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Deep River –
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Deep River-Portage Burns Waterway Watershed Plan

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Deep River-Portage Burns Waterway Watershed

1 Introduction

1.1 Watershed Community Initiative

Our watershed of interest is the Deep River-Portage Burns Waterway watershed (Figure 1). It is the largest of six watersheds located within the Little Calumet-Galien sub-basin, draining approximately 180 square miles of north central Lake and Porter Counties to Lake Michigan. Some the major streams located within the watershed include Deep River, Main Beaver Dam Ditch, Turkey Creek, and the Little Calumet River's West Branch. This watershed management plan is the result of numerous communities and organizations coming together to establish a framework to restore the nearly 125 miles of impaired stream within its boundaries.

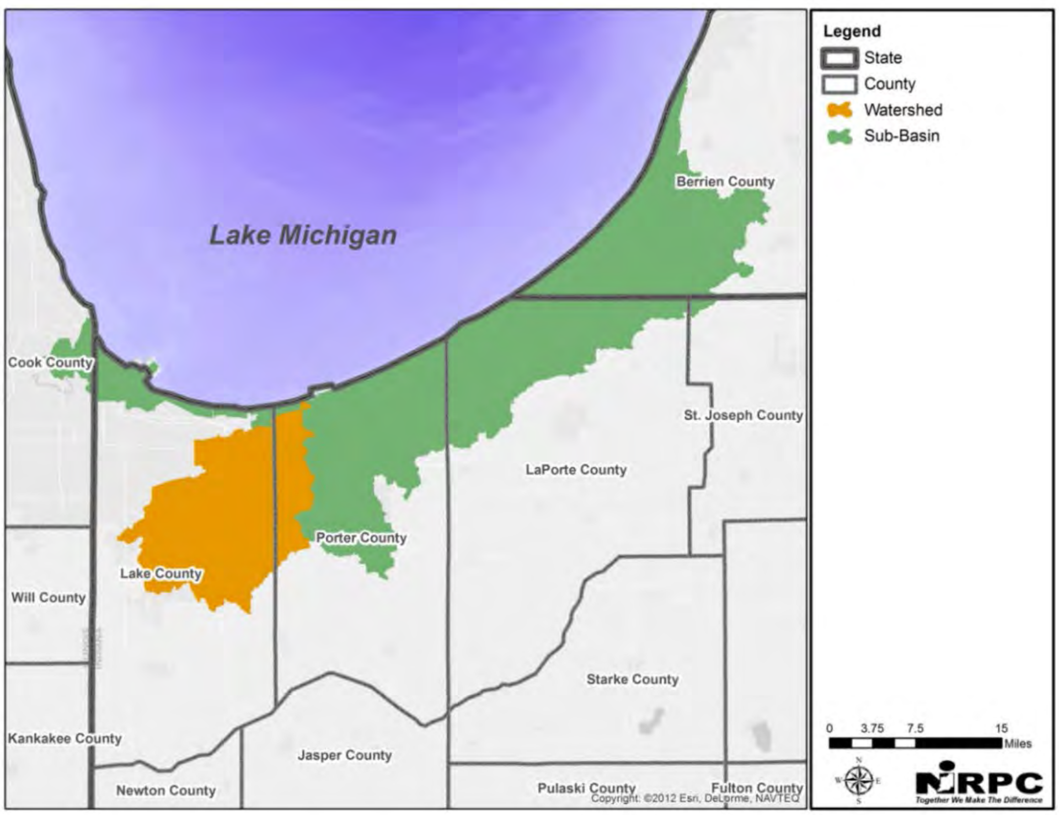


Figure 1 Watershed location

A watershed is an area of land that drains to some common point such as a location on a river. Human land use practices and activities can have a dramatic impact on the health of lakes and streams within a watershed. When rain or snowmelt moves over and through the ground it can pick up harmful pollutants and carry them to nearby lakes and streams. This is known as *polluted runoff* or *nonpoint source pollution* and it is one of the greatest threats to water quality in Northwest Indiana.

1.2 Project History

The first comprehensive planning effort to improve water quality and restore aquatic habitats in the Deep River-Portage Burns Waterway Watershed dates back to the 2002 *Deep River-Turkey Creek Watershed Management Plan.* The City of Hobart initiated the development of the *Deep River-Turkey Creek Watershed Management Plan* following a dredging project that resulted in more than 590,000 cubic yards of sediment being removed from Lake George at a cost of over two million dollars to City tax payers. Given the cost of dredging the City of Hobart realized a long-term solution was needed to reduce future sediment and nutrient loads to Lake George which threatened the City's lakefront and downtown revitalization efforts.

In 2009, the Gary Storm Water Management District led the development of a watershed management plan for the West Branch of the Little Calumet River. Originally, the intent of the project was to identify pollutant contributions to the mainstem West Branch Little Calumet River from inappropriate or failed septic systems, streambank erosion, aquatic habitat degradation and polluted runoff from land development. Eventually the project was reworked to include a watershed wide study of this problem.

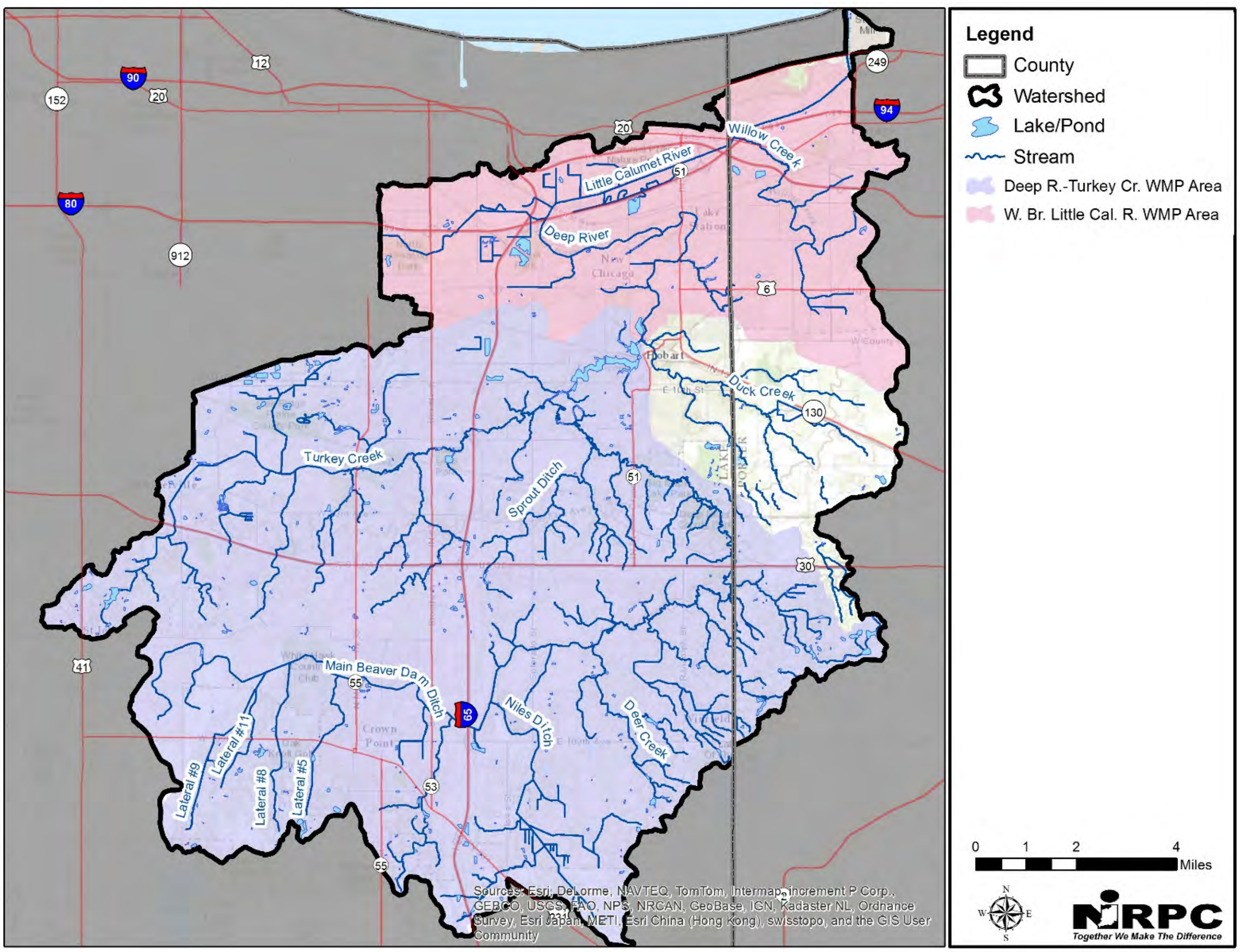


Figure 2 Previous Watershed Planning Efforts in the Current Project Area

One of the key hurdles faced by both watershed plans was that no project lead or organizational structure was set in place to coordinate implementation across multiple jurisdictions once they were completed. As a general observation, the challenge seems to have been related to capacity (resources) rather than lack of interest given the amount of time invested by stakeholders. The challenge of sustaining such efforts is not unique to Northwest Indiana.

In 2011, the Northwestern Indiana Regional Planning Commission (NIRPC) identified the Deep River-Portage Burns Waterway watershed as a priority in the *Northwest Indiana Watershed Management Framework*. The decision to include the watershed as a priority was based on persisting water quality issues, but more importantly, because stakeholders continued to express interest in reinvigorating these past efforts. With substantial changes in land use being evident and feeling that there was enough support to update the 2002 and 2009 watershed plans into a single comprehensive plan, NIRPC communicated to IDEM its intention to submit a 319 grant proposal for the 2013 funding cycle.

NIRPC began drafting some of the watershed characterization elements of the new plan in early 2012. Also knowing that more robust water quality data would be necessary to complete an update, NIRPC formalized its interest in having IDEM conduct the water quality monitoring by submitting a letter to them in June 2012 requesting that a Total Maximum Daily Load (TMDL) and baseline assessment be initiated for the watershed.

Finally, after nearly two years of developing partnerships and gathering support, a Section 319 grant application was submitted to IDEM during the fall of 2012 to facilitate the development and implementation of this watershed restoration plan. IDEM initiated the TMDL process with two public meetings in March 2013. NIRPC was notified that fall that it had been awarded the Section 319 grant.

Figure 3 summarizes the major stepping stones that lead up to this watershed restoration plans development.

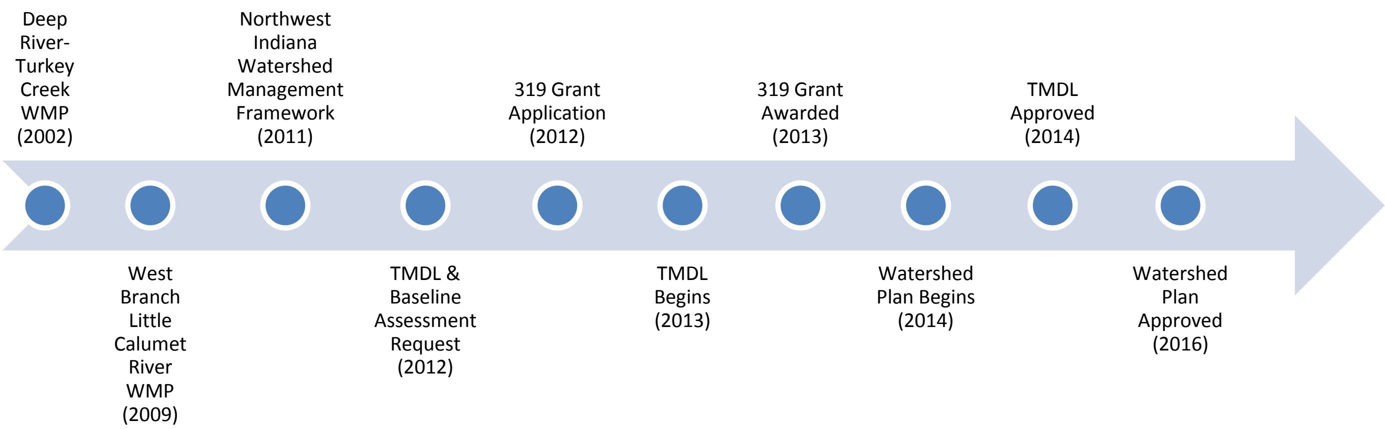


Figure 3 Project history timeline

1.3 Stakeholder Concerns & Involvement

On September 26, 2013, NIRPC sent out a press release announcing that the Deep River-Portage Burns Waterway Initiative project had been selected for funding by IDEM and that the project would officially begin in January 2014. A project kick-off meeting was held at the Hobart Community Center on January 21, 2014. NIRPC provided an overview of the four-year project and asked attendees why they value the watershed, how they use its streams and lakes, and what their initial concerns were relating to water quality and aquatic habitats. A second meeting was held on February 13, 2014 at the Lake County Soil & Water Conservation District (SWCD) in Crown Point to provide further opportunity for public input. The SWCD and Natural Resource Conservation Service (NRCS) helped promote this meeting by sending out personal invites to agricultural land owners within the watershed.

The following two tables are a summary of the responses provided by stakeholders during the public meetings held on January 21st and February 13th.

Values
• Recreational opportunities (swimming, fishing, canoeing/kayaking, bird watching, photography) • Aesthetics • Deep River is one of the few rivers in NWI that still has large sections of natural meanders • Connects so many cities • Drains to and affects Lake Michigan • Habitat/natural areas and biodiversity • Wildlife (ex. bald eagles, golden eagle, sandhill cranes) • Quality of life • Sense of place • Parks and trails • Economic and tourism • Eventually becomes our drinking water • Beauty of Lake George • Mix of agricultural and urban land uses • Agricultural production and local produce

Table 1 Stakeholder Watershed Values

Habitat Related Concerns
• Stream (fish) habitat loss • Riparian area encroachment (urban and agriculture) • Species loss (biodiversity) • Wetland loss • Wetland habitat degradation • Invasive species (aquatic and terrestrial) • Habitat loss to development • Proper habitat restoration • Lack of conserved open spaces • Need to acquire public/quasi-public riparian lands • Long-term management of habitat

Economic & Recreation Related Concerns
• Loss of recreational opportunities • Ability of residents and tourists to use waters safely for recreation • Healthy fishery (fishing) • Impaired streams- may not help to promote recreation • Loss of economic development around lake • Beach closings • Impact to tourism • Negative impact on property values • Outdoor recreational access • Financial support of restoration activities
Planning/Coordination/Management Related Concerns
• Coordination amongst municipalities, businesses, and residents • Maintenance of existing plans • “Me first” mentality community management • Lack of common goals/ manage for different (competing) outcomes • Development standards protective of watershed • Uncontrolled development in unincorporated or rural areas • Enforcement of existing regulations to protect stream health • Not enough inspection and monitoring • Loss of cropland to development • Maintenance of BMPs installed • Lack of retention/detention pond maintenance • Some absentee agricultural landowners that seem to be land speculators with less interest in investing in BMPs to protect water quality • Management of waterways strictly for drainage and not inclusive of water quality and habitat • Maintain drainage while protecting the quality of resources
Watershed Processes Related Concerns
• Drainage- ability of watershed to absorb and/or carry away excess water • Ability of watershed to clean water by removing pollutants and provide stable habitat for wildlife (green infrastructure) • Storm water storage
Storm Water Runoff (Sediment, Nutrient, & Pathogens) & Erosion Related Concerns
• Erosion and sedimentation • Excess nutrients • Increased runoff volume carrying pollutants and causing erosion • Streambank and shoreline erosion • Sediment loading from urban and agricultural areas • Dredging Lake George impacts to shoreline erosion • Sedimentation of Lake George from upstream areas • Failing septic systems • Impervious surface area • Chemicals in runoff • Areas of severe goose feces

• Construction site runoff • Parking lot runoff
Groundwater & Drinking Water Related Concerns
• Groundwater pollution (wells) • Drinking water
Floodplains/Flooding/Drainage Related Concerns
• Flooding • Reconciling need for drainage/flood control with water quality and habitat • Floodplain/floodway encroachment • People view water as “enemy” • Stream flashiness
Miscellaneous Concerns
• Soil health • Dams • Lack of public interest if conditions do not improve • Public involvement • Landowner/homeowner buy-in • Trash left behind after floodwater recede • Need to give upper reaches of watershed and subwatersheds special consideration • Combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) • Public health (water related) • Water quality impacts to Lake Michigan • Dredging Burns Ditch and Lake George

Table 2 Stakeholder Watershed Concerns

The following list provides an overview of stakeholder meetings, presentations, field day events, and webinars held through the TMDL and watershed restoration plan development process.

- March 13, 2013- TMDL kickoff meetings, Crown Point & Portage
- October 23, 2013- Deep River Monitoring Field Day, Hobart
- December 5, 2013- TMDL data meeting, Crown Point
- January 21, 2014- Initiative public meeting, Hobart
- February 13, 2014- Initiative public meeting, Crown Point
- March 6, 2014- Steering committee formation meeting, Portage
- April 18, 2014- Initiative South Shore Clean Cities webinar
- May 13, 2014- Initiative steering committee/public meeting, Portage
- July 15, 2014- Initiative steering committee/public meeting, Hobart
- August 7, 2014- Initiative presentation at NIRPC Environmental Management Policy Committee (EMPC)
- October 21, 2014- Initiative steering committee/public meeting, Gary
- February 17, 2015- Initiative steering committee/public meeting, Crown Point
- April 28, 2015- Initiative South Shore Clean Cities webinar
- June 4, 2015- Initiative presentation at NIRPC Environmental Management Policy Committee (EMPC)
- December 15, 2015 Initiative steering committee/public meeting, Portage
- March 3, 2015- Initiative presentation at NIRPC Environmental Management Policy Committee (EMPC)

1.4 Water Quality Public Survey

In 2010, the Northwestern Indiana Regional Planning Commission had a water quality survey completed to gauge the effectiveness of regional and local public outreach campaigns on water quality issues in the Northwest Indiana region.

Six hundred seven (607) landline and cellular phone interviews were completed with residents from each of the following four regions: (1) the City of Gary, (2) the Lake Michigan watershed within Lake County, (3) the Lake Michigan watershed within Porter County, and (4) municipalities outside of the Lake Michigan Basin. Interviews were conducted between October 1 and October 8, 2010. Sampling error for the entire sample is +/- 4% at a 95% confidence interval.

The following is a summary of findings from the survey. The full report is available at http://www.nirpc.org/environment/water/nirpc-water-outreach-programs/nwi-partnership-for-clean-water.aspx.

1.4.1 Resident Attitudes

Three in five residents (61%) value having clean rivers, lakes, and streams in their communities "a tremendous amount." Seven in ten residents (70%) say it's very important to look at clean water bodies. Nine in ten residents agree that the quality of local water bodies affects the quality of drinking water (90%), the quality of local water bodies affects enjoyment of water recreation activities (91%), and the quality of local rivers and stream affects whether or not local beaches remain open (90%).

The following percentages of residents think that local rivers, streams, lakes, or Lake Michigan are clean enough to:

- 42% - Boat in
- 40% - Look at
- 39% - Run or hike next to
- 38% - Picnic by
- 37% - Fish in
- 34% - Swim in

Nearly three in four residents (73%) disagree that there will be plenty of fresh water no matter what they do. More than three in four residents (77%) say their personal actions have a definite impact on water quality/quantity.

1.4.2 Resident Knowledge

Five in ten residents (50%) don't know or are unfamiliar with the term watershed, with only 8% saying they live in a watershed. One in three (33%) do not know where storm water goes after it enters a storm drain or roadside ditch. Nearly three in ten (27%) think storm water goes to a wastewater treatment plant. Slightly more than 1 in 10 (12%) think storm water that enters a storm drain goes to waterbodies with treatment. Two in five residents (42%) do not know what to do around the home to conserve/protect water.

The following percentages of residents know what to do to conserve/protect water, but:

- 25% say it's too much trouble
- 18% say it costs too much
- 8% don't think they'll make a difference

The following percentages of residents think that the following items had a great impact on the quality of water bodies:

- 79% - Motor oil, pain, and batteries
- 63% - Household water conservation
- 59% - Septic tank problems
- 56% - Lawn fertilizer
- 52% - Type of fertilizer
- 45% - Dog waste
- 37% - Lawn watering

1.4.3 Resident Actions

Regarding use and interaction with waterbodies (percentage of residents who say water bodies are clean enough for actions such as fishing, swimming, etc. are in parentheses):

- 41% of residents walked, ran, or biked trails through woods or parks near waterbodies (39%)
- 37% of residents walked, sat, or ran by waterbodies (40%)
- 25% of residents fished or hunted in or near waterbodies (37%)
- 24% of resident swam in waterbodies (34%)
- 23% of residents went boating, canoeing, or kayaking in waterbodies (42%)
- 11% of residents gave money or took actions to help conserve and preserve waterbodies

Three in four residents (75%) say they take actions most days that preserve water quality/quantity. Of the 30% of residents who have a dog, nearly one in five (18%) do not pick up the dog waste. Of the 89% of residents who have a lawn, more than two in five (42%) fertilize more than once a year.

The following percentages of residents report engaging in the following actions around the home:

- 18% - use low phosphate and slow release fertilizer
- 15% - use native landscaping
- 8% - test their soil before fertilizing
- 11%- fertilize lawn before heavy rains
- 66% (of the 11% of residents that have a septic tank) - service their septic tanks at least every 5 years
- 7% - dispose of leaves/grass clipping improperly
- 4% - dispose of motor oil improperly

1.4.4 Motivating People to do the Right Thing

In order to motivate residents to do the right thing when it comes to conserve/preserve water quality/quantity, the following percentages of residents recommend:

- 91% - teach the right actions in school
- 90% - advertise
- 74% - develop neighborhood councils

Residents rely more on television (37%), newspapers (29%), mail (27%), and water or sewer bill inserts (25%) for information about water conservation and protection. To a lesser degree residents felt that the internet (19%), signs or billboards (10%), or radio (8%) were the best way to be provided information. Fewer than 3% felt that posters at recreation areas, public meetings, classes or workshops were the best way to be provided with information.

1.5 Steering Committee

Stakeholders were invited to participate in a special meeting on March 6, 2014 to discuss the formation of a watershed steering committee to help guide the development and implementation of this watershed plan. The general consensus of the participants was to use the "potential list of stakeholders" included in the *Northwest Indiana Watershed Management Framework* as a starting point.

The steering committee is broken into general categories that include representatives from municipalities, county or regional agencies/departments/districts, environmental and conservation organizations, recreational groups, business and industry, universities, and state and federal government (Table 3). The steering committee, like the watershed plan itself, is dynamic and will likely include minor changes as the initiative moves forward.

The primary role of the Deep River-Portage Burns Waterway Initiative steering committee is to:

- Operate as a coordinating and information exchange group to help establish strategic direction and priorities for watershed restoration.
- Recommend key actions and projects needed to improve environmental conditions in the watershed.
- Seek support and resources for the initiatives/projects that it recommends.

Municipal	**Representative**
Crown Point	Vacant, Formerly Dan Niksch
Hobart	Tim Kingsland, Sergio Mendoza
Gary	Brenda Scott-Henry
Merrillville	Matt Lake
New Chicago	Alicia Barber, Lori Reno
Portage	Jenny Orsburn
County or Regional	**Representative**
County Soil & Water Conservation Districts	Julie Duttlinger (Lake Co.), Harvey Nix (Porter Co.)
County Surveyors Offices	Bill Emerson (Lake Co.), Kevin Breitzke (Porter Co.)
Lake County Parks Department	Craig Zandstra
Little Calumet River Basin Development Commission	Dan Repay
Environmental & Conservation	**Representative**
Izaak Walton League- Porter County Chapter	Jim Sweeney
The Nature Conservancy	Susan MiHalo
Save the Dunes	Vacant, Formerly Dr. Candice Smith
Shirley Heinze Land Trust	Vacant, Formerly Paul Quinlan
Sierra Club	Sandy O'Brien
Recreation	**Representative**
Northwest Indiana Paddling Association	Dan Plath, Gina Darnell
Business & Industry	**Representative**
Northwest Indiana Forum	Kay Nelson
The Wildlife Habitat Council	Daniel Goldfarb

Universities/Colleges	Representative
IL-IN Sea Grant	Leslie Dorworth
State & Federal Agencies	**Representative**
Natural Resource Conservation Service	Derek Schmitt
Indiana Department of Environmental Management	Ashley Snyder, Michelle Caldwell
Indiana Department of Natural Resources	Dorreen Carey
Indiana Dunes National Lakeshore	Dr. Charles Morris
Indiana State Department of Agriculture	Julie Morris, Jared Obrien
Urban Waters Federal Partnership	Natalie Johnson

Table 3 Steering Committee Members and Representative

* Denotes alternate representative

2 Watershed Inventory- Part I

2.1 Watershed Location

Located near the southern tip of Lake Michigan, the Deep River-Portage Burns Waterway watershed (HUC 0404000105) drains nearly 180 mi^2 of north central Lake and Porter Counties into Lake Michigan through the Burns Waterway in Portage (Figure 1). The watershed is comprised of nine smaller drainage areas known as subwatersheds and several municipalities including the entirety of Hobart and Merrillville and portions of Cedar Lake, Crown Point, Gary, Griffith, Lake Station, New Chicago, St. John, Schererville, Winfield, Portage, Lakes of the Four Seasons, and Ogden Dunes (Figure 4, Table 4).

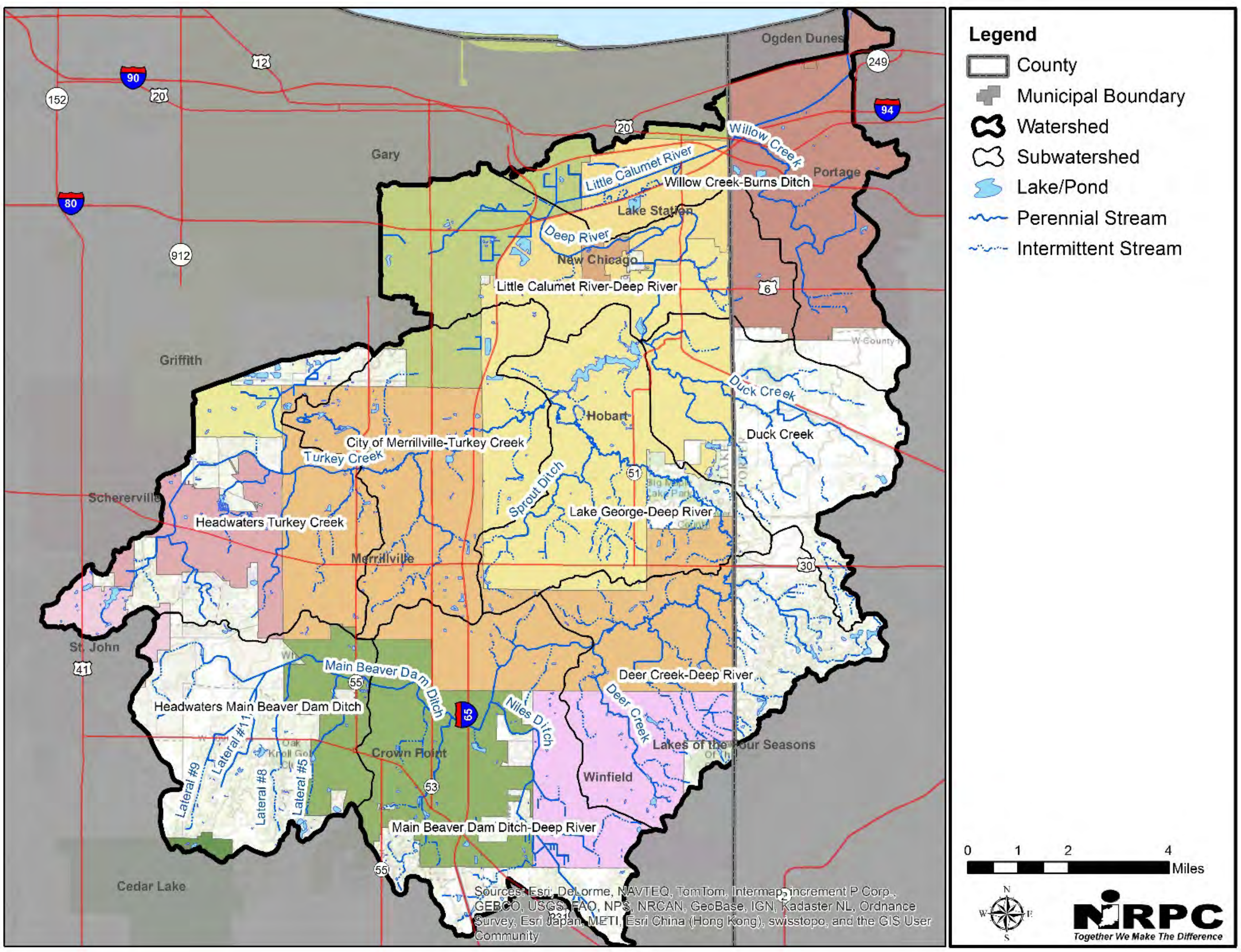


Figure 4 Subwatersheds & municipalities

Name	HUC-12	Area (ac.)	Area (mi²)	County	Downstream Subwatershed
Headwaters Main Beaver Dam Ditch	040400010501	11,709	18.3	Lake	040400010502
Main Beaver Dam Ditch-Deep River	040400010502	16,821	26.3	Lake	040400010504
Headwaters Turkey Creek	040400010503	13,595	21.2	Lake	040400010505
Deer Creek-Deep River	040400010504	13,745	21.5	Lake, Porter	040400010507
City of Merrillville-Turkey Creek	040400010505	12,493	19.5	Lake	040400010507
Duck Creek	040400010506	10,140	15.8	Lake, Porter	040400010507
Lake George-Deep River	040400010507	11,081	17.3	Lake, Porter	040400010508
Little Calumet River-Deep River	040400010508	12,148	19.0	Lake, Porter	040400010509
Willow Creek-Burns Ditch	040400010509	13,406	20.9	Lake, Porter	Lake Michigan
Watershed Total		115,138	179.9		

Table 4 Subwatershed drainage area and downstream subwatershed

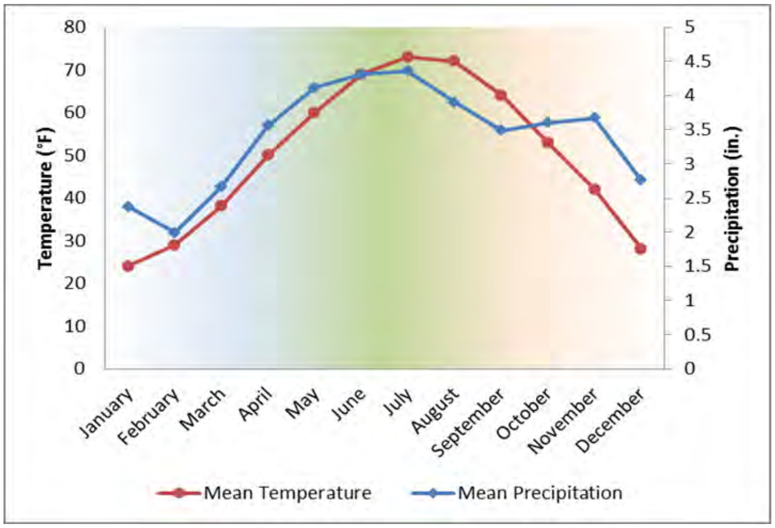
Hydrologic Unit Codes: What Are They?

A hydrologic unit code or HUC is a numbering system used by natural resource agencies to identify watersheds. It's the numeric equivalent to a home's mailing address. The U.S. Geological Survey has mapped the entire country using different HUC levels: 8-digit HUCs identify large drainage areas known as sub-basins (ex. the Little Calumet-Galien), 10-digit HUCs identify smaller drainage areas known as watersheds (ex. the Deep River-Portage Burns Waterway), and 12-digit HUCs identify even smaller drainage areas known as subwatersheds (ex. Duck Creek). Notice how each subwatershed in the table above share the same first 10 digits? That's because they are all part of the larger Deep River-Portage Burns Waterway watershed.

2.2 Climate

In Northwest Indiana, the presence of Lake Michigan has a pronounced influence on climatic conditions. The most distinct effects generally occur 1-2 miles inland but can extend as far as 25 miles inland. Overall our region experiences warmer falls, cooler springs, higher humidity, and greater amounts of snow compared to other nearby regions. This is primarily due to differences in Lake Michigan surface water temperature relative to land surface temperature.

On average, over the last 30 years, 40.8 inches of precipitation falls over the watershed during the course of a year with the highest amounts occurring between May and July (Figure 5). Approximately 64% of the precipitation that falls over a 24-hour period is 1-inch or less while 34% is between 1-2 inches. The normal monthly maximum temperature measures 83° F in July, while the minimum measures 18° F in January. Climate data is based on information from the Valparaiso Waterworks Cooperative weather station. Table 5 shows monthly average precipitation data and monthly extreme precipitation observed during the water quality monitoring baseline assessment conducted by IDEM.



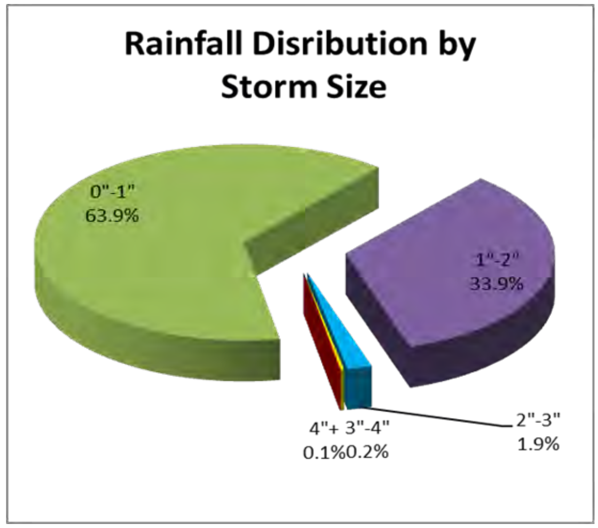


Figure 5 Precipitation & temperature

Date	Precipitation (in.)	Snowfall (in.)	High Precipitation (in.)
Apr-2013	6.02	0	1.58
May-2013	3.18	0	0.83
Jun-2013	4.81	0	1.19
Jul-2013	1.44	0	0.85
Aug-2013	4.11	0	1.78
Sep-2013	3.44	0	1.90
Oct-2013	5.42	0	2.67
Nov-2013	3.18	1.0	1.04
Dec-2013	1.03	5.6	0.46
Jan-2014	2.51	23.7	1.00
Feb-2014	2.28	16.6	0.90
Mar-2014	1.70	13.5	0.62

Table 5 Monthly precipitation data during baseline assessment monitoring period

Precipitation depth and frequency curves are presented in Figure 6. This data was obtained from NOAA's National Weather Service, Hydrometeorological Design Studies Center Precipitation Frequency Data Server. The precipitation depth of a 1-year, 24-hour storm is approximately 2.39 inches, while the 2-year 24-hour storm is approximately 2.91 inches.

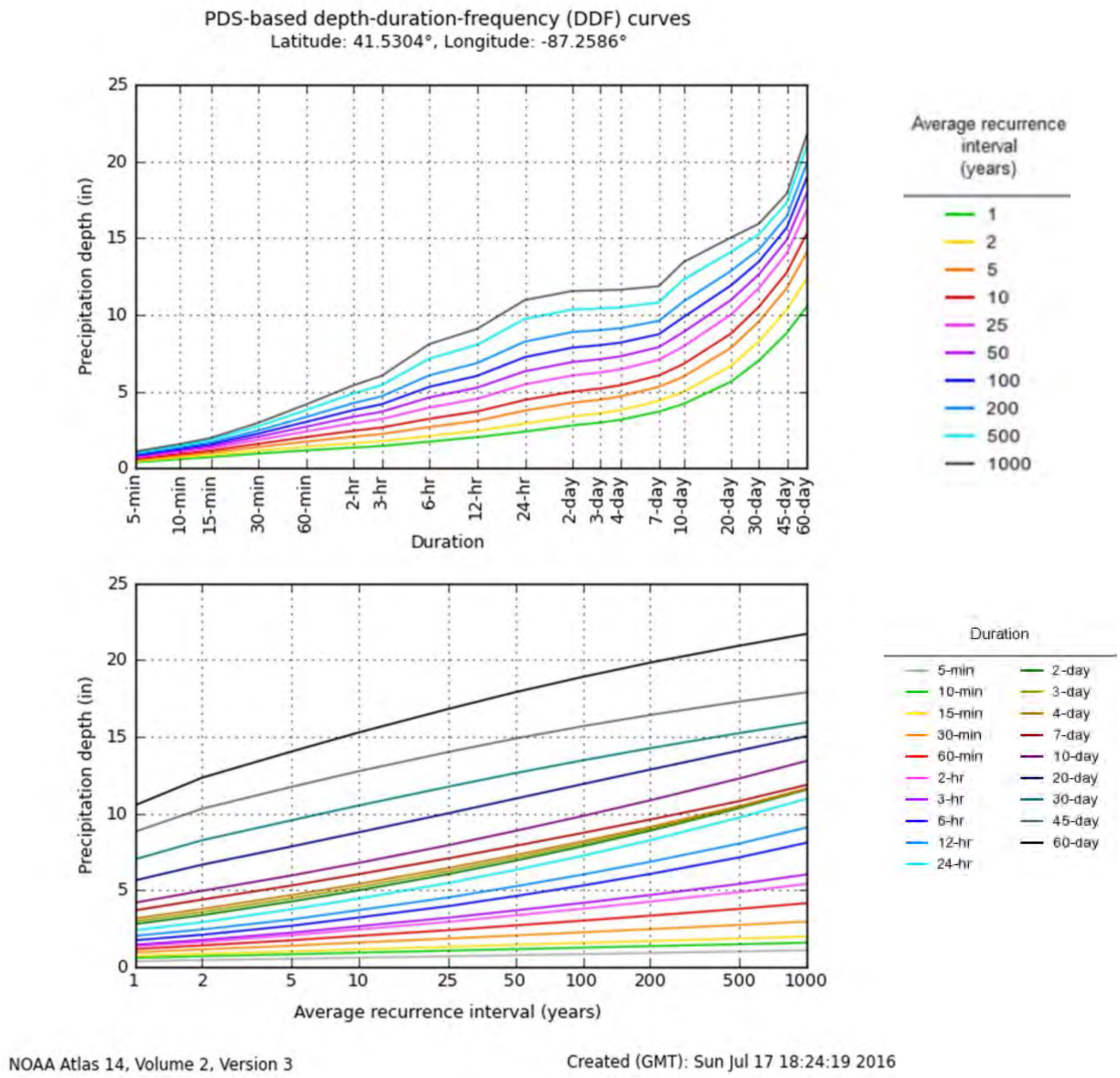


Figure 6 Precipitation depth-duration frequency curves

2.3 Geology and Topography

2.3.1 Surficial Geology

Surficial geology refers to the study of landforms and the unconsolidated (loosely arranged) sediments that lie beneath them. Surficial geology greatly influences topography and soil development, which in turn, control runoff and infiltration of precipitation. This influences water quality in streams, lakes and ground water.

In our region the majority of the unconsolidated sediments found at the land surface were deposited during the late Wisconsin glaciation, 21,000 to 13,600 years ago. These deposits range in thickness from 100 to more than 350 feet. Figure 7 shows that a large portion of the watershed's surficial deposits are comprised of clay-loam to silt-loam. Clay-loams typically have very high runoff potential.

Stakeholder Concerns Related to Geology & Topography:

- Increased runoff
- Erosion & sedimentation
- Stream flashiness
- Ability to absorb excess water

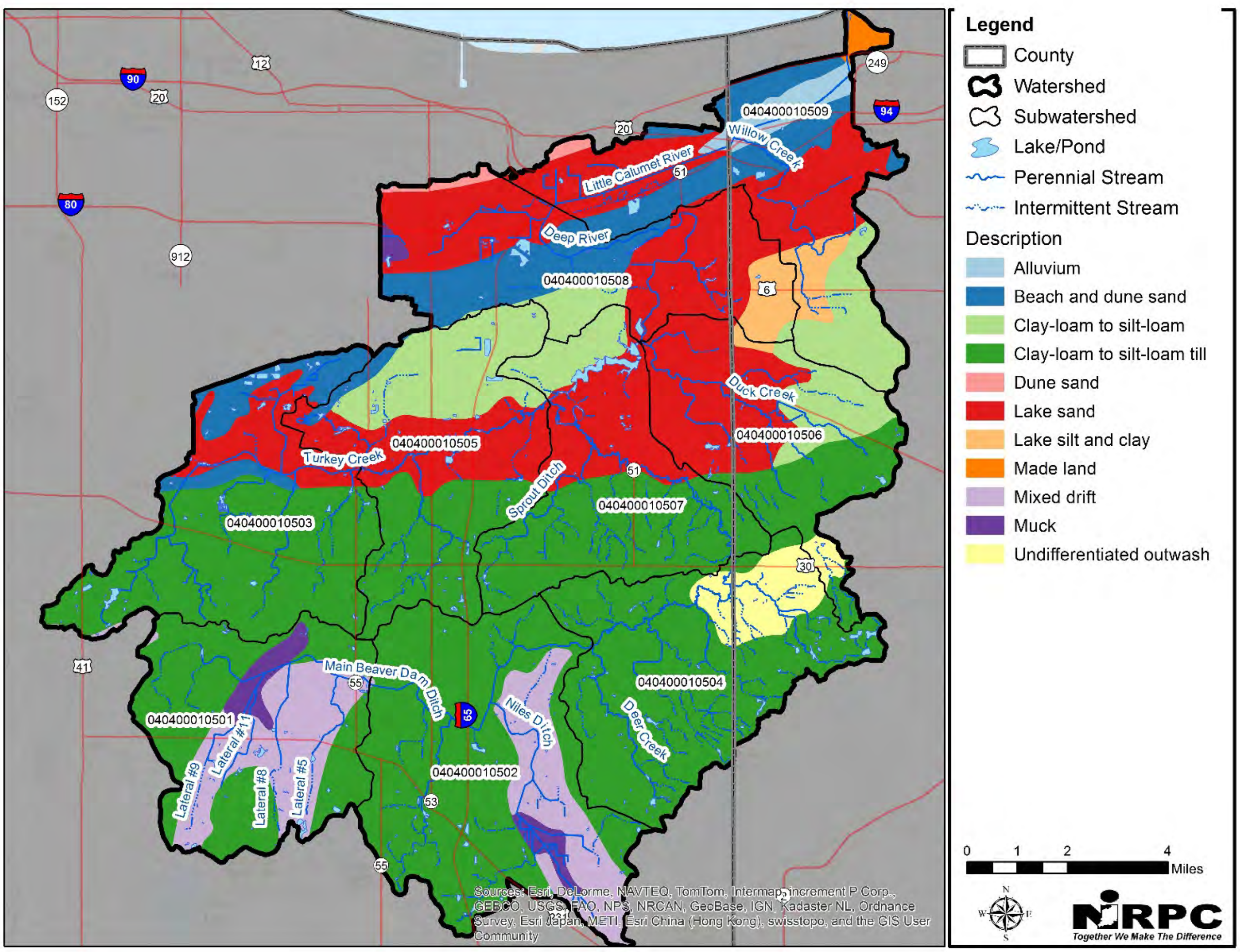


Figure 7 Surficial geology

2.3.2 Physiography

Physiographic regions share a similar topography, geologic structure and history. The Deep River-Portage Burns Waterway watershed is located in the physiographic region known as the Northern Moraine and Lake Region. The topography of our region was created almost entirely by the erosional and depositional forces of the last glaciation event, the Wisconsin. The Northern Moraine and Lake Region is dominated by moraines, which are accumulations of unconsolidated glacial debris, and includes almost all of Indiana's natural lakes. The Northern Moraine and Lake Region is further divided into several smaller physiographic sections. The Deep River-Portage Burns Waterway watershed is situated across two of these sections, the Lake Michigan Border and the Valparaiso Morainal Complex (Figure 8).

The Lake Michigan Border forms a 4-11 mile wide band along the southern shore of Lake Michigan. It includes a complex of beach ridges, dunes, moraines, lake floor deposits and related washed surfaces. The Valparaiso Morainal Complex forms a 13-20 mile wide band that is roughly concentric with the Lake Michigan shoreline. Its most dominate land forms include moraines and alluvial fans that grade to the southeast towards the Kankakee Drainageways. Lakes can be found in depressions of till areas and tunnel valleys of the moraines.

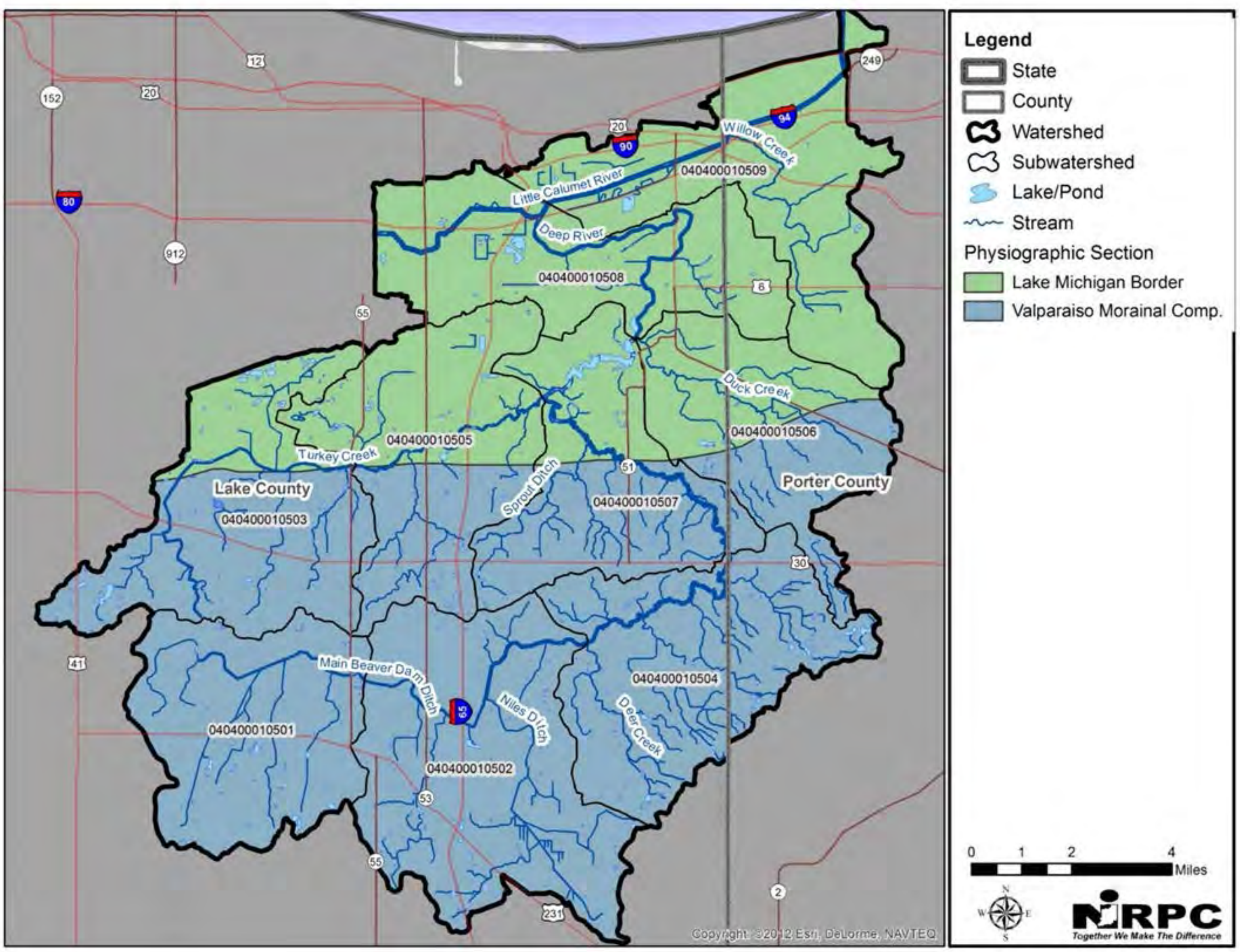


Figure 8 Physiography

2.3.3 Elevation

Elevation in the watershed ranges from a high of 823 ft. (251 m) to a low of 574 ft. (175 m) (Figure 9). The highest elevations occur in the southern portion of watershed along the Valparaiso Moraine. In general the lowest elevations occur along a corridor adjacent to the West Branch of the Little Calumet River west of State Road 51.

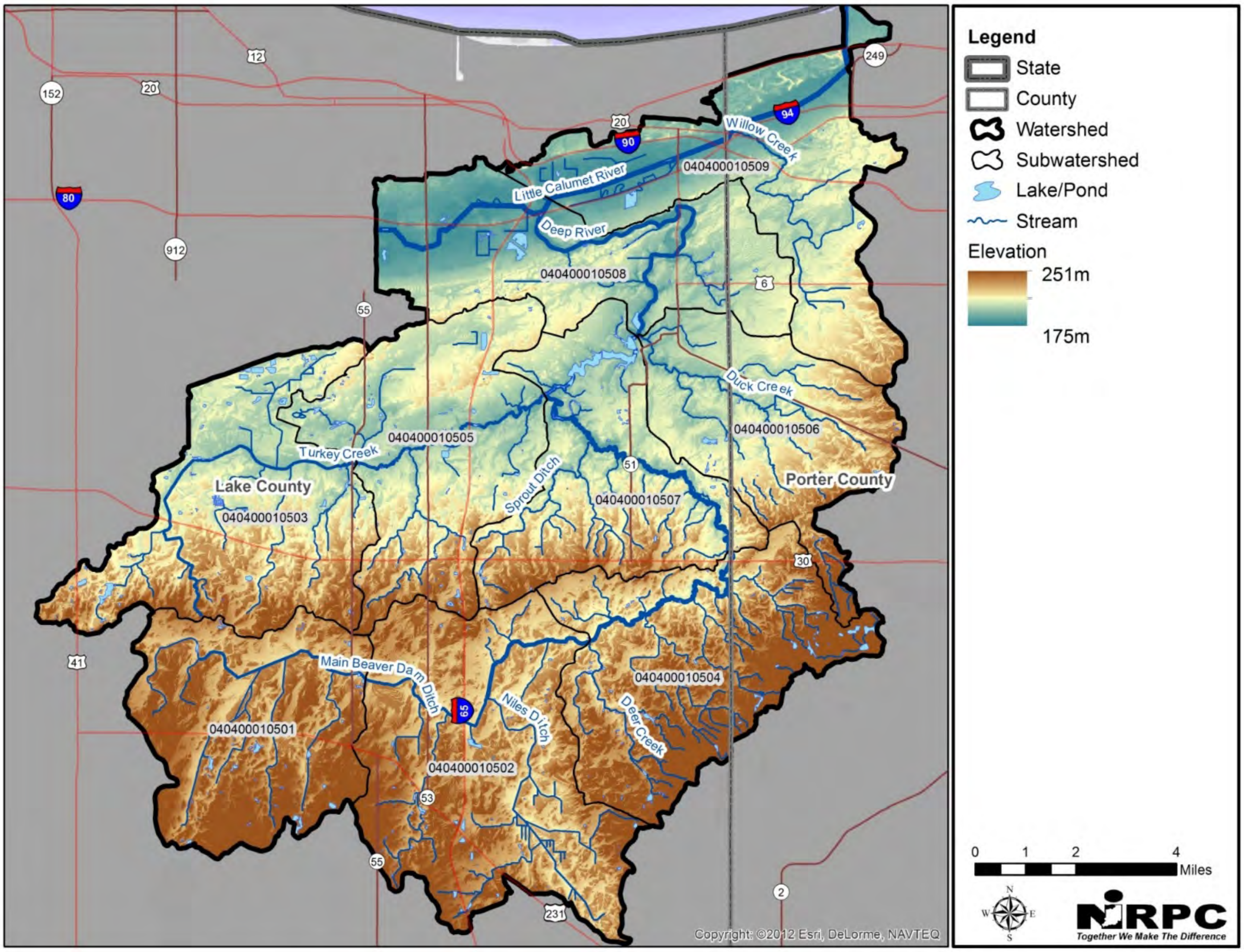


Figure 9 Elevation

2.3.4 Slope

Slopes influence a watershed's drainage pattern. Streams occurring in low gradient areas have meandering (winding) channels. Even straight channels will eventually erode into meandering channels if the streambank's soils are erodible. Because meandering streams are continually eroding on the outer bends and depositing sediment on the inner points, meandering stream channels tend to migrate back and forth across their floodplain. In areas where steep slopes do exist, it is difficult for rain to soak into the ground and for plant cover to become established. This combination of factors can lead to increased runoff and erosion potential.

Slope within the Deep River-Portage Burns Waterway watershed ranges from 0 to 71.5% (Figure 10). However most of the watershed can best be described as flat to gently rolling with an average slope of 2%. The areas of greatest topographic relief generally occur in the headwater areas of the Valparaiso Moraine and along Deep River. Slopes exceeding 15% can be found along Lake George, the river valley edges of Duck Creek, Deep River and one of its small, unnamed tributaries located south of U.S. Highway 30 in Porter County. Other areas with slopes exceeding 15% are found in the headwaters of Main Beaver Dam Ditch and Turkey Creek near St. John. In 2007, IDEM published the Indiana Storm Water Quality Manual (IDEM, 2007) which defines "steep" slopes as those exceeding 15%. The manual recommends prohibiting development on these slopes because of the high potential for soil erosion and degradation of surface water.

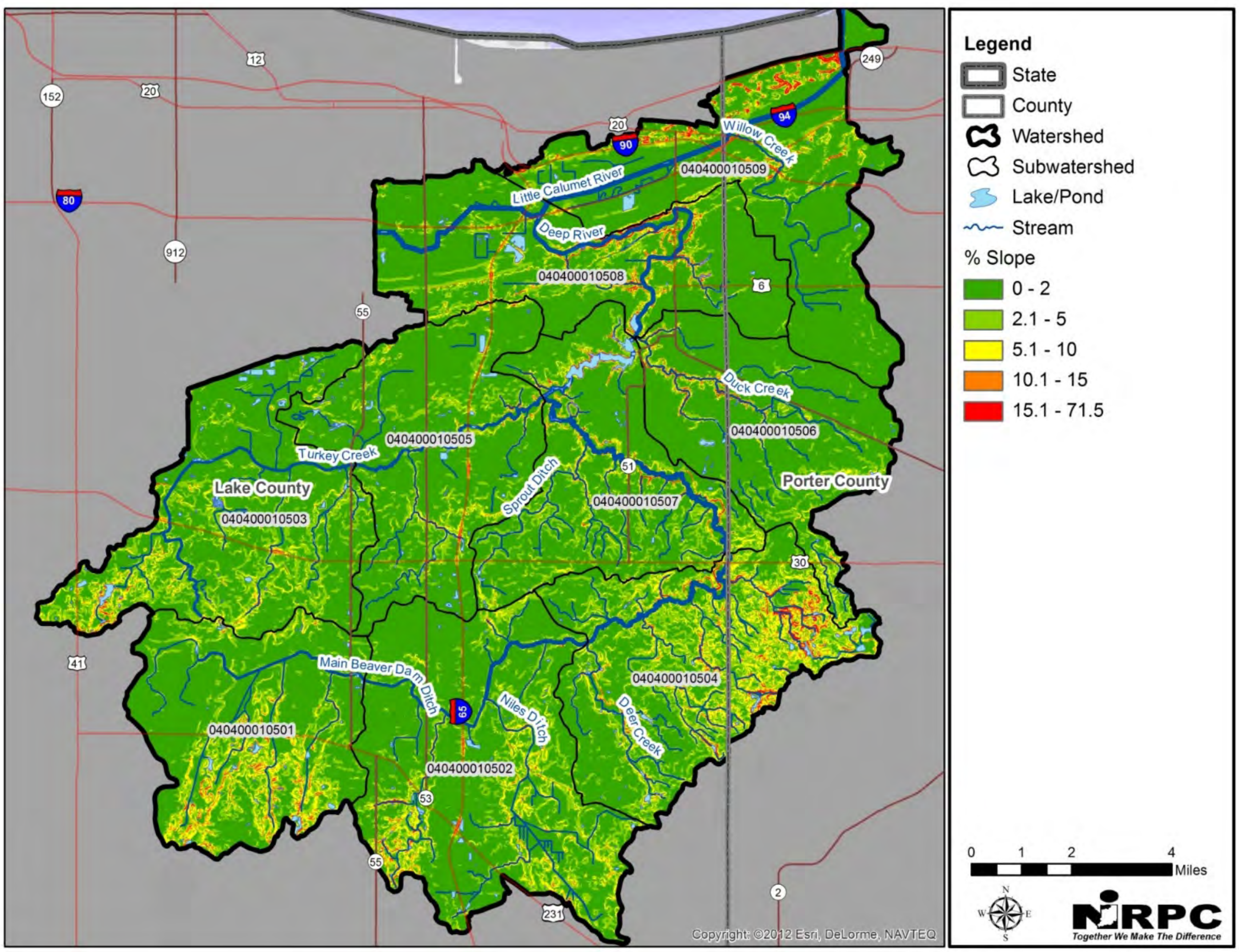


Figure 10 Slope

2.4 Soils

Soil development is the product of the interaction of parent material, topography, climate, organisms and time. Understanding the types of soils that exist within a watershed and their characteristics can be useful in identifying areas that are prone to erosion, are likely to experience runoff, or can affect water quality in some other way. Soils information can also be useful for identifying and prioritizing future restoration activities.

Stakeholder Concerns Related to Soils:

- Increased runoff
- Erosion & sedimentation
- Stream flashiness
- Ability to absorb excess water
- Failing septic systems
- Sediment loading
- Excess nutrients
- Chemicals in runoff
- Soil health
- Wetland habitat loss
- Increased runoff volume
- Streambank erosion
- Flooding
- Ability of watershed to store water
- Maintain drainage while protecting quality of resource

In the Lake Michigan region the distribution of major soil types is closely related to the physiographic terrain of the region (Section 2.3.2). Clayey or loamy soils are typical of the Valparaiso Morainal Complex while sandy soils are more typical in the Lake Michigan Border.

The following subsections provide details about soil characteristics that influence runoff and water quality.

2.4.1 Hydrologic Soil Groups

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups (A, B, C, and D) or one of three dual classes (A/D, B/D, and C/D) according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), then the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes. The groups are defined as follows:

- **Group A:** Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
- **Group B:** Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
- **Group C:** Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
- **Group D:** Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Table 6 provides a summary of hydrologic soil group data for each subwatershed and the watershed as a whole while Figure 11 shows their locations. Group C/D soils are the most common hydrologic soil group accounting for 43% of the watershed area. In drained areas these soils are classified as Group C and have a slow infiltration rate when thoroughly wet. In undrained areas they are classified as Group D and have a very slow infiltration rate (high runoff potential) when thoroughly wet. The second most common hydrologic soil group within the watershed is Group C. Areas either classified as Group C, C/D or D tend to strongly correspond with soil surface textures that are silty. In general, silty soils also tend to be more erodible than sandy or clayey soils. A wide band of Group A, A/D, and B soils is found in the northern portion of the watershed paralleling the Little Calumet River. Soil surface texture in this area is typically sandy to loamy and less prone to erosion.

Given the prevalence of Group C and C/D soils throughout the watershed, there is generally a moderate to high potential of runoff being generated during precipitation events. Between 80-90% of the soils in the Headwaters Main Beaver Dam Ditch, Main Beaver Dam Ditch-Deep River and City of Merrillville-Turkey Creek subwatersheds have low or very low infiltration rates.

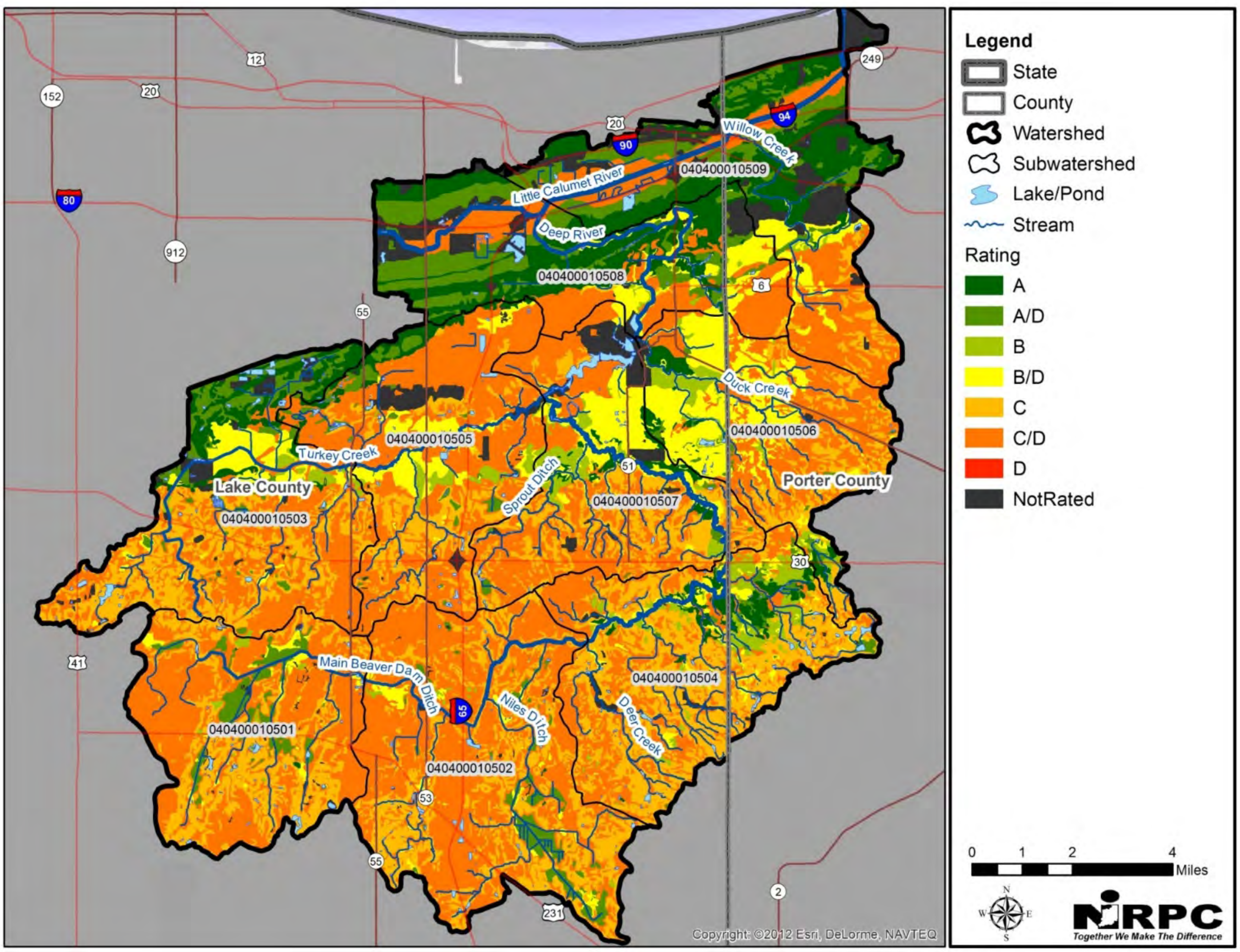


Figure 11 Hydrologic soil groups

Name	HUC-12	A (ac.)	%	A/D (ac.)	%	B (ac.)	%	B/D (ac.)	%	C (ac.)	%	C/D (ac.)	%	D (ac.)	%	NR (ac.)	%
Headwaters Main Beaver Dam Ditch	040400010501	12	0	959	8	95	1	331	3	3,386	29	6,737	58	0	0	189	2
Main Beaver Dam Ditch-Deep River	040400010502	10	0	889	5	80	0	384	2	4,918	29	10,427	62	0	0	113	1
Headwaters Turkey Creek	040400010503	1,344	10	1,231	9	260	2	1,137	8	3,790	28	5,108	38	0	0	724	5
Deer Creek-Deep River	040400010504	677	5	311	2	1,061	8	855	6	5,963	43	4,547	33	0	0	331	2
City of Merrillville-Turkey Creek	040400010505	570	5	534	4	350	3	1,250	10	1,998	16	7,064	57	0	0	726	6
Duck Creek	040400010506	386	4	216	2	646	6	3,138	31	1,788	18	3,830	38	0	0	136	1
Lake George-Deep River	040400010507	364	3	108	1	514	5	1,826	16	2,647	24	4,669	42	0	0	953	9
Little Calumet River-Deep River	040400010508	3,345	28	3,067	25	87	1	1,201	10	82	1	2,922	24	0	0	1,444	12
Willow Creek-Burns Ditch	040400010509	3,605	27	2,409	18	38	0	685	5	491	4	3,764	28	0	0	2,413	18
Watershed Total		10,313	9	9,724	8	3,132	3	10,808	9	25,063	22	49,067	43	0	0	7,031	6

Table 6 Hydrodologic soil groups data

2.4.2 Highly Erodible Land

Highly erodible land (HEL) is a classification used by the NRCS to identify land that is very susceptible to wind or water erosion for agricultural purposes. The NRCS maintains a list of highly erodible land units for each county. A list of the HEL or potentially HEL soil types and acreages within the watershed are listed by county in Table 7. To be eligible for USDA benefits, farmers that produce annually tilled agricultural commodity crops such as corn or soybeans must use an approved conservation system on all highly erodible land.

County	Map Unit	HES/Potential HES Soil Types	Acres
Lake	Bp	Borrow pits	305
	Cp	Clay pits	14
	DoB	Door loam	92
	DrB	Door loam, silty clay loam substratum	53
	LyB	Lydick loam	12
	MaB2	Markham silt loam	3,968
	MuD2	Morley silt loam	763
	MvB3	Morley silty clay loam	421
	OaE	Oakville fine sand	104
	OsA	Oshtemo fine sandy loam	636
	PlB	Plainfield fine sand	4,269
	TcC	Tracy loam	24
	TrB	Tracy loam, silty clay loam substratum	84
		Total	**10,745**
Porter	BaA	Blount silt loam	665
	ChB	Chelsea fine sand	312
	LyB	Lydick loam	22
	McB	Markham silt loam	979
	MfA	Martinsville loam	59
	MrD2	Morley silt loam	272
	MsC3	Morley silty clay loam	44
	OaE	Oakville fine sand	315
	Pk	Pits	13
	RaC2	Rawson loam	8
	RmC2	Riddles loam	73
	RlB	Riddles silt loam	223
	TcD	Tracy sandy loam	32
	UcG	Udorthents, loamy	81
		Total	**3,098**

Table 7 HEL/Potential HEL soil units by county

Table 8 provides a summary of HEL soils data for each subwatershed and the watershed as a whole. Figure 12 shows the locations of HEL soils in the watershed. Approximately, 14, 108 acres or 12.3% of the soils in the watershed are classified as HEL or potentially HEL.

Name	HUC-12	HEL (ac.)	%
Headwaters Main Beaver Dam Ditch	040400010501	828	7.1
Main Beaver Dam Ditch-Deep River	040400010502	1,848	11.0
Headwaters Turkey Creek	040400010503	1,946	14.3
Deer Creek-Deep River	040400010504	1,906	13.9
City of Merrillville-Turkey Creek	040400010505	1,616	12.9
Duck Creek	040400010506	1,268	12.5
Lake George-Deep River	040400010507	425	3.8
Little Calumet River-Deep River	040400010508	2,639	21.7
Willow Creek-Burns Ditch	040400010509	1,634	12.2
Watershed Total		14,108	12.3

Table 8 HEL/ Potentially HEL soil units by subwatershed

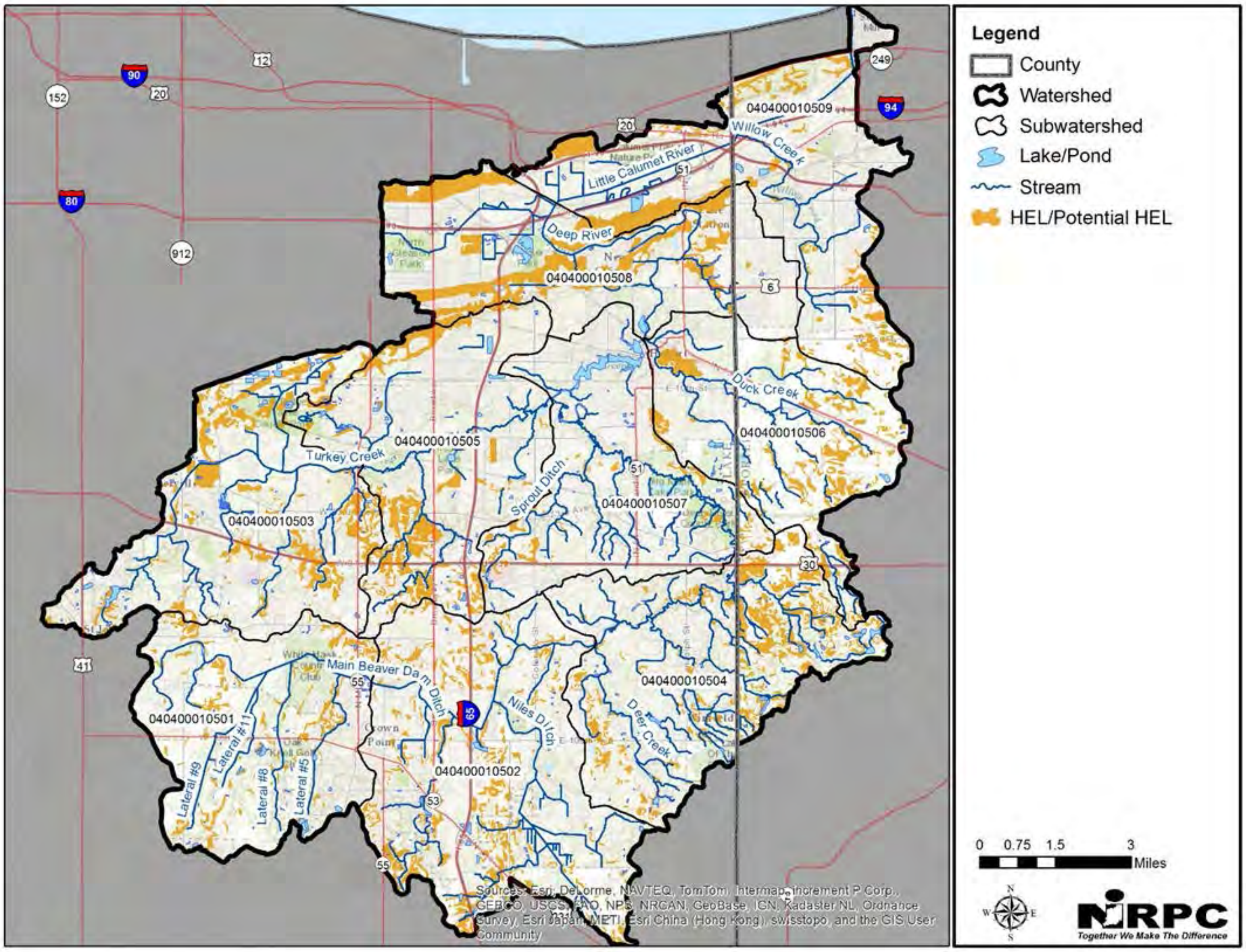


Figure 12 HEL/Potential HEL soils in the watershed

2.4.3 Hydric Soils

Hydric soils are one of three characteristics used to identify wetlands. These soils formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic (oxygen depleted) conditions in the upper part. These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic (water-loving) vegetation. Areas where hydric soils are present but wetlands no longer exist can be useful in identifying potential wetland restoration opportunities.

Table 9 provides a summary of hydric soils data for each subwatershed and the watershed as a whole while Figure 13 provides us with a sense of their locations. In total there are approximately 37,233 acres of hydric soil within the watershed. This represents about 32% of the land area. Hydric soils are relatively equally distributed throughout the watershed and its subwatersheds. Many hydric soils can be found adjacent to tributaries or ditches.

Name	HUC-12	All Hydric (ac.)	%	Partially Hydric (ac.)	%	Not Hydric (ac.)	%	Unranked (ac.)	%
Headwaters Main Beaver Dam Ditch	040400010501	4,540	39	0	0	7,146	61	24	0
Main Beaver Dam Ditch- Deep River	040400010502	5,665	34	0	0	11,137	66	21	0
Headwaters Turkey Creek	040400010503	4,922	36	0	0	8,236	61	430	3
Deer Creek- Deep River	040400010504	3,588	26	0	0	10,159	74	0	0
City of Merrillville- Turkey Creek	040400010505	4,278	34	25	0	7,690	62	500	4
Duck Creek	040400010506	2,781	27	0	0	7,282	72	82	1
Lake George- Deep River	040400010507	2,808	25	0	0	7,650	69	623	6
Little Calumet River- Deep River	040400010508	4,025	33	61	1	7,359	61	689	6
Willow Creek-Burns Ditch	040400010509	4,626	34	24	0	8,038	60	721	5
Watershed Total		37,233	32	111	0	74,698	65	3,091	3

Table 9 Hydric Soils Data

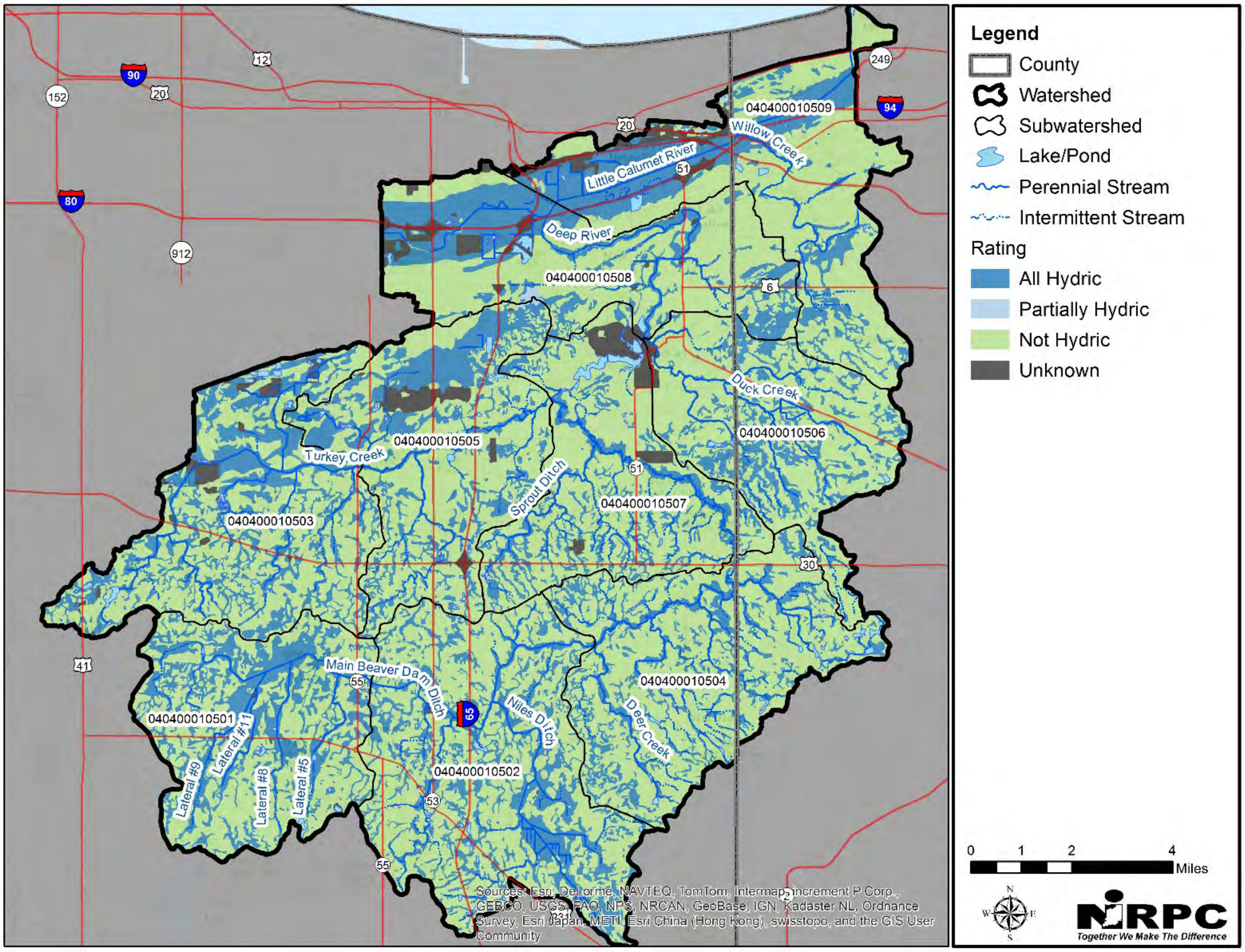


Figure 13 Hydric soils rating

2.4.4 Soils Drainage Class

Soil drainage classes identify the natural drainage condition of the soil and refer to the frequency and duration of periods when the soil is free of saturation. This information can be of value when trying to identify where field drain tiles may exist in agricultural lands or areas that might be prone to flooding.

The rating classes are described as follows:

- **Excessively drained**- Water is removed very rapidly. The occurrence of internal free water commonly is very rare or very deep. The soils are commonly coarse-textured and have very high hydraulic conductivity or are very shallow.
- **Somewhat excessively drained**- Water is removed from the soil rapidly. Internal free water occurrence commonly is very rare or very deep. The soils are commonly coarse-textured and have high saturated hydraulic conductivity or are very shallow.
- **Well drained**- Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to

plants throughout most of the growing season in humid regions. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soils are mainly free of features that are related to wetness.

- **Moderately well drained**- Water is removed from the soil somewhat slowly during some periods of the year. Internal free water occurrence commonly is moderately deep and transitory through permanent. The soils are wet for only a short time within the rooting depth during the growing season, but long enough that most mesophytic crops are affected. They commonly have a moderately low or lower saturated hydraulic conductivity in a layer within the upper 1 meter, periodically receive high rainfall, or both.
- **Somewhat poorly drained**- Water is removed slowly so that the soil is wet at a shallow depth for significant periods during the growing season. The occurrence of internal free water commonly is shallow to moderately deep and transitory to permanent. Wetness markedly restricts the growth of mesophytic crops, unless artificial drainage is provided. The soils commonly have one or more of the following characteristics: low or very low saturated hydraulic conductivity, a high water table, additional water from seepage, or nearly continuous rainfall.
- **Poorly drained**- Water is removed so slowly that the soil is wet at shallow depths periodically during the growing season or remains wet for long periods. The occurrence of internal free water is shallow or very shallow and common or persistent. Free water is commonly at or near the surface long enough during the growing season so that most mesophytic crops cannot be grown, unless the soil is artificially drained. The soil, however, is not continuously wet directly below plow-depth. Free water at shallow depth is usually present. This water table is commonly the result of low or very low saturated hydraulic conductivity of nearly continuous rainfall, or of a combination of these.
- **Very poorly drained**- Water is removed from the soil so slowly that free water remains at or very near the ground surface during much of the growing season. The occurrence of internal free water is very shallow and persistent or permanent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soils are commonly level or depressed and frequently ponded. If rainfall is high or nearly continuous, slope gradients may be greater.
- **Not rated**- Soils have characteristics that show extreme variability from one location to another. Often these areas are urban land complexes or miscellaneous areas. An on-site investigation is required to determine soil conditions present at the site.

Table 10 provides an overview of soil drainage class data for each subwatershed and the watershed as a whole while Figure 14 shows their locations. A majority (61%) of the watershed's soils are classified somewhere between somewhat poorly drained to very poorly drained. In agricultural areas, the wetness of these soils markedly restricts the production of most crops unless artificial drainage is provided. As referenced in the discussion about hydrologic soils groups, dual soil ratings are influenced by whether the soil is artificially drained or not. Section 2.10.5 includes further information about cultivated land existing on poorly drained soils where subsurface drainage would likely be needed.

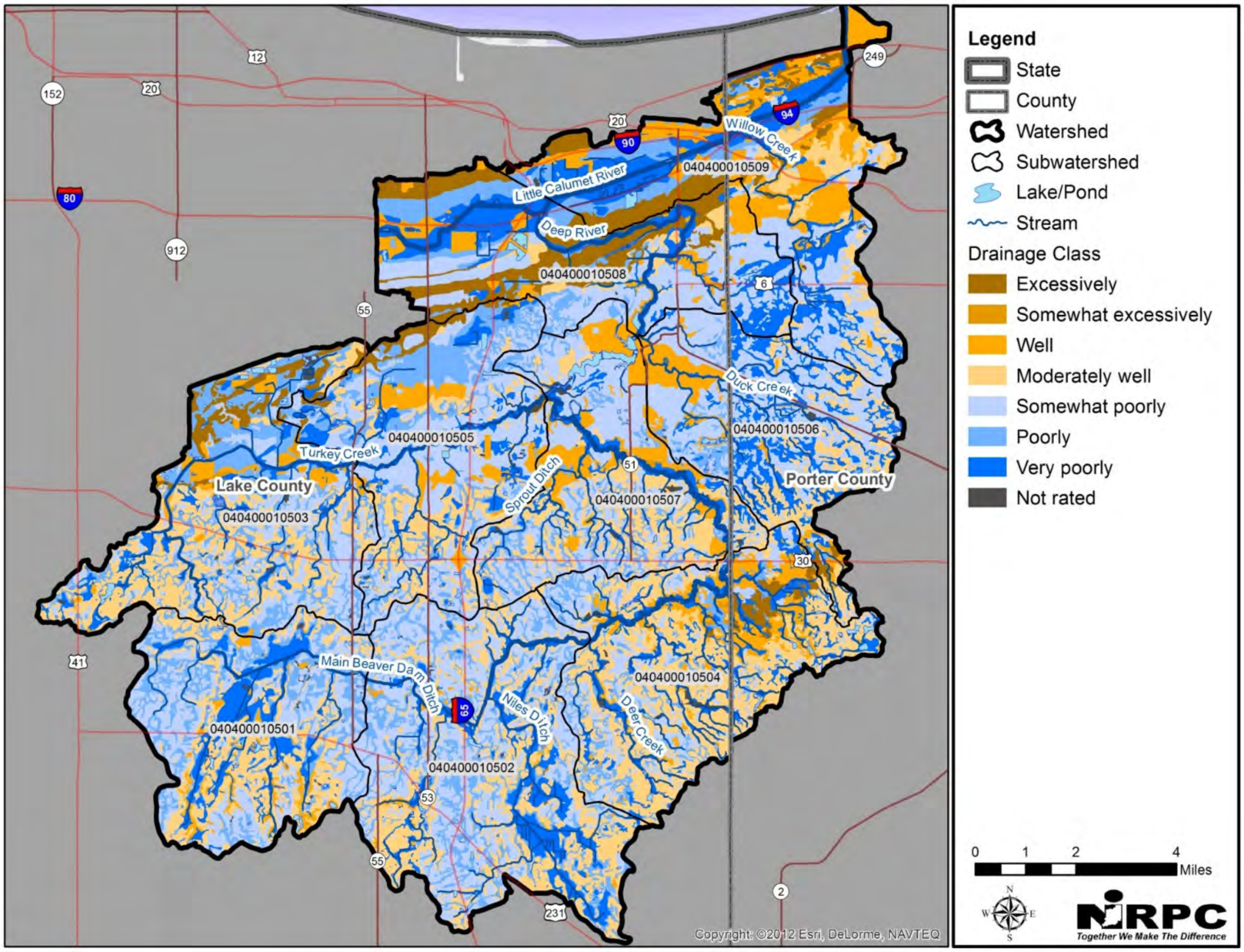


Figure 14 Soil Drainage Class

Name	HUC-12	Excessively Drained	%	Somewhat Excessively	%	Well Drained	%	Moderately Well Drained	%	Somewhat Poorly Drained	%	Poorly Drained	%	Very Poorly Drained	%	Not Rated	%
Headwaters Main Beaver Dam Ditch	040400010501	0	0	0	0	484	4	3,033	26	3,497	30	2,886	25	1,654	14	155	1
Main Beaver Dam Ditch-Deep River	040400010502	7	0	2	0	186	1	4,830	29	6,035	36	3,454	21	2,211	13	95	1
Headwaters Turkey Creek	040400010503	860	6	72	1	788	6	4,052	30	2,574	19	3,734	27	1,188	9	327	2
Deer Creek-Deep River	040400010504	395	3	48	0	1,480	11	5,783	42	2,203	16	1,505	11	2,084	15	247	2
City of Merrillville-Turkey Creek	040400010505	475	4	8	0	898	7	2,038	16	4,598	37	2,946	24	1,332	11	198	2
Duck Creek	040400010506	90	1	0	0	1,038	10	1,778	18	4,403	43	407	4	2,374	23	50	0
Lake George-Deep River	040400010507	0	0	21	0	1,511	14	2,615	24	3,803	34	1,735	16	1,073	10	322	3
Little Calumet River-Deep River	040400010508	2,655	22	7	0	1,253	10	499	4	3,427	28	1,514	12	2,511	21	281	2
Willow Creek-Burns Ditch	040400010509	1,398	10	0	0	3,301	25	1,542	12	2,323	17	1,336	10	3,290	25	216	2
Watershed Total		5,880	5	159	0	10,939	10	26,170	23	32,864	29	19,516	17	17,717	15	1,892	2

Table 10 Drainage Class Data

2.4.5 Septic System Soil Limitations

Conventional onsite sewage disposal systems (a.k.a. septic systems), while common, are not suitable for all areas. Among the limitations which might preclude installation of a conventional system are: high groundwater tables; shallow limiting layers of bedrock or fragipan; very slowly or rapidly permeable soils; topography; and lot size.

