

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 Quality 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/L for 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 macroinvertebrates 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.

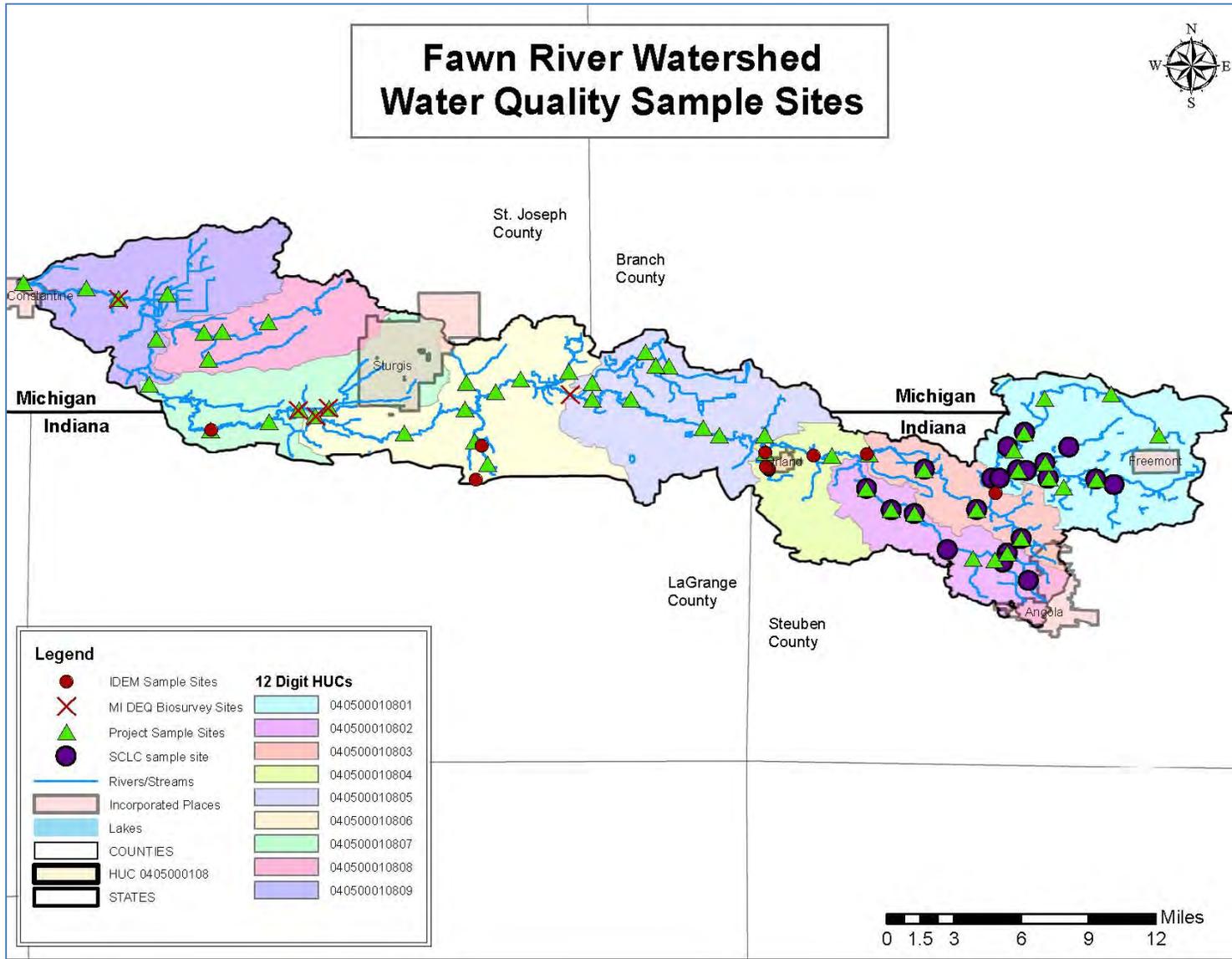
Table 3.1: Water Quality Targets

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_T1001	JIMMERSON LAKE INLET	3	2	2				
	INJ0183_T1002	JIMMERSON LAKE INLET	3	3	3				
	INJ0183_T1003	JIMMERSON LAKE INLET	3	3	3				
	INJ0183_T1004	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_T1001	CROOKED CREEK - UNNAMED TRIBUTARY	3	3	3				
	INJ0184_T1002	CROOKED CREEK - UNNAMED TRIBUTARY	3	3	3				
	INJ0195_T1040	ORLAND TRIB	3	3	2				
40500010805	INJ0185_02	FAWN RIVER	3	3	3				
	INJ0185_02A	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_02 B	FAWN RIVER - UNNAMED DITCHES	3	3	3				
	INJ01P1140_00	WALL LAKE	3	3	3				
	INJ01P1142_00	FENNEL 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_01 A	FAWN RIVER - UNNAMED DITCHES	3	3	3				
	INJ0186_02	FAWN RIVER	3	3	3				
	INJ0186_T1 001	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_T1 001	WENGER DITCH	2	3	3				

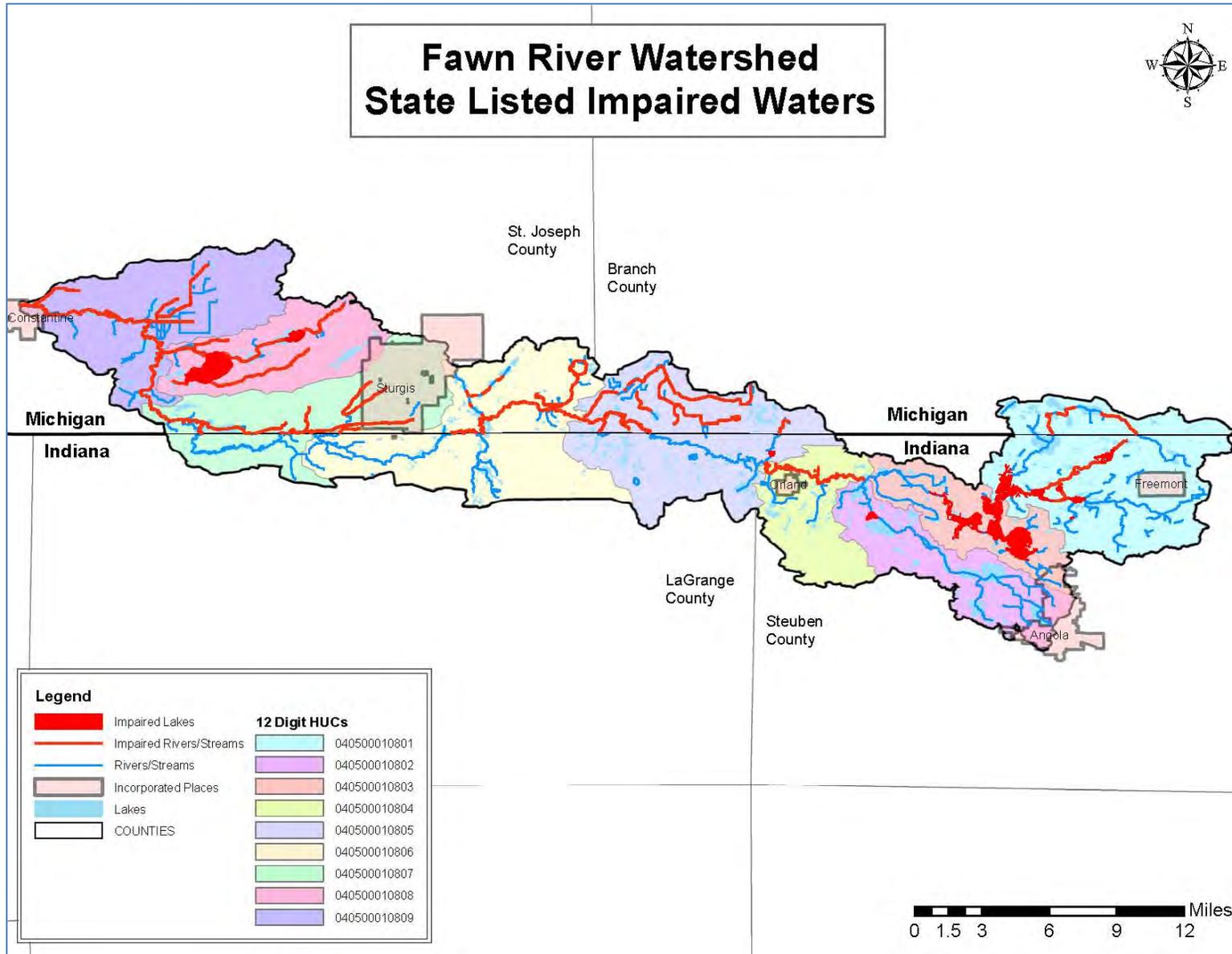
Category Description		Sub-Category
Category 1	Water Quality attainment for all designated uses and no use is threatened.	
Category 2	Water Quality attainment for some designated uses and no use is threatened; and insufficient data and information is available to determine if the remaining uses are attained 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 is 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
	040500010805-02	Fawn River and all tributaries from Himebaugh Drain upstream to IN line	31.938479	PCB in Water Column
				Mercury in Fish Tissue
40500010806	040500010806-01	Indiana Waterbodies	11.42625	PCB in Fish Tissue
	040500010806-02	Fawn River	0.455465	PCB in Water Column
				Mercury in Fish Tissue
	040500010806-03	UnNamed Tributary to Fawn River	0.227421	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.

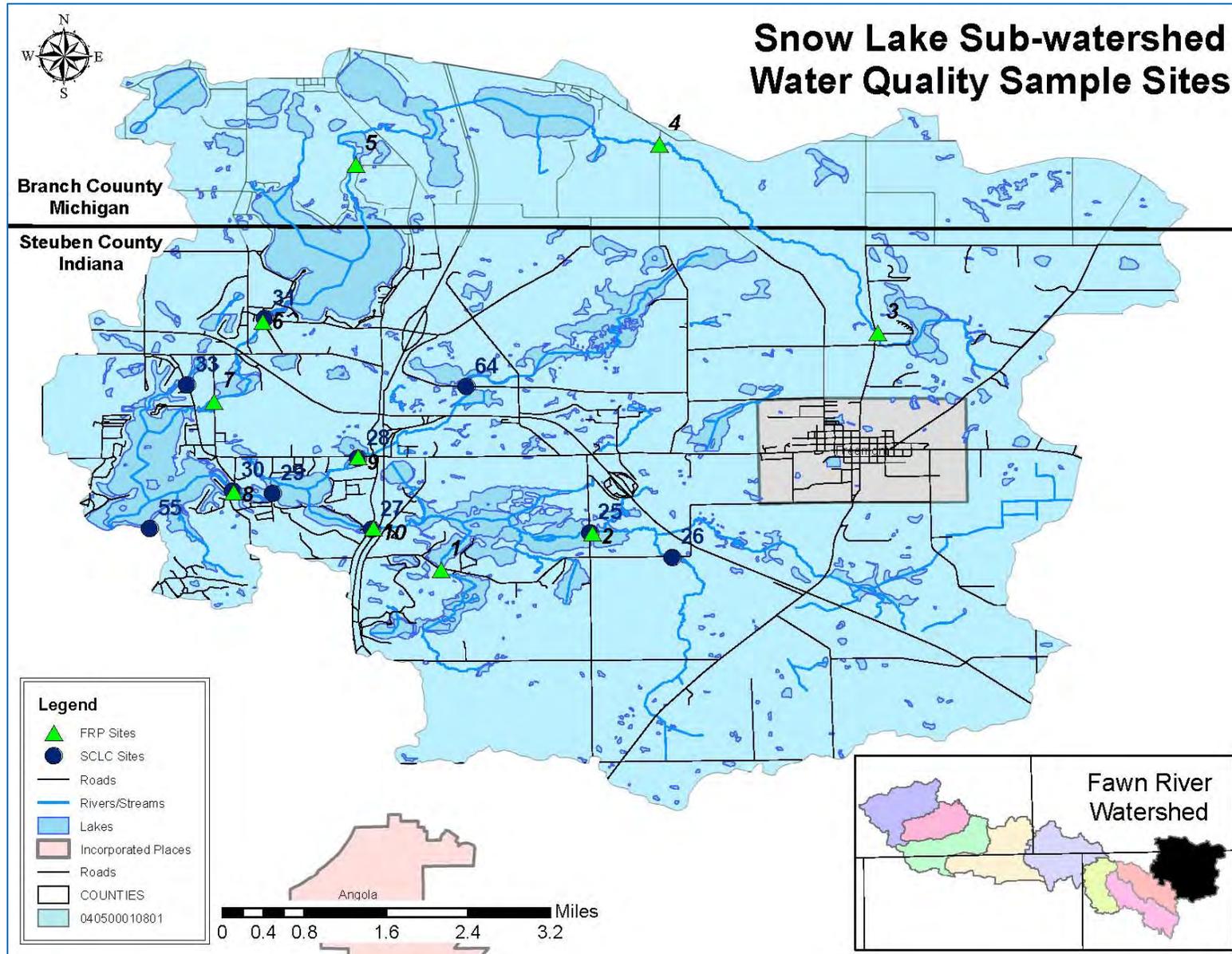
3.3.1 Snow Lake Sub-watershed Water Quality Analysis

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	°C	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	°C	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%
<i>E. coli</i>	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
<i>E. coli</i>	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	°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 Follett Creek

SCLC, Site 27, Follett Creek (Little Otter Lake Inlet)				
Parameter	Mean (Geomean)	Unit	# Does Not Meet Target	% Does Not Meet Target
<i>E. coli</i>	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	°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	°C	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%
<i>E. coli</i>	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
<i>E. coli</i>	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	°C	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	°C	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%
<i>E. coli</i>	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
<i>E. coli</i>	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	°C	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
<i>E. coli</i>	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%
<i>E. coli</i>	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
<i>E. coli</i>	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	°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	°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%
<i>E. coli</i>	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
<i>E. coli</i>	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	°C	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
<i>E. coli</i>	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	°C	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	°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	°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	.086	NTU	1/7	14%
<i>E. coli</i>	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	

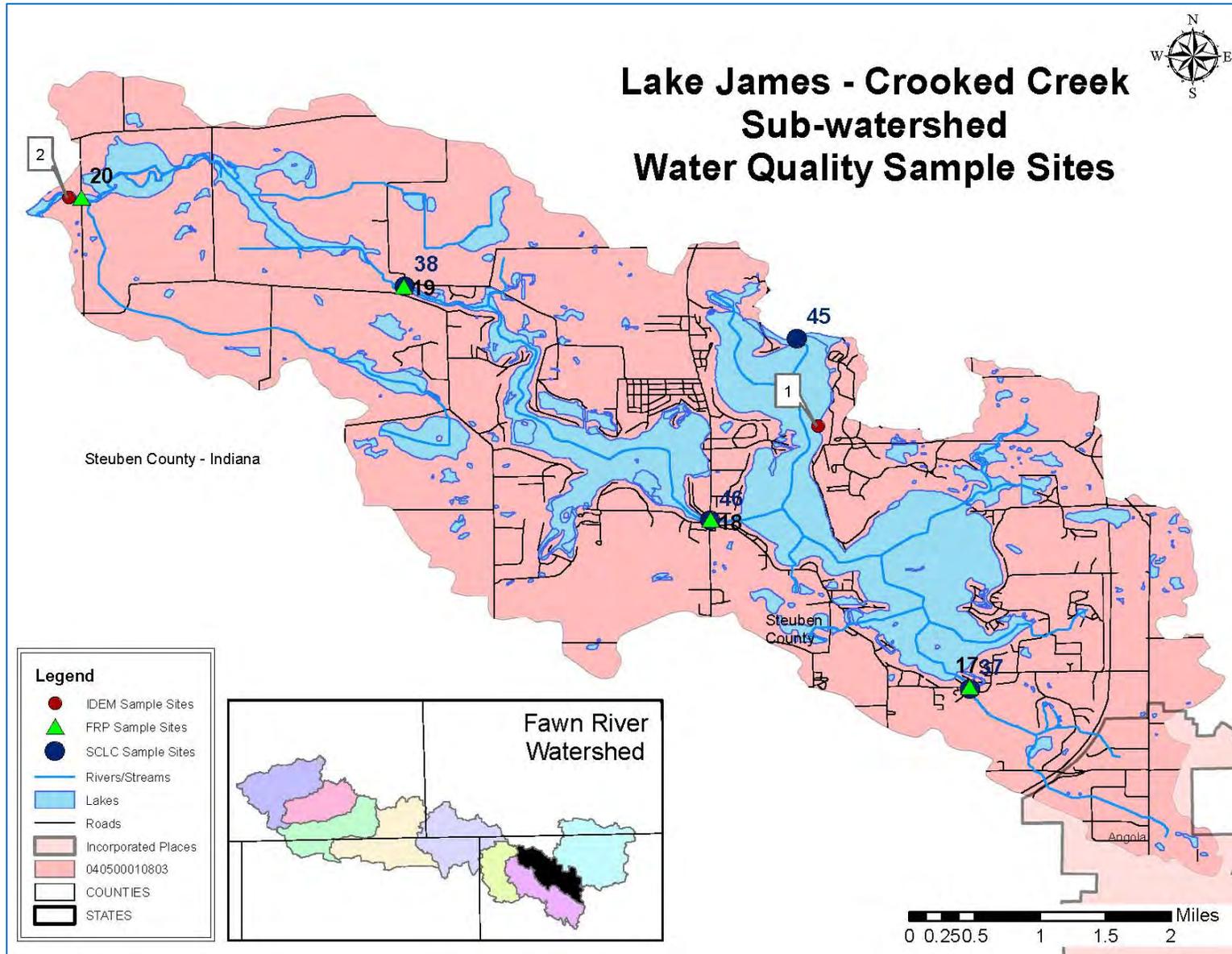
3.3.2 Lake James – Crooked Creek Sub-watershed Water Quality Analysis

