality throughout the sub-watersheds will be achieved. Test sites were selected and field varified to isolate segments of each watershed and allow easy access for personnel. If extremely high levels of contaminants are found in any given segment (higher than surrounding segments) additional sites may be added to futher isolate the source. If this occurs, then an addendum will be submitted.

9.5 Comparability

Data collected from this study will not be compared to other studies but will provide a baseline for future sampling to assess the effectiveness of water quality improvement practices. It is intended to follow sampling procedures used here in future projects administered by LaGrange County SWCD. Methods used will meet EPA-approved standards.

9.6 Sensitivity

Sensitivity for each parameter tested can be seen in Table 4 under "Performance Range or Detection Limits".

10.0 Non Direct (Secondary Data)

N/A

11.0 Monitoring Requirements

11.1 Monitoring Process Design

See Section 11.2

11.2 Monitoring Methods

Water chemistry samples will be taken at each station to test the parameters listed in Table 3. Temperature, dissolved oxygen, pH, turbidity, total dissolved solids and flow measurements will be made in the field using the following instruments: Hach sensION 156 for temperature, dissolved oxygen, total dissolved solids, and pH; Hach 2100P Turbidmeter for turbidity; and the Hach Flo-Mate 2000-11 for velocity. All measurements will be taken accordng to the standard operating procedures provided by the manufacturer of the equipment. Project personnel will record water chemistry field measurements on standardized field data sheets (Appendix B).

Flow measurements will be taken utilizing protocols outlined in Marsh-McBirdy (1990). A tape measure will be staked across the width of the channel prior to any measurements being taken. If the stream is less than 2" deep, then multiple point velocity measurements will be taken throughout the width of the channel. Channel depths will measured at a minimum of five points across the channel. Discharge will be calculated using the following formula:

$$\text{Discharge} = \frac{(\Sigma d_i)\, w * v}{(n+1)}$$

where d equals stream depth, n equals the number of stream depths measured, w equals the width of the stream, and v equals the velocity of the stream (0.9 times the fastest velocity recorded). The equation has been modified from EPA (1997).

If the stream is greater than 2" deep, then the trapezoid channel method will be utilized to calculate stream discharge. The interval width, thus the number of flow measurements recorded across the channel, is determined by channel width. If the channel width is less than 15', then the interval width will be equal to the stream width divided by 5. If the channel width is greater than 15', then the interval width will be equal to the channel width multiplied by 0.1. Stream depths will be recorded at the right and left edges of the predetermined trapezoid (SI_0 and SI_1). Flow measurements will be recorded at the midpoint of each trapezoid ($SI_{1/2}$). All data will be recorded on the data sheet included in Appendix C. Discharge will be calculated using an Excel spreadsheet to minimize errors.

Grab samples will be collected for the remaining parameters: total phosphorus, nitrates, total suspended solids and E. coli. Samples will be placed in prepared containers. Sample collection will follow the method outlined in EPA Volunteer Stream Monitoring: A Methods Manual (1997). The technician will wade or dip into the center of the streams thalweg to collect the water sample. The technician will then invert a clean sample bottle into the thalweg. The same procedure will be followed for a separate E. coli sample. At a depth of 8 to 12 inches below the water surface, the technician will turn the bottle into the current and allow collection of water. If the stream depth is shallower than 16", water collection will be midway between the surface and bottom. Once the bottle is full the technician will "scoop" the bottle toward the surface.

The sample containers will be labeled with date, time, technician initials, site, and parameter to be analyzed. All samples will be stored on ice and transported to the laboratory for immediate analysis. Technicians collecting samples will complete laboratory analysis. Water chemistry analysis will be in accordance with specified procedures as outlined in the manual for the DR 2500 or DR3800. E. coli samples will be prepared using the Coliform Easygel method.

Macroinvertebrate/Habitat Sampling

Macroinvertebrate/Habitat sampling will follow procedures described in the River Watch Manual.