Soil limitations within the watershed for conventional septic systems that use absorption fields for treatment are displayed in Figure 15. Only that part of the soil between depths of 24 and 60 inches is evaluated. The ratings are based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. Figure 15 is a general reference of likely field conditions. A soil scientist is necessary to determine actual site conditions which may vary greatly compared to what is shown in the figure. The rating class terms include:

- “Not rated”- Soils are highly disturbed such as in urban areas.
- “Not limited”- Soils have features that are very favorable for the specified use. Good performance and very low maintenance can be expected.
- "Somewhat limited" - Soils have features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected.
- "Very limited" - Soils have one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Slightly more than 92% of the watershed’s land area is rated as “very limited” for conventional systems that use absorption fields for treatment. This rating indicates that there are significant challenges and costs to assure functionality of the system. Furthermore poor performance and higher maintenance can be expected which is particularly problematic since there currently is no operation and maintenance program in place for existing systems within Lake and Porter Counties.

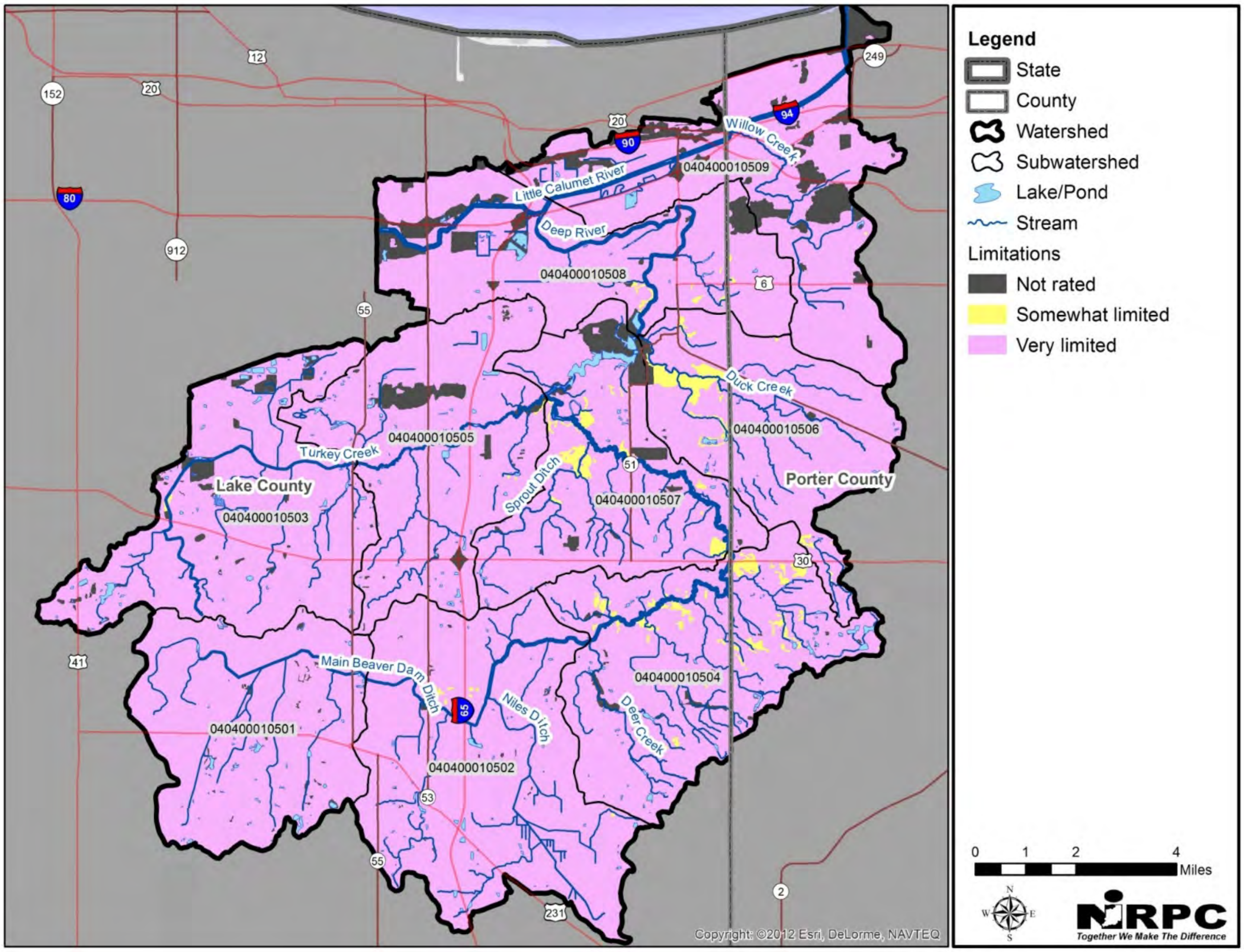


Figure 15 Septic System Soil Limitation Rating

2.5 Hydrology

Characterizing how water is transported from the watershed to stream channels (i.e. hydrology) and how water is transported within the stream channel and its floodplain (i.e. hydraulics) are very important components in understanding watershed processes that can affect water quality and aquatic life.

Hydrology in the watershed is markedly different from when the area was first settled. Pre-settlement vegetation data that has been pieced together from surveyor notes suggest that much of the watershed's landscape included a dynamic mix of prairie, savanna, marsh, wetland, and forest communities. As the area was settled, wetlands and marshes were drained and prairies were plowed under for agricultural production and forests and savannas were logged for their timber. The loss of natural land is known to increase surface runoff volume and rates which results in streams receiving more water as overland flow than they had developed under. Additionally, impervious surface cover has been steadily increasing with the expansion of development. This increase in impervious cover has resulted in even greater runoff and less infiltration.

Historically the Little Calumet River and the Grand Calumet River were once part of a single river called the Calumet. Its headwaters were located in LaPorte County in what is present-day Red Mill County Park. From here the river flowed sluggishly to the west through the Calumet Lacustrine Plain before making a hairpin turn back east near present-day Blue Island in Illinois and eventually emptying into Lake Michigan near the Marquette Park Lagoon in Gary.

In 1926 Burns Ditch was completed between Deep River in Lake County and Salt Creek in Porter County to improve local drainage. Around this same time period, Burns Waterway was excavated connecting Burns Ditch to Lake Michigan thereby diverting the eastern part of the Little Calumet River directly into Lake Michigan. Following the construction of harbors and canals, industries moved lakeward filling nearshore areas with slag and marshes and swamps with sand from nearby dunes and beaches. A series of levees and flood control projects were completed to protect low lying, flood prone urban areas along the mainstem of the Little Calumet River and its tributaries in northern Lake County.

Stakeholder Concerns Related to Hydrology:

- Flooding
- Floodway/ floodplain encroachment
- Stream flashiness
- Reconciling drainage w/ water quality & habitat
- Loss of recreational opportunities
- Impaired stream impacts on recreation & tourism
- Wetland loss
- Storm water storage
- Excess sediment & nutrient loading
- Stream habitat loss
- Riparian area and floodplain encroachment
- Reconciling drainage/ flood control w/ water quality and habitat
- Water viewed as "enemy"
- Streambank and shoreline erosion
- Ability of watershed to absorb or carry away excess water
- Dredging Burns Ditch and Lake George
- Dredging impacts on shoreline erosion
- Dams

Drainage improvement projects have altered the area to such an extent that land that once drained to Lake Michigan now empty into the Gulf of Mexico. Figure 16, which was provided by Steve Davis with the DNR's Division of Water, highlights flow directions for the Little Calumet River as well as some other nearby tributaries. Under certain conditions flows can reverse along the West Branch of the Little Calumet River due to control structures and changes in Lake Michigan water levels.

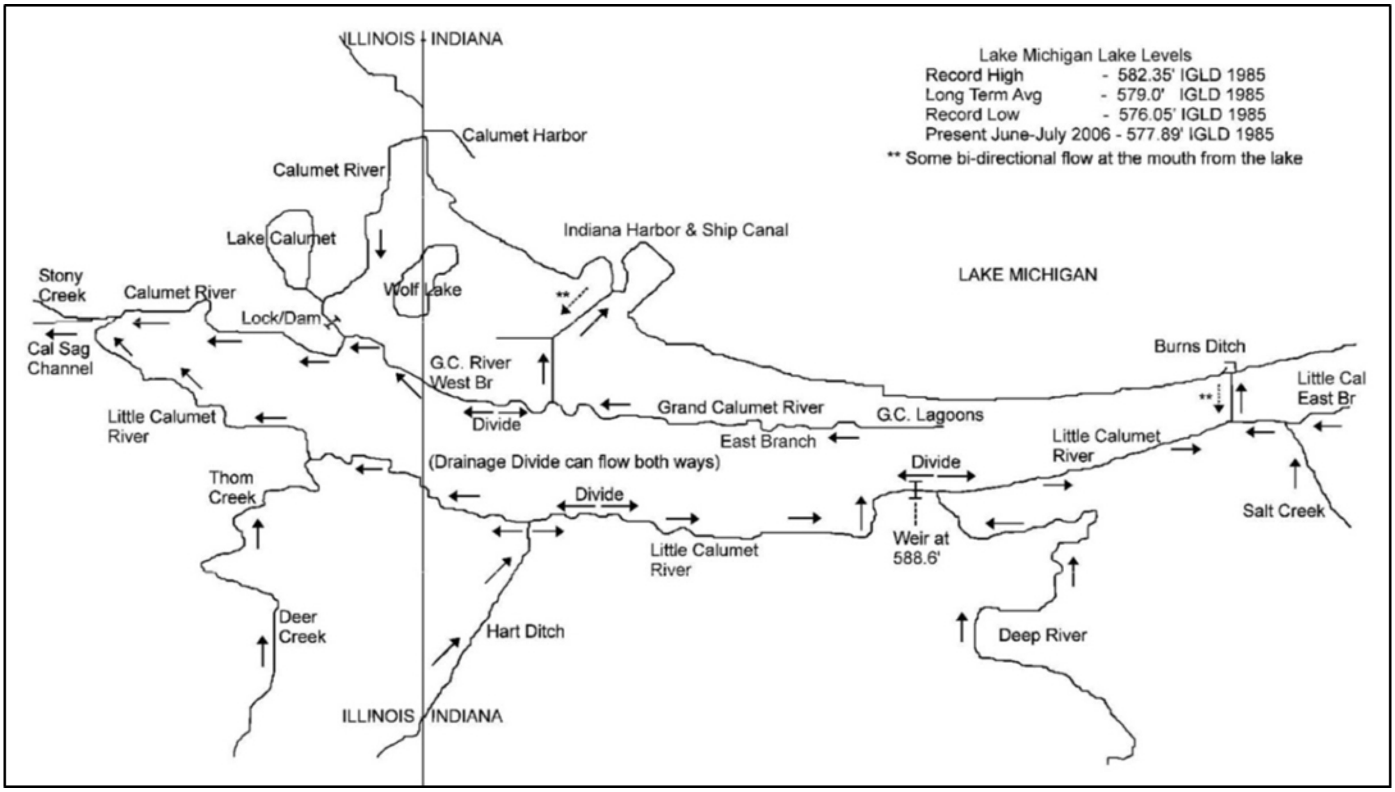


Figure 16 Stream Flow Directions

2.5.1 Surface Waterbody Features

2.5.1.1 *Streams*

Today, nearly 290 miles of stream and manmade ditch drain the landscape of the Deep River-Portage Burns Waterway watershed (Figure 17). Some of the major tributaries within the watershed include the West Branch Little Calumet River, Deep River, Turkey Creek, and Main Beaver Dam Ditch. Tributaries feeding into Deep River include Main Beaver Dam Ditch, Deer Creek, Duck Creek, and Turkey Creek. Deep River joins the West Branch Little Calumet River approximately ½-mile east of Interstate 65 and just north of Interstate 80-94. The East and West Branch of the Little Calumet River join approximately 1/3-mile south of U.S. Highway 20 near State Road 249 in Portage where they empty into Lake Michigan through the Burns Waterway. Turkey Creek joins Deep River approximately ½ mile southwest of Lake George in Hobart. Main Beaver Dam Ditch joins Deep River near Interstate 65 in Crown Point.

2.5.1.1.1 Special Designation Streams

Nearly 22 miles of Deep River is included on the “Outstanding Rivers List for Indiana” by the Natural Resources Commission, from one mile south of U.S. 30 to the Little Calumet River (Figure 17). Rivers and streams included on this list are considered to have a particular environmental, recreational, or aesthetic interest. The Burns Waterway is designated as a salmonid (trout and salmon) stream by the Indiana Department of Natural Resources. This man-made channel, measuring slightly more than 1 mile in length, cuts through the dunes connecting the East and West Branches of the Little Calumet River to Lake Michigan (Figure 17). No other stream segments within the watershed are designated salmonid streams or have the additional protections afforded to them under the state water quality standards (327 IAC 2-1.5). Natural water temperatures are generally not conducive of supporting put-and-take trout and salmon fishing in the Deep River-Portage Burns Waterway watershed like in the Little River East Branch watershed.

However, trout and salmon are known to stray/migrate up Willow Creek, the West Branch Little Calumet River, and Deep River as far upstream as the Lake George dam, shown as dam 45-2 in Figure 17, in Hobart when streamflow allows. Under typical conditions the Deep River dam in Lake Station, shown as dam 45-1, is a barrier to upstream fish migration.

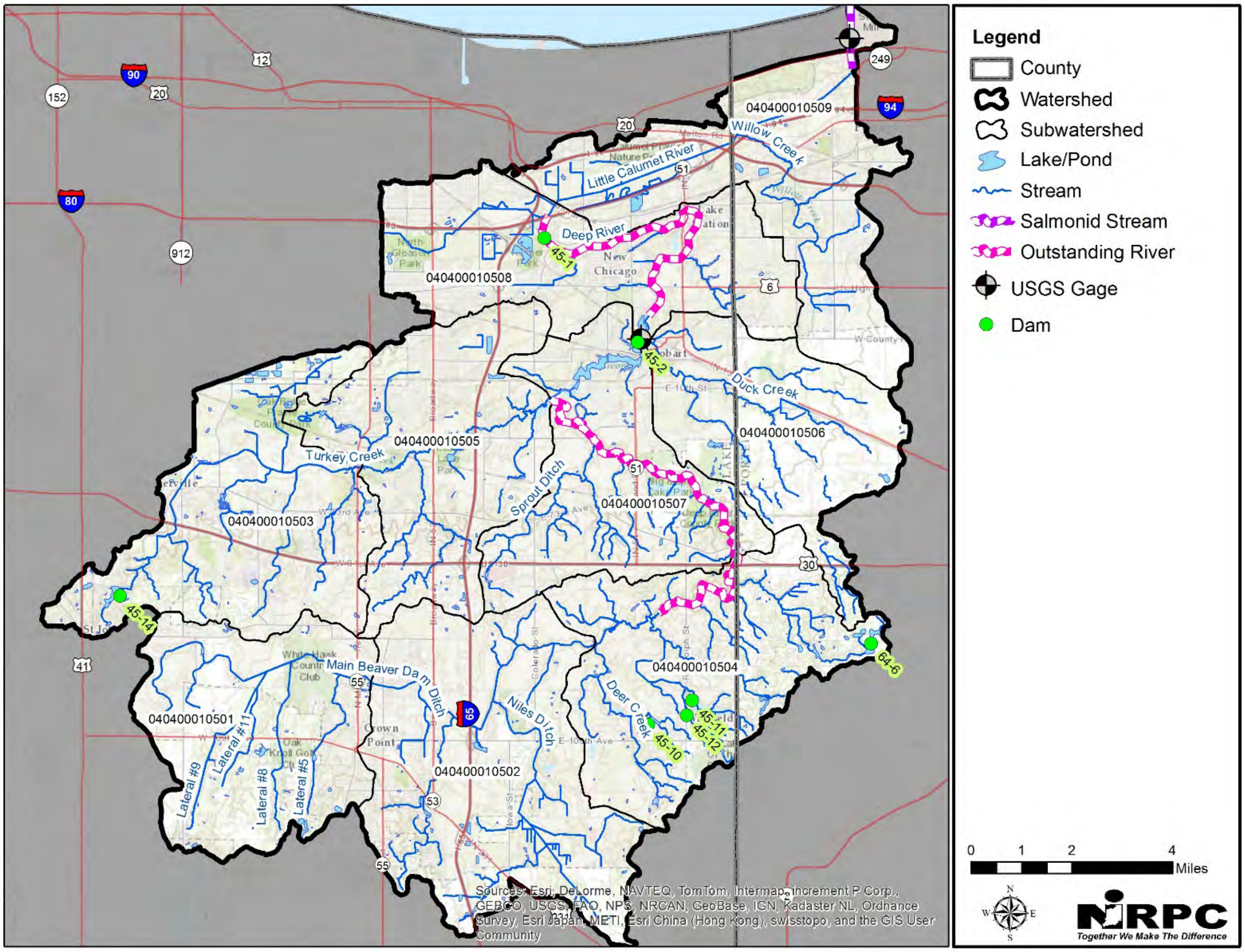


Figure 17 Surface Waterbody Features

2.5.1.1.2 Stream Flow Data

Flooding, stream geomorphology, and aquatic life are all influenced by stream flow. Additionally stream flow and surface runoff from precipitation events (See Section 2.2 for discussion on precipitation) drive the generation, transport, and delivery of many nonpoint source pollutants. Stream flow is simply the continuous movement of water in stream channels. It is often quantified as discharge which is defined as the volume of water that passes through a channel cross section in a specific time period.

The U.S. Geological Survey maintains and operates a stream gaging station (ID # 04093000) on Deep River at the outlet of Lake George in Hobart (Figure 17). Nearly 124 mi^2 (69%) of the watershed's land area drains through this point on Deep River.

The annual mean flow for Deep River at the Lake George outlet is 122 CFS. The highest annual mean was 233 CFS in 1993 and the lowest was 35 CFS in 1963. Monthly mean flow data for water years 1948-2014 is shown in Figure 18. The highest mean monthly flows occur during March and April. Mean monthly flows drop by nearly half in July and sustain those levels to nearly November.

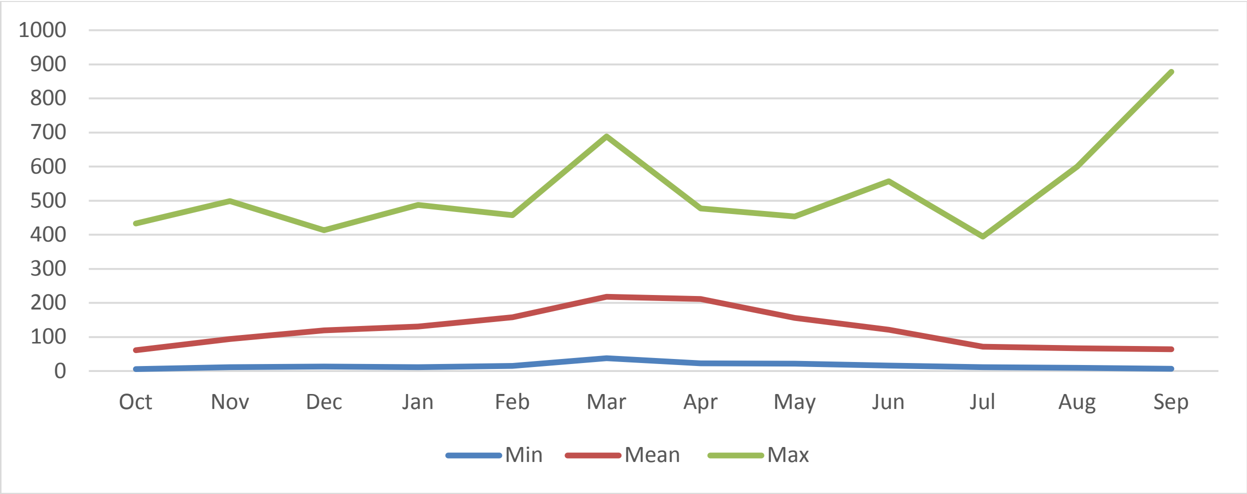


Figure 18 Monthly mean flow data for Deep River gage at Deep River Lake George Outlet Gaging Station

A flow-duration curve is a plot that shows the percentage of time that stream flow is likely to equal or exceed a specified value of interest. This type of information can be useful for the design of structures on a stream. The curve may also be used to evaluate the characteristics of a watershed. A flow-duration curve with a steep slope throughout denotes a highly variable stream whose flow is largely from direct runoff, whereas a curve with a flat slope reveals the presence of surface or groundwater storage, which tends to equalize the flow. The slope of the lower end of the flow-duration curve shows the characteristics of the perennial storage in the watershed; a flat slope at the lower end indicates a large amount of storage; and a steep slope indicates a negligible amount. Streams with large floodplain storage or those that drain wetland areas tend to have a flat slope at the upper end.

Figure 19 shows two flow-duration curves for comparison. The one on the left if for Deep River at Lake George. The one on the right is for the Galena River near LaPorte. Both are part of the Little Calumet-Galien sub-basin in Northwest Indiana. The Galena River has much less human land cover (development and agriculture) and a high percentage of forest and wetland. Deep River's curve is slightly steeper indicating higher streamflow variability from runoff while the Galena River's is flatter indicating the watershed has greater storage. The curve also indicates that during low-flow conditions, Deep River becomes stagnant with minimal flow.

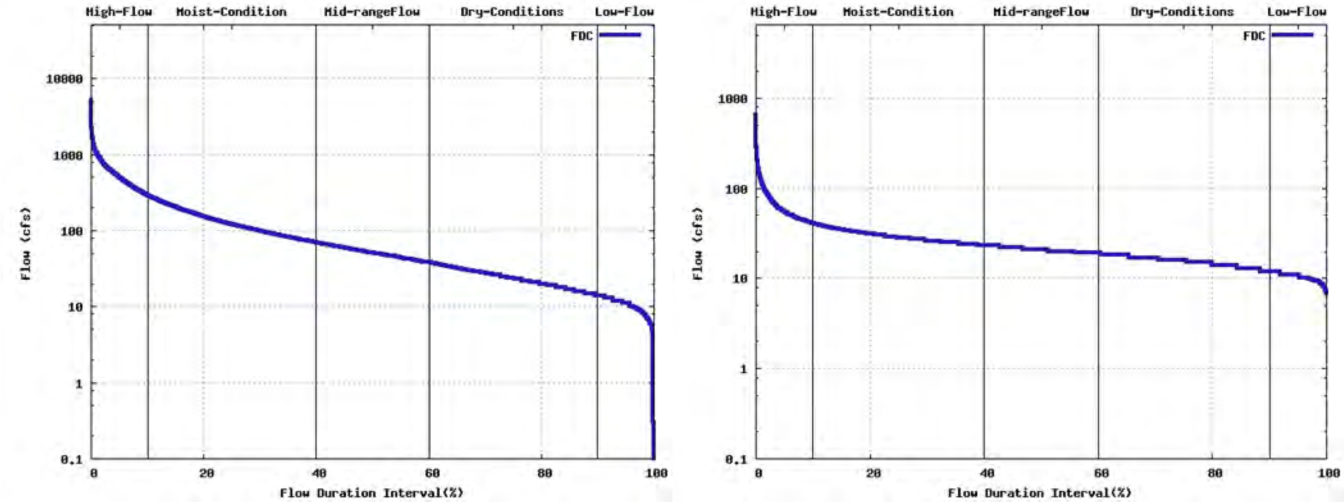


Figure 19 Flow duration-curve comparison between Deep and Galena River.

Figure 20 compares annual peak stream flow at this station with annual total precipitation. The figure indicates increasing trends for annual peak discharge and precipitation. However, annual peak discharge is increasing at a much higher rate (57%) than annual total precipitation (11%) over this time period. Peak flow is influenced by many factors, including the intensity and duration of storms and snowmelt, the topography and geology of stream basins, vegetation, and the hydrologic conditions preceding storm and snowmelt events. Land use and other human activities also influence the peak discharge by modifying how rainfall and snowmelt are stored on and run off the land surface into streams.

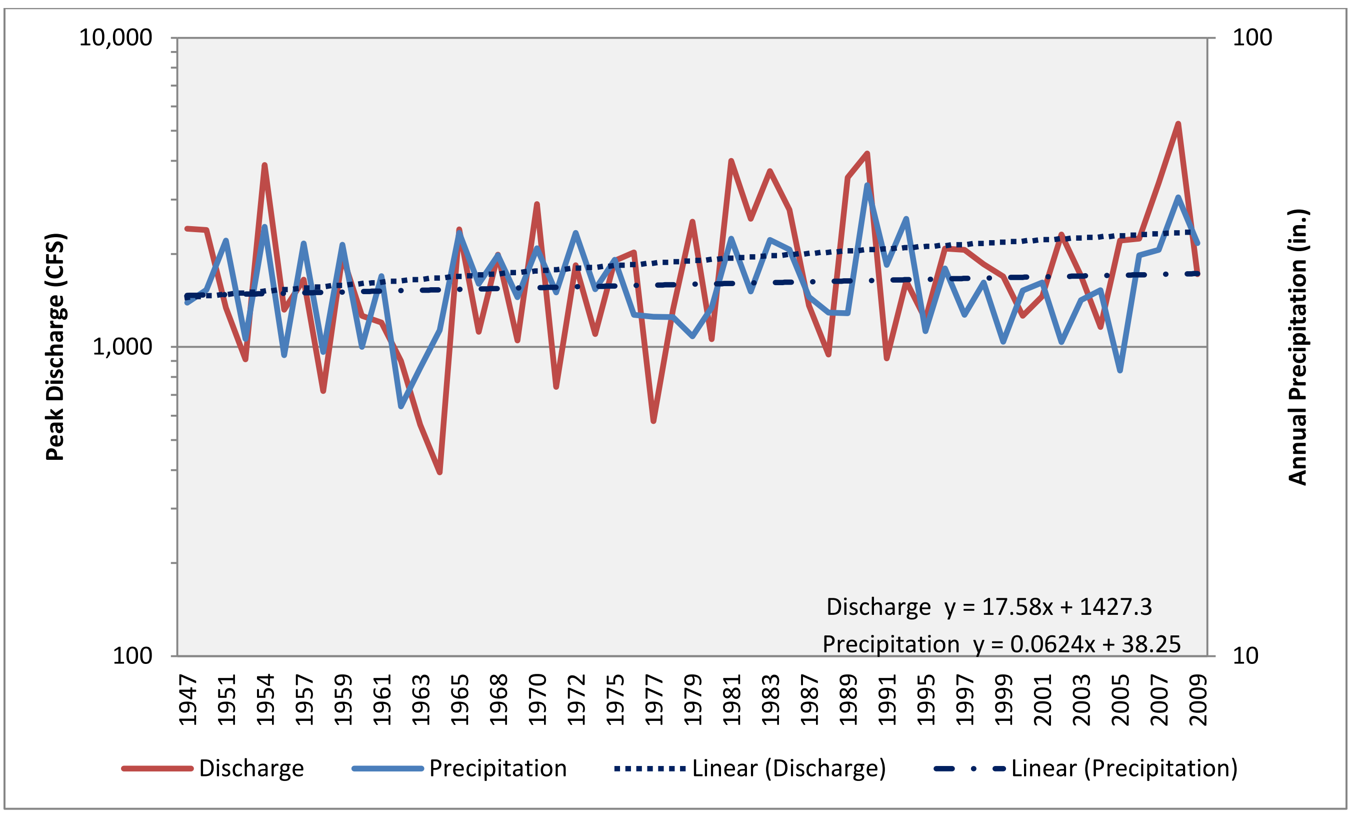


Figure 20 Trend Data for Annual Peak Discharge & Precipitation at Deep River Lake George Outlet Gaging Station

2.5.1.2 *Floodplains*

Floodplains play an important role in the health and function of streams. Development and alteration of floodplains can eliminate or degrade the beneficial services they provide. Table 11, adapted from the Ohio DNR Division of Soil & Water Resources, outlines some of these services.

Water Resources	
Natural Flood & Erosion Control	*Water Quality Maintenance*
• reduce flood velocities • reduce flood peaks • reduce erosion potential and impacts • stabilize soils • accommodate stream meander • provide a broad area for streams to spread out and for temporary storage of floodwater	• reduce sediment loads and amount of sediments • filter nutrients and impurities • process organic and chemical wastes • moderate water temperature • protect the physical, biological, and chemical integrity of water
Maintain Groundwater Supply and Balance	
• promote infiltration and aquifer recharge • reduce frequency and duration of low flow by increasing\enhancing base flow	
Biological Resources	
Support Flora	*Provide Fish and Wildlife Habitat*
• maintain high biological productivity of floodplain and wetland vegetation • maintain productivity of natural forests • maintain natural crops • maintain natural genetic diversity	• maintain breeding and feeding grounds • create and enhance waterfowl habitat • protect rare and endangered species habitat • maintain natural genetic diversity
Cultural Resources	
Maintain Harvest of Natural and Agricultural Products	*Provide Recreational Opportunities*
• create and enhance agricultural lands • provide areas for cultivation of fish and shellfish • protect and enhance silvaculture • provide harvest for fur resources	• provide areas for active and consumptive uses • provide areas for passive activities • provide open space values • provide aesthetic values
Provide Scientific Study and Outdoor Education Areas	*Improve Economic Base of Community*
• provide opportunities for ecological studies • provide historical and archaeological sites	• increase tourist activity • stimulate natural-resource businesses • improve property values

Table 11 Natural and Cultural Benefits of Floodplains

Floodplain (or more accurately, flood hazard) locations in the watershed are shown in Figure 21. Most of the critical flooding in the Lake Michigan region of Northwest Indiana occurs along the mainstem and tributaries of the Little Calumet River in Lake County. Extensive development, poorly drained soils, inadequate channel capacity and high water table all contribute to prolonged floods (Indiana Department of Natural Resources, 1994). Channelization and ditching add a further level of complexity to regional flooding. Channelization is the primary impact that has directly disconnected streams from their adjacent floodplains (Harman et al, 2012).

In the tributary areas of Deep River and Turkey Creek, poorly drained depressions allow considerable floodwater storage. As a result, the 10-year and 100-year flood flows are among the lowest for a given drainage area in Northwest Indiana's Lake Michigan region. Along the mainstem valley of Deep River, alluvial silt, sand and gravel serve as temporary storage features during periods of flooding. Alluvium in the Turkey Creek valley does not extend far from the channel resulting in little storage during floods (Indiana Department of Natural Resources, 1994).

Floodplain management regulations in Indiana are governed by statutory laws at both the state and federal levels. The state establishes minimum standards governing the delineation and regulation of flood hazard areas. The DNR, Division of Water administers the state flood control law and also serves as the state coordinator of the National Flood Insurance Program which helps regulate development on flood-prone lands. Construction, excavation or placement of fill in the floodplain is also regulated by the DNR.

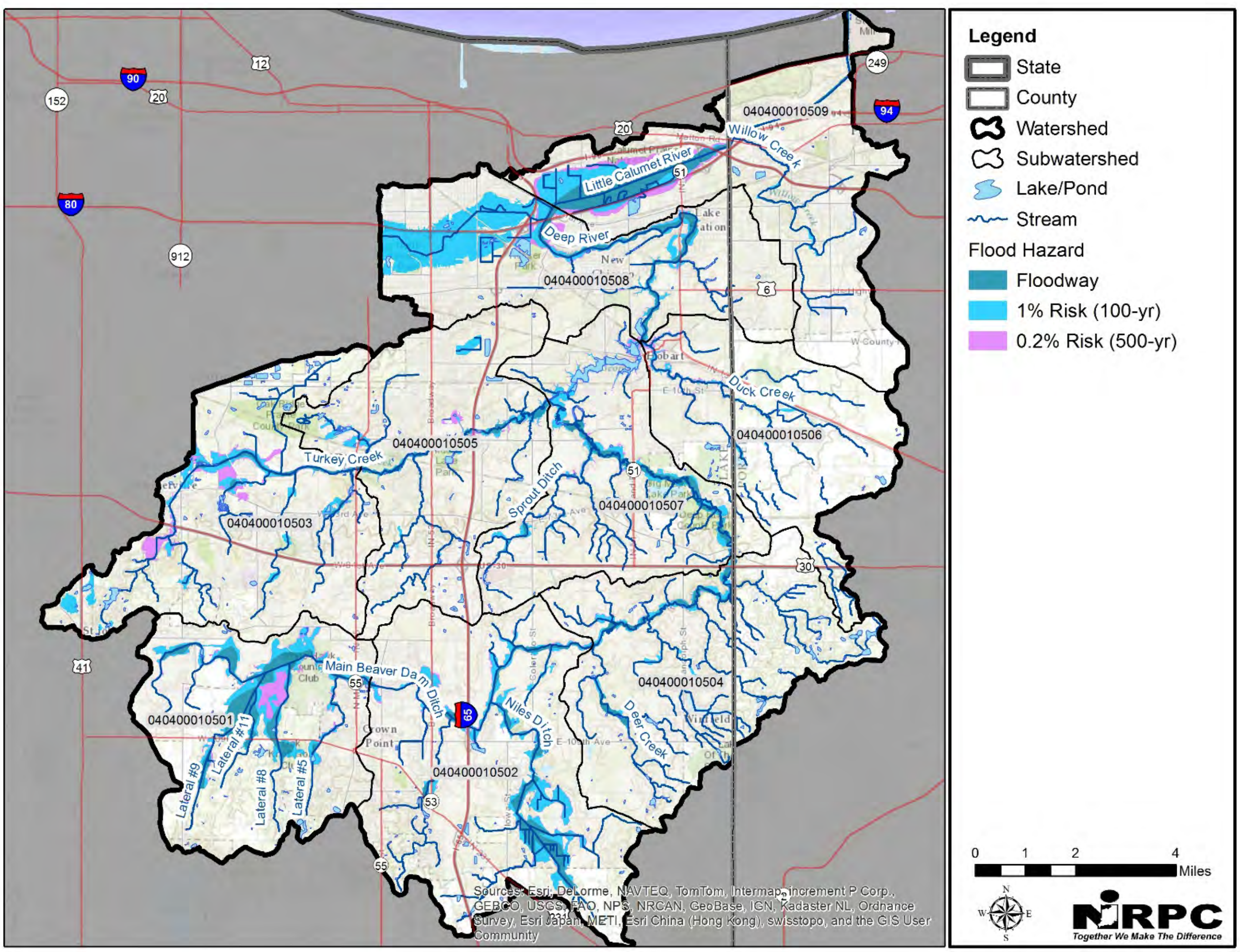


Figure 21 Floodplains (Flood Hazard)

Flooding

Flooding is defined differently by different disciplines. For example, the geomorphologist defines flooding as the flow that leaves the channel and spreads onto a floodplain that was built by a meandering river, sometimes called a geomorphic floodplain. A traditional water resources engineer might define flooding as the flow that would impact personal property, such as a home. In both cases, flood frequency can be used to predict the probability that a flow will reach a certain elevation (active floodplain or house) within a given timeframe. The geomorphologist typically associates the flood frequency of the active floodplain as the discharge with a 1.5-year return interval (on average). The water resources engineer typically delineates floodplains by the elevation of the 100-year return interval discharge. The 1.5-year return interval and the ability of the river to access this floodplain is extremely important for channel formation and maintenance. This is important to understand later on in the watershed plan when floodplain connectivity is further discussed.

2.5.1.3 *Lakes*

Many of the Little Calumet-Galien sub-basin's lakes are located in the urban and industrialized regions of Lake County and along the Valparaiso Moraine. An unknown number of lakes have been destroyed or greatly reduced in size due to drainage or filling for development purposes. Today there are approximately 518 lakes/ponds covering a combined surface area of 1,217 acres within the Deep River-Portage Burns Waterway watershed. Most are relatively small, unnamed lakes averaging 2.3 acres in size. Some of these lakes were formed as a result of past glacial activity others are man-made. Most of the artificial lakes consist of old gravel and borrow pits or are impoundments of rivers and streams. Lake George in Hobart is the largest lake in the watershed at approximately 175 acres in size. Lake George was created by the damming of Deep River sometime around 1840 by George Earle to power a gristmill and provide a community water supply. While Lake George no longer serves as a water supply or is used to power a mill, the gristmill burned down in 1953, the lake remains as a community focal point in downtown Hobart as a center for recreation and businesses.

2.5.1.4 *Wetlands*

Wetlands are an important feature in the landscape providing beneficial services for people, fish and wildlife. They function as natural sponges that trap, filter, and slowly release rain, snowmelt, groundwater and flood waters. Additionally many breeding bird populations including ducks and wading birds feed, nest, and raise their young in wetlands. Within our watershed, 214 state endangered, threatened or rare (ETR) species observations have been documented in or directly adjacent to wetland habitats. A discussion on ETR species and the natural communities types in which they occur is included in Section 2.8

Today, approximately 9,247 acres of wetland exist within our watershed (Table 12) accounting for 8% of its drainage area. Historically, there would have been nearly 37,354 acres of wetland covering 32% of the watershed's drainage area based on the hydrologic soils data presented earlier. Contiguous tracts of wetland exist along stream corridors such as Deep River, the Little Calumet River, and Main Beaver Dam Ditch (Figure 22). Subwatershed percent wetland area ranges from 4.7-10.3%.

Name	HUC-12	Emergent (ac)	Forested/ Shrub (ac)	Lake (ac)	Pond (ac)	Riverine (ac)	Total	% Wetland
Headwaters Main Beaver Dam Ditch	040400010501	547	363	23	213	0	1,146	9.8
Main Beaver Dam Ditch- Deep River	040400010502	516	134	0	146	0	797	4.7
Headwaters Turkey Creek	040400010503	438	396	56	299	0	1,189	8.7
Deer Creek- Deep River	040400010504	293	438	55	237	0	1,024	7.4
City of Merrillville- Turkey Creek	040400010505	296	463	67	182	8	1,016	8.1
Duck Creek	040400010506	183	262	0	74	0	520	5.1
Lake George- Deep River	040400010507	188	570	218	108	3	1,086	9.8
Little Calumet River- Deep River	040400010508	446	470	88	138	104	1,246	10.3
Willow Creek- Burns Ditch	040400010509	465	535	60	57	106	1,223	9.1
Watershed Total		3,374	3,631	567	1,454	221	9,247	8.0

Table 12 Subwatershed Wetland Data

The most common wetland type by total acreage in the watershed is forested/shrub wetland (3,572 acres) followed by emergent wetland (3,377 acres) (Table 13). The average forested/shrub wetland size is 8.4 acres while the average emergent wetland size is 4 acres. There is a total of 243 acres of riverine wetland located in the watershed. The largest contiguous tract is located on Deep River downstream of Lake George, continuing along Burns Ditch and Burns Waterway where it empties to Lake Michigan.

Wetland Type	Count	Minimum (ac)	Maximum (ac)	Sum (ac)	Mean (ac)
Emergent	848	<0.1	76.3	3,377.1	4.0
Forested/ Shrub	448	0.2	157.7	3,752.4	8.4
Lake	11	20.4	262.2	562.3	51.1
Pond	824	<0.1	20.7	1,456.0	1.8
Riverine	12	0.2	133.2	243.1	20.3

Table 13 Watershed Wetland Type Statistics

In a 1998 Wisconsin Department of Natural Resources publication on small wetlands and cumulative impacts of small wetland losses, the authors documented that watersheds with less than 10% wetland coverage had higher suspended solid loading per unit area and higher peak flows following storms and lower base flows between rains. This 10% threshold has already been surpassed for our watershed.

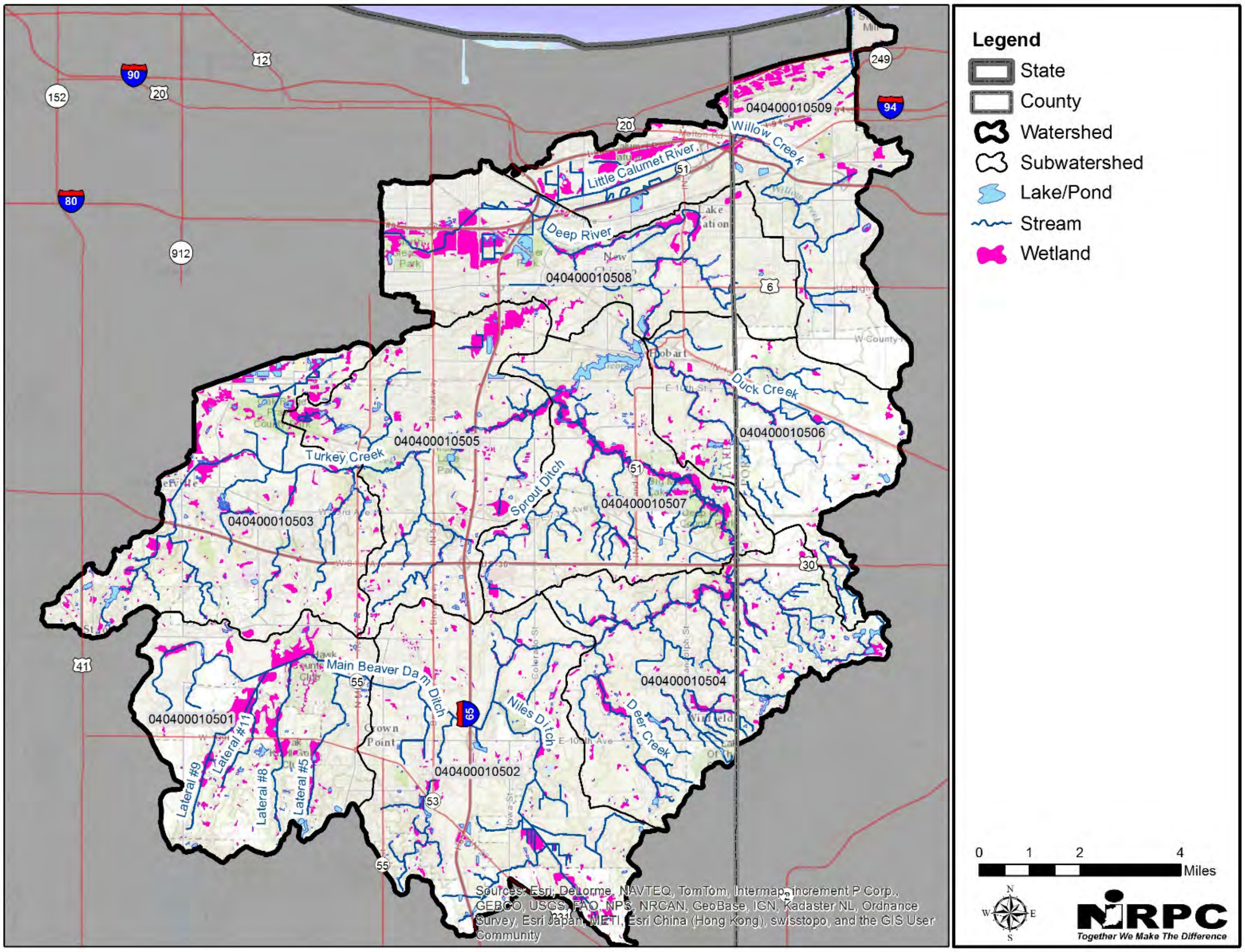


Figure 22 Wetlands

2.5.2 Hydromodification

Hydromodification is defined as alteration of the hydrologic characteristics of coastal and non-coastal waters, which in turn could cause degradation of water resources. According to the U.S. Environmental Protection Agency, hydromodification is one of the leading sources of impairment in streams, lakes and other waterbodies in the United States. Examples include dredging, straightening, stream relocation, construction along or in streams, dams, and land reclamation. The EPA has grouped hydromodification into three major types of hydromodification categories including (1) channelization and channel modification, (2) dams, and (3) streambank and shoreline erosion.

Historically, channelization occurred to reduce the risk of flooding and to drain wet areas for agriculture and development. Channelization can affect the timing and delivery of pollutants to downstream areas. Additionally during storm events, channelization can lead to higher flows which increase the risk of flooding and streambank erosion. In some cases the stream may no longer be able to access its floodplain to dissipated energy and deposit sediment loads carried by flood waters. In recent years regulatory requirements, primarily through the Clean Water Act, have limited traditional hydromodification activities within stream channels and waterbodies.

In both urban and rural areas, streambank and shoreline erosion is often associated with changes in watershed land use characteristics such as increased impervious surface cover (ex. streets, parking lots and rooftops). Because streambank and shoreline erosion is often closely related to upland activities that occur outside riparian areas, it is often necessary to consider solutions to these issues as a component of overall watershed protection and restoration objectives.

Dams are artificial barriers that control the flow of water. They are built for a variety of purposes such as flood control, power generation, irrigation, or to create recreational lakes and ponds. While dams can have societal benefits, they can also have detrimental impacts to aquatic resources. In some cases the original purpose for the dam's construction may no longer be present (ex. provide mechanical power for grist mills). Cost benefit analysis of dams have been conducted by communities, environmental agencies and organizations across the U.S. and the results often show that the benefits of dam removal outweigh the benefits of continuing to maintain and operate the dam.

In general some effects of channel modification activities and dams include:

- Changes in sediment supply
- Accelerated delivery of pollutants
- Floodplains disconnected from their streams
- Loss of in-stream and riparian habitats
- Impede or block fish migration routes
- Alter water temperature and chemistry

2.5.2.1 *Channelization & Channel Modification*

Throughout much of the watershed, streams have been modified or ditches excavated to enhance surface and subsurface drainage. These modifications generally involved lowering of the streambed or excavating channels through wetland sloughs to provide freeboard for subsurface drainage systems and enlargement of channels to increase downstream conveyance capacity.

As a general observation, areas that could be effectively drained by ditching to support cultivated crops when the area was being settled were. However, the true extent of past channelization and channel modification activities within the watershed is currently unknown. The most readily available data that provides at least some insight to the prevalence of ditching comes from county GIS data showing waterways maintained as "regulated drains" (Figure 23). However, it must be pointed out that more ditches exist beyond what is shown in this figure. Aerial imagery clearly shows waterways that were either channelized or excavated to improve drainage beyond reaches maintained as regulated drains. That being said, there are approximately 112 miles of regulated drain within the watershed. This alone equates to nearly 40% of the stream miles in the watershed.

Deep River and portions of Turkey Creek and Duck Creek near Deep River, appear to have avoided this outcome because of their location in floodplain valleys. These floodplain valleys are evident when viewing a hillshade representation of elevation data in GIS. Also streams within the eastern half of the Deer Creek subwatershed (HUC 040400010504) do not appear to have been altered to the extent of other streams in the watershed most likely due to greater topographic relief and subsequent soil conditions in this area.

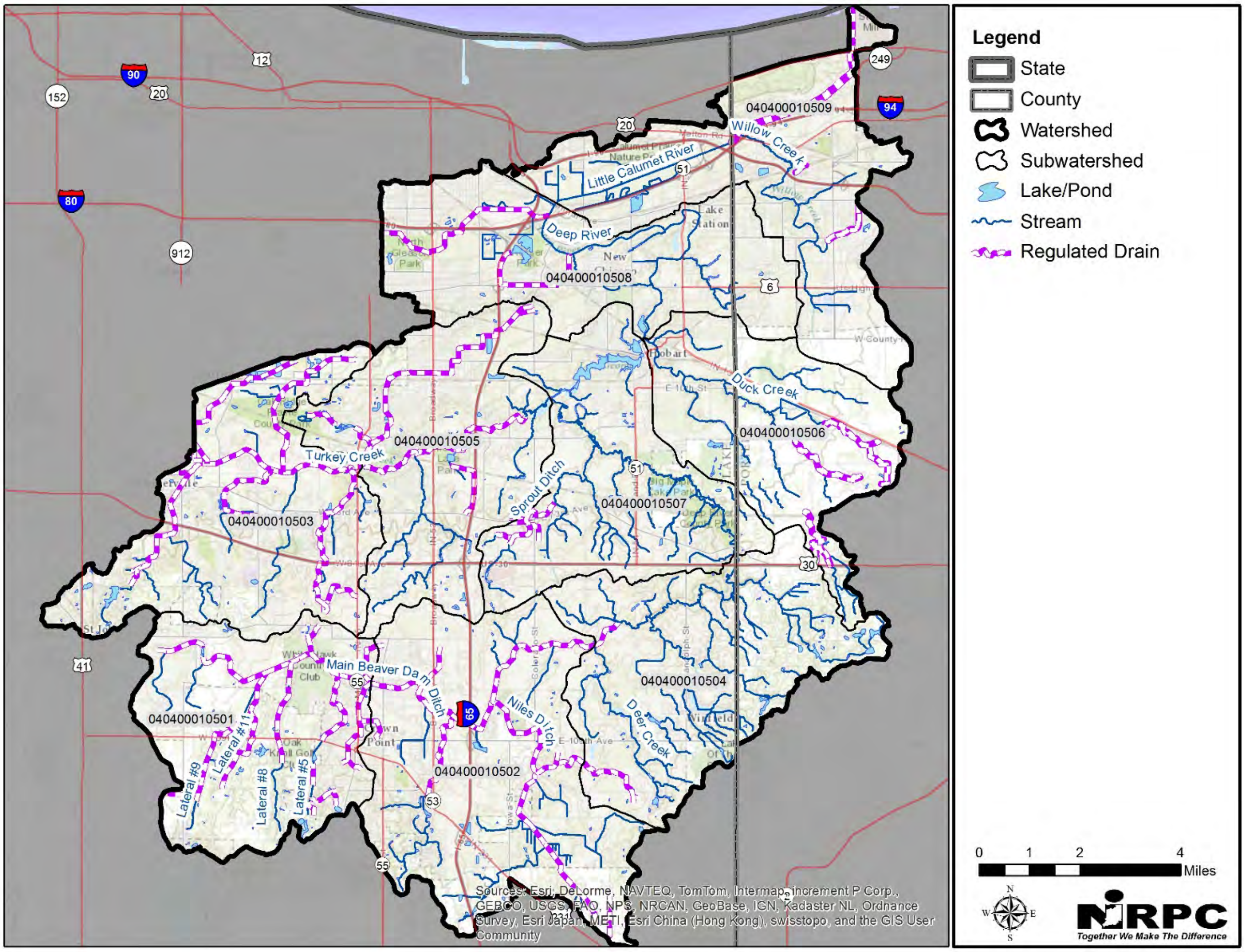


Figure 23 County Regulated Drains

Regulated Drains

A regulated drain (a.k.a. legal drain) is an open channel or closed tile/sewer that is subject to the provisions of the Indiana drainage code, I.C.-36-9-27. Under this code, a drainage board has the authority to construct, maintain, reconstruct or vacate a regulated drain. The board can maintain the regulated drain by dredging, clearing, tile repair, obstruction removal, erosional control or other work necessary to keep the drain in proper working order based on its original specifications.

2.5.2.2 *Dams*

Dams are another common type of hydromodification found within the watershed. Many dams in the region were built to either store and provide water for mechanical power generation (e.g., waterwheels to mill grain) or provide recreational opportunities (e.g., boating and fishing). However, dams can also be associated with a number of negative impacts including changes to hydrology, water quality, habitat, and river morphology. Additionally, human activities, such as agricultural and urban land uses, can contribute to contaminant and sediment loads to the impoundments created by these dams.

There are a total of 7 dams located within the watershed (Figure 17). General location, drainage area, associated lake surface area, and storage information is included in Table 14. Lakes with large drainage areas and small surface areas, such as Lake George, tend to be prone to nonpoint source pollution impacts.

Name	State ID	County	Drainage Area (mi^2)	Drainage Area (ac.)	Lake Surface Area (ac.)	DA:LSA	Max Storage (ac.-ft.)	Height (ft.)
Doubletree Lake Estates Dam (North)	45-11	Lake	1	640	90	7:1	NA	NA
Doubletree Lake Estates Dam (West)	45-12	Lake	NA	NA	90	NA	270	6
Deep River Dam (Lake Station)	45-1	Lake	141	89,600	NA	NA	0	14
Hooseline & Molchan Lake Dam	45-10	Lake	0.65	416	14	30:1	147	21
Lake George Dam	45-2	Lake	124	79,360	242	328:1	3,450	22
Lake Hills Dam	45-14	Lake	1.33	851	34	25:1	NA	12
Norman Olson Lake Dam	64-6	Porter	0.23	147	14	11:1	172	18

Table 14 Dams

In 1995 the U.S. Army Corps of Engineers (USACE), Chicago District, published a report investigating the feasibility of dredging Lake George. Lake George was created by the damming of Deep River sometime around 1840. The USACE concluded in the study that Lake George had "trapped large quantities of fine sediment from upstream agricultural areas, reducing water depths, making the lake bottom softer and the water murkier." Additionally, the report noted that "lake residents are not happy with these conditions, as they interfere with boating, swimming, fishing and clarity of the lake". More than 590,000 cubic yards of sediment were dredged from Lake George by 2000 at a cost of more than $2 million. The City of Hobart is once again considering dredging portions of Lake George because of sediment build up.

Another dam of particular interest in the watershed is the Deep River Dam (State ID # 45-1). It is located in Lake Station approximately 1/3 mile downstream from where Deep River joins the West Branch of the Little Calumet River (Figure 25) and is shown in Figure 24. The dam structure consists of a sheet pile wall crossing the channel with remnants of a rock-filled wooden crib structure. Crushed rock has been placed immediately downstream of the sheet pile wall in an effort to stabilize the channel and prevent erosion. The dam impounds approximately 10 feet of hydraulic head during normal river stage conditions. According to the Deep River Flood Risk Management Plan (Section 2.7.14), the dam controls the normal water level of Deep River up to 37th Avenue, a distance of nearly 6 miles. Due to the deteriorated physical nature of the dam, if a complete failure were to occur, it would likely be due to washout at the abutment ends or seep through the sheet pile wall.

Figure 24 Deep River Dam

Sometime around 2006, the Wildlife Habitat Council (WHC) approached the Gary Community School Corporation to discuss potential habitat restoration at the Deep River Outdoor Education Center whose property is adjacent to the dam. One of the potential restoration activities identified was dam removal. In 2009 several key stakeholder groups including staff from the Deep River Outdoor Education Center, the WHC, USACE, USFWS, DNR, and Shirley Heinze Land Trust met onsite to discuss this possibility further.

In 2013 the U.S. Army Corps of Engineers completed a Federal Interest Determination study to provide initial insight of the restoration of Deep River and adjacent riparian zone at this site. The study states that the existing structure inhibits fluvial functions that would support riverine fish species and other organisms and also physically prevents fish from migrating to upstream reaches. Upstream of the dam, Deep River resembles more of a lake system, devoid of critical fluvial hydraulics that support riverine specific organisms. The dam also prevents the downstream transport of fluvial materials such as silt, sand, gravel and cobbles, which is causing the stream to incise below the dam. This channel incision causes the resulting steep banks to fall or cave in, which has prompted the placement of broken concrete blocks or chunks to act as rip-rap in an attempt to armor the banks against further slumping. This technique, however, does not work for channel incision and is destined to fail.

Based on the results of the Federal Interest Determination study, the U.S. Army Corps of Engineers found that a viable and implementable restoration plan could be developed. The next steps with Section 506- Great Lakes Fishery and Ecosystem Restoration funding would include the development of a Project Management Plan, the initiation of a Detailed Project Report and a Feasibility Cost Sharing Agreement at a cost of approximately $150k. However, to date, there is a shortfall in local match ($60-87k) to proceed further.

The Indiana Department of Environmental Management monitored upstream and downstream (Sites 5 & 6) of the dam as part of the watershed baseline assessment and TMDL study as documented in Section 3.3. The strategy behind this was to: 1) help identify what potential water quality and aquatic life impacts the dam was having on this reach of Deep River; and 2) evaluate the impacts of any future restoration activity associated with the dams modification or removal.

The City of Lake Station has shown interest in acquiring the former Riverside Mobile Home Park parcel which is located on the opposite streambank of the Education Center. The trailer park had flooded several times in recent years including the severe September 2008 flood. The trailers have been since been removed, however a large amount of debris still remains. A significant opportunity exists to restore hydrology, habitat, and fish migration within this reach of Deep River by removing the dam.

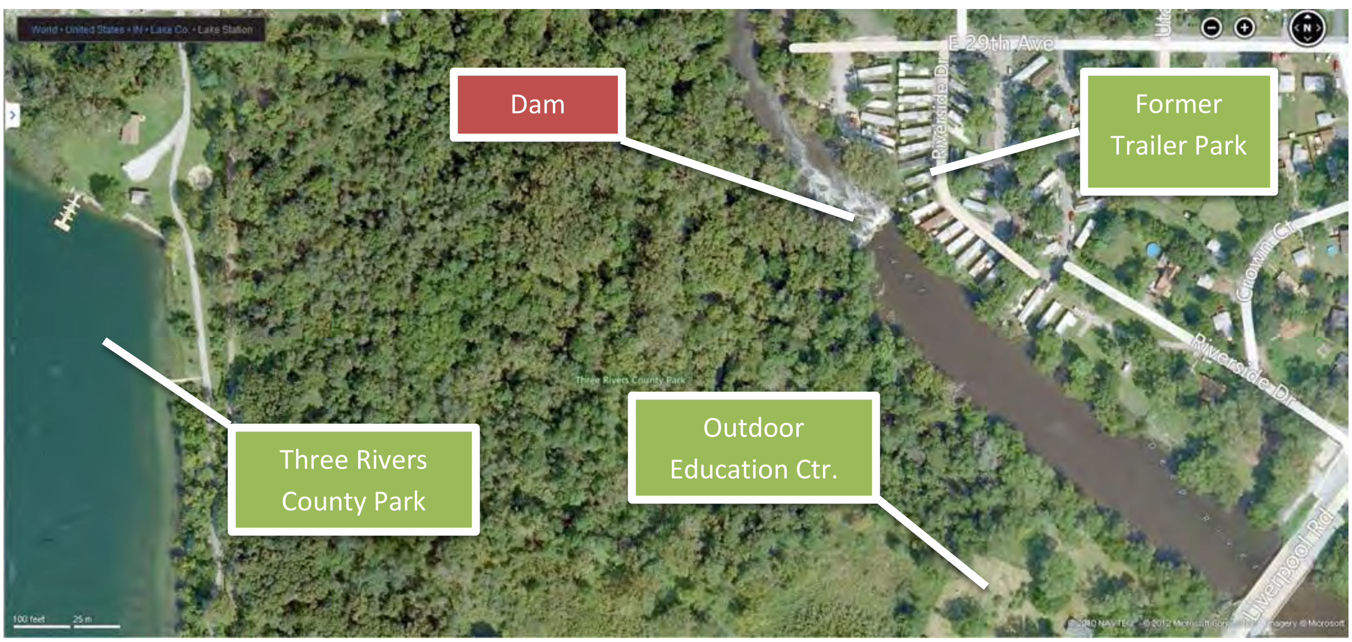


Figure 25 Hobart Deep River Dam Location

2.5.2.3 *Levees*

The Little Calumet River Basin Development Commission was created in 1980 by the Indiana General Assembly to serve as the required local sponsor for the Little Calumet River, Indiana Flood Control and Recreation Project. The Federal project, which was authorized for construction in the 1986 Water

Resources Development Act, is designed to provide structural flood protection up to the 200-year return frequency along the main channel of the Little Calumet River from the Illinois State Line to Martin Luther King Drive in Gary, Indiana.

The flood control project features include:

- Construction of over 9.7 miles of set-back levees in Gary and Griffith.
- Construction of 12.2 miles of levees and floodwalls in Hammond, Highland, and Munster.
- Installation of a flow diversion structure at the Hart Ditch confluence in Hammond/Munster.
- Modification of four major highway bridges along the river corridor to permit better flow.
- Creation of 16.8 miles of hiking/biking trails connecting recreational developments.

The levees end upstream of the confluence of Deep River and the West Branch Little Calumet River. During high flow conditions the diversion structure located immediately west of Hart Ditch on the Little Calumet River redirects water eastward towards the Burn Waterway and out to Lake Michigan.

2.5.2.4 *Tile Drainage*

Tile drainage (subsurface drainage) is a common practice for row crop production on agricultural lands where poorly drained soils exist. Many agricultural drainage systems include drain tiles placed strategically throughout a field to create a network of gravity fed drains. The drain tiles empty into a collection pipe that drains to a nearby waterbody. With the drain system in place and operating, water will leave the affected area quicker and at one or more focused points. Water from the drainage system can increase streambank erosion, contribute to stream flashiness, and increase the nutrient, sediment, and pesticide pollutant loading.

The exact location and extent of tile drainage in the watershed is unknown which is not all that uncommon. Purdue University Hydrologic Impacts Group has used a combination of agricultural land cover, soils drainage class, and soil slope data to identify potentially tile drained areas (www.agry.purdue.edu/hydrology/projects/indiana.asp). The same approach was used to identify potentially tile drained areas for the Deep River-Portage Burns Waterway watershed. See Section 2.10.5 for further discussion about cultivated land on poorly drained soils.

2.5.3 Water-Based Recreational Opportunities

The lakes and streams of the watershed provide many recreational opportunities including boating, fishing, swimming and nature watching for residents and visitors alike. A review of recreational facility information maintained by the DNR shows approximately 30 facilities have a lake, pond or stream on site. These facilities include parks, fish & wildlife areas, nature preserves, marinas, and golf courses.

A few of the popular public access sites/areas in the watershed include Deep River and Oak Ridge Prairie County Parks, Fred Rose and Jerry Pavese Park located on Lake George in Hobart, Riverview Park located on Deep River in Lake Station, and Portage Lakefront and Riverwalk located along Burns Waterway and Lake Michigan. Portage Lakefront and Riverwalk is a former brownfield reclamation site owned by the Indiana Dunes National Lakeshore and operated by the City of Portage.

In addition to these facilities, there is a growing effort to establish a water trail along Deep River from Lake George to Lake Michigan which would greatly expand water-based recreational opportunities within the watershed. The City of Hobart is currently installing a launch ramp for canoes and kayaks on Lake George and below the Lake George dam on Deep River.

Site ID	Site	Owner
1	Lake County Fairgrounds	Lake County Board of Commissioners
2	Beaver Dam Wetland Conservation Area	IDNR Division of Fish & Wildlife
3	Three Rivers County Park	Lake County Parks Department
4	Oak Ridge Prairie County Park	Lake County Parks Department
5	Griffith Izaak Walton League	Izaak Walton League
6	Gone Fishing Private Fishing Lake	Private
7	Deep River County Park	Lake County Parks Department
8	John Robinson Lake Park	Hobart Parks Department
9	Hobart Marsh	IDNR Division of Nature Preserves
10	Lakeshore Park	Hobart Parks Department
11	Jerry Pavese Park	Hobart Parks Department
12	Festival Park & Lakefront Park	Hobart Parks Department
13	Riverfront Park	Hobart Parks Department
14	Rosser Park	Hobart Township Trustee
15	Johnson Park	Lake Station Parks Department
16	Riverview Park	Lake Station Parks Department
17	Independence Park/Bicentennial Park	Lake Station Parks Department
18	Grand Boulevard Lake Recreation Area	Lake Station Parks Department
19	Broadmoor Country Club	Private
20	Independence Park	Ross Township Trustee
21	Innsbrook Country Club	Private
22	Hidden Lake Park	Ross Township Trustee
23	Turkey Creek Golf Course	Lake County Parks Department
24	Twin Oaks Park	New Chicago Parks Board
25	Lefty's Coho Landing	Private
26	Countryside Park	Portage Parks Board
27	Arthur H. Olson Memorial Park	Portage Parks Board
28	Yogi Bear Jellystone Campground	Private
29	Louis Estates Park	St. John Park Board
30	Lake Hills Park	St. John Park Board

Table 15 Recreational facilities with access to water

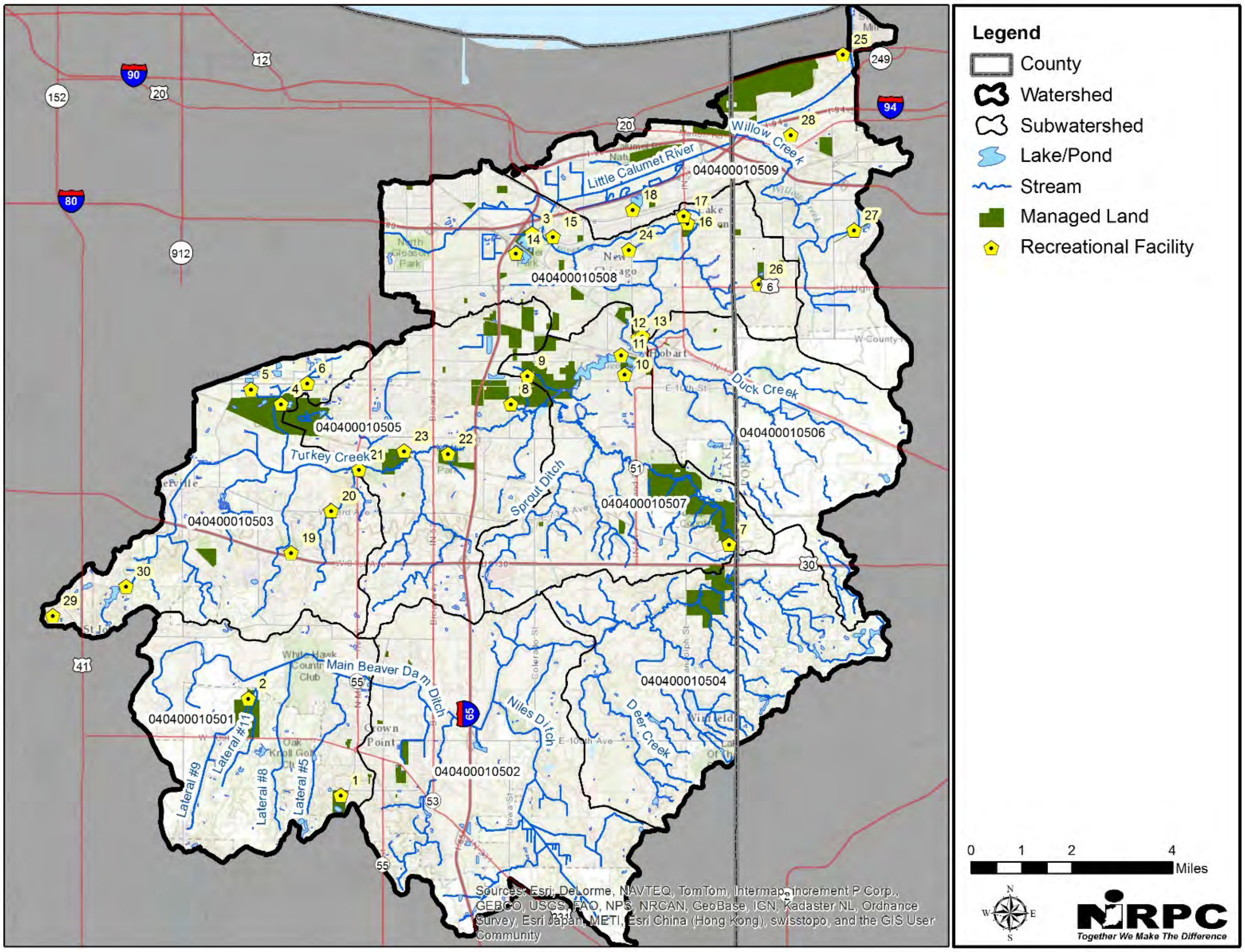


Figure 26 Recreational facilities with access to water

2.5.4 Impaired Waterbodies

The Indiana Department of Environmental Management (IDEM) prepares the 303d List of Impaired Waters on a biannual basis. The 303d list identifies where water quality problems exist and the nature of those impairments. The primary purpose of the 303d List, in accordance with the Clean Water Act, is to identify impairments for which a Total Maximum Daily Load (TMDL) study is needed. A TMDL identifies the maximum amount of pollutant that a waterbody can receive and still meet state water quality standards, and allocates pollutant loadings among point and nonpoint sources. A TMDL also provides information that can be used to guide restoration activities in the watershed aimed at mitigating the impairment(s). Once a TMDL has been completed for the impairment(s), the waterbody may be removed from the 303d list and placed under Category 4 on the consolidated list. Being placed under Category 4 in this case simply means that the waterbody is still impaired or threatened but a TMDL has been completed. An E. coli and Impaired Biotic Communities TMDL was approved for the watershed on September 26, 2014. See Section 2.7.1 for further information on the TMDL.

There are 30 stream segments within our watershed that will be included by IDEM on the draft 2016 303d List under Category 4A. The types and locations of these impairments are presented in Figure 27 and Table

16. The impairments identified include high *E. coli* levels, low dissolved oxygen (DO) concentrations, high levels of nutrients and siltation, and impaired biotic communities (IBC).

Approximately 210 miles of stream will be listed for *E. coli*, 97 miles for dissolved oxygen, 61 miles for nutrients, 12 miles for siltation and 225 miles for impaired biotic communities. Thirty four miles of stream are listed for PCB's in fish tissue. Approximately 223 miles of stream are listed for multiple impairments (example Willow Creek- *E. coli* and IBC). The most common impairment by far is for biotic communities.

Biological impairments differ from some traditional water quality impairments, such as *E. coli*, in that the impaired biotic communities (fish and macroinvertebrates) are indicators of disturbance rather than causes of disturbance. The composition of aquatic communities found in streams and rivers is determined by the interaction of numerous physical, chemical, and biological processes. As a result, biological impairments can be driven by natural or unnatural changes to one or many components of these systems. Biological impairments are commonly caused by stressors that are sometimes not considered conventional pollutants within our water quality rules (ex. altered flow regimes).

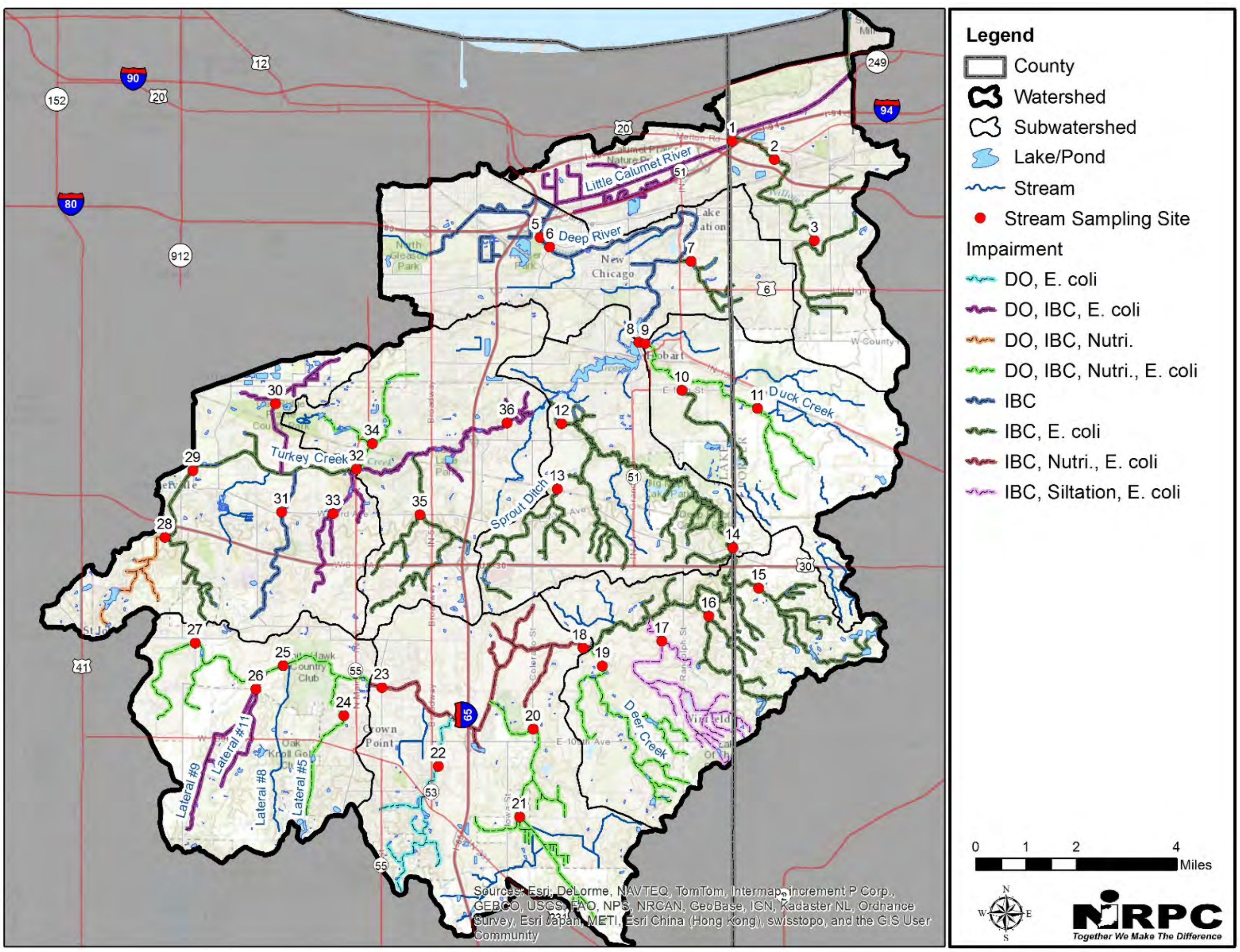


Figure 27 Impaired Waterbodies

Subwatershed (12-digit HUC)	AUID	2012Section 303(d) Listed Impairment	Updated Impairments to be Listed on 4A in 2016
Headwaters of Main Beaver Dam Ditch (040400010501)	INC0151_01	IBC	DO, *E. coli,* Nutrients, IBC
	INC0151_T1001		DO, *E. coli,* IBC
	INC0151_T1003		DO, *E. coli,* Nutrients, IBC
Main Beaver Dam Ditch (040400010502)	INC0152_04	IBC	*E. coli,* Nutrients, IBC
	INC0152_T1008		DO, *E. coli,*
	INC0152_T1009	IBC	DO, *E. coli,* Nutrients, IBC
Headwaters of Turkey Creek (040400010503)	INC0153_01	IBC, *E.coli*	IBC, *E.coli*
	INC0153_T1001		DO, IBC, Nutrients
	INC0153_T1003		DO, *E. coli,* IBC
	INC0153_T1004		IBC
	INC0153_T1005		DO, *E. coli,* IBC
Deer Creek (040400010504)	INC0154_01	IBC, *E.coli*	IBC, *E.coli*
	INC0154_T1001	*E.coli*	DO, *E. coli,* Nutrients, IBC
	INC0154_T1003	IBC, Siltation	IBC, *E.coli,* Siltation
	INC0154_T1004		IBC, *E.coli*
	INC0154_T1005		IBC, *E.coli*
City of Merrillville (040400010505)	INC0155_01	*E.coli*	DO, IBC, *E.coli*
	INC0155_T1002		IBC, *E.coli*
	INC0155_T1003		DO, *E. coli,* Nutrients, IBC
Duck Creek (040400010506)	INC0156_01		DO, *E. coli,* Nutrients, IBC
	INC0156_T1003		IBC, *E.coli*
Lake George (040400010507)	INC0157_01		IBC, *E.coli*
	INC0157_P1001		IBC, DO, *E.coli*
	INC0157_T1002		IBC, *E.coli*
Little Calumet River (040400010508)	INC0158_01	IBC, cyanide	IBC
	INC0158_T1002		IBC, *E.coli*
	INC0158_T1005	IBC, PCB Fish	IBC
Willow Creek (040400010509)	INC0159_01	DO, PCB Fish	DO, IBC, *E.coli*
	INC0159_02	IBC, *E.coli,* PCB Fish	IBC, *E.coli*
	INC0159_T1001	IBC, *E.coli,* PCB Fish	IBC, *E.coli*

Table 16 Impaired Waterbodies

2.6 Land Cover & Land Use

Land cover and land use within a watershed can have a profound impact on both water quality and habitat. Natural land cover types such as forest, wetland, and grassland help protect water quality and aquatic habitats by filtering pollutants from runoff, maintaining hydrologic functions, and supporting fish and wildlife needs. Alteration of natural land cover for human use almost inevitably leads to increased runoff which can carry associated pollutants to nearby waterbodies. The pollutants generated are dependent on the land uses within the given drainage area. Some of the common pollutants generated in urbanized areas include excess nutrients, sediment, metals, pathogens, and toxins. In agricultural areas common pollutants can include excess nutrients, sediment, pathogens, herbicides and pesticides. For this reason having an understanding of what land uses are present in a watershed can help determine what factors may be contributing to water quality problems and potential sources.

Stakeholder Concerns Related to Land Use:

- **Riparian area and floodplain encroachment**
- **Habitat loss to development**
- **Coordination amongst municipalities, businesses, and residents**
- **Development standards protective of watershed**
- **Uncontrolled development in unincorporated areas**
- **Enforcement of existing regulations to protect stream health**
- **Lack of retention/ detention pond maintenance**
- **Reconciling need for drainage/ flood control with water quality and habitat**
- **Storm water storage**
- **Ability of watershed to clean water by removing pollutants and provide habitat (green infrastructure)**
- **Impervious surface area**
- **Construction site runoff**
- **Parking lot runoff**
- **Combined sewer overflows (CSOs)**
- **Failing septic systems**
- **Erosion and sedimentation**
- **Excess nutrients**
- **Chemicals in runoff**
- **Loss of cropland to development**
- **Some absentee landowners seem to be land speculators and lack interest in investing in BMPs to protect water quality**
- **Reconciling need for drainage with water quality and habitat**
- **Soil health**

What is the difference between land cover and land use?

Land cover refers to the surface cover on the ground (ex. natural vegetation, agricultural crops, impervious surface, or waterbodies). Land use shows how people use the landscape (ex. agricultural, residential, commercial, or recreational).

2.6.1 Land Cover

A review of the most recent land cover data available (2010) shows that developed land is the most prominent land cover type within our watershed followed by agriculture (Figure 28, Figure 29 and Table 17). However, distinct differences in land cover can be observed at the subwatershed scale. Subwatersheds located in the southeastern portion of the watershed including Main Beaver Dam Ditch-Deep River (HUC 040400010502), Deer Creek-Deep River (HUC 040400010504), and Duck Creek (HUC 040400010506) are predominately agricultural (46-51% by land area). The Headwaters Main Beaver Dam Ditch (HUC 040400010501), Headwaters Turkey Creek (HUC 040400010503), City of Merrillville-Turkey Creek (HUC040400010505), Little Calumet River-Deep River (HUC 040400010508), and Willow Creek- Burns Ditch (HUC 040400010509) subwatersheds are predominately developed (44-71% by land area). The remaining subwatersheds is more balanced in the percent distribution of agricultural and developed land uses.

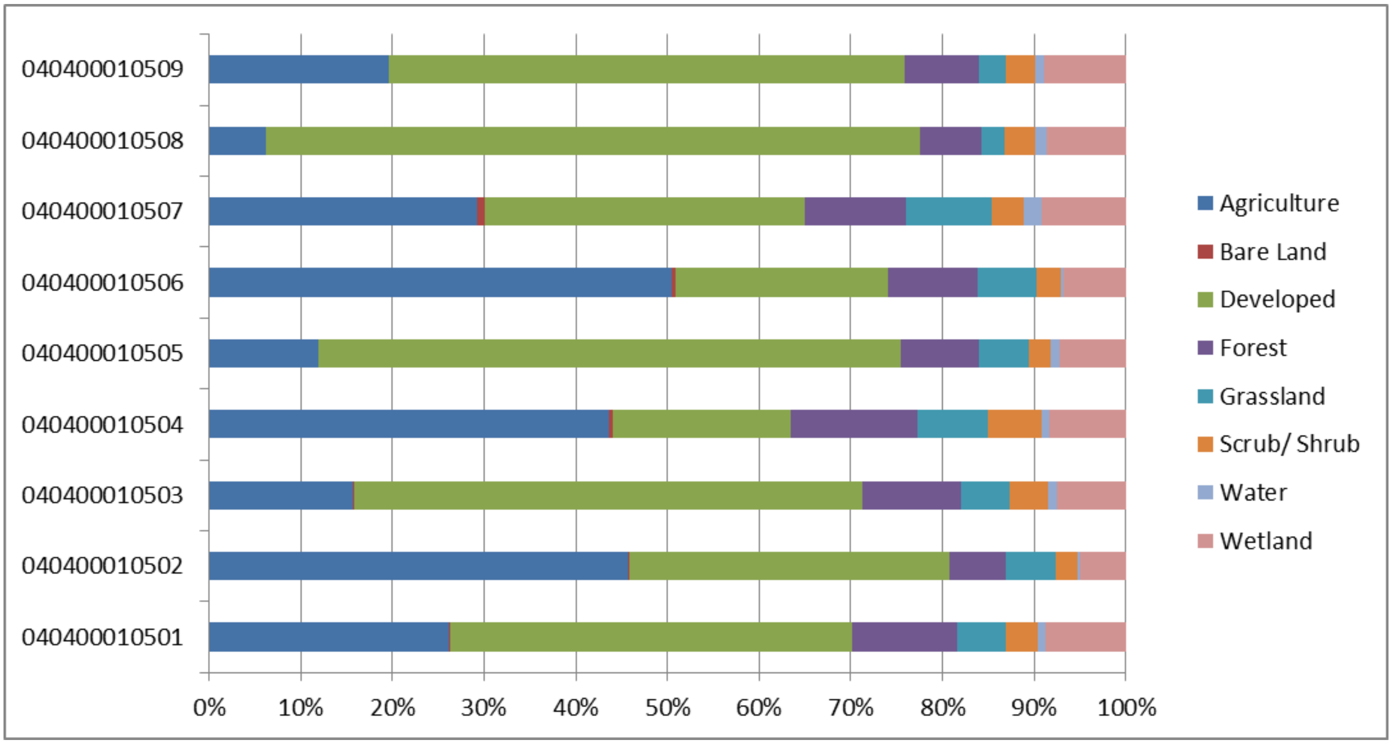


Figure 28 Land cover by subwatershed

Natural land cover (forest, grassland, scrub/shrub, water and wetland) accounts for 27% of the watershed's land area. The Deer Creek-Deep River (HUC 040400010504) subwatershed has the highest percentage of natural land cover in the watershed at 37%. Forestland covers approximately 9% of the watershed with subwatershed coverage ranging between 7-14%. Grassland covers 6% of the watershed with subwatershed coverage ranging from 5-9%. Wetland covers 8% of the watershed with subwatershed coverage ranging from 5-9%.