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	°C	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	°C	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%
<i>E. coli</i>	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	°C	0/10	0%
Microcystis	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	°C	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	°C	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	°C	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%
<i>E. coli</i>	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	°C	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	°C	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%
<i>E. coli</i>	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%
<i>E. coli</i>	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	

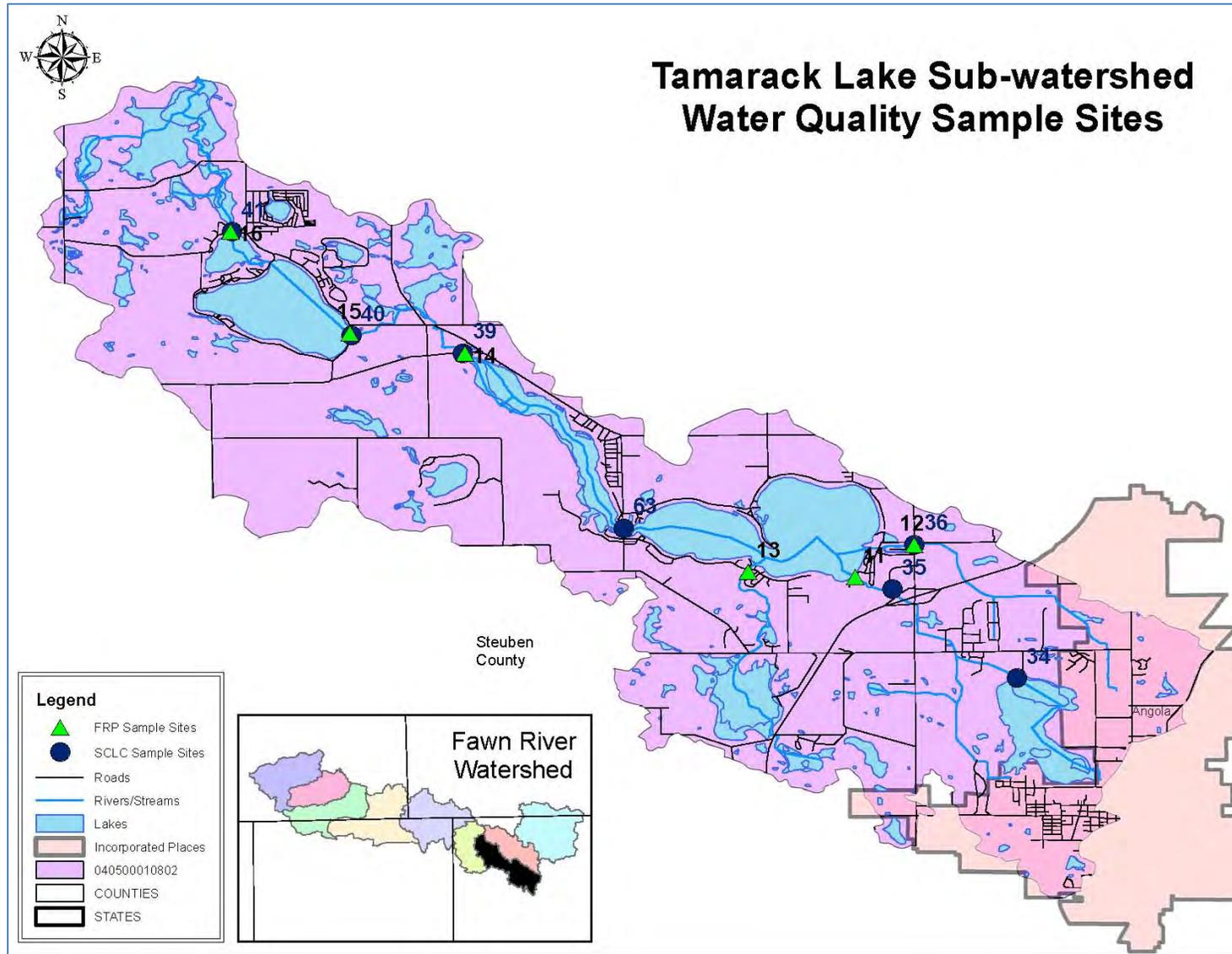
3.3.3 Tamarack Lake Sub-watershed Water Quality Analysis

Water quality in the Tamarack 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	°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	°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	°C	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%
<i>E. coli</i>	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
<i>E. coli</i>	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	°C	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	°C	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	°C	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%
<i>E. coli</i>	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
<i>E. coli</i>	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	°C	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	°C	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%
<i>E. coli</i>	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 30.1°C, 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
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	

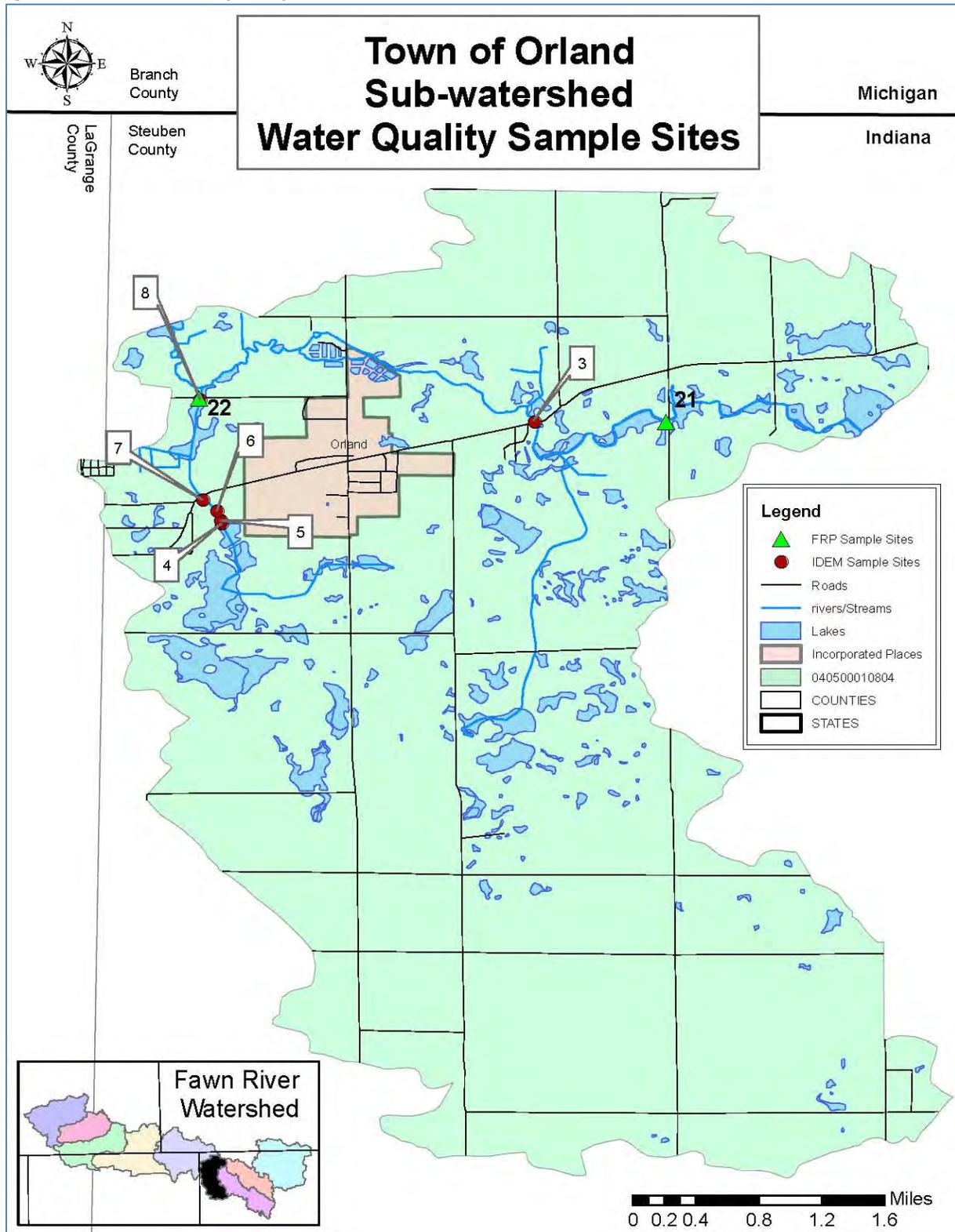
3.3.4 Town of Orland – Fawn River Sub-watershed Water Quality Analysis

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
<i>E. coli</i>	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%
<i>E. coli</i>	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
<i>E. coli</i>	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	°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	°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	°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	°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	°C	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	°C	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%
<i>E. coli</i>	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	

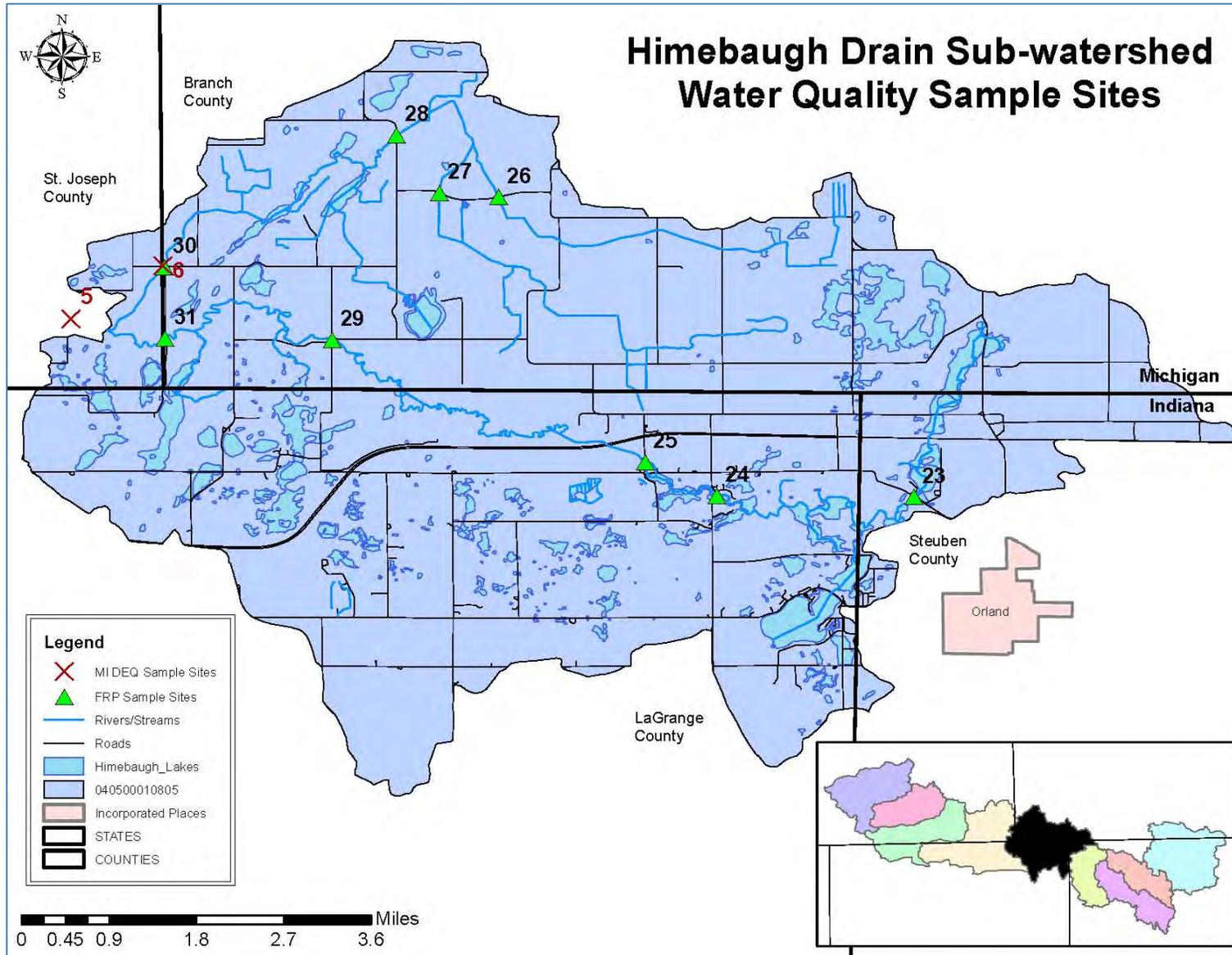
3.3.5 Himebaugh Drain Sub-watershed Water Quality Analysis

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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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%
<i>E. coli</i>	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%
<i>E. coli</i>	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%

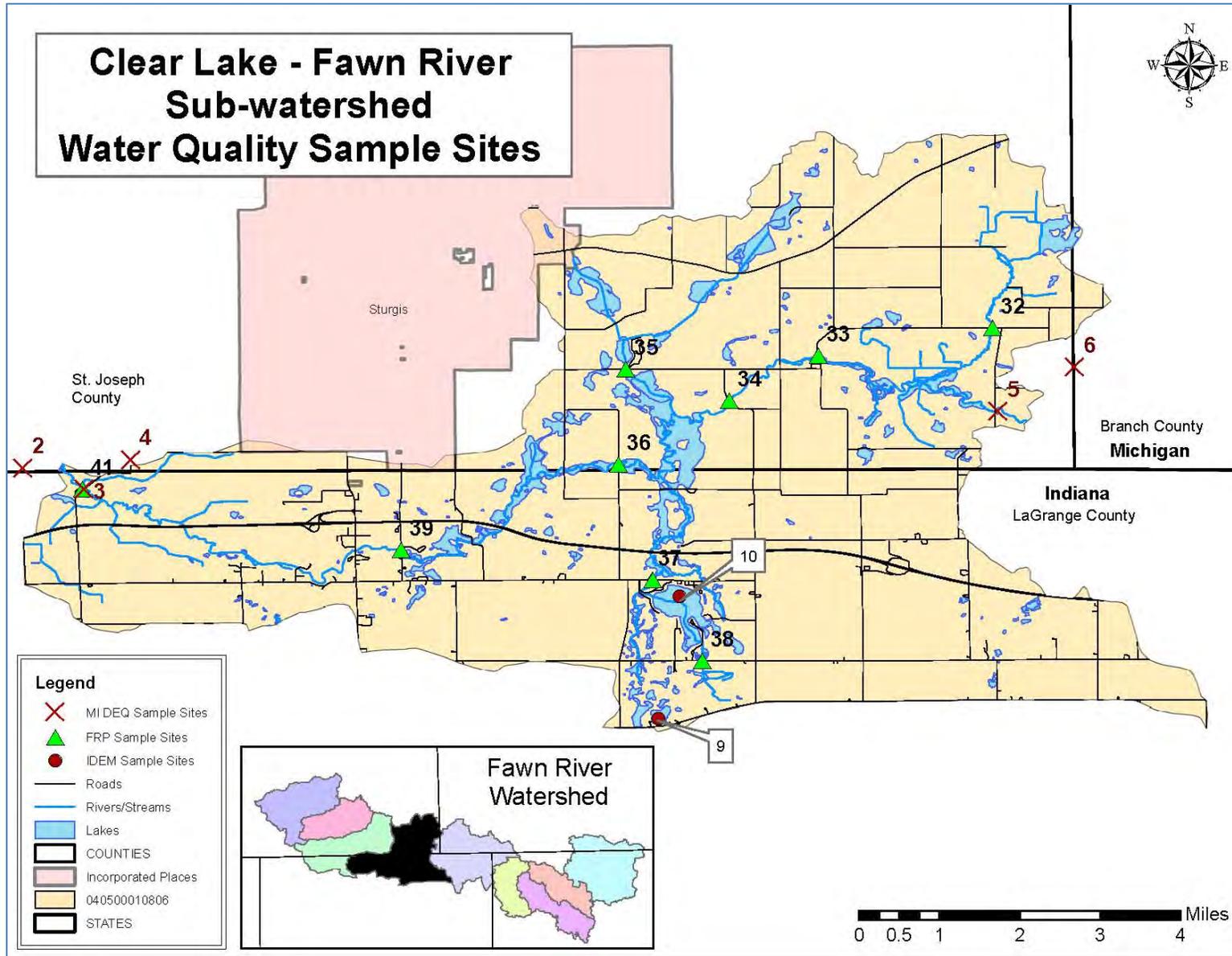
3.3.6 Clear Lake – Fawn River Sub-watershed Water Quality Analysis