Table 3: Sampling Procedures

Parameter	Sampling Frequency	Sampling Method	Sample Container	Sample Volume	Holding Time
DO	Monthly*	Field Meter-Hach sensION156	N/A	N/A	In field
pH	Monthly*	Field Meter-Hach sensION156	N/A	N/A	In field
TDS	Monthly*	Field Meter-Hach sensION156	N/A	N/A	In field
Turb	Monthly*	Field Meter-Hach 2100 Portable	100mL vial	100ml	In field
Temp	Monthly*	Field Meter-Hach sensION156	N/A	N/A	In field
TP	Monthly*	Grab Sample	500mL plastic bottle	25mL	7 days
TSS	Monthly*	Grab Sample	500mL plastic bottle	25mL	7 days
NO_3	Monthly*	Grab Sample	500mL plastic bottle	25mL	7 days
E. coli	Monthly*	Grab Sample	250mL sterile plastic cup	1mL	8 hours
Flow	Monthly*	Global Water Flow Probe/ISCO 6712/HOBO Flow Monitor	N/A	N/A	In field
Macro invertebrate/ Habitat	2013	Hoosier River Watch	N/A	N/A	In field

11.3 Site Description

See Appendix A

11.4 Field QC Activities

QC activities in the field will be conducted by the watershed coordinator at a minimum interval of once per quarter. The first three months of collection will include the watershed coordinator. Quality control and accuracy will be achieved by strict adherence to written protocol. To achieve precision in field measurements, replicate measurements and field blanks will be taken at 3 of the 54 sampling sites for each sampling event. Field equipment will be properly calibrated before each sampling event in accordance with manufacturer's guidelines. To achieve precision in the laboratory, a duplicate sample and field blank will be taken at 3 of the 54 sampling sites for each sampling event. Laboratory equipment will be calibrated according to manufacturers guidelines. In the laboratory reference standards and blanks will be used as necessary to assure data quality. Collection containers/equipment will be washed/maintained within manual outlined protocols. For macroinvertebrate sampling, strict adherence to protocol will be followed by all personnel. Any discrepancies in data will be resolved by the watershed coordinator.

12.0 Analytical Requirements

12.1 Analytical Methods

Equipment used in the field and labratory present data in usable form and require no analytical methods by the technician. For E. coli, procedures using the Coliscan Easygel method will be employed. Macroinvertibrate/habitat sampling will follow procedural guidelines under Hoosier River Watch method.

Table 4 lists analytical procedures and performance range for electronic equipment or each parameter .

Table 4: Analytical Procedures

Parameter	Analytical Method	Performance Range or Detection Limits	Units
DO	Hach sensION 156 Electronic Meter EPA 360.1	0 to 20; 0.1mg/l	mg/L
TDS	Hach sensION 156 Electronic Meter EPA 130.1	0 to 42; 0.1g/l	g/L
pH	Hach sensION 156 Electronic Meter EPA 150.2	-2 to 19.99;0.1SU	Standard Units
Turb	Hach 2100P Portable Meter EPA 180.1	0 to 1000; 0.1NTU	NTU
Temp	Hach sensION 156 Electronic Meter EPA 170.1	-10 to 110; 0.1°C	^{0}C
TP	Hach DR 2500/3800 Method 8190 EPA 360.3	0.06 to 3.5 mg/l; 0.01mg/l	mg/L
NO_3,	Hach DR 2500/3800 Method 10020 EPA 352.1	0.2 to 30.0mg/l; 0.1mg/l	mg/L
TSS	Hach DR 2500/3800 Method 8006 EPA 160.2	O to 750;0.1mg/l	mg/l
E. coli	Coliscan Easygel incubated at 35°C for 24 hours	N/A	Colonies/100 ml
Flow	Hach 2000-11 Flo-Mate Flow Monitor Manuals	0.1 to 30	FPS
Macroinvertibrate/Habitat	Hoosier River Watch	N/A	N/A

12.2 Analytical QC Activities
Statistical analysis will be used for HUC 12 comparisons using ANOVA procedures by the watershed coordinator.

DATA GENERATION & ACQUISITION

13.0 Sample Handling and Custody Requirements
Samples that require transportation will be clearly labled with date, time, technician initials, site, and parameter to be measured. Analysis of samples will occur in the laboratory by the same individual and will occur the same day as collection.