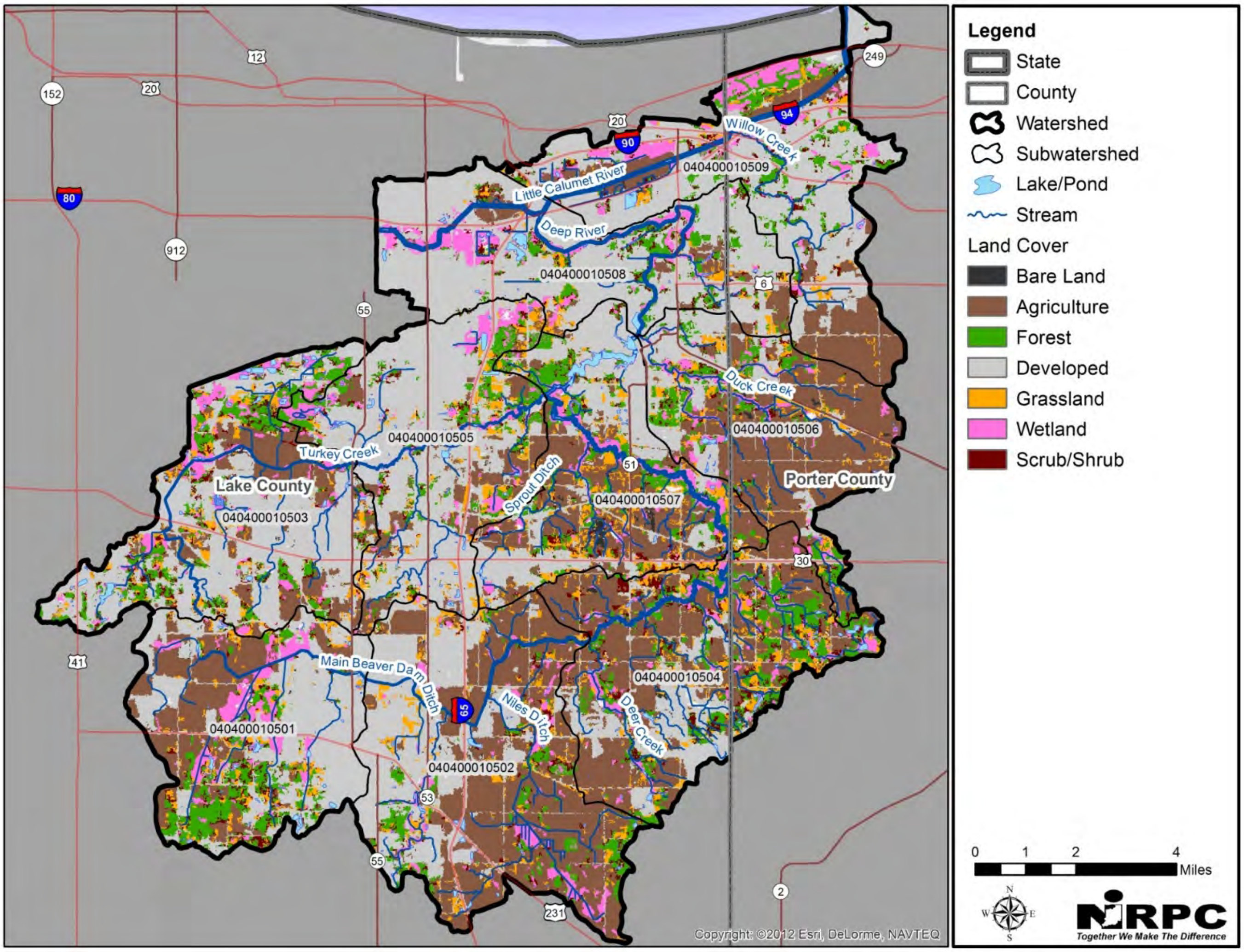


Figure 29 Land Cover (2010)

Name	HUC-12	Agriculture (ac.)	%	Bare Land (ac.)	%	Developed (ac.)	%	Forest (ac.)	%	Grassland (ac.)	%	Scrub/ Shrub (ac.)	%	Water (ac.)	%	Wetland (ac.)	%
Headwaters Main Beaver Dam Ditch	040400010501	3,072	26	17	0	5,131	44	1,336	11	617	5	415	4	88	1	1,034	9
Main Beaver Dam Ditch-Deep River	040400010502	7,690	46	19	0	5,874	35	1,038	6	916	5	390	2	57	0	837	5
Headwaters Turkey Creek	040400010503	2,133	16	19	0	7,545	55	1,445	11	728	5	568	4	127	1	1,031	8
Deer Creek-Deep River	040400010504	5,994	44	53	0	2,675	19	1,891	14	1,060	8	807	6	124	1	1,141	8
City of Merrillville-Turkey Creek	040400010505	1,485	12	11	0	7,924	63	1,063	9	693	6	285	2	125	1	905	7
Duck Creek	040400010506	5,121	51	35	0	2,344	23	995	10	653	6	262	3	32	0	693	7
Lake George-Deep River	040400010507	3,235	29	103	1	3,859	35	1,223	11	1,047	9	377	3	223	2	1,015	9
Little Calumet River-Deep River	040400010508	750	6	4	0	8,664	71	812	7	308	3	406	3	152	1	1,055	9
Willow Creek-Burns Ditch	040400010509	2,619	20	10	0	7,538	56	1,087	8	388	3	441	3	129	1	1,188	9
Watershed Total		32,100	28	270	0	51,555	45	10,891	9	6,411	6	3,950	3	1,058	1	8,899	8

Table 17 Land cover summary data

2.6.2 Land Use

A review of 2008 land use data compiled by the Northwestern Indiana Regional Planning Commission shows that residential and agricultural land uses are the most common within the watershed. Residential land use accounts for approximately 45% of the total land area while agricultural accounts for approximately 24%. The next most common land uses are park/open space (16%) and commercial/office (6%).

Land Use	Acres	%
Agricultural	25,914	24
Commercial/Office	6,230	6
Industrial	4,885	5
Institutional	1,776	2
Mixed Used	178	<1
Park/Open Space	16,480	16
Residential	47,179	45
Unknown	1,683	2
Vacant	909	1

Table 18 Land use summary data

Figure 30 shows the various land uses throughout the watershed. We can see from the figure that the U.S. Highway 30 and Broadway corridors have the highest concentration of commercial/office land use in the watershed. Smaller pockets of commercial/office can be seen along other primary roads and highways. Industrial areas (both light and heavy) area also readily apparent in the figure. The "unknown" land uses shown near Niles Ditch in the southern portion of the watershed generally appear to correspond with agricultural uses that include a dairy operation and equestrian facilities.

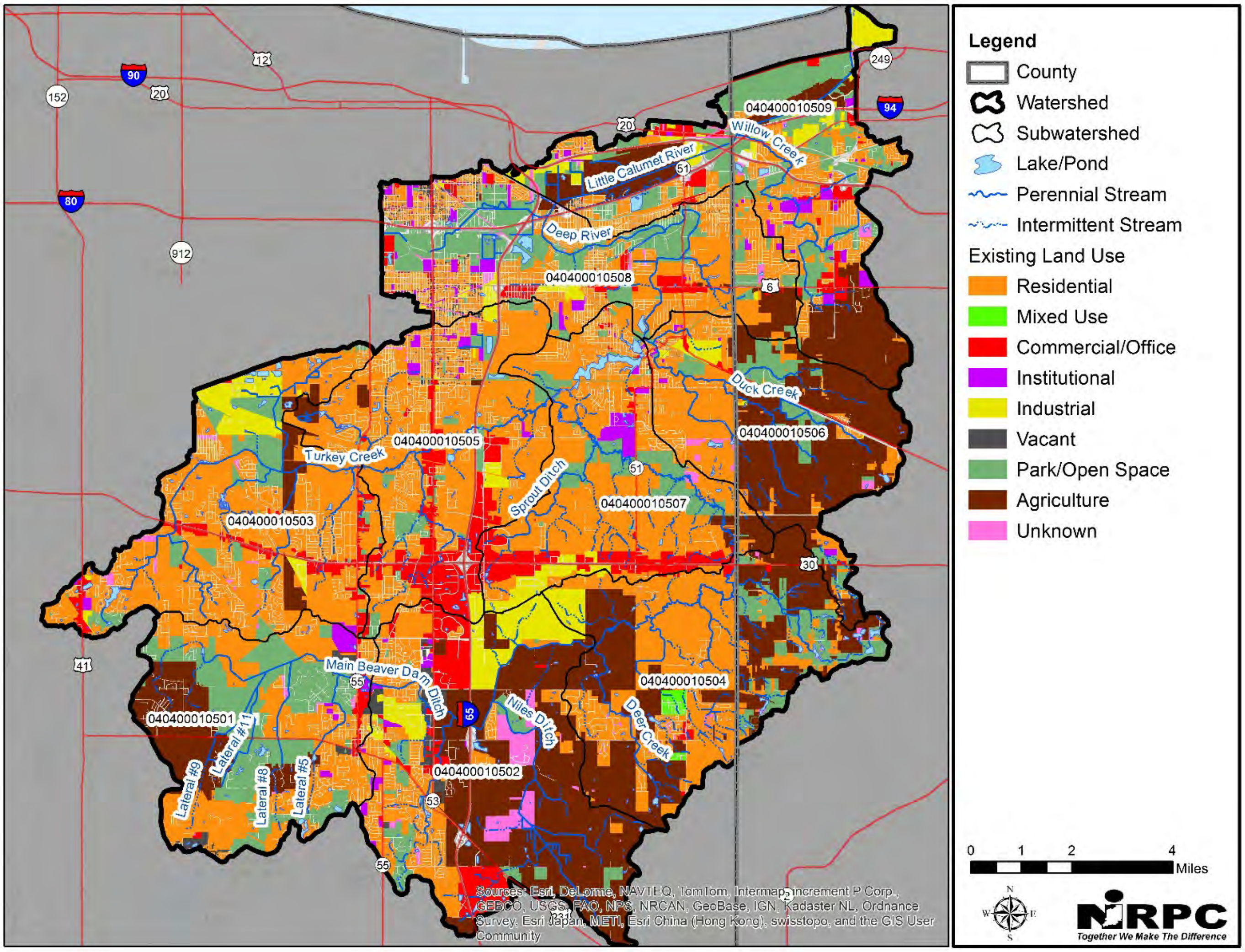


Figure 30 Existing land use

2.6.3 Agricultural Lands

Agriculture remains a prominent land use within portions of the watershed. In 2010, approximately 32,100 acres (28%) of land was devoted to agricultural production. Cultivated land accounted for 81% of agricultural use with corn and soybeans being the predominant crops. Pasture/hay accounted for the remaining 19%. The percentage of agricultural land cover for each subwatershed is presented in Table 17.

A number of the stakeholder concerns associated with agriculture are related to soil health on cultivated lands. Assessing overall soil health for our watershed is difficult because it is site (field) specific. However, we can approximate to what extent some of the conservation practices that promote soil health, as identified by the Conservation Cropping Systems Initiative, are being used.

- Continuous no-till/ strip-till
- Cover crops
- Precision farming
- Nutrient and pesticide management

2.6.3.1 *Cropland Conservation Tillage Practices*

In cultivated areas, tillage practices can have a major effect on water quality. Conventional tillage leaves the soil surface bare and loosens soils particles making them susceptible to wind and water erosion. Conservation tillage reduces erosion by leaving at least 30% of the soil surface covered with crop residue after planting. Residues protect the soil surface from the impact of raindrops and act like a dam to slow water movement. Rainfall stays in the crop field allowing the soil to absorb it. With conservation tillage less soil and water leave a field.

Tillage System Definitions

- “No-till” - any direct seeding system, including site preparation, with minimal soil disturbance.
- “Mulch-till” - any tillage system leaving 30% - 75% residue cover after planting, excluding no-till.
- “Reduced-till” - any tillage system leaving 16% - 30% residue cover after planting.
- “Conventional-till” - any tillage system leaving less than 15% residue cover after planting
- “Conservation Tillage” - any system that leaves at least 30% residue cover after planting is considered to be conservation tillage.

While no watershed scale data currently exists for conservation tillage practice use, countywide data is available from the Indiana State Department of Agriculture. Cropland tillage data for 2004-2013 is displayed in Figure 31. The data shows that the use of conservation tillage practices is much more common with soybeans than corn.

Figure 31 Conservation Tillage Data

2.6.3.2 *Confined Feeding Operation Facilities*

Indiana's Confined Feeding Control Law (IC-13-18-10) defines a confined feeding operation (CFO) as any animal feeding operation engaged in the confined feeding of at least 300 cattle, or 500 horses, or 600 swine or sheep, or 30,000 poultry. A concentrated animal feeding operation (CAFO) is a larger scale confined feeding operation. Approval must be received from IDEM before starting construction of a CFO, or expanding to increase animal population or manure storage capacity.

As of July 1, 2012, the Confined Feeding Program has two types of approvals:

1. CFOs or CAFO-sized CFOs that do not discharge manure or pollutant-bearing water need a CFO Approval under 327 IAC 19 [PDF]. There are slightly different requirements for a CFO versus a CAFO.
2. CFOs and CAFO-sized CFOs that discharge manure or pollutant-bearing water to waters of the state must have a NPDES CAFO Individual Permit under 327 IAC 15-16 [PDF]. The CAFO rule incorporates by reference the federal NPDES CAFO regulations.

The purpose of the confined feeding program is to help producers construct and operate CFOs in a manner that protects human health and the environment. The main environmental and public health concern with CFOs is manure and pollutant-bearing water contaminating surface and ground water resources. The program has three main areas of focus to protect these resources:

1. Design, construction, and capacity requirements for confinement buildings, manure storage structures, and other waste management structures.
2. Operation and maintenance requirements including self-inspections, record keeping, and spill response.
3. Land application requirements including setbacks, application at agronomic rates, and avoiding weather conditions that could lead to contaminated runoff.

A review of CFO facility data showed one facility located in the Main Beaver Dam Ditch-Deep River subwatershed. IDEM records indicate that the facility houses dairy cattle and that manure is managed in an earthen waste treatment lagoon system and dry manure storage shed. Land application of waste is periodically applied to 200 acres of cropland. In May of 2011 the facility was granted a "Request for Approval Voidance" by IDEM since they no longer operated as a CFO having less than 300 cattle. The facility is still required to meet spill rule requirements and therefore cannot discharge any manure.

2.6.3.3 *Agricultural Animals*

The table below presents the approximate types and numbers of agricultural animals located in the watershed and its subwatersheds. This data was obtained by querying the EPA's STEPL Data Server which used data gathered from the USDA 2007 Census of Agriculture. Animal wastes can be a potential source of nutrient and pathogen loading to adjacent waterbodies if appropriate pollution prevention practices are not implemented. Additionally unrestricted livestock access to streams can lead to streambank erosion and sedimentation.

Name	HUC-12	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck
Headwaters Main Beaver Dam Ditch	40400010501	19	50	0	5	36	12	0	12

Name	HUC-12	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck
Main Beaver Dam Ditch-Deep River	40400010502	27	72	0	8	54	20	0	14
Headwaters Turkey Creek	40400010503	22	57	0	8	44	15	0	13
Deer Creek-Deep River	40400010504	25	42	200	9	36	10	0	6
City of Merrillville-Turkey Creek	40400010505	21	53	0	8	39	13	0	12
Duck Creek	40400010506	29	20	324	13	25	9	0	2
Lake George-Deep River	40400010507	17	44	17	4	32	12	0	9
Little Calumet River-Deep River	40400010508	23	45	86	8	36	13	0	10
Willow Creek-Burns Ditch	40400010509	36	29	427	19	37	16	1	6
Watershed Total		219	412	1054	82	339	120	1	84

Table 19 Agricultural Animals

A desktop analysis was done using GIS land cover data and Google Maps aerial imagery and street views to identify the approximate number and location of livestock facilities. Indicators such as fencing, buildings, worn paths, absent vegetation, and potential watering areas were used in this process. In some cases the livestock were visible in the aerial image or a facility name indicative of an operation was shown in Google Maps. A point was placed in the general location of the facility as the confinement boundaries were too difficult to determine (Figure 32).

A total of 56 potential livestock facilities were identified through the desktop analysis. As a general observation many of the facilities appeared to be for equestrians. There was no clear evidence of unrestricted livestock access to streams using this process. However, 21 of these general locations did fall within 500 feet of a stream. The Lake George subwatershed had the greatest number of facilities followed by the Main Beaver Dam Ditch and Duck Creek subwatershed.

Name	HUC-12	Approximate # of Livestock Facilities
Headwaters Main Beaver Dam Ditch	40400010501	5
Main Beaver Dam Ditch-Deep River	40400010502	12
Headwaters Turkey Creek	40400010503	3
Deer Creek-Deep River	40400010504	9
City of Merrillville-Turkey Creek	40400010505	4
Duck Creek	40400010506	10
Lake George-Deep River	40400010507	13
Little Calumet River-Deep River	40400010508	0
Willow Creek-Burns Ditch	40400010509	0
Watershed Total		56

Table 20 Estimated number of livestock facilities by subwatershed

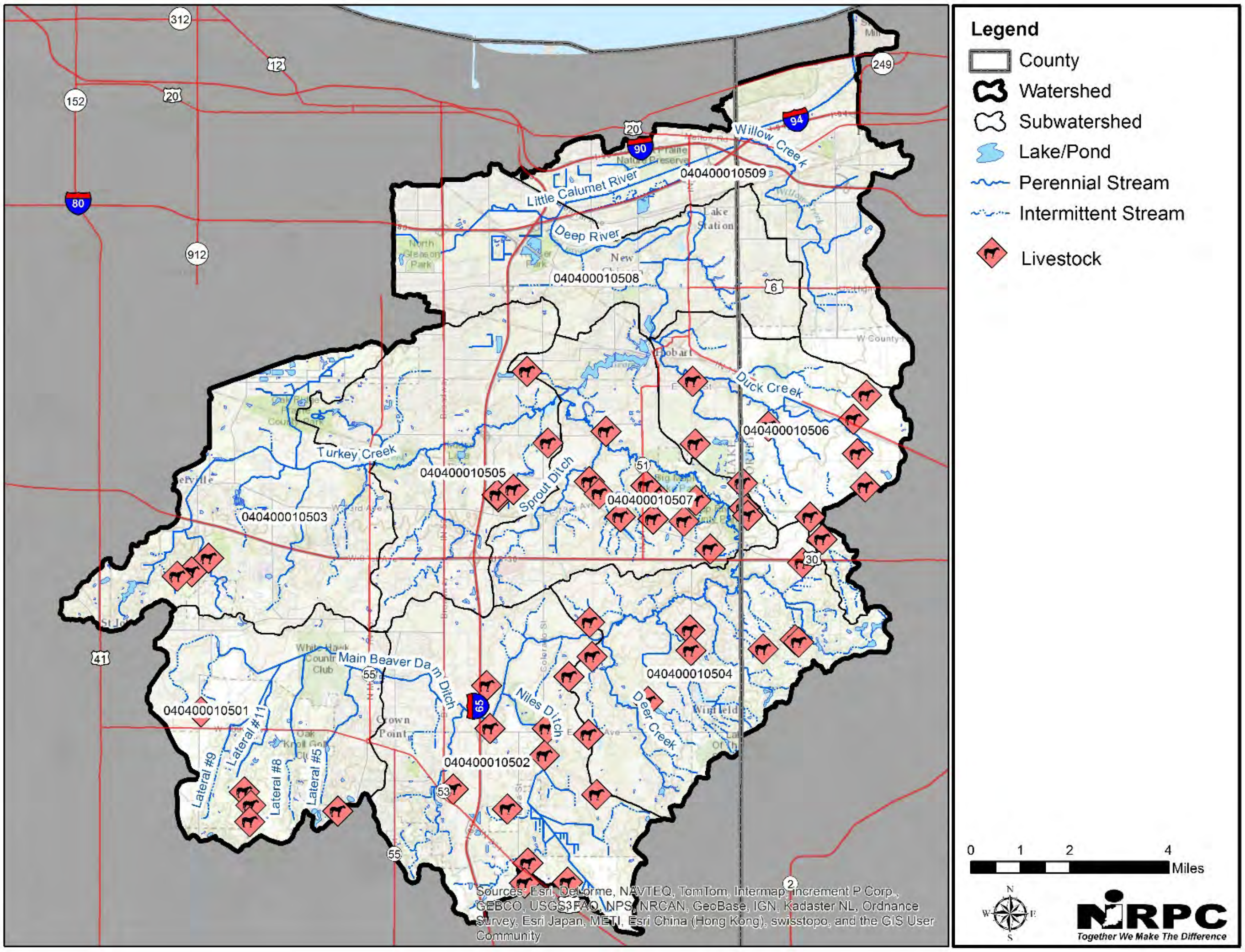


Figure 32 Livestock facilities

2.6.4 Developed Lands

In 2010, approximately 51,555 acres (45%) of land in the watershed was developed. This includes low, medium, high intensity development as well as developed open space. The percentage of developed land cover for each subwatershed is presented in Table 17.

Poor development practices and planning can have detrimental impacts to streams. The following table, adapted from the Ohio DNR Division of Soil & Water Resources, shows some of the impacts that can occur to stream hydrology, geomorphology, water quality, habitat and ecology.

Changes in Hydrology	Changes in Geomorphology
• increase in magnitude and frequency of severe floods • increased frequency of erosive bankfull floods • increase in annual volume of surface runoff • more rapid stream velocities • decrease in dry weather stream baseflow	• stream channel widening and down-cutting • increased streambank erosion • shifting bars of course-grained sediments • elimination of pool\riffle structure • imbedding of stream sediments

Changes in Water Quality	Changes in Aquatic & Terrestrial Habitat and Ecology
• sedimentation • nutrient enrichment • bacterial contamination during dry and wet weather • higher toxic levels, trace metals, and hydrocarbons • increased water temperatures • trash\debris jams	• shift from external to internal stream energy production • reduction in diversity of aquatic and terrestrial species • destruction of wetlands, riparian buffers, and springs

Table 21 Development Impacts on Streams

2.6.4.1 *Population Growth & Density*

Over the past 30 years development in the region of Northwest Indiana has been expanding southward. In the *2040 Comprehensive Regional Plan for Northwest Indiana*, NIRPC showed a decreasing trend in urban core community populations with populations shifting towards the suburbs and unincorporated areas to the south. Table 22 shows population change between 1980 and 2010 for the municipalities located within the watershed. Between 1980 and 2010 the population of Crown Point increased by nearly 11,000 people. Winfield's population increased from 0 to 4,383 over this same time period.

According to NIRPC, new housing units were built at a pace of more than double that of population growth in the region between 1990 and 2009. This means more land is being consumed for development than needed for housing with surplus housing being vacant. Population density based on 2010 census block data is displayed in Figure 33.

Community	Population				Change by Decade			% Change by Decade		
	1980	1990	2000	2010	1980-1990	1990-2000	2000-2010	1980-1990	1990-2000	2000-2010
Cedar Lake	8,754	8,885	9,279	11,560	131	394	2,281	0.015	0.044	0.246
Crown Point	16,455	17,728	19,806	27,317	1,273	2,078	7,511	0.077	0.117	0.379
Gary	151,953	116,646	102,746	80,294	-35,307	-13,900	-22452	-0.232	-0.119	-0.219
Griffith	17,026	17,914	17,334	16,893	888	-580	-441	0.052	-0.032	-0.025
Hobart	22,987	24,440	25,363	29,059	1,453	923	3,696	0.063	0.038	0.146
Lake Station	15,083	13,899	13,948	12,572	-1,184	49	-1,376	-0.078	0.004	-0.099
Merrillville	27,677	27,257	30,560	35,246	-420	3,303	4,686	-0.015	0.121	0.153
New Chicago	2,585	2,066	2,063	2,035	-519	-3	-28	-0.201	-0.001	-0.014
Ogden Dunes	1,489	1,499	1,313	1,110	10	-186	-203	0.007	-0.124	-0.155
Portage	27,409	29,060	33,496	36,828	1,651	4,436	3,332	0.060	0.153	0.099
Schererville	13,209	20,155	24,851	29,243	6,946	4,696	4,392	0.526	0.233	0.177
St. John	3,974	4,921	8,382	14,850	947	3,461	6,468	0.238	0.703	0.772
Winfield	0	0	2,298	4,383	NA	2,298	2,085	NA	2.563	0.907

Table 22 Population Change by Municipality

The high population density of urban areas can potentially increase the concentration of pollutants in runoff when compared with less populated rural areas. Examples would include higher nutrient concentrations from lawn fertilizer use and pathogens from pet waste. Residential areas surrounding ponds or lakes can also be localized hotspots for elevated pathogen levels from the droppings of nuisance level goose populations.

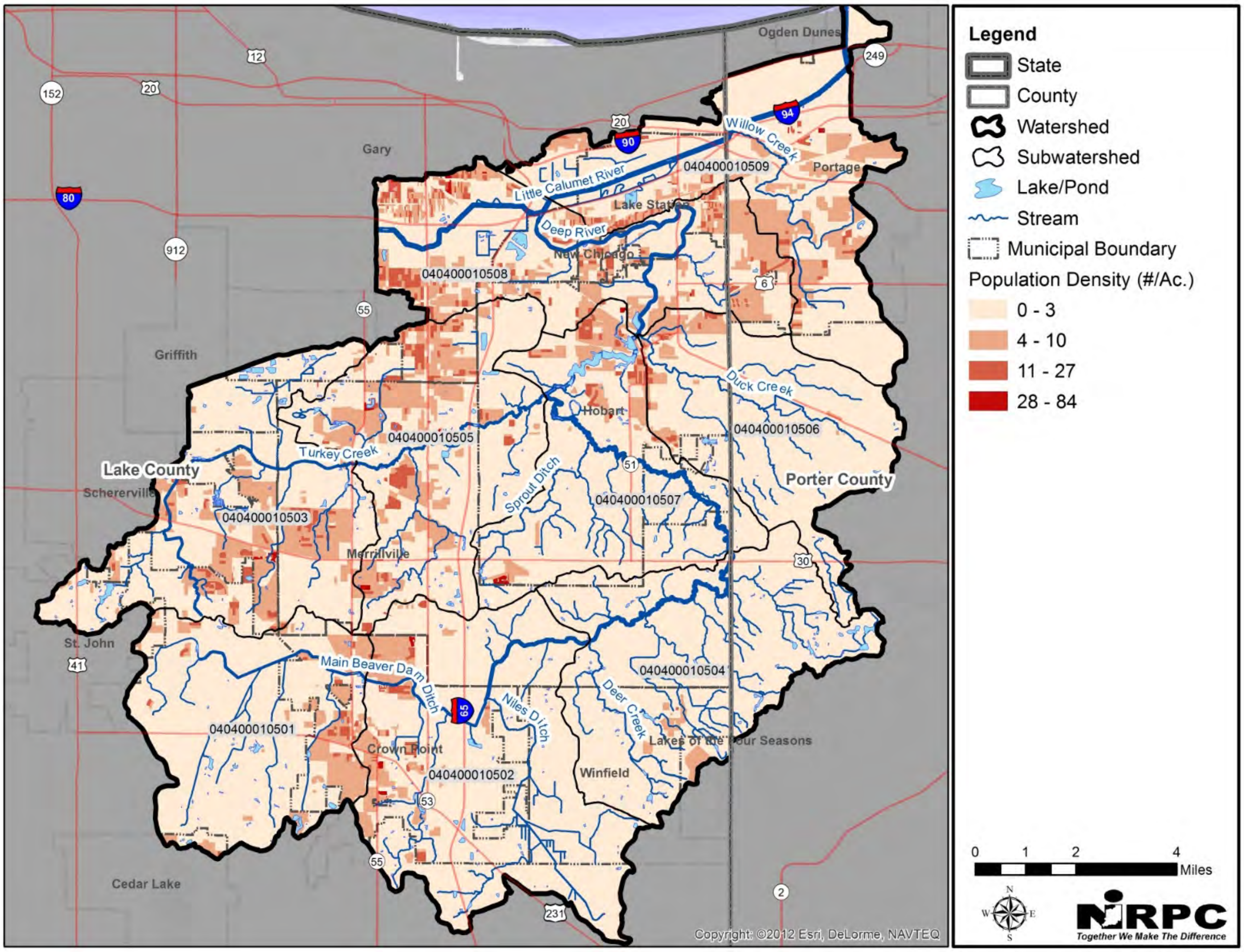


Figure 33 Population Density

2.6.4.2 *Impervious Cover*

A considerable amount of research has been done to evaluate the direct impact of urbanization on streams. Much of this research has focused on hydrologic, physical and biological indicators. In recent years, impervious cover (IC) has emerged as a way to explain and sometimes predict how severely these indicators change in response to varying levels of watershed development. Impervious cover includes surfaces that are impenetrable to water such as rooftops, roads and parking lots. The

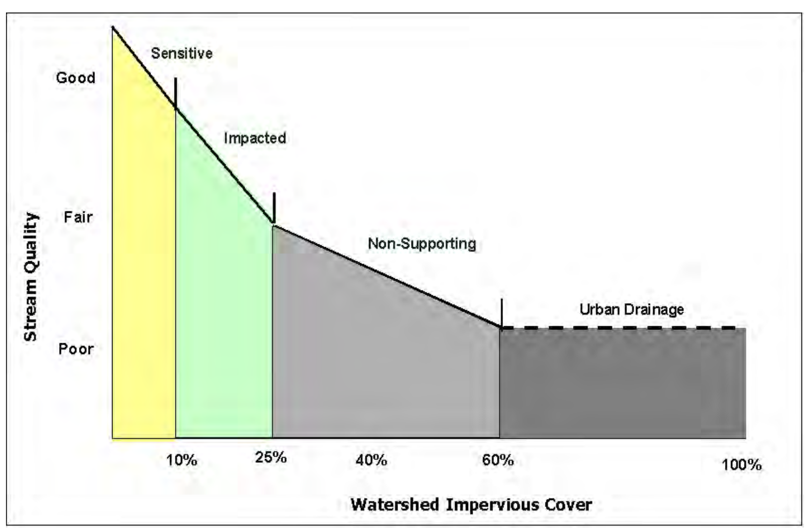


Figure 34 Relationship between Impervious Cover & Stream Quality

Center for Watershed Protection (CWP) has integrated research findings into a general watershed planning model, known as the Impervious Cover Model (ICM). The ICM predicts that most stream quality indicators decline when watershed IC exceeds 10%, with severe degradation expected beyond 25% IC (CWP, 2003). Center for Watershed Protection studies indicate that the size of one-hundred-year floods (or floods that have a one percent chance of occurring in any given year) can potentially double in watersheds with impervious cover levels greater than 20-30%. The following table adapted from the CWP's Watershed Vulnerability Analysis (2002) provides general observation descriptions for each ICM category.

ICM Category Category	Description
Sensitive (0-10% IC)	Streams are of high quality, and are typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects. Since impervious cover is so low, they do not experience frequent flooding and other hydrological changes that accompany urbanization.
Impacted (11-25% IC)	Streams show clear signs of degradation due to urbanization. Greater storm flows begin to alter stream geometry. Both erosion and channel widening are evident in alluvial streams. Stream banks become unstable, and physical habitat in the stream declines noticeably. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with the most sensitive fish and aquatic insects disappearing from the stream.
Non-Supporting (>25% IC)	Streams essentially become a conduit for conveying storm water flows and can no longer support a diverse stream community. The stream channel is often highly unstable and stream reaches can experience severe widening, down-cutting and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated, and the stream substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Water quality is consistently rated as fair to poor, and water contact recreation is no longer possible due to the presence of high bacterial levels. The biological quality is generally considered poor, and is dominated by pollution tolerant insects and fish.

Table 23 Impervious Cover Model Category Observation Descriptions

An analysis of impervious cover was done for each subwatershed using USGS impervious surface cover data (Table 24). The impervious surface data was derived from the 2011 National Land Cover Database. The results show that seven of the nine subwatersheds are impacted by impervious cover, exceeding the 10% threshold classification for a sensitive stream. Figure 35 shows the areas of high to low impervious cover throughout the watershed.

Name	HUC-12	Downstream Subwatershed	% IC	IC Category
Headwaters Main Beaver Dam Ditch	40400010501	040400010502	15.2	Impacted
Main Beaver Dam Ditch-Deep River	40400010502	040400010504	14.4	Impacted
Headwaters Turkey Creek	40400010503	040400010505	20.7	Impacted
Deer Creek-Deep River	40400010504	040400010507	5.9	Sensitive
City of Merrillville-Turkey Creek	40400010505	040400010507	26.4	Non-Supporting
Duck Creek	40400010506	040400010508	7.0	Sensitive
Lake George-Deep River	40400010507	040400010508	14.6	Impacted

Little Calumet River-Deep River	40400010508	040400010509	28.5	Non-Supporting
Willow Creek-Burns Ditch	40400010509	Lake Michigan	2	Non-Supporting

Table 24 Subwatershed Percent Impervious Cover

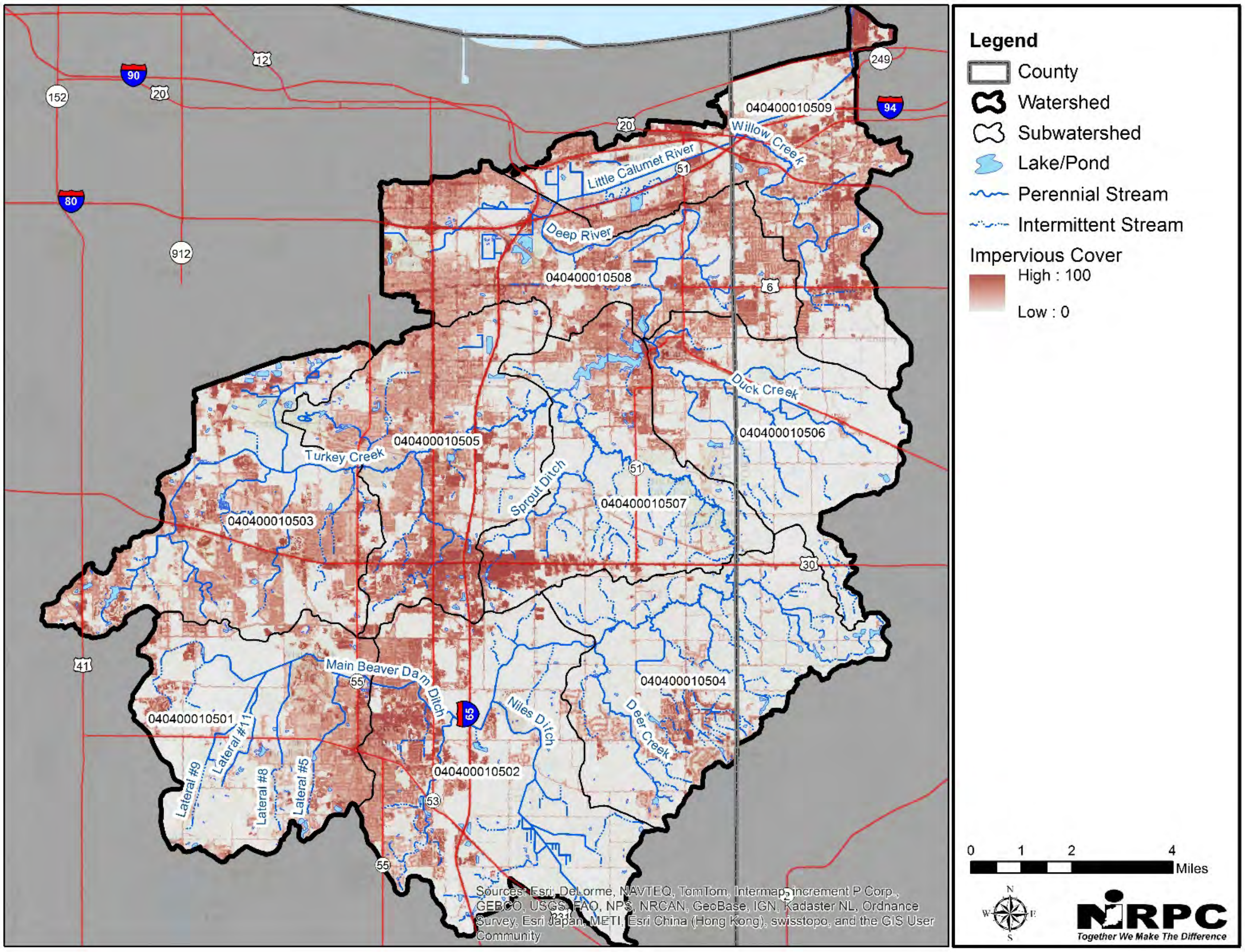


Figure 35 Impervious surface cover

2.6.4.3 *Point Sources*

This section summarizes the potential point sources of pathogens (*E. coli*), nutrients, and total suspended solids in the watershed as regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

2.6.4.3.1 Wastewater Treatment Plants

There are seven active NPDES permitted wastewater treatment plants WWTPs that discharge wastewater containing *E. coli*, nutrients, and TSS within the watershed (Figure 36, Table 25). As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating WWTPs that discharge pollutants into waters of the United States.

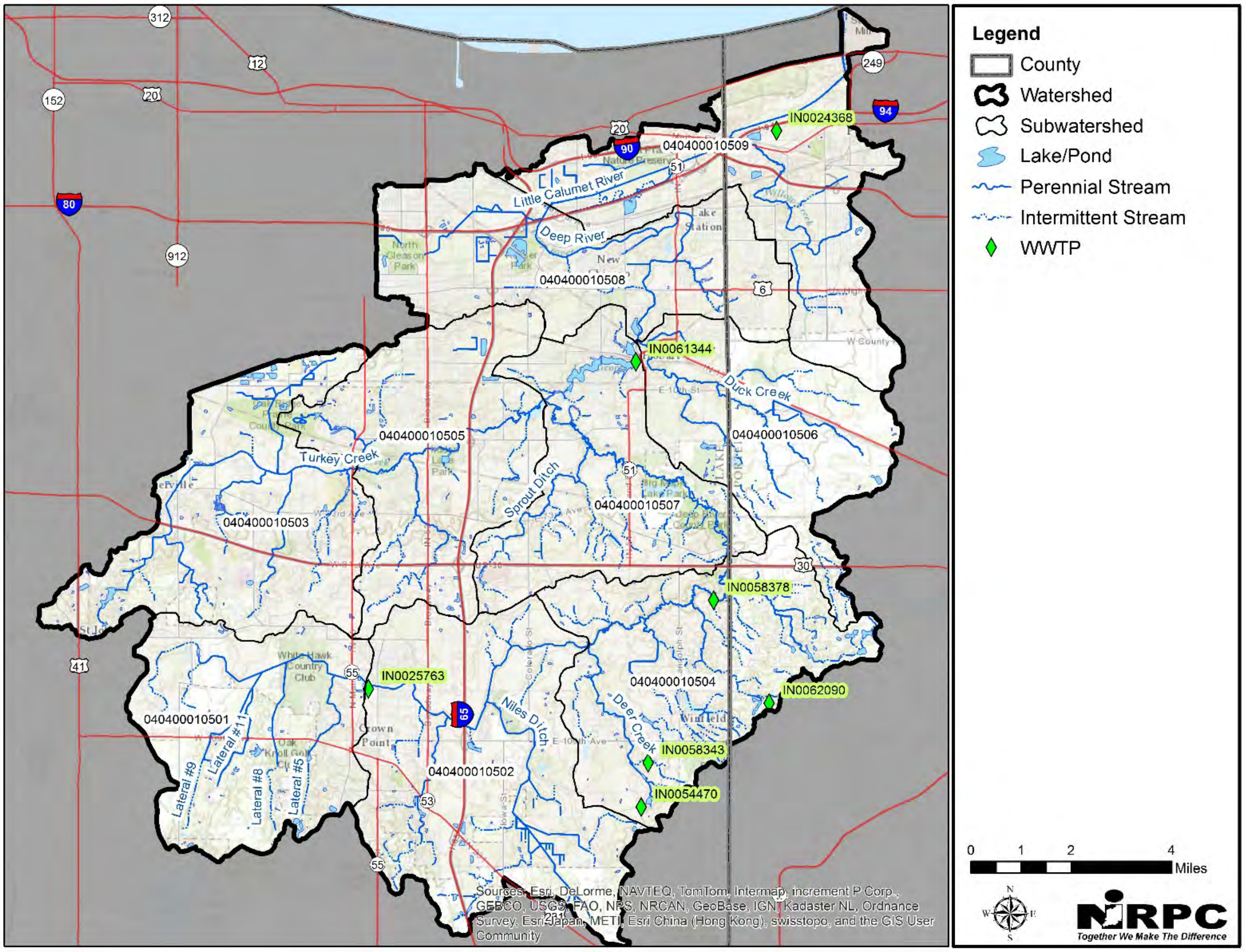


Figure 36 Wastewater treatment plants

The City of Crown Point currently owns and operates a Class III, 5.2 MGD conventional activated sludge treatment facility with primary and secondary clarification, phosphorus removal, mixed media filters and ultraviolet light disinfection. Biosolids are anaerobically treated to a Class B product, dewatered via a belt filter press and disposed of through a permitted land application program. The effluent limits contained in the permit are based on an effluent peak design flow of 8.1 MGD in accordance with IDEM's CSO policy to allow for the maximization of flow through the treatment facility in accordance with 327 IAC 5-2-11.6(g) (2). The collection system is comprised of combined sanitary and storm sewers with five Combined Sewer Overflow (CSO) locations. The CSO locations have been identified and permitted with provisions in Attachment A of their permit. The facility discharges into Main Beaver Dam Ditch via outfall 001. The receiving water has a seven day, ten year low flow (Q7,10) of zero cubic feet per second at the outfall location. There is no significant industrial flow into the City of Crown Point WWTP; the NPDES permit doesn't authorize the facility to accept industrial contributions until the permitee has provided IDEM with a characterization of the waste.

The Town of Winfield currently operates a Class II, 0.4 MGD activated sludge treatment facility consisting of a semi-cylindrical fine screen, an equalization influent basin, two-bioreactor basins, three secondary clarifiers, three final chlorine contact basins with fine bubble diffused post-aeration, dechlorination, phosphorus removal, an effluent flow meter, and one sludge holding tank. The collection system is comprised of 100% separate sanitary sewers be design with no overflow or bypass points. The facility discharges into an unnamed tributary to Deer Creek via Outfall 001. The receiving water has a seven day, ten year low flow (Q7,10) of 0.0 cubic feet per second at the outfall location. There is no industrial flow into the WWTP; the NPDES permit doesn't authorize the facility to accept industrial contributions until the permitee has provided IDEM with a characterization of the waste.

The Deep River Water Park (IN0062596) is limited to pool filter backwash. Samples taken in compliance with the monitoring requirements in the permit shall be taken at a point representative of the discharge but prior to entry into the unidentified ditch into Deep River. The Deep River Water Park WWTP (IN0058378) currently operates a Class I, 0.030 MGD treatment facility consisting of two septic tanks, with two re-circulating sand filters containing eight submersible pumps that recirculate the inflow through the sand filters, chlorination/dechlorination facilities, and an effluent flow meter. The collection system is comprised of 100% separate sanitary sewers by design with now overflow or bypass points. The facility discharges into the Deep River to Burns Ditch via Outfall 001. The Deep River has a seven day, ten year low flow (Q7,10) of 2.9 cubic feet per second (1.9 MGD) at the outfall location; this provides a dilution ratio of 63:1. There is no industrial flow into the WWTP; the NPDES permit doesn't authorize the facility to accept industrial contributions until the permitee has provided IDEM with a characterization of the waste.

The Chicagoland Christian Village WWTP currently operates a Class I, 0.05 MGD extended aeration type wastewater treatment plant consisting of a surge tank, a bar screen, a splitter box, two aeration basins, two primary clarifiers, three secondary clarifiers, a contact chamber, ultraviolet light disinfection, two digester, and an effluent flow meter. Final sludge is hauled offsite for disposal. The collection system is comprised of 100% separate sanitary sewers be design with no overflow or bypass points. The facility discharges to an on-site lake via Outfall 001. The on-site lake flows to an unnamed tributary of Deer Creek. The receiving water has a seven day, ten year low flow (Q7,10) of 0.0 cubic feet per second at the outfall location. There is no industrial flow into the WWTP; the NPDES permit doesn't authorize the facility to accept industrial contributions until the permitee has provided IDEM with a characterization of the waste.

The Falling Waters Conservancy District WWTP currently operates a Class I, 0.214 MGD Intermittent Cycle Extended Aeration System (ICEAS) Sequential Batch Reactor (SBR) treatment facility consisting of ultraviolet light disinfection and an effluent flow meter. The collection system is comprised of 100% separate sanitary sewers be design with no overflow or bypass points. The facility discharges into an unnamed tributary to Deep River via Outfall 001. The receiving water has a seven day, ten year low flow (Q7,10) of 0.0 cubic feet per second at the outfall location. There is no industrial flow into the WWTP; the NPDES permit doesn't authorize the facility to accept industrial contributions until the permitee has provided IDEM with a characterization of the waste.

The City of Hobart WWTP proposes to construct a wastewater treatment plant which would be a Class IV, 4.8 MGD facility with two equalization basins, microscreening, grit removal, extended aeration basins operated in conjunction with membrane filtration, chemical addition for pH and phosphorus control, ultraviolet light disinfection, and effluent reaeration. The collection system is comprised of 100% separate sanitary sewers be design with no overflow or bypass points. The facility discharges to the Deep River via Outfall 001. The receiving water has a seven day, ten year low flow (Q7,10) of 5.8 cubic feet per second (3.7 MGD) at the outfall location. There are no plans for significant industrial flow into the WWTP; the NPDES permit doesn't authorize the facility to accept industrial contributions until the permitee has provided IDEM with a characterization of the waste.

The Portage Utility Service Facility WWTP currently operates a Class III, 4.95 MGD extended aeration wastewater treatments facility with a 12 MGD equalized flow treatment capacity and a 15 MGD peak hydraulic capacity. The treatment facility consists of two mechanical screens, two aerated grit chambers, two primary clarifiers, and Aqua Diamond cloth media filtration system, post-aeration, ultra violet light (UV) disinfection and influent and effluent flow meters. Final solids are land applied under Land Application Permit No. INLA000076. The collection system is comprised of 100% sanitary sewers by design with one Sanitary Sewer Overflow (SSO) point. The SSO has been identified and prohibited in Attachment A of the permit. The facility discharges to Burns Ditch via outfall 001, Burns ditch has a seven day, ten year low flow (Q7,10) of 7.2 cubic feet per second (4.7 MGD) at the outfall location. This provides a dilution ratio of receiving stream flow to treated effluent of 1:1.1. The permitee accepts industrial flow from Advanced Waste Services, Indiana Pickling and Processing Co., Meritex, Inc., MonoSol, Rx Melton, Monosol, Rx Ameriplex, NEO industries Inc., and Precoat Metals Division- Sequa Coatings Division.

Subwatershed	Facility Name	Permit Number	AUID	Receiving Stream	Maximum Design Flow (MGD)
Headwaters of Main Beaver Dam Ditch	Crown Point WWTP	IN0025763	INC0151_01	Main Beaver Dam Ditch	8.1
Main Beaver Dam Ditch	NA	NA	NA	NA	NA
Headwaters of Turkey Creek	NA	NA	NA	NA	NA
Deer Creek	Winfield WWTP	IN0058343	INC0154_T1001	Unnamed Tributary to Deer Creek	0.4
	Deep River Water Park WWTP	IN0058378	INC0154_01	Deep River	0.030
	Chicagoland Christian Village	IN0054470	INC0154_T1001	Unnamed Tributary to Deer Creek	0.05
	Falling Waters Conservancy District	IN0062090	INC0154_T1004	Unnamed Tributary to Deep River	0.124
City of Merrillville	NA	NA	NA	NA	NA
Duck Creek	NA	NA	NA	NA	NA
Lake George	NA	NA	NA	NA	NA
Little Calumet River	Hobart WWTP	IN0061344	INC0157_P1001	Deep River	4.8
Willow Creek	Portage Utility Service Facility WWTP	IN0024368	INC0159_01	Burns Ditch	4.95

Table 25 Wastewater treatment plants

2.6.4.3.2 Combined Sewer Overflows

Combined sewer overflows (CSO) systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater into the same pipe. Most of the time, combined sewer systems transport all of their wastewater to a sewage treatment plant, where it is treated and then discharged to a waterbody. During periods of heavy rainfall or snowmelt, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other waterbodies. These overflows, called CSOs, can contain both storm water and untreated human and industrial waste, including pollutants such as *E. coli*, nitrogen, phosphorus, and total suspended solids. Because they are associated with wet weather events, CSOs typically discharge for short periods of time at random intervals. IDEM regulates CSOs in Indiana through the state's NPDES program. Combined Sewer Overflows are point sources subject to both technology-based and water quality based requirements of the Clean Water Act and state law. The permitee is authorized to have wet weather discharges from outfalls listed in their permit. One key component of this program is locating all CSO outfalls for tracking purposes. There are two combined sewer systems in the watershed operated by City of Crown Point and the City of Gary. There are nine CSO outfalls associated with these combined sewer systems.

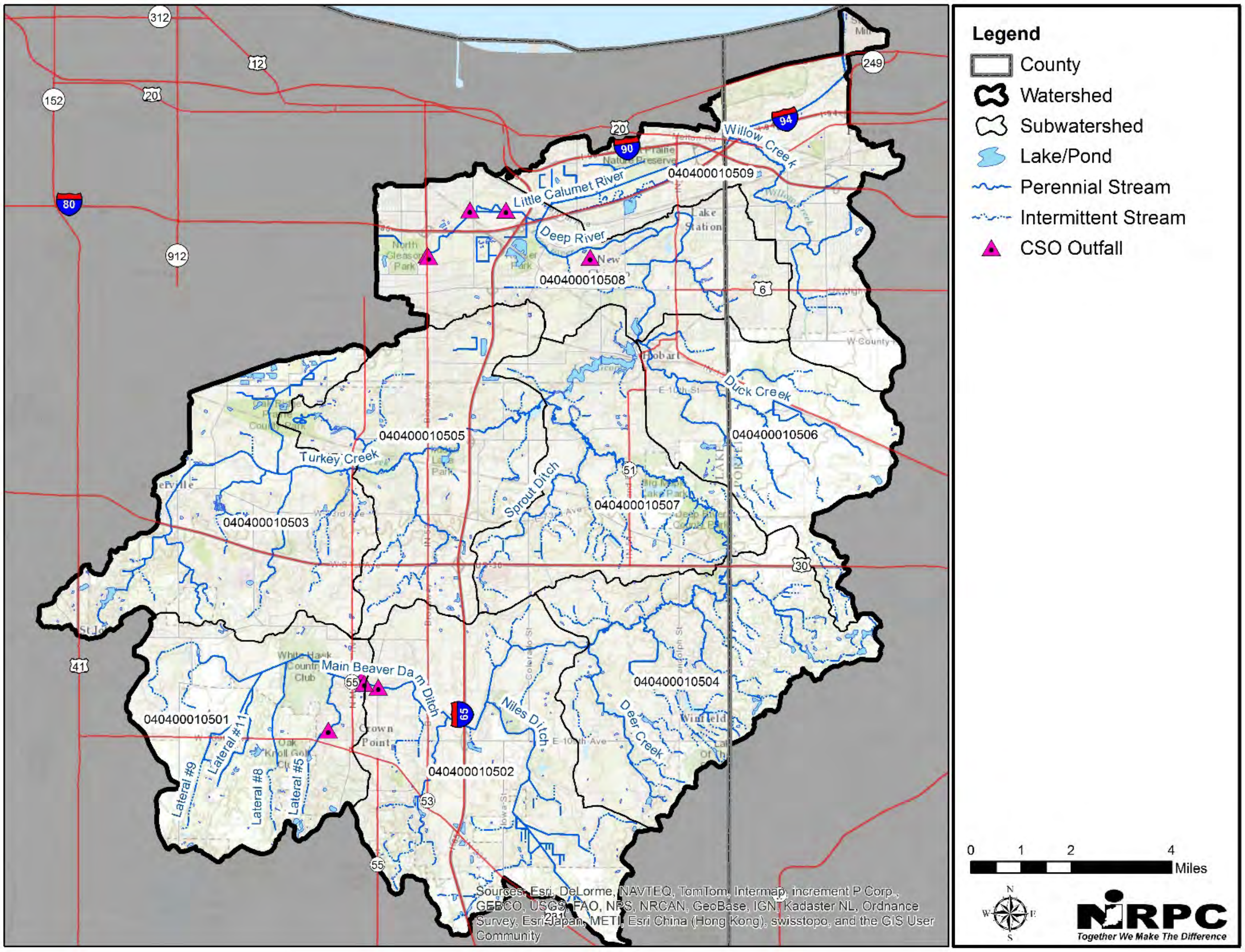


Figure 37 Combined sewer overflows

Subwatershed	Facility	Permit #	AUID	Outfall #	Pipe Description	Receiving Stream
Headwaters of Main Beaver Dam Ditch	Crown Point WWTP	IN0025763	INC0151_01	002	Treated CSO	Main Beaver Dam Ditch
				003	Untreated CSO	Main Beaver Dam Ditch
				005	Untreated CSO	Main Beaver Dam Ditch
				006	Untreated CSO	Main Beaver Dam Ditch
Main Beaver Dam Ditch	Crown Point WWTP	IN0025763	INC0152_04	004	Untreated CSO	Main Beaver Dam Ditch

Headwaters Turkey Creek	NA	NA	NA	NA	NA	NA
Deer Creek-Deep River	NA	NA	NA	NA	NA	NA
City of Merrillville-Turkey Creek	NA	NA	NA	NA	NA	NA
Duck Creek	NA	NA	NA	NA	NA	NA
Lake George-Deep River	NA	NA	NA	NA	NA	NA
Little Calumet River- Deep River	Gary Sanitary District WWTP	IN0022977	INC0142_T1009	004	Untreated CSO	Little Calumet River
				005	Untreated CSO	Little Calumet River
				013	Untreated CSO	Little Calumet River
				014	Untreated CSO	Little Calumet River
				015	Untreated CSO	Little Calumet River
Willow Creek-Burns Ditch	NA	NA	NA	NA	NA	NA

Table 26 Combined sewer overflows

2.6.4.3.3 Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unintentional and illegal discharges of raw sewage from municipal sanitary sewers. Sanitary sewer overflows discharge *E. coli* to waterbodies and may occur due to:

- Severe weather resulting in of excessive runoff of storm water into sewer lines
- Vandalism
- Improper operation and maintenance
- Malfunction of lift stations
- Electrical power failures

Overflows in the sanitary sewer system or in a sanitary portion of a combined sewer system are expressly prohibited from discharging at any time. Should any release from the sanitary sewer system occur, the permitee is required to notify the Enforcement Section of the Office of Water Quality orally within 24 hours and in writing within 5 days of the event in accordance with the requirements in Part II.C.2.b of the permit. The correspondence shall include the duration and cause of discharge as well as the remediation action taken to eliminate it.

The Merrillville Conservancy District operates a sewer collection system. The Merrillville Conservancy District transports wastewater to the Gary Sanitary District Wastewater Treatment Plant (WWTP). The wastewater collection system is 100% separate sanitary sewers by design with no bypass points and one SSO point.

For discussion on the Portage Utility Service Facility WWTP, see the WWTP discussion in Section 2.6.4.3.1.

Two permitted sites with two SSO locations were identified in the watershed (Figure 38, Table 27).

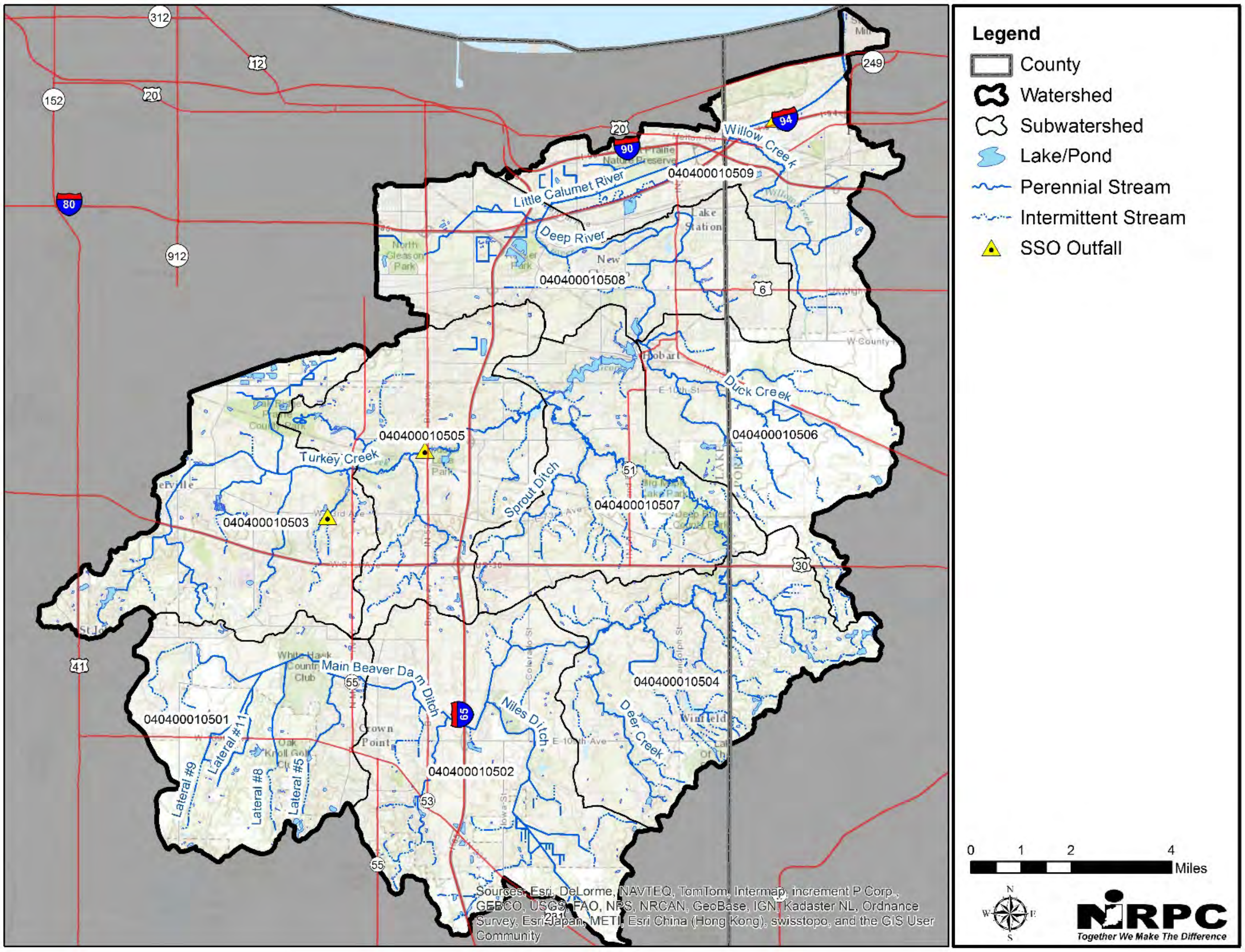


Figure 38 Sanitary sewer overflows

Subwatershed	Facility Name	Permit #	Type	AUID
Headwaters of Main Beaver Dam Ditch	NA	NA	NA	NA
Main Beaver Dam Ditch	NA	NA	NA	NA
Headwaters of Turkey Creek	NA	NA	NA	NA
Deer Creek- Deep River	NA	NA	NA	NA
City of Merrillville- Turkey Creek	Merrillville Conservancy District	INJ035548	Lift Station	INC0155_01
Duck Creek	NA	NA	NA	NA
Lake George- Deep River	NA	NA	NA	NA
Little Calumet River- Deep River	NA	NA	NA	NA
Willow Creek- Burns Ditch	Portage Utility Service Facility WWTP	IN0024368	Lift Station	INC0159_01

Table 27 Sanitary sewer overflows

2.6.4.3.4 Industrial Facilities

Industrial facilities with NPDES permits produce wastewater generated through producing a product. Wastewater discharges from industrial sources may contain pollutants at levels that could affect the quality of receiving waters. The NPDES permit program establishes specific requirements for dischargers from industrial sources. If the industrial facility discharges wastewater directly to a surface water then it requires an individual or general NPDES permit. A general permit, or permit-by-rule, is a “one size fits all” type of activity-specific permit. The general permit rule (327 IAC 15-1 through 15-4 and 15-10) covers the following activities: coal mining, coal processing, and reclamation activities, noncontact cooling water, petroleum products terminals, groundwater petroleum remediation systems, hydrostatic testing of commercial pipelines, and sand, gravel and stone operations. In contrast, individual permits are tailored to the specific activities of the facility and may regulate a number of additional pollutants other than those described under the general permits.

Depending on the type of industrial facility operated more than one NPDES program may apply. Some industrial facilities require an additional permit under the storm water program.

Industrial storm water permits are required for facilities where activities of the industrial operation are exposed to storm water and runoff is discharged though a point source to waters of the state. The general permit 327 IAC 15-6 (Rule 6) applies to specific categories of industrial activities that must obtain permit coverage. Determination of applicable industrial activities is based on a facility’s Standard Industrial Classification (SIC) Code(s) or facility activities included in the listed narrative descriptions within the rule. Under certain circumstances, a facility may require an individual storm water permit. This permit is typically required only if a regulated industrial activity category has established effluent limitations or IDEM determines the storm water discharge will significantly lower water quality.

The facility must develop and implement a Storm Water Pollution Prevention Plan (SWP3), and submit a completed SWP3 Checklist Form certifying to IDEM that such a plan is in place. The SWP3 is used to identify potential and actual storm water pollutant sources, and to determine best management practices and measures that will minimize the pollutants transported in storm water run-off. The SWP3 itself must be retained at the facility, and made available for review during any on-site inspection. Periodically, the plan must be reviewed, and revised if changes at the facility alter conditions that could affect run-off.

Based on information from the TMDL, there are a total of 23 industrial facilities with NPDES permits within the watershed (Table 28).

Subwatershed	Facility Name	Permit Number	Receiving Stream
Headwaters Main Beaver Dam Ditch	Bulk Marathon 2108	ING080230	Main Beaver Dam Ditch
	Speedway LLC Store 6677	ING080263	Main Beaver Dam Ditch
Main Beaver Dam Ditch	Vesuvius USA Crown Point Plant	INR00B062	Main Beaver Dam Ditch
	East Chicago Machine Tool Corporation	INR00B085	Main Beaver Dam Ditch
	Conquest Ready Mix	INR00C073	Main Beaver Dam Ditch
	Crown Brick & Supply Inc.	INR210008	Main Beaver Dam Ditch
	US Gypsum Company	INR210155	Niles Ditch
	Illiana Disposal and Recycling	INR800146	Main Beaver Dam Ditch

Headwaters of Turkey Creek	Calumet Bus Service Inc.	INR00C114	Unnamed Tributary to Turkey Creek
	Laketon Refining Corporation	INR00L018	Unnamed Tributary to Turkey Creek
	American Chemical Service Inc.	INR230064	Unnamed Tributary to Turkey Creek
	Wild Bills Incorporated	INR600286	Unnamed Tributary to Turkey Creek
	Travel Centers of America	INR700040	Unnamed Tributary to Turkey Creek
	Griffith Merrillville Airport	INR800012	Unnamed Tributary to Turkey Creek
	Walsh and Kelly Incorporated	INRM00438	Unnamed Tributary to Turkey Creek
Deer Creek	NA	NA	NA
City of Merrillville	CHNUPA & Hoffman Corp. Nummies Auto Parts	INR00N049	Unnamed Tributary to Turkey Creek
	Frito Lay Incorporated	INRM00083	Unnamed Tributary to Turkey Creek
Duck Creek	NA	NA	NA
Lake George	NA	NA	NA
Little Calumet River	NA	NA	NA
Willow Creek	Precoat Metals Division Sequa	INR200111	Burns Ditch
	Steel Technologies LLC	INR200173	Little Calumet River
	Illiana Transfer 4	INR500030	Little Calumet River
	Pauls Auto Lake Station Yard	INRM00623	Little Calumet River
	NLMK- Indiana	IN0059714	Burns Ditch
	US Steel Corp Midwest Plant	IN0059714	Burns Ditch

Table 28 NPDES permitted industrial facilities

2.6.4.3.5 NPDES Facility Inspection and Compliance

The following table presents a summary of permit compliance for all NPDES facilities in the watershed for the five year period between 2010 and 2014. It presents the date of the facility's last inspection and findings from the inspection (i.e., compliance or violation for facility maintenance). The table also presents the total number of violations in the five year period for the NPDES permitted parameters. According to the table, there have been 31 NPDES facility inspections resulting in violations in the five year period. Overall, there are a total of 52 permit violations for the NPDES permitted parameters in the watershed.

Subwatershed	Facility Name	Permit Number	Stream	Date of Inspection for the Last Five Years	Violations for the Last Five Years				
					Month	Year	Parameter	Type	# violations

Headwaters of Main Beaver Dam Ditch	Crown Point	IN0025763	Main Beaver Dam Ditch	8/25/2009: No Violations 2/24/2010: No Violations 9/24/2010: No Violations 8/10/2011: Potential Problems Observed 1/30/2012: Potential Problems Observed 9/27/2013: No Violations 1/3/2014: Violations Observed 6/27/2014: Violations Observed (Phosphorus June 2013- May 2014)	Dec. Jan. Jan. Feb. Feb. July July Feb. Feb. Jan. Jan. Jan. Feb. Apr. Sep. Oct. Oct. Nov. Nov.	2010 2011 2011 2011 2011 2011 2011 2011 2011 2011 2013 2013 2013 2013 2013 2013 2013 2013 2013	TSS TSS TSS Copper Copper NH3-N NH3-N Copper Copper TSS TSS NH3-N NH3-N TSS Copper TSS Copper NH3-N NH3-N	Mx Wk Avg Mo. Avg Mx Wk Avg Mo. Avg D. Max Mx Wk Avg Mo. Avg D. Max Mo. Avg Mx Wk Avg Mx Wk Avg Mx Wk Avg Mx Wk Avg Mx Wk Avg Mo. Avg Mx Wk Avg Mo. Avg Mx Wk Avg Mo. Avg	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Main Beaver Dam Ditch	NA	NA	NA	NA	NA				
Headwaters Turkey Creek	NA	NA	NA	NA	NA				
Deer Creek-Deep River	Winfield WWTP	IN0058343	Unnamed Tributary to Deer Creek	2/23/2010: Violations Observed 9/2/2010: No Violations Observed 1/3/2012: Violations Observed 2/6/2014: No Violations Observed	Sep	2011	TSS	Mx Wk Avg	1
	Deep River Water Park WWTP	IN0058378	Deep River	12/15/2010: Violations Observed 7/16/2012: No Violations Observed 6/7/2013: No Violations Observed 6/5/2014: No Violations Observed	Jan. July July Aug. Aug. Aug. May	2010 2010 2010 2010 2010 2010 2013	NH3-N NH3-N NH3-N NH3-N NH3-N *E. coli* Chlorine	Mo. Avg Mo. Avg Mx Wk Avg Mx Wk Avg Mo. Avg D. Max D. Max	1 2 2 1 1 1 3
City of Merrillville-Turkey Creek	Chicagoland Christian Village	IN0054470	Unnamed Tributary to Deer Creek	8/28/2010: Violations Observed 12/6/2010: No Violations Observed 11/15/2011: Violations Observed 6/21/2013: Violations Observed:(Referred to Enforcement) 11/14/2013: Violations Observed	May June June Nov April June June July July July Aug. Aug. Aug. May May May May May June June July Aug Aug Aug Sep Sep	2010 2010 2010 2010 2011 2011 2011 2011 2011 2011 2011 2011 2011 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012 2012	CBOD *E. coli* *E. coli* NH3-N TSS NH3-N NH3-N *E. coli* NH3-N NH3-N NH3-N NH3-N *E. coli* *E. coli* NH3-N NH3-N NH3-N NH3-N *E. coli* *E. coli* *E. coli* NH3-N NH3-N Phosphorus NH3-N NH3-N	Mx Wk Avg Mo. Avg Mo. Geo Mean Mo. Avg % removal Mx Wk Avg Mo. Avg D. Max D. Max Mo. Avg D. Max Mo. Avg D. Max D. Max Mo. Avg Mx Wk Avg Mo. Avg Mx Wk Avg D. Max Mo. Geo Mean D. Ma Mx Wk Avg Mo. Avg Mo. Avg Mx Wk Avg Mo. Avg	1 3 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 3 1 1 3 1 1 1 1
	Falling Waters Conservancy District	IN0062090	Unnamed Tributary to Deep River	1/29/2010: No Violations Observed 1/25/2012: No Violations Observed 2/8/2013: Violations Observed 5/22/2014: Violations Observed	Jul. Aug. Apr. May. May. Jun. Aug.	2011 2011 2012 2012 2012 2012 2013	*E. coli* *E. coli* *E. coli* *E. coli* NH3-N NH3-N *E. coli*	D. Max D. Max D. Max D. Max Mx Wk Avg Mx Wk Avg D. Max	1 1 2 1 1 1 1

Duck Creek	NA	NA	NA	NA	NA				
Lake George-Deep River	NA	NA	NA	NA	NA				
Lake George-Deep River	NA	NA	NA	NA	NA				
Little Calumet River- Deep River	Hobart WWTP	IN0061344	Deep River	3/31/2010: Violations Observed 4/5/2010: Violations Observed 6/15/2011: Violations Observed:(Referred to Enforcement)	NA	NA	NA	NA	NA
Willow Creek-Burns Ditch	Portage Utility Service Facility WWTP	IN0024368	Burns Ditch	4/27/2010: No Violations Observed 5/2/2011: No Violations Observed 6/12/2012: No Violations Observed 2/20/2013: Violations Observed	NA	NA	NA	NA	NA

Table 29 Wastewater treatment plant summary of inspections and permit compliance

2.6.4.4 *Remediation & Waste Sites*

Although not identified as a public concern, information on remediation and waste sites located within the watershed is included here because of their potential environmental impact. The data used to create the map figure below was generated by IDEM and is also available to the general public through Indiana Map (www.indianamap.org). Descriptions of site types is provided below.

Industrial waste sites- facilities that generate and/or manage hazardous waste, non-hazardous industrial waste, and solid waste.

Waste treatment disposal sites- facilities that may treat, store, and/or dispose hazardous waste. These facilities are also usually generators of hazardous waste.

Waste transfer stations- facilities that transfer solid waste from one collection vehicle to another. The waste is later disposed of at a state approved solid waste permitted facility.

Tire sites- facilities that contain tires for processing, storage, or transport, as well as some illegal tire dumps.

Active permitted solid waste sites- facilities that are permitted solid waste landfills.

Restricted waste sites- facilities that accept only specific types of solid wasted.

Voluntary Remediation Program (VRP) sites- sites where owners or operators have voluntarily entered into an agreement with IDEM to clean up contaminated property. When the cleanup is successfully completed, IDEM will issue a Certificate of Completion and the Governor's office will issue a Covenant Not to Sue to the cleaned up property.

Superfund sites- Sites include current and former chemical and manufacturing plants; rail yards; smelter sites; landfill and dump sites; and sediment sites. These sites are typically large and complex, requiring long-term investigations and cleanups. Many sites require ground water treatment and monitoring that may continue for 30 years or more after construction completion.

Open dumps sites- sites that are not regulated and are illegal dump sites of solid waste.

Landfill boundary- shows boundaries for open dump sites, approved landfills, and permitted landfills.

Institutional control sites- When any amount of contamination above a residential closure level is left on a property, a legal measure called an Institutional Control (IC) may be needed. An IC protects human health and the environment by restricting property activity, use, or access.

Corrective action sites- facilities that are subject to RCRA Corrective Action if they meet any of the following conditions: operating under a hazardous waste permit (A or B) or an interim status facility and lawsuit against any handler.

Cleanup sites- sites that are on the Commissioner's Bulletin or referred remedial response locations or other IDEM programs that require mitigation of risk to human health and the environment through investigation, remediation or institutional controls.

Brownfield sites- a parcel of real estate that is abandoned or inactive, or may not be operated at its appropriate use, and on which expansion, redevelopment, or reuse is complicated because of the presence or potential presence of a hazardous substance, a contaminant, petroleum, or a petroleum product that poses a risk to human health and the environment.

Leaking underground storage tanks- Shows regulated leaking underground storage tank locations. Regulated underground storage tanks are those that have 10 percent or more of the tank and piping buried beneath the ground and contain a regulated substance.

Waste disposal storage handling- sites for the disposal, storage, and handling of solid and hazardous waste. Types of waste sites include constructions/demolition waste, composting of CFO waste, clean fill, municipal, non-municipal, open dumps, restricted waste, surface impoundments, sanitary landfills, incinerators, material recovery, medical waste, recycling, and waste transfer stations.

In general, the location of remediation and waste sites corresponds to areas of medium to high intensity development. By number, leaking underground storage tanks is the most extensive remediation and waste site concern (Table 30). A review of the Deep River-Portage Burns Waterway TMDL did not reference remediation or waste sites contributions to any of the observed stream impairments in the watershed.

Site Type	# of Sites	Site Type	# of Sites
Industrial Waste Sites	100	Open Dump Sites	4
Waste Treatment Disposal Sites	3	Landfill Boundary	9
Waste Transfer Stations	5	Institutional Controls Sites	31
Tire Sites	1	Corrective Action Sites	5
Active Permitted Solid Waste Sites	2	Cleanup Sites	26
Restricted Waste Sites	1	Brownfield Sites	10
VRP Sites	4	Leaking Underground Storage Tanks	434
Superfund Sites	1	Waste Disposal Storage Handling	21

Table 30 Summary of remediation and waste sites

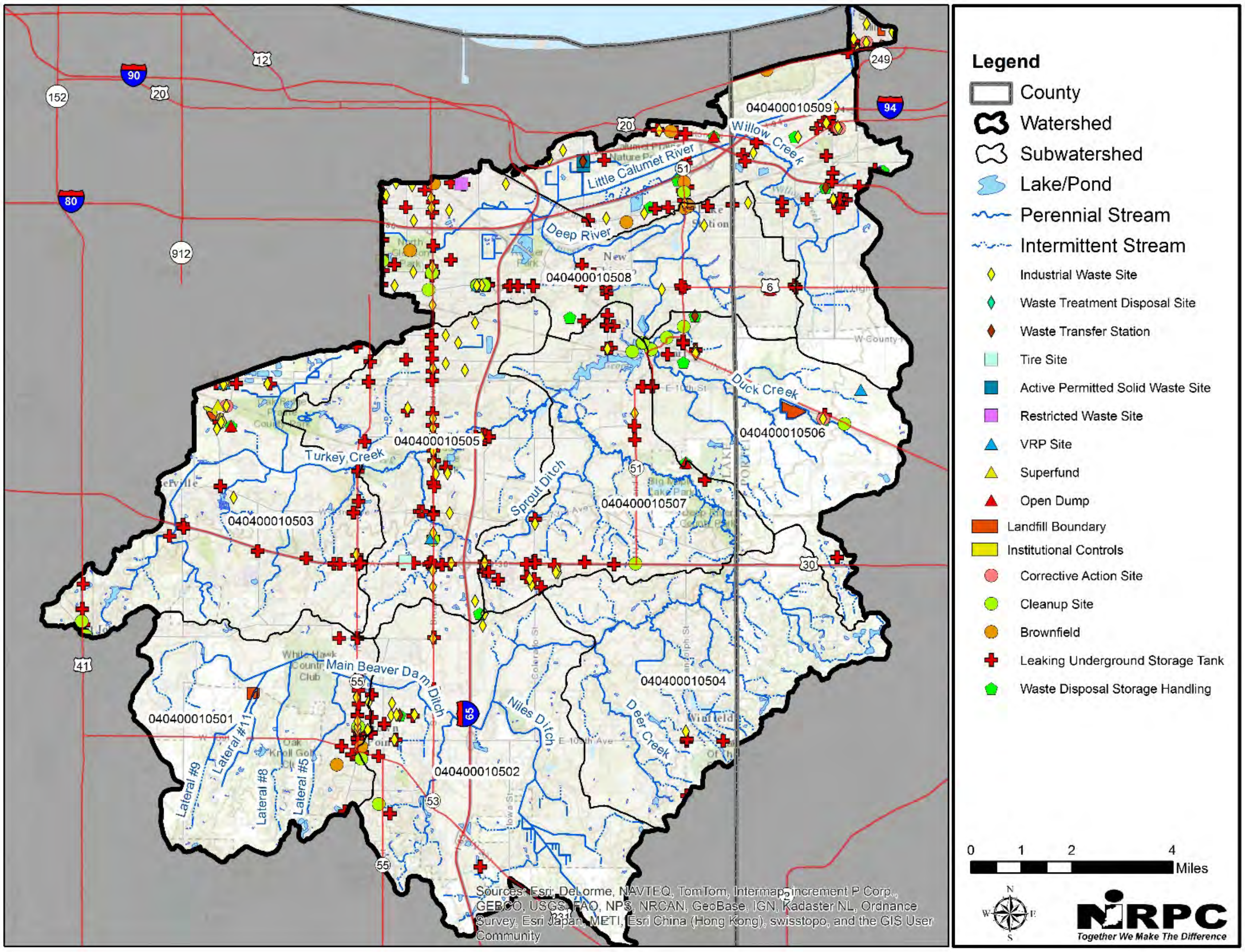


Figure 39 Remediation and waste sites

2.6.5 Natural Land Cover

The type, quantity, and structure of the natural vegetation within a watershed have important influences on aquatic habitats. Natural vegetative land cover regulates watershed hydrology, stabilizes soil, cycles nutrients, and provides habitat for terrestrial and riparian species. Natural land cover provides connectivity among riparian habitats and between terrestrial and aquatic ecosystems. Many aquatic organisms depend on being able to move through connected systems to habitats in response to variable environmental conditions.

Figure 40 shows the distribution of natural land cover in the watershed. Overall there is approximately 30,150 acres of forest, scrub/shrub, grassland and wetland cover in the watershed. Forest habitat comprises the largest percentage of natural land cover at 36% followed by wetland (30%), grassland (21%), and scrub/shrub habitat (13%).

Pre-settlement vegetation data, based on the accounts of land survey information, suggests that much of the watershed's upland landscape was dominated by savanna and prairie habitat. The Little Calumet River was bound by wetland and marshes. Marshes surrounded the low lying areas along Turkey Creek, Deep River and what is now Main Beaver Dam Ditch and Niles Ditch. Forested land was described along Deep River and a Duck Creek. The northern edge of the watershed was described as dune.

Today, the largest contiguous tract of natural cover is located along Deep River. This corridor is comprised or upland forest and floodplain wetland. Other notable concentrations of natural land cover include the eastern portion of the Deer Creek subwatershed, an the south central portion of the Headwaters Main Beaver Dam Ditch subwatershed, the northern portion of the Headwaters Turkey Creek subwatershed, and the area west of Lake George.

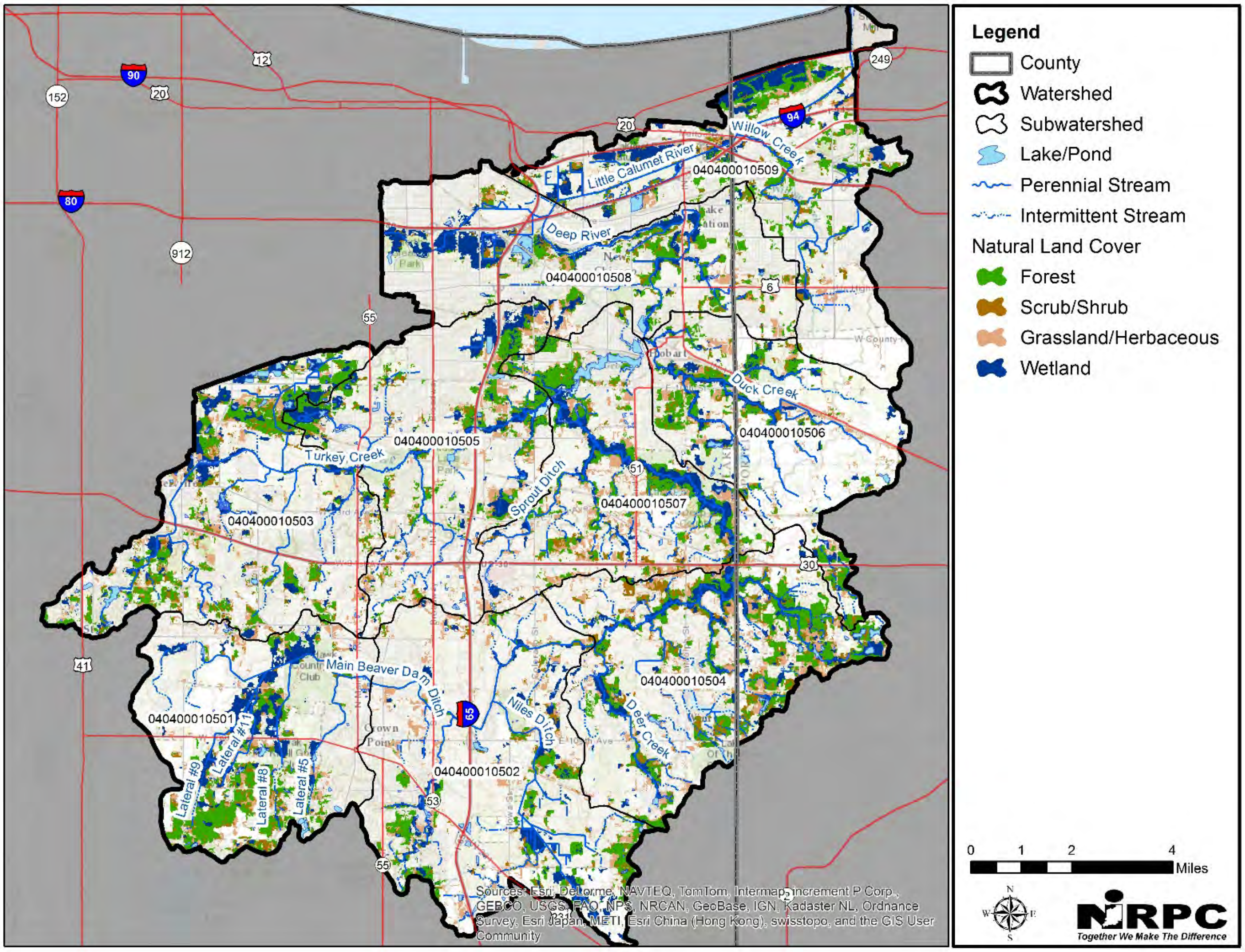


Figure 40 Natural land cover

2.6.5.1 *Forests*

The following section includes further discussion on watershed forested land cover and urban forests.

2.6.5.1.1 Forested Lands

Forests play a critical role in the health of a watershed. Forest cover reduces storm water runoff and flooding by intercepting rainfall and promoting infiltration into the ground. Trees growing along streams help prevent erosion by stabilizing the soil with their root systems. They help improve water quality by filtering sediment and associated pollutants from runoff and they provide cover for both terrestrial and aquatic life. Forests also reduce summer air and water temperatures and improve regional air quality.

In 2010 there was approximately 10,891 acres of forestland within the watershed. Overall this accounts for 9% of the land area. Forest cover by subwatershed ranged from a low of 6% in the Main Beaver Dam Ditch-Deep River subwatershed to a high of 14% in the Deer Creek-Deep River subwatershed.