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
<i>E. coli</i>	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%
<i>E. coli</i>	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 macroinvertebrate 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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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 Meter 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 Meter Lake (Site 9)

IDEM - 2000: Meter 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	°C	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 macroinvertebrate 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	°C	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%
<i>E. coli</i>	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	°C	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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 an 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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	

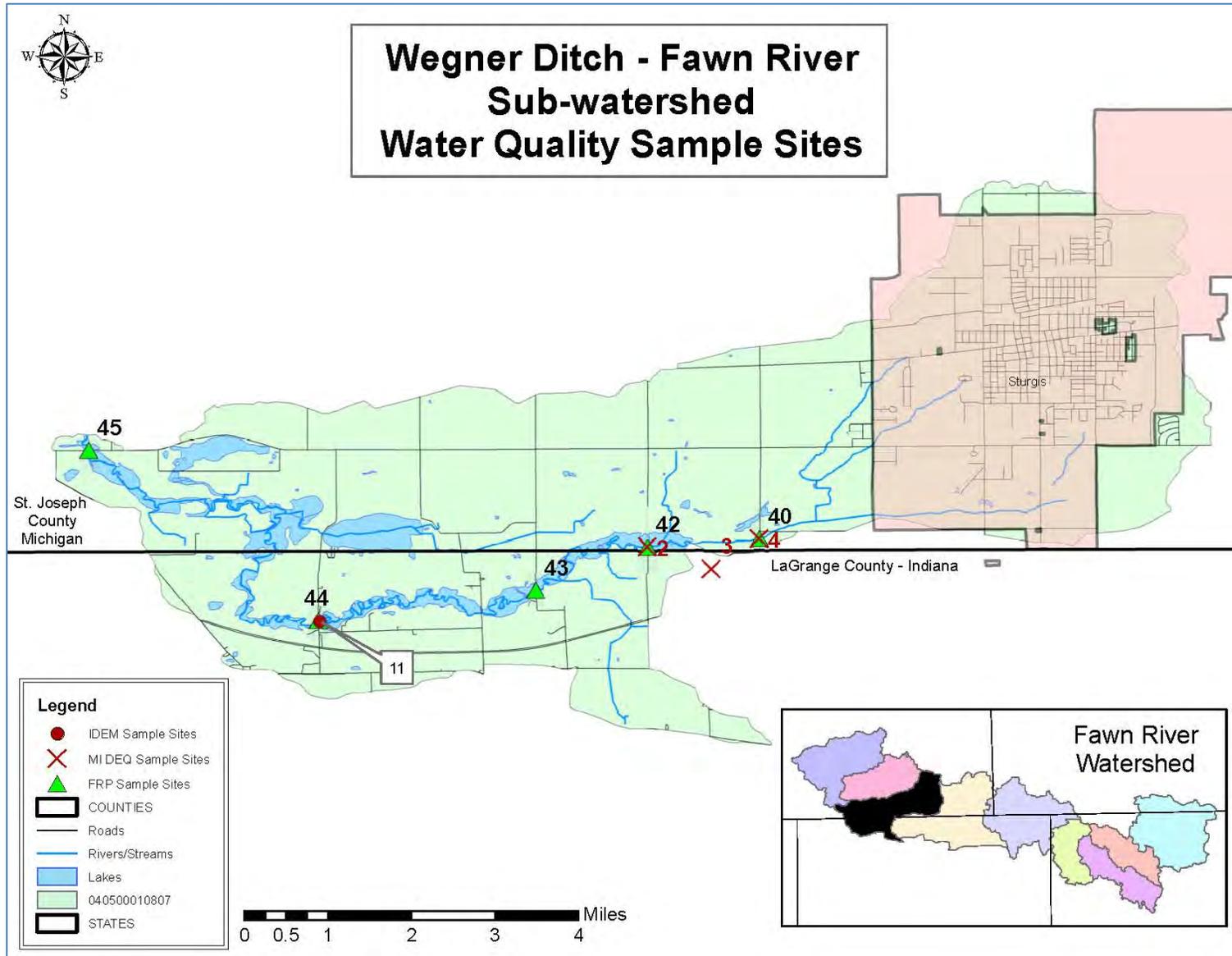
3.3.7 Wegner Ditch – Fawn River Sub-watershed Water Quality Analysis

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 Ditch - Fawn River Sub-watershed			
Parameter	Mean	Unit	% Does Not Meet Target
<i>E. coli</i>	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. Macroinvertebrates 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	°C	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%
<i>E. coli</i>	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%
<i>E. coli</i>	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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
<i>E. coli</i>	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	°C	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	°C	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%
<i>E. coli</i>	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	

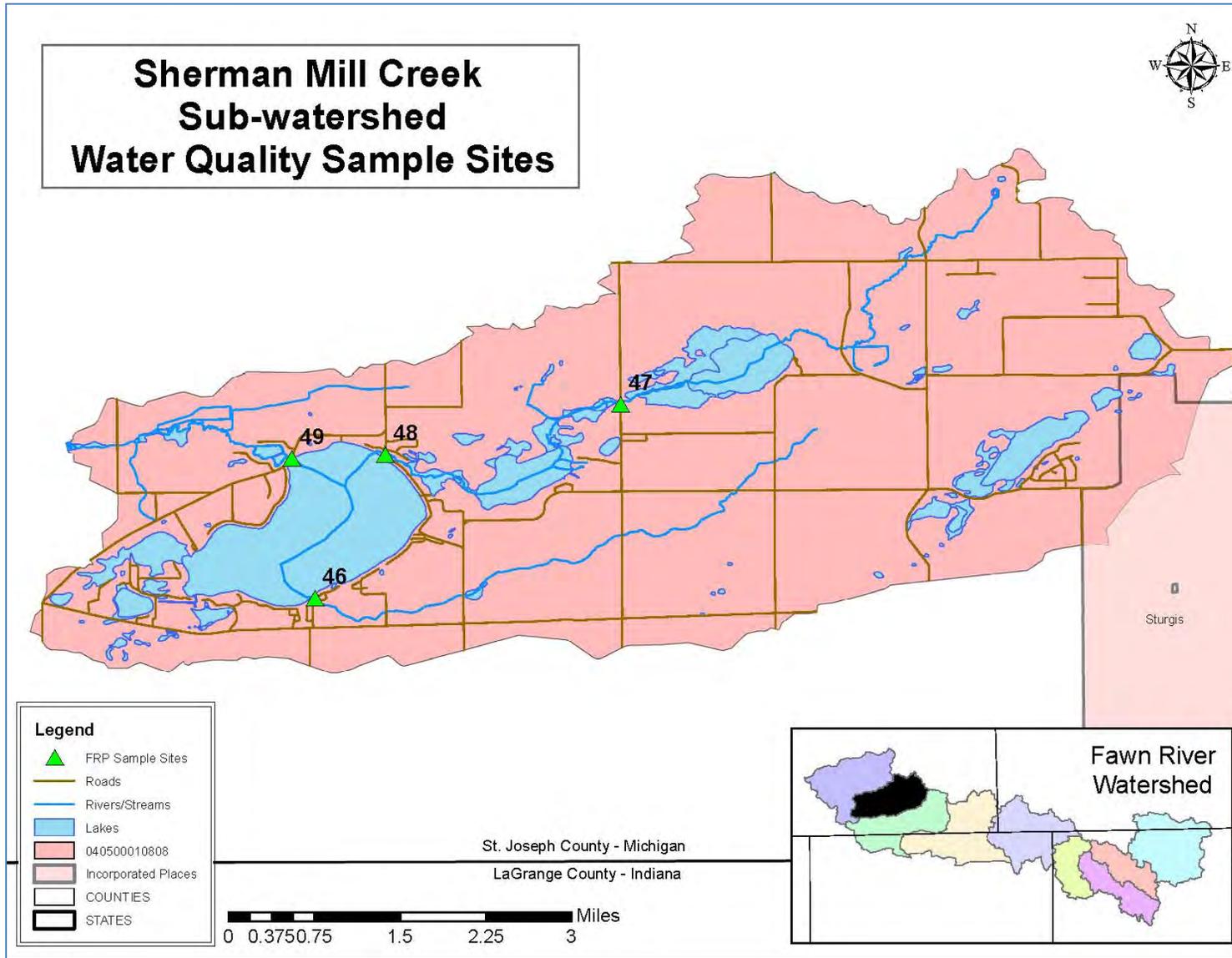
3.3.8 Sherman Mill Creek Sub-watershed Water Quality Analysis

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
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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%
<i>E. coli</i>	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%
<i>E. coli</i>	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%
<i>E. coli</i>	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	

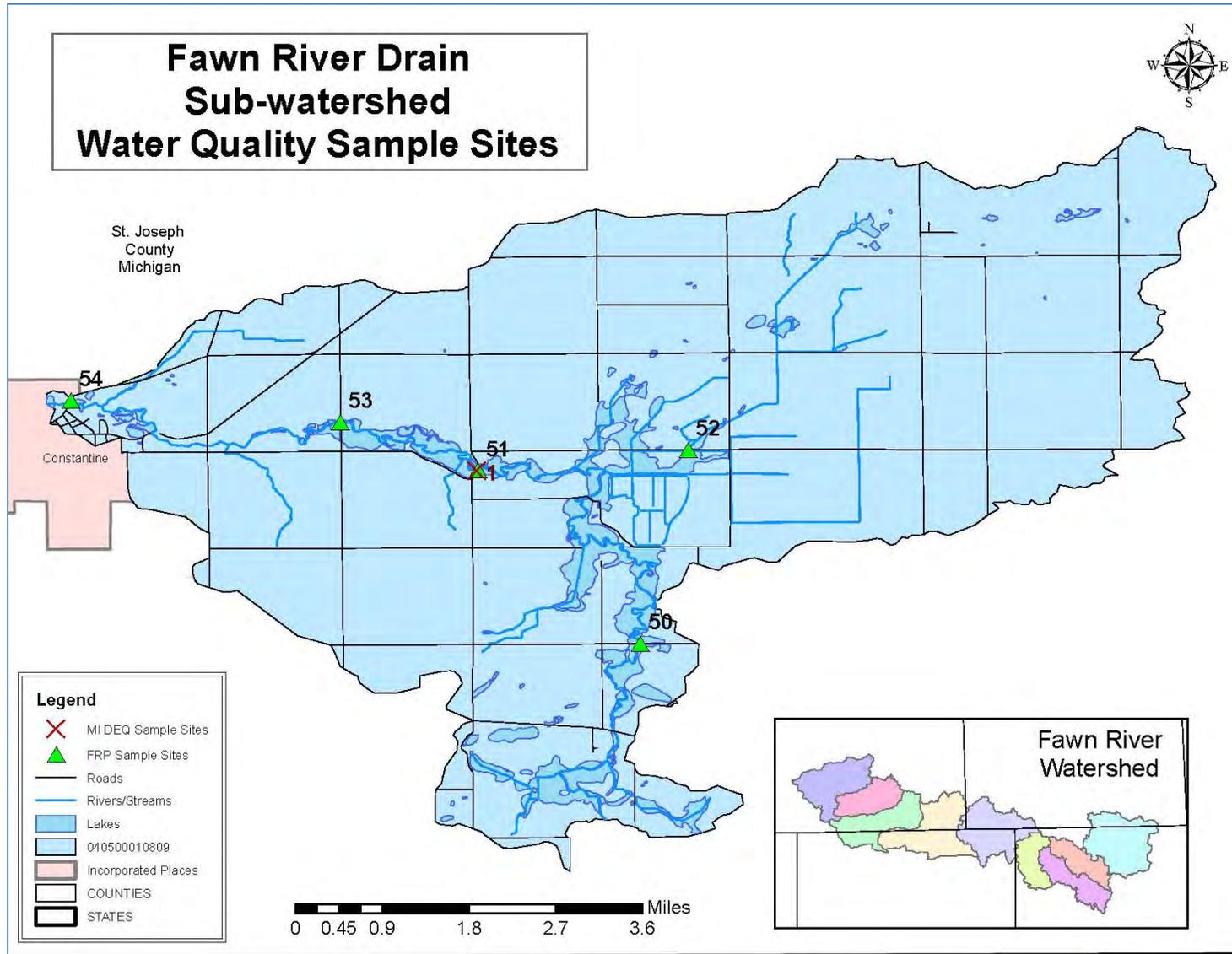
3.3.9 Fawn River Drain Sub-watershed Water Quality Analysis

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
<i>E. coli</i>	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	°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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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 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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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	°C	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%
<i>E. coli</i>	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.