Samples will be placed on ice in a small cooler for transportation that is clearly labled with "Water Samples" on the outside. Since the same individual will be doing the analysis, no transfer sheets are required.

14.0 Testing, Inspection Maintenance and Calibration

The multi-parameter meter, the turbidity meter, and the spectrophotometers will require calibration. Calibration procedures will be followed for the field meters before sampling begins that day. The spectrophotometer will be calibrated before each sampling cycle for each parameter being measured.

Calibration will be in accordance with manufacturer's instructions.

ASSESSMENTS/OVERSIGHT

15.0 Assessment/Oversight/Data Quality Assessment & Decision Rules

15.1 Data Quality Indicators

Precision-Accuracy/Bias
Data will be reviewed after each collection stage for validity. For invalid data (data that does not meet criteria outlined in Table 2) the effected sites will be immediately resampled. All data determined to be accurate will be considered valid and will be reported even if completeness objectives are not met.

Water chemistry data will be checked with blanks randomly each month. If data has been compromised the sampling process will be immediately repeated for the effected parameter at all sites. E. coli analysis (colony counts) will be conducted by both technicians. If there is discepancy in counts the watershed coordinator will conduct a count in an attempt to resolve the difference. If unable to resolve the descrepency, samples will be retaken for the effected sites. Biological monitoring will be conducted by one technician and the watershed coordinator *to ensure agreement on identification. The watershed coordinator will make all final decisions concering discrepancies.*

Completeness

Data will meet completeness criteria if percentages outlined in Section 3 are met for each parameter.

If completeness goals are not met data will still be used. Data will be qualified by association with time of year and flow rates.

15.2 Corrective Action

Unusually high/low readings in the field will be used to trigger a potential corrective action. Corrective action will be an immediate equipment check and recalibration followed by another site sample. In the labratory unusually high/low readings and positive blanks will trigger corrective action. Corrective action will include an equipment check and recalibration. Positive blanks will require resampling.

16.0 Performance and System Audits

Performance audits for each section will be performed once each quarter by the SWCD District Manager. Systems audits will be conducted semi-annually by an external scientist selected by the SWCD District Manager.

IDEM reserves the right to conduct external performance and/or systems audits of any component of this study.

17.0 Preventative Maintenance

Preventative maintenance will be performed in accordance with the associated equipment manual.

An ample supply of batteries will be kept with field equipment. In addition, any parts associated with equipment that have limited time performance will have duplicates readily available.

VALIDATION & USABILITY

18.0 Data Review, Verification, Validation and Reconciliation with DQIs.

18.1 Data Review and Verification

Unusually high/low readings in the field will be used to trigger a potential corrective action. Corrective action will be an immediate equipment check and recalibration followed by another site sample. In the labratory unusually high/low readings and positive blanks will trigger *corrective action. Corrective action will include an equipment check and recalibration. Positive blanks will require resampling.*

18.2 Validation & Qualifiers

Qualifiers and Flags will be applied to collected data when necessary. See IDEM table below.

18.3 Reconciliation with User Requirements

The application of Qualifiers and Flags will be applied by the Watershed Coordinator and the IDEM QA Officer will verify the application when receiving data in the Required Spreadsheet.

Equipment used in the field and laboratory completes all data conversions into meaningful units.

Below is an ***example table*** *of a qualifiers and definitions used by IDEM Watershed Assessment & Planning Branch to validate data.*

Data Qualifiers and Flags

R: Rejected

J: Estimated.

Q: One or more of the QC checks or criteria was out of control.

H: The analysis for this parameter was performed out of the holding time. The results will be estimated or rejected on the basis listed below:

1) *If the analysis was performed between the holding time and 1½ times the holding time the result will be estimated.*
2) *If the analysis was performed outside the 1½ times the holding time window the result will be rejected.*

D: The Relative Percent Difference (RPD) for this parameter was above the acceptable control limits. The parameter will be considered estimated or rejected on the basis listed below:

1) *If the RPD is between the established control limits and two times the established control limits then the sample will be estimated.*
2) *If the RPD is twice the established control limits then the sample will be rejected.*

B: This parameter was found in field or lab blank. Whether the result is accepted, estimated, or rejected will be based upon the level of contamination listed below.