While it is important to have a general understanding of how much forest cover exists in a watershed, it is also at least equally as important to understand the quality and location of that forest cover. Forest fragmentation occurs when large, contiguous stands of mature forest are divided into smaller isolated patches known as "forest fragments." Forest fragmentation is caused by human activities, such as road construction, agricultural clearing, and urbanization, or by natural processes that include fire and climate change. Forest fragmentation is considered a useful indicator of forest ecosystem health. The degradation of core forest into fragments can cause loss of native flora and fauna species, alterations to water cycles, and adverse impacts on air and water quality. Forests weakened by fragmentation become more susceptible to damage from insects and diseases, and this stress often degenerates into a condition of chronic ill health.

Forest fragmentation data for the watershed is shown in Figure 41 and Figure 42. The data is classified into four different categories: patch, edge, perforated, and core. These categories have been identified as indicators of forest ecosystem quality and can be used to assess the amount of fragmentation present in a landscape and potential habitat impacts. Core forest area decreased approximately 219 acres or 2.8% between 1996 and 2006 while patch forest area increased nearly 70 acres or 4.2% over the same time period. The figure shows a subtle yet increasing trend in forest habitat fragmentation.

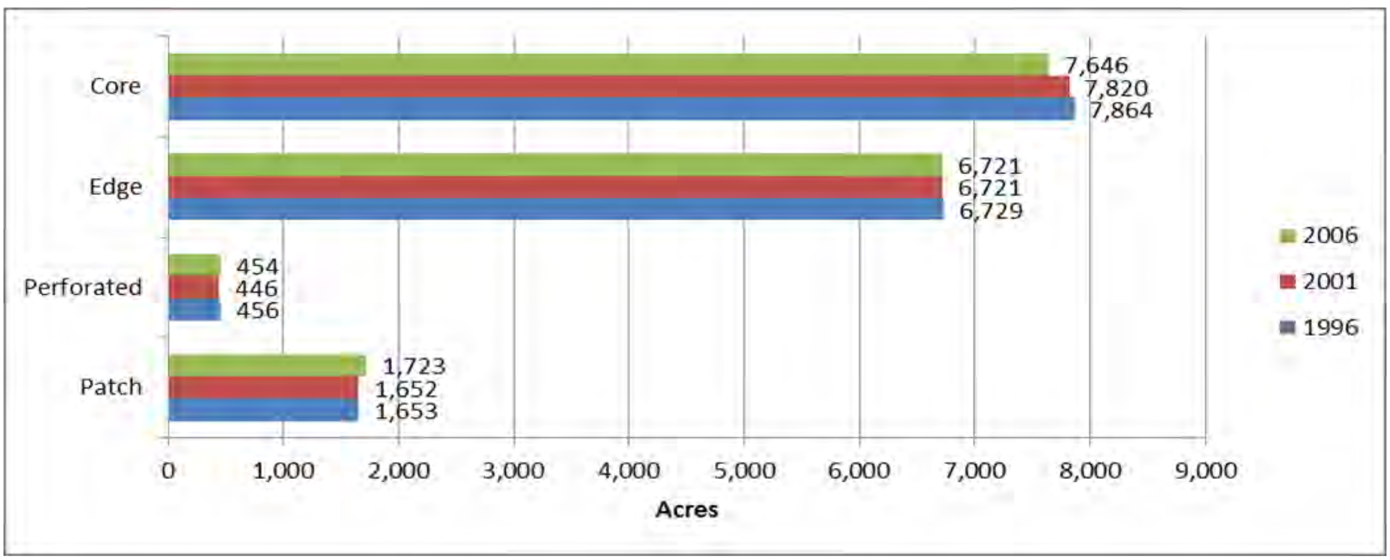


Figure 41 Forest fragementation data (1996-2006)

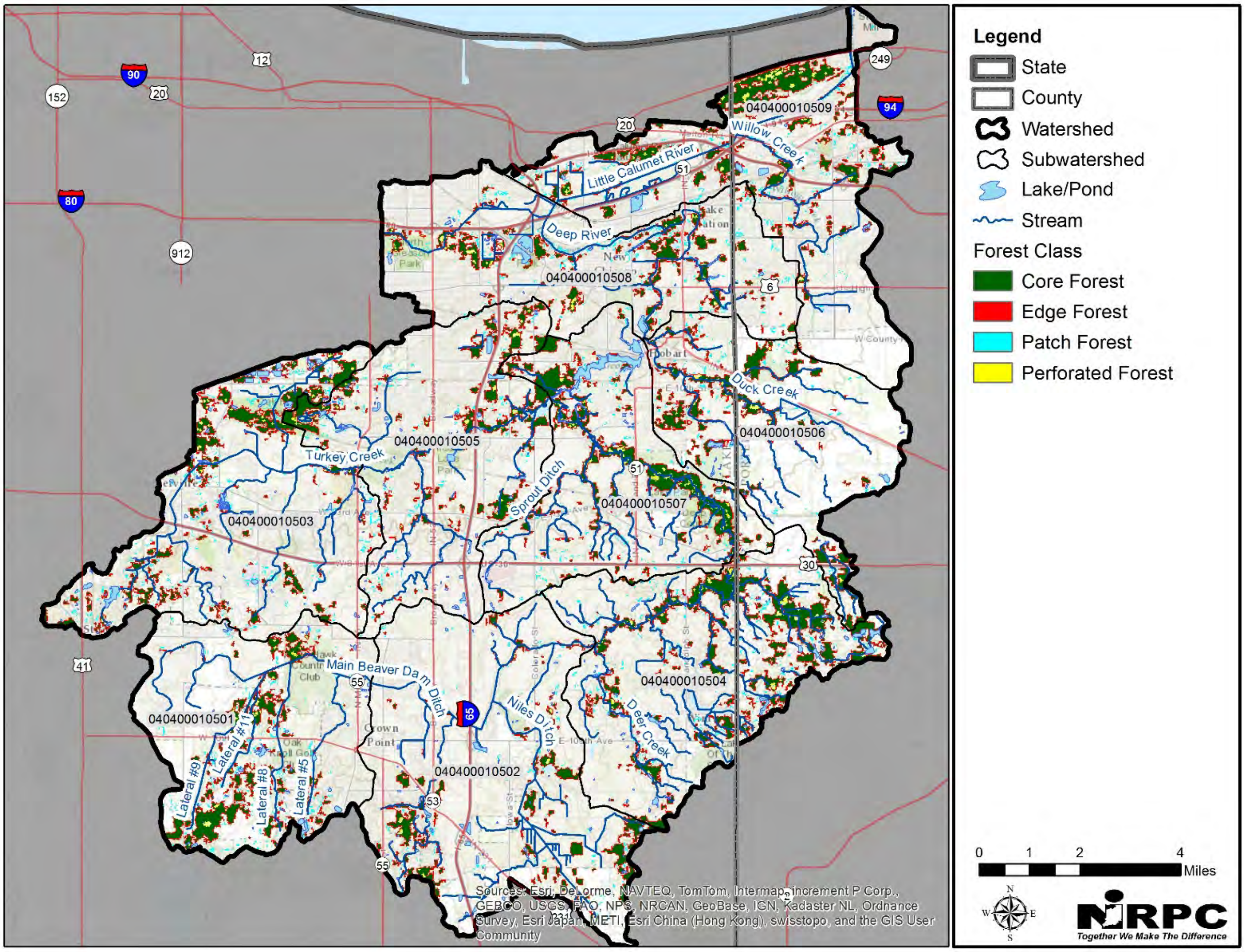


Figure 42 Forest Habitat

2.6.5.1.2 Urban Forest

There is an increasing awareness of how trees and forests in the urban landscape can improve air and water quality, reduce storm water runoff, conserve energy, and protect public health. At the same time, the loss of trees and forest cover to development continues. Also within existing developed areas, the urban tree canopy deteriorates through removal or lack of replacement. Impacts due to the loss of green space in urban watersheds, such as increased runoff and impervious cover, demonstrates the vital role of urban forestry in watershed management.

Urban tree canopy is defined as the layer of tree leaves, branches, and stems that cover the ground when viewed from above. Measuring tree canopy is important because it is the tree canopy that provides such benefits as rainfall interception, pollutant removal, and shading of streams and impervious surfaces. The following figure shows the percent canopy cover for municipalities within the watershed. The percent canopy cover ranges from a low of 14.4% in Crown Point to a high of nearly 58% in Ogden Dunes. The average percent canopy cover is slightly more than 26%. Forty percent (40%) canopy cover for metropolitan areas is a common target based on the recommendation by American Forests. However, it may not be realistic for some communities to meet this canopy cover goal, while others may surpass it.

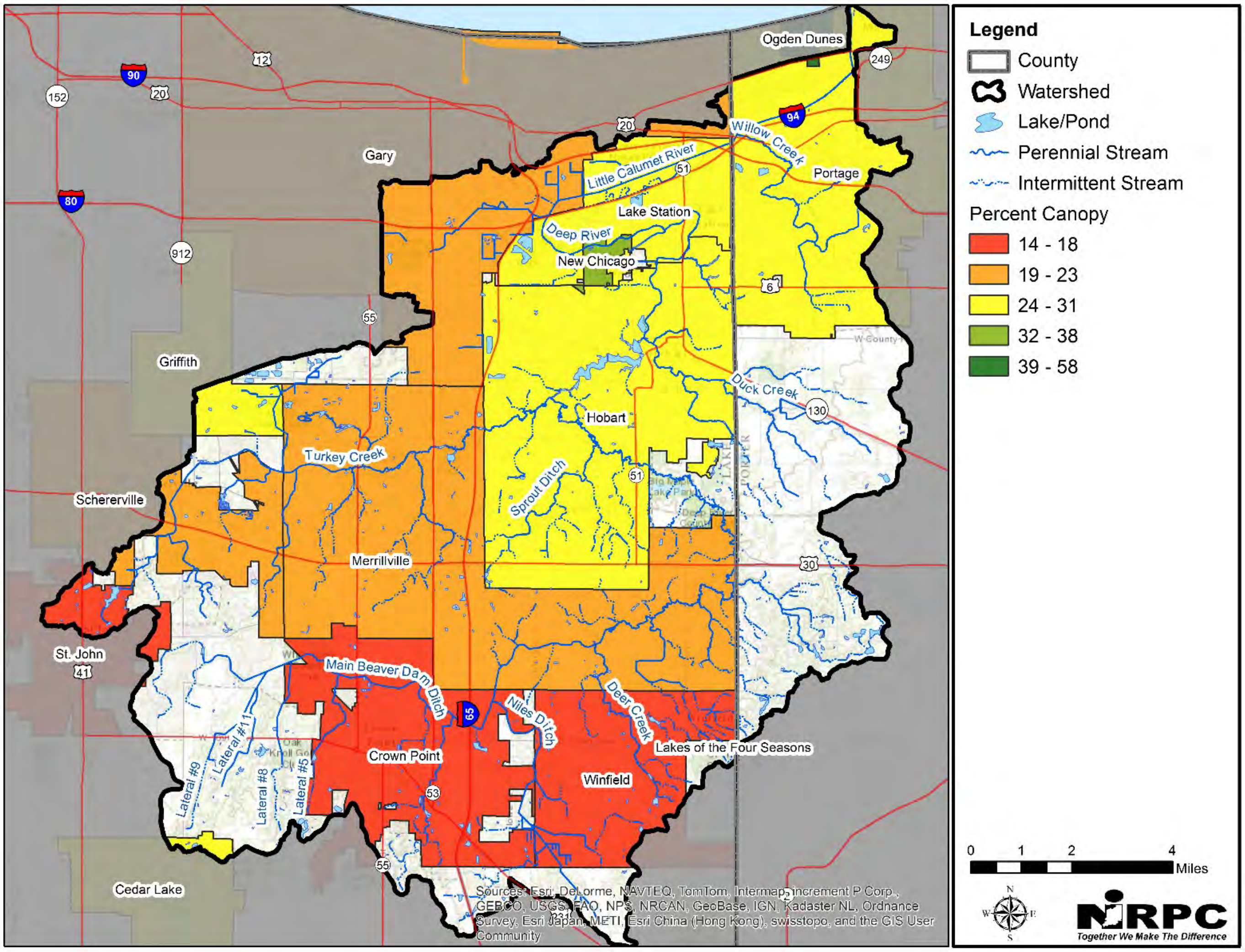


Figure 43 Municipal tree canopy cover

2.6.6 Land Cover Change & Trends

A review of land cover data from 1985 to 2010 shows a steady decline in agricultural land and increase in development (Figure 44). Between 1985 and 2010, 6,644 acres of agricultural land (-17%) was converted to other uses while development expanded by nearly 10,578 acres (26%). Decreases in natural land cover were also observed over this time period: 95 acres of forest (-1%), 1,427 acres of scrub/shrub (-27%), 2,061 acres of grassland (-24%), and 461 acres of wetland (- 5%). The most drastic changes came between 2006 and 2010 with 6,870 acres of new development (15%) and a loss of 2,718 acres of agricultural land (-8%), 2,004 acres of grassland (-24%), 1,330 acres of scrub/shrub habitat (-25%), and 423 acres of wetland (-5%).

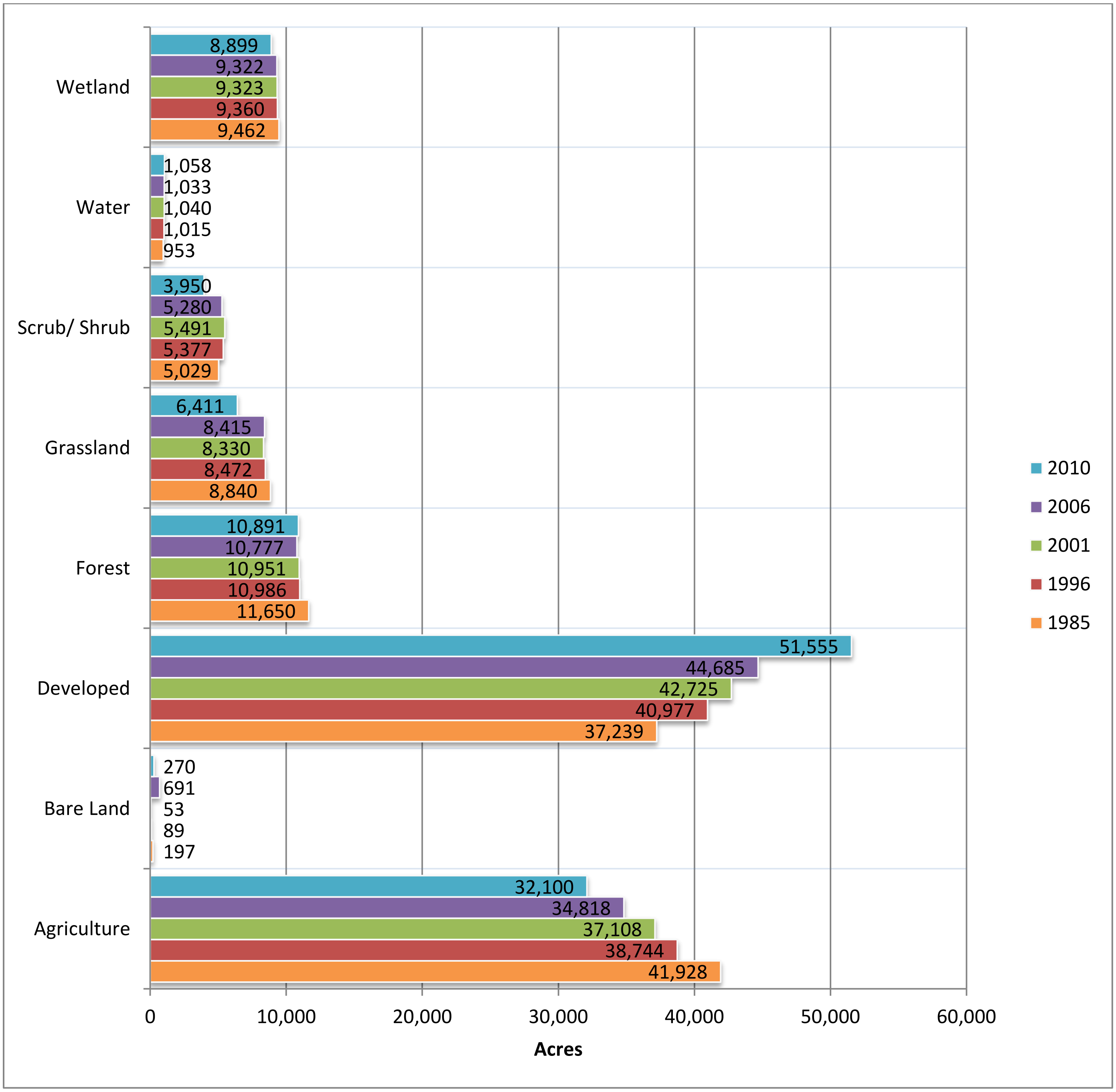


Figure 44 Land Cover Change (1985-2010)

Figure 45 highlights the successive pattern of new development observed in the watershed between 1985 and 2010. The heaviest area of recent growth is located south of US 30 around Crown Point, Merrillville and Winfield. Winfield's development has been considerable since its incorporation in 1993. Much of the development in the watershed appears to have occurred within municipal boundaries and not in unincorporated areas. However, this observation does not take into account any annexation that may have occurred.

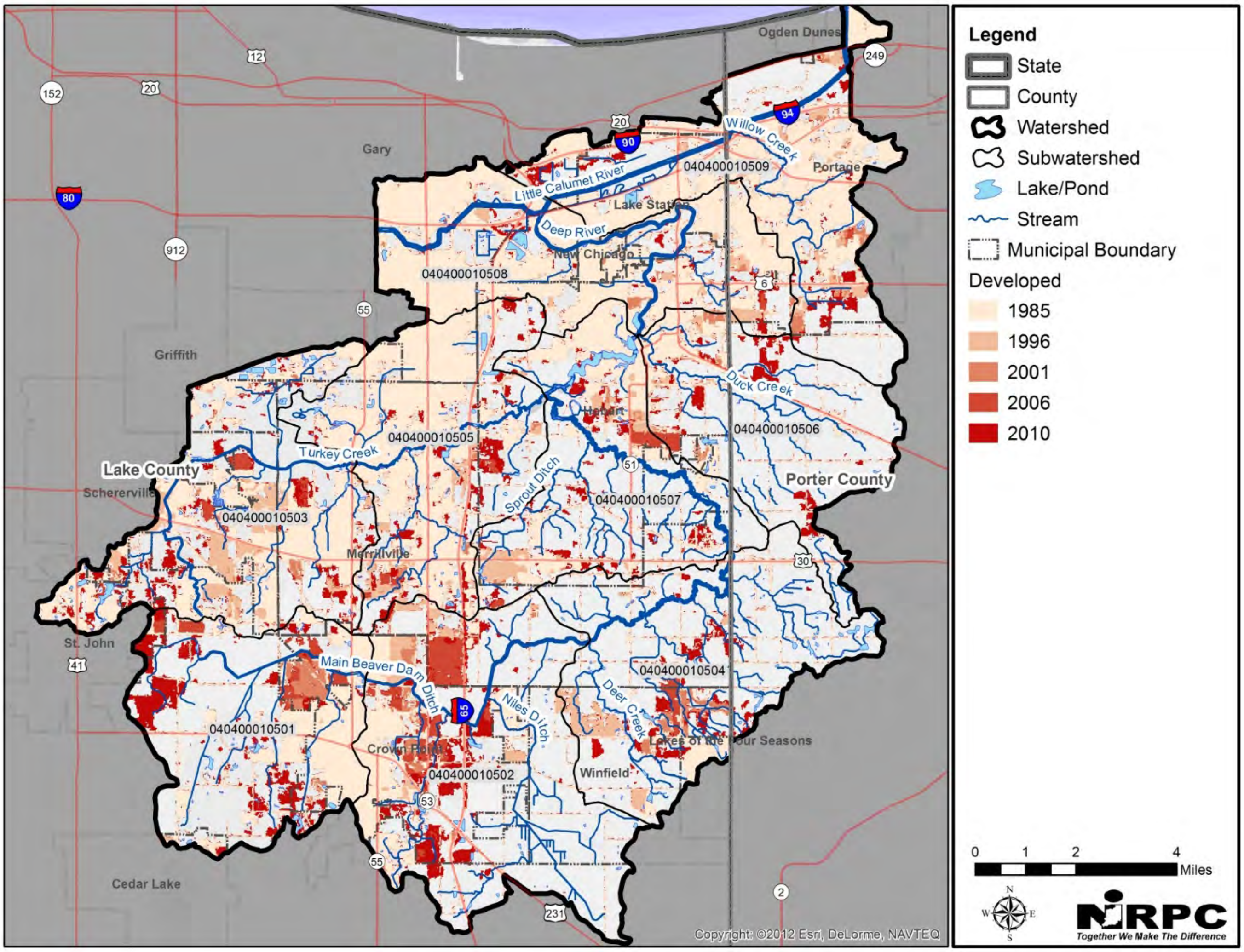


Figure 45 Successive Development Pattern for Watershed (1985-2010)

2.7 Other Planning Efforts

There are a number of past and current projects and other planning efforts that complement components of this watershed plan watershed plan.

Stakeholder Concerns Related to Other Planning Efforts:

- **Coordination amongst municipalities, businesses, and residents**
- **Maintenance of existing plans**
- **Lack of common goals/ manage for competing outcomes**
- **Enforcement of existing regulations to protect stream health**
- **Not enough inspection and monitoring**
- **Reconciling need for drainage/flood control with water quality and habitat**

2.7.1 Total Maximum Daily Load Reports

A Total Maximum Daily Load (TMDL) calculates the maximum amount of a pollutant that can enter a waterbody and still have that waterbody meet water quality standards. The load for the particular pollutant for which the TMDL is developed (ex. *E. coli*) is allocated towards point and nonpoint sources. A TMDL also includes a margin of safety to account for uncertainty. The following formula is used to calculate the TMDL where WLA is the sum of wasteload allocations (point sources), LA is the sum of load allocations (nonpoint sources and background), and MOS is the margin of safety.

$$\mathbf{TMDL = \Sigma WLA + \Sigma LA + MOS}$$

The TMDL process offers an excellent opportunity to identify and restore water quality and aquatic life in streams, rivers, and lakes, as well as enhance the involvement of watershed residents and stakeholders in water quality issues. Other potential benefits of the TMDL process include:

- Encourages the development of a consistent framework for conducting water quality studies
- Defines existing impairments and pollution sources, quantifies source reductions, and sets comprehensive restoration strategies to meet water quality standards
- Provides a framework for assessing future impacts to water quality
- Accelerates the schedule at which impaired waters are addressed through more effective coordination of existing and future resources among local entities, state, and federal environmental agencies
- Provides a basis for revising local regulations (e.g., zoning and sub-division) and developing performance-based standards for future development
- Facilitates the incorporation of TMDL schedules and implementation activities into local government water plans

An *E. coli* TMDL for the Little Calumet River and Portage Burns Waterway was completed in 2004 by Earth Tech. Analysis of pollutant loads indicated that nonpoint source pollution was the dominant cause of the water quality impairment. The report also found that E. coli impairs water quality in the Little Calumet and Portage Burns Waterway even without the impact of CSOs. Estimated loads under wet conditions were not that much different from those estimated for drier conditions in the more developed western portion of the study area, including Deep River. A 95% reduction in pollutant loads from nonpoint sources is needed in wet conditions and 80% in dry conditions according to the report. Sources of E. coli in the West Branch Little Calumet River/ Portage Burns Waterway included urban nonpoint, illicit discharges, bacteria laden sediments, and wildlife.

The Indiana Department of Environmental Management completed a TMDL study for the Deep River-Portage Burns Waterway Watershed in 2014 (Figure 67). The TMDL was developed for *E. coli*, phosphorus, dissolved oxygen, impaired biotic communities, and siltation. Exceedances of water quality standards and target values often occurred across low to high stream flow conditions at many sites indicating the contribution of both point and nonpoint sources. Through the load duration curve approach, IDEM determined that load reductions for the parameters of concern are needed for specific flow conditions; the critical conditions (the periods when the greatest reductions are required) vary by parameter and location (Table 50 in the TMDL report).

The following table summarizes the percent reductions needed for total phosphorus, total suspended solids, and *E. coli* based on the highest observed concentrations to meet the TMDL. Dissolved oxygen is presented as the percentage below the water quality standard based on the minimum observed concentration. IDEM requires that load reductions in this plan be at least as stringent as those called for in the TMDL.

Subwatershed	IDEM Station #	Site #	DO % Below WQS	TP % Reduction	TSS % Reduction	*E. coli* % Reduction
Headwaters Main Beaver Dam Ditch	LMG-05-0022	27	72%	59%	32%	35%
	LMG-05-0020	25	83%	29%	0%	43%
	LMG-05-0021	26	87%	52%	66%	70%
	LMG-05-0019	24	92%	14%	0%	82%
Main Beaver Dam Ditch	LMG-05-0018	23	26%	82%	0%	37%
	LMG-05-0015	18	0%	53%	82%	70%
	LMG-05-0036	22	22%	0%	60%	66%
	LMG-05-0017	21	94%	77%	89%	0%
	LMG-05-0016	20	86%	0%	0%	63%
Headwaters Turkey Creek	LMG-05-0024	19	0%	0%	0%	65%
	LMG-05-0027	22	0%	0%	64%	1%
	LMG-05-0023	28	71%	89%	77%	70%
	LMG-05-0025	30	60%	0%	0%	0%
	LMG-05-0026	31	49%	0%	0%	58%
	LMG-05-0028	33	64%	0%	32%	71%
Deer Creek- Deep River	LMG-05-0035	19	15%	35%	67%	54%
	LMG-05-0014	17	0%	0%	0%	53%
	LMG-05-0034	16	0%	0%	73%	67%
	LMG-05-0013	15	0%	0%	0%	66%
	LMG-05-0031	36	0%	0%	63%	82%

Subwatershed	IDEM Station #	Site #	DO % Below WQS	TP % Reduction	TSS % Reduction	*E. coli* % Reduction
City of Merrillville- Turkey Creek	LMG-05-0030	35	0%	19%	80%	77%
	LMG-05-0029	34	90%	23%	70%	33%
Duck Creek	LMG-05-0032	11	76%	65%	69%	81%
	LMG-05-0009	9	5%	0%	0%	62%
	LMG-05-0010	10	0%	0%	0%	65%
Lake George- Deep River	LMG-05-0012	14	59%	14%	83%	46%
	LMG-05-0011	12	48%	0%	3%	65%
	LMG-30-0008	8	3%	0%	0%	62%
	LMG-05-0033	13	0%	57%	89%	76%
Little Calumet River- Deep River	LMG-05-007	6	0%	0%	0%	0%
	LMG-05-006	5	17%	0%	0%	0%
	LMG-05-0008	7	49%	0%	9%	64%
Willow Creek- Burns Ditch	LMG-05-0002	1	22%	0%	3%	57%
	LMG-05-0004	3	0%	0%	62%	81%
	LMG-05-0003	8	0%	0%	0%	83%

Table 31 Load reductions required from TMDL

2.7.2 Watershed Management Plans

Two previous watershed management plans were previously developed within the current Deep River-Portage Burns Waterway watershed boundary. These include the 2002 Deep River-Turkey Creek Watershed Management Plan and the 2008 West Branch Little Calumet River Watershed Management Plan (Figure 2). The current watershed planning effort was undertaken largely because of large changes in land use/land cover and persisting water quality issues. Additionally, neither of the two previous plans had an active watershed group or committee structure in place once they were completed to coordinate implementation watershed wide.

The following sections provide brief descriptions and information from these plans.

2.7.2.1 *Deep River-Turkey Creek Watershed Management Plan*

The Deep River-Turkey Creek Watershed Management plan was coordinated by the City of Hobart and completed in 2002. The plan was developed at the 11-digit watershed scale (HUC 04040001030), covering an area of approximately 124 mi^2 in Lake and Porter Counties. However the plan's primary focus was the Deep River-Lake George Dam subwatershed (HUC 04040001030060).

According to the plan there appeared to be a strong correlation between pollutant loading (total suspended solids, nutrients, and *E. coli*), potential soil erodibility ratings, and the presence of highly erodible lands in the Deep River subwatersheds. In the Turkey Creek subwatersheds, *E. coli* concentrations and poor in-stream habitat quality showed a correlation with urban land uses and channel modifications. Streambank erosion was also identified as an issue partly due to riparian zone and floodplain modifications.

Water quality improvement and protection goals identified in the plan included:

1. Minimize deposition of new sediments into Lake George
   - Reduce sedimentation in Lake George by 75% over the next 5 years via BMP treatment train principle for both urban/ rural areas
2. Improve water quality in Deep River/Turkey Creek watersheds
   - Reduce sediment, nutrient, and *E. coli* loads in DR/ TC upstream of Lake George by 15% over the next 5 years
   - Improve in-stream habitat in DR/ TC by 15% over the next 5 years
3. Improve education about water quality problems/concerns
   - Educate 75% of Lakeshore residents about watershed protection efforts for Lake George over the next 2 years
   - Educate 75% of community officials in the DR/ TC watersheds about watershed protection efforts for Lake George over the next 2 years
4. Eliminate illegal discharges
   - Conduct dry weather screening/ surveys of 100% of MS4 outfalls into Lake George/ tributaries over the next 5 years – Hobart
   - Conduct dry weather screening/ surveys of 100% of MS4 outfalls in DR/ TC watersheds over the next 5 years – All Designated SW Phase II Entities
   - Conduct dry weather screening/ surveys of 25% of outfalls in non-MS4 areas in DR/ TC watersheds over the next 5 years
5. Eliminate failing septic systems
   - Survey 30% of non-sewered areas to identify failing septic systems within municipal jurisdictions over the next 5 years
   - Implement appropriate community solutions for 10% of problematic septic systems over the next 5 years
6. Promote consistency among communities developing storm water management programs
   - Develop joint storm water/ water quality education programs w/ communities in DR/ TC watershed over the next 5 years
   - Develop consistent storm water ordinances w/ communities in DR/ TC watershed over the next 5 years

A review of the implementation measures and strategies in the plan show a mix of both structural and non-structural practices. However, a number of the implementation measures (ex. developing storm water programs- ordinances, enforcement, and illicit discharge detection and elimination) are now consistent with MS4 requirements and have therefore have been or should be met. At the time the Deep River-Turkey Creek WMP was being developed, Rule 13 had not yet come into effect.

The plan does not specifically identify critical areas where implementation is needed. Rather discretion is left to the municipalities. However the plan does encourage the following restoration strategies throughout the watershed where opportunities present themselves:

- Wetland and tree conservation
- Minimizing impervious surfaces
- Linear parks and open space preservation
- Constructed wetlands, bio-filters, catch basin inserts, buffer/ filter strips, etc.
- Shoreline and streambank bioengineering stabilization
- Native shoreline plantings
- Bridge storm water outlet retrofits

- Target BMP's towards highly erodible lands

Besides the implementation of MS4 requirements, a number of plan milestones have been reached including:

- Several hundred feet of Lake George shoreline has been stabilized at Pavese Park and Fred Rose Park using bioengineering techniques
- Streambank stabilization project at Deep River County Park
- Web-based septic system tracking database (ISDH's iTOSS)
- City of Hobart has initiated a sanitary sewer connection program to address known septic system problem areas

2.7.2.2 *West Branch Little Calumet River Watershed Management Plan*

The West Branch Little Calumet River Watershed Management Plan was coordinated by the City of Gary Storm Water Management District and completed in 2008. The plan was developed for three, 14-digit subwatersheds which encompassed the West Branch of the Little Calumet River including the Deep River-Little Calumet River subwatershed (HUC 04040001040020) and Burns Ditch-Willow Creek (HUC 04040001040030) in the current study area. The primary pollutants of concern identified in the plan include *E. coli*, total suspended solids, nitrogen and phosphorus.

The goals identified as part of this plan include:

- Reduce E. coli levels in the Little Calumet River by reducing loads to the River to meet beneficial uses.
- Reduce sediment loads by source reduction strategies and, in priority subwatersheds, through the use of Best Management Practices (BMPs).
- Reduce nutrient loads by source reduction strategies and, in priority subwatersheds, through the use of BMPs.
- Restore, improve, and/or protect floodplains, wetlands, natural areas, and riparian corridors.
- Improve public awareness/knowledge of pollutant loads, sources, and solutions, especially with regard to E. coli, and the impacts and risks associated with them.
- Create an active watershed alliance or conservancy district that facilitates and implements information sharing including ordinances, projects/experiences, and educational materials in a central location.
- Increase river corridor connectivity, river navigability, and public access sites and make the public aware of them.

The following long-term implementation actions were identified for critical areas within the watershed:

- Land acquisition and funding to restore 4,780 acres of wetland
- Install 300 rain gardens in participating communities
- Install 20 green roofs or green parking lots
- Install infiltration BMP's at 10 sites
- Install 2,000 lineal feet of vegetated buffer
- Install 10 retention/detention ponds
- Implement stream and riparian restoration at 5 sites
- Install 5,000 lineal feet of vegetated channel in urban area
- Identify 20 existing priority wetland and riparian restoration areas and mitigate/restore at least 10

- Acquire at least 10 existing priority wetland and riparian areas through purchase or conservation easement
- Design and construct at least five projects that improve connectivity along river
- Install at least three projects that increase navigability along river
- Acquire land and construct at least 3 new public access sites

A majority of the critical areas identified within the plan occur within the Little Calumet River levee system. While there are likely restoration activities that could occur within this area, this approach does not account for upland sources contributing to observed impairments. This may be just an oversight given that some of the BMPs identified above would be most appropriate for upland urbanized areas (ex. rain gardens and green roofs).

The City of Gary is implementing some of the recommended actions from the watershed plan through the Vacant to Vibrant (V2V) program in the Aetna neighborhood. The Vacant to Vibrant program is a Great Lakes Protection Fund initiative led by Cleveland Botanical Garden in collaboration with project partners in Gary, IN, Cleveland, OH, and Buffalo, NY. The goal of the project is to create joint storm water management / neighborhood recreational assets on small, distributed vacant residential parcels in urban neighborhoods and to measure the effectiveness of these installations as green storm water infrastructure and as tools for neighborhood stabilization. To date, several community raingardens have been installed through the program in the neighborhood. Further information is available at www.cbgarden.org/lets-learn/research/vacant2vibrant.aspx.

Adjacent to the Indiana University Northwest campus, the university is expanding and managing a nature preserve in Gary. The Little Calumet River Prairie & Wetlands Nature Preserve consists of 11 acres of prairie, wetland, and woodland immediately north of the main campus parking lot. Prior to settlement, the site featured the Little Calumet River as it meandered among associated wetlands and low dunes. During settlement, the river was straightened and ditched, and the wetlands filled in and covered with topsoil. The lowest areas still retain water and the whole area is vulnerable to flooding during heavy rain.

The Little Calumet River Prairie & Wetlands is a nature preserve that restores ecological habitats once common in the local area. The Prairie & Wetlands primary goal is to have more than 250 native plant species living on the site. Prior to the intense flood of 2008, that goal had been reached, however due to flooding, plant diversity was diminished. With knowledge gained, the site is now at 200 species and is being partially reworked to better withstand flood conditions. Additional information is available at www.iun.edu/coas/related-information/little-calumet-river-prairie-and-wetlands-preserve.htm.

2.7.3 Municipal Separate Storm Sewer System (Rule 13) & Rule 5 Programs

Municipal Separate Storm Sewer Systems (MS4s) are defined as storm water conveyances owned by a state, city, town, or other public entity that discharges to waters of the United States. Regulated conveyance systems include roads with drains, municipal streets, catch basins, curbs, gutters, storm drains, piping, channels, ditches, tunnels and conduits. The Clean Water Act requires storm water discharges from certain types of urbanized areas to be permitted under the National Pollutant Discharge Elimination System (NPDES) program. Under Phase II, 327 IAC 15-13 (Rule 13) was written to regulate most MS4 entities (cities, towns, universities, colleges, correctional facilities, hospitals, conservancy districts, homeowner's associations and military bases) located within mapped urbanized areas, as delineated by the United States Census Bureau, or, for those MS4 areas outside of urbanized areas, serving an urban population greater than 7,000 people.

MS4 conveyances within urbanized areas have one of the greatest potentials for polluted storm water runoff. The Federal Register Final Rule explains the reason as: "urbanization alters the natural infiltration capacity of the land and generates...pollutants...causing an increase in storm water runoff volumes and pollutant loadings." Urbanization results "in a greater concentration of pollutants that can be mobilized by, or disposed into, storm water discharges."

A review of MS4 entities data from IDEM shows there are twelve municipalities within the watershed that are designated MS4s. These include Cedar Lake, Crown Point, Gary, Griffith, Hobart, Lake Station, Merrillville, New Chicago, Saint John, Schererville, Portage, and Lakes of the Four Seasons (Figure 46). The entirety of Hobart, Lake Station, Merrillville and New Chicago fall within the watershed's boundary. Significant portions of Crown Point, Gary, Griffith, Saint John, Schererville and Portage are also located within the watershed boundary. Very small parts of Cedar Lake and Lakes of the Four Seasons fall within the watershed boundary. Portions of unincorporated Lake and Porter Counties are also designated MS4s.

MS4s are required to develop and implement a Storm Water Quality Management Plan (SWQMP). Two of the most important aspects of the SWQMP are Parts B and C. The SWQMPs are updated periodically for instance when the entities MS4 permit expires and needs to be reissued or when a significant program element is changed.

Part B requires MS4s to collect baseline data to characterize all known receiving waterbodies. The baseline characterization is expected to provide a "snapshot" of existing water quality, determination where improvements need to be made and where BMPs should be utilized, and documentation that an opportunity for the public to give feedback and suggestions was provided. The baseline characterization assessment is to include an evaluation of:

- Land use
- Identification of sensitive areas
- Review of existing and available monitoring data
- Identification of problem areas
- Current structural and nonstructural BMPs

The identification of problems areas and determination of where improvements need to be made and BMPs utilized is particular importance for the watershed management process.

Part C outlines the priorities, goals, and implementation strategies that the MS4 will utilize to improve water quality. Each MS4 must address six minimum control measures in their Part C. These include:

- Public education and outreach
- Public participation and involvement
- Illicit discharge detection and elimination
- Construction site storm water runoff control
- Post-construction storm water runoff control

- Municipal operations pollution prevention and good housekeeping

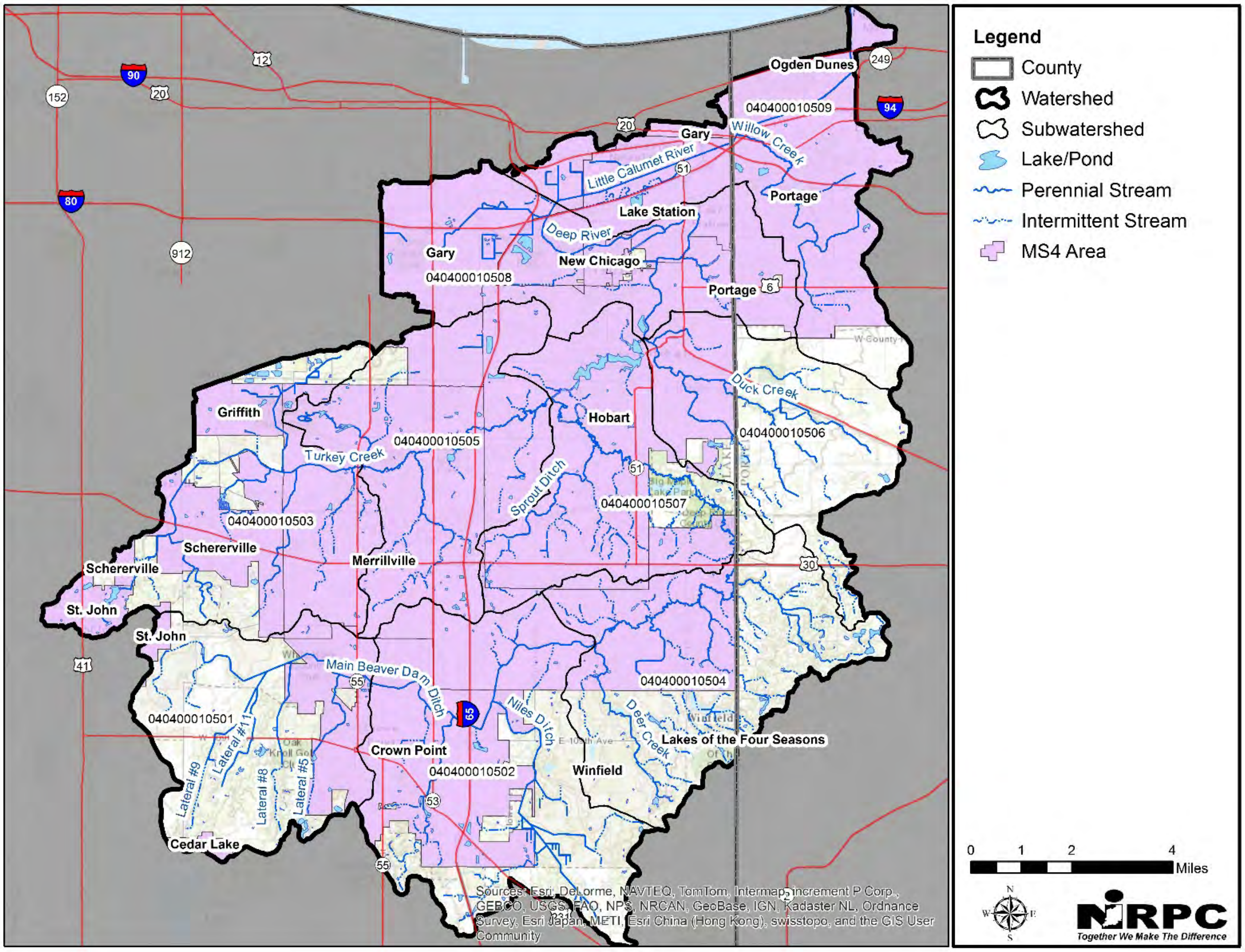


Figure 46 MS4 areas

Areas outside of the MS4 boundaries are subject to Rule 5 (327 IAC 15-5). Rule 5 is intended to reduce pollutants, principally sediment, that are a result of soil erosion and other activities associated with construction land-disturbing activities. IDEM administers a general permit program in cooperation with local Soil & Water Conservation Districts that targets construction activities that result in land disturbance of one acre or more. Construction plans are submitted to the county Soil & Water Conservation Districts for review.

The MS4, Rule 5 and Section 319 programs are both aimed at reducing storm water runoff pollution. However the MS4 and Rule 5 programs are regulatory in nature while the 319 program is generally considered a voluntary assistance program. While each of the programs are aimed at reducing runoff pollution, 319 grant funds cannot be used to pay for the storm water pollution controls required by the MS4 area's Storm Water Quality Management Plan (SWQMP).

MS4s share many of the same goals as watershed groups do. While some separation is necessary, MS4 requirements are not so broad that they preclude work from being done in the watershed. Familiarity with the individual MS4 entities and its requirements is paramount. Partnership opportunities typically exist. The greatest opportunities for collaboration exist in public education and outreach, public participation and involvement, and post-construction storm water runoff control. Using a watershed scale approach in implementing education and outreach messaging and activities usually goes above and beyond what an individual MS4 entity would include in its SWQMP. Implementing post-construction runoff control measures as retrofits in existing developed areas also typically goes above and beyond permit requirements under the MS4 rule.

2.7.4 Combined Sewer Overflow Long Term Control Plans

Combined sewer overflow communities are required to submit Long Term Control Plans (LTCP) to IDEM as an NPDES permit requirement. IDEM's CSO program augments the NPDES municipal permitting program by implementing a strategy for the maintenance and management of combined sewer collection systems. The primary objective of this group is to insure the minimization of impacts to waters of the state from CSOs.

CSO controls may be grouped into four broad categories: operation and maintenance practices, collection system controls, storage facilities, and treatment technologies. Most of the early efforts to control CSOs emphasized "gray infrastructure," which describes traditional practices for storm water management that involve pipes, sewers and other structures involving concrete and steel. One of the most commonly implemented types of gray infrastructure is off-line storage. Off-line storage facilities store wet weather combined sewer flows in tanks, basins, or deep tunnels located adjacent to the sewer system until a wastewater treatment plant has the capacity to treat the stored wastewater.

There are two CSO communities, which include the Cities of Crown Point and Gary, that have outfalls in the watershed (Figure 37). Based upon information from IDEM's Municipal NPDES Permits Section, LTCP's have been submitted by the Crown Point Waste Water Treatment Plant (WWTP) and Gary WWTP. Crown Point's LTCP was approved in 2008. Gary's LTCP was still awaiting approval at the time this watershed plan was drafted. Crown Point has implemented a number of tasks included in their LTCP since its approval. These include construction of Anderson Pond (2008), floatable/solids controls (2008), and high priority inflow/infiltration (I/I) reduction. WWTP filter system replacement and biosolids facility improvements are planned between 2015 and 2016 along with further inflow/infiltration reductions.

An alternative to the reliance on conventional control approaches is the incorporation of green infrastructure. Green infrastructure practices mimic natural hydrologic processes to reduce the quantity and/or rate of storm water flows into the combined sewer system (CSS). By controlling storm water runoff through the processes of infiltration, evapotranspiration, and capture and use (rainwater harvesting), green infrastructure can help keep storm water out of the CSS. Although green infrastructure alone is often unlikely to fully control CSOs, it may be able to reduce the size of more capital-intensive, "downstream" gray infrastructure control measures, such as storage facilities or treatment technologies.

Green infrastructure also supports the principals of Low Impact Development (LID), an approach to land development (or re-development) that works with nature to manage storm water as close to its source as possible. Green infrastructure can be utilized at varying scales—both at the site and watershed level. For example, small source control practices such as rain gardens, bioswales, porous pavements, green roofs, infiltration planters, trees, and rainwater harvesting can fit into individual development, redevelopment or retrofit sites. Larger scale management strategies such as riparian buffers, flood plain preservation or restoration, open space, wetland and forest preservation and restoration, and large infiltration systems can be used at the subwatershed or watershed level.

More information about incorporating green infrastructure into CSO Long Term Control Plans is available through the U.S. EPA's Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow Control www.epa.gov/sites/production/files/2015-10/documents/greening_cso_plans_0.pdf.

Inclusion of green infrastructure implementation strategies could be a common thread linking the Deep River-Portage Burns Waterway Watershed Plan and the CSO community Long Term Control Plans.

2.7.5 Comprehensive Watershed Plan: Little Calumet River- Lake County Basin (LCRBDC)

This plan is in part a result of legislation passed in 2012 under House Bill 1264 which greatly expanded the Little Calumet River Basin Development Commission's responsibilities beyond just the upkeep of the Little Calumet River levee system. The new law introduced an annual fee for all property owners within the "Little Calumet River Watershed". These funds can be used for expenses directly related to the operation, repair and maintenance of flood protection systems within the entire project area which includes the Lake County Portion of the Deep River-Portage Burns Waterway watershed (Figure 4).

A primary objective of the plan, which was completed in August 2013, was to identify opportunities within the watershed that improve the quality of life by reducing flooding and improving recreational and environmental aspects within the watershed. Flooding, recreational use, and environmental quality are also public concerns that have been identified here in the Deep River-Portage Burns Waterway Watershed Plan.

The plan's project consulting team interviewed local stakeholders who included municipal and county representatives and U.S. Army Corps of Engineer technical staff to develop a list of opportunities within the Little Calumet River watershed. Project opportunities were classified as regional, semi-regional, local, maintenance or operational. The focus was on conveyance and storage to reduce flooding impacts. Both conveyances and storage play important roles in a watershed. They can both keep an area from flooding if managed properly. Conveyances play the important role of carrying storm water to the outfall. Storage plays a vital role in the attenuation of downstream flood flows, the recharge of groundwater, enhancement of water quality, and enhancement of wildlife habitat. Conveyances include streams, channels, waterways, culverts, sewers, and even overland routes (e.g. roadways, fields). Storage occurs in floodplains, depressional areas, detention basins, retention basins, and natural and constructed wetlands

The following table adapted from the Comprehensive Watershed Plan outlines opportunities within the Deep River-Portage Burns Waterway watershed. Further details about project opportunities is available at http://littlecalriverbasin.org/pdf/WatershedStudy.pdf.

Summary of Regional Opportunities					
Unique ID	**Community**	**Major Project Name**	**Minor Project Name**	**Major Watershed**	**Minor Watershed**

General 2	General	Little Calumet River/Deep River- Confluence Improvement	Storage Adjacent to LCR at I-65/I-80	Little Calumet River	Little Calumet River
General 4	General	Little Calumet River/Deep River- Confluence Improvements	Burns Ditch Conveyance Improvements	Little Calumet River	Little Calumet River
General 5	General	Little Calumet River/Deep River- Confluence Improvements	Deep River Deep Tunnel	Deep River	Deep River
Lake Station 3	Lake Station	Little Calumet River/Deep River- Confluence Improvements	Deep River Dam Rehabilitation	Deep River	Deep River
Lake Station 7	Lake Station	Little Calumet River/Deep River- Confluence Improvements	Lake George Dam Control Policy	Deep River	Deep River
LCRBDC 15	LCRBDC	Little Calumet River/Deep River- Confluence Improvements	I-65/I-94 Interchange Storage Area Repairs	Little Calumet River	Deep River

Summary of Semi-Regional Opportunities

Unique ID	Community	Major Project Name	Minor Project Name	Major Watershed	Minor Watershed
Lake County 7	Lake County	Beaver Dam Ditch- Storage	Beaver Dam Ditch- Lateral 1 (Regional Detention Basin)	Deep River	Beaver Dam Ditch
LCHWY 14	LCHWY	Deep River Conveyance- Bridge Reconstruction	Bridge 254 Reconstruction	Deep River	Lake George
LCHWY 15	LCHWY	Deep River Conveyance- Bridge Reconstruction	Bridge 252 Reconstruction	Deep River	--
LCHWY 18	LCHWY	Deep River Conveyance- Bridge Reconstruction	Bridge 89 Reconstruction	Deep River	--
LCHWY 19	LCHWY	Deep River Conveyance- Bridge Reconstruction	Bridge 98 Reconstruction	Deep River	--
LCHWY 20	LCHWY	Deep River Conveyance- Bridge Reconstruction	Bridge 92 Reconstruction	Deep River	Niles Ditch
Winfield 1	Winfield	Deep River- Storage	Hidden Creek Subdivision Regional Stormwater Project	Beaver Dam	Hidden Creek
LCHWY 3	LCHWY	Turkey Creek Conveyance- Bridge Reconstruction	Bridge 116 Reconstruction	Turkey Creek	--
LCHWY 4	LCHHWY	Turkey Creek Conveyance- Bridge Reconstruction	Bridge 113 Reconstruction	Turkey Creek	--
Lake County 1	Lake County	Turkey Creek Storage	Upper Turkey Creek Stormwater Storage Project	Turkey Creek	--
Lake County 4	Lake County	Turkey Creek Storage	Upper Turkey Creek Overbank Detention	Turkey Creek	--
Lake County 5	Lake County	Deep River Storage	121^{st} and Iowa Drainage	Deep River	Niles Ditch

			Improvements w/ NRCS		
Merrillville 1	Merrillville	Turkey Creek Storage	Lincoln Gardens and Southbrook Subdivision Drainage Project	Deep River	Kaiser Ditch
Merrillville 2	Merrillville	Turkey Creek Storage	Country Club Heights and Meadowdale Subdivision Drainage Project	Deep River	Griffith Lateral 6

Summary of Local Opportunities

Unique ID	Community	Major Project Name	Minor Project Name	Major Watershed	Minor Watershed
Hobart 20	Hobart	Deep River Storage	Northwinds Regional Detention Basin	Deep River	--
Hobart 21	Hobart	Deep River Storage	Nob Hill Regional Detention Basin	Deep River	--
Hobart 14	Hobart	Turkey Creek Storage	Evergreen Memorial Park Storage	Turkey Creek	--
Schererville 6	Schererville	Turkey Creek Storage	Potential Stormwater Storage Project	Turkey Creek	--
Schererville 7	Schererville	Turkey Creek Storage	Potential Stormwater Storage Project	Turkey Creek	--
Schererville 8	Schererville	Turkey Creek Storage	Potential Stormwater Storage Project	Turkey Creek	--
Crown Point 3	Crown Point	--	Stillwater Subdivision Drainage Improvements	Beaver Dam	Crooked Creek
New Chicago 4	New Chicago	--	Culvert Improvements under Wisconsin St. at Huber Blvd.	Deep River	--
New Chicago 5	New Chicago	--	Twin Oaks Park Pond Improvements	Deep River	--
Hobart 4	Hobart	--	"Stinky Creek"	Deep River	Stinky Creek
Hobart 5	Hobart	--	Brickie Bowl Flooding	Deep River	Duck Creek
Hobart 6	Hobart	--	Barrington Ridge Stormwater Drainage Improvements	Deep River	Duck Creek
Hobart 7	Hobart	--	61st Ave. and Wisconsin St. Regional Storage	Deep River	Lake George
Hobart 8	Hobart	--	Preserves Storage	Deep River	Turkey Creek
Hobart 9	Hobart	--	Liverpool Rd. Constructed Wetland	Deep River	--

Lake Station 6	Lake Station	--	Residential Drainage Improvements between 27th and 29th Avenues	Deep River	--
Summary of Maintenance Opportunities					
Unique ID	**Community**	**Major Project Name**	**Minor Project Name**	**Major Watershed**	**Minor Watershed**
LCRBDC 10	LCRBDC	Culvert Repair/Maintenance	Culvert Repair between Chase and Grant	Deep River	--
LCRBDC 11	LCRBDC	Little Calumet River-Conveyance Opportunity	Aerial Sanitary Sewer East of Broadway	LCR	LCR
Hobart 2	Hobart	Dredging	Lake George Dredging	Turkey Creek	Turkey Creek
Merrillville 3	Merrillville	General Waterway Stabilization and Sediment Control Opportunities	Turkey Creek Stabilization	--	--
Hobart 15	Hobart	Stabilization and Sediment Control Opportunities	Sediment Control for Deep River and Turkey Creek	Deep River	--
Hobart 16	Hobart	Stabilization and Sediment Control Opportunities	Lake George Shoreline Stabilization	--	Niles, Crooked Creek
Crown Point 5	Crown Point	Waterway Clearing Opportunities	Beaver Dam Ditch Maintenance	Deep River	Deep River
Lake County 6	Lake County	Waterway Clearing Opportunities	Unregulated Deep River Clearing	--	--

Table 32 LCRBDC Comprehensive Watershed Plan project opportunities to improve conveyance and storage

2.7.6 Indiana Coastal Nonpoint Pollution Control Plan

As a part of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA), Congress created a stand-alone provision, Section 6217, which requires that states and territories with approved coastal management programs develop a coastal nonpoint pollution control program to address water quality impairment of coastal waters. Indiana's Coastal Nonpoint Pollution Control Plan identifies the programs and enforceable authorities that the state uses to control nonpoint pollution in each of six nonpoint source categories which include:

- Agriculture
- Forestry
- Urban and Rural Areas
- Marinas
- Hydromodification
- Wetlands, Riparian Areas and Vegetated Treatment Systems

Watershed management is a key implementation mechanism for the Indiana Coastal Nonpoint Program and its plan. IDEM requires that watershed plans developed in the Coastal Program area be consistent with the Coastal Nonpoint Program. While there is no formal review process or checklist that check for consistency, NIRPC has and will continue to coordinate with the Coastal Program to assure consistency between this watershed plan and the Coastal Nonpoint Program plan. Further details about the Coastal Nonpoint Pollution Control Plan can be found on the DNR's Lake Michigan Coastal Program website http://www.in.gov/dnr/lakemich/6084.htm.

2.7.7 Regional Land Use Planning

In 2011, NIRPC completed the Northwest Indiana 2040 Comprehensive Regional Plan (CRP). It was developed as a comprehensive, citizen-based regional vision to guide the development of land use and transportation programming in Northwest Indiana. It is a policy program with strong coordination and implementation elements. The CRP deals largely with multijurisdictional needs and opportunities that no single entity can manage or effect on its own. The means of enhancing the region's prosperity and quality of life, improving mobility, supporting communities and realizing environmental justice were among the key considerations during the CRP's development.

While the CRP's vision, goals and objectives provide a critical policy framework for the CRP, the Growth and Revitalization Vision presents a physical expression of the vision and goals combined. The Growth and Revitalization Vision was developed through the CRP's scenario planning process. The rationale behind the development of the Growth and Revitalization Vision and, by extension, the growth of Northwest Indiana through 2040, is based on the following principles:

- Support urban reinvestment
- Ensure environmental justice/social equity
- Protect natural resources and minimize impact to environmental features and watersheds
- Integrate transportation and land use

Using a watershed approach has been recognized as an effective way to deal with often complex water quality and quantity issues. Therefore the development and implementation of local watershed management plans was identified as a key strategy to help the region meet a number of the CRP goals and objectives. Additionally the CRP called for the need to invest in green infrastructure as a means of protecting and connecting environmentally sensitive natural areas, managing storm water and attenuating flood impacts, and increasing passive recreational opportunities.

2.7.8 Northwest Indiana Greenways & Blueways Plan

The goals of the Northwest Indiana Greenways & Blueways Plan include:

- Create a vision for greenway preservation and water trail development in Northwest Indiana
- Create a conversation among stakeholders on the attributes in greenway development and conservation
- Provide an interactive resource for local and county jurisdictions to utilize as they develop their visions and plans and negotiate development proposals that affect their remaining open space corridors
- Facilitate active discussion on potential water trail opportunities

Water trail opportunities have been identified along portions of Beaver Dam Ditch, Turkey Creek and Deep River. The Northwest Indiana Regional Planning Commission is will be updating this plan in 2016. Recreational access and the potential impacts that stream impairments have on recreational use were identified as public concerns for the watershed.

2.7.9 Wellhead Protection Program

In Northwest Indiana a vast majority, approximately 97%, of the public water supply comes from Lake Michigan. However, in the rural areas of the watershed many residents and business rely on groundwater.

IDEM's Ground Water Section administers the Wellhead Protection Program, which is a strategy to protect ground water drinking supplies from pollution. The Safe Drinking Water Act and the Indiana Wellhead

Protection Rule (327 IAC 8.4-1) mandates a wellhead program for all Community Public Water Systems. The Wellhead Protection Programs consists of two phases. Phase I involves the delineation of a Wellhead Protection Area (WHPA), identifying potential sources of contamination, and creating management and contingency plans for the WHPA. Phase II involves the implementation of the plan created in Phase I, and communities are required to report to IDEM how they have protected ground water resources.

Due to recent legislation wellhead protection area locations are no longer spatially available. However, a data request to IDEM's Ground Water-Drinking Water sections shows that there are six wellhead protection areas within the Deep River-Portage Burns Waterway watershed. Three of these have been modeled (systems that pump over 100,000 GPD) while the remaining three are 3,000-foot fixed radius (systems that pump less than 100,000 GPD) protection areas. Additionally there are at least 58 active drinking water wells within the watershed. Of these, 13 are community drinking water wells, nine are non-transient non-community, and 35 are transient non-community.

- Community: Serves at least 15 service connections used by year-round residents or regularly serves 25 year-round residents.
- Non-Transient Non-Community: Serves at least the same 25 non-residential individuals during 6 months of the year.
- Transient Non-Community: Regularly serves at least 25 non-residential individuals (transient) during 60 or more days per year.

The Wellhead Protection Program is relevant to the Deep River-Portage Burns Waterway Watershed Plan because groundwater and drinking water quality were identified as public concerns.

2.7.10 Indiana Wetland Program Plan

The Indiana Wetland Program Plan was coordinated by the Indiana Department of Environmental Management (IDEM). The intent of the plan is to guide continued wetland conservation and restoration. Like the Deep River-Portage Burns Waterway Watershed Restoration Plan, the Indiana Wetland Program Plan is a voluntary plan. It describes what goals a state or tribe wants to achieve related to its wetland resources over time.

The vision of this Indiana Wetland Program Plan is to advance the understanding of the beneficial services that wetlands provide, to promote the restoration and creation of high quality wetlands, and to conserve and protect remaining wetlands. The plan includes priorities, goals, and action items reflecting the opinions and needs of many wetland stakeholders located throughout the state. A number of the goals and action items in the plan reference partner groups like watershed groups. For example one of the goals calls for increasing wetland acreage and functions by targeting restoration of key properties and leveraging financial resources between agencies and partner organizations.

The Indiana Wetland Program Plan is available at www.in.gov/idem/wetlands/files/program_plan.pdf.

2.7.11 Hobart Marsh Plan

The Hobart Marsh Plan was completed in 2012 by the City of Hobart. The City was awarded a grant from the DNR Lake Michigan Coastal Program to develop a plan that would help explore future open space, educational and recreational opportunities in the area of Hobart Marsh. A wetland mitigation project required for the USACE Little Calumet River Flood Control Project was a major reason behind the plan's development. A portion of the mitigation will be taking place on approximately 355 acres in the area of Hobart Marsh.

The Hobart Marsh project area is generally flat and has poorly drained soils that are considered good for intensive cropping and topsoil. However the area is also vulnerable to periodic flooding and has highly erodible soils. Lake George and Turkey Creek flow along the southeastern edge of the project area, and fingers of deep ravines reach up into the southern properties of the Hobart Marsh, offering diverse ecosystems and relatively dramatic topography given the flatness of the surroundings.

The City held a series of stakeholder input meetings that included residents, elected officials and the owners of the various managed lands near Hobart Marsh. Connectivity between the mitigation sites and the adjacent open space and recreation areas was considered important by the stakeholders, as was the exploration of shared management opportunities for the agencies with land ownership.

The Hobart Marsh area has been identified as a priority preservation area as part of this watershed plan. Please see Section 10 for more information.

2.7.12 Deep River Flood Risk Management Plan

The Deep River Flood Risk Management Plan was completed in May 2015 for the City of Hobart and Little Calumet River Basin Development Commission by SEH. The primary purpose of this Plan is to evaluate several flood risk management concepts to determine their effectiveness using a detailed hydraulic model. LiDAR-based topographic data and extensive bathymetric survey data were used together to create a significantly more detailed representation of the existing ground surface than was used for previous modeling. Several potential flood risk management alternatives were evaluated including both structural and non-structural options.

A number of findings and risk management alternatives presented in the plan are directly related to the public concerns identified here in the Deep River-Portage Burns Waterway Watershed Plan.

2.7.12.1 *Structural Alternatives*

Levee

Based on inundation mapping a set-back levee was identified a potential flood mitigation alternative in the area between the Deep River dam in Lake Station and the confluence with the Little Calumet River. Levees are a form of hydromodification that need to be planned, operated and maintained to mitigate potential negative impacts to water quality and aquatic habitats. According to the flood risk management plan, if a levee was constructed in this area, interior drainage facilities would need to be introduced to drain interior storm water through the barrier. Currently, there is limited storm sewer infrastructure in this area, with most runoff routed to Deep River through overland flow. Construction of a levee would interrupt this overland drainage pattern and would require construction of a gated storm sewer outlet system and possibly a pump station to convey storm water to Deep River. This could result in the acceleration of pollutant delivery to Deep River.

Deep River Dam in Lake Station

The Deep River dam located in Lake Station was also evaluated as part of the Flood Risk Management Plan. Due to the deteriorated physical condition of the dam, if failure were to occur, it would likely be due to washout at the abutment ends of the sheet pile wall or seepage through the sheet pile wall. If such a failure were to occur during a high flow event, when tailwater inundates the dam, it is unlikely that a significant flood wave would be produced. However, if such a failure were to occur during a low base flow or "sunny day" event, a flood wave would likely result due to the greater differential between the pool and tailwater elevations. This failure mode may be a threat to persons directly below the dam. Additionally, sediment that has accumulated over 70+ years in the upstream pool would be suddenly released.

Given the current condition of the existing dam, two different scenarios were evaluated for the site, one without the dam and one with a new dam that is capable of being used as a drawdown structure. If the existing dam was removed completely, the normal water surface elevation would be lowered nearly 3 feet which would reduce the river from 235 feet to 120 feet in the pool area immediately upstream. This degree of change would impact upstream wetland habitat along the periphery of the impoundment and current recreational uses (i.e. boating and fishing). Replacement of the dam showed minimal benefit in peak water surface elevations for an event similar to the September 2008 flood because of the high tailwater condition.

Floodplain Storage

Three potential areas were identified that could be used to construct flood storage basins which would serve as offline storage. The first storage area considered, Rosser Storage, involves the use of existing Rosser Lake, which is immediately south of the Three Rivers County Park in Lake Station. The second storage area considered is an undeveloped area along the left bank of Deep River between Indiana Street and Arizona Street, north of 35th Avenue. The third storage option considered is agricultural land along the left bank of Deep River immediately upstream of the 37th Avenue Bridge and along the right bank of Deep River immediately downstream of the 37th Avenue Bridge. In order to be used as flood storage basins, significant construction would be required to excavate the areas and construct inlet structures to connect them to Deep River. Based on the modeling results described above, it was determined that for the amount of storage that could be added in this area, addition of floodplain storage in this area would not be beneficial and therefore was not modeled in detail.

2.7.12.2 *Nonstructural Alternatives*

Channel Conveyance

Overbank clearing was evaluated as a means to improve conveyance. The results show that clearing the trees in the overbank area between the CFE railroad bridge and the confluence with the Little Calumet River could reduce the peak water surface elevations by up to approximately 0.8 feet for the September 2008 event. However, such an effort would significantly change the habitat and aesthetics of the Deep River corridor, and may not be economically feasible. The plan noted that while it may not be desirable to clear the overbank areas as described herein, it may be prudent to snag and remove fallen trees which could eventually become floating debris. This section of Deep River is included on the "Outstanding Rivers List for Indiana" by the Natural Resources Commission. Rivers and streams included on this list are considered to have a particular environmental, recreational, or aesthetic interest.

Another option to increase channel conveyance was to widen the channel by excavating to increase the available flow area. This would be most beneficial in an area where the channel narrows and causes a bottle-neck effect. After reviewing the study reach for this type of condition, the most significant channel narrowing was identified at the 37th Avenue Bridge. A field survey showed that rock was placed on the bridge abutments, significantly narrowing the channel through the bridge.

Lake George Sediment Management

The current average lake depth based on the bathymetric survey conducted in 2014 as part of the Flood Risk Management Plan is approximately 3 feet in the two pools immediately east and west of Wisconsin Street, approximately 6 feet for the two pools immediately upstream of the Lake George Dam, and approximately 1.5 feet for the two most upstream pools (not dredged previously). Cross sections of the post-dredging lake bottom from the 2001 record drawings were compared to the 2014 bathymetric data. The comparison shows that approximately 70,000 cubic yards of material has accumulated in the past 14 years. This evaluation also showed that the most significant accumulation occurred in the two pools immediately east and west of Wisconsin Street.

The plan states there is interest in constructing sediment traps upstream of Lake George in order to minimize the sedimentation occurring in the lake. However, calculations showed that the sediment basin(s) would need to be 110 to 230 acres, dependent on average flows, to effectively capture the very fine silt that is currently accumulating in Lake George. In effect, a basin roughly the size of Lake George itself would need to be constructed.

The U.S. Army Corps of Engineers documented in its pre-dredging environmental assessment report that sedimentation will continue to occur in Lake George, causing the lake to become increasingly shallow and converting to wetlands through natural lake succession. Aerial imagery shows that the areas of Lake George which were not dredged in 2000 have already converted back to wetlands. The plan states that when this occurs in the rest of Lake George, the reduced surface area will greatly reduce the sediment removal efficiency and suspended sediment will continue downstream, either settling out in other areas of the Deep River floodplain, or eventually discharging into Lake Michigan. The plan also states that if the sediment settles out in the Deep River floodplain downstream of Lake George, it will result in a decrease in overall floodplain storage and in increased flood risk for this reach.

2.7.12.3 *Green Infrastructure*

The plan states that green infrastructure improvements should be focused in the upstream reaches of the watershed and specifically in the Headwaters Turkey Creek, Headwaters Main Beaver Dam Ditch, and Main Beaver Dam Ditch subwatersheds. The steep rising limb of the 2008 flood hydrograph (provided in Section 3.2 of the plan) demonstrates the quick response of rainfall/runoff in the Deep River watershed. The concept of detaining more runoff in the upper watershed will allow for the lower reaches of the watershed to convey runoff through the system early in the storm thus flattening out the flood hydrograph and potentially dampening the peak flow while also maximizing available storage volume and flow capacity as the runoff from the upper watershed reaches Lake George and the downstream reaches of Deep River.

The plan mentions that care should be taken in siting future detention ponds or significant green infrastructure projects within the lower reaches of the watershed because implementation of some of these techniques could actually adversely impact flooding. The plan states that the key to implementation of green infrastructure in the lower reaches of the watershed, from a hydrologic perspective, is to get the excess storm water out of the system prior to the upstream runoff reaching Lake George. Therefore implementation of smaller green infrastructure projects in the lower watershed would be best built around water quality benefits, but once the water quality volume is exceeded, the excess storm water should be quickly moved into the downstream conveyance system.

2.7.13 Chicago Wilderness Green Infrastructure Vision 2.1

In 2004, the Northeastern Illinois Planning Commission completed a Green Infrastructure Vision (GIV 1.0) for the Chicago Wilderness region. This product identified large resource protection areas and recommended protection approaches including additional land preservation, ecological restoration or development restrictions. These recommendations were based primarily on charrettes that distilled the professional judgment of natural resource experts within Chicago Wilderness.

GIV 2.1 is a refinement of the previous work that is intended to classify and characterize important resources in a consistent and analytically robust manner, as well as to define ecological and human connectivity needs and provide enhanced information to support conservation development decisions. The building blocks of the network are core areas that contain well-functioning natural ecosystems that provide high quality habitat for native plants and animals. The hubs are aggregations of core areas as well as nearby lands that contribute significantly to ecosystem services like clean water, flood control and recreational opportunities. Finally, corridors are relatively linear features that link cores and hubs together, providing essential connectivity for animal, plant and human movement. A full description of the methodologies and results can be found in the REFINEMENT OF THE CHICAGO WILDERNESS GREEN INFRASTRUCTURE VISION FINAL REPORT- JUNE 2012.

The Chicago Wilderness Green Infrastructure Vision is relevant to the Deep River-Portage Burns Waterway Watershed Plan because of the numerous public concerns related to habitat loss, preservation, and water quality benefits associated with protecting, restoring and reestablishing natural areas.

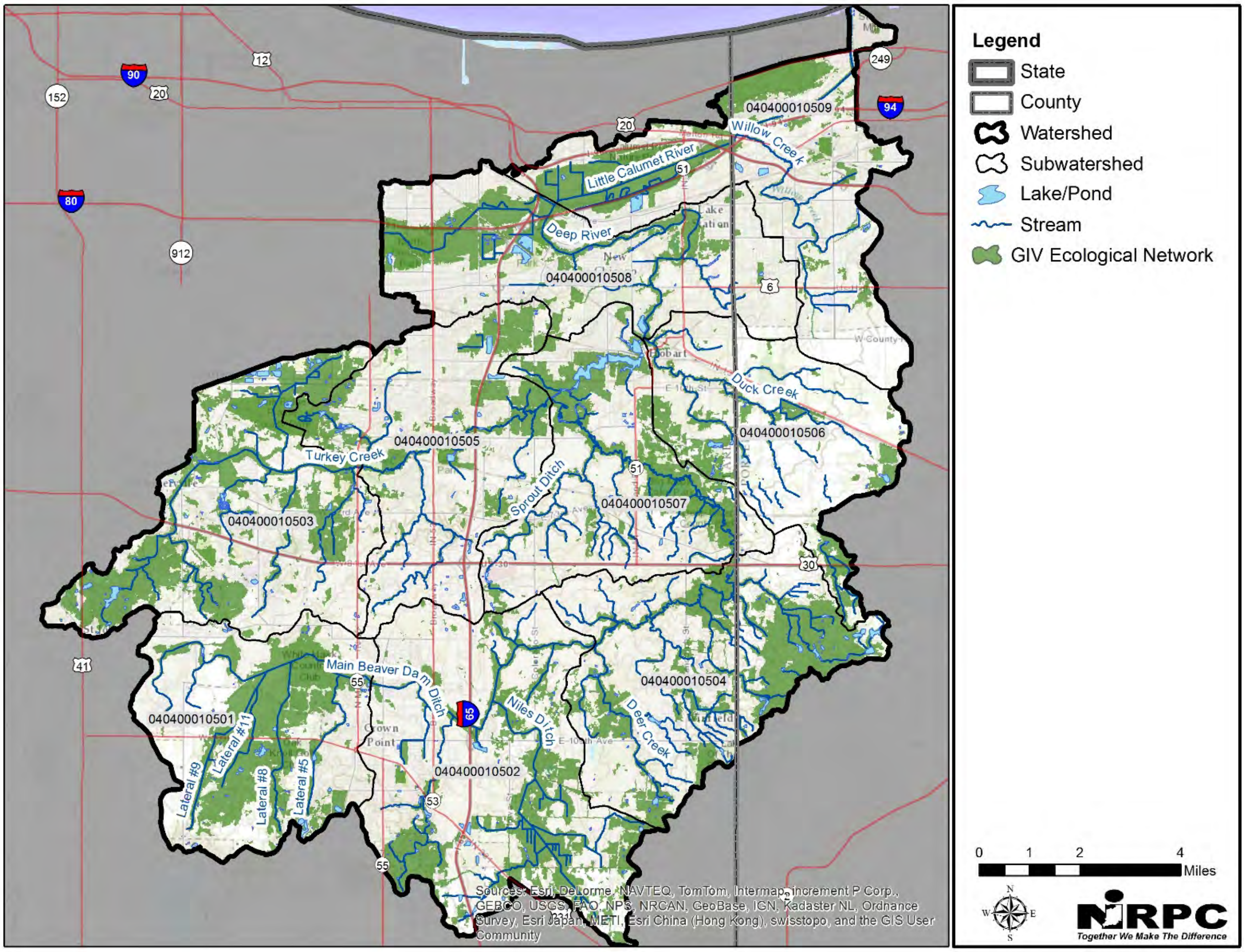


Figure 47 Chicago Wilderness Green Infrastructure Vision Ecological Network

2.7.14 Ecosystem Services Valuation Study for Lake, Porter, and LaPorte Counties

Ecosystem services are the collective benefits from an array of resources and processes that are supplied by nature. Forests, wetlands, prairies, water bodies, and other natural ecosystems support our existence. Green infrastructure is the interconnected network of forests, wetlands, waterways, grasslands, and other natural areas that support native species, maintain natural ecological resources and processes, and contribute heavily to human health and quality of life.

Since 2004, the Chicago Wilderness Green Infrastructure Vision (GIV) has served as a visual representation of the Chicago Wilderness Biodiversity Recovery Plan, but it also served as a spatial representation of the region's ecosystem services. Only recently has it become possible to reliably estimate the contributions the GIV makes to human well-being and to measure the benefits that nature provides us for free. The Chicago Wilderness GIV can be used every day by planners and decision makers at the local, state, regional, and federal levels to prioritize and guide existing planning efforts and evaluate conservation and restoration opportunities that support preserving and managing the GIV network. Balmford et al. (2002)

found that if the values of ecological services are considered, the benefits from conserving natural land gives a return on investment of at least 100 to 1.1.

The Conservation Fund recently completed GIV Version 2.3, which focused on mapping ecosystem services within the Northwestern Indiana Regional Planning Commission (NIRPC) region. This study found that natural ecosystems contribute $8 billion per year in economic value to the three county NIRPC. Using the GIV 2.3 to estimate the monetized social benefit of conservation in comparison with the investments required to protect land can lead to increased awareness of decision makers and the general public regarding the importance and contribution of green infrastructure to the region's quality of life. The approximate value of ecosystem services provided by the GIV within our watershed is:

- $31 million in water purification
- $493 million in water flow regulation/ flood control
- $126 million in groundwater recharge

Ecosystem Service	Description
Water purification	Maintain water quality sufficient for human consumption, recreational uses like swimming and fishing, and aquatic life.
Water flow regulation/ flood control	Maintain water flow stability and protect areas against flooding (e.g., from storms).
Groundwater recharge	Maintain natural rates of groundwater recharge and aquifer replenishment

Table 33 Ecosystem services

2.7.14.1 *Water purification*

The water purification ecosystems helps maintain water quality sufficient for human consumption and support recreational uses like swimming and fishing, and aquatic life. Clean water is essential to public health and ecosystem health. Natural systems can be an effective way to reduce nonpoint source pollution, sediment, nutrients (i.e. nitrogen, phosphorus), bacteria, and other pollutants from water supplies. Natural systems also can help avoid the need to invest in or replace expensive, energy intensive gray infrastructure systems that treat water or manage storm water. Poor water quality can have other significant economic impacts, including beach closures due to high bacteria levels, the need for dredging due to sedimentation, and limits on water-based recreational activities. The Chicago Wilderness GIV helps with water purification that benefits people and wildlife by containing nearly all of wetlands and other open spaces that currently provide this ecosystem service.

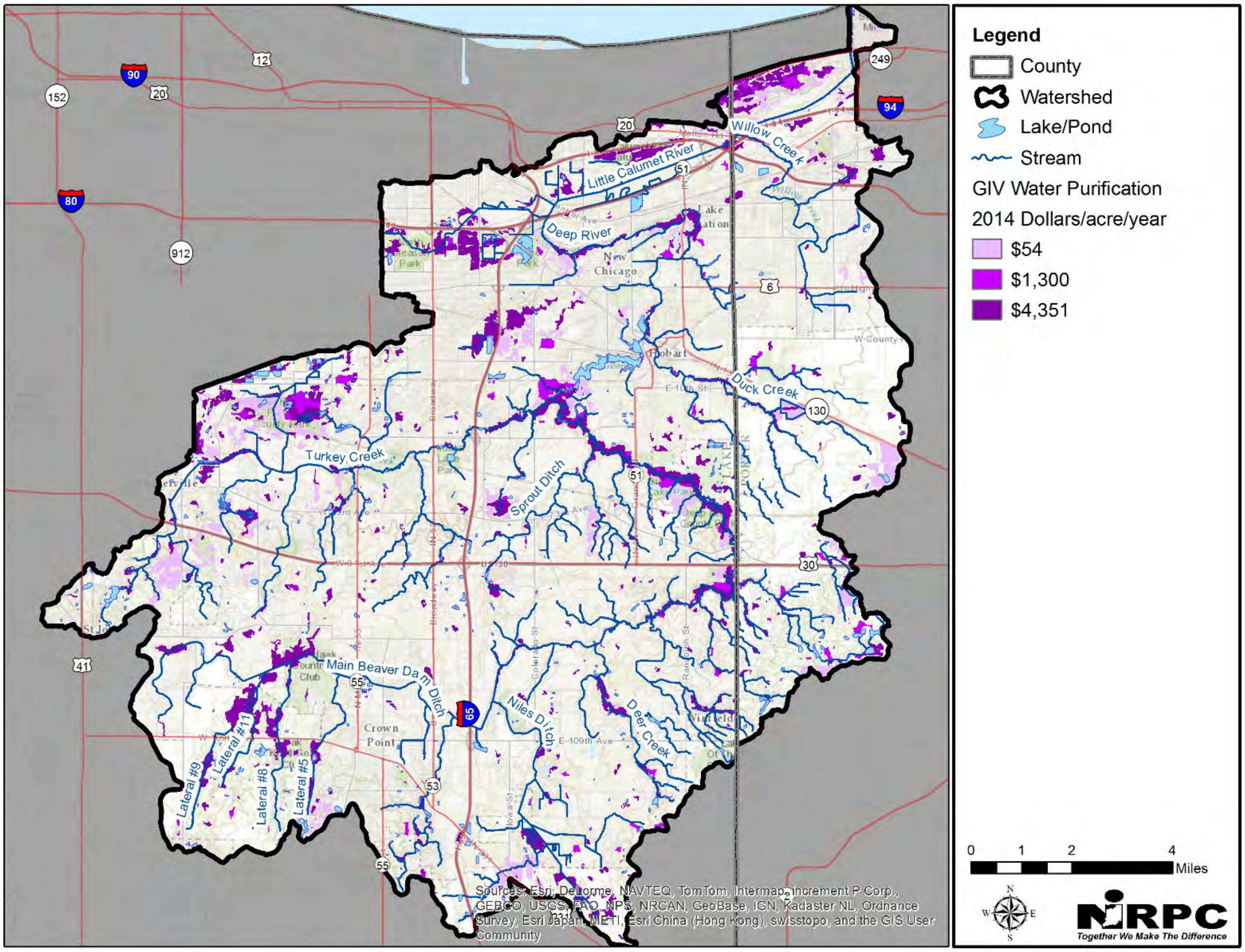


Figure 48 GIV ecosystem services water purification

2.7.14.2 *Water Flow Regulation*

The Water Flow Regulation ecosystem service helps maintain water flow stability and protect human infrastructure against flooding. One way the GIV provides flood control and water flow regulation is through reductions in peak discharges of storm water flows. Maintaining green infrastructure helps ensure that water can infiltrate in the soil and recharge the groundwater rather than enter the combined sewer and storm water systems.

This can help reduce flood damage to community infrastructure and damage to natural hydrology that could result in a loss of native riparian vegetation and loss of wildlife habitat. Fortunately, the GIV contains nearly all of the natural interconnected wetlands and riparian zones that provide this ecosystem service. Natural systems cannot manage all of the flood control needs of communities, but protection of existing green infrastructure can help avoid the problem getting worse in locations where the GIV absorbs flood waters before entering engineered flood control infrastructure.

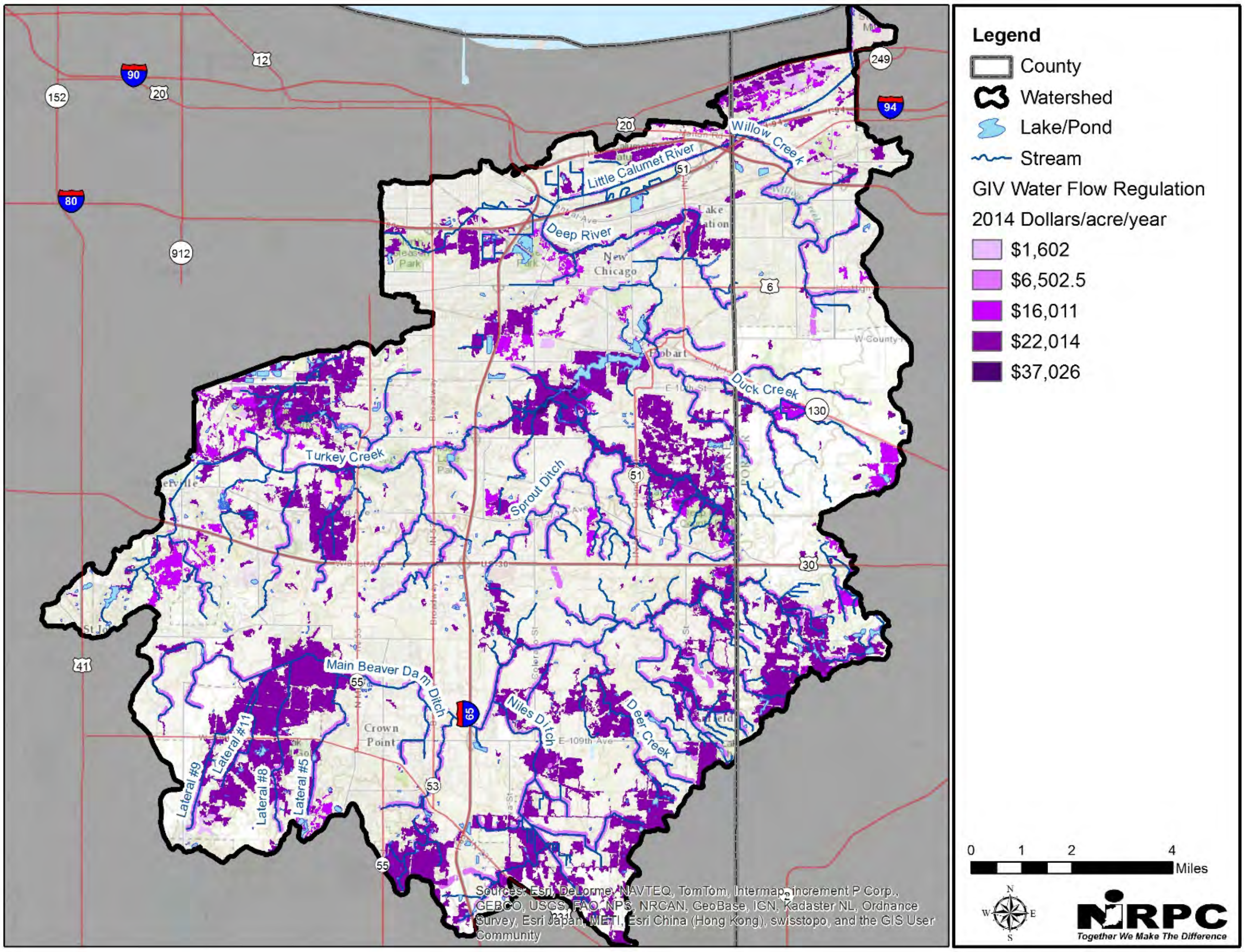


Figure 49 GIV ecosystem services water flow regulation

2.7.14.3 *Groundwater Recharge*

The groundwater recharge ecosystem service helps maintain natural rates of groundwater recharge and aquifer replenishment, which is particularly important for those municipalities that rely on groundwater aquifers for their drinking water supplies. Significant costs can be incurred when there is a need to develop, treat, and maintain deeper wells and associated treatment systems. Groundwater also helps maintain the natural base flow of rivers and streams, which is important for human and ecosystem health. The geology of groundwater infiltration and capture is complex, but one of the keys is minimizing impervious surface that diverts water into combined sewers and other storm water management infrastructure before it can soak into the ground. The Chicago Wilderness GIV includes the natural river and stream network and lands that serve as infiltration areas to underground aquifers.