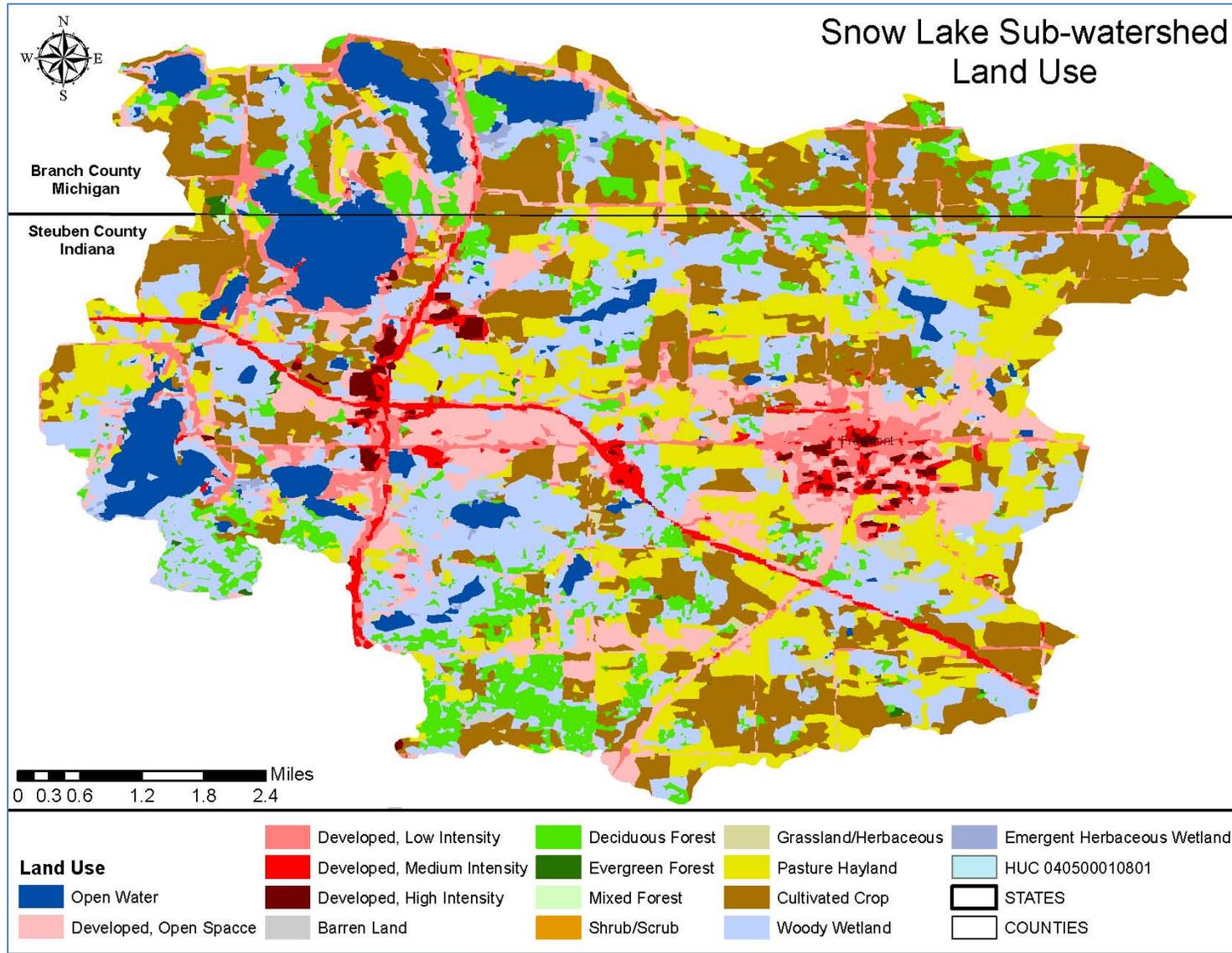
3.4.1 Snow Lake Sub-watershed Land Use

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

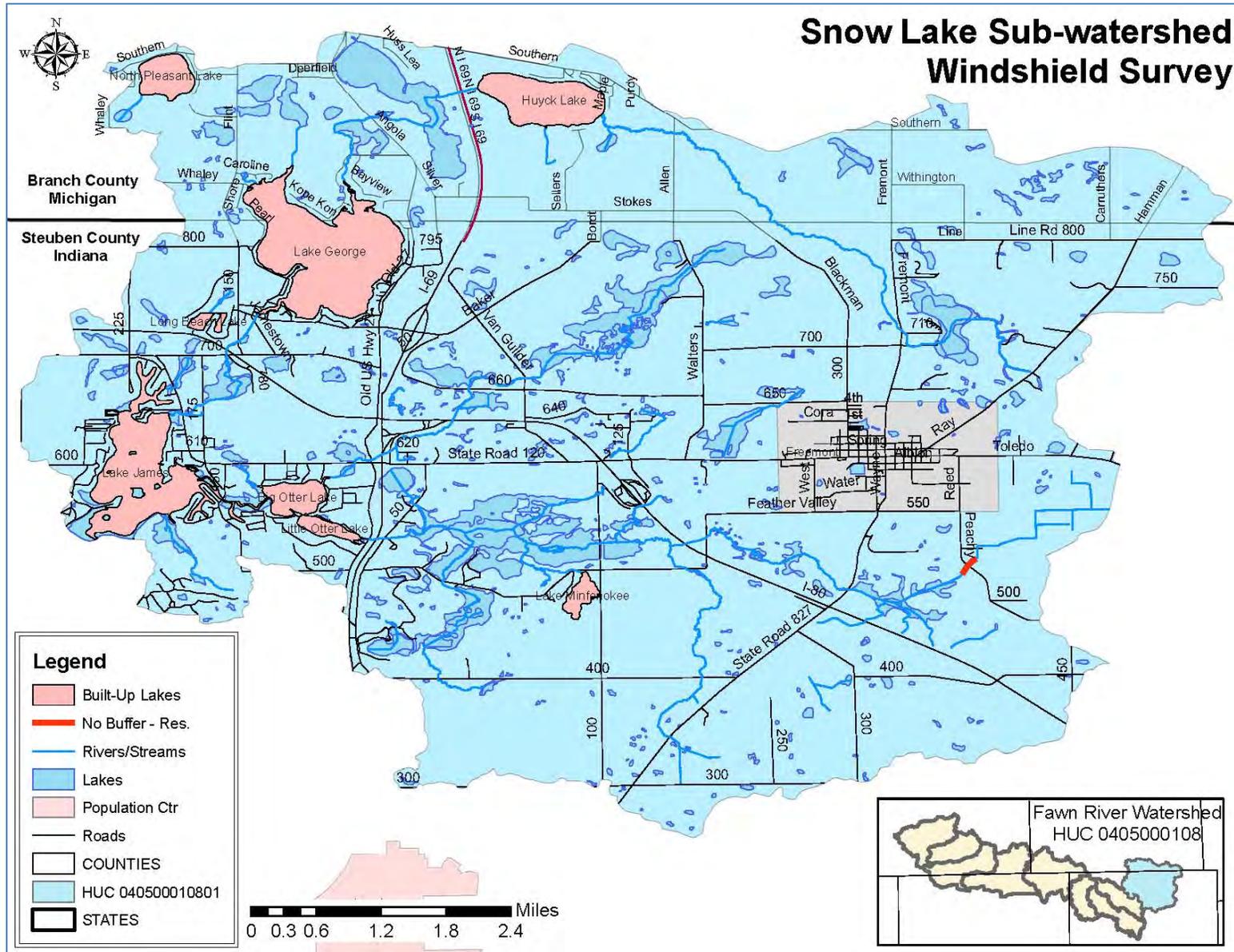


Figure 3.14: Septic Suitability in Snow Lake Sub-watershed

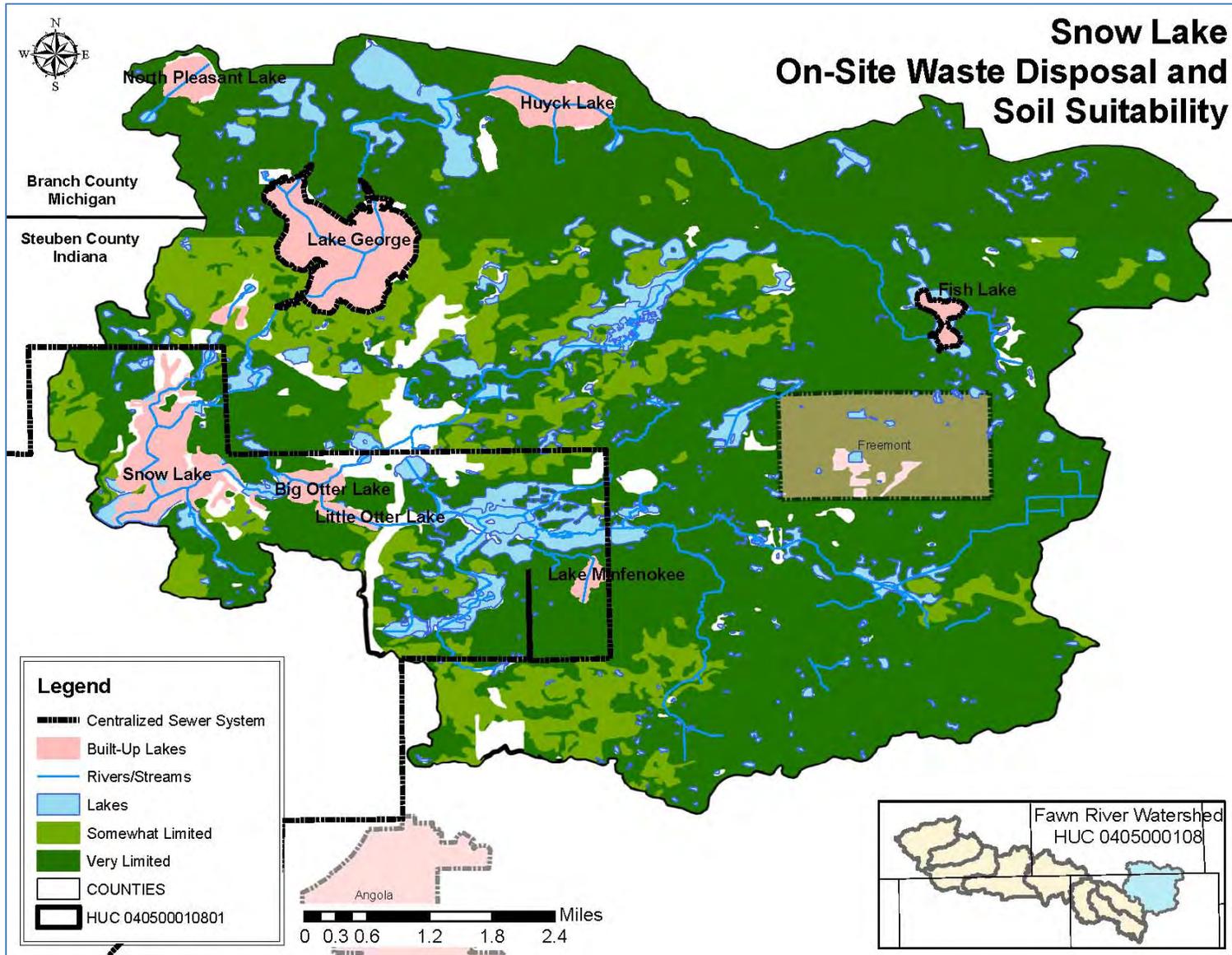


Figure 3.15: Highly Erodible Land in Agricultural Areas in the Snow Lake Sub-watershed

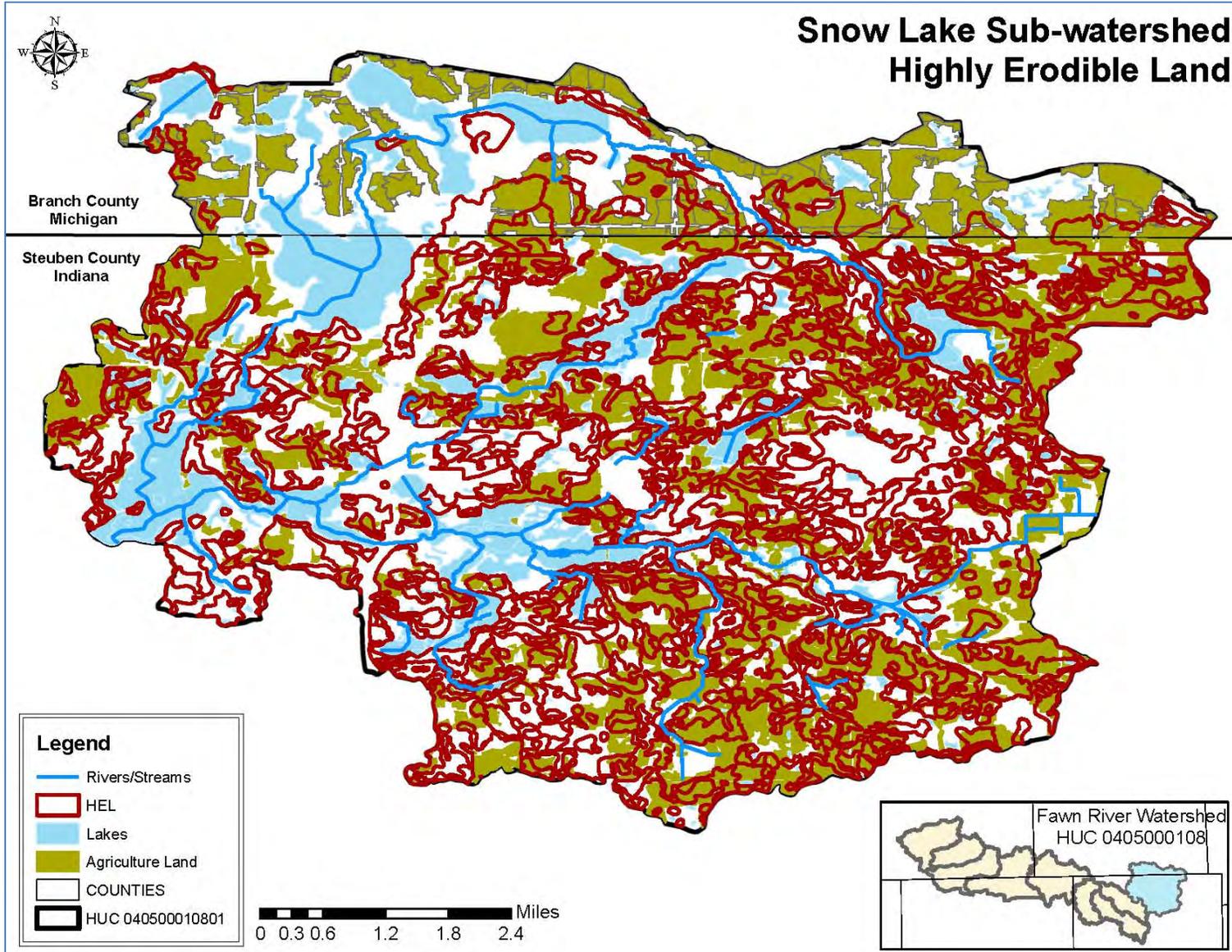
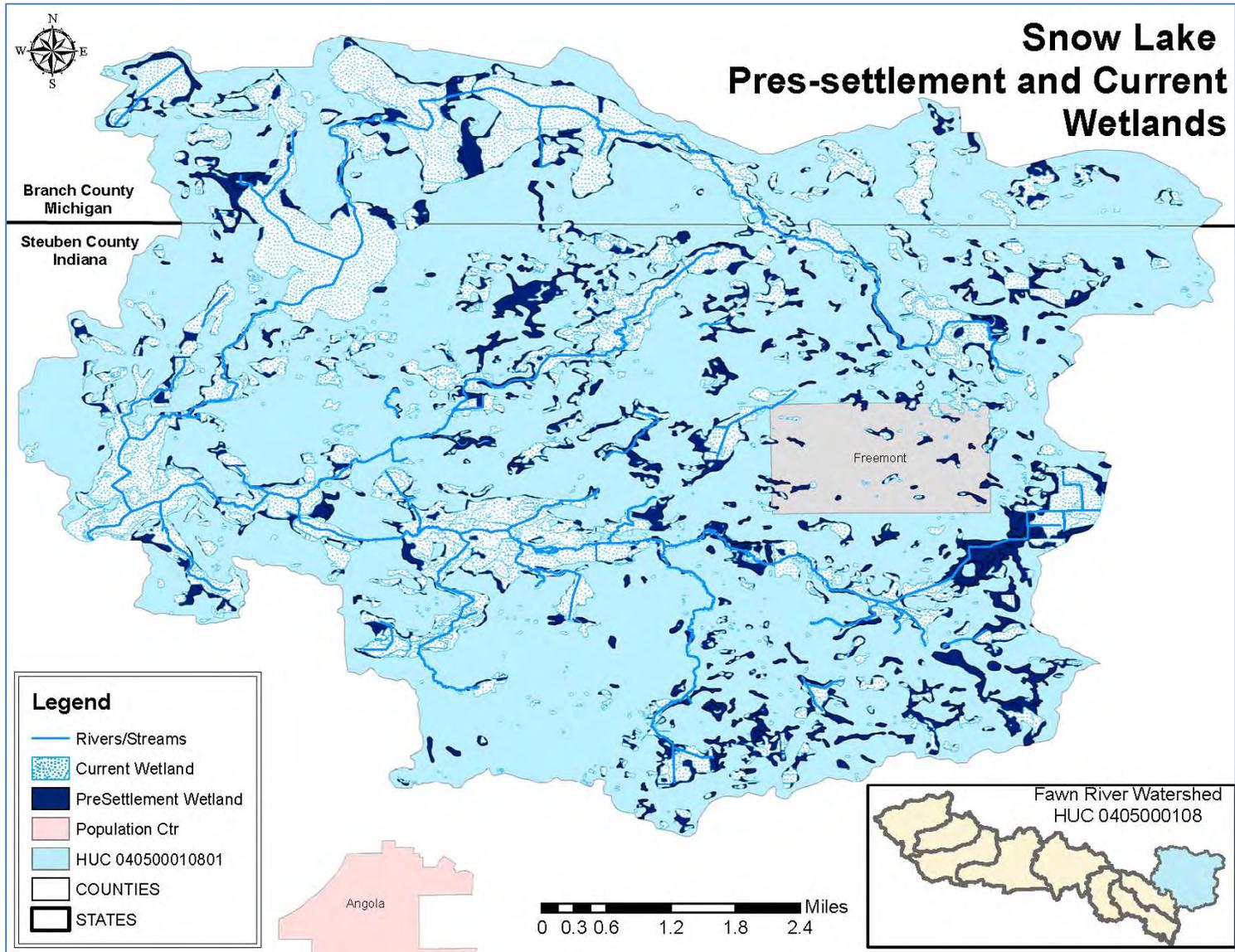


Figure 3.16: Current and Pre-settlement Wetlands in the Snow Lake Sub-watershed



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	Qtrs 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.

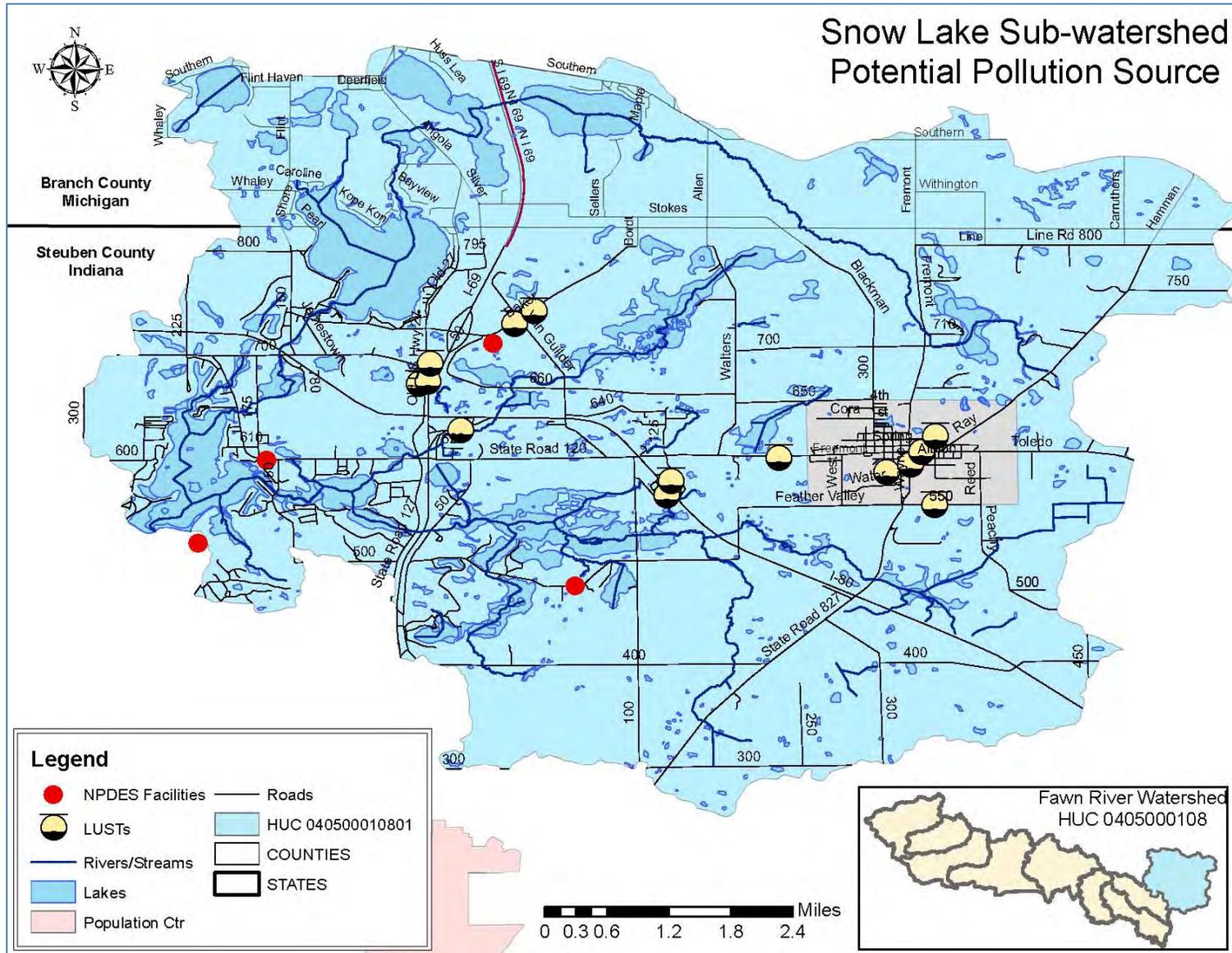
Table 3.4.3: Leaking Underground Storage Tanks in the Snow Lake Sub-watershed

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.