1) *If the Sample result is greater than the reporting limit but less than five times the blank contamination the result will be rejected.*
2) *If the Sample result is between five and ten times the blank contamination the result will be estimated.*
3) *If the Sample result is less than the Reporting limit or greater than ten times the Blank contamination the result will be accepted.*
4) *If the Sample result is < 10 times the Reporting limit then the result will be flagged (J+) as estimated high. In other words it is usable but the result is probably biased high.*

U: The result of the parameter is above the Method Detection Limit (MDL) but below the reporting limit and will be estimated.

18.4 Modeling or Statistical Methods Used

Final analysis approaches will be determined after four months of sampling and consultation with Purdue University. It is likely correlation and regression analysis will be employed along with ANOVA techniques.

19.0 Reports to Management, Documentation, Records

All data will be checked for errors and omissions by the watershed coordinator.

19.1 Data Reporting

The data and associated information will be collected by the project staff in a preformatted spreadsheet provided by the IDEM QA Officer.

19.2 Data Management

Data records such as field sheets and lab sheets will be stored for 5 years and/or provided to IDEM to be added to the project data as a pdf file in the AIMs database and to EPA.

19.3 Quality Assurance Reports

Quality Assurance (QA) reports will be submitted to IDEM's Watershed Planning and Restoration Section every three months as part of the Quarterly Progress Report and/or Final Report. The report will be a writen narrative listing any descrepencies found during QA reviews.

20.0 References

Ledet, N.D. 1991. Fawn River, LaGrange and Steuben Counties. Indiana Department of Natural Resource Report.

Marsh - McBirney. 1990. Model 2000 Installation and Operations Manual

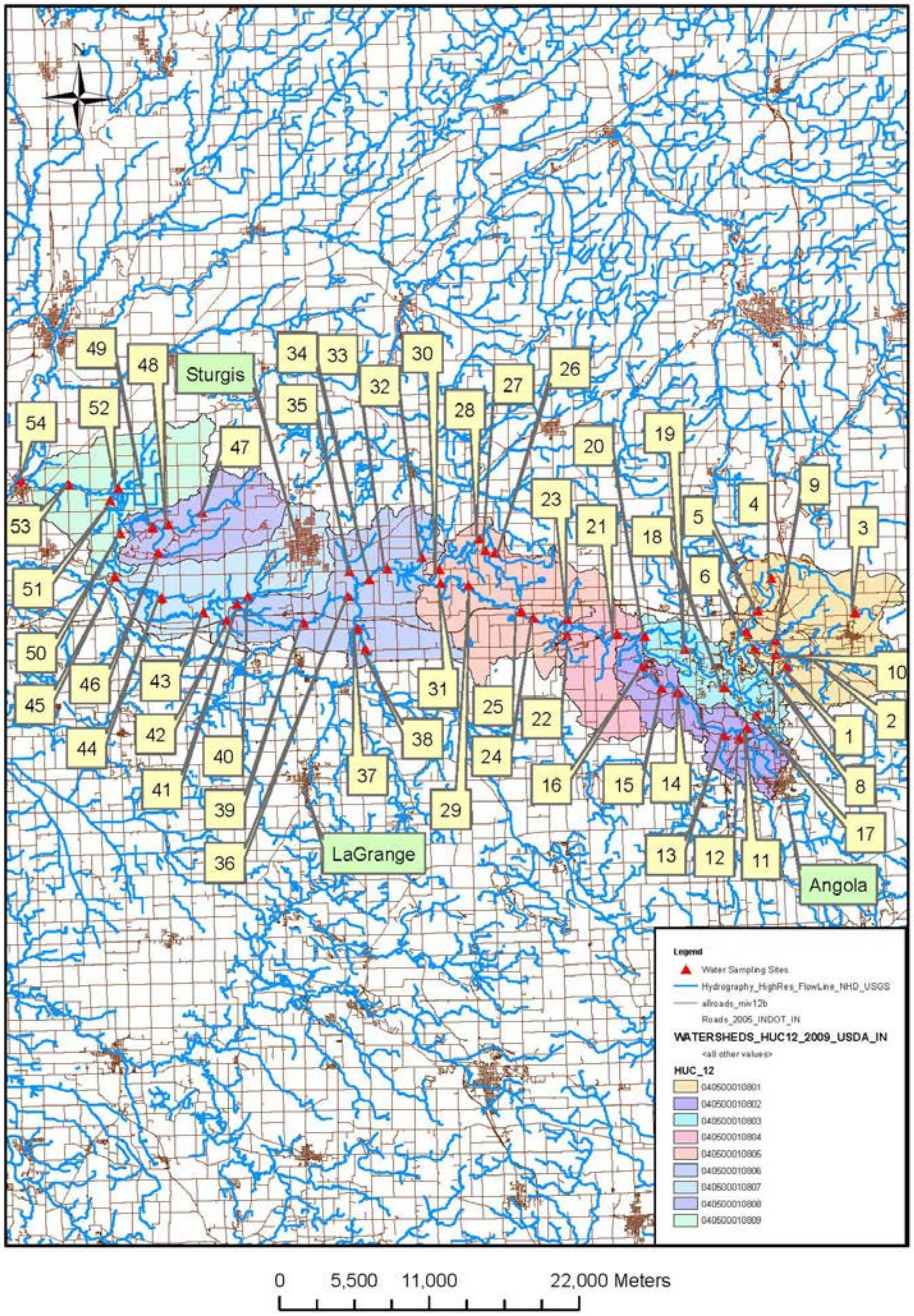
Ohio Environmental Protection Agency. 1989. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Monitoring and Assessment, Columbus, Ohio.