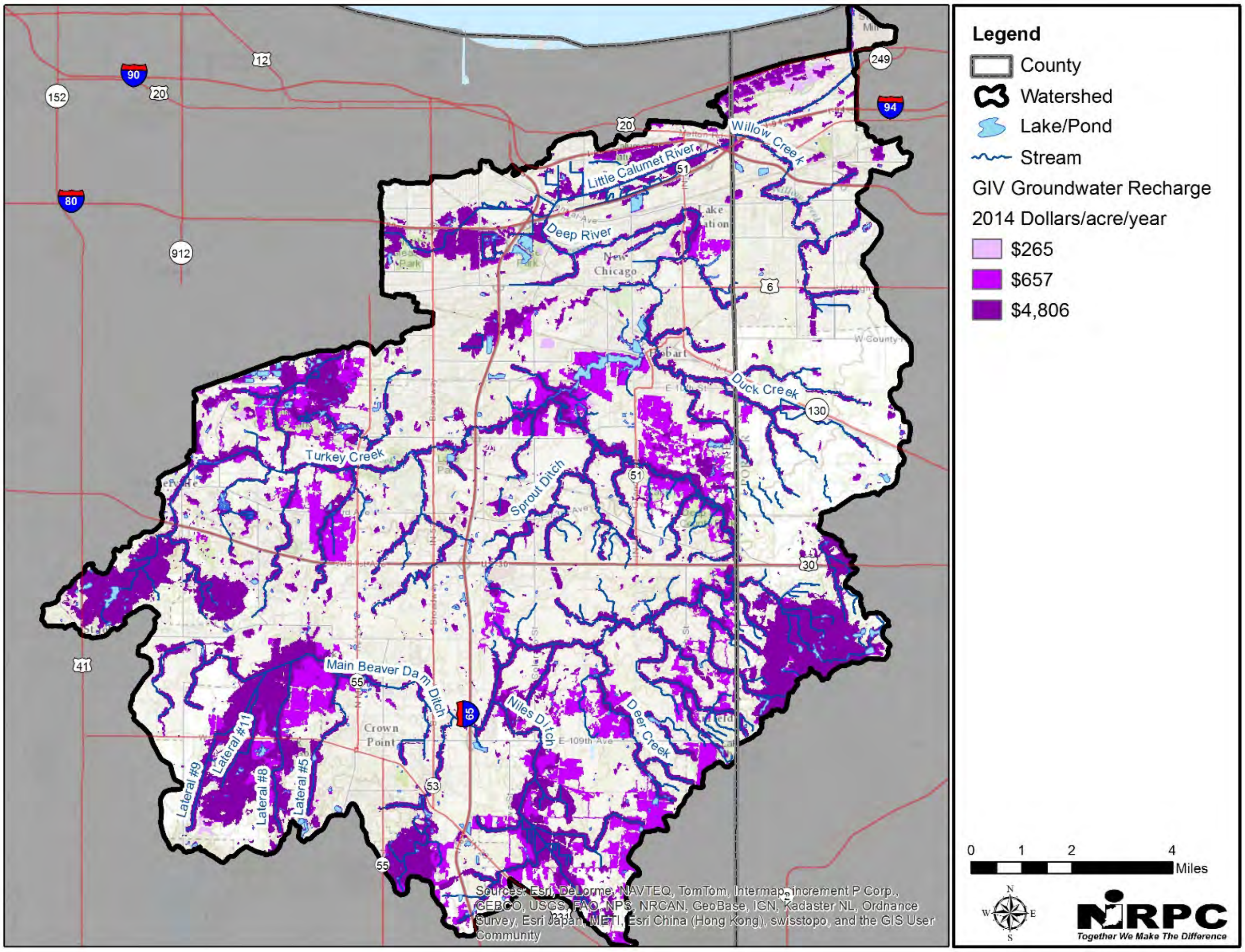


Figure 50 GIV ecosystem services groundwater recharge

2.8 Endangered, Threatened & Rare Species and High Quality Natural Areas

A fairly large variety of endangered, threatened, and rare (ETR) species and high quality natural areas have been documented within the Deep River-Portage Burn Waterway watershed. The Indiana Natural Heritage Data Center has recorded nearly 400 observations of ETR species including plant, reptile, amphibian, bird, mammal, crayfish, mollusk and crayfish species and 32 high quality natural communities including forest, savannah, prairie, and wetland habitats within its boundary. The watershed's diversity can be attributed to its location in the landscape. The Deep River-Portage Burns Waterway watershed falls in an area known as the Northwestern Morainal Natural Region. Several major vegetation types including the eastern deciduous forest, the tall grass prairie, and northern forest and wetland merge in this natural area. No other natural region compares in species diversity on an acre by acre basis because of this (Homoya et al, 1985).

Stakeholder Concerns Related to ETR Species & High Quality Natural Areas:

- **Stream habitat loss**
- **Riparian area encroachment**
- **Species loss**
- **Wetland habitat loss and degradation**
- **Habitat loss to development**
- **Proper habitat restoration**
- **Lack of conserved open spaces**
- **Need to acquire public/ quasi-public riparian lands**
- **Long-term management of habitat**

Figure 51 shows the general location of ETR observations and high quality natural communities in relation to managed lands within our watershed. The National Park Service, DNR, local land trusts, parks departments and environmental organizations have focused a great deal of their land conservation efforts around these areas. However, high concentration areas still remain unprotected. Notable areas include along the Little Calumet River and Deep River downstream of Lake George. Conservation of these land areas is not only important to protect critical habitat for ETR species, but also in protecting the variety of services (ex. flood attenuation) they provide to society and the watershed as a whole. Additional high quality natural communities and ETR species may still be present in the watershed that have yet to be documented.

A list of the ETR species and high quality natural communities that have been documented in the watershed is included in the appendices. Information on which community types the ETR species and high quality natural communities occur is also provided (Source: Derek Nimetz, DNR Division of Nature Preserves).

The Indiana Natural Heritage Data Center represents a comprehensive attempt to determine the state's most significant natural areas through an extensive statewide inventory. However, the inventory is a continuous process. Over the past 10 years, 57 element occurrences were documented in the watershed including 54 ETR species and 3 high quality natural communities.

In general, land trusts active within the watershed restore and manage their properties for community types and not necessarily the ETR species themselves.

The Calumet Land Conservation Partnership, which is comprised by organizations including Shirley Heinze Land Trust, The Nature Conservancy, Indiana Department of Natural Resources, Indiana Dunes National Lakeshore, Save the Dunes, Lake County Parks Department, OpenLands, and the Northwestern Indiana Regional Planning Commission are coordinating to develop a conservation plan and coordinated management implementation plan for the Hobart Marsh area and to develop a long-term vision and strategy for the Deep River Outstanding River Corridor.

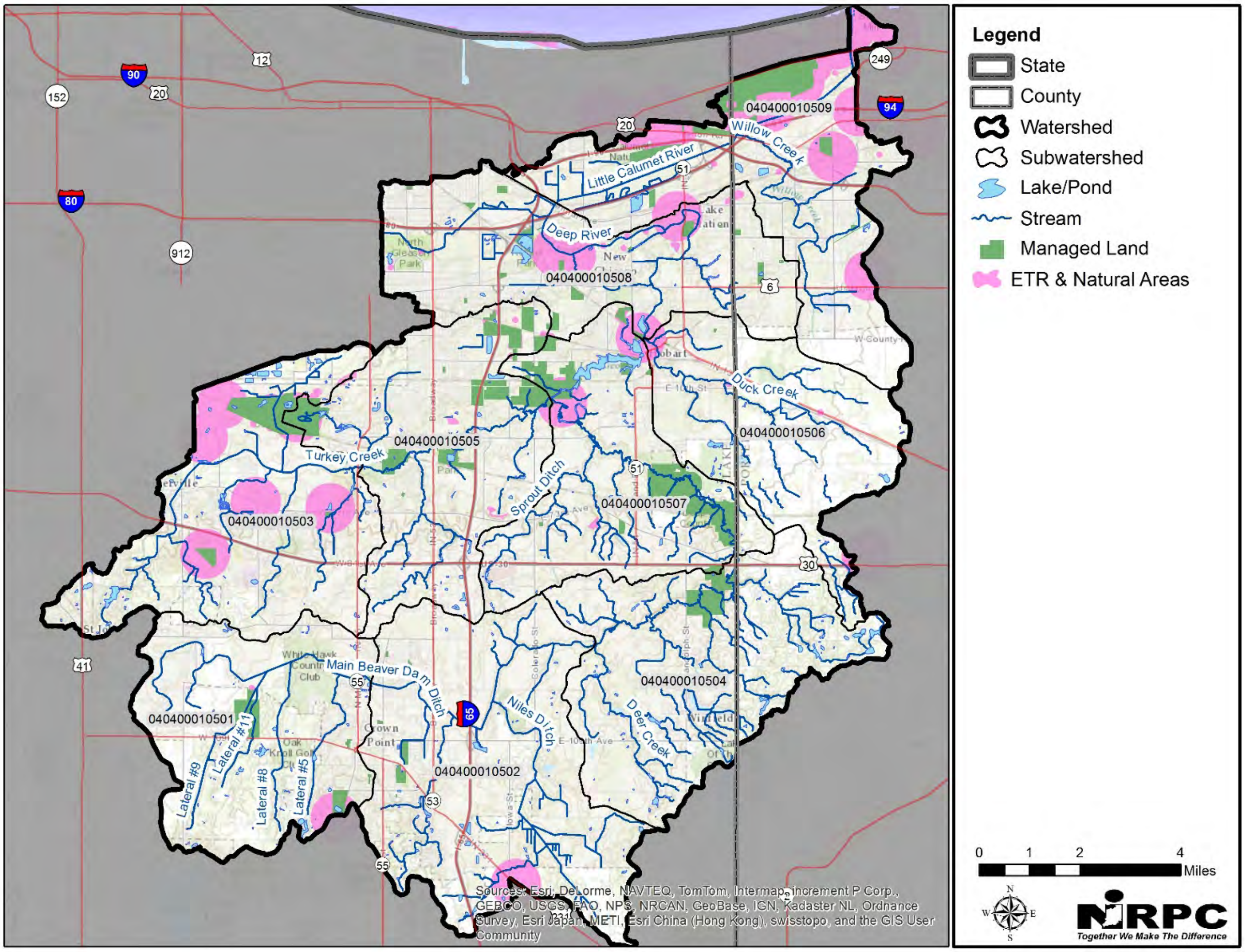


Figure 51 Endangered, Threatened & Rare Species and High Quality Natural Areas in Relation to Managed Lands

2.9 Exotic & Invasive Species

This section on exotic and invasive species was graciously prepared by Susan Mihalo with The Nature Conservancy.

Exotic and invasive species in our watershed can infest natural as well as agricultural areas, and can cause environmental and economic harm. Several species, such as giant hogweed (*Heracleum mantegazzianum*), are also known to cause harm to human health, and some species can also alter hydrology and cause erosion by changing the structure and soil of riparian areas.

According to the Indiana Invasive Species Council:

- Invasive plants hurt wildlife by crowding out the plants our native animals need for food and cover.
- Invasive plants destroy habitat for rare wildflowers and animals threatening two-thirds of all endangered species. This is very relevant to Lake County in that it contains nearly 30 percent of all of Indiana's rare, endangered and threatened species.
- Invasive plants cost money. A 2012 survey of agencies and landowners in Indiana found $5.7 million has been spent to manage these species and protect our natural areas, and each year the cost grows.
- Invasive plants can also decrease the public's ability to enjoy hunting, fishing, bird-watching, and other recreational pursuits.

The purpose of this section is to identify the most common invasive species and habitats they invade, and to promote awareness of species that are considered early detection species whose introduction could cause harm to the watershed. These species have been identified by the Indiana Coastal Cooperative Weed Management Area (ICCWMA) Steering Committee as of February 2015. The Steering Committee includes representatives from The Nature Conservancy, Shirley Heinze Land Trust (watershed landowner), Save the Dunes (watershed landowner) and the National Park Service (watershed landowner), the Indiana Department of Natural Resources (watershed landowner), the Coffee Creek Watershed Conservancy, and the Wildlife Habitat Council.

The list of invasive species targeted for control was first developed by members of the Steering Committee in 2011 and includes 83 aquatic species, flowering species, grasses, reeds, cattails, shrubs, trees and vines. Of these species, 20 are considered early detection species that have not yet been detected in our watershed. A copy of this list can be found on http://www.nature.org/cs/groups/webcontent/@web/@indiana/documents/document/prd_246280.pdf

It should be noted that this list is not static as species expand their range, new species are introduced (many times unwittingly by homeowners), and ongoing efforts are made to control invasive species. As a result, the ICCWMA Steering Committee reviews this list at least every-other year, and members have made a commitment to report new detections to Indiana's early detection and distribution mapping system known as "EDDMaps," which can be found on http://eddmaps.org/indiana/. This system can also be used by the public to report species as reports are always verified before they are included in the system and map.

A general rule-of-thumb in invasives control is that it can take several years to get rid of or minimize an infestation and exhaust the existing seed bank. Early detection and control of new infestations can be especially helpful.

Each species may require different treatment methods, which might also change based on other factors such as the size of the infestation and whether or not the plant spreads through its root system. Each species should be carefully researched prior to implementing specific control methods such as herbiciding, cutting and/or hand-pulling, and keep in mind that new methodologies and herbicides are periodically introduced.

2.9.1 Invasive Plant Species Commonly Found in the Deep River Watershed

Buckthorns (*Rhamnu frangula*, and *Rhamnus cathartica*) are present our watershed and can be expected to expand. Floodplains, mesic woodlands and areas with moist but not wet soils are most threatened. Control is possible with early detection and rapid response to new populations.

Bush Honeysuckle (*Lonicera spp*.) and **Autumn Olive** (*Eleagnus umbellata*) shrubs were introduced simultaneously and planted in the past for their hardiness and as wildlife forage. Birds do, in fact, enjoy the fruits of both plants, but they unfortunately carry the seeds far beyond their existing populations. Large amounts of money and time are being spent throughout the Midwest to control them with relative success. Both species tend to thrive in sunlit areas, but honeysuckle has the ability to infest woodlands under complete canopies. In our watershed, they are widespread and mostly infest woodlots, fallow fields and disturbed areas.

Canada Thistle (*Cirsium arvense*) is a noxious weed that occurs essentially in all sunlit areas of our watershed including prairies, savannas, streambanks, forest openings and disturbed areas. Because this plant also spreads through a creeping root system, herbicides should be used to control it that are foliar sprayed and that systemically move down to the roots.

Cattail (*Typha x glauca; Typha angustifolia*) is a serious problem throughout our watershed. The hybridization of the exotic form has essentially eliminated the native cattail (Typha latifolia). The hybrids are extremely aggressive and have infested ditches, streams, marshes, and other wetlands, including water retention basins. Further spread of this plant can be somewhat minimized by careful cleaning of equipment when road and ditch crews move from site-to-site. Because this plant also spreads through a creeping root system, herbicides should be used to control it that are foliar sprayed and that systemically move down to the roots. This species also must be controlled with an herbicide approved for aquatic use.

Common Reed (*Phragmites australis*) is an aggressive invader throughout the Lake Michigan Watershed, and our watershed is no exception. While generally limited to roadside ditches and water retention basins, it can expand rapidly and is a dominant wetland invader. Because this plant also spreads through a creeping root system, herbicides should be used to control it that are foliar sprayed and that systemically move down to the roots. This species also must be controlled with an herbicide approved for aquatic use.

Garlic Mustard (*Alliaria petiolata*) is also present our watershed. Floodplains and vectoring by foot traffic and wildlife, like deer, are the major routes of expansion of this weed. This plant has invaded to the point where it has become ubiquitous and is often ignored by the general public. However, the long-term impacts of this invader need to be more fully understood in that it is allelopathic (chemically inhibits others in its environment in order to gain competitive advantage) and emits chemicals that suppress tree seedling growth.

(http://harvardforest.fas.harvard.edu/sites/harvardforest.fas.harvard.edu/files/publications/pdfs/Stinson_PlosBiology_2006.pdf).

Japanese knotweed (*Fallopia japonica*) is well-established our watershed and is unfortunately very difficult to control. It can be found along disturbed roadsides, riparian areas, floodplains, the Oak-Savanna bike trail, abandoned farmland and woodlands. A large stand of it can be found just north of the Gordon & Faith Greiner Nature Preserve in Hobart, just south of Ridge View Elementary School's backyard in Hobart.

In some states like Washington, Japanese knotweed is considered to be a state-listed noxious weed that is particularly troublesome to watersheds because it creates bank erosion problems and is considered a potential flood control hazard. It can also lower the quality of riparian habitat for fish and wildlife by displacing native species. This plant grows densely and thickets of it are also known to clog small waterways.

Multiflora Rose (*Rosa multiflora*) is present in every woodland of our watershed. The plant grows unimpeded in shady understories. Conventional control is somewhat effective, but the result in treated areas tends to be bare soil.

Purple Loosestrife (*Lythrum salicaria*) is very prevalent our watershed and can be found in wetlands and along many ditches and streams. If a natural area is being intensively managed, populations of this invasive species can be reduced, but never entirely eliminated, by *Galerucella pussila* and *G. calmariensis*, leaf-eating beetles that have been introduced or have migrated from other areas into the watershed. These beetles seriously affect growth and seed production by feeding on the leaves and new shoot growth of purple loosestrife plants. If herbicides are used for control, they must be approved for use in aquatic habitats.

Oriental Bittersweet (*Celastrus orbiculata*). This woody, vining species is present and widespread in our watershed. This species has the ability to colonize fields, woodlands, floodplains, and essentially all other available habitats. It is extremely destructive to not only surface vegetation, but also climbs trees and competes for sunlight, resulting in tree death. This plant can also be easily confused with native bittersweet (*Celastrus scandens),* therefore positive ID is important prior to control.

Reed Canary Grass (*Phalaris arundinacea*) has invaded much of the sunlit portions of our watershed, particularly along ditches and creeks, and has smothered native vegetation. Control of this species with conventional tactics is extremely difficult, and it can spread via waterways. As forest and riparian tree canopies are reduced due to emerald ash borer (EAB) infestations of ash trees, this species will quickly invade areas previously shaded and now open to sunlight. If herbicides are used for control in a riparian or wetland habitat, they must be approved for use in aquatic habitats.

Spotted Knapweed (*Centaura maculosa*) can mainly be found in the northern half of our watershed where it thrives in sandy soils and along Right-of-Ways (ROWs). This species is also allelopathic and produces chemicals that kill soil microflora. The plant is also carcinogenic and control by hand pulling should be done with gloves. It is extremely important to eliminate small populations as they occur. Biological control has been somewhat effective out west.

Tree of Heaven (*Ailanthus altissima*) is also established and is prevalent in our watershed. This urban weed is present along many woodland edges. While no monocultures have been detected, it can be expected to dominate remnant canopies. It prolifically produces winged seeds that help it to expand very rapidly. This plant is also allelopathic. This species also poses a risk to human health, as there have been cases of heart arrhythmia in individuals after contact with its sap.

2.9.2 Invasive Plants Popular in Landscaping

The following shrub species are popular as ornamental plants and in residential landscaping and can easily be spread by birds and other wildlife eating their berries. All are making their way into woodlots and wooded natural areas, driving out native species that insects and birds are dependent upon. The public can be integral to reducing the spread of these species by not planting them.

Japanese Barberry (*Berberis thunbergii*), is established in our watershed. While it has not reached the density of Multiflora Rose, it may become a dominant species soon.

Burning Bush (*Euonymus alatus*) is a popular landscape plant due to its striking red fall foliage but is, unfortunately, finding its way into natural areas.

Privet (*Ligustrum vulgare*) has been a popular landscape plant for as long as groomed hedges have existed and can be very problematic to natural areas.

Avoid planting these species. Consider instead native species or nonnative but non-invasive, species such as:

- Black haw *(Viburnum prunifolium)*
- Common juniper (*Juniperus communis)*
- Ninebark (*Physocarpus opulifolius)*
- Red chokeberry *(Aronia arbutifolia)*
- Redosier dogwood *(Cornus sericea)*
- Serviceberry (*Amelanchier* spp.)
- Smoke bush *(Cotinus coggygria*)
- Spicebush (*Lindera benzoin*)
- Weigela (*Weigela florida)*

2.9.3 Early Detection Species Likely to Expand into the Watershed

Air Potato (*Diascorea bulbifera*) is a species that has not yet been detected in our watershed, but may be established in adjacent watersheds. This vine is a vigorous climber and often forms deep mats over low vegetation. Established populations have proven to be nearly unstoppable in southern Indiana, yet can be controlled with early detection. Its method of dispersal seems to be by following moving water and right-of-ways or perhaps has been spread by utility trucks.

Black swallow-wort *(Cynanchum louiseae)*, also known as the black dog-strangling vine, is also a species that needs early detection in order to keep it from spreading. It not only drives out native species but also is deadly to monarch caterpillars that eat it after hatching. Monarch butterflies lay their eggs on this species because it is in the milkweed family, and some research has indicated that they may even prefer it over common milkweed. A small infestation was found several years ago along a railroad line in Ogden Dunes, which is not far from our watershed.

Giant Hogweed (*Heracleum mantegazzianum*), a federally listed noxious weed, as of 2015 has not yet been found in the Lake Michigan Watershed of Northwest Indiana nor in Lake, Porter or LaPorte counties. However, periodically cow parsnip and angelica are misidentified as this plant. One way to distinguish this plant is that it is extremely tall – 13'-15' in comparison to these other species. The sap from this plant, in combination with moisture and sunlight, can cause severe skin and eye irritation, painful blistering, permanent scarring and blindness in humans. If it is found, IDNR should be immediately notified.

Japanese Stilt Grass (*Microstegium vimineum*), another species from the Orient, has not yet been reported in our watershed. However, its northward migration through the state has been relatively unimpeded by management efforts. It can be expected to establish in our watershed at some point in the future because it is easily carried on hiking and hunting boots from southerly areas.

Kudzu *(Pueraria lobata)* was detected in 2013 on the banks of the Deep River in New Chicago by members of the Northwest Indiana Paddling Association, and has since been verified by the Indiana Department of Natural Resources (IDNR), and ongoing control efforts have commenced. This regulated species needs to be reported if found to IDNR. Note: kudzu looks very similar to hog peanut (*Amphicarpaea bracteata)* is sometimes mistaken for kudzu but has much smaller leaves and the plant is much more diminutive than kudzu.

Leafy Spurge (*Euphorbia esula L*.) is a creeping perennial that reproduces from seed and vegetative root buds. It is an early detection species of great concern to ICCWMA members because entire fields of it can be found in other parts of the country, particularly west of the Mississippi.

In the highly built environment of our watershed, disturbance and fragmentation of natural areas are high hurdles to overcome with respect to preventing and controlling invasive plant species. However, with the help of early detection efforts, as well as careful planning by natural-area landowners that includes an understanding of conservation targets and how they interact with the health of a watershed, some invasive species could potentially become more manageable. This is why it is important to document invasive species reports on http://eddmaps.org/indiana/, and to understand how it spreads (sometimes via waterways) as well as how it impacts native plant communities and hydrology.

2.9.4 Invasive Forest Pests

Tree-health and the control of nonpoint source pollution are inexorably linked. Trees reduce storm water flow by intercepting rainwater on leaves, branches, and trunks. Some of the intercepted water evaporates back into the atmosphere, and some soaks into the ground, reducing run-off in the watershed.

Tree-health and water quality are also inexorably linked. Trees also reduce the amount of storm water flow from heated impervious surfaces, keeping warmer temperatures from impacting sensitive stream and river species. Forests also help slow soil erosion through canopy dispersal and with the help of surface litter cover. As a result, landowners, especially in riparian areas, are strongly encouraged to replace trees killed by forest pests with native trees appropriate for the habitat – especially trees that can survive weather extremes.

The emerald ash borer (EAB) (*Agrilus planipennis fairmaire*) and the Asian longhorn beetle (ALB) (Anoplophora glabripennis) are two exotic tree-killing pests that bear mentioning in this watershed management plan due to their devastating effects on tree health and forests.

2.9.5 EAB Impacts on the Watershed

It is highly likely that by the time this watershed management plan is published most, if not all, all varieties of ash trees will have been impacted by EAB, unless a particular tree or set of trees have been consistently treated with recommended pesticides. The adult beetles nibble on ash foliage but cause little damage. The larvae feed on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients. Even if the tree is not killed outright by this damage, all it takes is extreme drought or other factors to weaken a tree and cause it to die.

According to the Purdue University Extension Service, ash trees provide substantial economic and ecosystem benefits, ranging from increased property value, to storm water mitigation, to decreased energy demands.

2.9.6 ALB Impacts on the Deep River Watershed

If not detected early and controlled, the Asian longhorn beetle (ALB) could devastate numerous other species of hardwood trees in the watershed – especially elm, maple, willow, hackberry and birch trees. Once this pest infests a tree, there is no cure, and the tree will die.

For more information on identifying this beetle that has already devastated more than 80,000 trees – mostly in the eastern part of the U.S. - visit the U.S. Department of Agriculture website at http://asianlonghornedbeetle.com/. Again, early detection is key. Report sightings or suspected damage to IDNR by calling (317) 232-4120 and asking to speak with an entomologist.

2.10 Relevant Relationships

A number of the watershed characteristics when examined together can help provide a clearer picture of water quality and habitat issues.

2.10.1 Riparian Land Cover

Ideally, riparian areas would occur as natural buffers between human land uses and adjacent waterbodies. Vegetated riparian areas help filter out pollutants carried by storm water runoff such as sediment, nutrients, pathogens, and metals before they reach water. The vegetation growing in healthy riparian areas help stabilize shorelines and streambanks, provide shade which in turn helps in maintaining cooler water temperatures and higher dissolved oxygen levels, provide an important food source for fish and aquatic insects, and provide a source of large woody debris for critical in-stream habitat. Generally, the wider the buffer the greater benefit they provide (Figure 52).

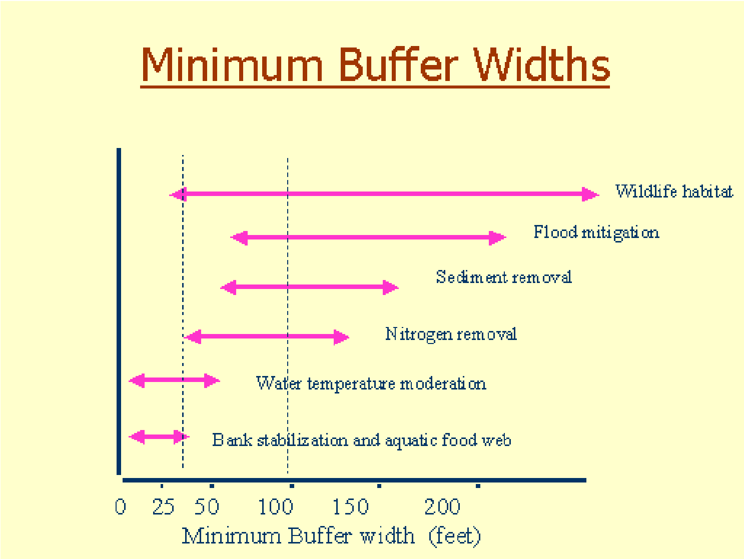


Figure 52 Riparian Buffer Widths & Benefits

Related Stakeholder Concerns:

- Riparian area and floodplain encroachment
- Habitat loss to development
- Need to acquire public/ quasi-public riparian lands
- Development standards protective of watershed
- Ability of watershed to clean water and provide habitat
- Erosion and sedimentation
- Excess nutrients
- Increased runoff volume
- Streambank and shoreline erosion

A desktop analysis of riparian land cover was done for the watershed using methodologies developed by the Indiana DNR Division of Forestry. Thirty-meter buffers were created on each side of the stream centerline and land cover data shown in Figure 29 was extracted from this zone. A 30-meter (approximately 100-foot) buffer was the smallest buffer distance that could be evaluated based on the land cover datasets 30-meter resolution. Human land use/land cover occurring within the riparian zone is shown in Figure 53. The data was then grouped by subwatershed and is presented in Figure 54 as percent contribution.

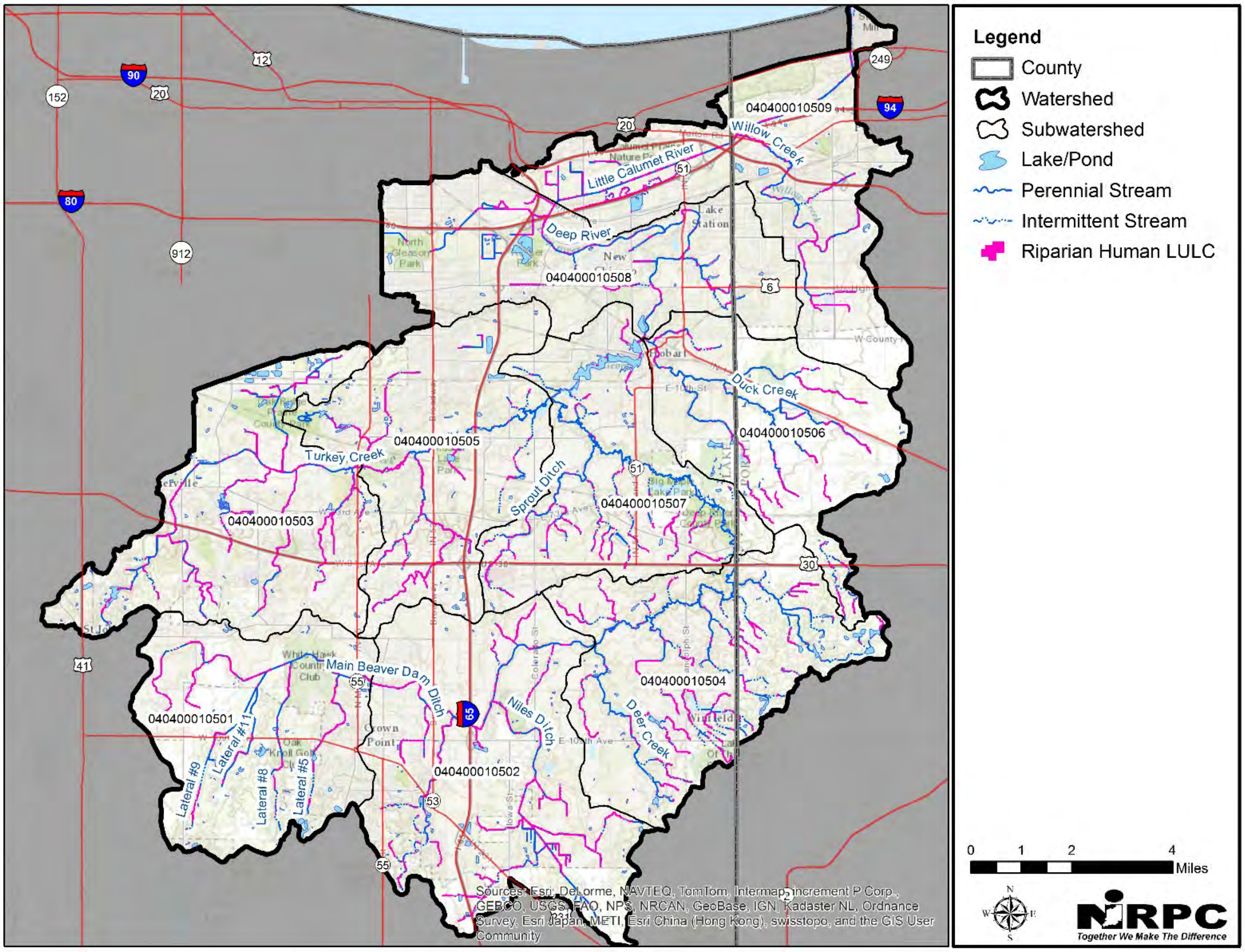


Figure 53 Riparian human land use/land cover

The results of this analysis show that human disturbance (agricultural, bare and developed land) within the riparian zone ranges from 35% to 65%. Development is the most common land cover type in the riparian zone accounting for nearly 43,000 acres followed by row crop at approximately 26,000 acres.

The highest levels of riparian encroachment occur along Main Beaver Dam Ditch, Turkey Creek and their tributaries as well as the Little Calumet River and Willow Creek. Deep River still maintains large reaches of core forest habitat within its riparian zone especially upstream of Lake George.

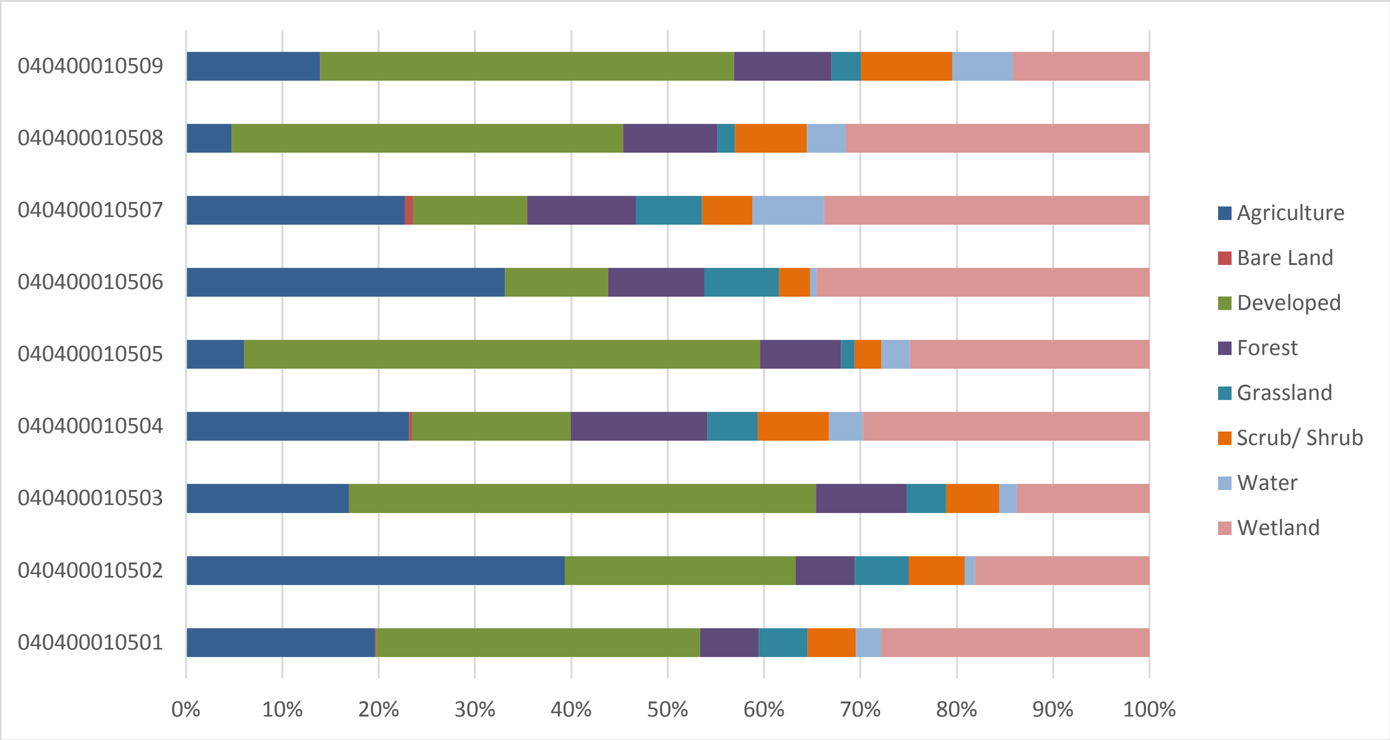


Figure 54 Subwatershed Riparian Area Land Cover

The DNR methodology also included an analysis of other indicators to help prioritize riparian buffer restoration including percent riparian lands, percent storm water runoff (nonpoint source) contributing land cover from both the riparian zone and the subwatershed, and average annual estimated erosion. For this analysis a higher score means a higher priority. The results of the analysis are presented in Table 34 and Figure 55.

Subwatershed	% Subwatershed NPS Land Cover	Score	% Riparian NPS Land Cover	Score	% Riparian Land	Score	Erosion	Score	Final Score
040400010501	70.20	1	53.37	2	4.45	1	0.69	2	6
040400010502	80.75	3	63.30	3	5.73	2	1.14	3	11
040400010503	71.33	2	65.38	3	5.45	2	0.42	2	9
040400010504	63.45	1	39.94	1	9.39	3	1.40	3	8
040400010505	75.42	2	59.58	3	4.70	1	0.33	1	7
040400010506	73.99	2	43.82	1	6.09	3	0.69	2	8
040400010507	64.94	1	35.44	1	8.46	3	0.71	3	8
040400010508	77.50	3	45.38	3	4.48	1	0.18	1	7
040400010509	75.87	3	56.88	3	4.87	2	0.24	1	8

Table 34 Riparian Buffer Analysis Results

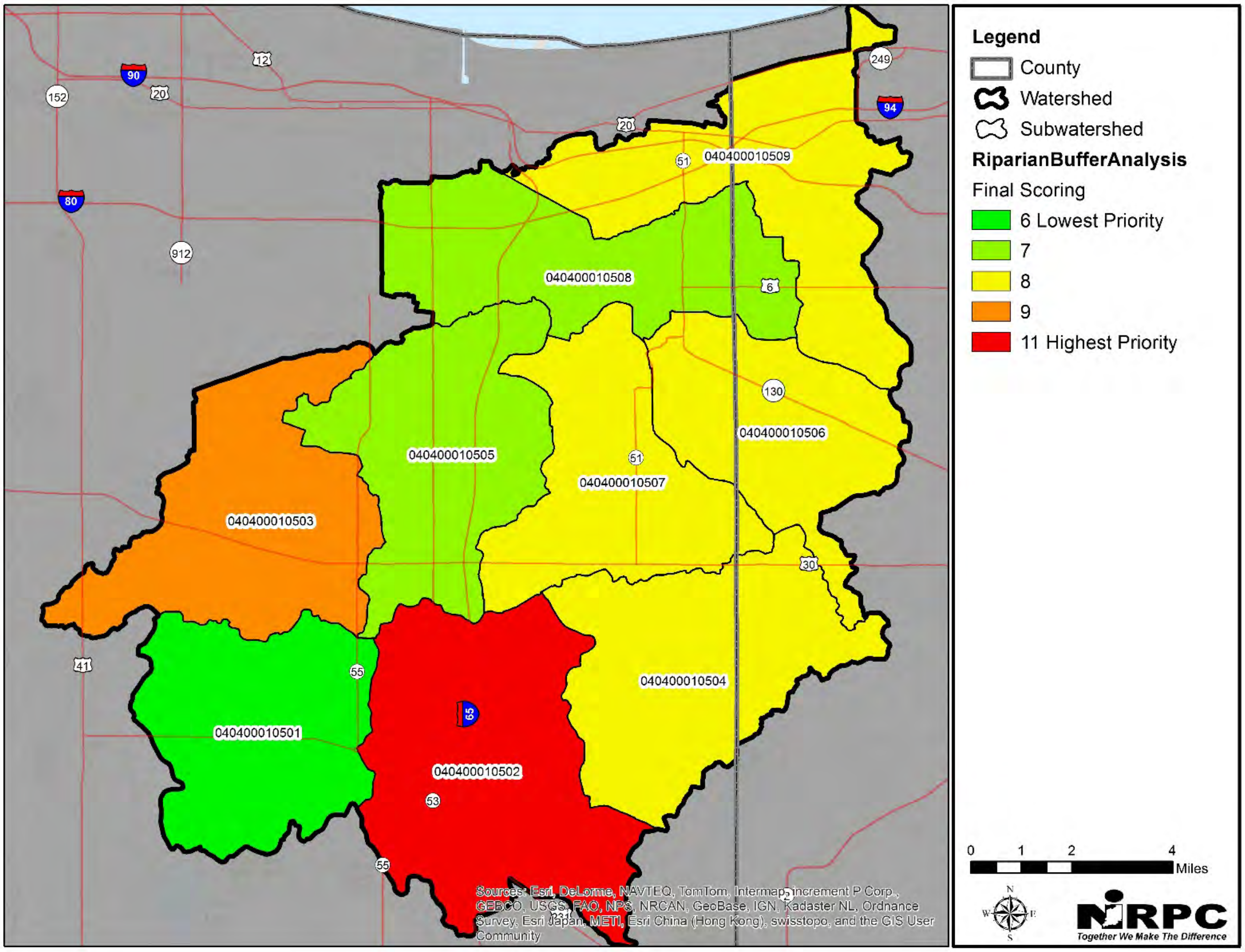


Figure 55 Riparian Buffer Analysis Results

2.10.2 Wetland Loss

Wetlands are an important landscape feature in a watershed. By intercepting runoff from upland areas they can sequester excess nutrients, sediment and other pollutants that would otherwise negatively impact receiving waterbodies and aquatic life. They also function as natural sponges, trapping and slowly releasing rain, snowmelt, groundwater and floodwaters. In watersheds where wetlands have been lost, flood peaks have been shown to increase by as much as 80% (Vermont DEC, 2011). Large wetlands located in the mid or lower reaches of a watershed contribute the most to flood control since they lie in the path of more water than their upstream counterparts (Wisconsin DNR, 2008). However, smaller wetlands located in the upper reaches of a watershed can have cumulative water storage benefits. Wetlands located downstream of urban areas are particularly valuable in offsetting the greatly increased rate and volume of runoff from impervious areas.

Based on hydric soils data, approximately 37,233 acres of wetland would have historically existed within the watershed, representing 25-39% of each subwatershed's land area. Today only about 9,247 acres or 25% of that wetland area remains with wetlands accounting for 5-10% of each subwatershed's land area (Table 35). The greatest wetland losses have occurred in the Main Beaver Dam Ditch-Deep River and Duck Creek subwatersheds.

Name	HUC-12	Hydric Soils (Historic Wetland) (ac.)	% of Drainage Area	Existing Wetland (ac.)	% of Drainage Area	Acres Lost	% Change (Wetland Loss)
Headwaters Main Beaver Dam Ditch	040400010501	4,540	39	1,146	9.8	3,394	-75
Main Beaver Dam Ditch-Deep River	040400010502	5,665	34	797	4.7	4,868	-86
Headwaters Turkey Creek	040400010503	4,922	36	1,189	8.7	3,733	-76
Deer Creek-Deep River	040400010504	3,588	26	1,024	7.4	2,564	-71
City of Merrillville-Turkey Creek	040400010505	4,278	34	1,016	8.1	3,262	-76
Duck Creek	040400010506	2,781	27	520	5.1	2,261	-81
Lake George-Deep River	040400010507	2,808	25	1,086	9.8	1,722	-61
Little Calumet River-Deep River	040400010508	4,025	33	1,246	10.3	2,779	-69
Willow Creek-Burns Ditch	040400010509	4,626	34	1,223	9.1	3,403	-74
	Watershed Total	37,233	32	9,247	8.0	27,986	-75

Table 35 Wetland Loss Data

As noted above, wetland functional values are closely associated with landscape position. Figure 56 shows the extent to which wetland loss has occurred in both upland and riparian areas. In a Wisconsin DNR publication that focused on small wetlands and wetland loss, Trochlell and Bernthal (1998) compiled research that showed there was a threshold in which watersheds with less than 10% wetland area often experienced pronounced negative hydrological and water quality impacts, including deceased stream stability, higher peak flows, lower base flows and increased suspended solid loading rates. Within our watershed only 8% of the land area is wetland. The Little Calumet River-Deep River subwatershed is the only subwatershed with a wetland area greater than 10%. Many of the small upland wetlands and riparian wetlands downstream of urban areas have been lost. The loss of wetland storage is exacerbated by high percentage of soils with low infiltration rates and high percentage of impervious cover in some subwatersheds.

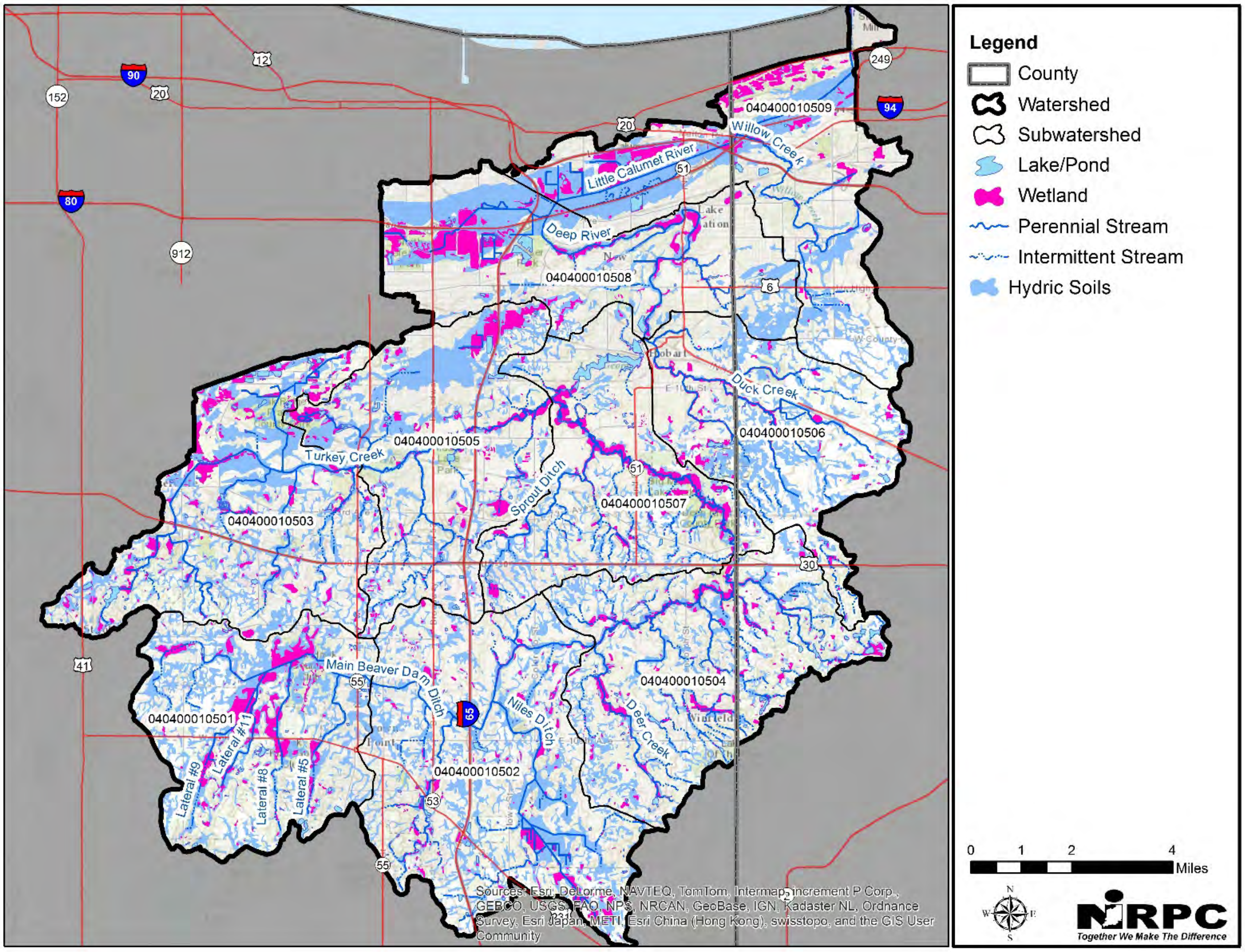


Figure 56 Wetland Loss

2.10.3 Floodplain Land Cover

Floodplains play an important role in the health and function of streams. Development and alteration of floodplains can eliminate or degrade the beneficial services they provide (Table 11). In total there is apporximatley 12,682 acres land within the 100-year and 500-year floodplain. Figure 57 shows nearly equal distribution of natural and human enfluenced land cover types within these floodplain areas.

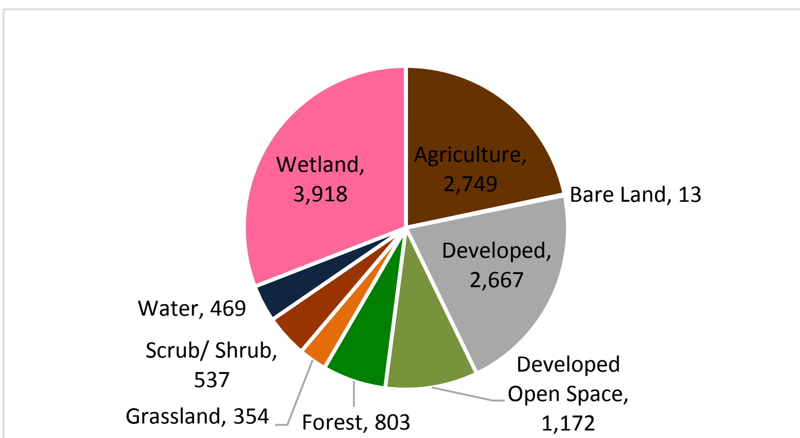


Figure 57 Floodplain Land Cover Composition

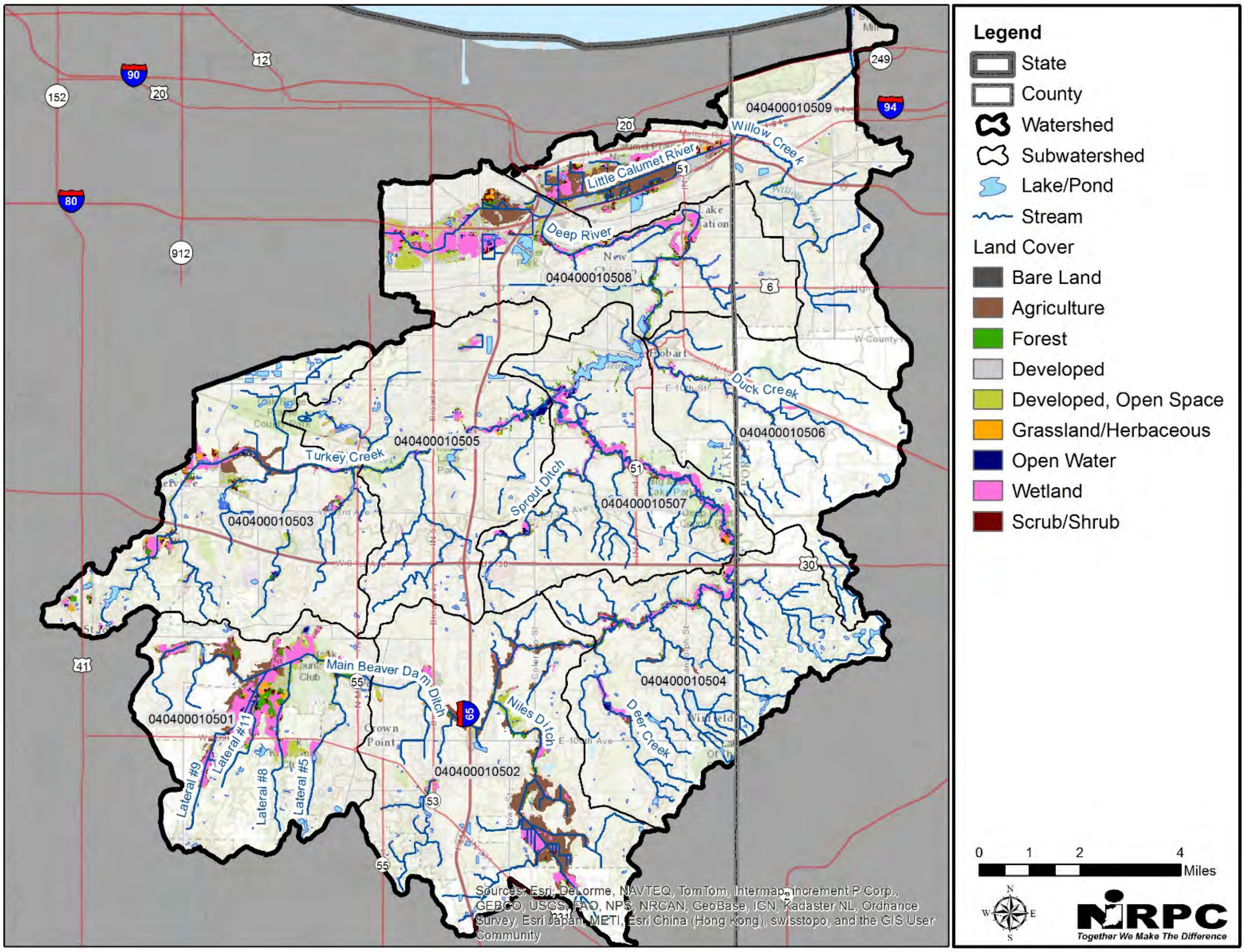


Figure 58 Floodplain land cover

2.10.4 Cultivated Land on Soils Classified as Highly Erodible Land

Highly erodible land is cropland, pasture or hay land that can erode at excessive rates. A field is considered highly erodible if either one-third or more of the field is highly erodible, or if the highly erodible land in the field totals 50 acres or more. NRCS can make an HEL determination upon request. The Food Security Act of 1985 requires producers participating in most programs administered by the Farm Service Agency (FSA) and the Natural Resources Conservation Service (NRCS) to abide by certain conditions on any land owned or farmed that is highly erodible or that is considered a wetland. Producers participating in these programs and any person or entity considered to be an "affiliated person" of the producer, are subject to these conditions. If a producer has a field identified as highly erodible land, they are required to maintain a conservation system of practices that keeps erosion rates at a substantial reduction of soil loss. Fields that are determined not to be highly erodible land are not required to maintain a conservation system to reduce erosion (Farm Service Agency, 2012).

Approximately 14, 108 acres or 12.3% of the soils in the watershed are classified as HEL or potentially HEL. Of the 26,135 acres of cultivated land in the watershed approximately 2,685 acres or 10% occurs on soils that are considered highly erodible.

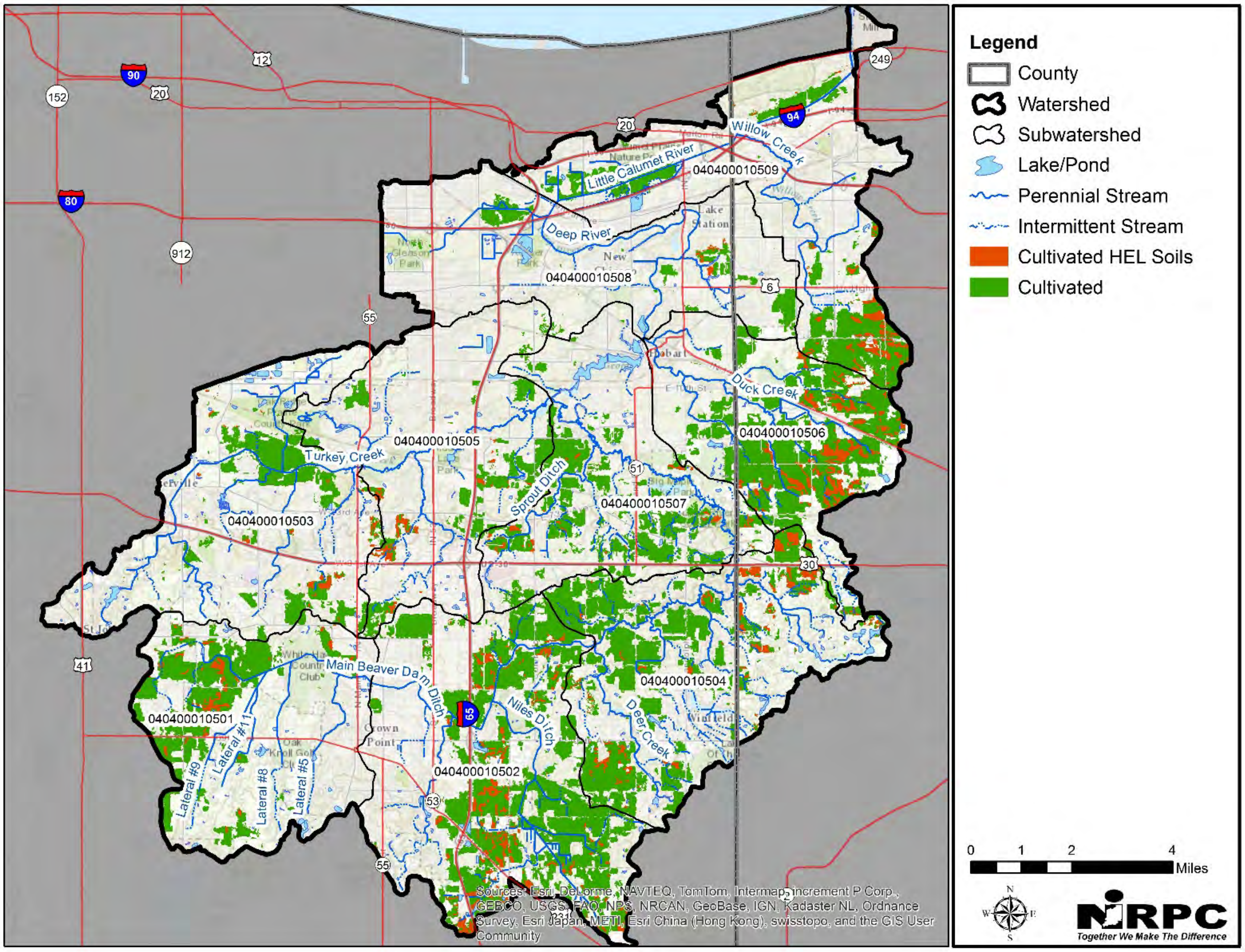


Figure 59 Cultivated Crops on Soils Classified as HEL

2.10.5 Cultivated Land on Poorly Drained Soils

Drainage improvements such as surface, open ditch and subsurface practices are often necessary for efficient row crop production in Indiana. Without these improvements, plantings would be delayed in the spring and the crop's roots would be saturated for long periods. Additionally, some soils would be more prone to surface runoff as described in Section 2.4.1 without drainage improvements.

While there are positives associated with drainage improvement on agricultural lands, there can also be negatives. A number of studies have been done comparing drained to undrained cropland. Drainage enhancements can increase the chance of down-stream flooding because of water leaving the fields more quickly compared to undrained areas. This may result in increased peak flows for receiving streams which in turn can lead to increased streambank erosion. Some additional findings that have been highlighted in The Indiana Soils Evaluation and Conservation Manual include:

- Up to 63% of the rain that falls on a drained field leaves the field through the drainage system.
- Surface runoff is 29% to 65% less in drained fields.

- Soil erosion is reduced by 16% to 65% in drained fields.
- Phosphorus loss is reduced by up to 45% in drained fields because much of the phosphorus is bound to the soil.
- Total nitrogen loss is reduced in drained fields because much of the nitrogen also moves with the sediment.
- Loss of nitrate-nitrogen, a soluble form of nitrogen, is increased in drained fields because nitrate moves with water.

Some level of nitrate is usually present at all times in tile drains. However it is usually most concentrated when water first begins to flow from the field tiles after the growing season in late fall or early winter. Nitrate levels in tile outflows can exceed the 10mg/l water quality standard for drinking water (Purdue University, 2009). Recent research in the St. Joseph River watershed (Lake Erie basin) indicates that nearly 50% of the soluble and total phosphorus losses in that watershed occur via tile drainage and that treating surface runoff may not be sufficient to meeting phosphorus runoff goals (Smith et al, 2015).

There are approximately 27,739 acres of cultivated land within our watershed of which 19,593 acres (71%) exists on a poorly drained soil class. The locations of cultivated land on poorly drained soil classes are shown in Figure 60. The Main Beaver Dam Ditch subwatershed has the greatest number of acres and highest percentage of cultivated land on poorly drained soils followed by the Duck Creek and Headwaters Main Beaver Dam Ditch subwatersheds.

Name	HUC-12	Acres	% of Drainage Area
Headwaters Main Beaver Dam Ditch	040400010501	2,515	21.5
Main Beaver Dam Ditch-Deep River	040400010502	5,012	29.8
Headwaters Turkey Creek	040400010503	1,401	10.3
Deer Creek-Deep River	040400010504	2,338	17
City of Merrillville-Turkey Creek	040400010505	1,067	8.54
Duck Creek	040400010506	3,181	31.4
Lake George-Deep River	040400010507	1,328	12
Little Calumet River-Deep River	040400010508	517	4.26
Willow Creek-Burns Ditch	040400010509	2,234	16.7
	Watershed Total	19,593	17.0

Table 36 Acres & Percentage of Cultivated Land on Poorly Drained Soil Classes

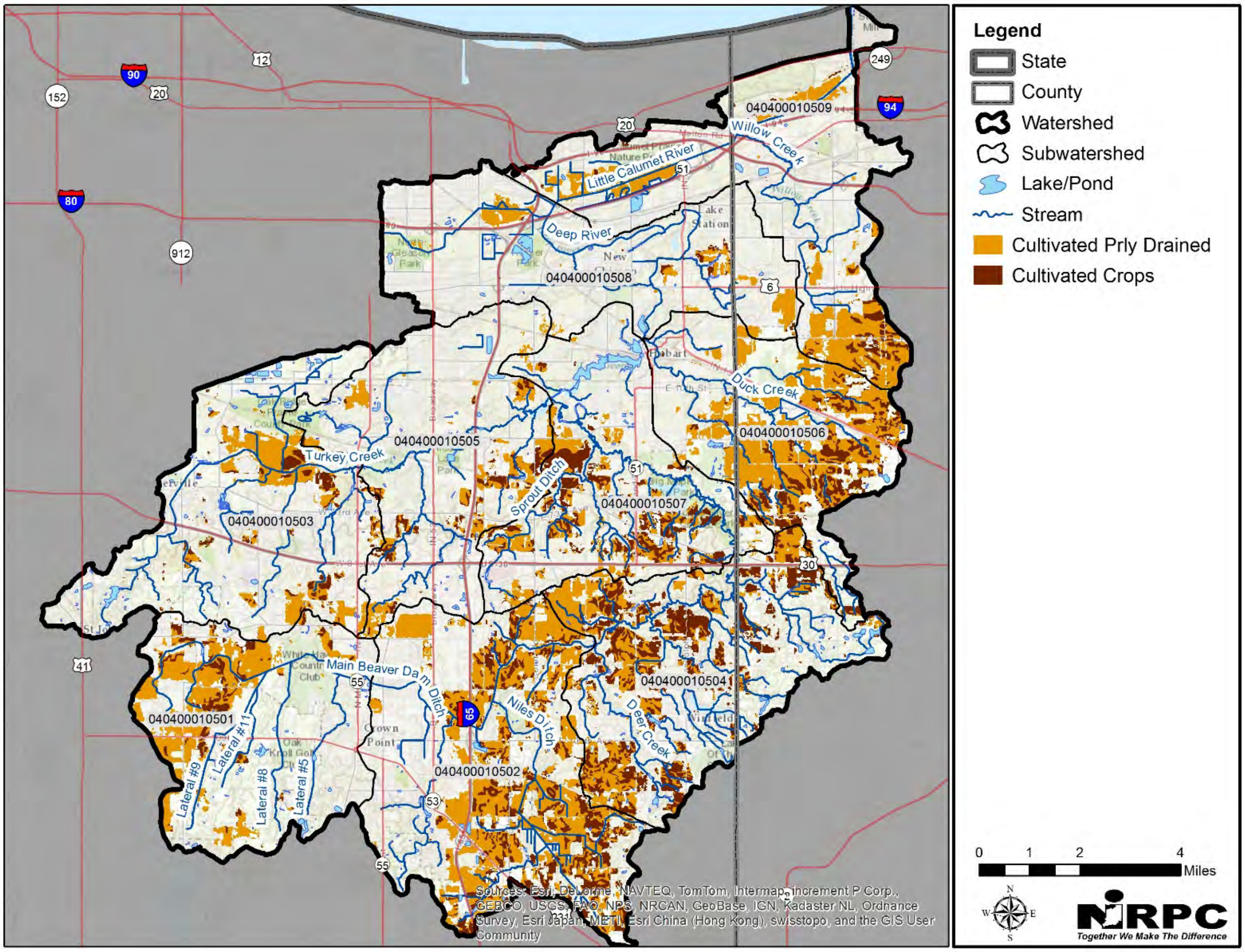


Figure 60 Cultivated Land on Poorly Drained Soil Classes

2.10.6 Unsewered Areas

There are several active waste water treatment plants that provide sanitary waste service for a large portion of the watershed's homes and businesses. However, there are areas that lie outside their service area and therefore rely on septic systems for waste treatment. As referenced previously, slightly more than 92% of the watershed's land area is rated as "very limited" for conventional septic systems that use absorption fields for treatment. This rating indicates that there are significant challenges and costs to assure functionality of the system. Furthermore poor performance and high maintenance can be expected which particularly problematic since there currently is no operation and maintenance program in place for existing systems within this region.

The following figure shows an approximation of unsewered areas and low intensity development occurring in these areas. The figure is meant to serve as a proxy of where septic systems may exist in the watershed. The Lake and Porter County Health Departments do not have an inventory of where all systems exist at this time.

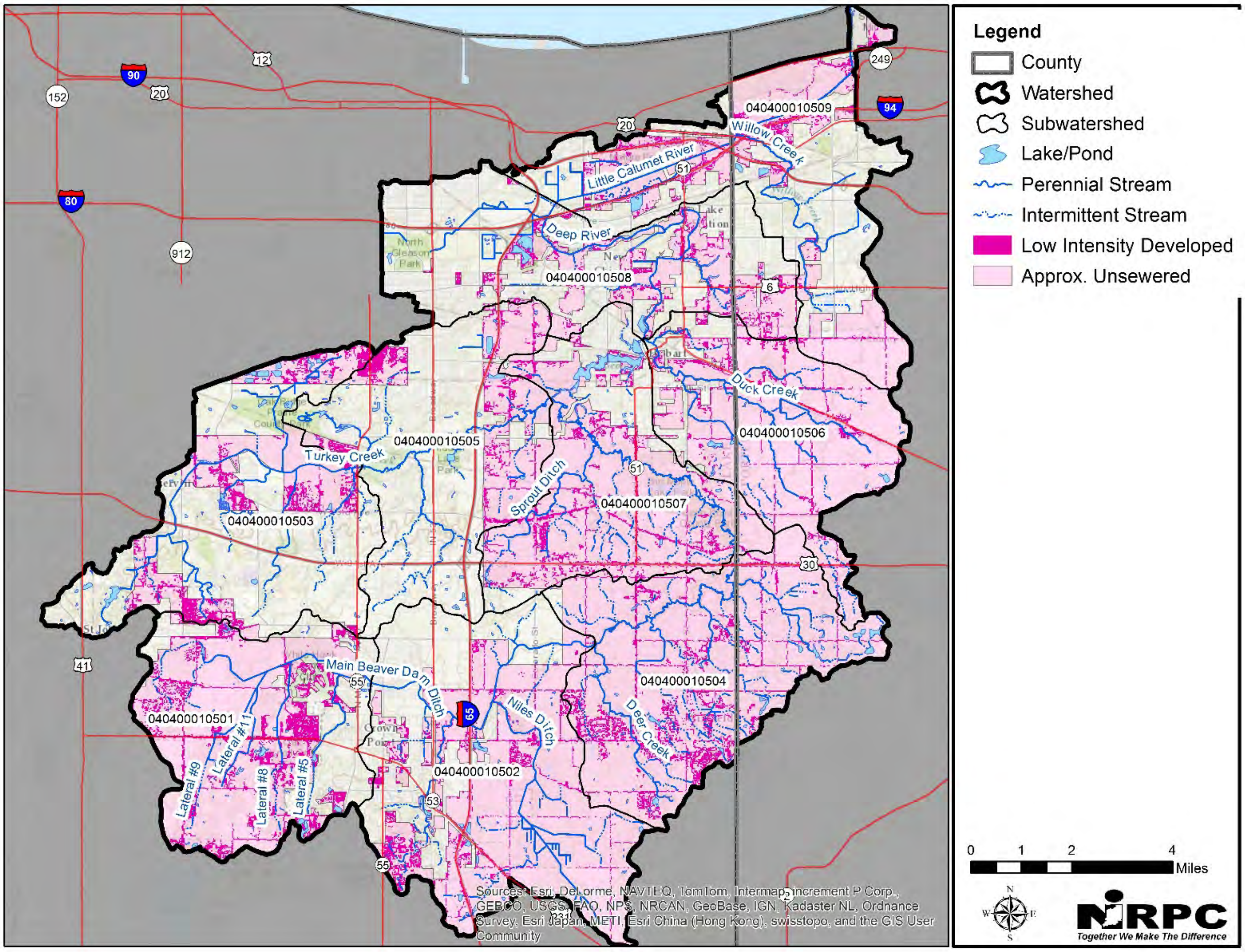


Figure 61 Approximate Unsewered Area

3 Watershed Inventory- Part II

3.1 Water Quality Standards

Under the Clean Water Act (CWA), every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the CWA goal of "swimmable/fishable" waters. Water quality standards consist of three different components:

- **Designated uses** reflect how the water can potentially be used by humans and how well it supports a biological community. Examples of designated uses include aquatic life support, drinking water supply, and full body contact recreation. Every waterbody in Indiana has a designated use or uses; however, not all uses apply to all waters. The designated uses for streams within the Deep River-Portage Burns Waterway include aquatic life support and full body contact recreational uses.
- **Numeric criteria** represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. **Narrative criteria** are the general water quality criteria that apply to all surface waters. Numeric criteria for *E. coli*, nutrients, and TSS were used as the basis of the Deep River-Portage Burns Waterway TMDLs.
- **Antidegradation** policies protect existing uses and provide extra protection for high-quality or unique waters.

The water quality standards and targets in Indiana pertaining to *E. coli*, dissolved oxygen, nutrients, and suspended solids are described below.

E. coli is an indicator of the possible presence of pathogenic organisms such as pathogenic bacteria, viruses, protozoa, and parasites which may cause human illness. The direct monitoring of these pathogens is difficult; therefore, *E. coli* is used as an indicator of potential fecal contamination. *E. coli* is a sub-group of fecal coliform, the presence of *E. coli* in a water sample indicates recent fecal contamination is likely. Concentrations are typically reported as the count of organisms in 100 milliliters of water (count/100 mL) and may vary at a particular site depending on the baseline *E. coli* level already in the river, inputs from other sources, dilution due to precipitation events, and die-off or multiplication of the organism within the river water and sediments.

The numeric *E. coli* criteria associated with protecting the recreational use:

> *"The criteria in this subsection are to be used to evaluate waters for full body contact recreational uses, to establish wastewater treatment requirements, and to establish effluent limits during the recreational season, which is defined as the months of April through October, inclusive. E. coli bacteria, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period..."* [Source: Indiana Administrative Code Title 327 Water Pollution Control Board. Article 2 Section 1-6(d) (3)]

The numeric dissolved oxygen criteria associated with protecting aquatic life use:

> *"Concentrations of dissolved oxygen shall:*
> *(A) average at least five (5.0) milligrams per liter per calendar day; and*
> *(B) not be less than four (4.0) milligrams per liter at any time. "* [Source: Indiana Administrative Code Title 327 Water Pollution Control Board. Article 2. Section 1-6(a).]

Additionally the Indiana consolidated assessment and listing methodology (CALM) identifies dissolved oxygen levels greater than 12 mg/l as a potential indicator of nutrient impairment when combined with other factors such as high nitrogen and phosphorus concentrations, pH, and algae presence.

The term nutrients refers to the various forms of nitrogen and phosphorus found in a waterbody. Both nitrogen and phosphorus are necessary for aquatic life, and both elements are needed at some level in a waterbody to sustain life. The natural amount of nutrients in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no nutrients, whereas a lowland, mature stream flowing through wetland areas might have naturally high nutrient concentrations. Streams draining larger areas are also expected to have higher nutrient concentrations.

Nutrients, in general are not directly toxic to aquatic communities. However, excess nutrients primarily nitrogen (N) and phosphorus (P) have been linked to nutrient enrichment of aquatic systems. Nutrient enrichment can lead to shifts in species composition, reduced dissolved oxygen concentrations, fish kills, and toxic algae blooms; and also results in taste and odor problems if the system is used as a drinking water source. For these reasons, excessive nutrients can result in the non-attainment of biological criteria and impairment of the designated use.

Indiana has not yet adopted numeric water quality criteria for nutrients. The relevant narrative criteria that apply to the Deep River-Portage Burns Waterway TMDLs state the following:

> *"All surface waters at all times and at all places, including waters within the mixing zone, shall meet the minimum conditions of being free from substances, materials, floating debris, oil, or scum attributable to municipal, industrial, agricultural, and other land use practices, or other discharges that do any of the following:" [327 IAC 2-1-6. Sec. 6. (a)(1)]*
>
> *"are in concentrations or combinations that will cause or contribute to the growth of aquatic plants or algae to such degree as to create a nuisance, be unsightly, or otherwise impair the designated uses." [327 IAC 2-1-6. Sec. 6. (a) (1) (D)]*
>
> *"are in amounts sufficient to be acutely toxic to, or to otherwise severely injure or kill, aquatic life, other animals, plants, or humans." [327 IAC 2-1-6. Sec. 6. (a) (1) (E)]*

IDEM has not yet adopted numeric water quality criteria for total suspended solids (TSS). The relevant narrative criteria that apply to the Deep River-Portage Burns Waterway TMDLs state the following:

> *"All surface waters at all times and at all places, including waters within the mixing zone, shall meet the minimum conditions of being free from substances, materials, floating debris, oil, or scum attributable to municipal, industrial, agricultural, and other land use practices, or other discharges that do any of the following:" [327 IAC 2-1-6. Sec. 6. (a)(1)]*
>
> *"are in concentrations or combinations that will cause or contribute to the growth of aquatic plants or algae to such degree as to create a nuisance, be unsightly, or otherwise impair the designated uses." [327 IAC 2-1-6. Sec. 6. (a) (1) (D)]*
>
> *"are in amounts sufficient to be acutely toxic to, or to otherwise severely injure or kill, aquatic life, other animals, plants, or humans." [327 IAC 2-1-6. Sec. 6. (a) (1) (E)]*

In addition, the narrative biological criterion [327 IAC 2-1-3(2)] states the following:

"All waters, except those designated as limited use, will be capable of supporting a well-balanced, warm water aquatic community."

The water quality regulatory definition of a "well-balanced aquatic community" is "*an aquatic community which is diverse in species composition, contains several different trophic levels, and is not composed mainly of strictly pollution tolerant species*" [327 IAC 2-1-9(49)]. Table 37 presents the criteria associated with the fish community Index of Biotic Integrity (IBI) and benthic aquatic macroinvertebrate community Index of Biotic Integrity (mIBI) that indicates whether a watershed is fully supporting or not supporting the aquatic life use.

Biotic Index		Integrity Class	Corresponding Integrity Class	Attributes
Fish community Index of Biotic Integrity (IBI) Scores (Range of possible scores is 0-60)	Fully Supporting IBI ≥ 36	Excellent	53-60	Comparable to "least impacted" conditions, exceptional assemblage of species
		Good	45-52	Decreased species richness (intolerant species in particular), sensitive species present
		Fair	36-44	Intolerant and sensitive species absent, skewed trophic structure
	Not Supporting IBI < 36	Poor	23-35	Many expected species absent or rare, tolerant species dominant
		Very Poor	12-22	Few species and individuals present, tolerant species dominant
		No Organisms	12	No fish captured during sampling.
Benthic aquatic macroinvertebrate community Index of Biotic Integrity (mIBI) Scores Multihabitat MHAB methods (Range of possible scores is 12-60)	Fully Supporting mIBI ≥ 36	Excellent	53-60	Comparable to "least impacted" conditions, exceptional assemblage of species
		Good	45-52	Decreased species richness (intolerant species in particular), sensitive species present
		Fair	36-44	Intolerant and sensitive species absent, skewed trophic structure
	Not Supporting mIBI < 36	Poor	23-35	Many expected species absent or rare, tolerant species dominant
		Very Poor	12-22	Few species and individuals present, tolerant species dominant
		No Organisms	12	No macroinvertebrates captured during sampling.

Table 37 Aquatic Life Use Support Criteria

TIERED AQUATIC LIFE USE

If Indiana were to move towards a Tiered Aquatic Life Use designation in the future, similar to Ohio, revision of this watershed plan should be strongly considered. The tiered system provides for different levels of protection that reflect the choices of reconciling the "ideal" (represented by least impacted reference conditions) with the "reality" of ongoing effects of 200+ years of intensive human use. As an example, Ohio's biological criteria for a wadable stream in the Huron/Erie Lake Plains ecoregion using the IBI is 50 for "exceptional warmwater habitat", 32 for "warmwater habitat", and 22 for "modified warmwater habitat". Under current Indiana Administrative Code, we essentially expect natural streams, manmade channels and modified stream channels to meet the same expectations.

3.2 Water Quality Parameters & Thresholds

Water quality thresholds were selected for our watershed based on applicable Indiana Administrative Code, the Deep River-Portage Burns Waterway TMDL, a nutrient-fish assemblage study by Morris and Simon (2012), and input from the watershed steering committee (Table 38). *E. coli* was monitored to determine if the streams met their designated use for full body contact recreation (i.e. is the waterbody swimmable) during the recreational season (April 1- Oct 31). Fish and macroinvertebrate communities were assessed to determine if the streams met their designated use for aquatic life support. The remaining parameters were assessed to evaluate potential candidate causes (stressors) contributing to biotic impairments.

Monitored to Assess	Parameter	Threshold Level	Source
Recreational Use	*E. coli*	Maximum: • 235 CFU/100 mL (single sample) • 125 CFU/100 mL (geomean)	Indiana Administrative Code (327 IAC 2-1.5-8)
Aquatic Life Use	Index of Biotic Integrity (IBI)	≥36 points	Aquatic Life Use Support Criteria
Aquatic Life Use	Macroinvertebrate Index of Biotic Integrity (mIBI)	≥36 points	Aquatic Life Use Support Criteria
Aquatic Life Use	Temperature	Dependent on time of year (varies by month)	Indiana Administrative Code (327 IAC 2-1-6)
Aquatic Life Use	Dissolved Oxygen (DO)	Minimum: 4.0 mg/L Maximum: 12 mg/L	Indiana Administrative Code (327 IAC 2-1-6)
Aquatic Life Use	Biological Oxygen Demand (BOD_5)	2 mg/L	Hoosier Riverwatch
Aquatic Life Use	Total Nitrogen	3.3 mg/L (fish community protection threshold)	Morris & Simon (2012)
Aquatic Life Use	Total Phosphorus (TP)	Maximum: 0.3 mg/L 0.07 mg/L (fish community protection threshold)	TMDL Morris & Simon (2012)

Monitored to Assess	Parameter	Threshold Level	Source
Aquatic Life Use	Nitrate + Nitrite	Maximum: 10 mg/L in waters designated as a drinking water source 1.09 mg/L (fish community protection threshold)	Indiana Administrative Code (327 IAC 2-1-6) Morris & Simon (2012)
Aquatic Life Use	Total Kjeldahl Nitrogen (TKN)	1.27 mg/L (2nd break point for observed community response) 0.68 mg/L (fish community protection threshold)	Morris & Simon (2012)
Aquatic Life Use	Ammonia	0 – 0.21 mg/L (pH & temperature dependent) 0.03 mg/L (fish community protection threshold)	Indiana Administrative Code (327 IAC 2-1-6) Morris & Simon (2012)
Aquatic Life Use	Total Suspended Solids (TSS)	Maximum: 30 mg/L	TMDL
Aquatic Life Use	Turbidity	10.4 NTU 25 NTU	EPA Recommendation Minnesota TMDL
Aquatic Life Use	Qualitative Habitat Evaluation Index (QHEI)	> 51 points	Aquatic Life Use Support Criteria

Table 38 Water Quality Targets for Watershed Improvement & Protection

The U.S. EPA's Causal Analysis Diagnosis Decision Information System (CADDIS) was used as a guide for this process (https://www3.epa.gov/caddis/index.html). The candidate causes for our watershed include increased stream temperatures, low dissolved oxygen levels, nutrient loading, ammonia toxicity, excessive sediment loading, and poor habitat quality. Conceptual diagrams illustrating causal pathways are include for each potential stressors.

The diagrams are presented to help visualize the potential links between human activities, the stressor, and the observed biotic impairment. Stressors are any physical, chemical, or biological parameters or entities that directly or indirectly result in one or more biotic responses of concern. Proximate stressors are directly responsible for these responses. Other stressors (interacting stressors) may be indirectly responsible for these responses by their effects on proximate stressors. Sources are activities, land uses, or entities that directly or indirectly result in one or more stressors. Responses are the biological results of exposure to proximate stressors.

A conceptual diagram is a visual representation of how a system works. In CADDIS, these diagrams are used to describe hypothesized relationships among sources, stressors, and biotic responses within aquatic systems. Conceptual diagrams and accompanying narrative descriptions are useful tools throughout the Stressor Identification process, from structuring initial brainstorming, to providing a framework for data collection and analysis, to organizing and presenting results.

These diagrams provide overviews of how specific stressors may be linked to sources and biological effects, by illustrating *potential* linkages among stressors (or candidate causes) and their likely sources and effects based on scientific literature and professional judgment. Inclusion of a linkage indicates that the linkage *can* occur, not that it *always* occurs.

Shape	Causal Relationship
human activity	Activity or land use that directly or indirectly leads to one or more sources
source	Entity that directly or indirectly leads to one or more proximate stressors
additional step in causal pathway	Process or state that causally connects a source to a proximate stressor
proximate stressor	Physical, chemical or biological entity that directly induces one or more biotic responses of concern
modifying factor	Process, state, or other factor that modifies delivery or expression of a stressor
interacting stressor	Physical, chemical, or biological entity that interacts with the focal (proximate) stressor
mode of action	Process or state that causally connects a proximate stressor to a response
response	Effect of proximate stressor on aquatic biota

Within each shape, ↑ indicates an increase, ↓ indicates a decrease, and Δ indicates a change in the given parameter, either through time or when compared to a reference site. Arrows leading from one shape to another indicate potential causal relationships, which can be interpreted as the originating shape resulting in or leading to the shape to which it points. Brackets leading from one shape to other shapes indicate hierarchical relationships, with the bracketed shapes being sub-categories of the originating shape.