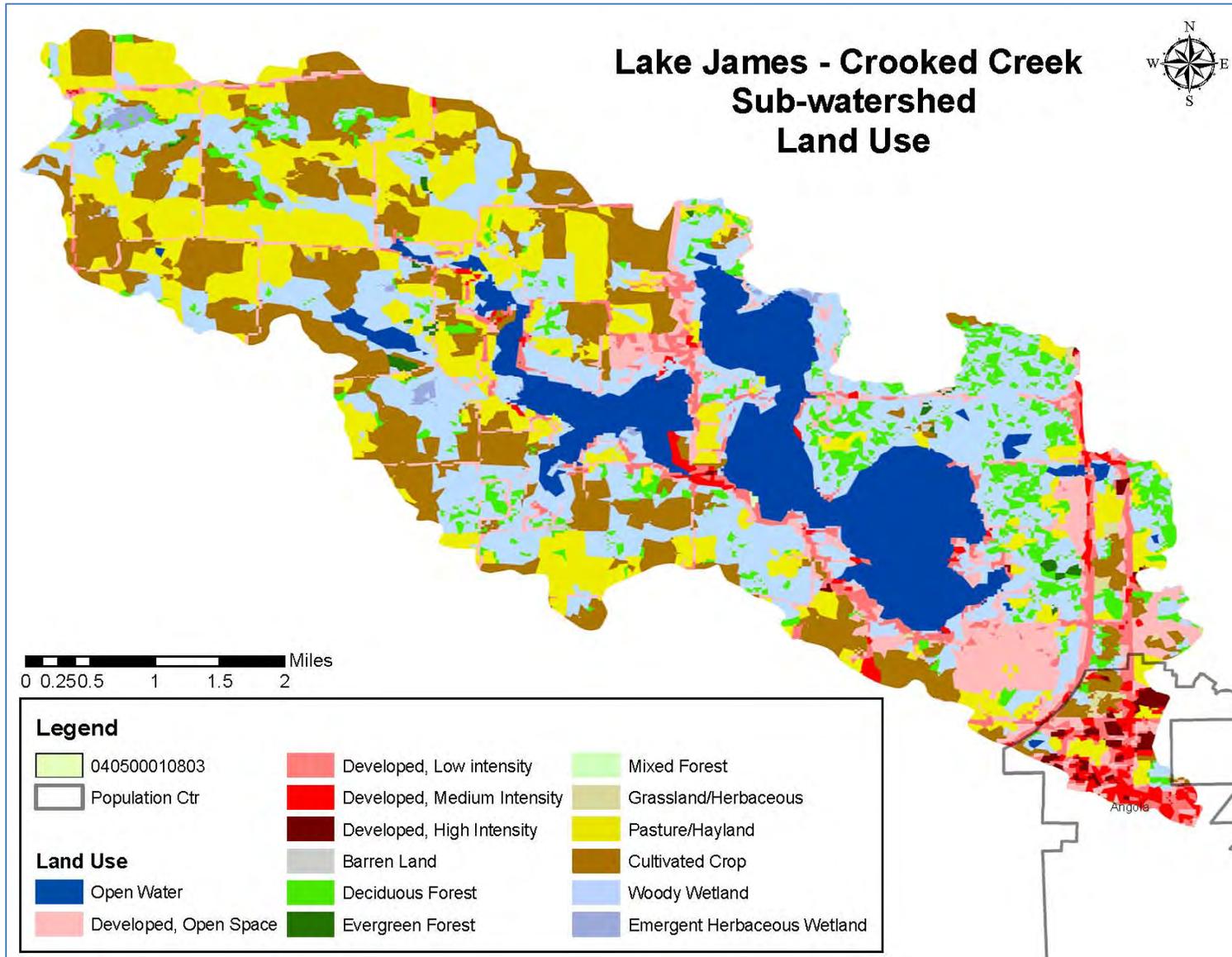
3.4.2 Lake James – Crooked Creek Sub-watershed Land Use

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 land use 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 Intensity	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 <i>E. coli</i>	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, over 75% 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

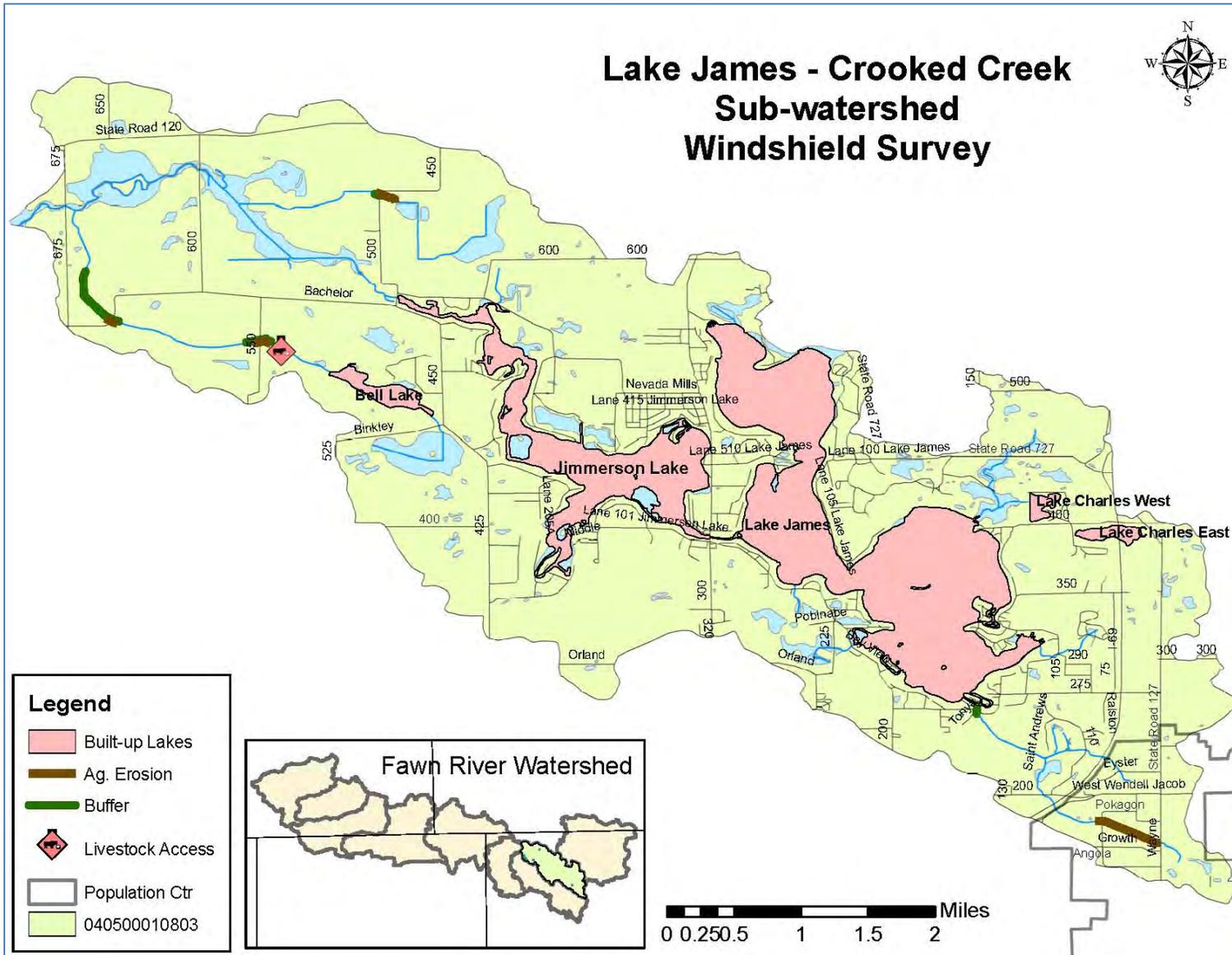
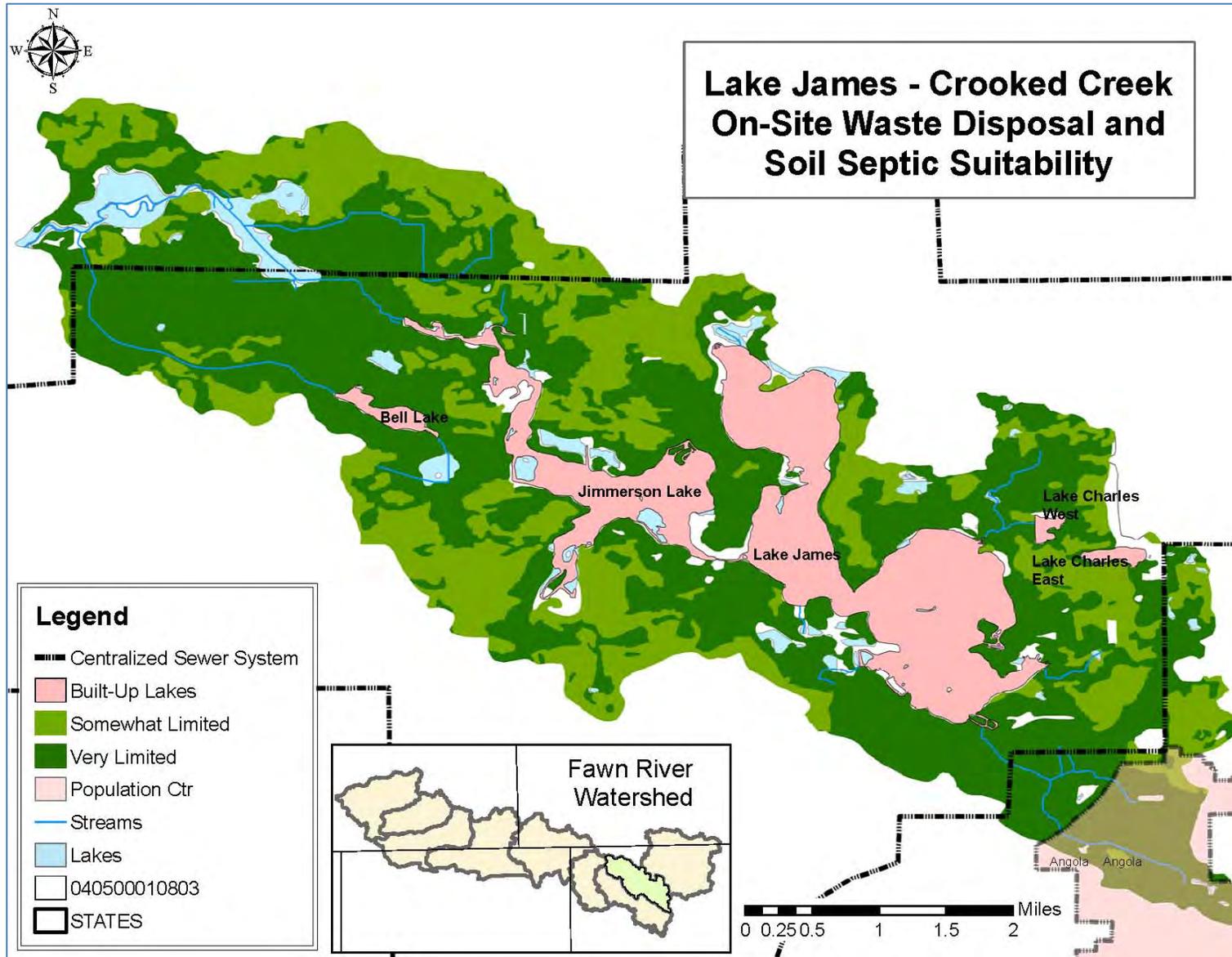