U.S.Environmental Protection Agency. 1997. Volunteer Stream Monitoring. A Methods Manual. EPA-841-B-97-003.

Volunteer Stream Monitoring Training Manual: Hoosier Riverwatch - Indiana's Volunteer Stream Monitoring Program. Indiana Department of Natural Resources, March 2001.

21.0 Appendices

Appendix A: Water Quality Sample Site Map



Appendix B: Water Sampling Field Log Sheet

WATER QUALITY SAMPLING FIELD LOG

SITE NUMBER AND LOCATION: ____
DATE: ______________ PROJECT NAME: ___________________________
TIME: ______________
FIELD CREW: ____________________________________
WEATHER CONDITIONS: ____
OTHER OBSERVATIONS: ____
EQUIPMENT CALIBRATION (Date): ______________________

FIELD PARAMETERS REPLICATE/Field Blank (if taken)

pH: ____________ pH: ___________ RPD = _______
Temp: __________ Temp: _
DO: ____________ DO: ___________ RPD = _______
TDS: ___________ TDS: __________ RPD = _______
Turb: ___________ Turb: __________ RPD= _______
Calculated Flow: _____________

Relative Percent Difference (RPD) = $\frac{(sample1-sample2)}{((sample1+sample2)/2)}$

LAB PARAMETERS

E. Coli: __________
Nitrate: __________
TP: _____________
BOD: ____________
TSS: ____________
Field Crew Leader Signature: _________________________

Appendix C: Discharge Measurement Sheet

DISCHARGE MEASUREMENT

Site: ____________________ Date: _________ Time: ________
Project#: _________________ Project Name: ________________
Crew Members: _______________________ Equipment: ___________________
Site Physical Description: ____

If stream is <2" deep:
Stream width: ______ feet
Stream Depths: ______, ______, ______, _____, _____, _____, _____, _____, _____feet
U: _____, _____, _____, _____, _____, _____, _____, _____, _____, _____ ft/s
U_{max}: _____ft/s

If stream is >2" deep:
Stream width: ______ feet
Interval Width (IW) (If W<15', then IW=W/5. If W>15', then IW=W*0.1): _____ feet

Segment	SI_0 Location Depth	SI_1 Location Depth	½ IW Location Depth	$U_{0.4}$ Set Depth Rate
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Field Crew Leader Signature: ________________________________