3.2.1 *E. coli*

Escherichia coli (*E. coli*) is a bacteria commonly found in the intestines of warm blooded animals and humans. Its presence in water is a strong indicator of recent sewage (ex. combined sewer overflows or failing septic systems) or animal waste (ex. livestock or nuisance levels of geese and other waterfowl) contamination. While not necessarily pathogenic in itself, *E. coli* is relatively easy to test for and is used as an indicator other more severe waterborne disease causing organisms. The single sample water quality standard of 235 CFU/100 ml and geomean water quality standard of 125 CFU/100 ml are used to protect human health during the recreational season (full body contact) of April through October.

3.2.2 Biotic Communities: Fish & Macroinvertebrate Index of Biotic Integrity

The Index of Biotic Integrity (IBI) provides a measure of a stream’s health based upon the fish species collected from that stream. The IBI is comprised of a series of metrics to evaluate the health of the fish community. The metrics included in the IBI change by ecoregion however they all generally consider species richness and composition, indicator species, trophic function, and reproduction function. When the metrics are added together you get a total IBI score. The higher the total score (maximum score of 60), the better the stream’s health based upon the fishery. An IBI score great or equal to 36 is considered fully supporting.

The macroinvertebrate Index of Biotic Integrity (mIBI) provides a measure of a stream’s health based upon the macroinvertebrate species collected from that stream. Like the IBI, the mIBI is comprised of a series of metrics to evaluate the health of the macroinvertebrate community. When the metrics are added together you get a total mIBI score. The higher the total score, the better the stream’s health based upon the macroinvertebrate community. A mIBI score great or equal to 36 is considered fully supporting.

3.2.3 Water Temperature

Water temperature is important because it strongly influences the kinds of aquatic life that can live in a stream. Fish, aquatic insects, plankton, and other aquatic life all have a preferred temperature range. If temperatures get too far above or below this range, the number and variety species can begin to decline. Temperature also is important because it influences water chemistry. The rate of chemical reactions generally increases at higher temperatures, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen.

In addition to seasonal variations in stream temperature caused by changing air temperatures, many other physical aspects of a stream cause natural variation in temperature. The origin of the stream (ex. spring or wetland) determines its initial temperature. Inflowing tributaries may alter the stream temperature as they mix with the mainstem. Velocity also influences temperature. A stream shaded by trees and other vegetation reduces the impact of warming by the sun.

The process of watershed development also can affect stream temperatures. Streambank vegetation often is lost when land is cleared, thereby exposing the stream to increased warming by sunlight. Storm water runoff may be warmer, especially during the summer months when it flows over hot asphalt or concrete.

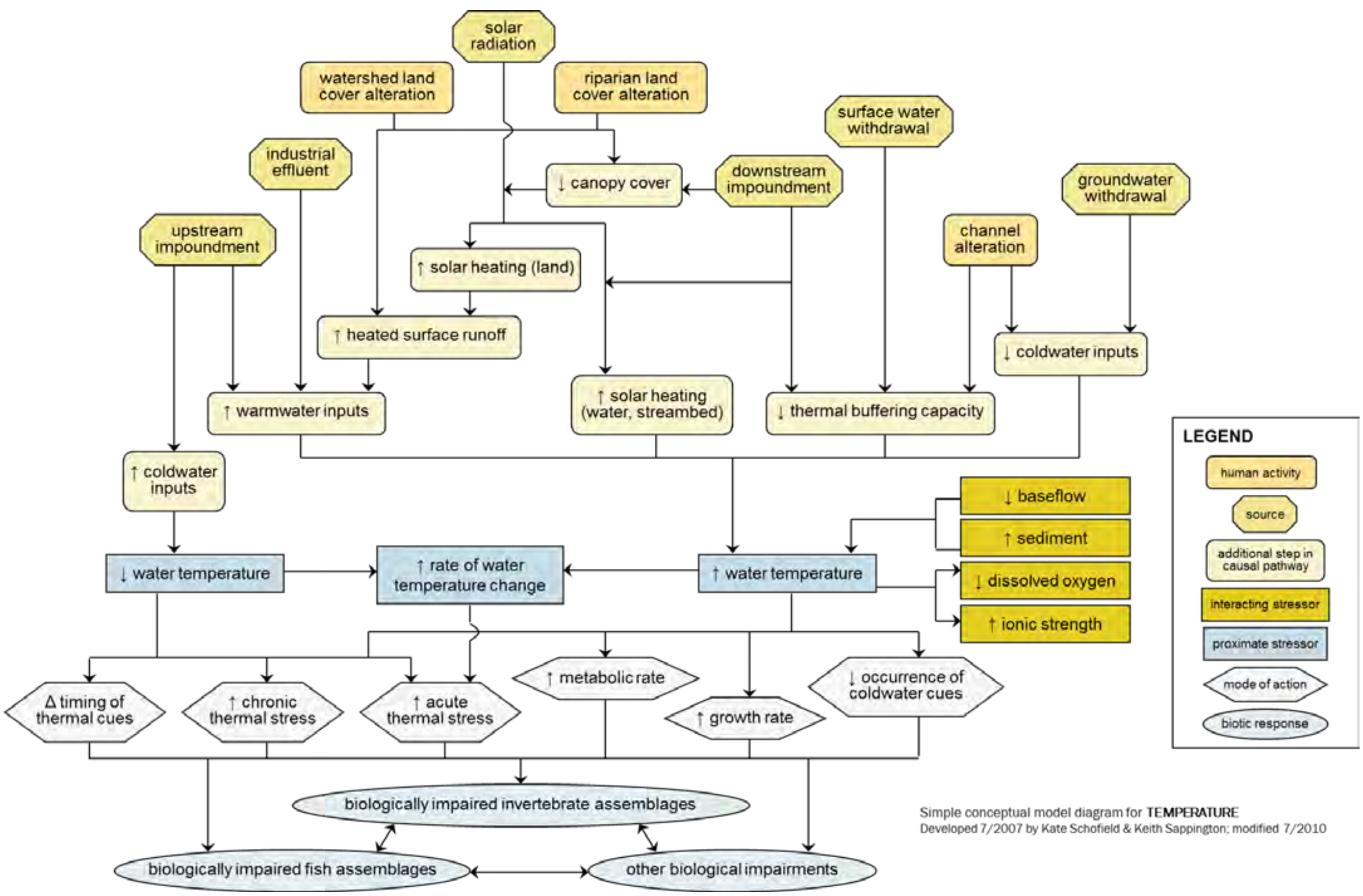


Figure 62 Conceptual diagram illustrating causal pathways, from sources to impairments, related to temperature

3.2.4 Dissolved Oxygen

Dissolved oxygen is a very important measure of how healthy a stream is. Like terrestrial animals, fish and other aquatic organisms need oxygen to live. Many gamefish (ex. bass and bluegill) require dissolved oxygen levels between 4 to 12 mg/L. When levels drop below 4mg/L, fish become stressed and prone to disease. In severe cases fish kills can occur or the stream reach may become totally devoid of most if not all desirable aquatic life.

A number of natural and human influenced factors can effect a stream's dissolved oxygen levels including water temperature, stream flow, nutrient/organic material loading, and turbidity. For example, a stream reach that receives runoff high in sediment becomes turbid. The soil particles suspended in the water gather more of the sun's energy making it warmer. Warm water is physically unable to hold as much oxygen as cool water so dissolved oxygen levels begin to drop. Excess nutrients and organic materials often carried with the sediment only exacerbate the problem, as bacteria in the stream consume oxygen to breakdown the organic material depriving the fish and aquatic insects of oxygen. (Total Organic Carbon (TOC) was measured as an indicator of organic material loading. Generally, higher TOC concentrations indicate that more oxygen will be consumed as bacteria break down organic material, which may result in an oxygen deficient stream.)

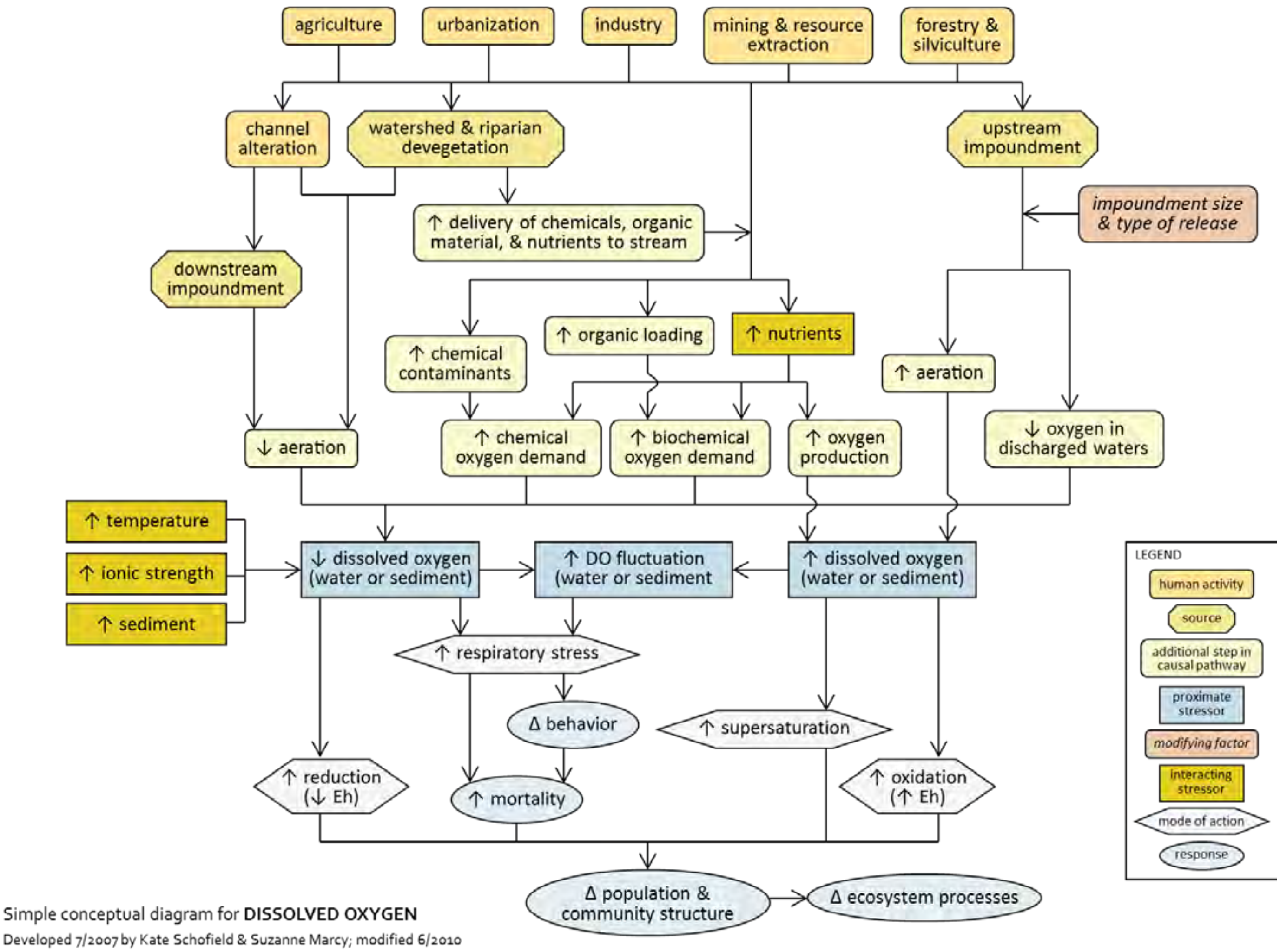


Figure 63 Conceptual diagram illustrating causal pathways, from sources to impairments, related to dissolved oxygen

3.2.5 Nutrients: Phosphorus & Nitrogen

Like nitrogen, phosphorous is essential for plant and animal life. In aquatic systems phosphorous occurs as organic or inorganic phosphate. Organic phosphate is associated with organic material such as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic and is the form required by plants. Unlike nitrogen, phosphorous does not have a gaseous phase. Once it is in an aquatic system it remains there and cycles through different form unless physically removed (e.g. plant harvesting or dredging).

Phosphorus is usually in short supply in freshwater lakes and streams. So even a small increase can lead to a series of water quality problems including accelerated plant and algae growth, low dissolved oxygen levels, and fish kills. Sources of phosphorus, both natural and human, include soils and rocks, wastewater treatment plants, fertilizer runoff, failing septic systems, and runoff from pastures or animal manure storage areas.

Nitrogen makes up about 80% of the air we breathe and is found in all living things. In water it occurs as nitrate (NO3), nitrite (NO2), and ammonia (NH3). Ammonia is a toxic form of nitrogen that forms when organic matter breaks down in water. Its level of toxicity depends on water temperature and pH. Nitrate is a very common form of nitrogen and is the most water-soluble and least attracted to soil particles. Nitrite is uncommon and usually converts to nitrate in surface waters. Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen and ammonia in a water body.

Common human sources of nitrogen include runoff from fertilized lawns, cropped fields, animal manure application and storage areas, wastewater treatment plants, failing septic systems, industrial discharges, and decaying organic matter. Given it solubility in water, nitrate can move quite readily in runoff and through subsurface drainage (field tiles) to surface waters. In surface waters high nitrate levels can lead to excessive aquatic plant growth through a process known as eutrophication. Excessive algae growth can increase turbidity and biochemical oxygen demand and which negatively affects water temperature and dissolved oxygen levels. In severe cases of nutrient enrichment dissolved oxygen concentrations can drop below the levels needed to support aquatic life (<4 mg/l).

Morris & Simon (2012) evaluated nutrient and fish assemblage data collected from 1274 stream reaches between 1996 and 2007 with the Corn Belt and Northern Great Plain Nutrient Region of Indiana to help establish nutrient threshold concentrations above which fish assemblages showed alterations. We used these threshold concentrations to establish nutrient targets for the protection of aquatic life. (Note: The lab detection limit for ammonia was 0.05 mg/L, so any observation was considered an exceedance of the 0.03 mg/L threshold.)

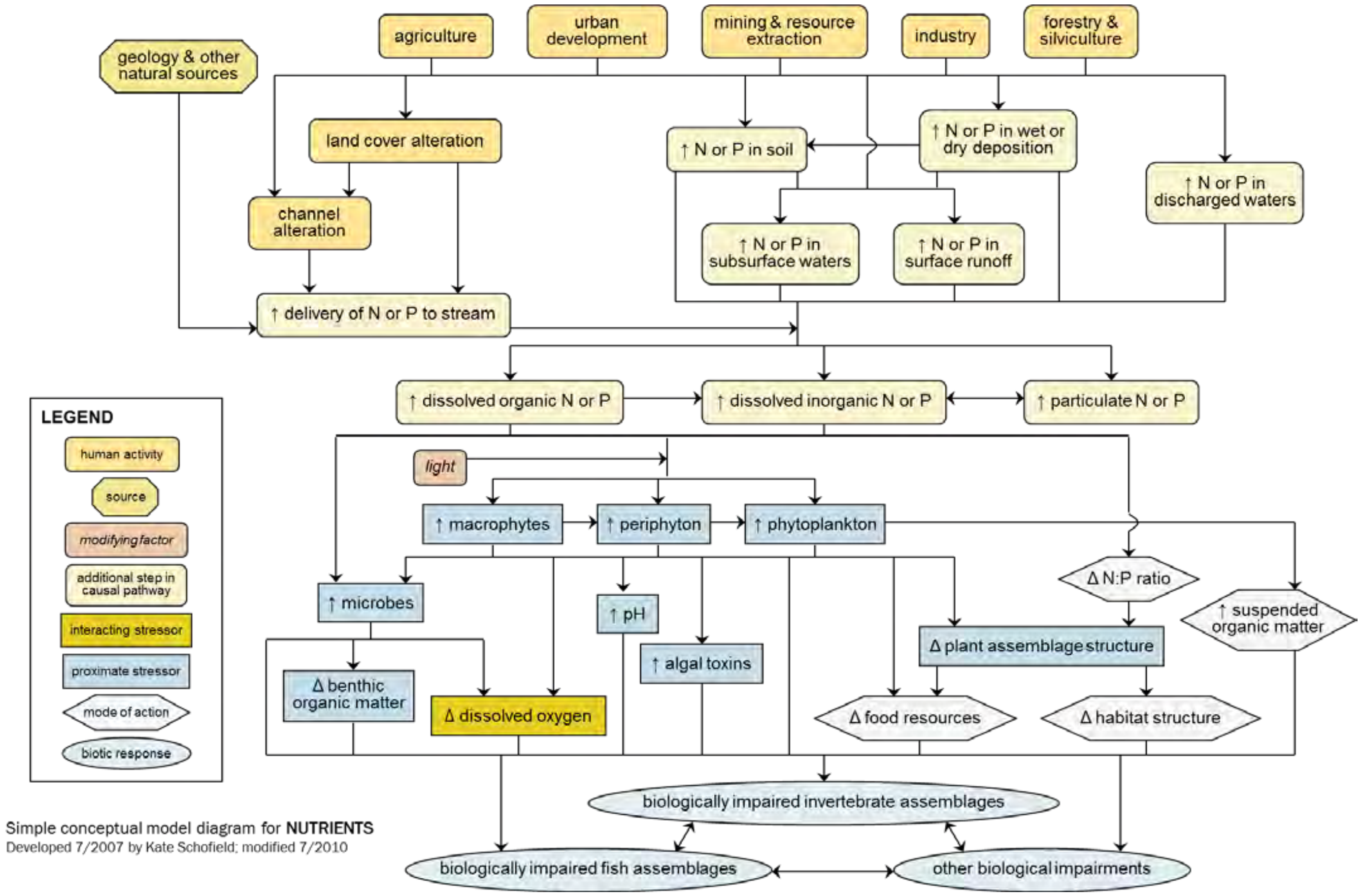


Figure 64 Conceptual diagram illustrating causal pathways, from sources to impairments, related to nutrients

3.2.6 Sediments: Suspended & Deposited

Total suspended solids (TSS) is a measure of the amount (weight per volume of water) of solids suspended in the water. Total suspended solids values vary for two main reasons – one physical, the other biological. Runoff from heavy rains can pick up sediment and debris from the surrounding landscape and carry them to nearby streams making them look muddy. Warm water temperatures, prolonged daylight, and release of nutrients from decomposing organic matter may cause algae blooms that also increase total suspended solid concentrations. High concentrations of particulate matter in water can affect light penetration and plant productivity, water temperature, recreational values, habitat quality, and cause lakes to fill in faster. The particles also provide attachment places for other pollutants like bacteria and nutrients.

Turbidity is another way to measure the amount of solids suspended in water. While total suspended solids measures of the actual weight of materials suspended in water, turbidity measures the amount of light scattered by those materials.

Embeddedness is a way to measure deposited and bedded sediment. Embeddedness is the degree to which interstitial spaces between course substrates like gravel and cobble are filled by finer particles. Results are typically expressed as a percentage. IDEM includes an evaluation of embeddedness when conducting habitat assessments using the Qualitative Habitat Evaluation Index (QHEI) as described below. The QHEI reports the results in a percent range that correspond to the level of severity of embeddedness. For example “moderate” corresponds to 50-75% of the sampling area being embedded.

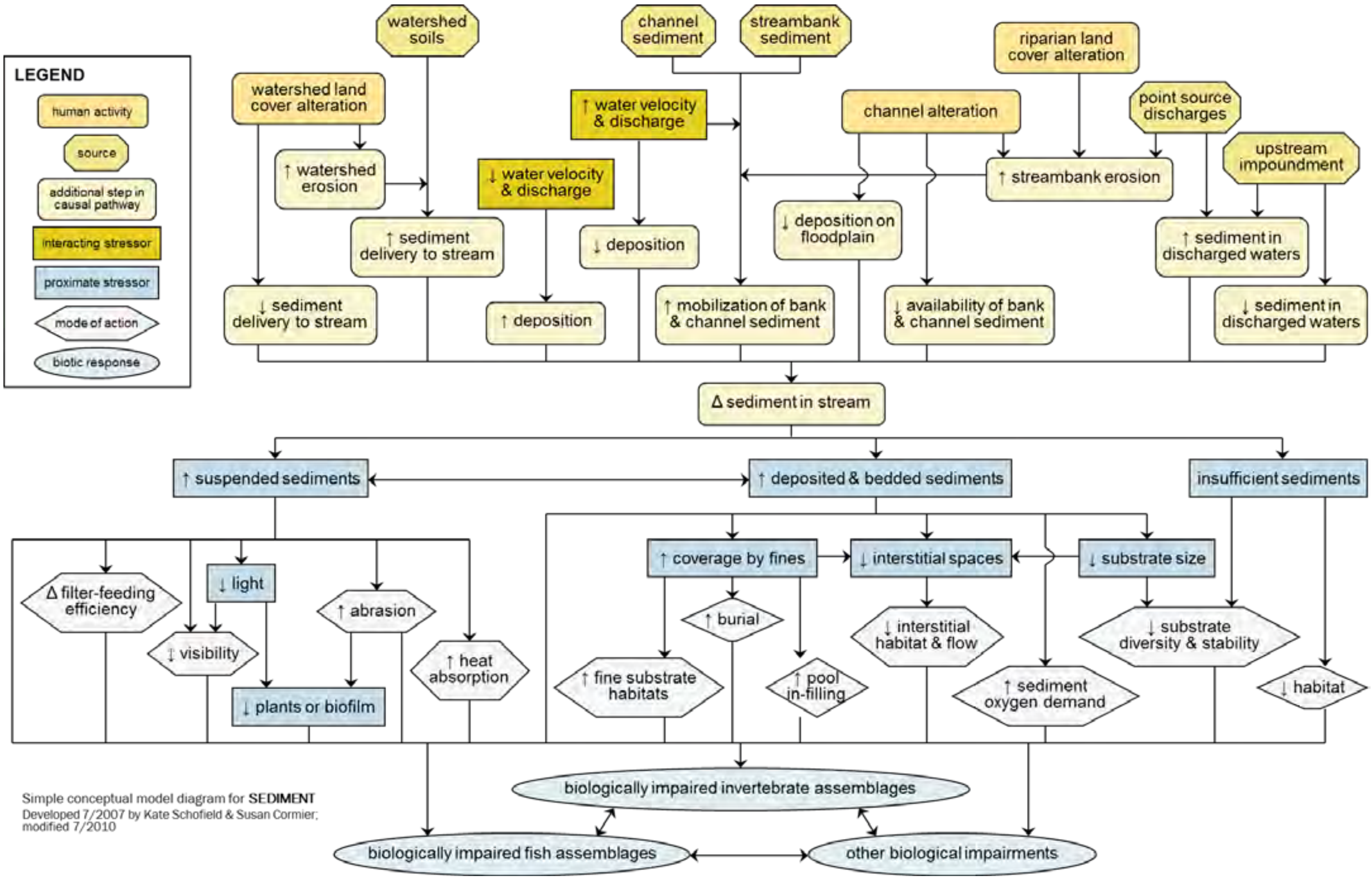


Figure 65 Conceptual diagram illustrating causal pathways, from sources to impairments, related to sediment

3.2.7 Habitat: Qualitative Habitat Evaluation Index

The Qualitative Habitat Evaluation Index (QHEI) provides information on a stream's ability to support healthy fish and macroinvertebrates communities by evaluating in-stream habitat and the land that surrounds it. The QHEI is composed of six separate metrics each designed to evaluate a different portion of a stream site. The metrics include substrate (20pts), in-stream cover (20pts), channel morphology (20pts), bank erosion and riparian zone (10pts), pool/current (12pts) and riffle/run quality (8pts), and gradient (10pts). When the six metrics are added together (maximum score of 100) you get a total QHEI score. The higher the total score, the better the habitat. For streams where the macroinvertebrate and/or fish community (mIBI and/or IBI) scores indicate impaired biotic communities (IBC), QHEI scores are evaluated to determine if habitat is the primary stressor on the aquatic communities or if there may be other stressors/pollutants causing the impairment. A stream reach receiving a score greater than 51 is generally conducive to supporting a healthy warm water fishery. The habitat evaluations conducted by IDEM during the TMDL fishery surveys were used the development of our watershed plan.

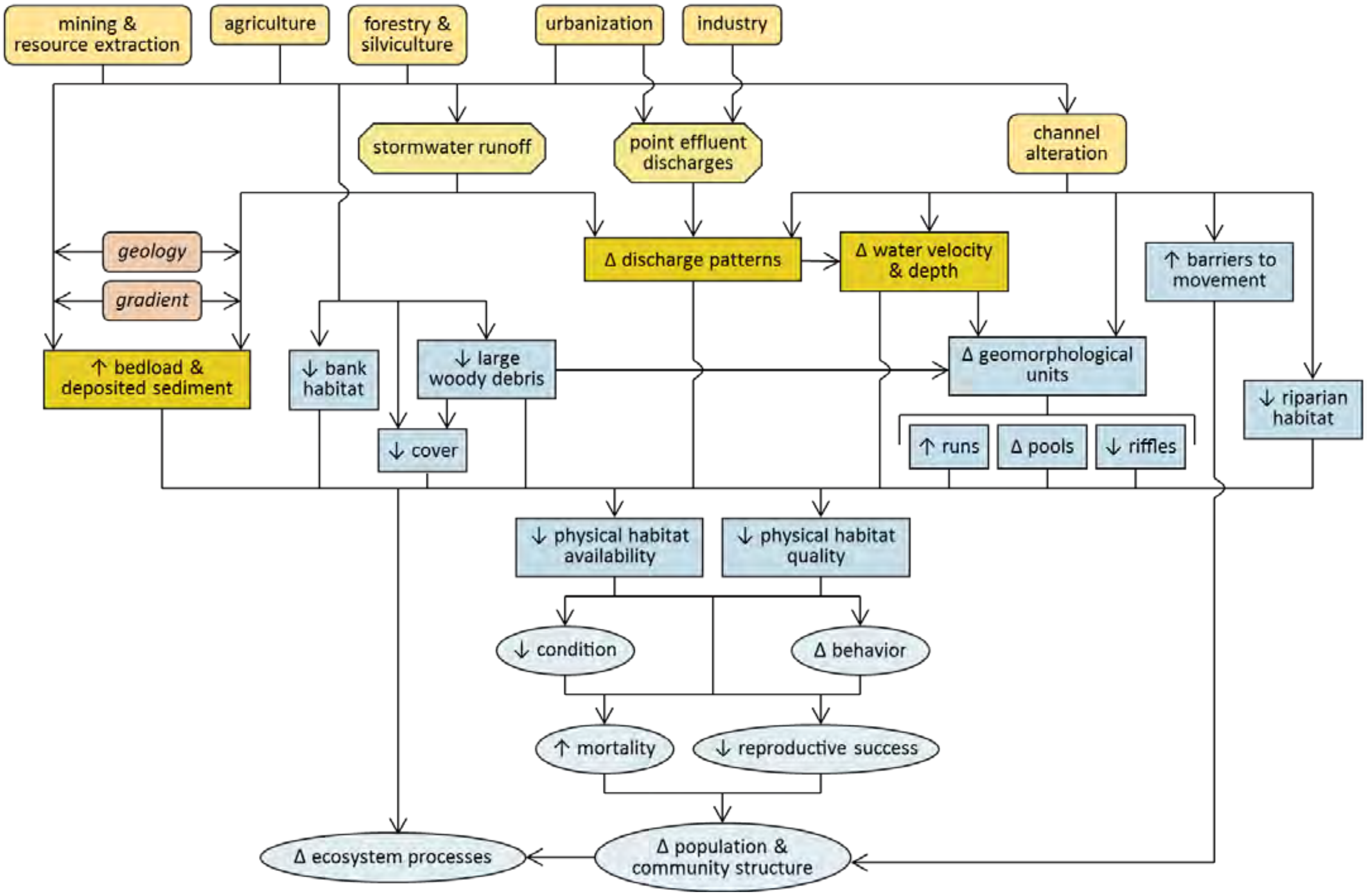


Figure 66 Conceptual diagram illustrating causal pathways, from sources to impairments, related to physical habitat

3.3 Water Quality Data

3.3.1 IDEM Baseline Assessment (2013-2014)

In April 2013, the Indiana Department of Environmental Management initiated a year-long baseline monitoring program to support the development of our watershed plan and a Total Maximum Daily Load (TMDL) study. IDEM field crews collected water chemistry, *E. coli*, habitat, fish and macroinvertebrate data from 35 stream sites located throughout the watershed (Table 39 and Figure 67). Stream flow data was also collected at nine sites considered representative of each subwatershed's drainage area. Water chemistry and *E. coli* samples were collected monthly during the recreational season (April-October) at all 35 sites. Outside the recreational season, monitoring was limited to the nine representative subwatershed (TMDL) sites. Water quality monitoring did not occur in January or February of 2014 because of ice cover. Habitat, fish and macroinvertebrate communities were evaluated once during the study period. For a description of the methodologies used by IDEM please see the Sampling and Analysis Work Plan for the Baseline Monitoring project available at www.in.gov/idem/nps/3893.htm.

Site #	IDEM Site #	Stream Name	Road Name	AUID 2012
1	LMG-05-0002	Burns Ditch	US 20	INC0159_01
2	LMG-05-0003	Willow Creek	Clem Road	INC0159_T1001
3	LMG-05-0004	Willow Creek	Stone Ave	INC0159_T1001
5	LMG-05-0006	Deep River	29th Ave	INC0158_01
6	LMG-05-0007	Deep River	Liverpool Road	INC0158_01
7	LMG-05-0008	Tributary of Deep River	Shelby Street	INC0158_T1002

Site #	IDEM Site #	Stream Name	Road Name	AUID 2012
8	LMG030-0008	Deep River	Ridge Road	INC0157_P1001
9	LMG-05-0009	Duck Creek	Front Street	INC0156_01
10	LMG-05-0010	Tributary of Duck Creek	10th Street	INC0156_T1003
11	LMG-05-0032	Duck Creek	750 W	INC0156_01
12	LMG-05-0011	Deep River	Arizona Street	INC0157_01
13	LMG-05-0033	Sprout Ditch	70th Ave	INC0157_T1002
14	LMG-05-0012	Deep River	Joliet Road	INC0157_01
15	LMG-05-0013	Tributary of Deep River	750 W	INC0154_T1005
16	LMG-05-0034	Tributary of Deep River	89th Avenue	INC0154_T1004
17	LMG-05-0014	Tributary of Deep River	93rd Avenue	INC0154_T1003
18	LMG-05-0015	Deep River	Clay Street	INC0152_04
19	LMG-05-0035	Deer Creek	97th Street	INC0154_T1001
20	LMG-05-0016	Niles Ditch	Colorado Street	INC0152_T1009
21	LMG-05-0017	Niles Ditch	121st Avenue	INC0152_T1009
22	LMG-05-0036	Smith Ditch	113th Street	INC0152_T1008
23	LMG-05-0018	Main Beaver Dam Ditch	Grant Street	INC0152_04
24	LMG-05-0019	Tributary of Main Beaver Dam Ditch	Summit Street	INC0151_T1003
25	LMG-05-0020	Main Beaver Dam Ditch	Clark Road	INC0151_01
26	LMG-05-0021	Tributary of Main Beaver Dam Ditch	77th Avenue	INC0151_T1001
27	LMG-05-0022	Main Beaver Dam Ditch	Blaine Street	INC0151_01
28	LMG-05-0023	Tributary of Turkey Creek	77th Avenue	INC0153_T1001
29	LMG-05-0024	Turkey Creek	Broad Street	INC0153_01
30	LMG-05-0025	Johnson Ditch	Oak Ridge Prairie Park	INC0153_T1003
31	LMG-05-0026	Tributary of Turkey Creek	W Old Lincoln Hwy	INC0153_T1004
32	LMG-05-0027	Turkey Creek	SR55	INC0153_01
33	LMG-05-0028	Tributary of Turkey Creek	73rd Avenue	INC0153_T1005
34	LMG-05-0029	Tributary of Turkey Creek	Arthur Street	INC0155_T1003
35	LMG-05-0030	Tributary of Turkey Creek	73rd Avenue	INC0155_T1002
36	LMG-05-0031	Turkey Creek	Liverpool Road	INC0155_01

Table 39 IDEM Stream Water Quality Monitoring Site Information

Catchment (drainage) areas were delineated for each monitoring site by NIRPC using the union tool in ArcMap and the original delineation GIS data provided by IDEM. Further refinement of the site drainage areas was necessary for analysis and pollutant load modeling using the Spreadsheet Tool for Estimating Pollutant Load (STEPL). Site catchment areas are shown in Figure 67 and their drainage area size in Table 40.

Site	Area (ac)	Site	Area (ac)	Site	Area (ac)	Site	Area (ac)
1	9,287	10	2,325	19	1,895	28	1,808
2	2,046	11	4,846	20	4,110	29	1,355
3	3,414	12	1,857	21	1,783	30	1,690
4	106	13	1,508	22	1,615	31	1,438
5	4,120	14	2,240	23	3,188	32	3,578
6	2,473	15	7,943	24	1,499	33	2,541
7	4,695	16	3,765	25	4,599	34	3,977
8	5,405	17	1,788	26	5,420	35	1,978
9	9,287	18	4,615	27	1,813		

Table 40 Site catchment drainage area size

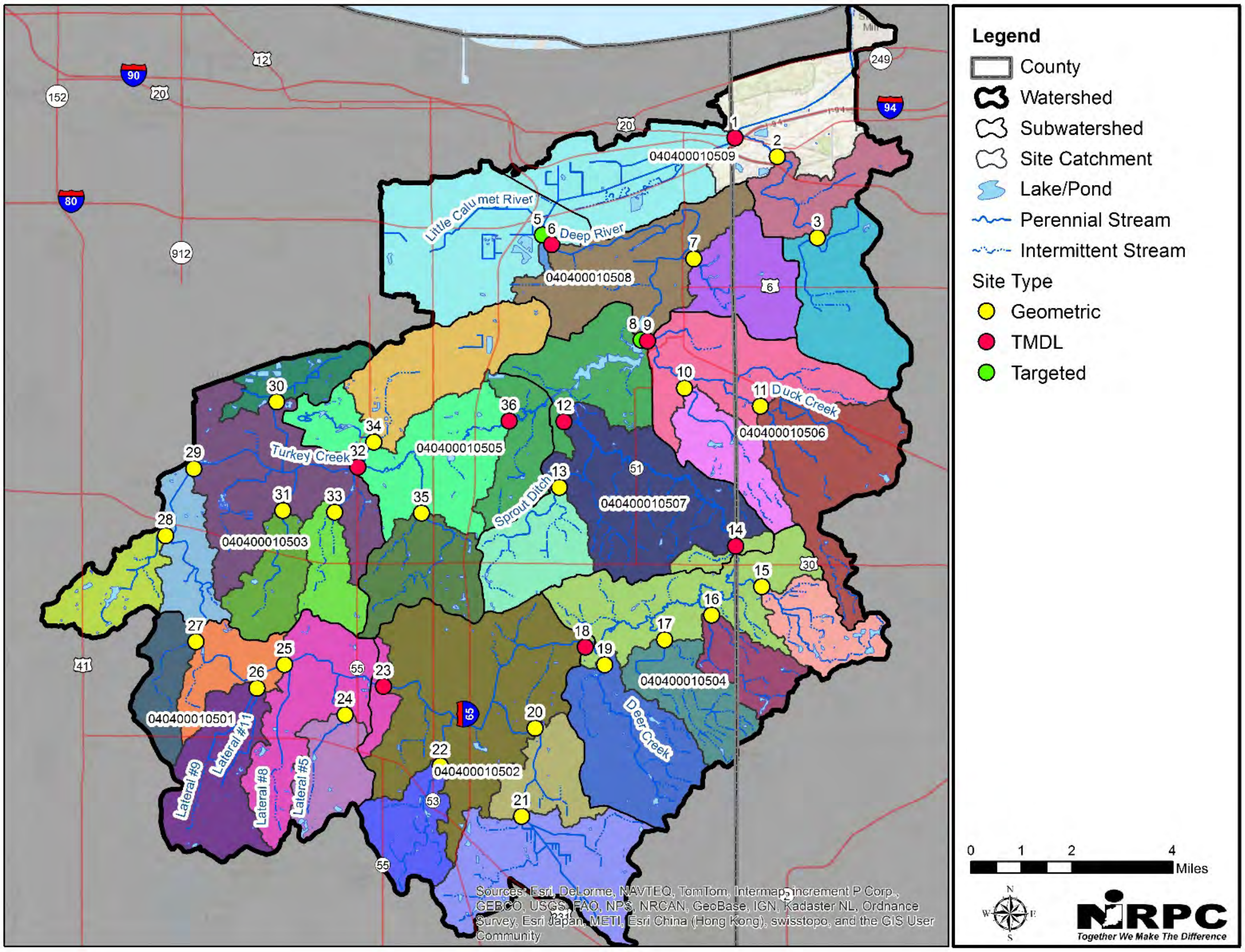


Figure 67 IDEM baseline assessment stream monitoring sites and their catchments

3.3.2 Historical Water Quality Data

The following section provides a brief summary of historical water quality data that was collected within the past 15 years. Because of the limited nature (spatial coverage, time period, parameters monitored, and sampling frequency), this data was not considered further for analysis but is presented as required by IDEM's watershed planning checklist.

3.3.2.1 *IDEM (2000-2010)*

Prior to its baseline assessment in 2013-2014, IDEM has previously monitored several sites throughout the watershed (Table 41 and Figure 68). However, given the limited nature of the data (spatial coverage, time period, parameters monitored, and sampling frequency), this data was not considered further. This was the primary reason that NIRPC requested IDEM complete a comprehensive baseline assessment for the watershed based on findings in the Northwest Indiana Watershed Framework. A review of the TMDL report also indicates IDEM did not include the historical site information into the TMDL process.

Station ID	Year(s)	Project Name	Events
LMG030-0002	2000	2000 Corvallis	3
LMG030-0006	2000	2000 E. coli	5

LMG030-0007	2000	2000 E. coli	5
LMG030-0008	2000, 2002-2006	Clean Sampling & Ultra-Clean Analysis	25
LMG030-0009	2000	2000 E. coli	5
LMG030-0010	2000	2000 E. coli	5
LMG030-0011	2000	2000 E. coli	5
LMG030-0022	2005	2005 Corvallis	8
LMG040-0001	2000	2000 Corvallis	4
LMG040-0003	1999-2010	Fixed station	140
LMG040-0004	2000	2000 E. coli	5
LMG040-0005	2000	2000 E. coli	5
LMG040-0008	2005	2005 Corvallis	8
LMG060-0006	2000	2000 Burns Ditch TMDL Assessment	5
LMG060-0007	1999-2010	Fixed Station	140
LMG060-0012	2000	2000 Burns Ditch TMDL Assessment	5

Table 41 IDEM historical stream monitoring site information

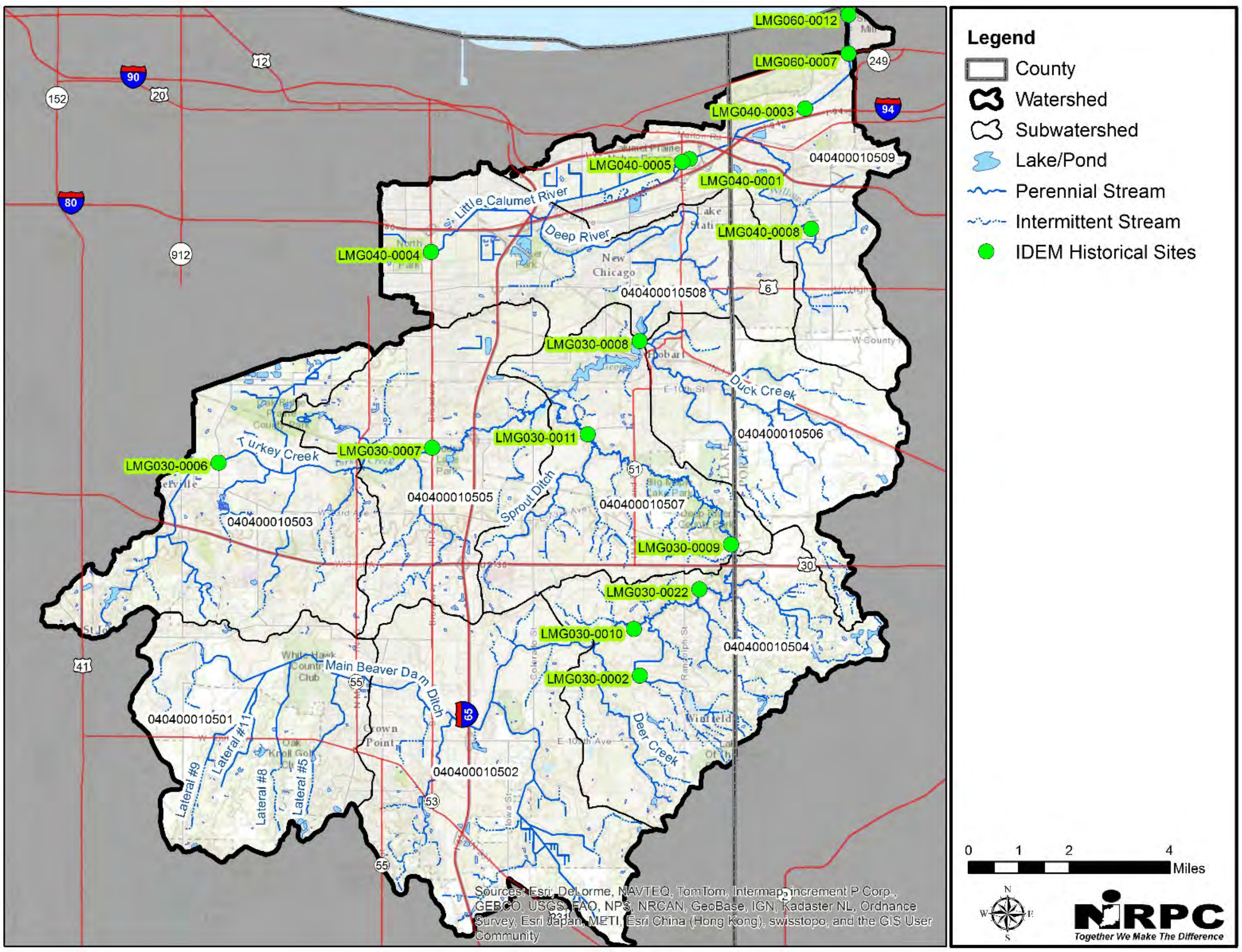


Figure 68 IDEM historical water quality monitoring sites

3.3.2.2 *Deep River-Turkey Creek Watershed Management Plan Data (2002)*

To facilitate the development of the 2002 Deep River-Turkey Creek Watershed Management Plan, an assessment of existing water quality from nine sites in the watershed was done to supplement historical water quality data (Figure 69). Sampling was generally focused around the Deep River-Lake George Dam subwatershed and limited to two dates. The first monitoring event on January 28, 2002 evaluated baseflow conditions following a period of little precipitation. The second monitoring event on April 3, 2002 evaluated stormflow conditions following two days of 1/2-1 inch of rain. Water quality data is from the study is presented in Table 42 and Table 43. Further discussion is available in the Deep River-Turkey Creek Watershed Management Plan.

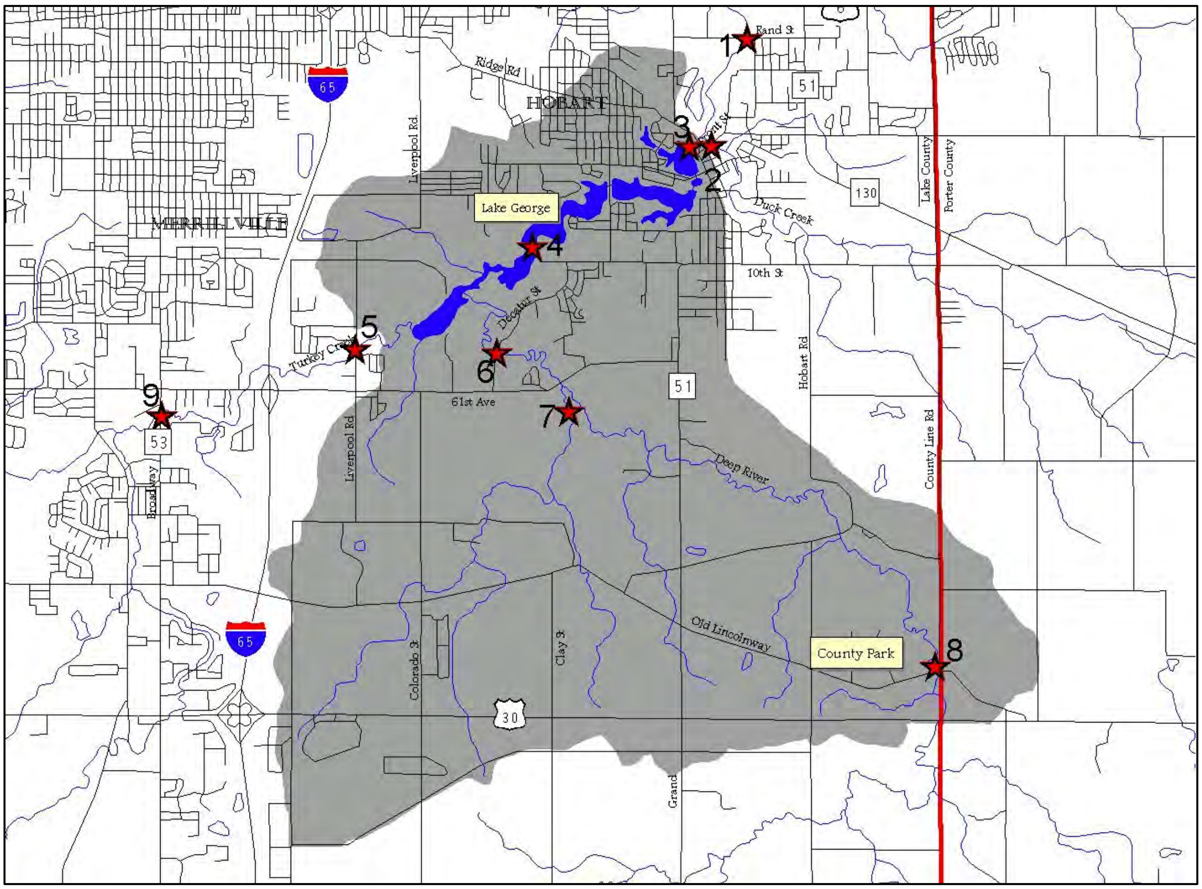


Figure 69 Stream sampling sites monitored during development of Deep River-Turkey Creek Watershed Plan

Site	Date	Timing	Flow (cfs)	Temp (ºC)	DO (mg/L)	DO Sat (%)	Conductivity (ųmho s/cm)	pH (SU)	BOD (mg/L)
1	1/28/2002	Base	53.43	3.0	12.20	92.0	900	6.9	2.3
	4/3/2002	Storm	525.99	6.0	10.72	84.9	900	8.1	<2.0
2	1/28/2002	Base	5.79	3.0	11.10	85.0	700	8.1	<2.0
	4/3/2002	Storm	78.83	5.0	9.70	75.3	400	8	<2.0
3	1/28/2002	Base	40.65	3.0	12.20	92.0	900	8.1	<2.0
	4/3/2002	Storm	592.52	7.0	10.96	89.4	900	8.5	<2.0
4	1/28/2002	Base	41.27	3.5	11.60	90.0	800	8.4	<2.0
	4/3/2002	Storm	633.50	6.0	9.98	78.5	500	7.8	4

5	1/28/2002	Base	8.32	5.5	9.20	75.0	900	8.3	<2.0
	4/3/2002	Storm	139.13	6.0	9.88	78.7	700	8.5	2.8
6	1/28/2002	Base	18.11	5.0	11.00	88.0	800	8.4	<2.0
	4/3/2002	Storm	335.34	6.0	9.95	79.1	400	8.5	3.2
7	1/28/2002	Base	0.75	5.5	10.80	88.0	1200	8.2	<2.0
	4/3/2002	Storm	--	--	--	--	--	--	--
8	1/28/2002	Base	1.30	5.0	11.20	90.0	700	8.1	3.6
	4/3/2002	Storm	364.17	6.0	10.56	83.8	500	8.7	3.3
9	1/28/2002	Base	11.25	6.0	10.80	89.0	800	6.8	<2.0
	4/3/2002	Storm	87.48	6.0	10.01	80.5	700	8.1	3.4

Table 42 Physical water quality parameter data collected for Deep River-Turkey Creek Watershed Plan

Site	Date	Timing	Nitrate (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E. coli (col/100mL)
1	1/28/2002	Base	1.62	0.07	1.30	0.17	5.2	48
	4/3/2002	Storm	0.55	0.39	0.55	<0.10	43.0	180
2	1/28/2002	Base	2.37	0.04	1.00	<0.10	22.0	140
	4/3/2002	Storm	1.20	0.13	1.20	0.24	48.0	760
3	1/28/2002	Base	1.53	0.07	1.60	0.14	14.0	42
	4/3/2002	Storm	0.71	0.36	0.71	<0.10	29.0	80
4	1/28/2002	Base	0.88	0.10	1.00	<0.10	18.0	48
	4/3/2002	Storm	1.10	0.27	1.10	0.26	150.0	800
5	1/28/2002	Base	0.21	0.10	1.10	<0.10	13.0	94
	4/3/2002	Storm	0.77	0.16	0.77	0.11	56.0	440
6	1/28/2002	Base	1.75	0.24	1.80	<0.10	8.4	24
	4/3/2002	Storm	1.00	0.31	1.00	0.28	120.0	1,000
7	1/28/2002	Base	0.36	<0.01	0.71	<0.10	<5.0	50
	4/3/2002	Storm	--	--	--	--	--	--
8	1/28/2002	Base	2.23	1.50	5.20	0.18	<5.0	110
	4/3/2002	Storm	1.30	0.40	1.30	0.30	120.0	2,100
9	1/28/2002	Base	0.19	0.15	1.30	<0.10	8.0	480
	4/3/2002	Storm	0.71	0.36	0.71	0.10	62.0	310

Table 43 Chemical and bacterial data collected for Deep River-Turkey Creek Watershed Plan

3.3.2.3 *West Branch Little Calumet River Watershed Management Plan Data (2007)*

Water quality sampling was also conducted to facilitate the development of the West Branch Little Calumet River Watershed Management Plan. Seven (7) monitoring sites were sampled once during stormflow conditions and once during baseflow in 2007. The water quality parameters measured included ammonia, nitrate, total phosphorus, orthophosphate, total suspended solids, dissolved oxygen, pH, and *E. coli*. An additional forty (42) sites were sampled for *E. coli* four times in 2007. Sampling location are shown in the figure below and the results are presented in Table 44 and Table 45. Further discussion is available in the West Branch Little Calumet River Watershed Management Plan.

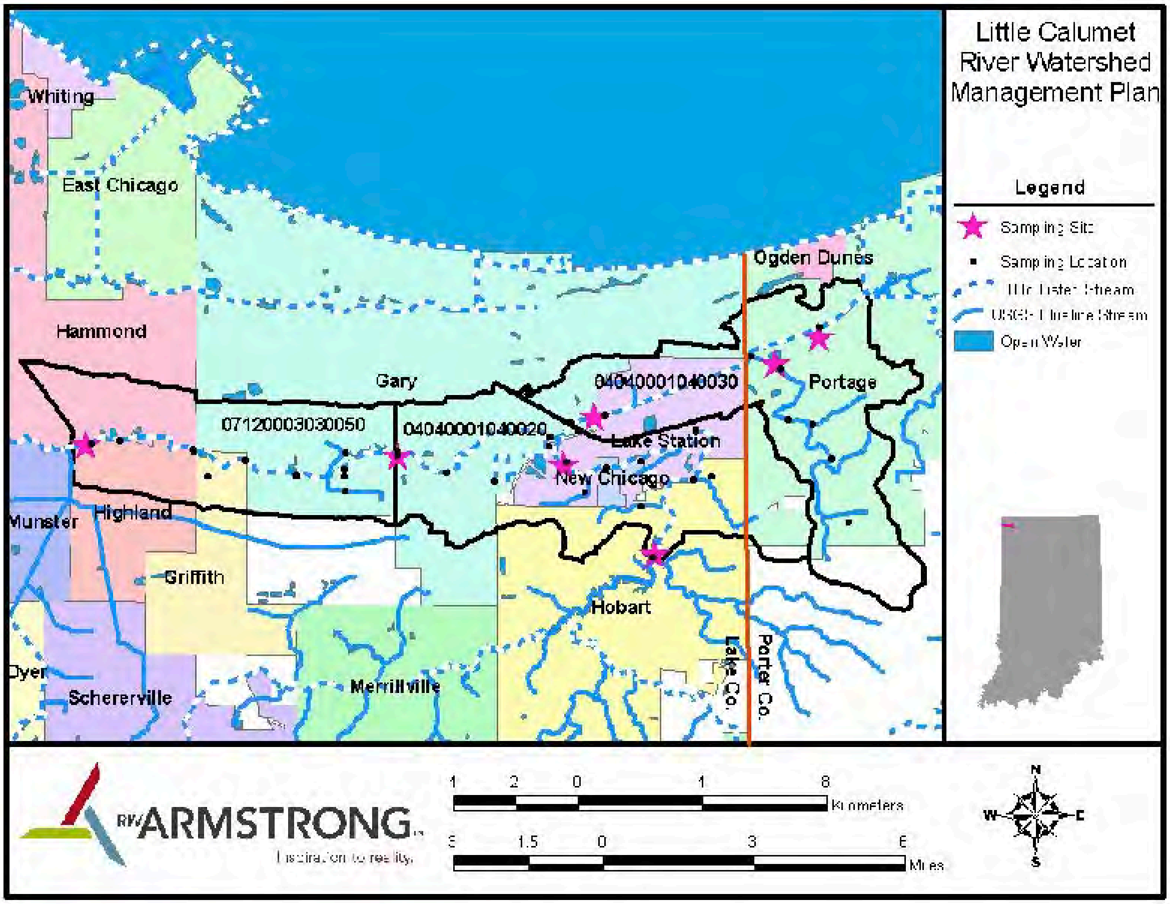


Figure 70 Stream monitoring sites for West Branch Little Calumet River Watershed Plan

Site	Timing	Flow (cfs)	E.coli (cfu/100mL)	pH SU	DO (mg/L)	NH3 (mg/L)	NO3 (mg/L)	TP (mg/L)	Ortho- P (mg/L)	TSS (mg/L)
1*	Base	2.0	3,150	7.4	6.7	0.5	8.5	4.8	2.7	11.0
	Storm	52	1,820	7.1	0.3	1.0	1.5	0.2	0.2	23.5
2	Base	2.7	255	7.6	3.4	0.9	2.8	0.13	0.12	93.0
	Storm	70	1,320	7.3	2.9	0.9	1.4	0.10	0.09	16.0
3**	Base	17.0	501	7.9	5.1	0.5	1.2	0.24	0.15	22.0
	Storm	435	2,380	7.3	6.1	0.8	1.1	0.14	0.13	29.0
4	Base	20.6	61	7.5	3.3	0.5	0.9	0.26	0.13	26.0
	Storm	526	1,240	7.4	4.8	2.0	1.1	0.06	0.05	28.0
5	Base	23.3	118	7.5	3.1	0.3	1.2	0.13	0.09	13.0
	Storm	597	1,760	7.4	6.0	1.3	0.9	0.06	0.05	28.0
6	Base	1.2	927	7.7	7.6	0.9	1.4	0.18	0.15	6.0
	Storm	30	2,900	7.4	7.1	1.9	1.2	0.12	0.11	23.5
7	Base	24.5	125	7.5	6.2	0.5	3.0	0.24	0.22	9.0
	Storm	626	2,600	7.3	6.0	1.3	1.0	0.22	0.18	36.0

Table 44 Water quality data collected for West Branch Little Calumet River Watershed Plan

Sampling Location	*E. coli* (cfu/100ml)			
	Dry Weather (7/24/2007)	Wet Weather (8/21/2007)	Wet Weather (9/26/2007)	Dry Weather (10/30/2007)

1		695	2	225
2	1804	3890	0	341
3	448	465	4	190
4	25	1620	0	218
5	396	2570	6	174
6	94	220	2	52
7	2	200	0	3
8	3	1385	2	5
9	1	2775	0	32
10	228	910	6	15
11	207	11130	0	144
12	108	340	2	15
13	56	215	6	1
14	353	415	14	20
15	270	3760	0	46
16	692	2765	0	75
17	119	1010	982	78
18	345	695	0	58
19	1	345	0	428
20	88	310	0	113
21	51	720	0	79
22	111	130	6400	7
23	374	945	8	40
24	505	685	2	77
25	275	565	2540	48
26	68	2285	114	16
27	937	2145	182	445
28	375	1220	56	260
29	158	4120	170	5
30	168	735	6	18
31	5	2310	1030	72
32	72	1610	792	102
33	50	405	882	8
34	71	1065	110	19
35	129	1100	358	27
36	51	755	4	2
37	4	1600	654	92
38	3	4580	2700	79
39	36	4515	62	67
40	9	2375	292	2
41	86	105	2440	44
42	913	2040	3100	586

Table 45 E. coli data collected for West Branch Little Calumet River Watershed Plan

4 Subwatersheds of the Deep River-Portage Burns Waterway Watershed

The following section provides a summary of water quality, habitat, biological, and land use information for each of Deep River-Portage Burns Waterway's subwatersheds.

4.1 Headwaters Main Beaver Dam Ditch (HUC 040400010501)

4.1.1 Overview

The Headwaters Main Beaver Dam Ditch subwatershed is located in the southwestern portion of the watershed. It drains approximately 18.3 mi² of primarily developed (39%) and agricultural (26%) land. Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities, and high nutrient and *E. coli* levels.

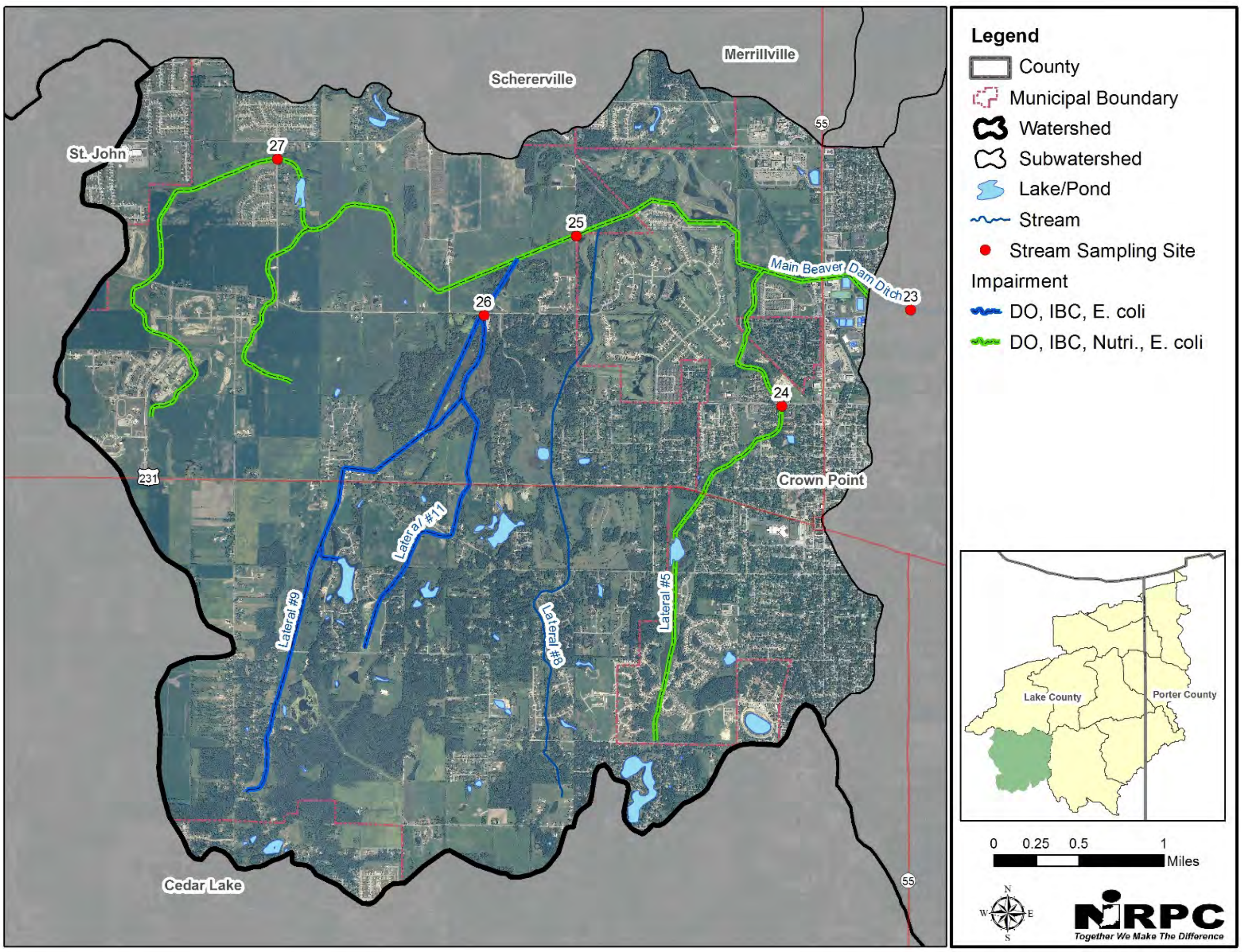


Figure 71 Stream Impairments within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2 Water Quality

IDEM collected water quality data at four monitoring stations (Sites 27-24) within the subwatershed (Figure 71). Site 23 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.1.2.1 *Pathogens*

Water quality sampling at Sites 23-27 show that any full body contact recreational use would be threatened by high pathogen levels (Figure 72). Each site at least occasionally failed to meet the water quality standard of 235 CFU/mL. Site 24 stands out in having the highest frequency of exceedances (>90%) and concentrations observed. Exceedances at Sites 23, 24 and 27 occurred across high to dry stream flow conditions indicating contributions from nonpoint and point sources from within their respective drainage areas. Exceedances at Sites 25 and 26 typically occurred when stream flows were high indicating nonpoint source contributions.

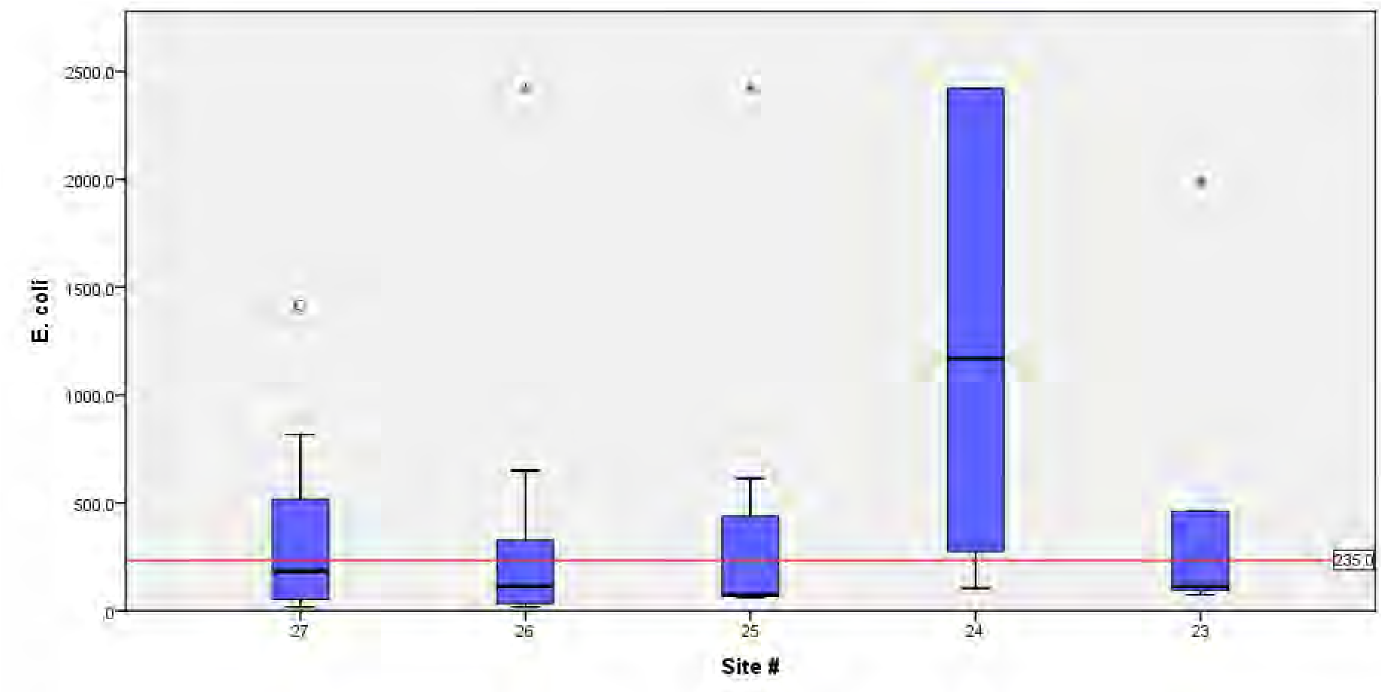


Figure 72 Box plot illustrating site E. coli concentrations within the Headwaters Main Beave Dam Ditch Subwatershed

4.1.2.2 *Fish*

An assessment of fish community structure showed that the stream reaches represented by Sites 24-26 do not fully supporting their Aquatic Life Use designation (Table 46). While Sites 27 and 23 were found to be fully supporting, they only received an integrity classification of “fair”. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were lacking and numbers of fish collected was extremely low. Fish species that require clean gravel/cobble substrates to spawn were also lacking. Metric scores that evaluated trophic structure, the position the fish occupies in the food chain (ex. carnivore or insectivore), indicated some degree of environmental degradation at Sites 26-23.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
27	40	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
26	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
25	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
24	14	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
23	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 46 Site fish index of biotic integrity scores within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed that none of the sites were supporting of Aquatic Life Use and received "poor" integrity classifications (Table 47). All sites were dominated by macroinvertebrates that are tolerant of pollution and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
27	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
26	26	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
25	26	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
24	24	Not Supporting	Poor	Few species and individuals present, tolerant species dominant
23	26	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 47 Site macroinvertebrate index of biotic integrity scores within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.4 *Water Temperature*

No site had any water temperature observations that exceeded the monthly maximum water quality standard. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 17-21°C (63-70°F). Figure 73 shows a subtle decreasing trend in water temperature, in both maximum and median values, moving from upstream to downstream locations. Site 24 stands out in having the lowest maximum water temperature observed and least variability in temperature.

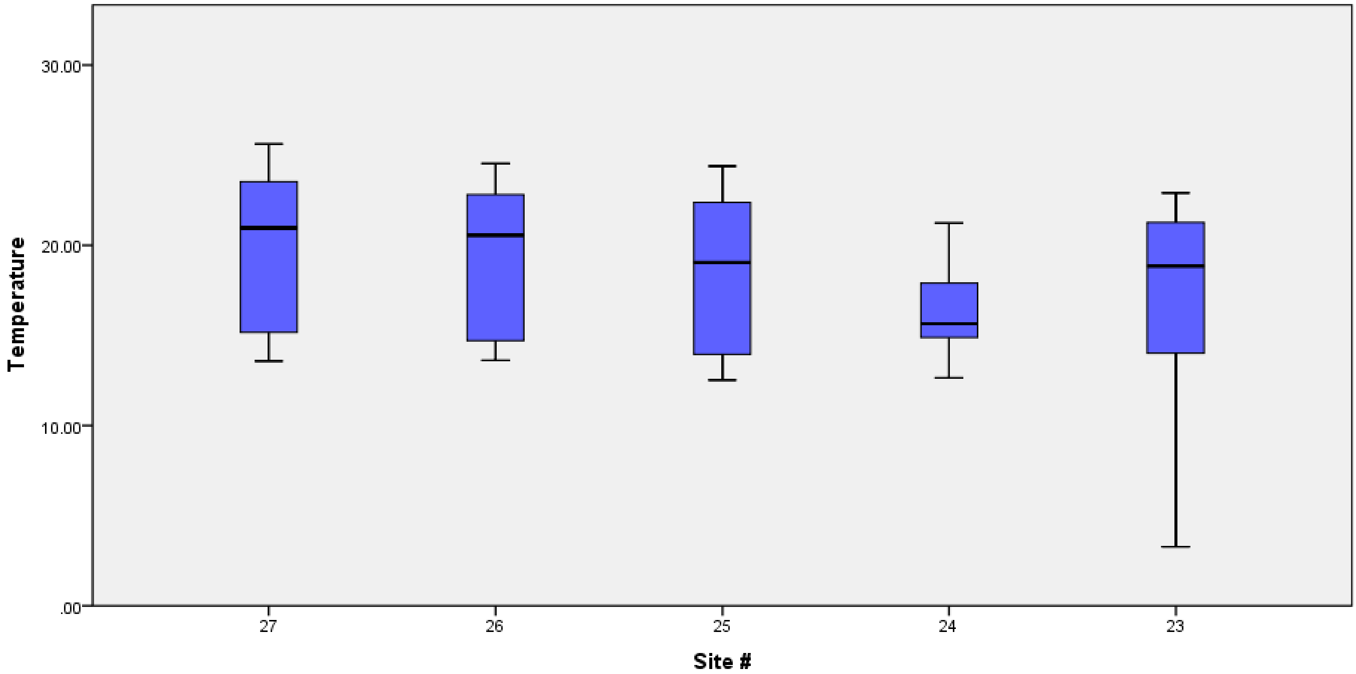


Figure 73 Box plot illustrating site water temperature observations within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.5 *Dissolved Oxygen*

Figure 74 shows that Sites 24-27 all had periods in which they failed to meet the dissolved oxygen water quality standard of 4-12mg/L. Median dissolved oxygen concentrations fell below 4 mg/L for Sites 24-26. The median concentration was only slightly higher than 4 mg/L at Site 27. Violations most frequently occurred during the summer and fall when water temperatures are at or near their warmest.

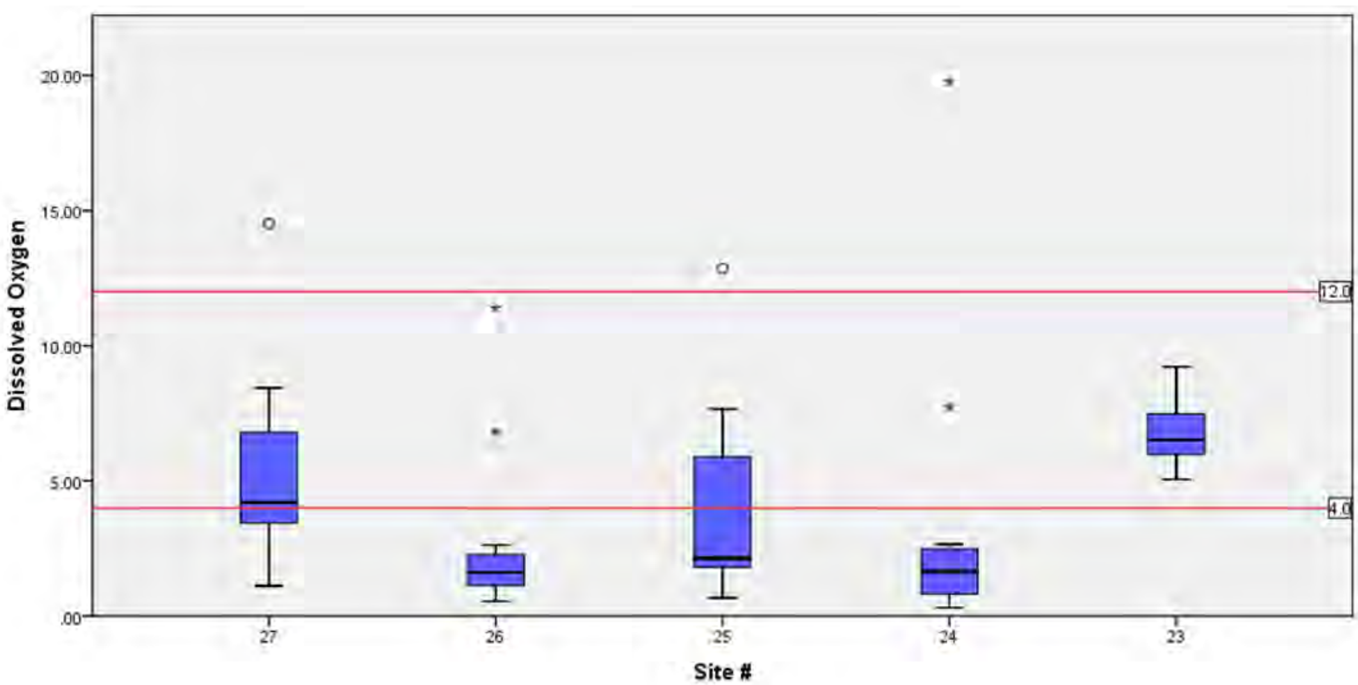


Figure 74 Box plot illustrating site dissolved oxygen concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.6 *Total Organic Carbon*

Figure 75 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Sites 24-27.

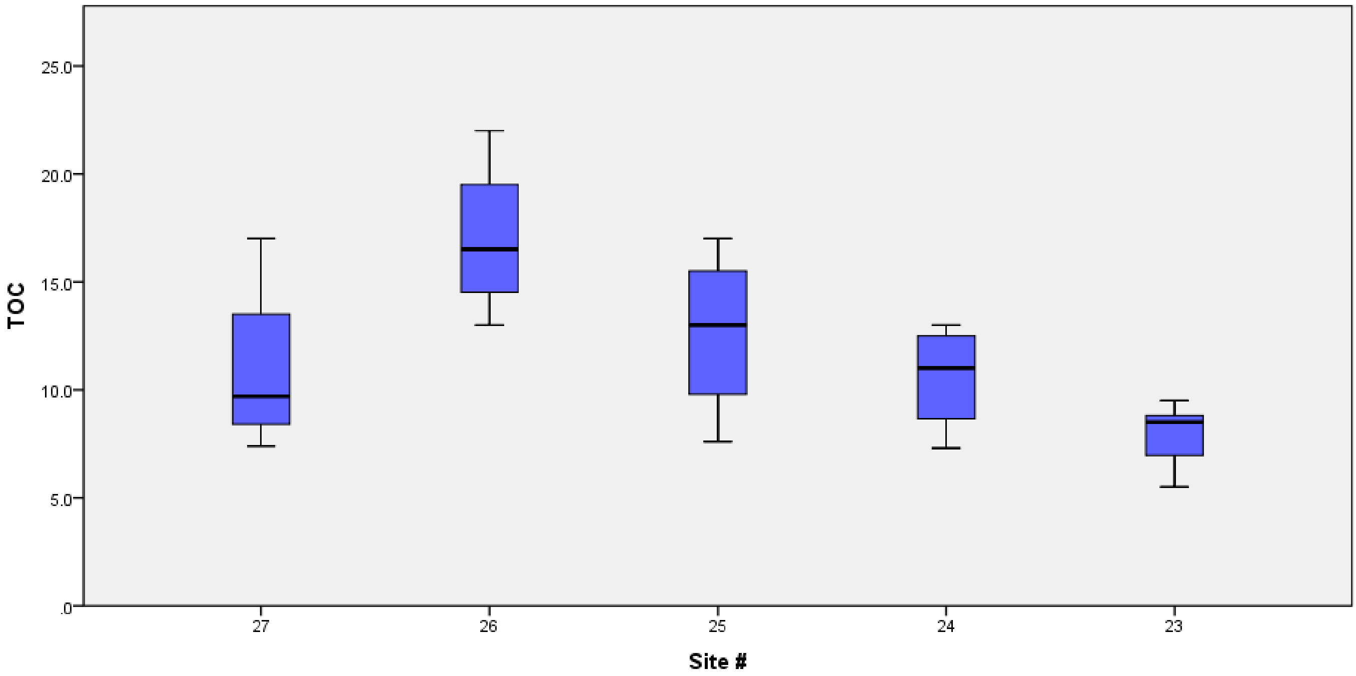


Figure 75 Box plot illustrating site TOC concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.7 *Nutrients*

Figure 76 shows that all sites consistently exceeded the 0.07mg/L total phosphorus threshold. Sites 23 and 26 had the highest median concentrations, exceeding the 0.3mg/L threshold. Seasonally, mean total phosphorus concentrations were highest during the fall for Sites 23 (0.89 mg/L), 25 (0.32 mg/L), and 26 (0.62 mg/L) and the summer for Sites 24 (0.24 mg/L) and 27 (0.34 mg/L). However, the distribution of total phosphorus concentrations was not found to be statistically different across seasons.

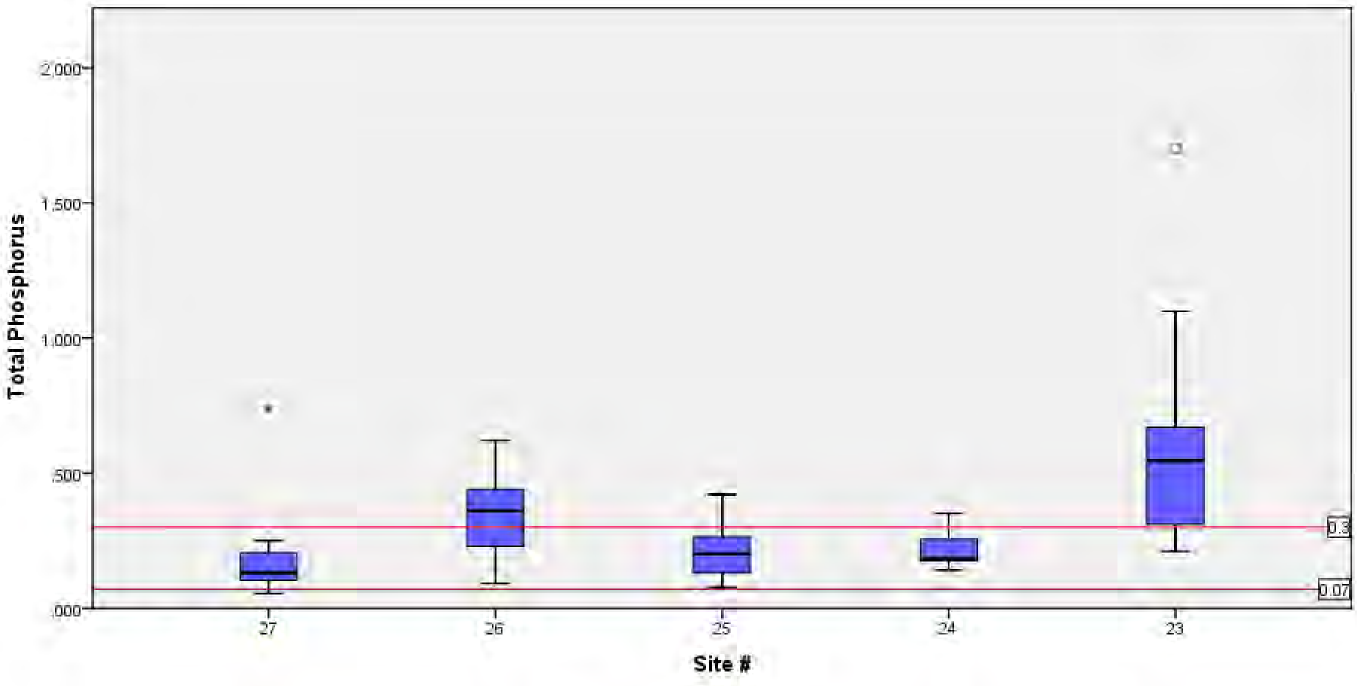


Figure 76 Box plot illustrating site total phosphorus concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

Figure 77 shows that Site 23 had a median nitrate concentration in excess of 10mg/L. If Main Beaver Dam Ditch was a designated drinking water supply this would be a considered a violation of the state water quality standard. More than 25% of the samples at Site 25 exceeded the 1.09 mg/L nitrate threshold while 100% of the samples exceeded this threshold at Site 23.

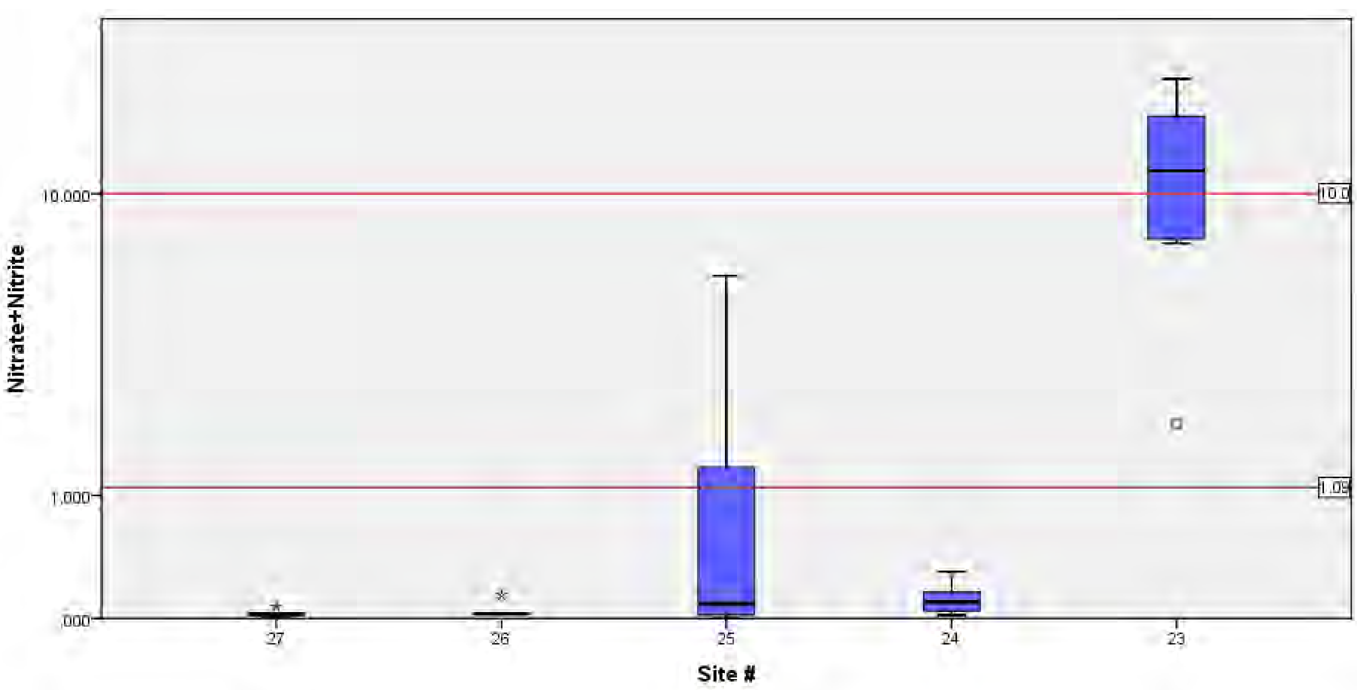


Figure 77 Box plot illustrating site nitrate concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 78 shows that Sites 23-26 had median total Kjeldahl nitrogen concentrations that exceeded the 1.27 mg/L threshold. Over 75% of the samples at Sites 24 and 26 exceeded this threshold. Approximately 25% of the samples from Site 27 exceeded 1.27 mg/L threshold.