Figure 3.20: Septic Suitability in Lake James –Crooked Creek Sub-watershed



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

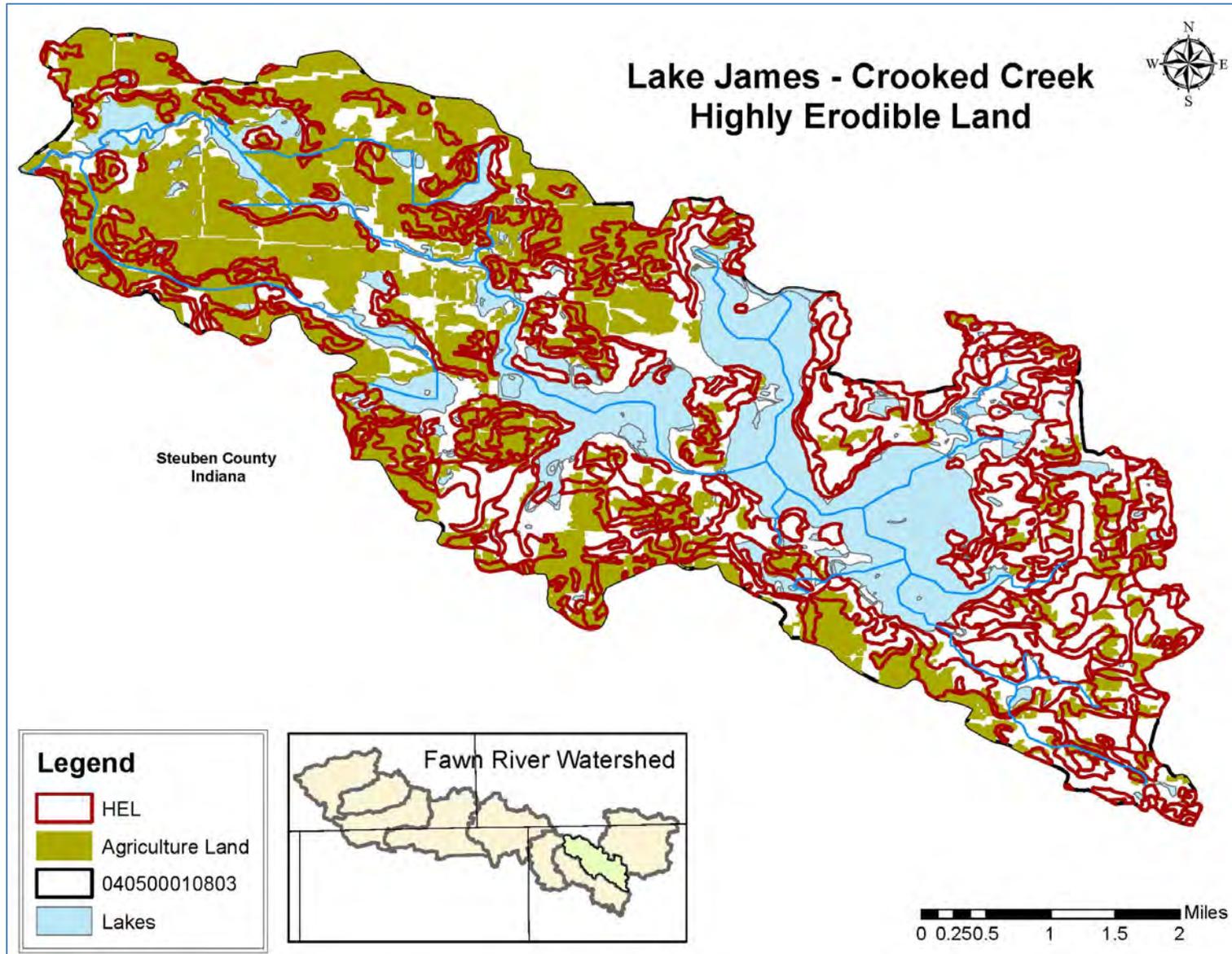
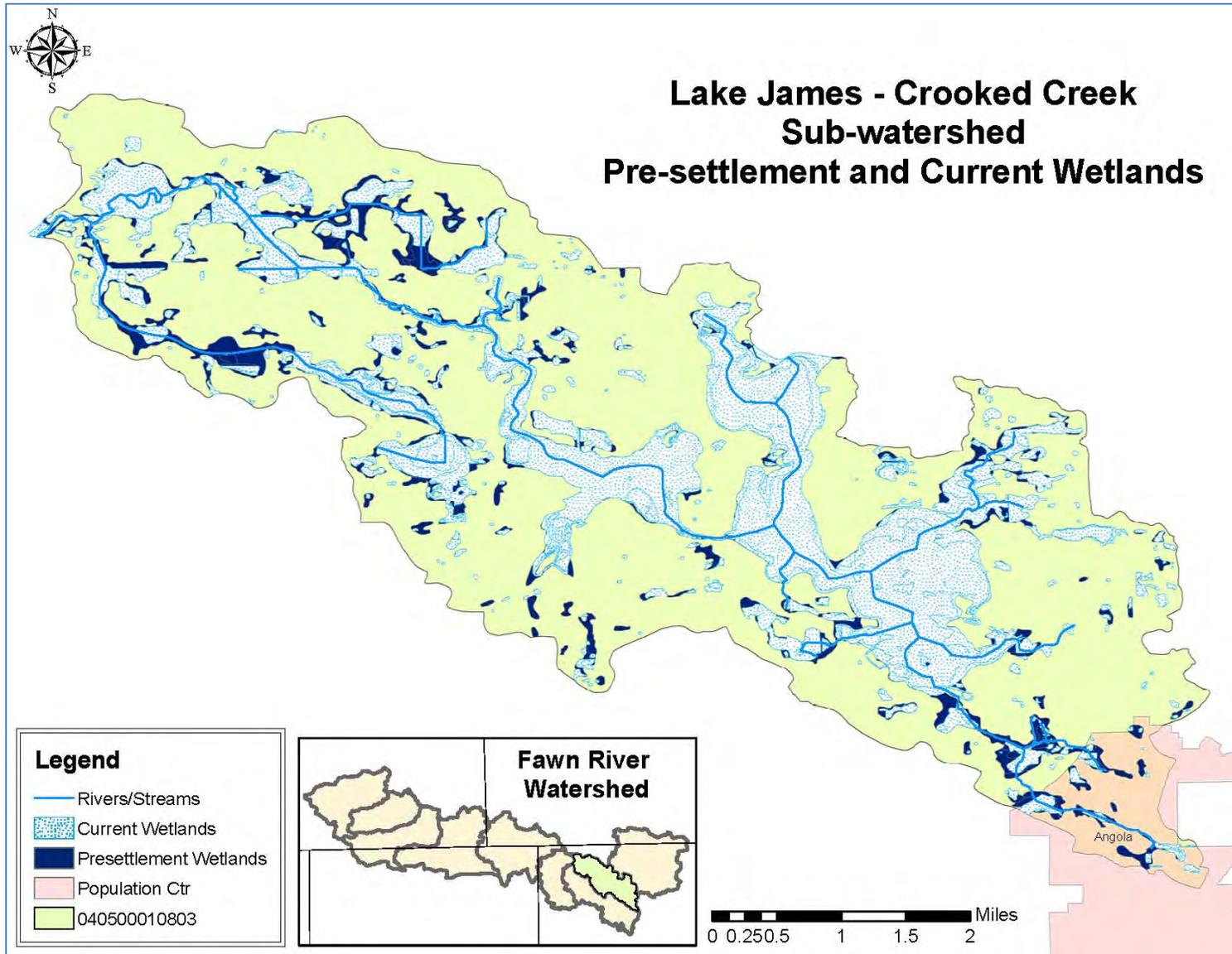


Figure 3.22: Wetlands in Lake James-Crooked Creek Sub-watershed



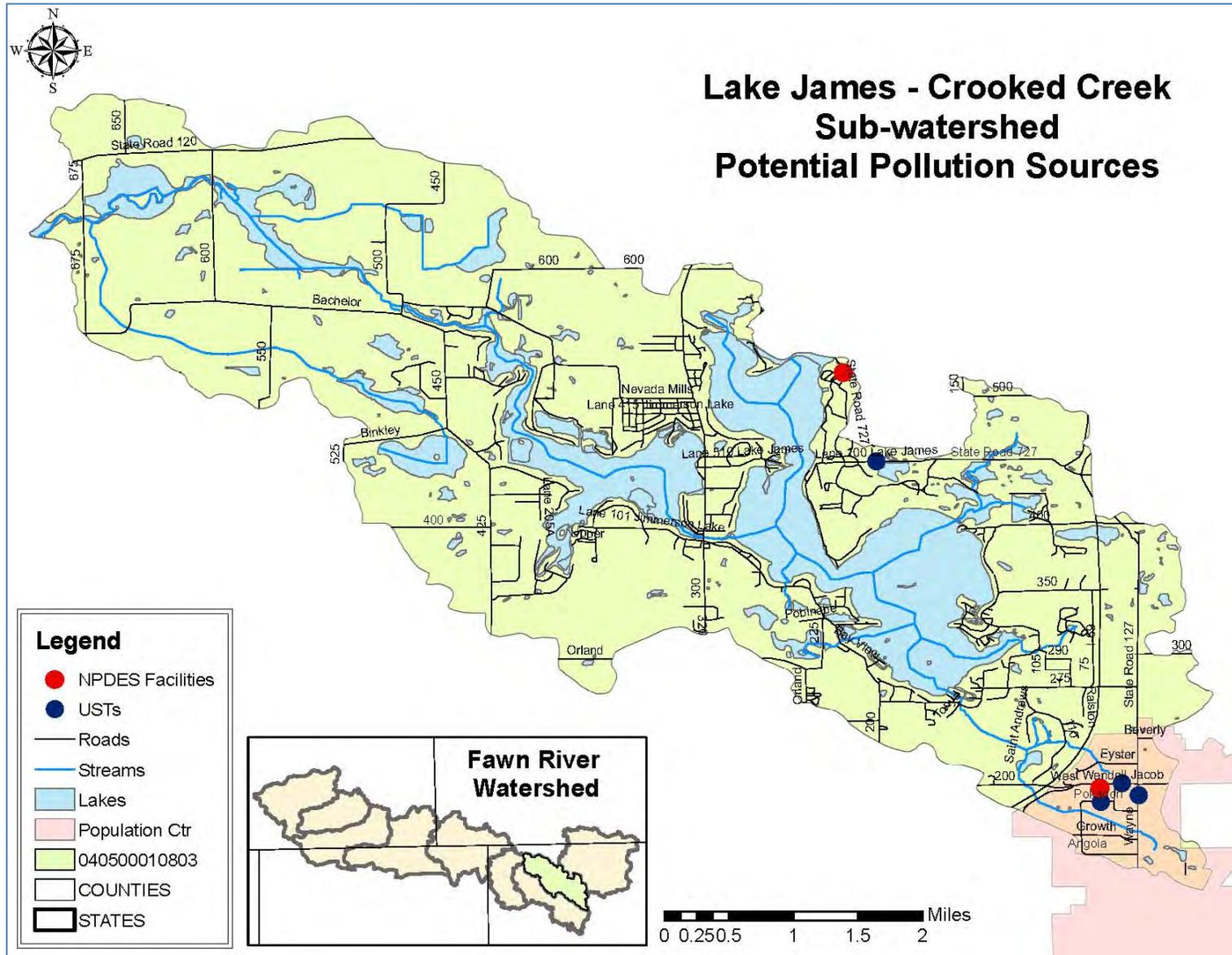
A final threat to water quality found during the inventory of Lake James – Crooked Creek sub-watershed is potential point sources of pollution. There are two NPDES permitted facilities located within this sub-watershed, however one of them, Meridian Automotive Systems, discharges outside the watershed to the Pigeon River. Both of the facilities have been in non-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	Qtrs 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.

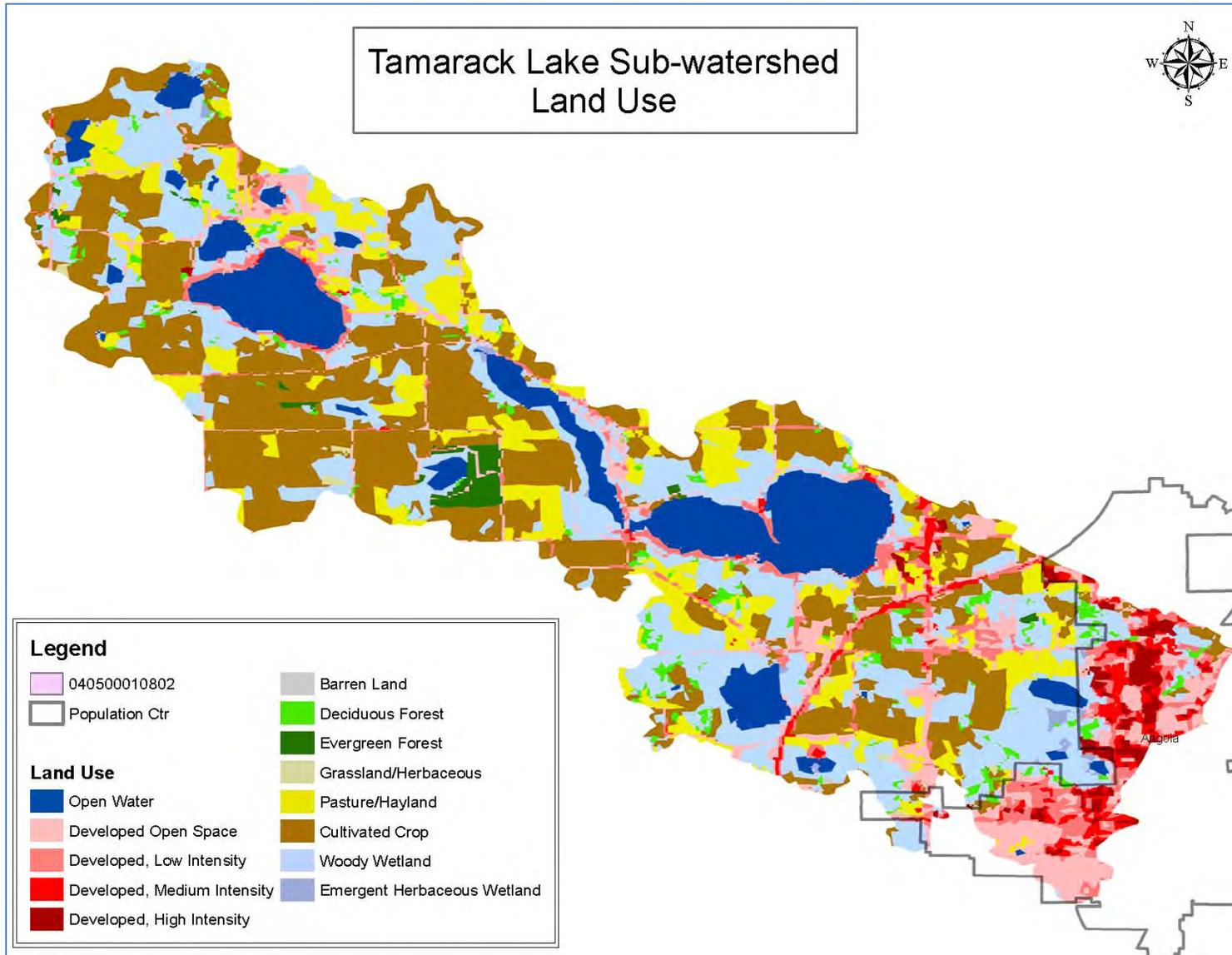
3.4.3 Tamarack Lake Sub-watershed Land Use

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 Intensity	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

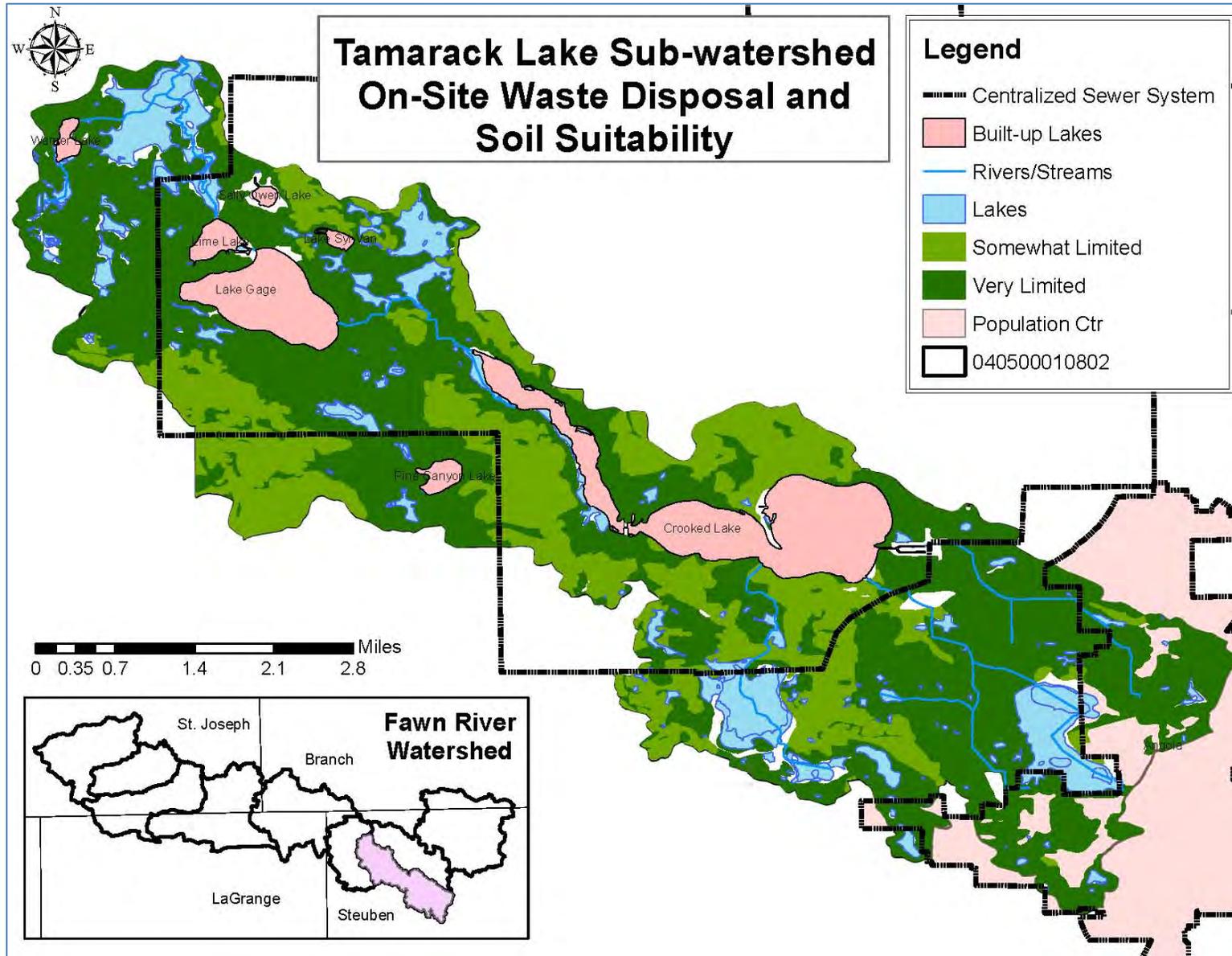


The windshield survey conducted as part of this project in May, 2014 revealed some common concerns scattered throughout the Tamarack Lake sub-watershed including agriculture land that lacks a riparian buffer along adjacent open water, sea walls constructed along the lakes in the watershed, and lush green 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: 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