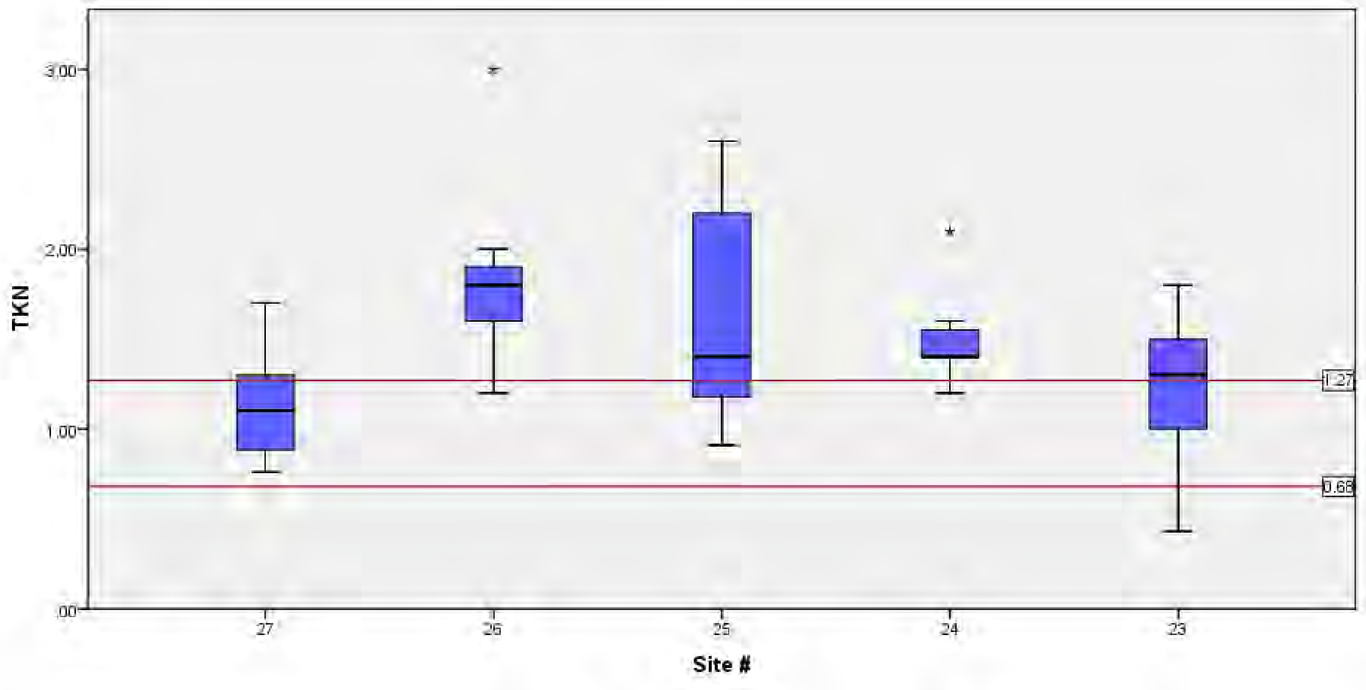


Figure 78 Box plot illustrating site total kjehldahl nitrogen concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

Figure 79 shows that ammonia concentrations at Site 24 frequently exceeded (>75%) the 0.21 mg/L maximum threshold. Sites 23, 25 and 26 also occasionally exceeded this threshold. All sites had at least one exceedance of the 0.03 mg/L threshold.

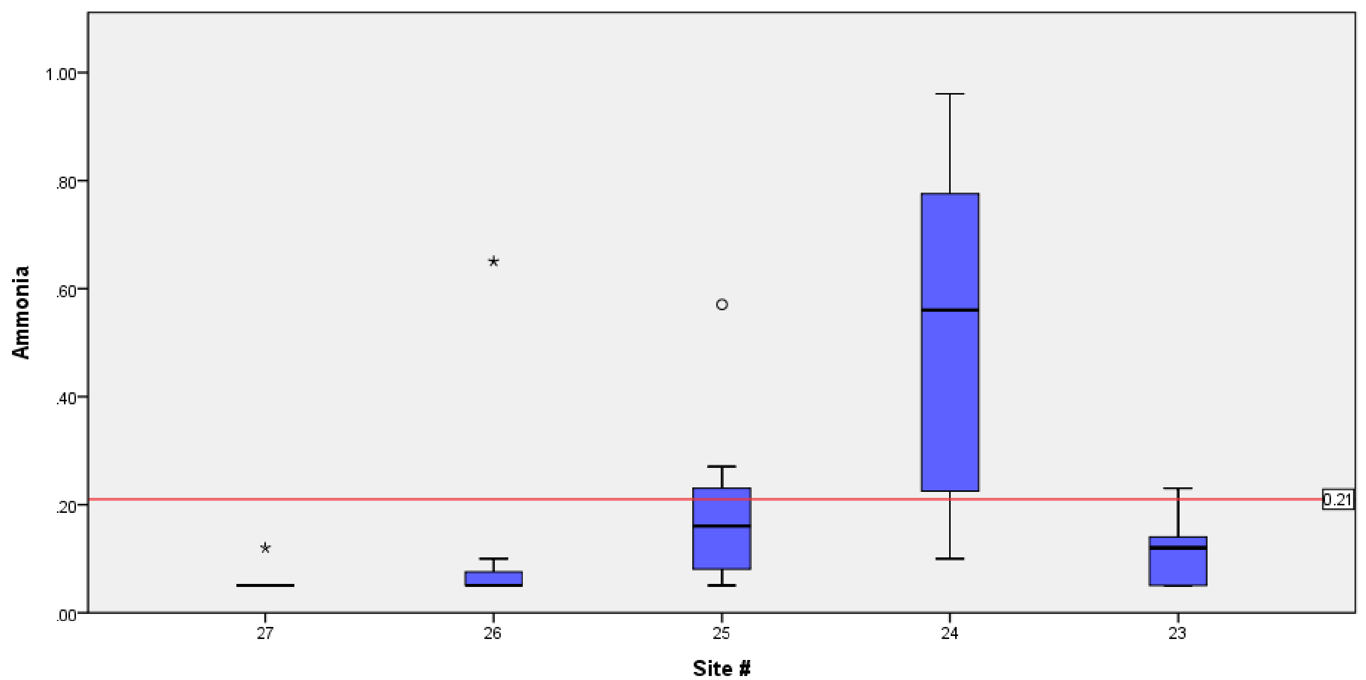


Figure 79 Box plot illustrating site ammonia concentrations within the Headwatershed Main Beaver Dam Ditch Subwatershed

4.1.2.8 *Suspended Solids & Turbidity*

Figure 80 shows that all sites had median total suspended solids concentrations well below the 30 mg/L threshold. Sites 27 had the highest frequency of exceedances (>25%). The single observation at Site 26 is considered an outlier in the dataset. The exceedances generally corresponded to rain events a few days prior to sampling and higher stream flows with the exception of an exceedance at Site 27 which occurred during dry/low flow conditions in late summer. This could be linked to an algal bloom observed at the site.

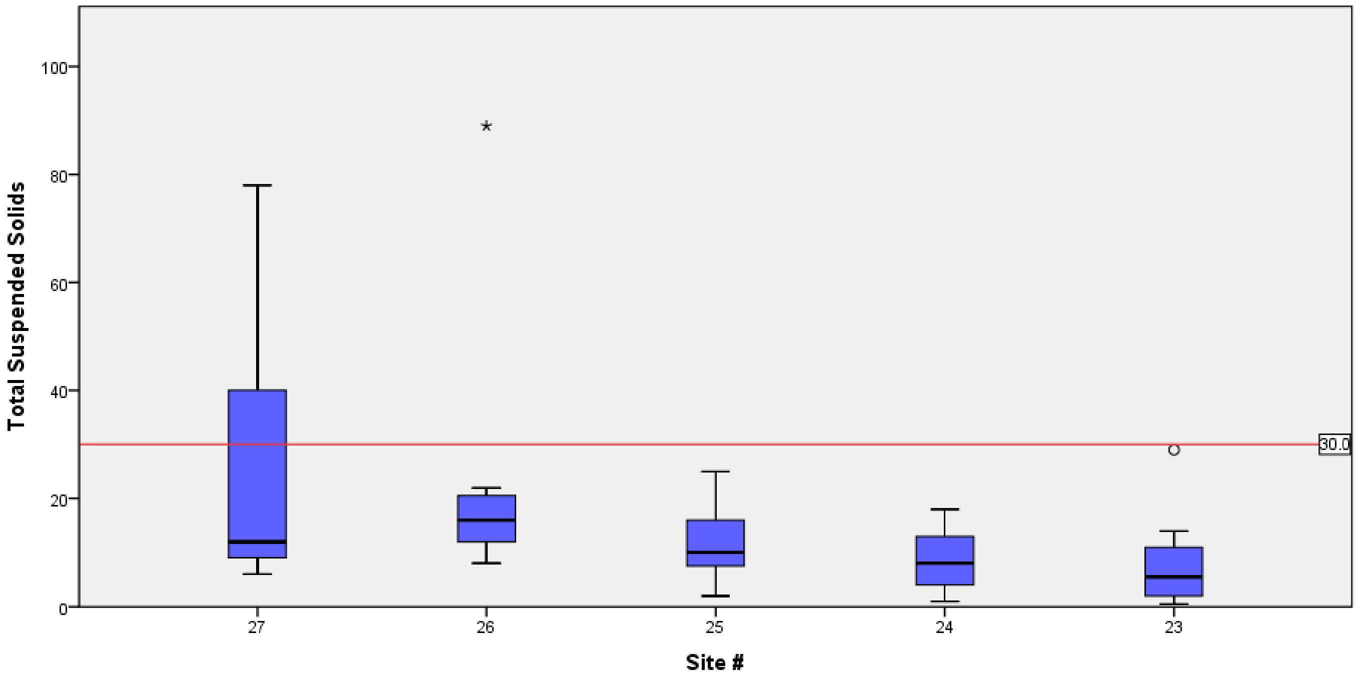


Figure 80 Box plot illustrating site total suspended solid concentrations within the Headwaters Main Beaver Dam Ditch Subwatershed

Figure 81 shows that Sites 25-27 had median concentrations exceeding the 10.4 NTU threshold recommended by the U.S. EPA. Nearly all the observations at Sites 26 and 27 eexceeded this threshold.

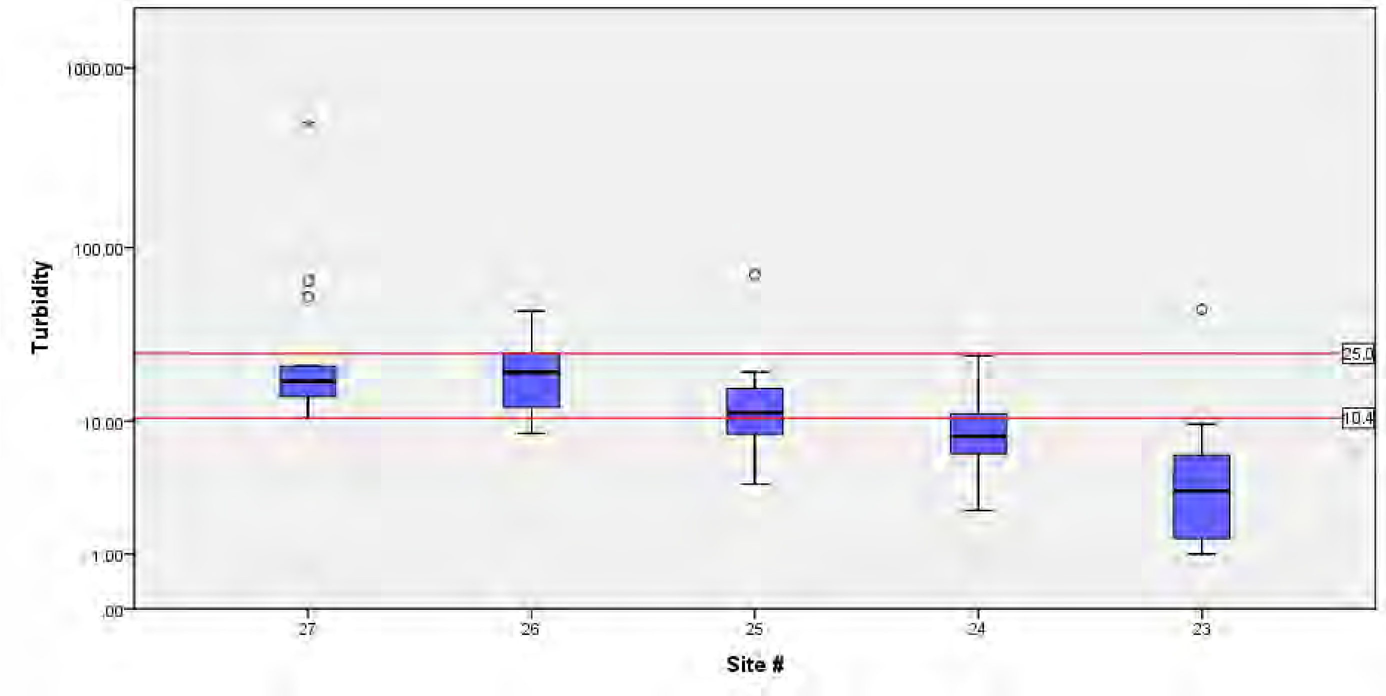


Figure 81 Box plot illustrating site turbidity levels within the Headwaters Main Beaver Dam Ditch Subwatershed

4.1.2.9 *Habitat*

The habitat evaluation performed by IDEM revealed that Sites 27-24 generally do not possess the habitat quality that is conducive of supporting a healthy warm water fishery (QHEI <51). Figure 82 shows that the major habitat limitations for Sites 27-24 include poor substrate, in-stream cover, channel morphology, and riffle/run quality. All sites had poor gradients. Stream substrates at Sites 27-24 were characterized by muck and silt, and had moderate to heavy siltation and extensive embeddedness. All sites had poor channel morphology characterized by no channel sinuosity, poor riffle/pool development, and moderate to low stability.

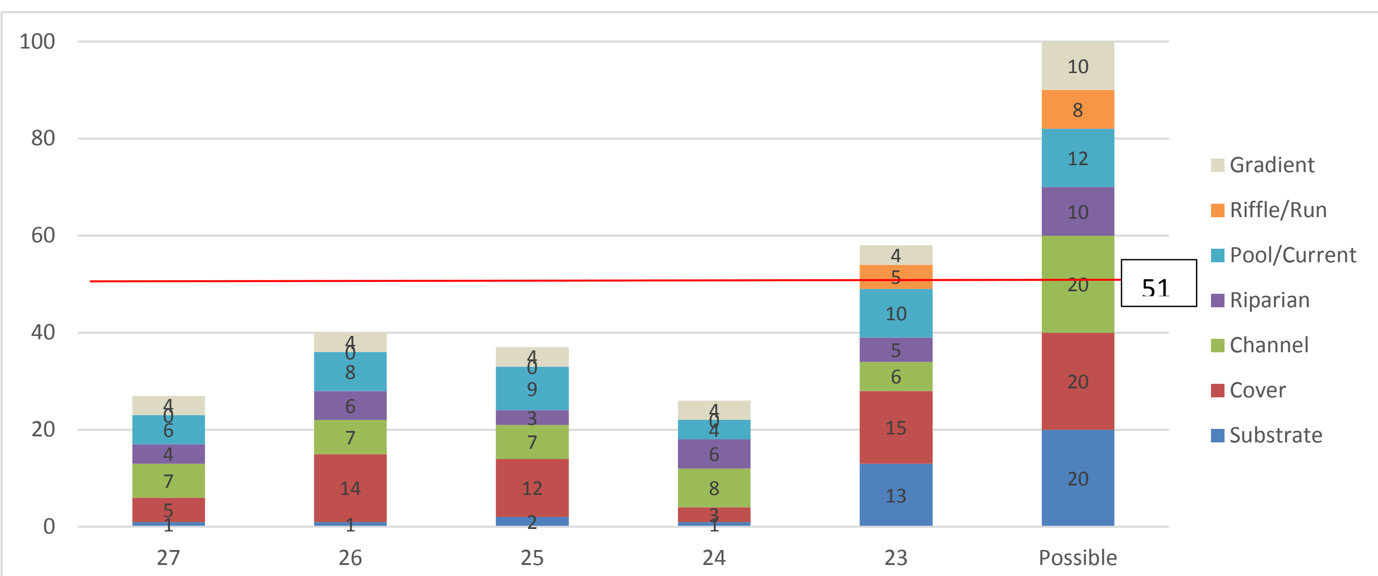


Figure 82 Site qualitative habitat evaluation index scoring within the Headwaters Main Beaver Dam Ditch Subwatershed

The poor habitat quality is symptomatic of the waterways being excavated into existence or modified to improve drainage. All sites in the subwatershed are located on reaches that are maintained as legal drains (Figure 84).

4.1.3 Land Cover & Land Use

Overall, the predominant land cover types within the subwatershed are developed (44%) and agricultural (26%) lands (Figure 83). Crown Point has the largest municipal footprint within the subwatershed and much of the development can be found here and the adjoining unicorporated areas. Further to the west, the subwatershed takes on a more rural agricultural setting. These unicorporated areas are mostly unsewered.

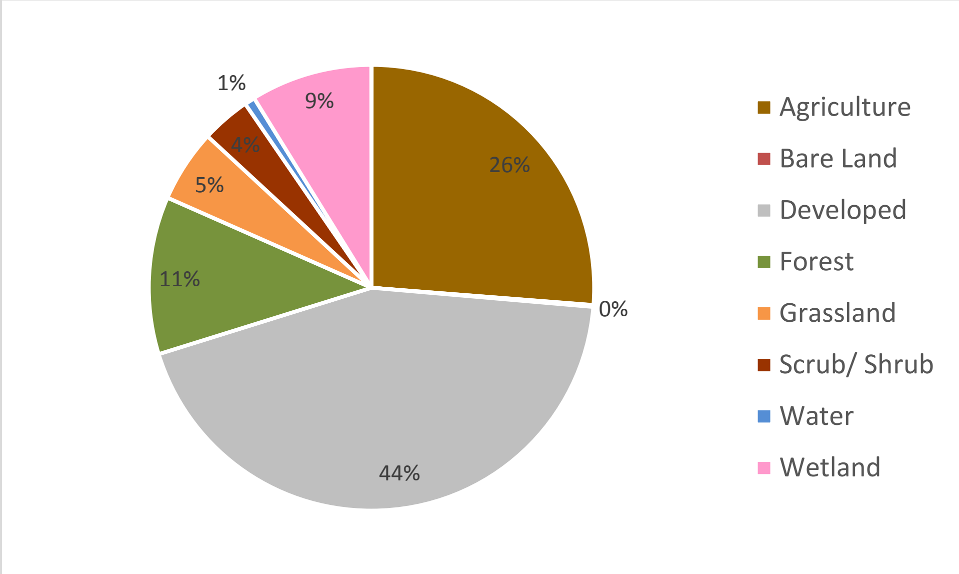


Figure 83 Percent land cover within the Headwaters Main Beaver Dam Ditch Subwatershed

Land cover information for each site's drainage area is provided in Table 48. There is nearly an equal mix of developed and agriclultral land within Site 27's drainage area. The site is bordered by subdivisions and a wetland immediately upstream. A large wetland area surrounds Site 26. Further up in its drainage area land cover includes a mix of agricultural, forest, wetland and developed lands. Site 25 includes the drainage areas of Sites 27 and 26. Site 25's drainage area is primarily agricultural immediately upstream but is also bordered by wetland. Site 24 drains primarily developed land within the City of Crown Point.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
27	44.1	0.5	48.8	0.3	1.5	0.5	0.4	3.9
26	32.7	0.1	16.0	23.0	7.0	5.8	1.0	14.4
25	43.4	0.2	24.2	12.6	5.3	3.6	0.7	10.1
24	1.9	0.0	80.5	6.4	4.8	1.3	1.5	3.6
23	25.5	0.1	45.6	11.0	5.2	3.4	0.7	8.5

Table 48 Site percent land cover within the Headwaters Main Beaver Dam Ditch Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 49. Agriculture and developed land are the dominant cover types within the riparian zone for Site's 27, 25, 24, and 23. Site 26 has slightly less agriculture and development within the riparian zone however they still account for nearly 30% of the cover. The prevalence of human land uses and associated cover types is reflected in the poor riparian habitat quality scores observed in the QHEI above.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
27	37.2	1.6	38.0	0.0	1.6	0.0	1.9	19.8

26	10.8	0.0	19.6	4.5	7.3	4.5	3.7	49.5
25	31.2	0.3	22.6	3.0	4.1	3.2	2.4	33.2
24	0.0	0.0	60.5	5.2	7.3	2.4	10.9	13.7
23	19.4	0.2	34.4	6.0	5.0	5.0	2.6	27.5

Table 49 Site percent riparian land cover within the Headwaters Main Beaver Dam Ditch Subwatershed

There are two NPDES industrial facilities located in the subwatershed based on the TMDL. (See TMDL for facility locations map.) The TMDL does not reference any permit violations for either of these facilities over the five year period between 2010 and 2014. There are four CSO outfalls in the subwatershed. The one located upstream of Site 24 is listed as inactive. According to the TMDL there have been 60 CSO events between 2009 and 2013 from outfalls in the subwatershed. In addition to these point sources, there is a land fill and two dumps located in a wetland area of the subwatershed adjacent to Site 26 (Figure 84).

Five potential livestock facilities were identified in the subwatershed (Figure 84). One is located south of an intermittent tributary that flows in Main Beaver Dam Ditch downstream of Site 27. Three are located south of Lateral #11. The other is located south of Lateral #5.

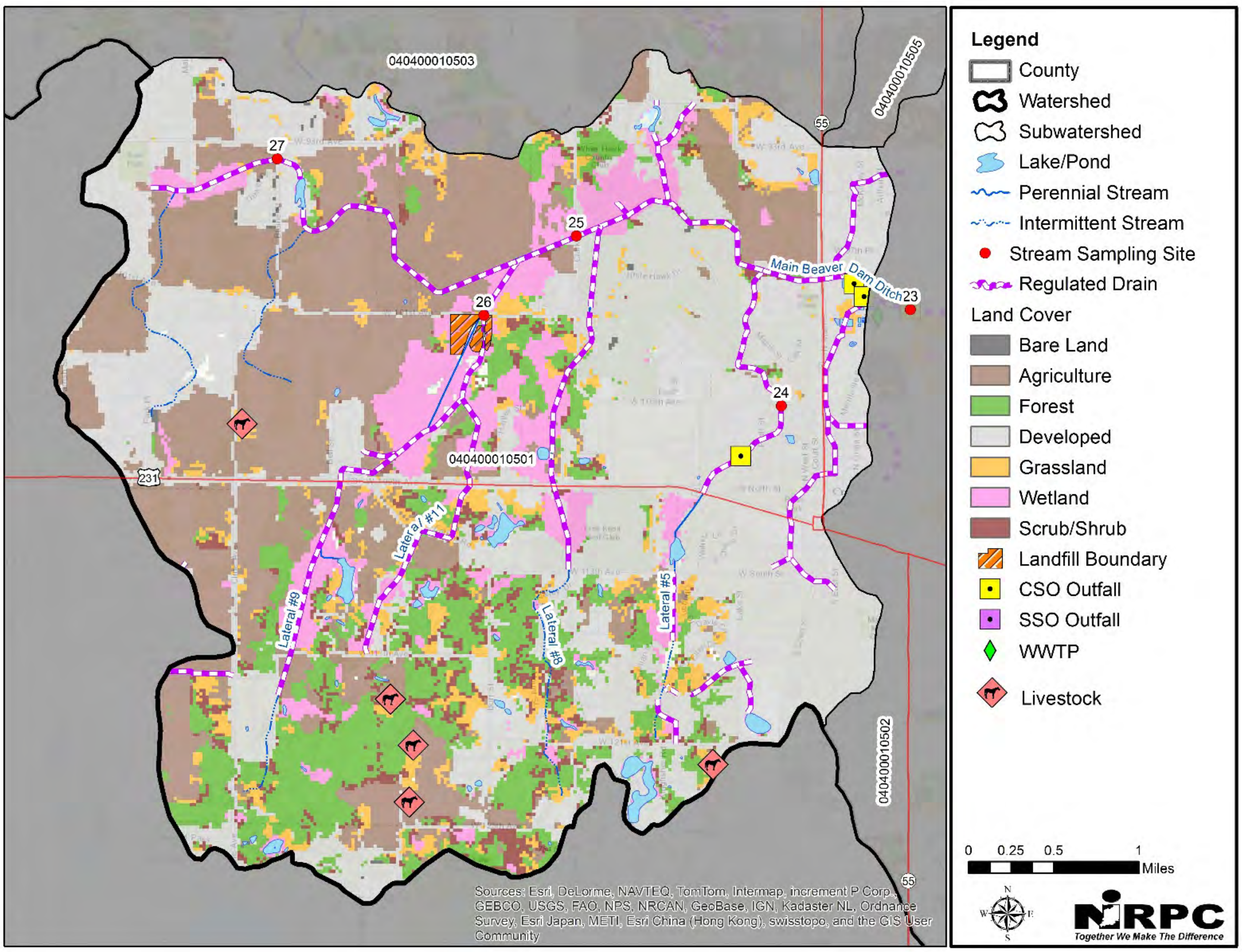


Figure 84 Land cover and land use in the Headwaters Main Beaver Dam Ditch subwatershed

4.1.4 Soils

Most of the soils immediately surrounding the tributaries within the subwatershed are rated as hydric indicating these areas would have historically been wetland (Figure 85). Highly erodible or potentially highly erodible soils appear equally distributed within the subwatershed. Soils with steep slopes bound lateral drain # 5, 8, 9, and 11. Soil surface textures adjacent to the tributaries are primarily classified as silty clay loam or muck (Figure 7). A majority of the soils in the subwatershed have poor infiltration rates and are prone to producing runoff (Figure 11). These soil characteristics in part help explain the poor substrate conditions observed at Sites 27-24 (Section 4.1.2.9).

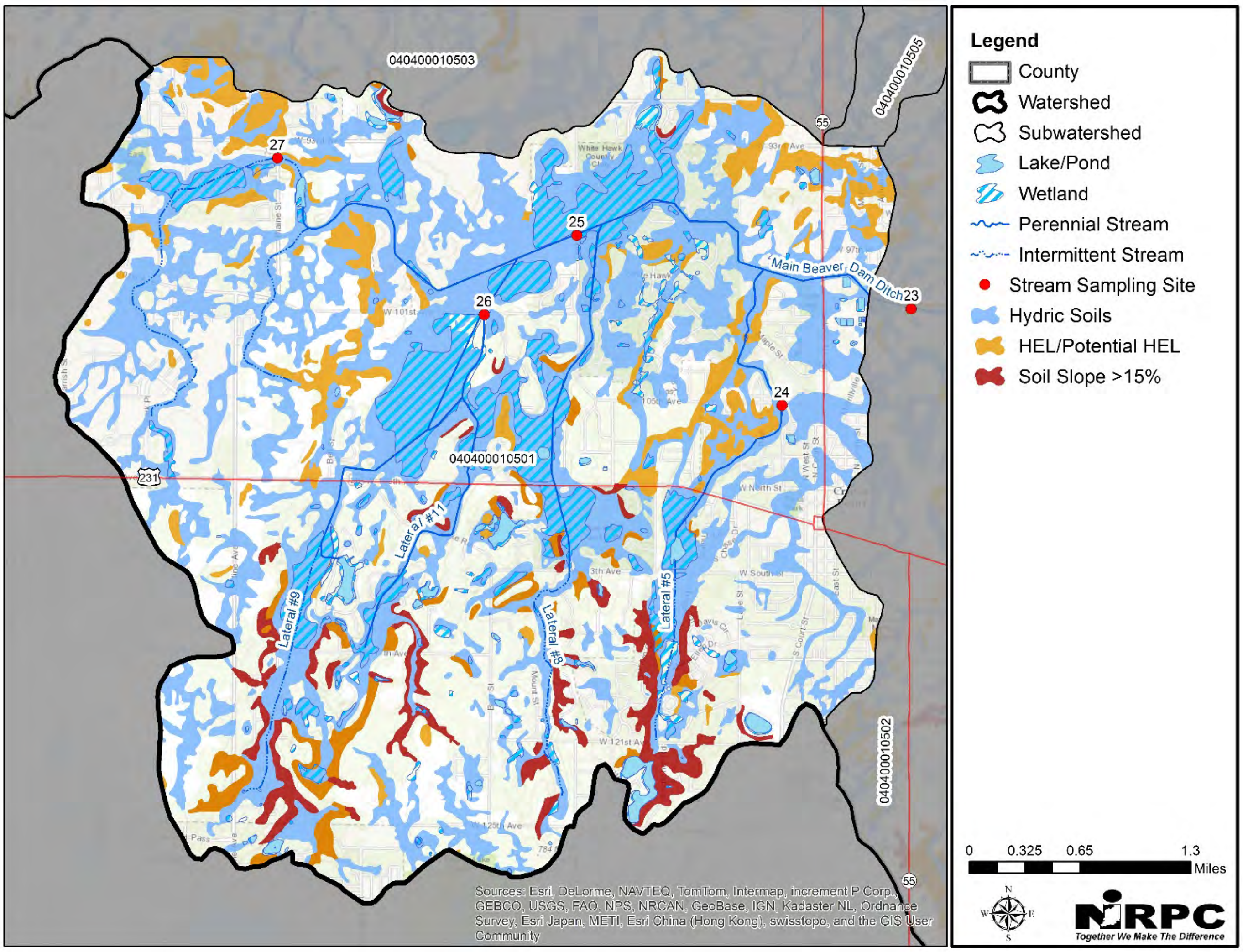


Figure 85 Hydric, highly erodible, & steep slope soils within the Headwaters Main Beaver Dam Ditch Subwatershed

4.2 Main Beaver Dam Ditch Subwatershed (HUC 040400010502)

4.2.1 Overview

The Main Beaver Dam Ditch subwatershed is located in the south-central portion of the watershed. It drains approximately 26.3 mi² of primarily agricultural (46%) and developed (35%) land. Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities, and high nutrient and *E. coli* levels.

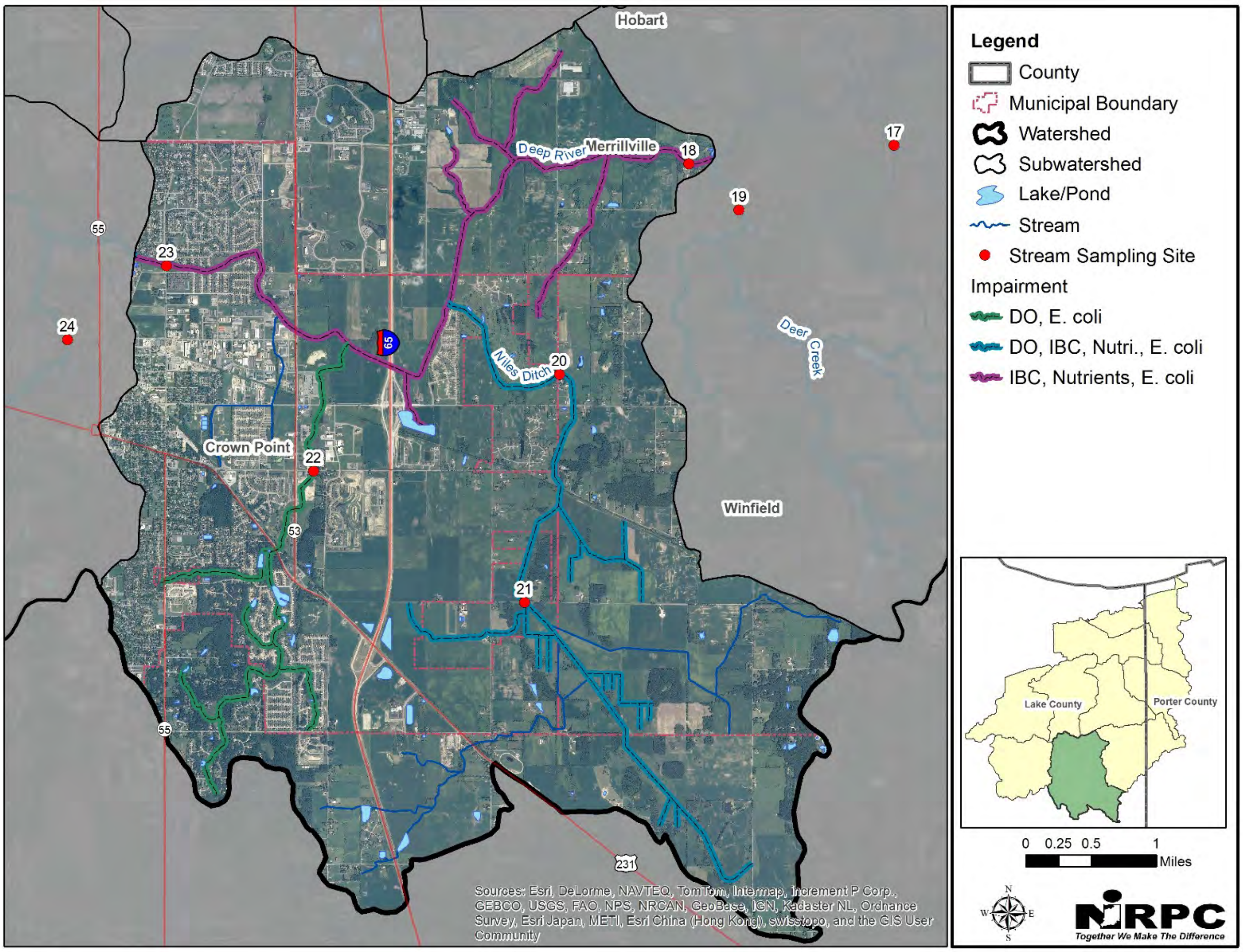


Figure 86 Stream impairments within the Main Beaver Dam Ditch Subwatershed

4.2.2 Water Quality

IDEM collected water quality data at five monitoring stations (Sites 18, 20-23) within the Main Beaver Dam Ditch subwatershed (Figure 86). Site 18 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.2.2.1 *Pathogens*

Figure 87 shows that any full body contact recreational use would be threatened by high pathogen levels as indicated by *E. coli*. Sites 18, 20 and 22 have median *E. coli* concentrations in excess of 235 CFU/100 mL. Over 75%

of the samples collected at Sites 18 and 22 exceeded 235 CFU/100 mL. Exceedances occurred across high flow and dry conditions indicating both nonpoint and point source contributions.

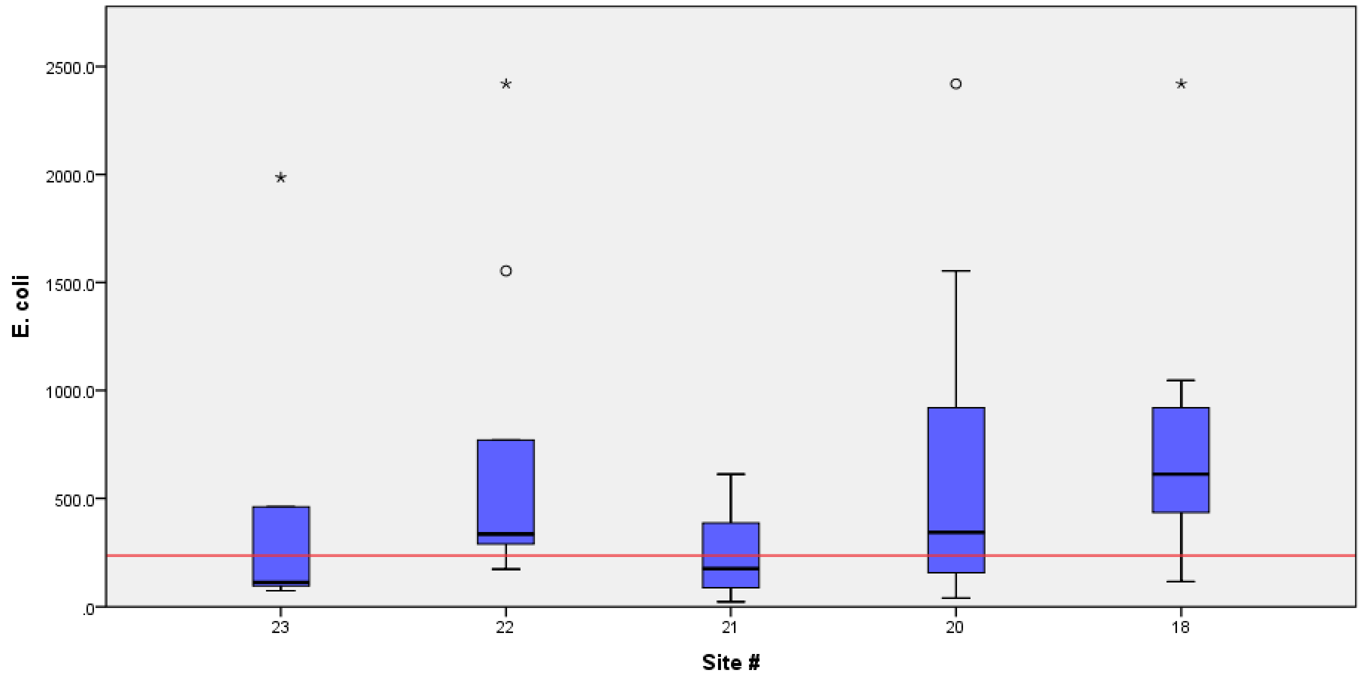


Figure 87 Box plot illustrating site E. coli concentrations within the Main Beaver Dam Ditch Subwatershed

4.2.2.2 *Fish*

Site 21 was the only site found not to be fully supporting of Aquatic Life Use. Only one fish was collected from this site. Sites 23, 22, 20, and 18 were found to be fully supporting however, they only received a "fair" integrity class rating. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent. Fish species that require clean gravel/cobble substrates to spawn were also generally lacking.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
23	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
22	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
21	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
20	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
18	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 50 Site fish index of biotic integrity scores within the Main Beaver Dam Ditch Subwatershed

4.2.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed Sites 21 and 22 were not supporting of Aquatic Life Use. All sites were dominated by macroinvertebrates that are tolerant of pollution and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
23	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
22	24	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
21	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
20	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
18	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 51 Site macroinvertebrate index of biotic integrity scores within the Main Beaver Dam Ditch Subwatershed

4.2.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the water quality standard maximum limit for any month. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 19-22°C, (66-72°F). Figure 88 shows that Site 22 was generally warmer than the other sites within the subwatershed (highest max and temperatures skewed above the median). A review of aerial imagery shows a number of inline ponds associated with housing development within Site 22's drainage area. Site 22's drainage area is also predominately developed which can be a sources of warmer runoff due the large amounts of impervious surface cover which act as a heat sink.

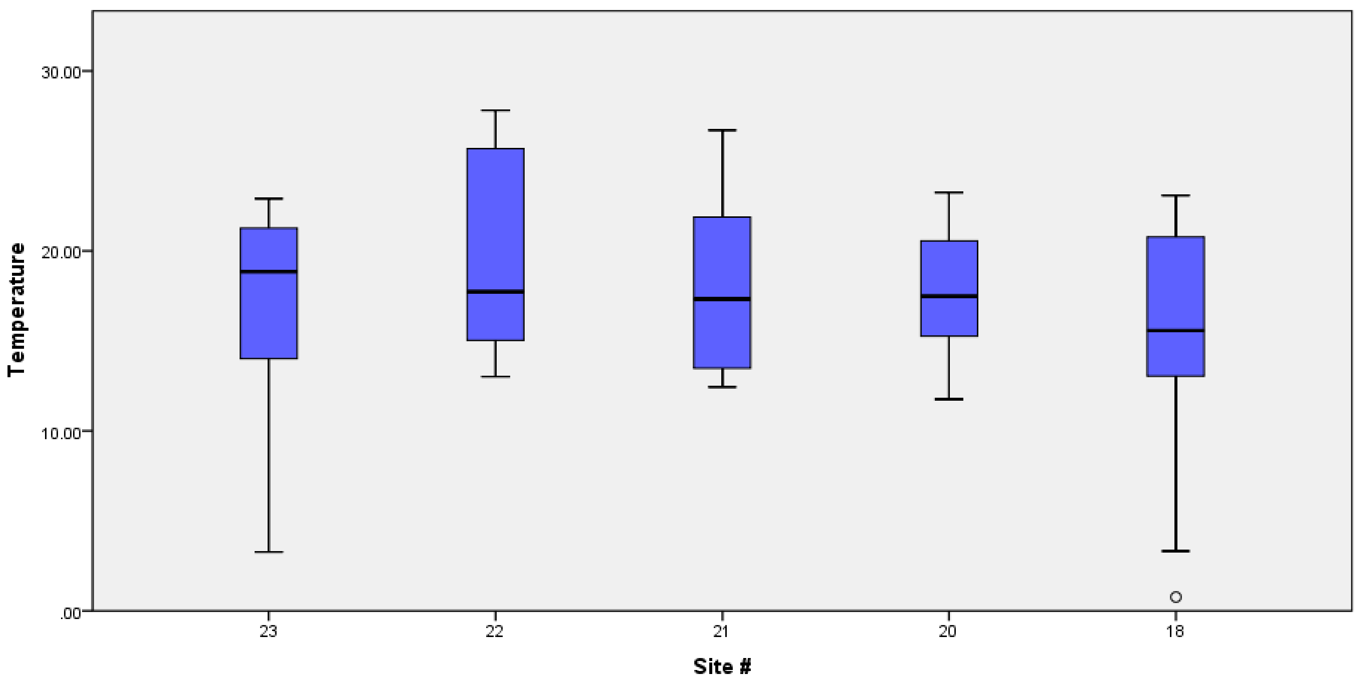


Figure 88 Box plot illustrating site water temperatures within the Main Beaver Dam Ditch Subwatershed

4.2.2.5 *Dissolved Oxygen*

Figure 89 shows that dissolved oxygen levels at Sites 21 and 20 are a problem, with median concentrations well below 4 mg/L. Sites 22 also occassionally failed to meet the minimum concentration of 4 mg/L. Violations typically occurred during the summer and fall when water temperatures are at their warmest.

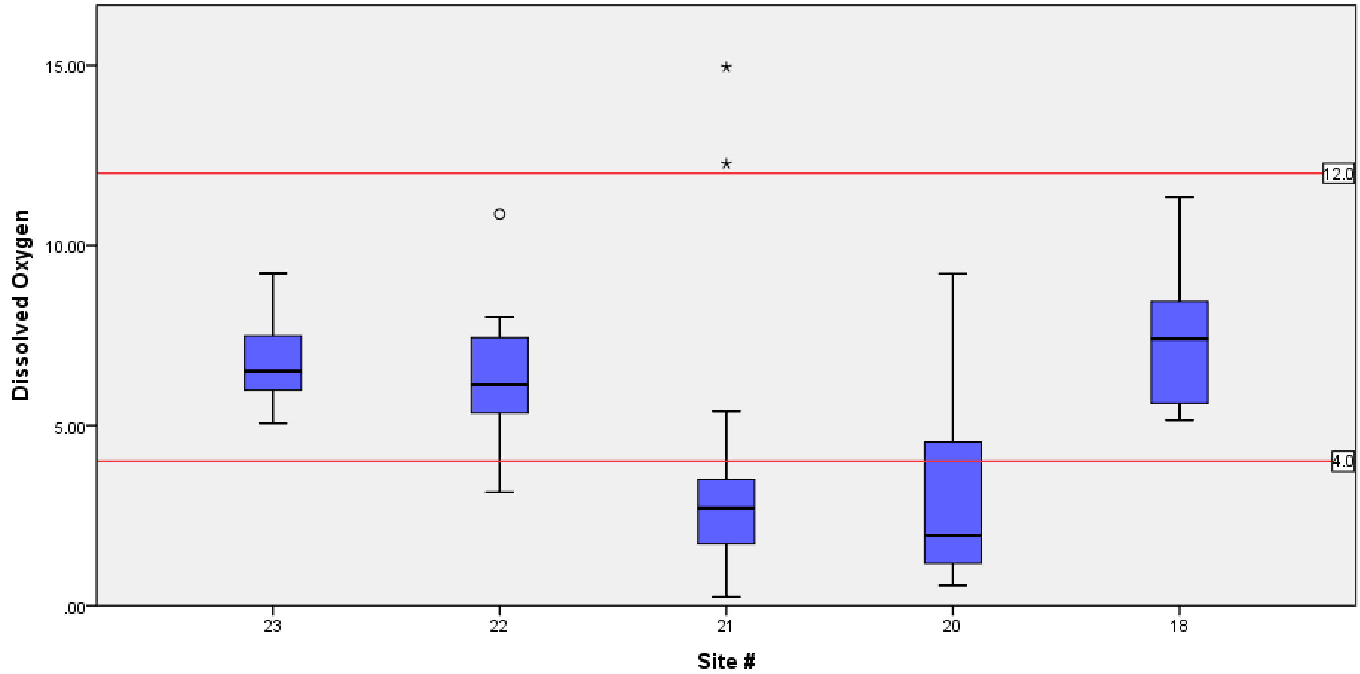


Figure 89 Box plot illustrating site dissolved oxygen concentrations within the Main Beaver Dam Ditch Subwatershed

4.2.2.6 *Total Organic Carbon*

Figure 90 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Sites 20-22.

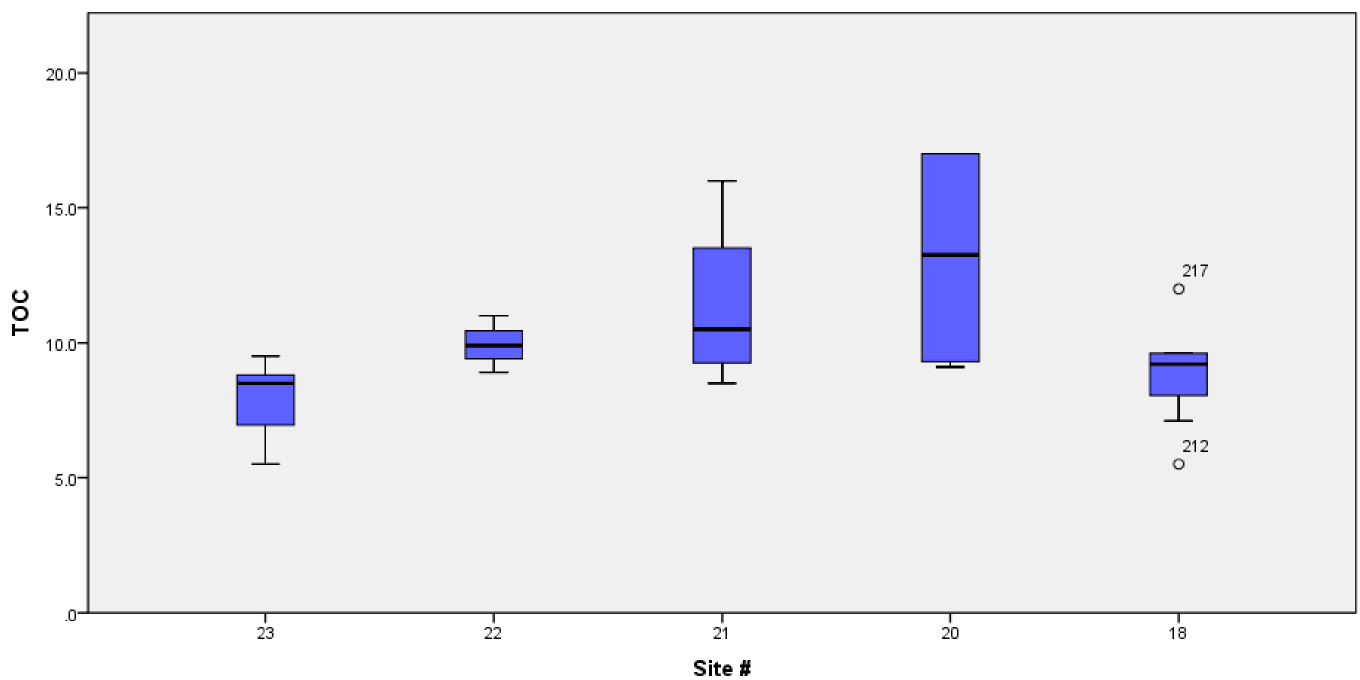


Figure 90 Box plot illustrating site TOC concentrations within the Main Beaver Dam Ditch Subwatershed

4.2.2.7 *Nutrients*

Figure 91 shows that none of the site samples collected fell below the 0.07 mg/L total phosphorus threshold. Sites 18 and 23 had the highest median concentrations each being above the 0.3 mg/L threshold. Sites 21 and 20 exceeded the 0.3 mg/L threshold during the summer months with mean concentrations of 0.6 mg/L and 0.4 mg/L respectively. Site 18 exceeded the threshold during the summer, fall, and winter months. Site 23's exceedances occurred year round and were attributed to permit violations at the Crown Point Waste Water Treatment Plant. The distribution of total phosphorus concentrations was found to be significantly different across seasons.

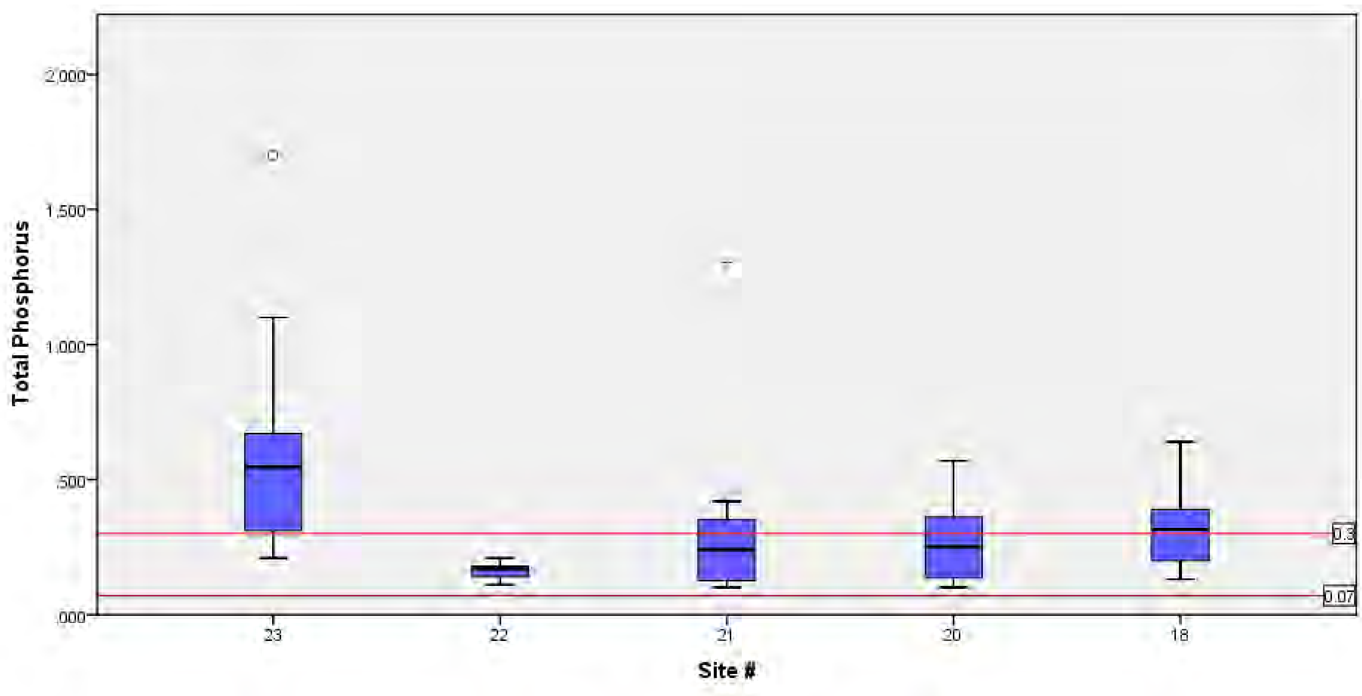


Figure 91 Box plot illustrating site total phosphorus concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 92 shows that 100% of the samples collected at Sites 18 and 23 exceeded the 1.09 mg/L nitrate threshold. Site 23 had a median nitrate concentration greater than the 10 mg/L threshold. Nitrate concentrations at Sites 20 and 21 typically (>75%) fell below 1.09 mg/L.

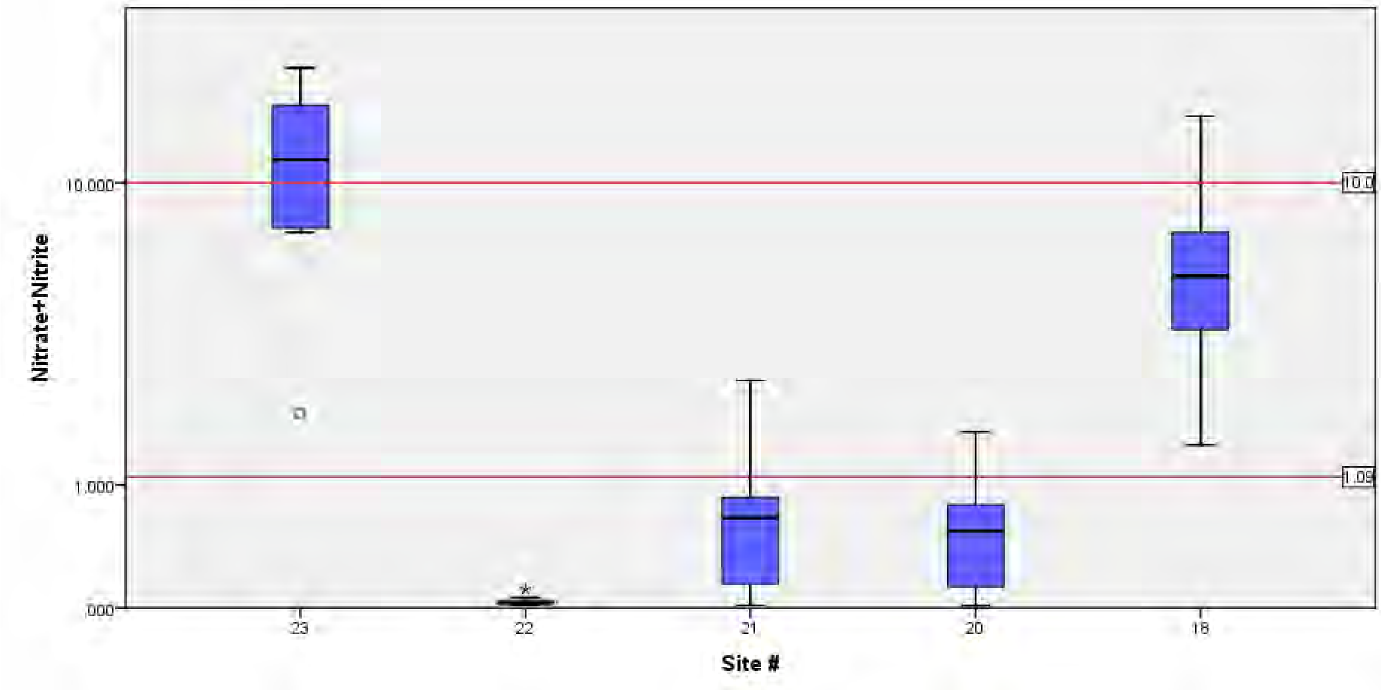


Figure 92 Box plot illustrating site nitrate concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 93 shows that all sites within the subwatershed had median total Kjeldahl nitrogen concentrations in excess of the 0.68 mg/L threshold. Sites 20, 21, and 23 had median concentrations in excess of 1.27 mg/L. Aside from the outlier observed at Site 21, Site 20 generally had the highest total Kjeldahl nitrogen concentrations.

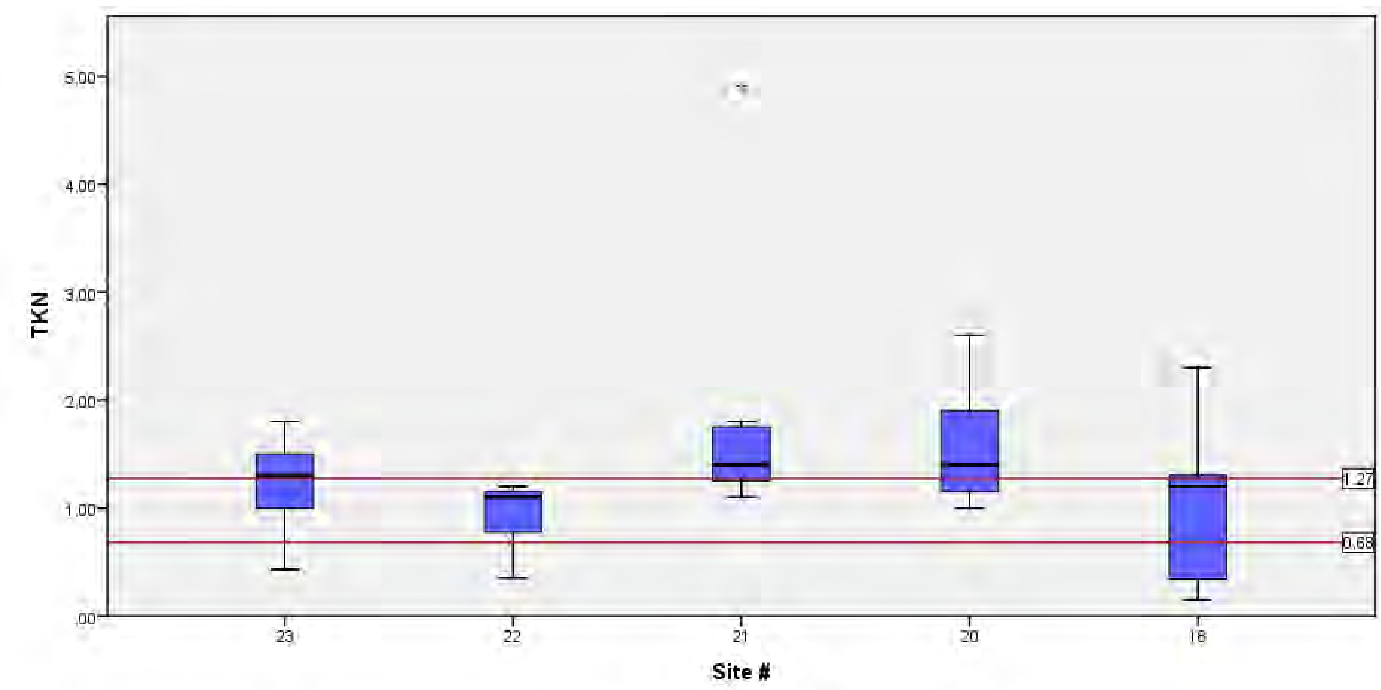


Figure 93 Box plot illustrating site total kjeldahl nitrogen concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 94 shows that median ammonia concentrations were above 0.03 mg/L at all sites. Median ammonia concentrations at Sites 21 and 20, were in excess of 0.21 mg/L. Ammonia concentrations show a slight overall decrease moving downstream from Site 21 to Site 20. However, the median concentration actually increases indicating there may be an additional source between the sites.

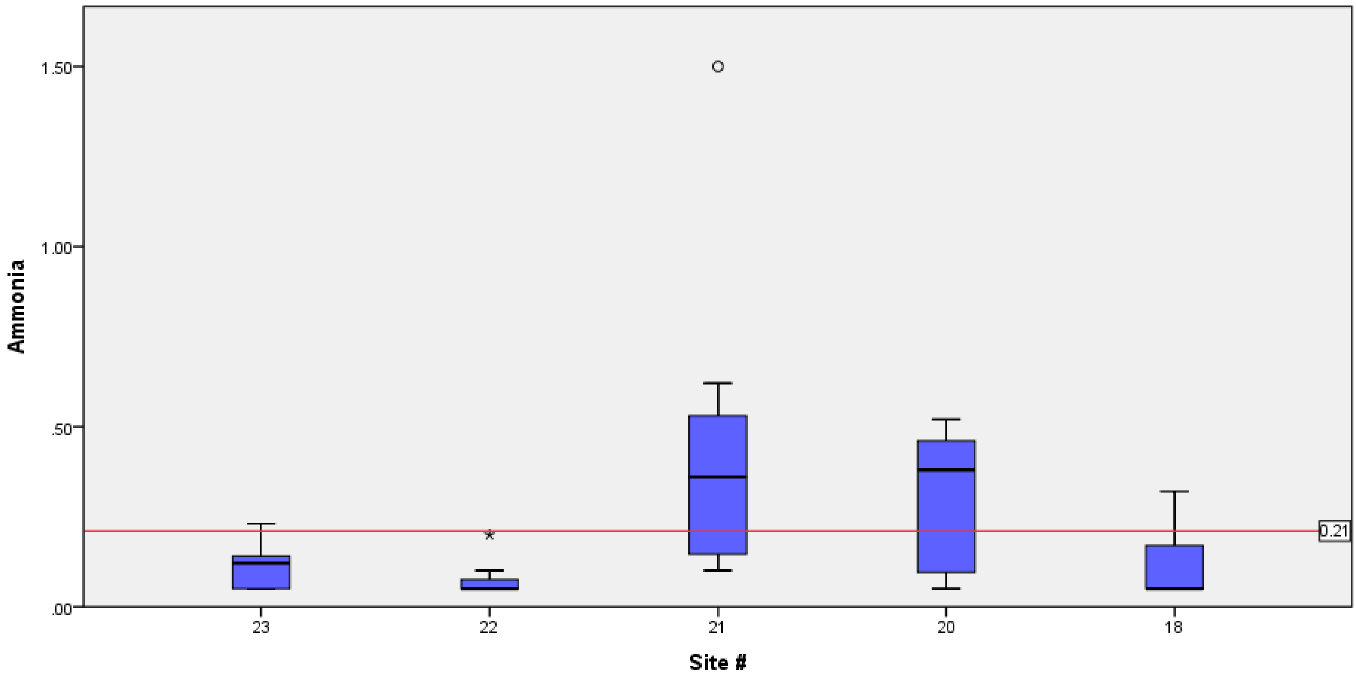


Figure 94 Box plot illustrating site ammonia concentrations within the Main Beaver Dam Ditch Subwatershed

4.2.2.8 *Suspended Solids & Turbidity*

Figure 95 shows that Site 22 regularly exceeded (>75%) the 30 mg/L total suspended solids threshold value. Exceedances at this site occurred both during dry and wet weather conditions. There was an increasing trend in suspended solid median concentrations moving from Site 21 downstream to Site 20. Site 21 and 18 had one observation each exceeding the threshold. These exceedances corresponded to rain events a few days prior to sampling.

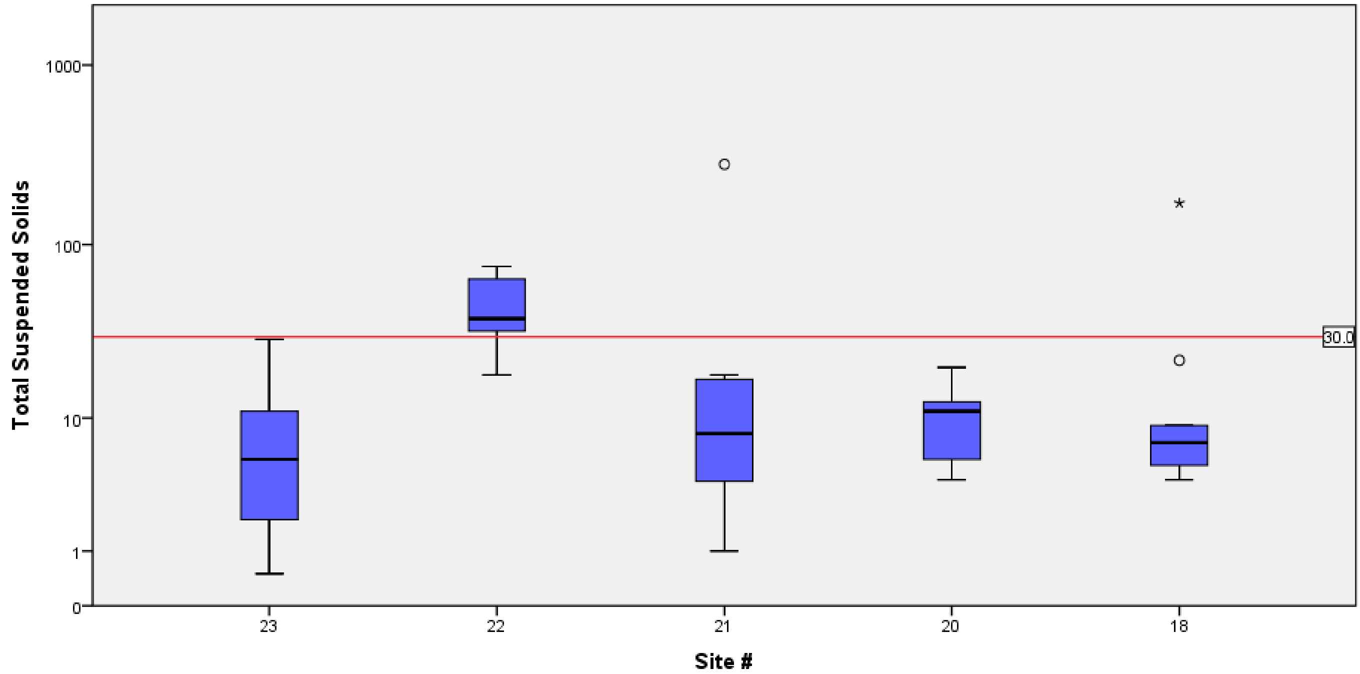


Figure 95 Box plot illustrating site total suspended solids concentrations within the Main Beaver Dam Ditch Subwatershed

Figure 96 shows similar site patterns for turbidity as was observed for total suspended solids. Site 22 had the highest turbidity levels with more than 75% of the samples exceeding the 25 NTU threshold. Sites 18, 20, 21 and 23 had median turbidity concentration below the 10.4 NTU threshold. However, median concentrations at Sites 20 and 21 were very near 10.4 NTU and almost 50% of the samples exceeded this threshold.

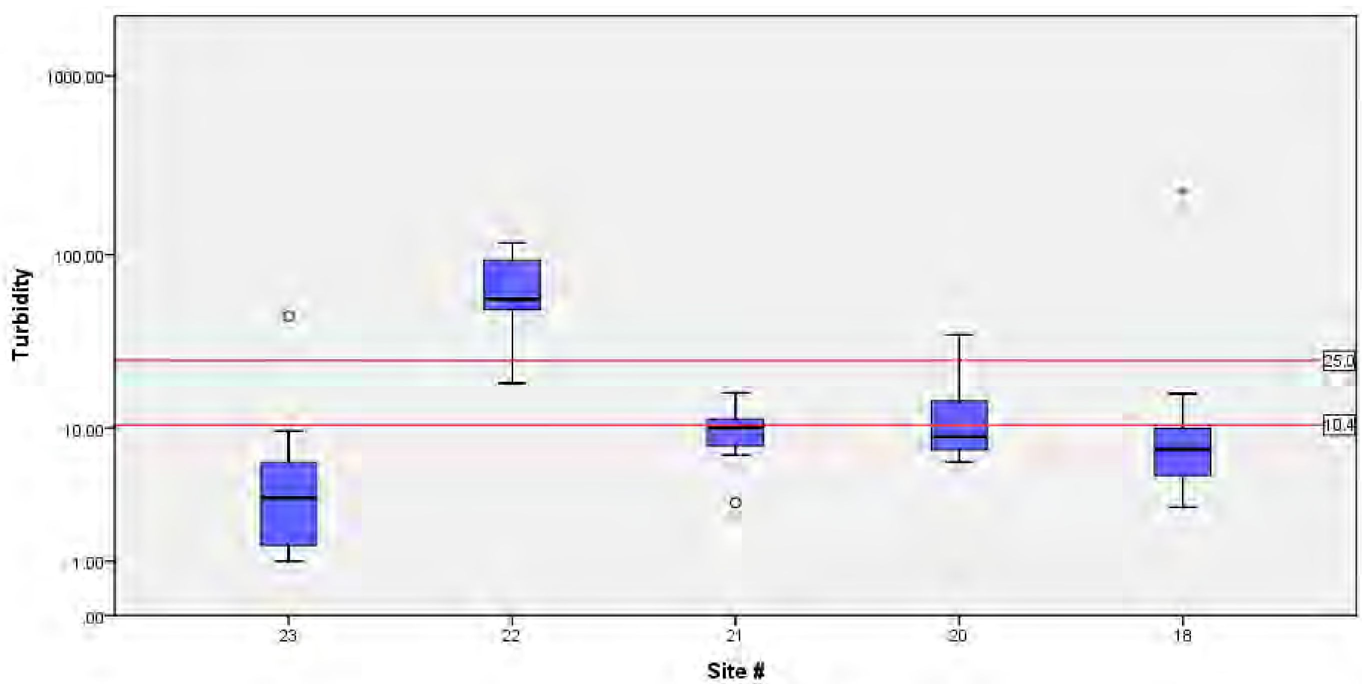


Figure 96 Box plot illustrating site turbidity levels within the Main Beaver Dam Ditch Subwatershed

4.2.2.9 *Habitat*

Figure 97 shows that Sites 22-20 generally do not possess the habitat quality that is conducive of supporting a healthy warm water fishery (QHEI <51). The major habitat limitations for Sites 22-20 include poor substrate, in-stream cover, channel morphology, riparian and riffle quality. Stream substrates at Sites 22 and 21 were characterized by muck, heavy siltation and extensive embeddedness. Sites 23, 20, and 18 had sand bottoms. Sites 20 and 18 had moderate levels of siltation and embeddedness. Sites 23-20 had poor channel morphology characterized by low to no channel sinuosity, poor riffle/pool development, recent or recovering from channelization, and moderate stability.

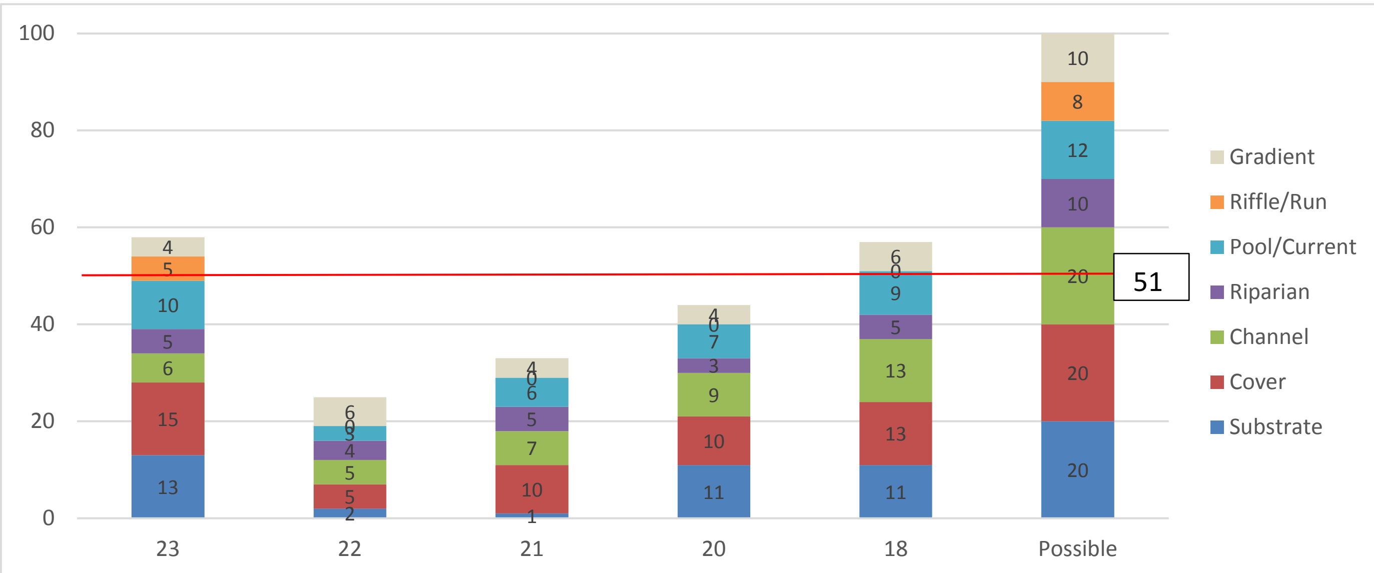


Figure 97 Site qualitative habitat evaluation index scores within the Main Beaver Dam Ditch Subwatershed

The poor to generally poor habitat quality is symptomatic of the waterways being excavated into existence or modified to improve drainage. All sites in the subwatershed are located on reaches that are maintained as legal drains (Figure 99).

4.2.3 Land Cover & Land Use

Agricultural and developed lands account for a majority of the land cover within the subwatershed (Figure 98). The greatest concentration of development is located west of Broadway (State Road 53) in Crown Point. Moving east the subwatershed begins to transisiton to a more rural landscape. Most of the homes and small developments located in the unicorporated areas are unsewered. Many areas in the Town of Winfield are also unsewered.

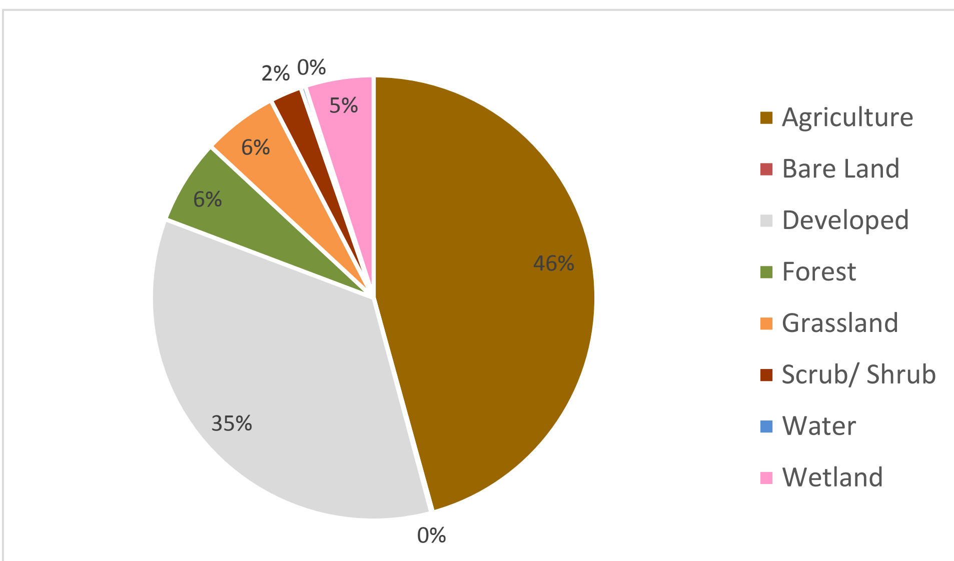


Figure 98 Percent land cover within the Main Beaver Dam Ditch Subwatershed

Table 52 includes land cover information for each site's drainage area. Sites 23 and 22 are predominately developed while Sites 21-20 are mostly agricultural. Site 18 has nearly an equal mix of developed and agriclultral land.

Site 23 and 22's surrounding land use is development within the City of Crown Point. Wetland and forest provide a small buffer from the adjacent developed areas upstream of Site 22 on Smith Ditch. A series of inchannel ponds have have also been excavated along Smith Ditch in this area as well. Site 21's immediated surrounding land use is agriculture. A dairy farm that was once classified as a CAFO is located immediately to the west of the site. Manure from the facility is land applied to the neighboring fields. Upstream of Site 21, Niles Ditch drains contiguous wetland areas surrounded by row crop. Site 20's immediate surrounding land uses low density residential development and agriculture. A majority of the Niles Ditch drainage area is unsewered.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
23	25.5	0.1	45.6	11.0	5.2	3.4	0.7	8.5
22	4.7	0.3	66.7	14.1	4.1	2.2	0.4	7.5
21	67.3	0.0	7.5	9.0	4.8	2.8	0.4	8.2
20	67.3	0.0	7.5	9.0	5.6	3.3	0.3	7.2
18	37.7	0.1	38.6	8.3	5.3	2.8	0.5	6.6

Table 52 Site percent land cover within the Main Beaver Dam Ditch Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 53. Agriculture and/or developed land make up a fairly large percentage of the riparian zone for each site's drainage. The prevalence of human land uses and associated cover types is reflected in the poor riparian habitat quality scores observed in the QHEI above.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
23	19.4	0.2	34.4	6.0	5.0	5.0	2.6	27.5
22	2.4	0.0	45.6	8.6	6.1	2.5	2.1	32.8
21	59.0	0.0	4.5	2.6	5.7	5.1	0.6	22.4
20	61.4	0.0	4.0	3.5	5.8	5.4	0.5	19.4
18	32.5	0.1	27.4	5.9	5.4	5.5	1.6	21.6

Table 53 Site percent riparian land cover within the Main Beaver Dam Ditch Subwatershed

The TMDL reports six NPDES permitted industrial facilities located in subwatershed. (See TMDL for facility locations map). The TMDL does not reference any permit violations for these facilities over the five year period between 2010 and 2014. The Crown Point WWTP and a CSO outfall are located on Main Beaver Dam Ditch near Site 23 (Figure 99). The TMDL includes this CSO with the other CSO points in the Headwaters Main Beaver Dam Ditch subwatershed in reporting the number of CSO events, which was 60 between 2009 and 2013. The TMDL documents 19 permit violations for TSS, copper, and ammonia between 2010 and 2013 for the Crown Point WWTP. The baseline assessment conducted as part of the TMDL also documented violations for phosphorus between June 2013 and July 2014 for the Crown Point WWTP.

Twelve potential livestock facilities were identified in the subwatershed (Figure 99). Most of the facilities are located east of I-65 with the greatest number occurring in the Niles Ditch drainage area. The facility located east of Site 21 was formerly regulated as a CFO operation (Section 2.6.3.2).

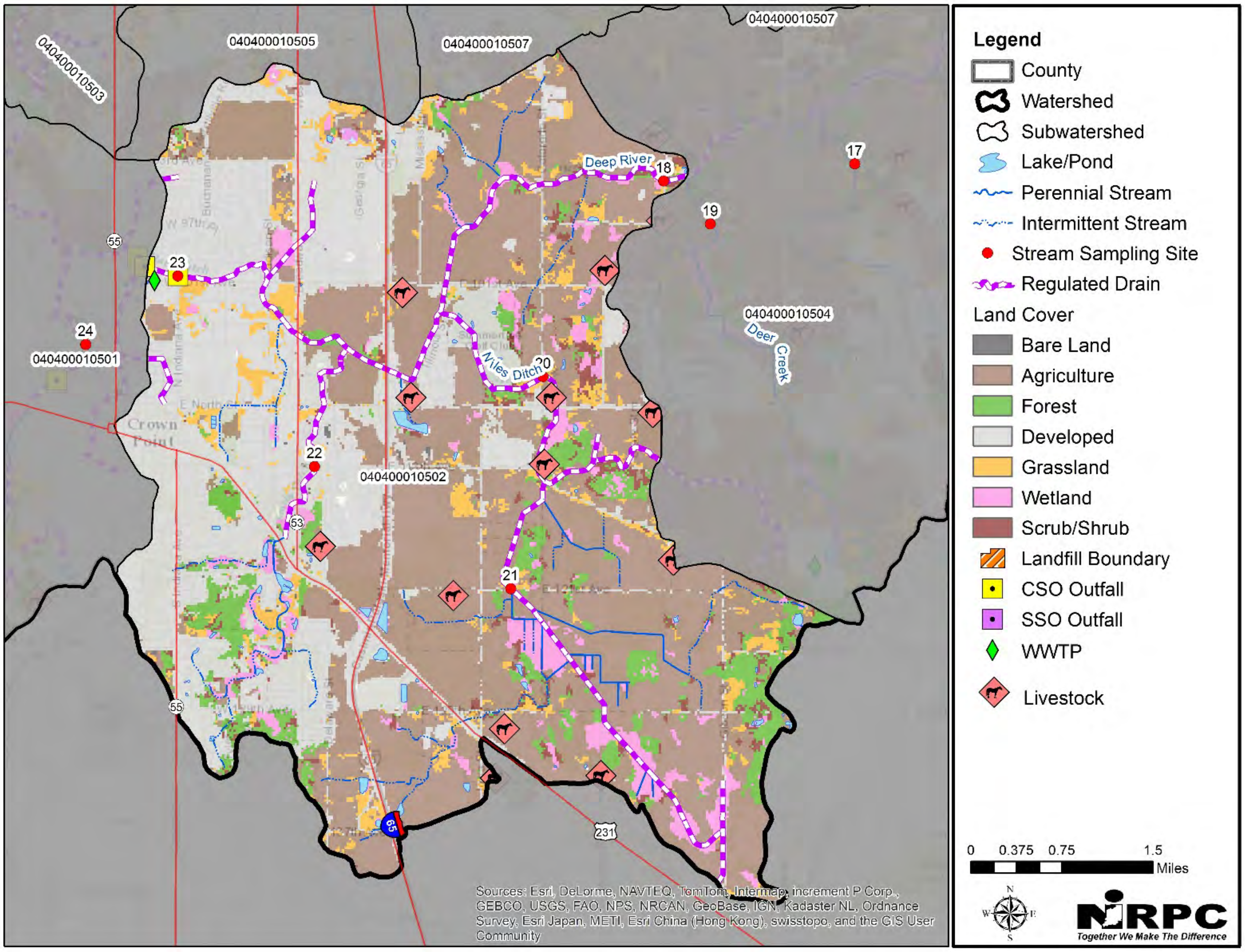


Figure 99 Land cover and land use within the Main Beaver Dam Ditch Subwatershed

4.2.4 Soils

Many of the soils immediately surrounding the tributaries within the subwatershed are rated as hydric indicating these areas would have historically been wetland (Figure 100). Highly erodible or potentially highly erodible soils appear to be most widely distributed west of Niles Ditch. These soils border or are located in close proximity to a number of tributaries in this area. There are only a few locations where soil slopes are greater than 15%. The most relevant location is upstream of Site 22, adjacent to an intermittent stream south of US Hwy 231. Soil surface textures adjacent to the tributaries are primarily classified as silty clay loam or muck (Figure 7). A majority of the soils in the subwatershed have poor infiltration rates and are prone to producing runoff (Figure 11). These soil characteristics in part help explain the poor substrate conditions observed at Sites 22 and 21 (Section 4.2.2.9).