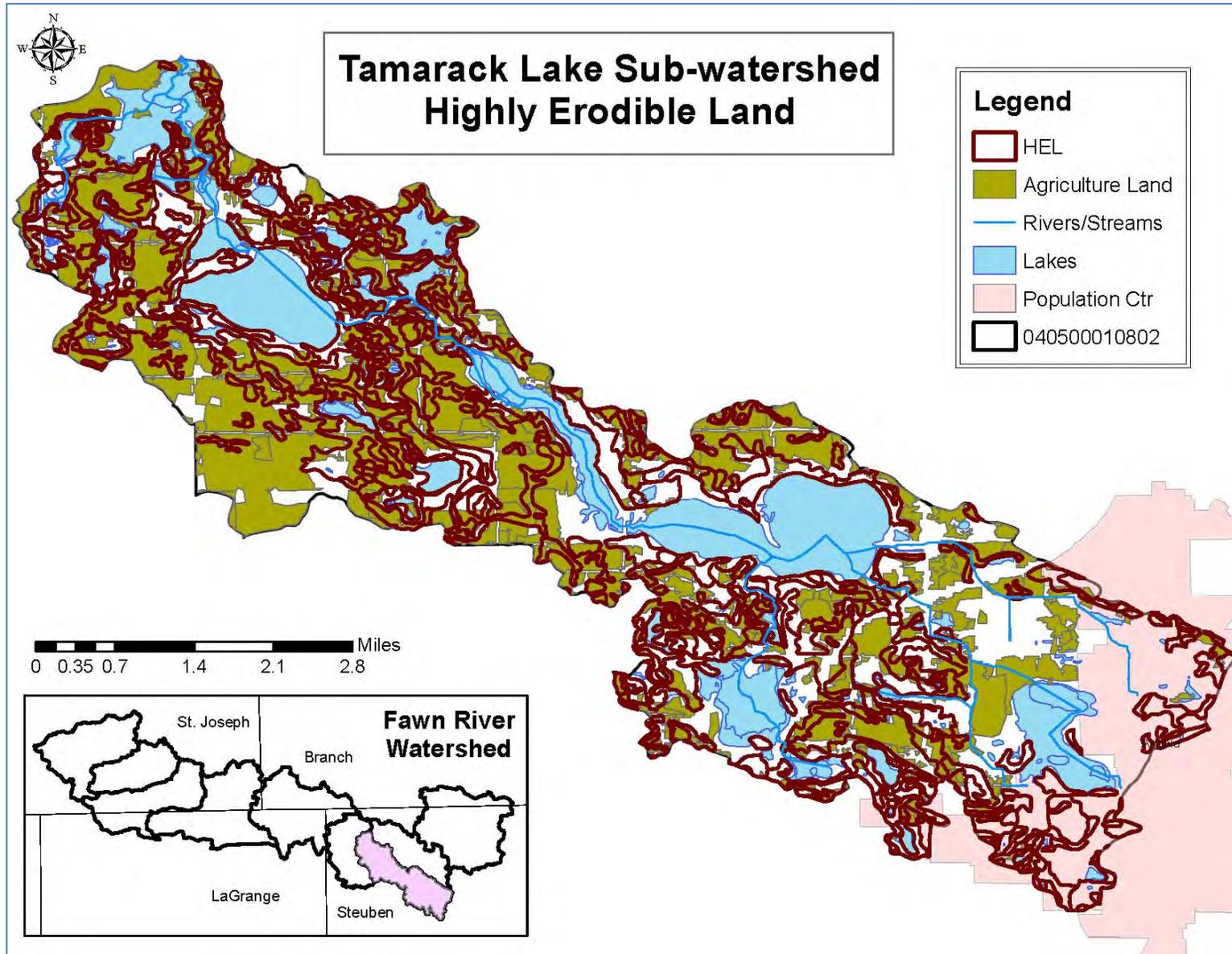
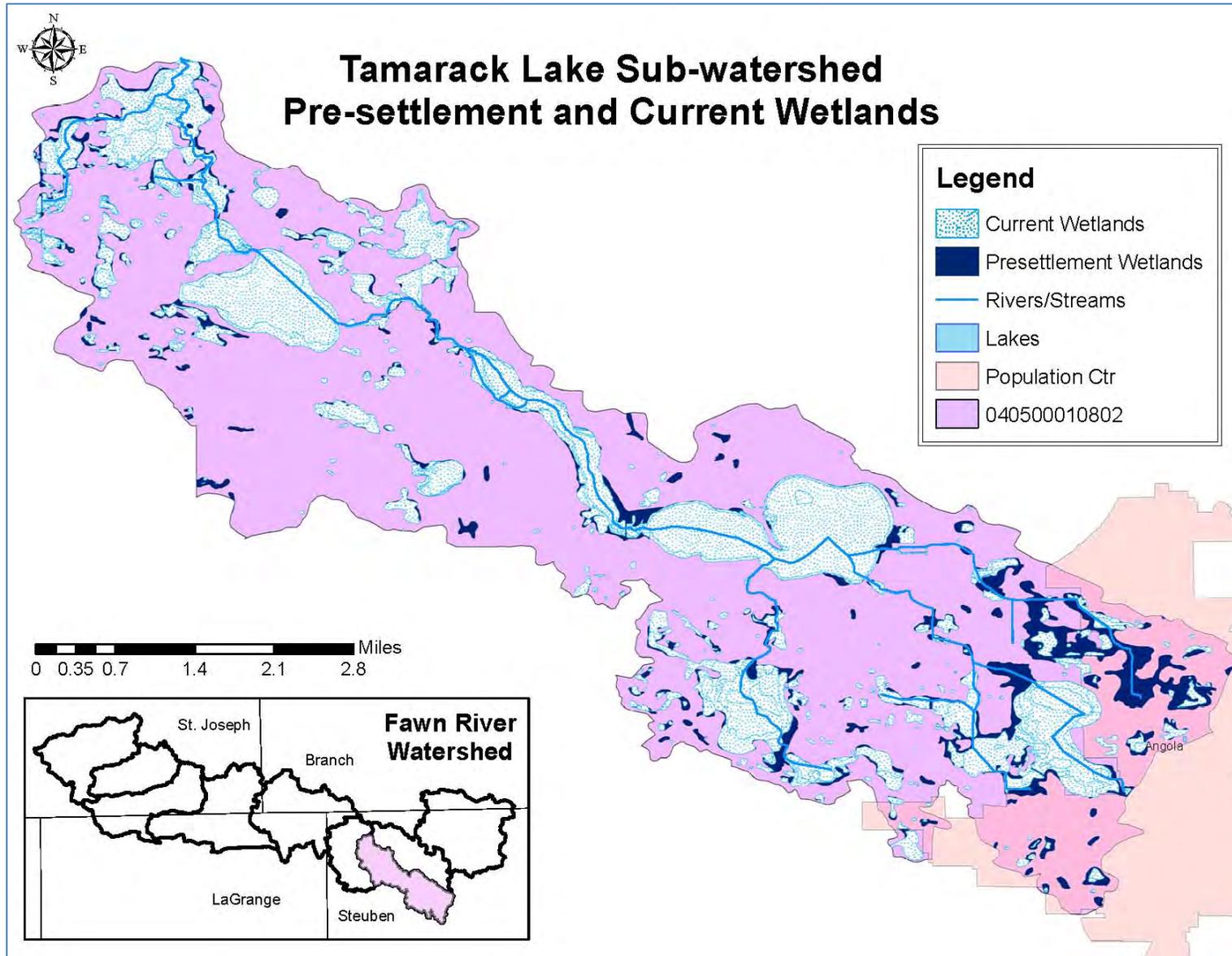


Figure 3.27: Current and Pre-settlement Wetlands in the Tamarack Lake Sub-watershed



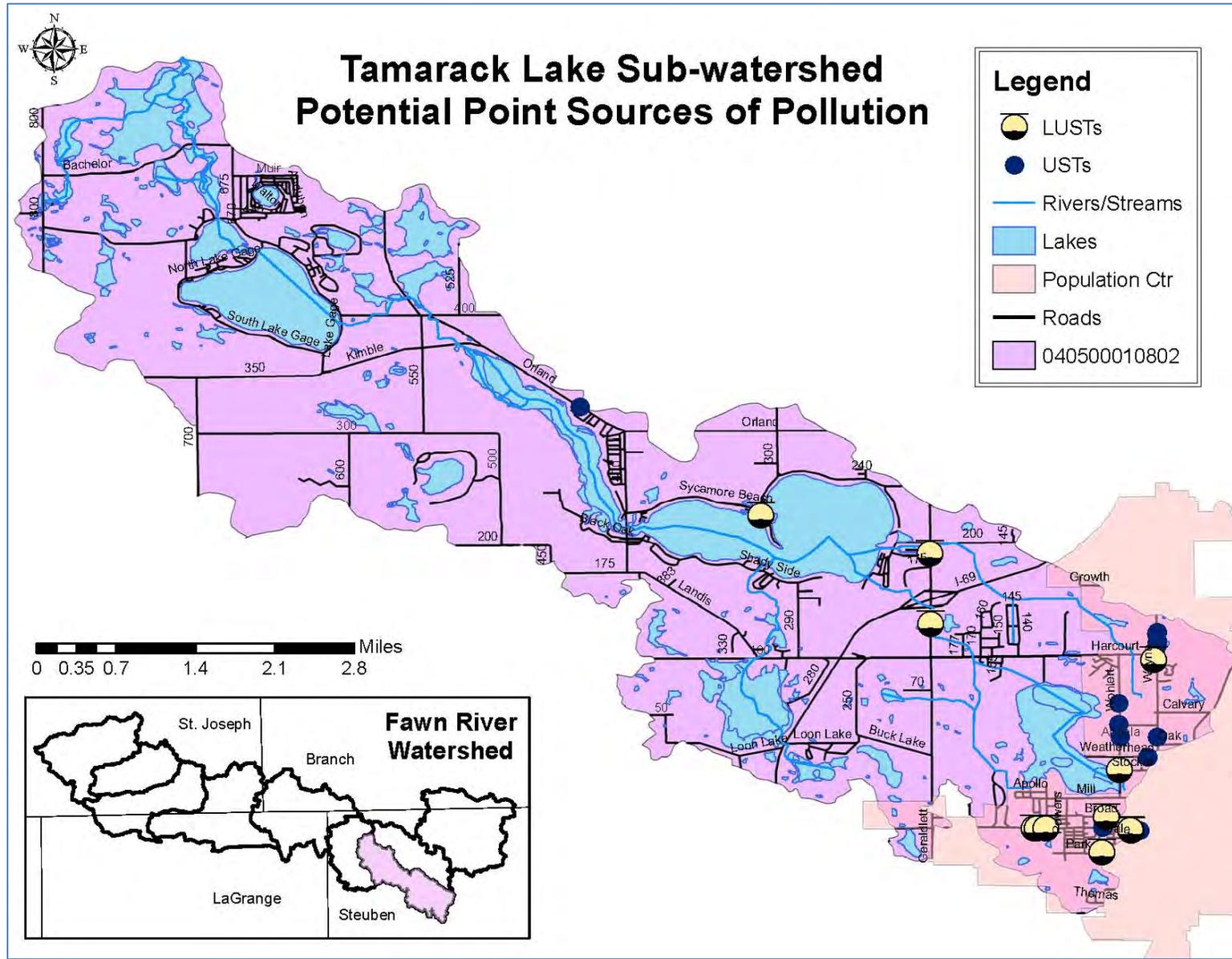
A final threat to water quality found during the inventory of Tamarack Lake sub-watershed are potential point sources of pollution. There are not any NPDES permitted facility located within this sub-watershed. However, there are 27 USTs located within the Tamarack Lake sub-watershed. While USTs do not 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.

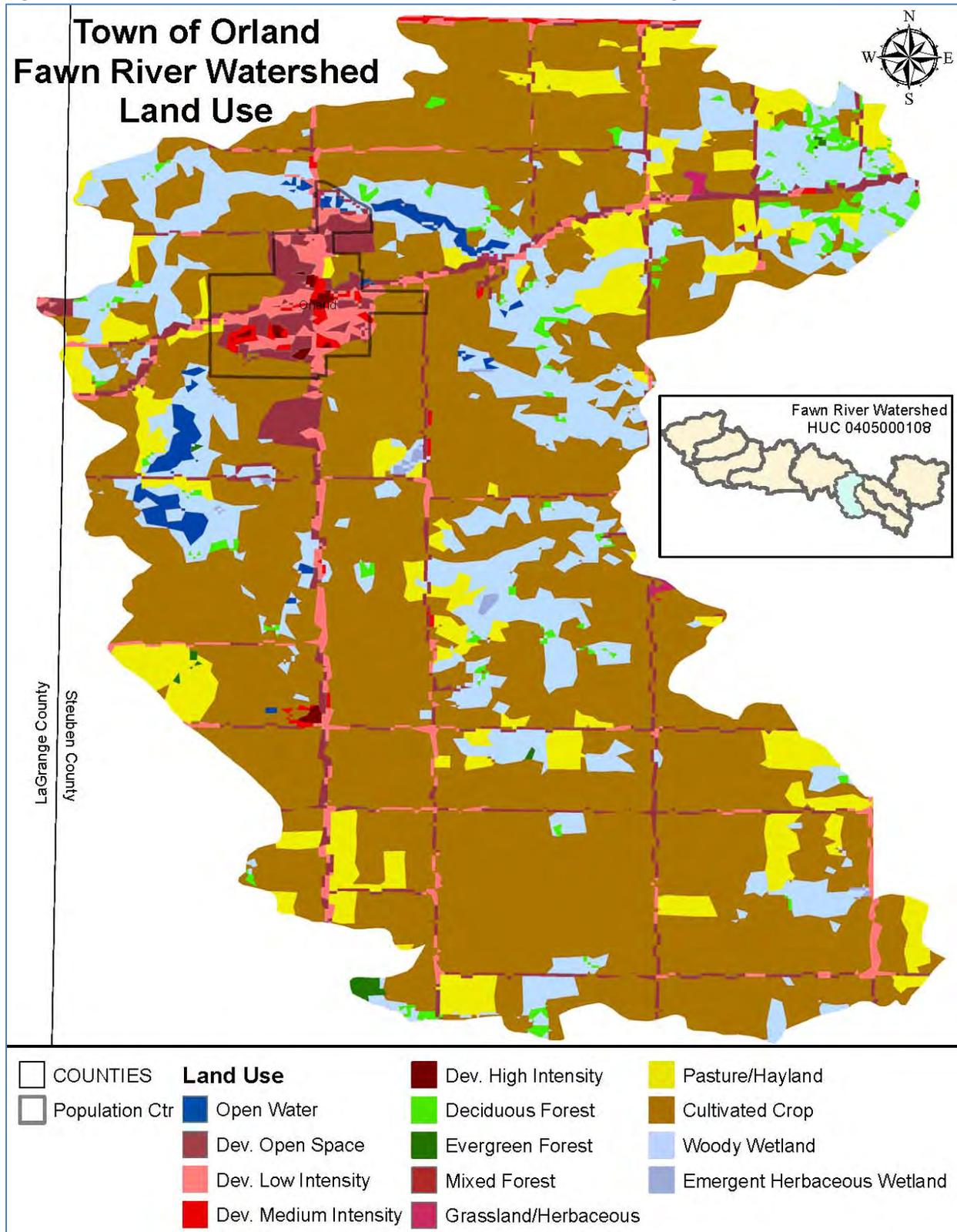
3.4.4 Town of Orland – Fawn River Sub-watershed Land Use

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 Intensity	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

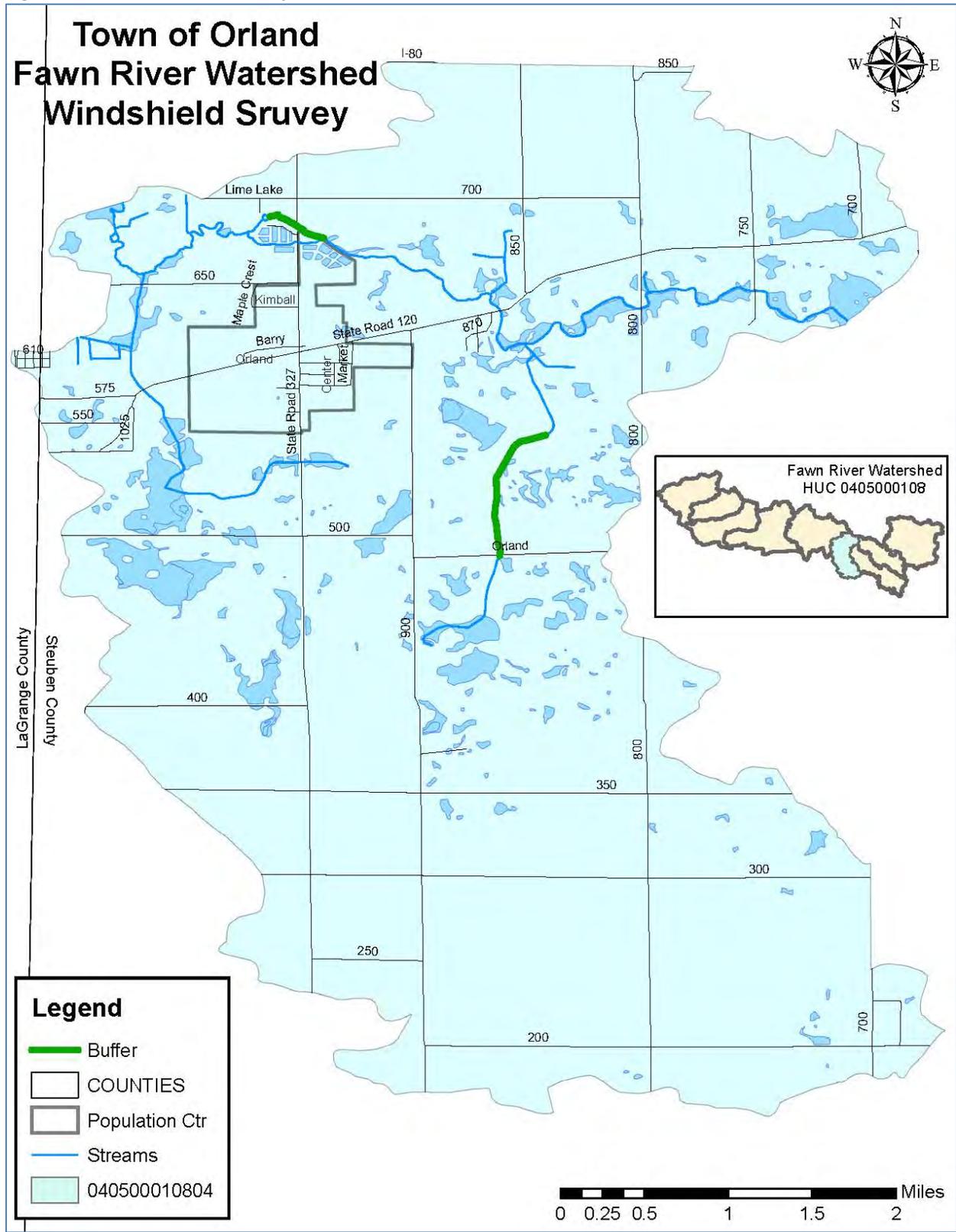
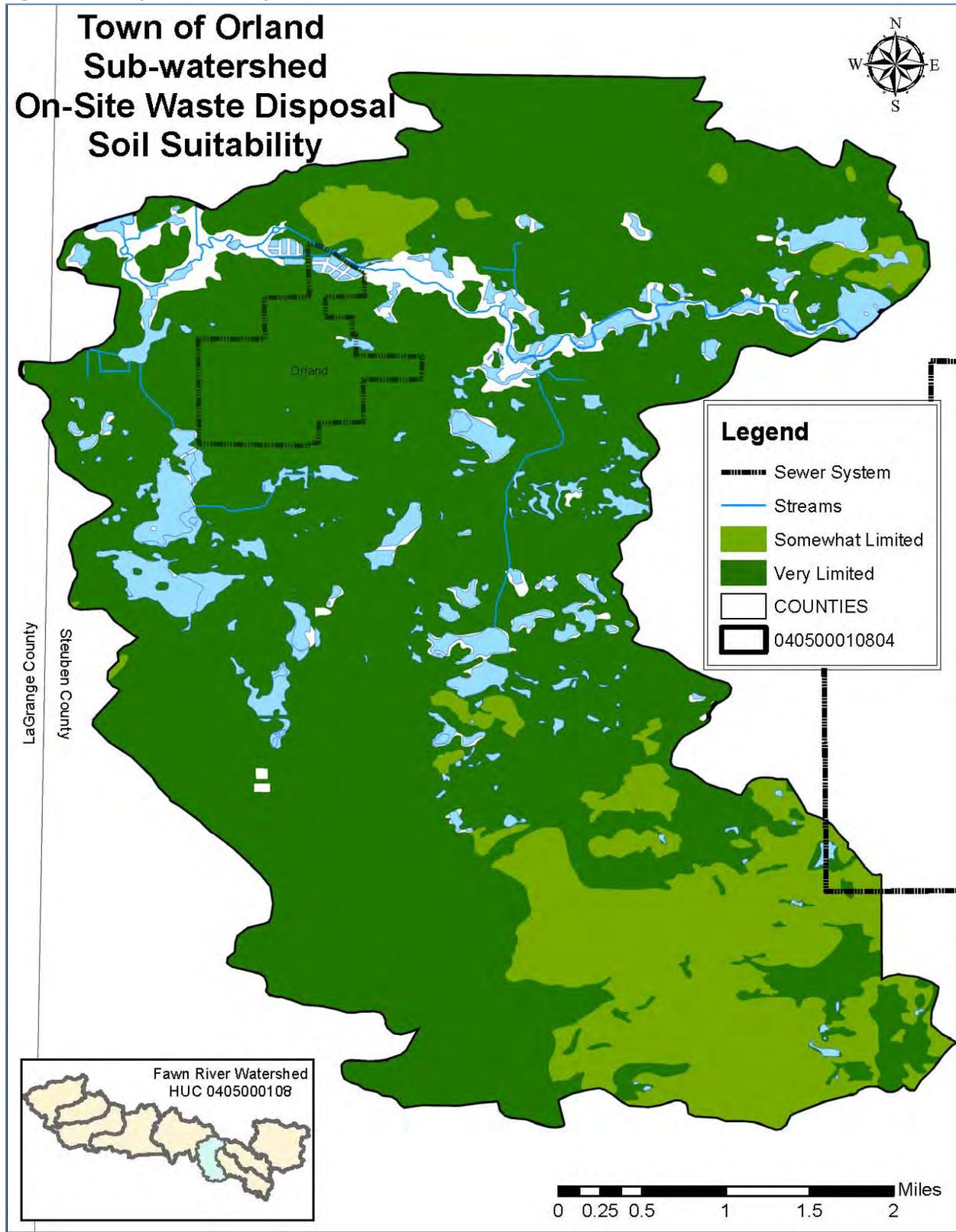


Figure 3.31: Septic Suitability in Town of Orland – Fawn River Sub-watershed



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

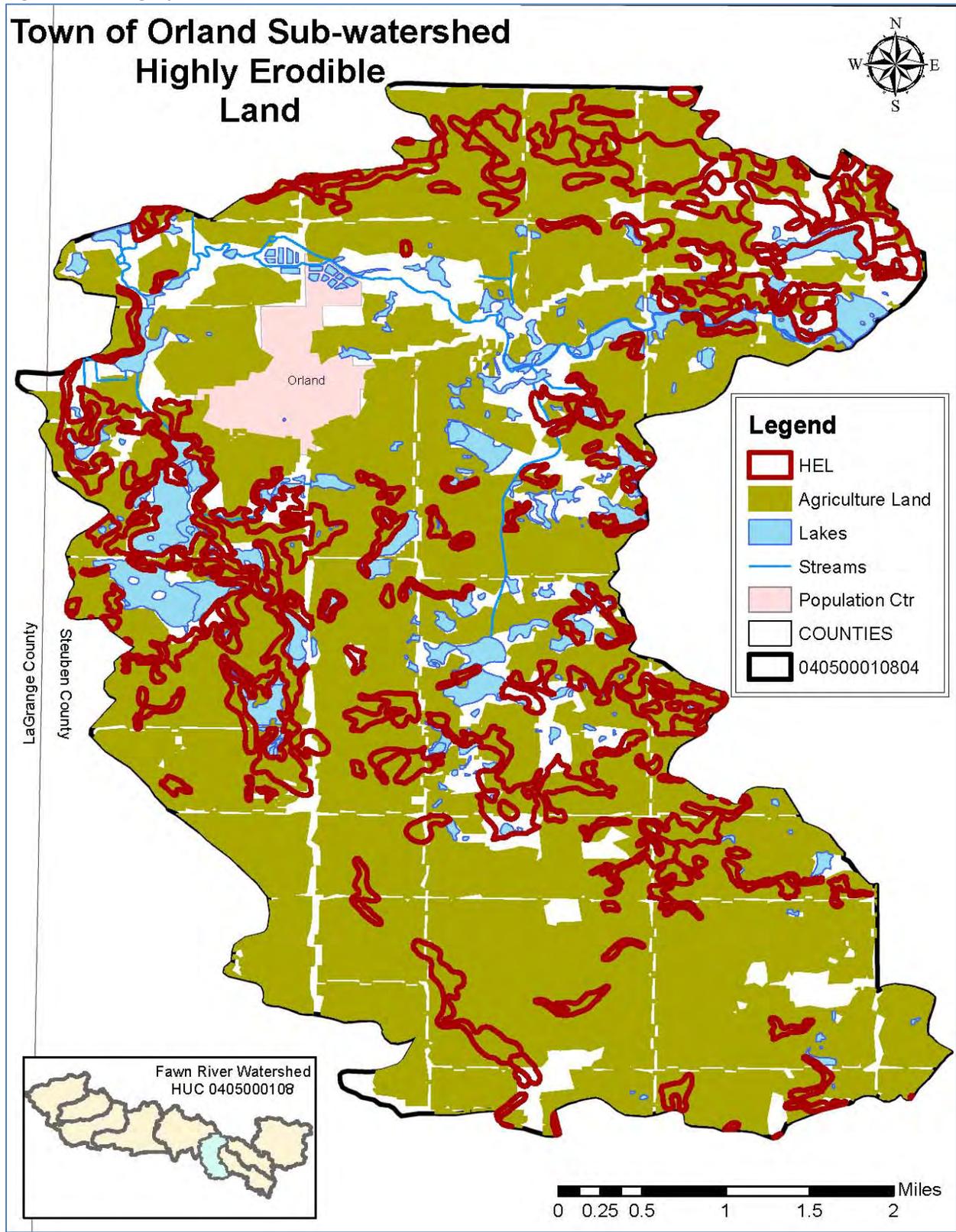
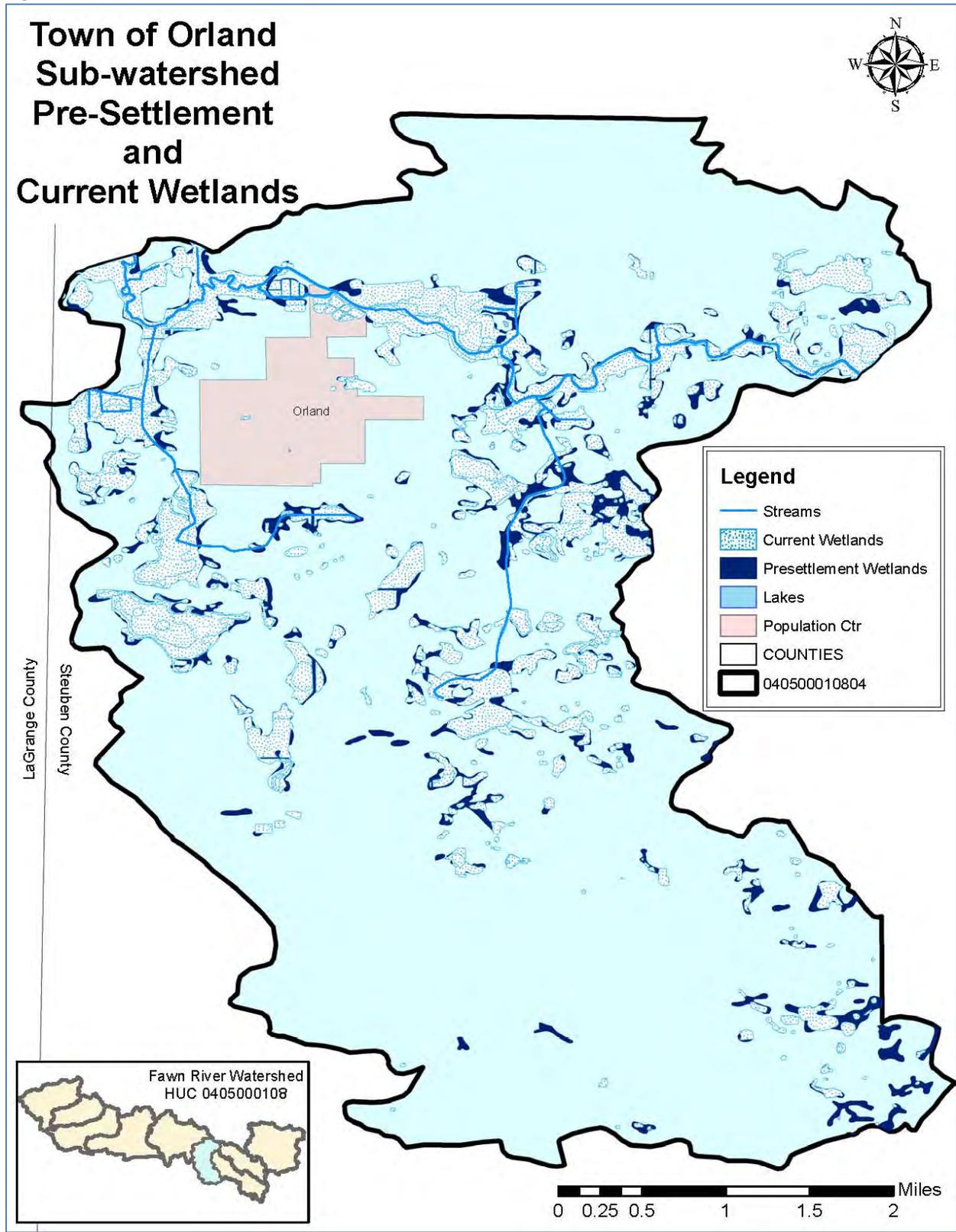


Figure 3.33: Wetlands in the Town of Orland – Fawn River Sub-watershed

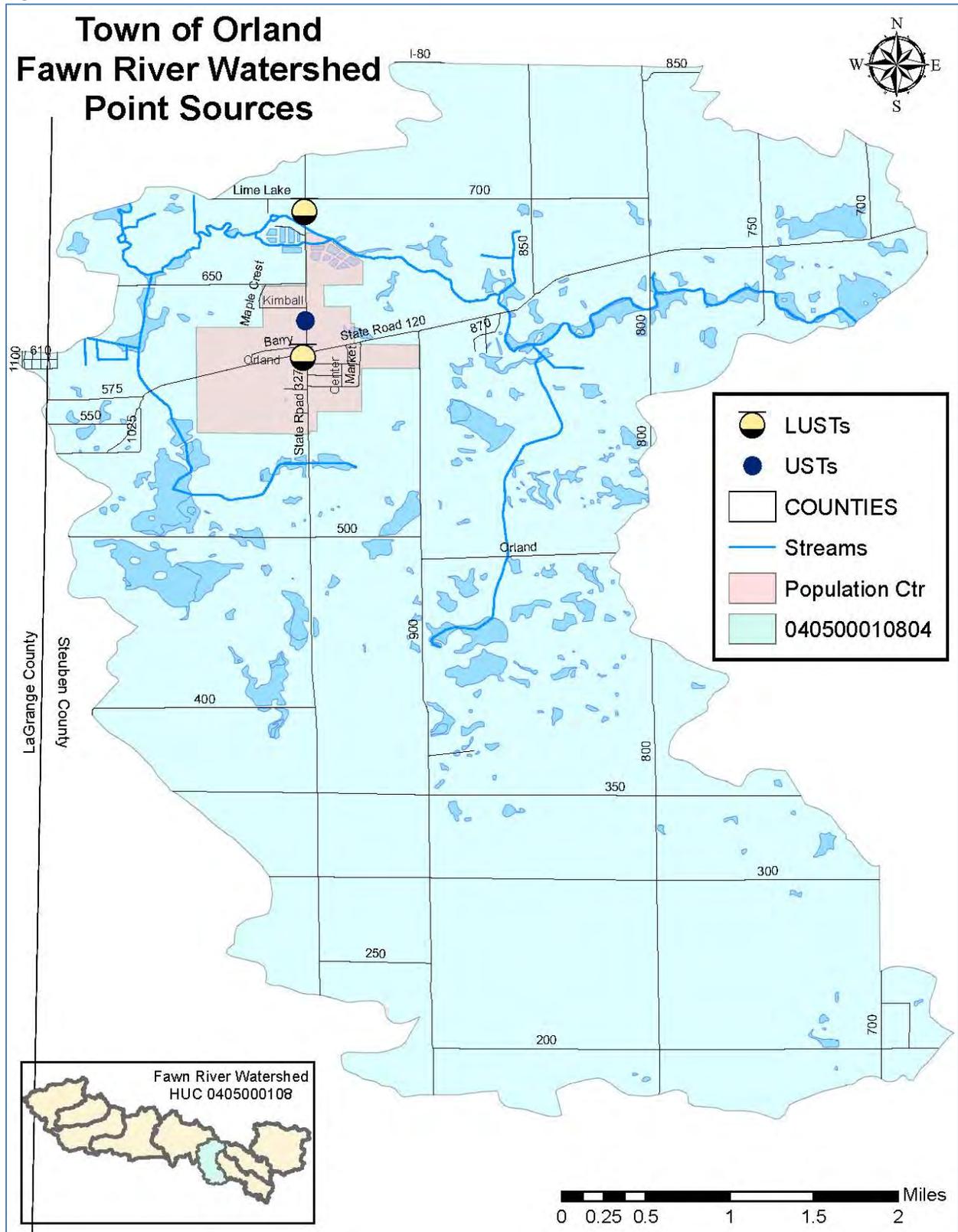


A final threat to water quality found during the inventory of Town of Orland – Fawn River sub-watershed is potential point sources of pollution. There are not any NPDES permitted facility located within this sub-watershed. However, there are three USTs located within the this sub-watershed. While USTs 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.