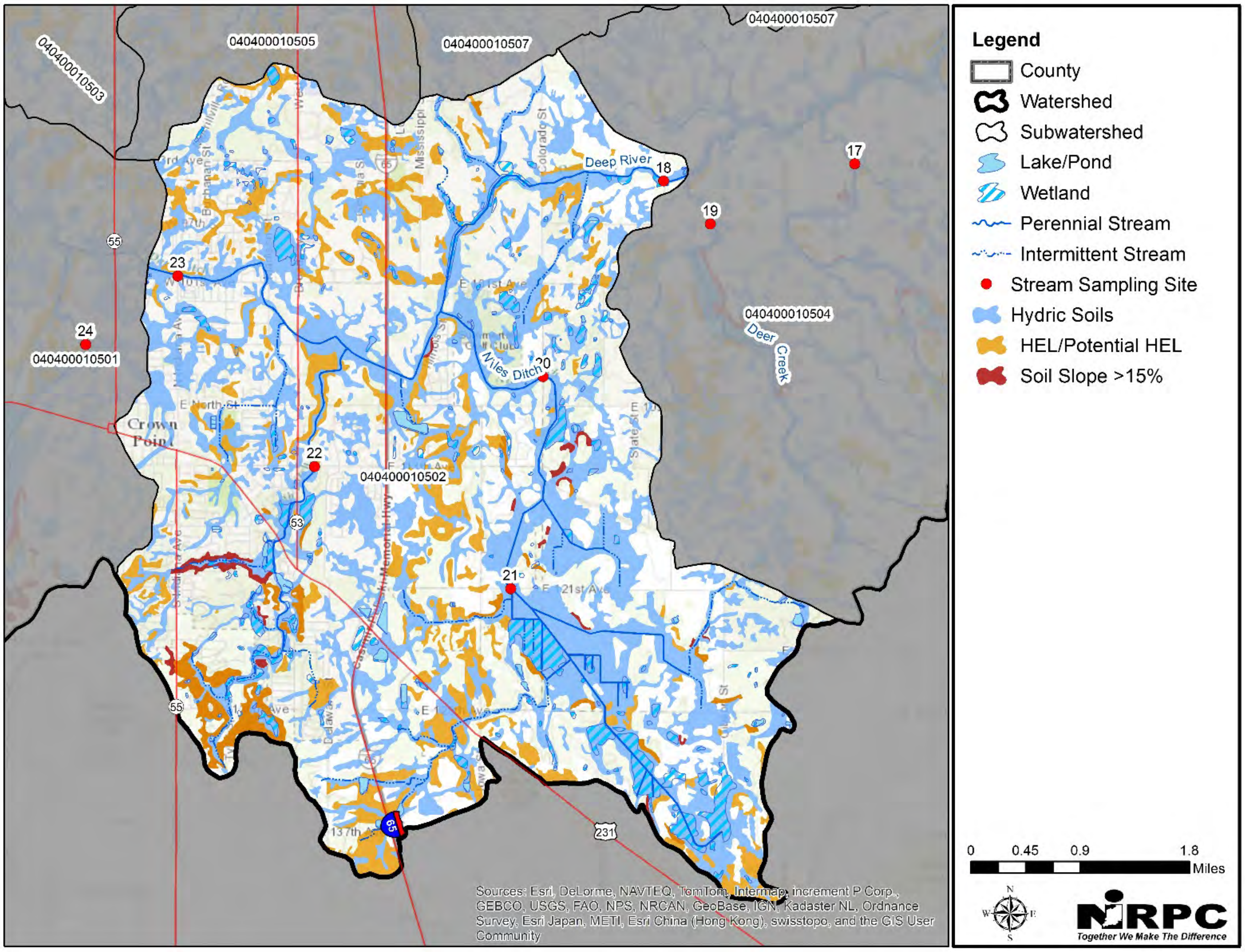


Figure 100 Hydric, highly erodible and steep slope soils within the Main Beaver Dam Ditch Subwatershed

4.3 Headwaters Turkey Creek Subwatershed (HUC 0404000103)

4.3.1 Overview

The Headwaters Turkey Creek subwatershed is located in the west central portion of the watershed. It drains approximately 21.2 mi² of primarily developed (55%) land. Based on the monitoring completed by IDEM, five stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities and high *E. coli* and nutrient levels.

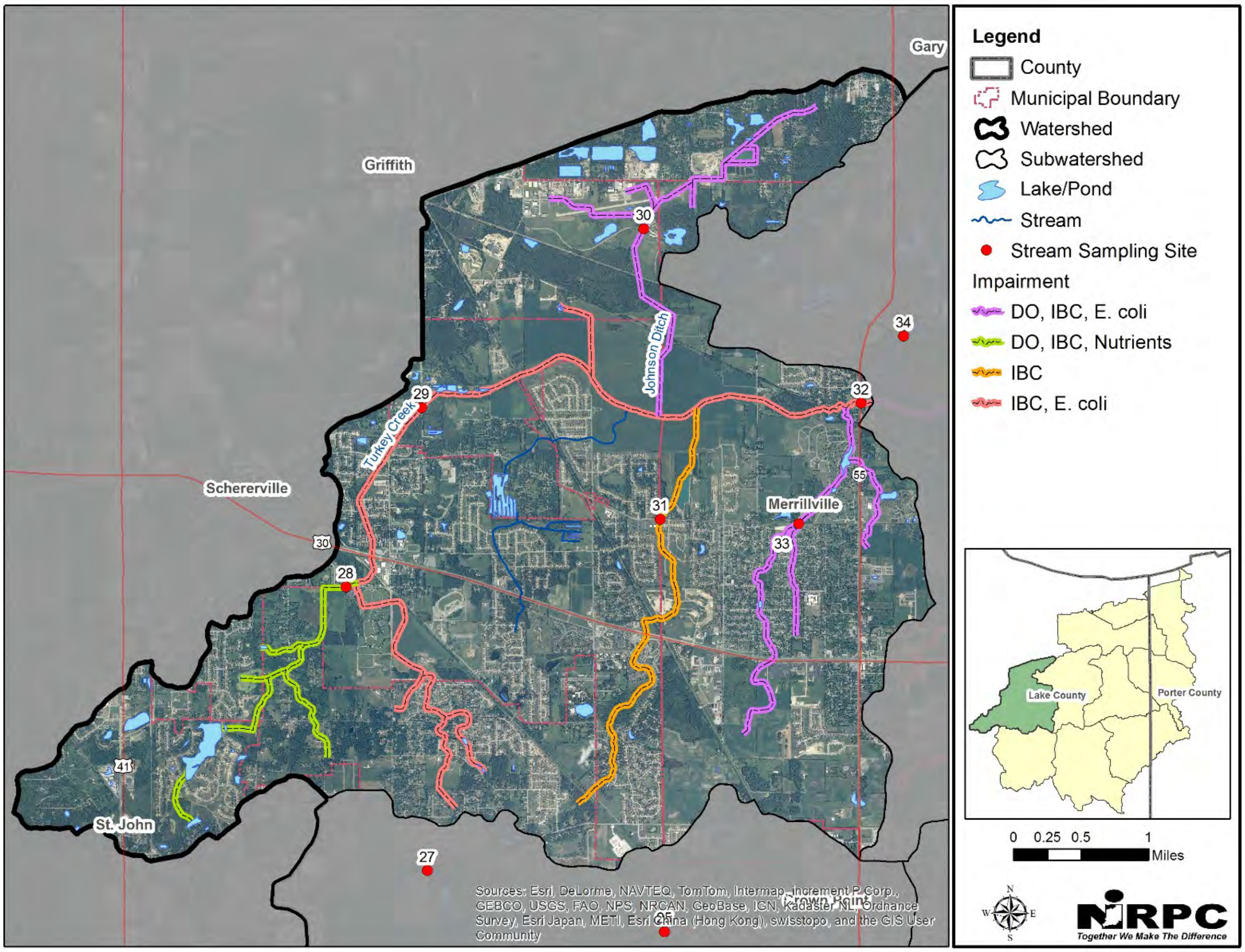


Figure 101 Impaired streams within the Headwaters Turkey Creek Subwatershed

4.3.2 Water Quality

IDEM collected water quality data at six monitoring stations (Sites 28-33) within the Headwaters Turkey Creek subwatershed (Figure 101). Site 32 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.3.2.1 *Pathogens*

Figure 102 shows that any full body contact recreational use would be threatened by elevated pathogen levels. Sites 29, 31, and 33 regularly exceed the single sample *E. coli* water quality standard with median concentrations above 235 CFU/100 mL. Exceedances occurred across dry to high flow stream flow conditions indicating input from point and nonpoint sources. 75% or less of the observations at Sites 28, 30 and 32 were above 235 CFU/100 mL.

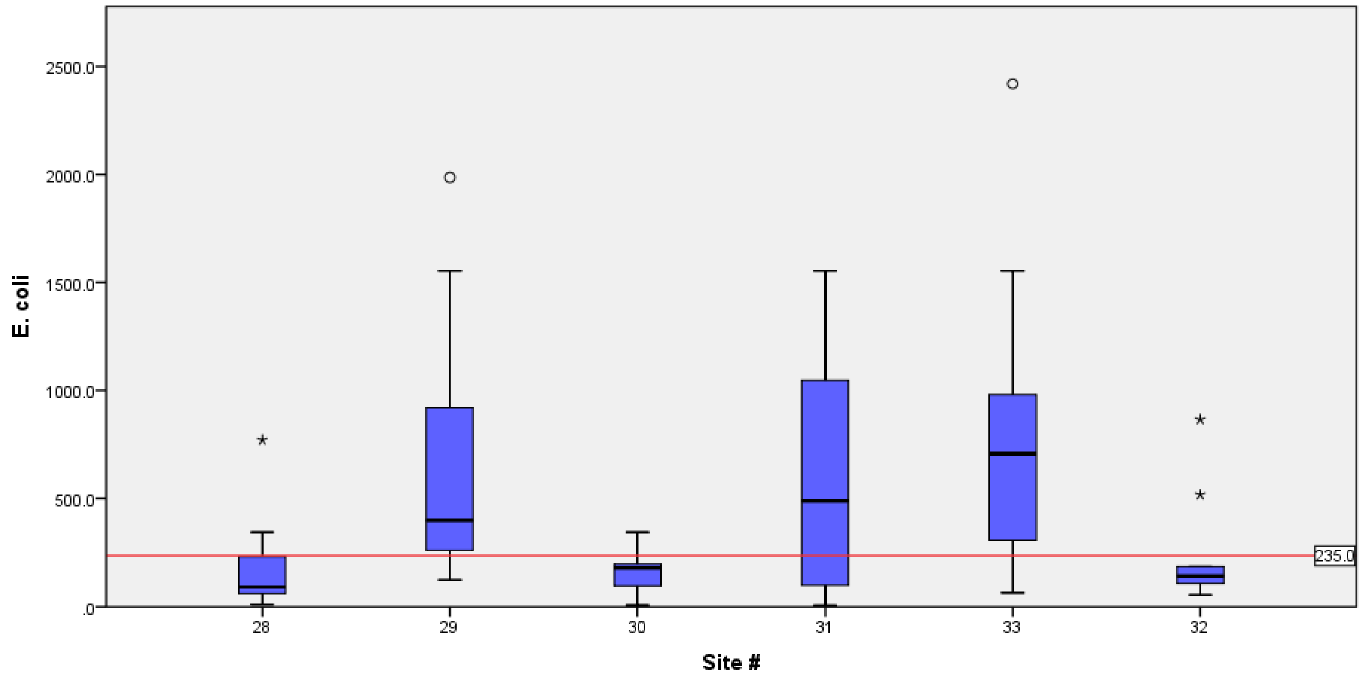


Figure 102 Box plot illustrating site E. coli concentrations within the Headwaters Turkey Creek Subwatershed

4.3.2.2 *Fish*

An evaluation of each site's fish community structure revealed that Sites 28, 30, 31 and 33 are not supporting of their Aquatic Life Use designation. Sites 29 and 32 are considered to be fully supporting however, they only received a "fair" integrity class rating. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
28	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
29	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
30	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
31	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
33	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
32	44	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 54 Site fish index of biotic integrity scores within the Headwaters Turkey Creek Subwatershed

4.3.2.3 *Macroinvertebrates*

An evaluation of each site's macroinvertebrate community structure revealed that none of them meet their Aquatic Life Use designation. No sample was taken at Site 28 due to the stream being choked with vegetation which prevented the use of the dip net. The individual metrics used to evaluate the macroinvertebrate communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
28	No Sample	NA	NA	NA
29	26	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
30	34	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
31	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
33	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
32	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 55 Site macronvertebrate index of biotic integrity scores within the Headwaters Turkey Creek Subwatershed

4.3.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 20-22°C, (68-72°F) with Sites 28 and 30 being the warmest.

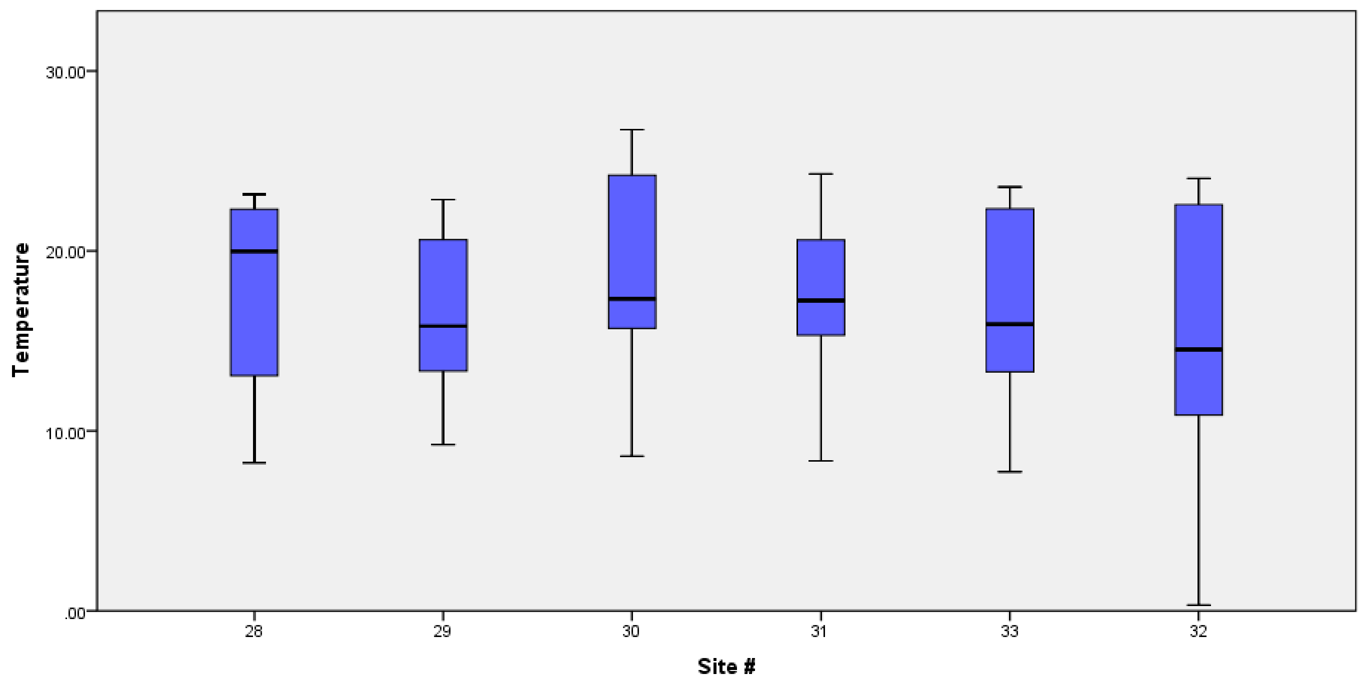


Figure 103 Box plot illustrating site temperatures within the Headwaters Turkey Creek Subwatershed

4.3.2.5 *Dissolved Oxygen*

Figure 104 shows that low dissolved oxygen levels are primarily an issue at Sites 28 and 33. Site 28 has a median dissolved oxygen concentration below the 4 mg/L water quality standard. Site 33's median concentration was much higher, but more than 25% of the observations fell below 4 mg/L. Site 30 had two samples that were slightly less than 4 mg/L. Site 32's exceedance of 12 mg/L occurred in December so is not likely a concern given the dissolved oxygen concentrations observed at the site during other times of the year.

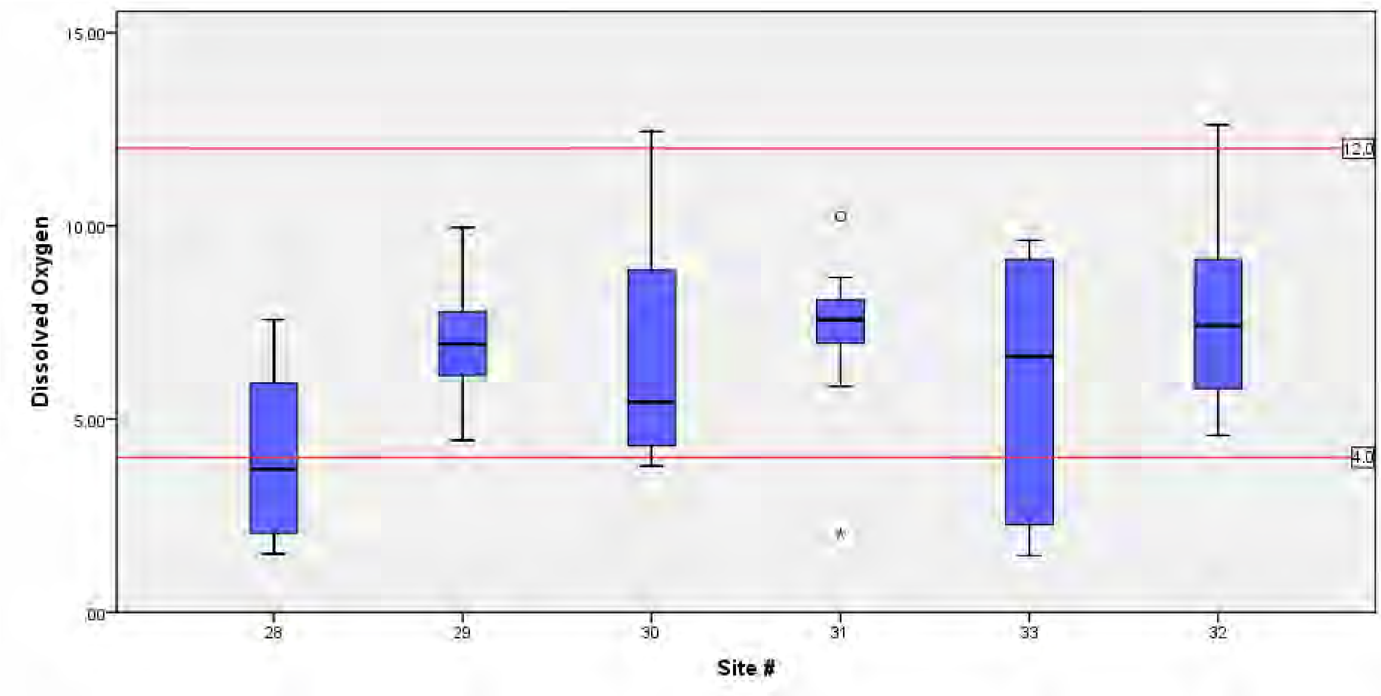


Figure 104 Box plot illustrating site dissolved oxygen concentrations within the Headwaters Turkey Creek Subwatershed

4.3.2.6 *Total Organic Carbon*

Figure 105 shows organic material loading and decomposition is at least partially driving the dissolved oxygen issues observed at Site 28. Organic material doesn't appear to be a factor in the low oxygen levels observed at Site 33.

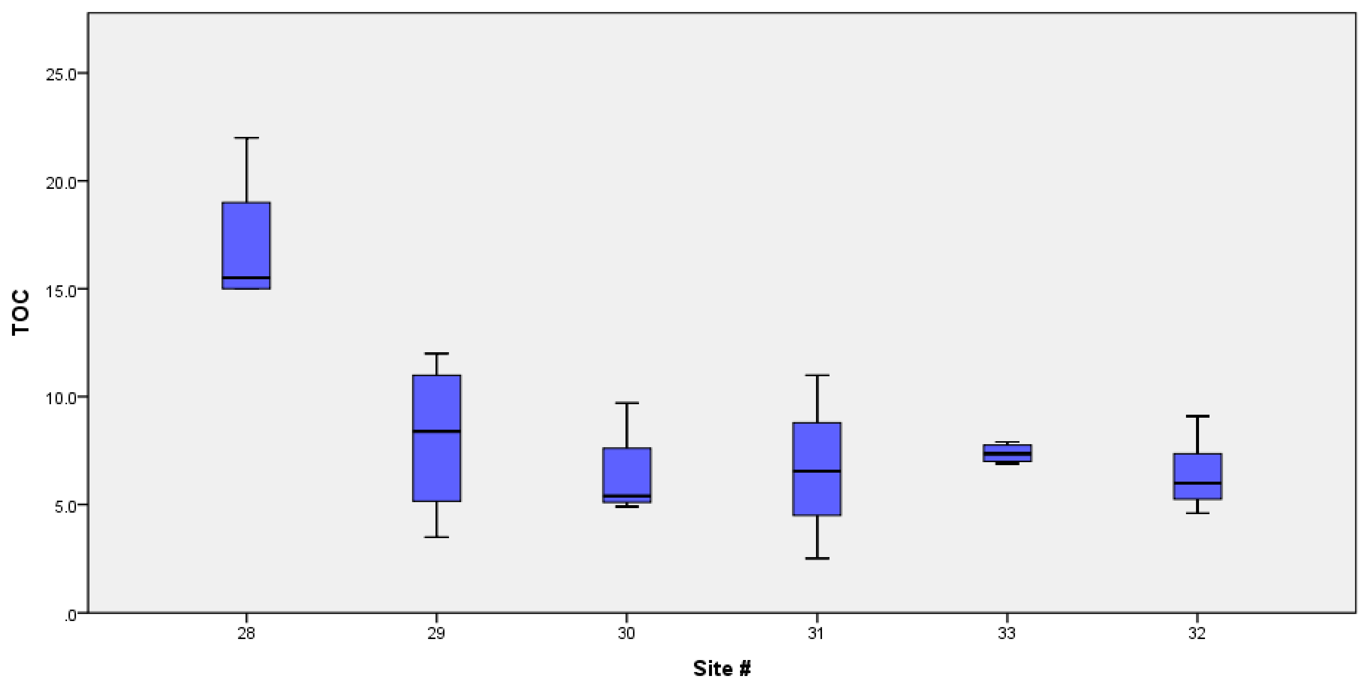


Figure 105 Box plot illustrating site TOC concentrations within the Headwaters Turkey Creek Subwatershed

4.3.2.7 *Nutrients*

Figure 106 shows that Site 28, 29, 31, and 33 had median total phosphorus concentrations above 0.07 mg/L. Aside from the outlier data point observed at Site 28, Site 31 generally had the highest total phosphorus concentrations. Site 28's exceedance of the 0.3 mg/L threshold occurred during dry stream flow conditions in the summer indicating a possible point source contribution.

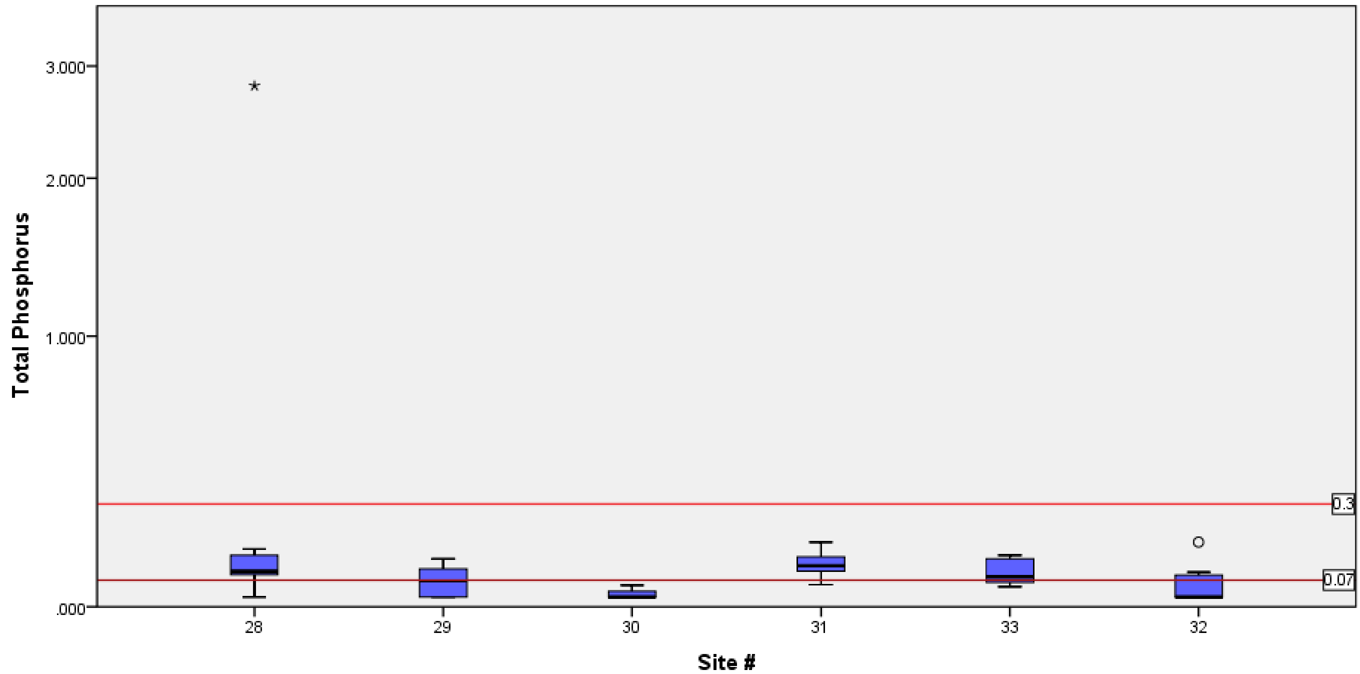


Figure 106 Box plot illustrating site total phosphorus concentrations within the Headwaters Turkey Creek Subwatershed

Figure 107 shows that none of the sites had nitrate concentrations that exceeded the 1.09 mg/L threshold.

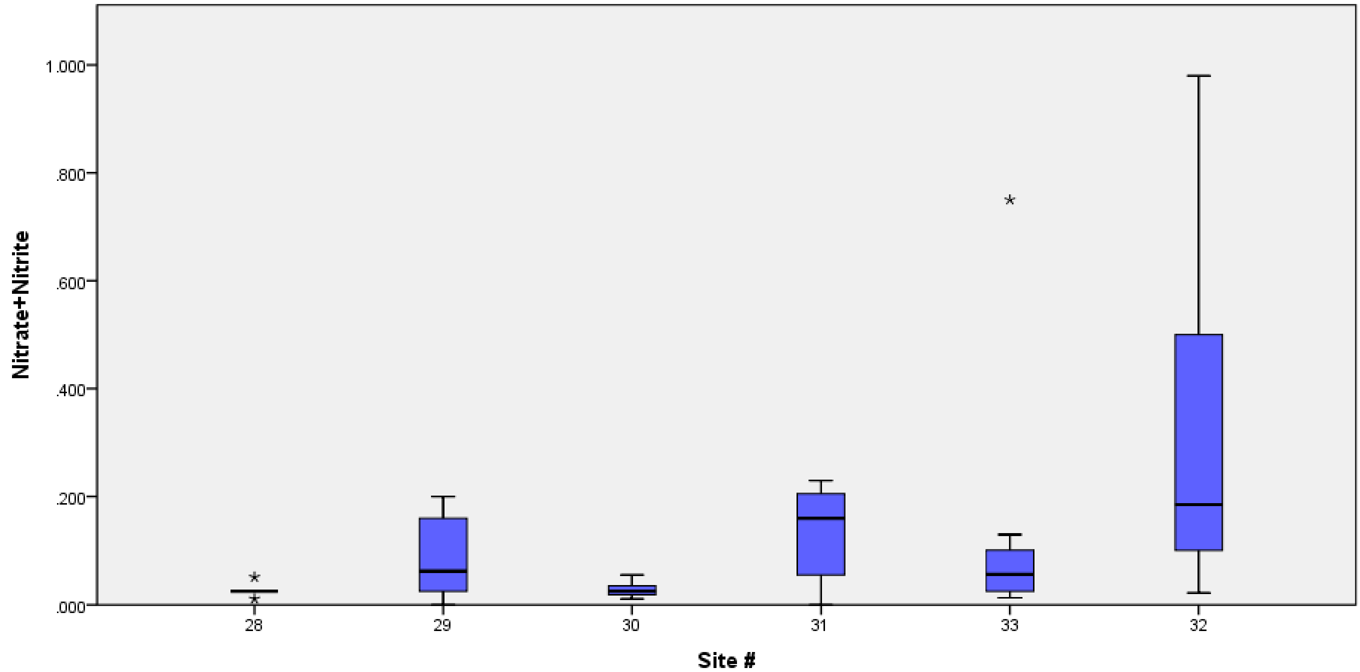


Figure 107 Box plot illustrating site nitrate concentrations within the Headwaters Turkey Creek Subwatershed

Figure 108 shows that Sites 28, 29 and 33 have median total Kjeldahl nitrogen concentrations above 0.68 mg/L. Sites 28 and 23 generally had the highest concentrations with approximately 90% of the observations above 0.68 mg/L. The sample in which the total Kjeldahl nitrogen outlier was observed at Site 28 also resulted in the total phosphorus outlier.

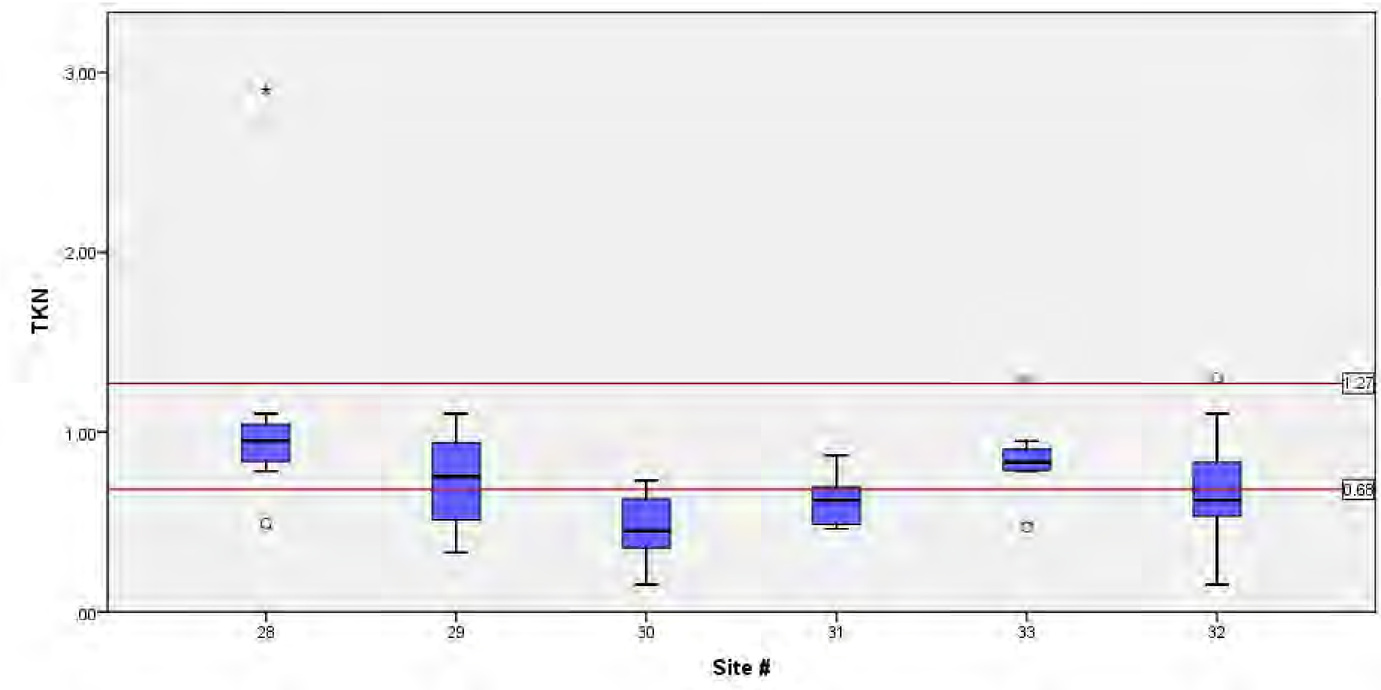


Figure 108 Box plot illustrating site total kjeldahl nitrogen concentrations within the Headwaters Turkey Creek Subwatershed

Figure 109 shows Sites 28, 29, and 32 had median ammonia concentrations above 0.03 mg/L. Sites 30, 31, and 33 typically had ammonia concentrations that fell below the lab detection limit (0.05 mg/L). Sites 28, 30, and 33 each had single observations above the 0.21 mg/L threshold and were considered outliers in this dataset. The outlier observed at Site 28 corresponds with those seen for total phosphorus and total Kjeldahl nitrogen. As levels near 2.0 mg/L, even ammonia-tolerant fish like carp begin to die.

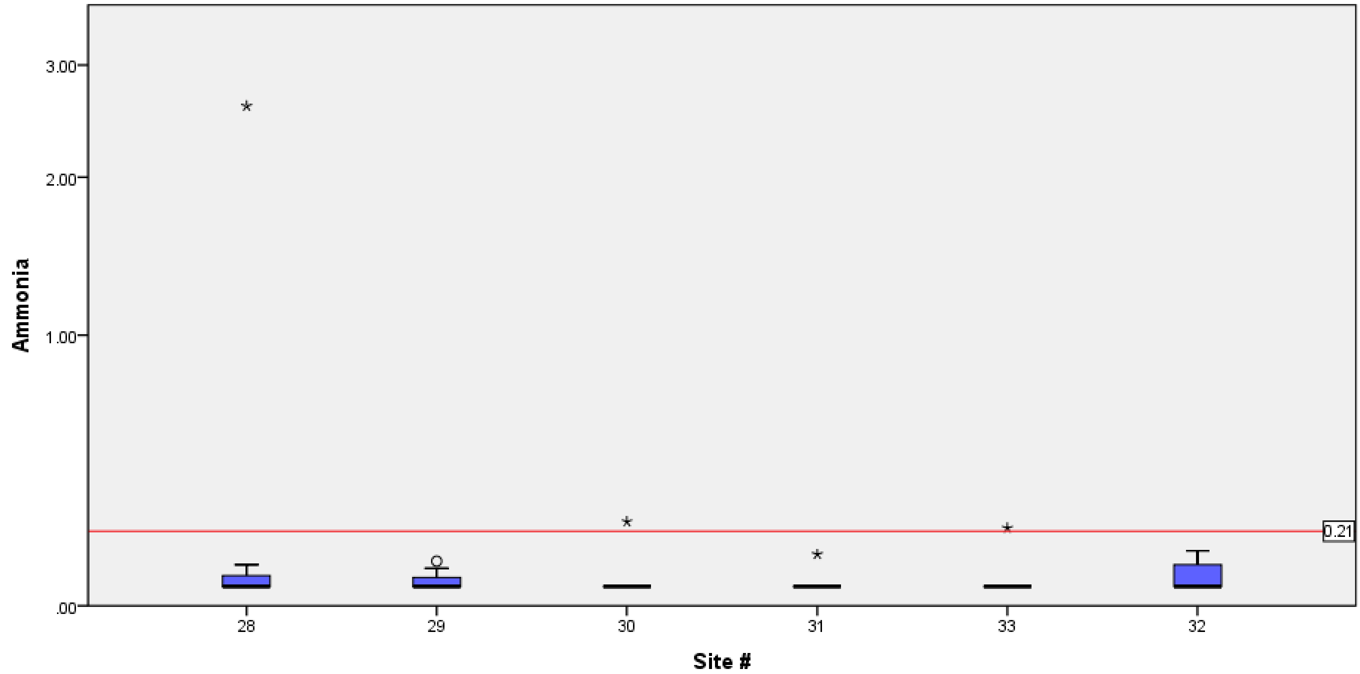


Figure 109 Box plot illustrating site ammonia concentrations within the Headwaters Turkey Creek Subwatershed

4.3.2.8 *Suspended Solids & Turbidity*

Figure 110 shows that total suspended solid concentration almost always fell below the 30 mg/L threshold and anything above was considered an outlier in the dataset. The exceedance occurring at Site 28 corresponds to the exceedances observed above for nutrients. Site 32's exceedance occurred during high stream flows and is indicative of runoff and streambank erosion. Site 33's exceedance occurred during low stream flow conditions in March.

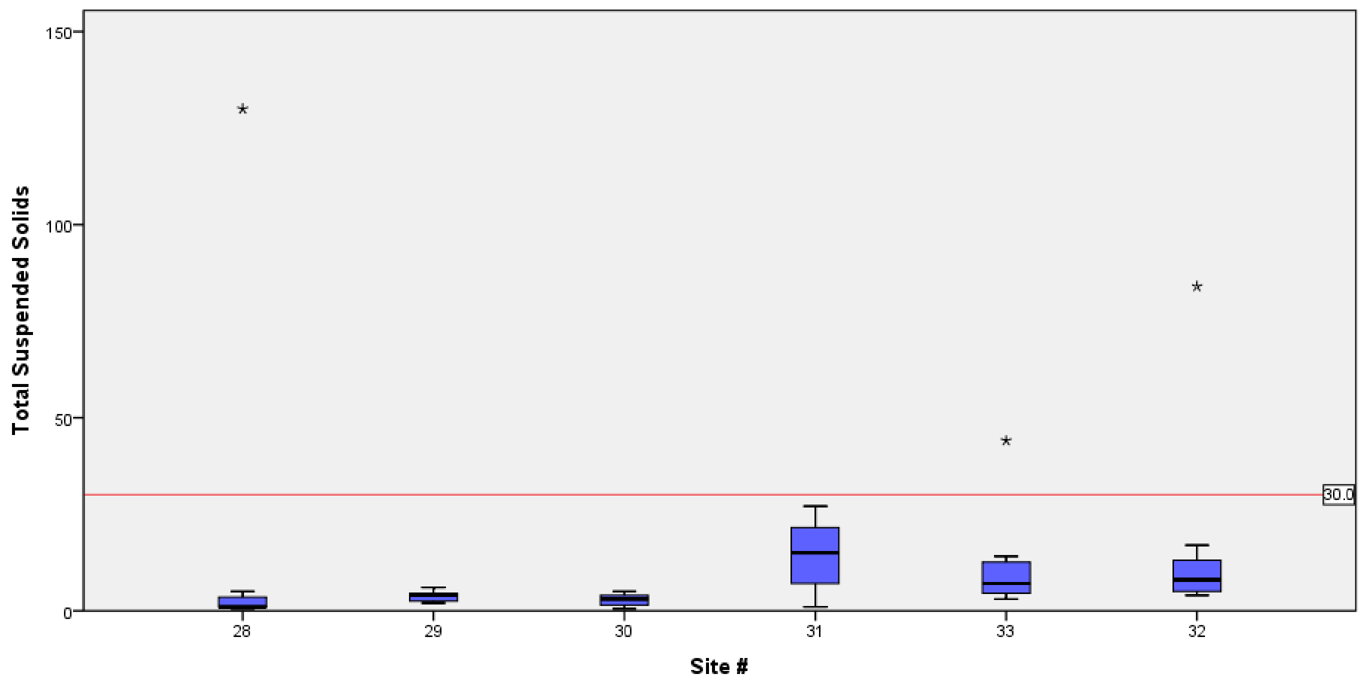


Figure 110 Box plot illustrating site total suspended solids concentrations within the Headwaters Turkey Creek Subwatershed

Figure 111 shows similar site patterns for turbidity as those observed for total suspended solids. Turbidity levels for Sites 28-30 were low, typically falling below the 10.4 NTU threshold. Site 31 and 33 had median turbidity levels greater than 10.4 NTU. Site 31 had the highest median level and more than 25% of its samples were above the 25 NTU threshold.

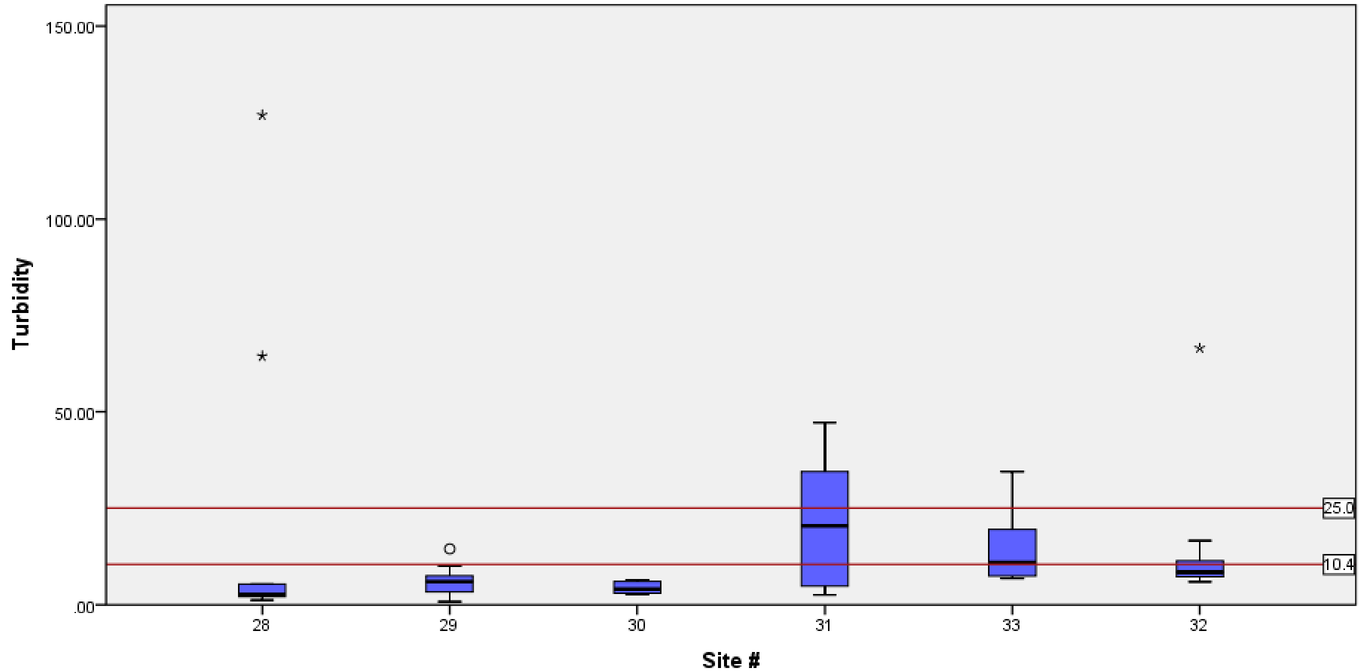


Figure 111 Box plot illustrating site turbidity levels within the Headwaters Turkey Creek Subwatershed

4.3.2.9 *Habitat*

Figure 112 shows that none of the sites generally possess the habitat quality conducive to supporting a healthy warm water fishery (QHEI < 51) with the exception of Site 32 which only had a QHEI score 51. Site 29 received a QHEI score of 49. The major habitat limitations included poor substrate, in-stream cover, and riparian quality and poor channel morphology. None of the sites had riffle/run habitat. Stream substrates at Sites 28, 30, 31, and 33 were characterized by muck, and moderate to heavy siltation and moderate to extensive embeddedness. Stream substrates at Sites 29 and 32 were characterized as sandy with moderate siltation and embeddedness. Sites 28-30 and 33 had poor channel morphology characterized by low to no channel sinuosity, poor to fair riffle/pool development, showed recent sign of channelization or recovery, and had low to moderate stability.

The poor habitat quality at many of these sites is symptomatic of the waterways being excavated into existence or modified to improve drainage. All sites in the subwatershed, except Site 31, are located on reaches that are maintained as county legal drains (Figure 114). Aerial imagery however shows that at least portions of this tributary to Turkey Creek were modified at some point to improve drainage.

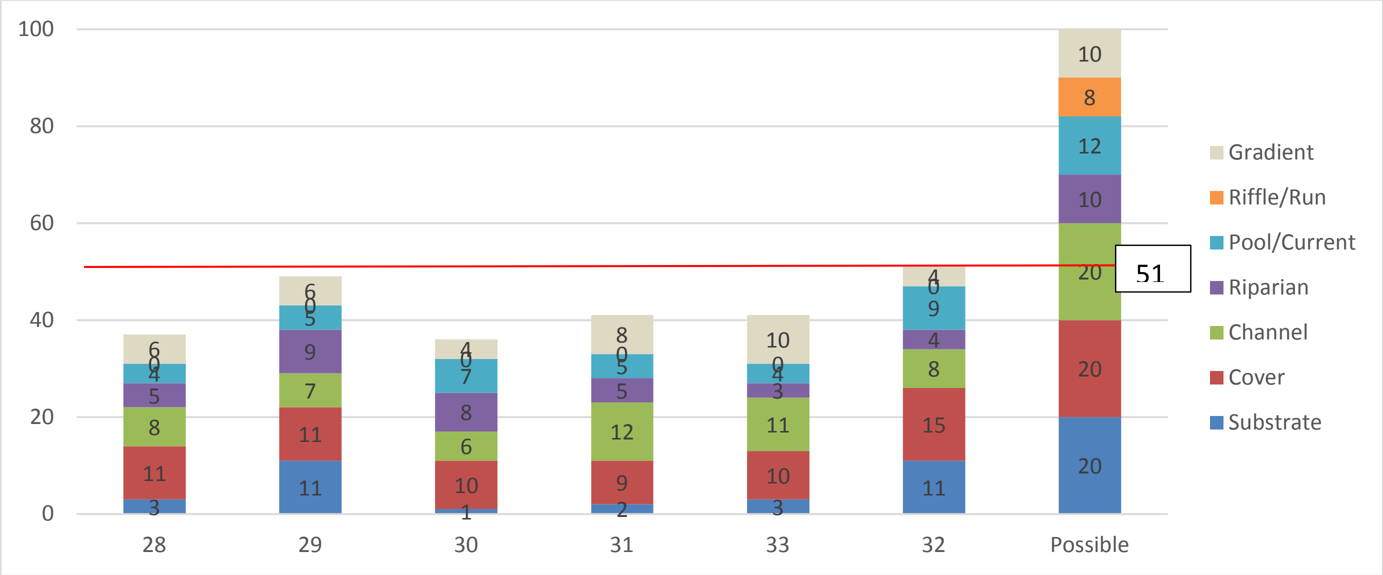


Figure 112 Site qualitative habitat evaluation index scores within the Headwaters Turkey Creek Subwatershed

4.3.3 Land Use & Land Cover

Overall, the predominant land cover type within the subwatershed is developed land (55%) followed distantly by agriculture (16%) lands (Figure 113). Portions of Griffith, St. John, Schererville, and Merrillville fall within the boundaries of the subwatershed. The unincorporated areas are mostly unsewered.

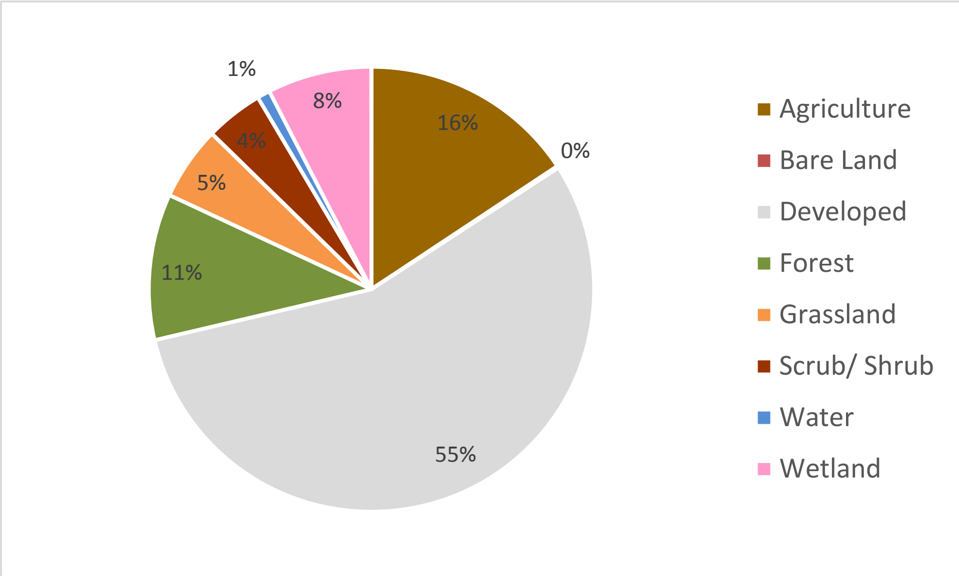


Figure 113 Percent land cover within the Headwaters Turkey Creek Subwatershed

Table 56 includes land cover information for each site's drainage area. Every site's drainage area includes a large percentage of developed land. Site's 28 and 30 have the largest percentage of natural land cover within their drainage areas. The riparian area upstream of Site 28 includes patches of wetland, forest and scrub/shrub habitat that provide a buffer to adjacent development and the small amount of agricultural lands. Site 30 is primarily surrounded by grasslands within Oak Ridge County Park. The area surrounding Site 29 is primarily wetland habitat along Turkey Creek. However most of the land draining to the sites is development. The stream segments draining to Sites 31 and 33 are bordered by development for almost their entire length. Small patches of forest and scrub/shrub habitat are located near their headwaters. The largest agricultural area within the subwatershed borders Turkey Creek between Sites 29 and 32. There appears to be a limited amount of stream buffer along this stretch.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
28	3.6	0.0	61.3	15.6	5.2	5.2	1.4	7.5
29	7.9	0.0	60.3	13.2	6.8	5.4	0.8	5.6
30	0.8	0.0	46.5	22.3	6.7	4.6	4.1	15.0
31	13.3	0.2	65.6	8.5	4.2	3.7	0.7	3.9
33	24.9	0.1	61.6	5.7	3.4	2.5	0.3	1.6
32	15.7	0.1	55.4	10.7	5.4	4.2	0.9	7.6

Table 56 Site percent land cover within the Headwaters Turkey Creek Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 57. Developed land is the most prevalent land cover type within each drainage's riparian zone. In many instances, when agriculture is factored in, human uses comprise over 60% of the riparian zone. The prevalence of human land uses and associated cover types is reflected in the poor riparian habitat quality scores observed for a number of sites in the QHEI above.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
28	7.0	0.0	32.7	18.5	1.6	11.2	5.1	23.8
29	11.4	0.0	49.3	11.2	4.3	8.0	2.6	13.2
30	0.8	0.0	59.0	12.9	10.8	6.7	4.6	5.1
31	6.9	0.0	69.1	13.5	1.3	3.9	1.3	3.9
33	12.5	0.0	80.4	2.2	0.0	2.2	2.2	0.6
32	17.0	0.0	48.3	9.5	4.1	5.5	1.9	13.8

Table 57 Site percent riparian land cover within the Headwaters Turkey Creek Subwatershed

The TMDL reports seven NPDES permitted industrial facilities located in subwatershed. (See TMDL for NPDES industrial facility location map.) The TMDL does not reference any permit violations for these facilities over the five year period between 2010 and 2014. There is one sanitary sewer overflow outfall located in the subwatershed upstream of Site 33 on Kaiser Ditch (Figure 114).

Three potential livestock facilities were identified in the subwatershed. All three are located in the upstream area around Site 28, south of U.S. Hwy 30 (Figure 114). At least one of these, potentially two, drain to the tributary that joins Turkey Creek north of Site 28.

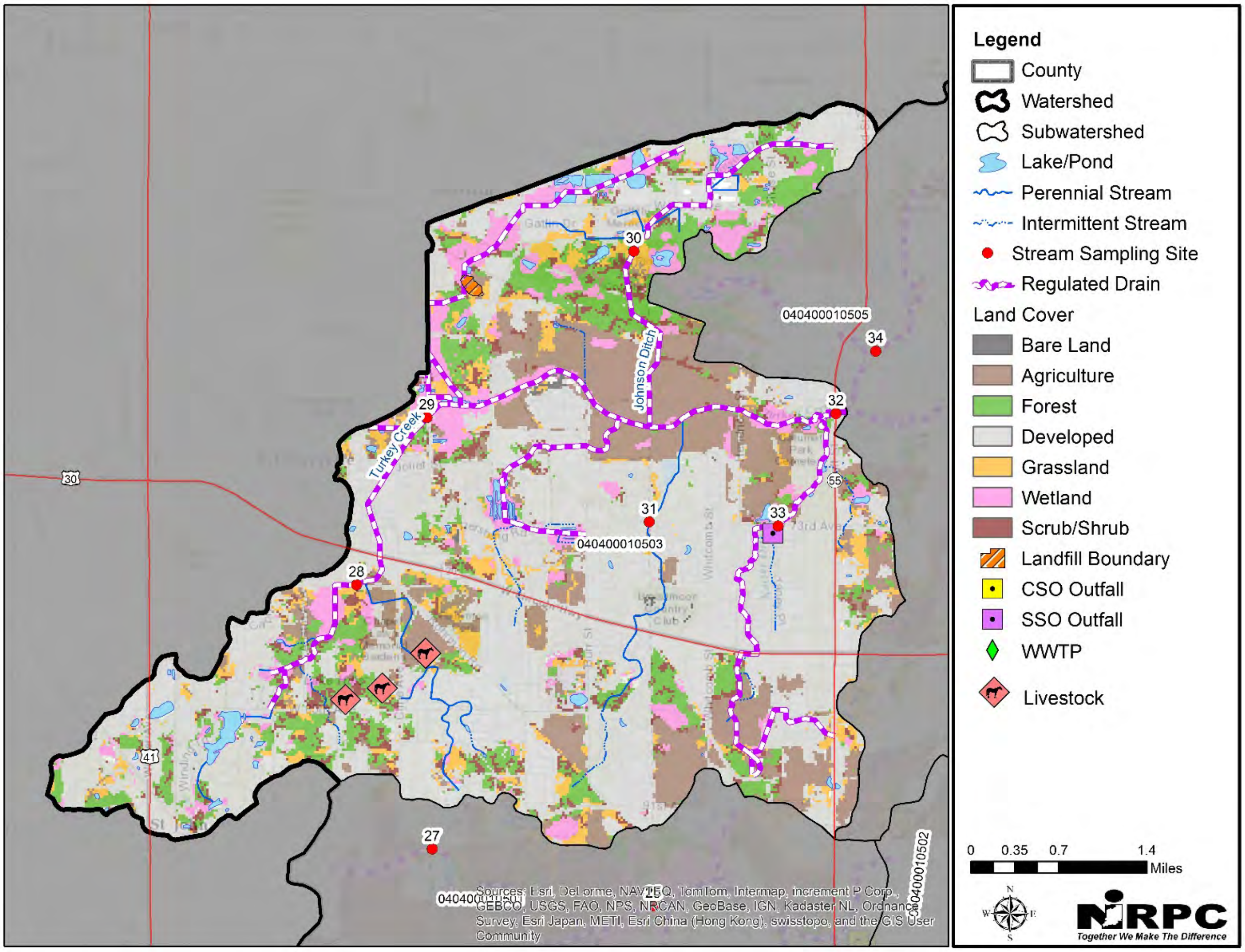


Figure 114 Land cover and land use within the Headwaters Turkey Creek Subwatershed

4.3.4 Soils

Generally the soils located south of Turkey Creek are prone to producing runoff. Many of the streams in this southern half of the subwatershed are bordered by silty clay loam and silt loam which in part explains the poor streambed substrate quality documented in Section 4.3.2.9. The Headwaters Turkey Creek subwatershed has the highest percentage of hydric soils in the entire watershed (Table 9). Much of the area surrounding Turkey Creek and its tributaries were formally wetland. Many of these areas were originally drained for agricultural production but have since been converted to development. A majority of the highly or potentially highly erodible soils in the subwatershed are located in areas with natural land cover or have been developed. Some of these soils are still in agriculture production within the drainage areas of Site 31 and 33. There is one area with steep slopes upstream of Site 30 adjacent to Johnson Ditch (Figure 115).

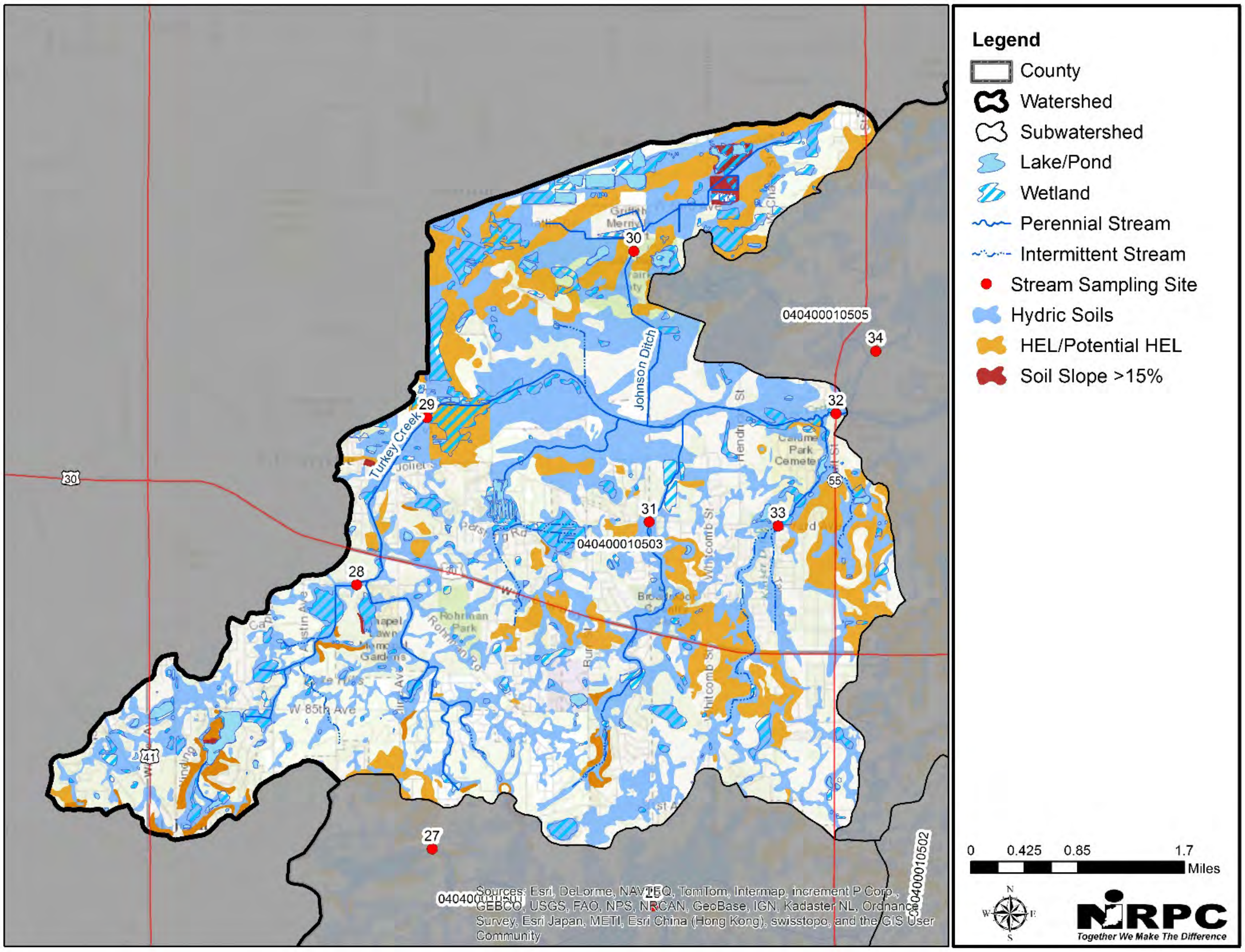


Figure 115 Soils within the Headwaters Turkey Creek Subwatershed

4.4 Deer Creek Subwatershed (HUC 0404000104)

4.4.1 Overview

The Deer Creek subwatershed is located in the south-western portion of the watershed. It drains approximately 26.3 mi² of primarily agricultural (44%), developed (19%), and forested (14%) land. Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities, siltation, and high nutrient and E. coli levels.

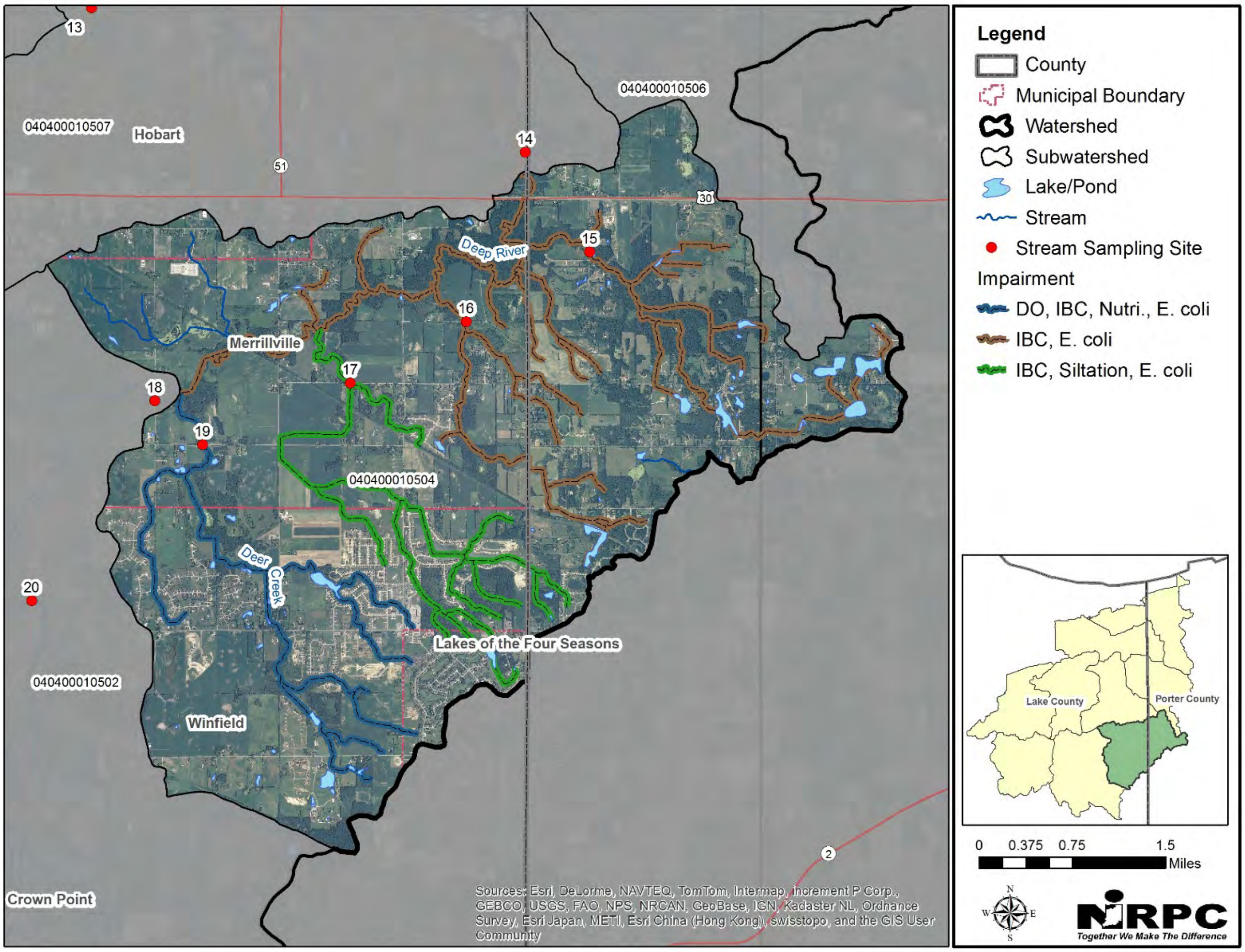


Figure 116 Stream impairements within the Deer Creek Subwatershed

4.4.2 Water Quality

IDEM collected water quality data at four monitoring stations (Sites 15-17 and 19) within the Deer Creek subwatershed (Figure 116). Site 14, which provided the safest road access point, was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.4.2.1 *Pathogens*

Figure 117 shows that any full body contact recreational use would be threatened by elevated pathogen levels. Sites 15-17 and 19 had median *E. coli* concentration in excess of the 235 CFU/100 mL water quality standard. Site 14 was the only site within the subwatershed in which the median concentration fell below this threshold. The exceedances occurred across high flow and dry conditions indicating both nonpoint and point source contributions.

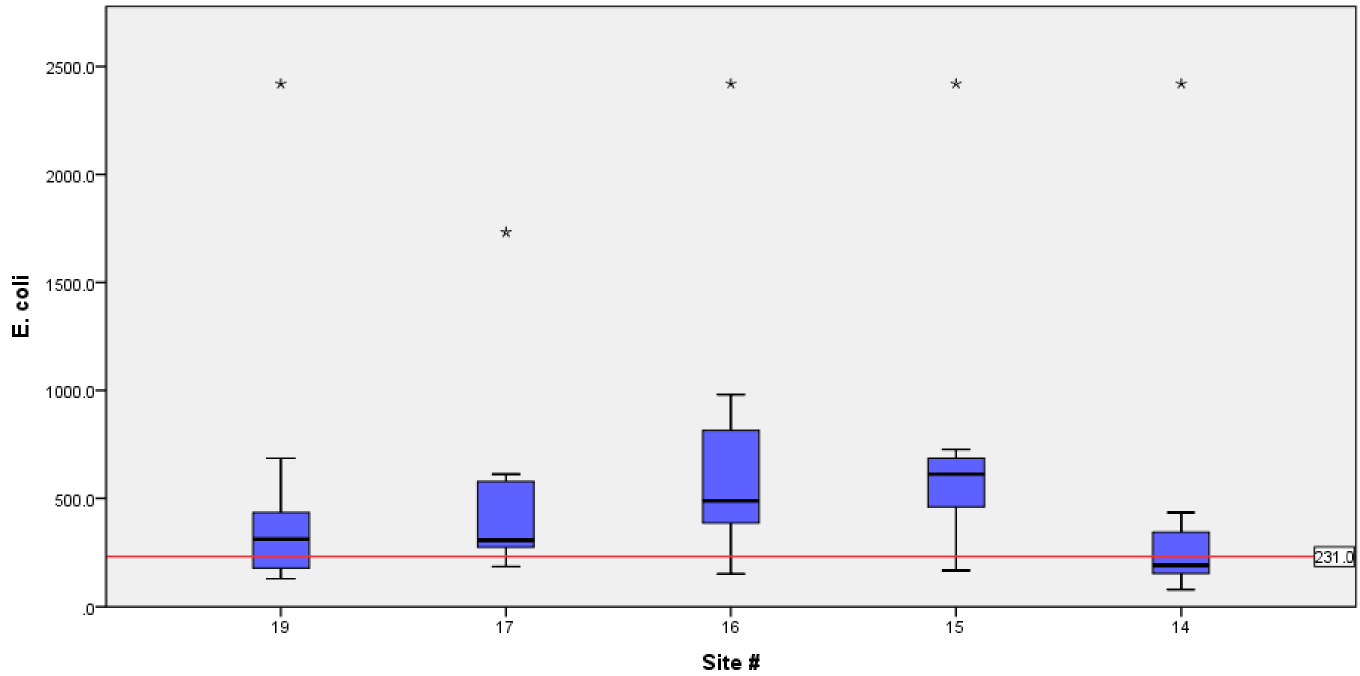


Figure 117 Box plot illustrating site E. coli concentrations within the Deer Creek Subwatershed

4.4.2.2 *Fish*

An evaluation of each site's fish community structure revealed that Sites 15, 17 and 19 are not supporting of their Aquatic Life Use designation. Sites 14 and 16 are considered to be fully supporting however, they only received a "fair" integrity class rating. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent. Fish species that require clean gravel/cobble substrates to spawn were absent/nearly absent at sites 16, 17, and 19.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
19	32	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
17	34	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
16	40	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
15	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
14	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 58 Site fish index of biotic integrity scores within the Deer Creek Subwatershed

4.4.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed that Site 15, 16 and 19 are not supporting of their Aquatic Life Use designation. All sites were dominated by macroinvertebrates that are tolerant of pollution and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
19	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
17	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
16	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
15	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
14	40	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 59 Site macroinvertebrate index of biotic integrity scores within the Deer Creek Subwatershed

4.4.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 17-21°C, (63-70°F) with Sites 19 and 14 being the warmest.

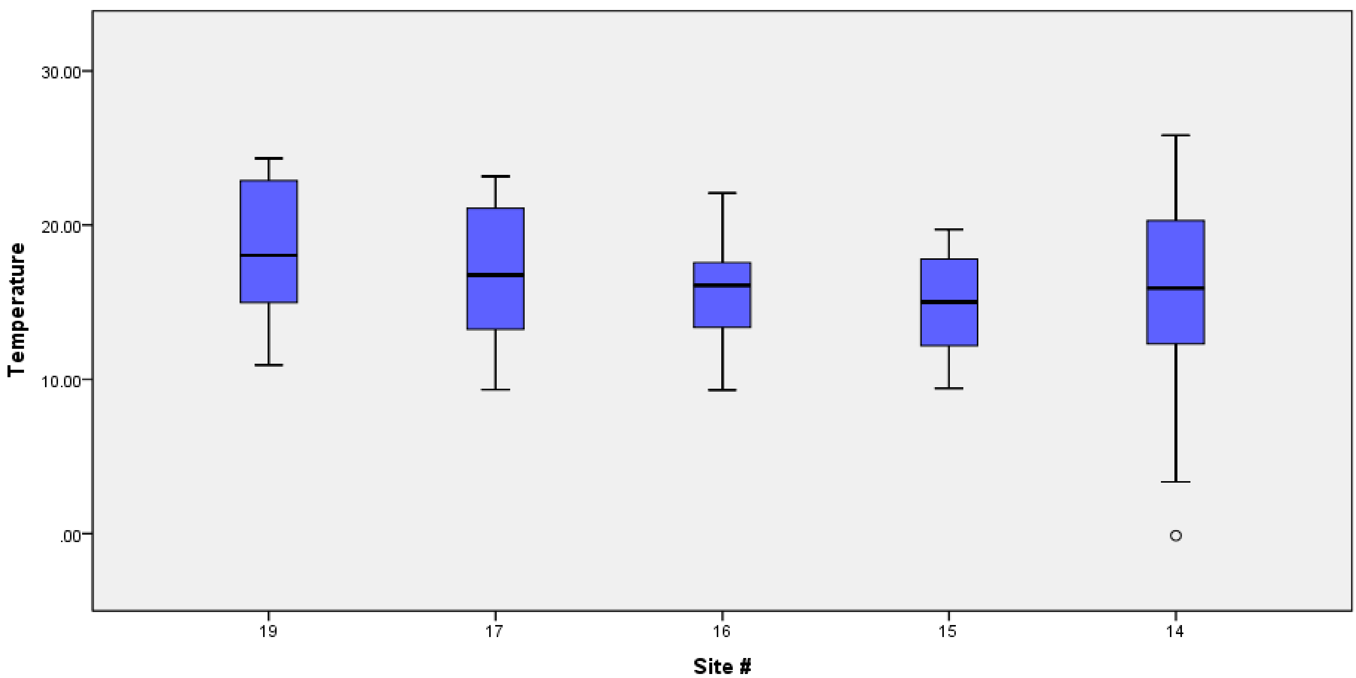


Figure 118 Box plot illustrating site temperatures within the Deer Creek Subwatershed

4.4.2.5 *Dissolved Oxygen*

Figure 119 shows that all sites typically met the dissolved oxygen water quality standard of 4-12mg/L. Site 19 had the lowest median dissolved oxygen concentration and was the only site to have an observation below 4 mg/L. Dissolved oxygen concentrations at Site 19 dropped fairly more rapidly once water temperatures began to warm during late spring. Site 14's exceedance is not likely an issue since this location has extensive riffle habitat and the observation occurred during the winter.

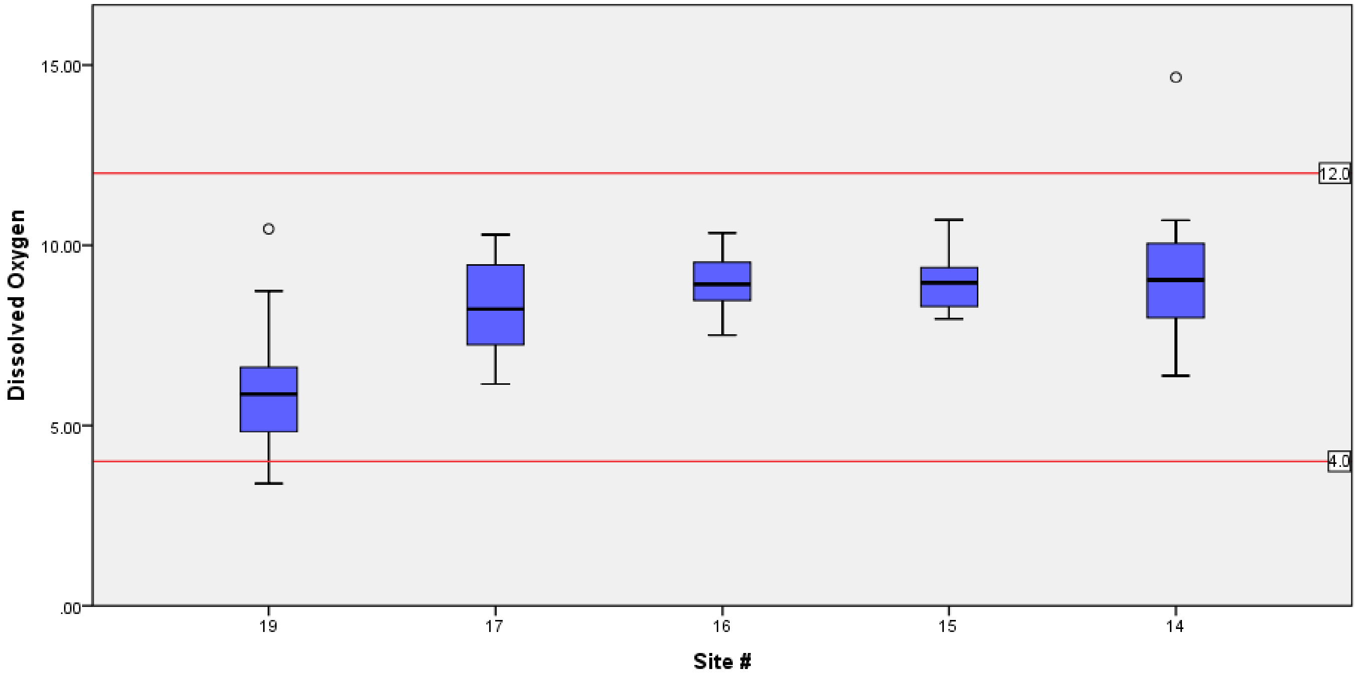


Figure 119 Box plot illustrating site dissolved oxygen concentrations within the Deer Creek Subwatershed

4.4.2.6 *Total Organic Carbon*

Figure 120 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the occasional dissolved oxygen issues observed at Site 19.

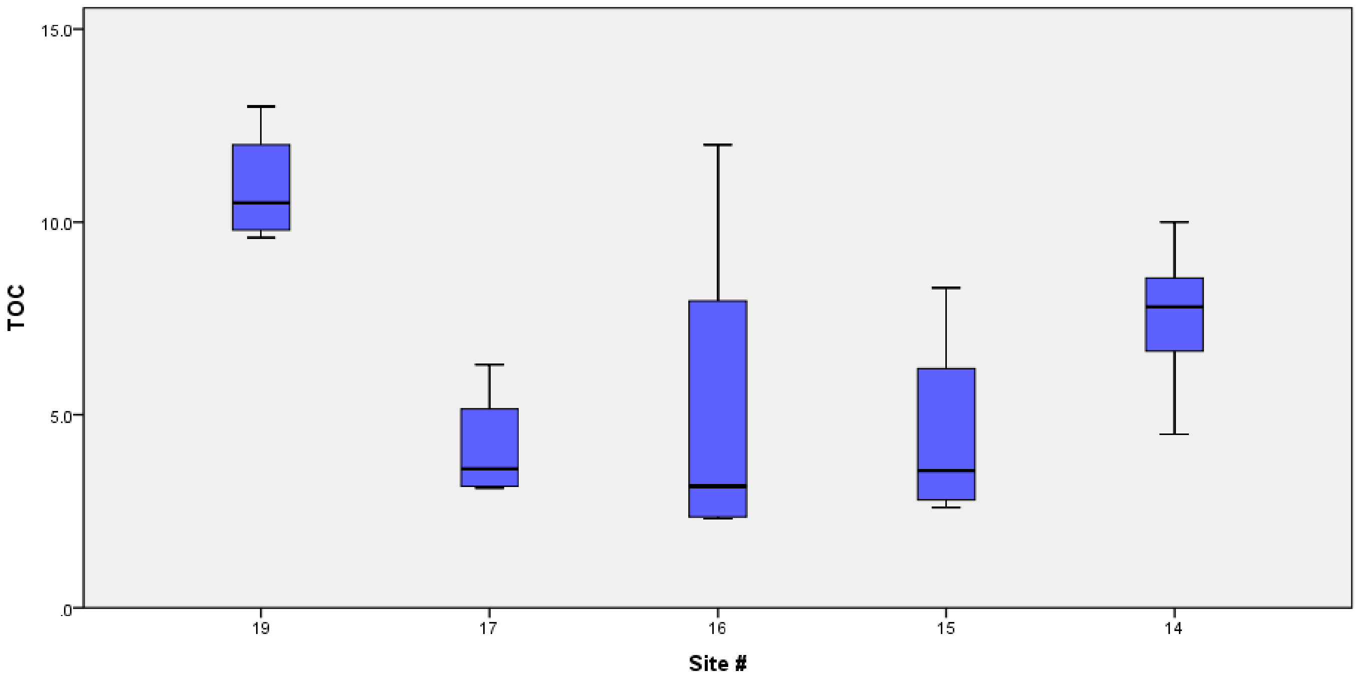


Figure 120 Box plot illustrating site TOC concentrations within the Deer Creek Subwatershed

4.4.2.7 *Nutrients*

Figure 121 shows that the median total phosphorus concentration for Sites 14, 16, and 19 exceed the 0.07 mg/L threshold. Sites 14 and 19 occasionally had observations exceed 0.3 mg/L. Seasonally, mean total phosphorus concentrations were highest during the summer for Sites 19 (0.36 mg/L), 17 (0.06 mg/L), 16 (0.14 mg/L) and 15 (0.05 mg/L) and winter for Site 14 (0.34 mg/L). However, the distribution of total phosphorus concentrations was not found to be statistically different across seasons.

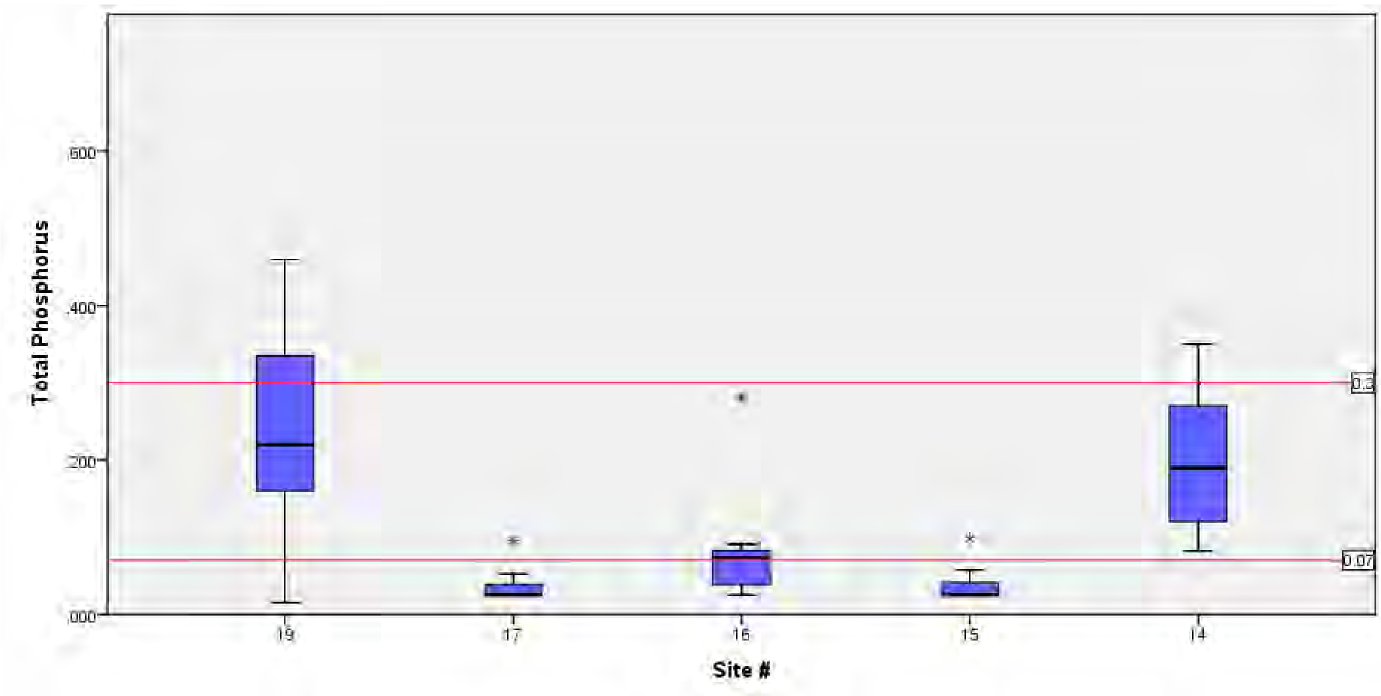


Figure 121 Box plot illustrating site total phosphorus concentrations within the Deer Creek Subwatershed

Figure 122 shows that Site 14 was the only site within the subwatershed to have nitrate concentrations exceed the 1.09 mg/L threshold. All of the nitrate samples collected from Site 14 exceeded this threshold. The maximum concentration observed was 6.9 mg/L.

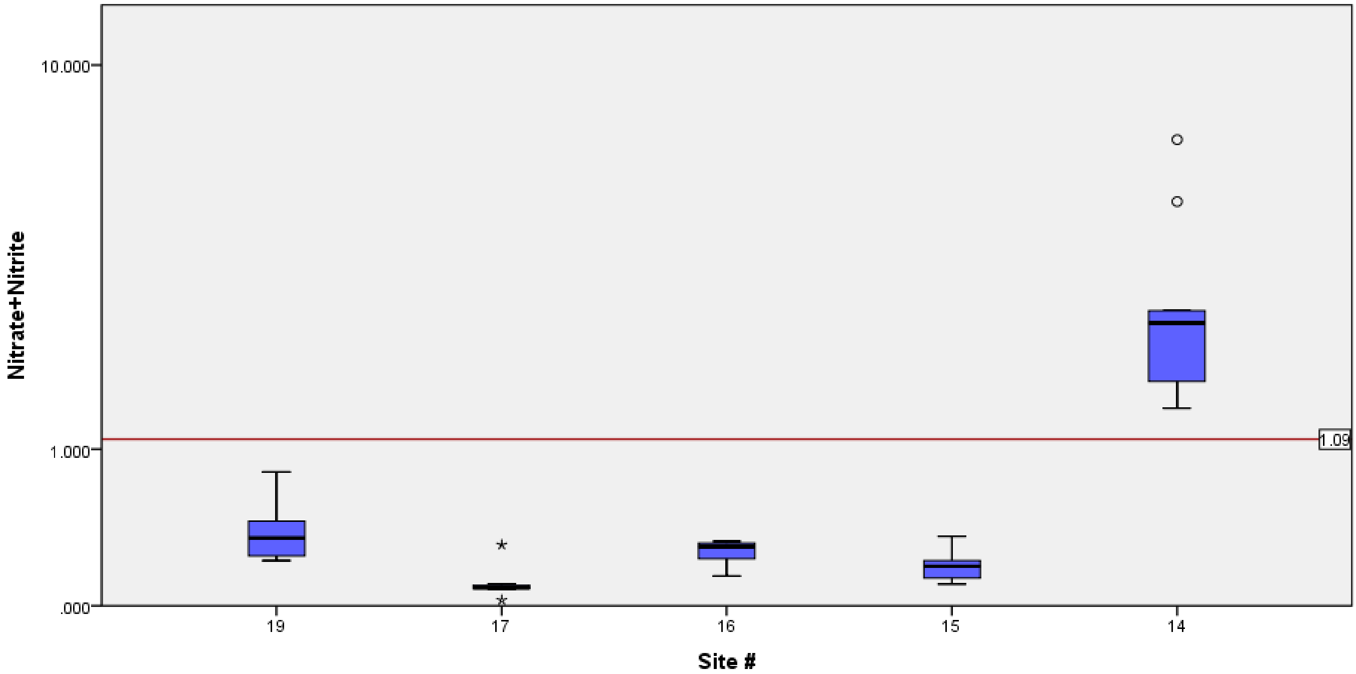


Figure 122 Box plot illustrating site nitrate concentrations within the Deer Creek Subwatershed

Figure 123 shows that Site 19 generally had the highest total Kjeldahl nitrogen concentrations with a median concentration greater than 1.27 mg/L. Approximately 75% of the samples from Site 14 exceeded the 0.68 mg/L threshold. Almost all the samples collected (>90%) from Sites 15-17 fell below 0.68 mg/L threshold.

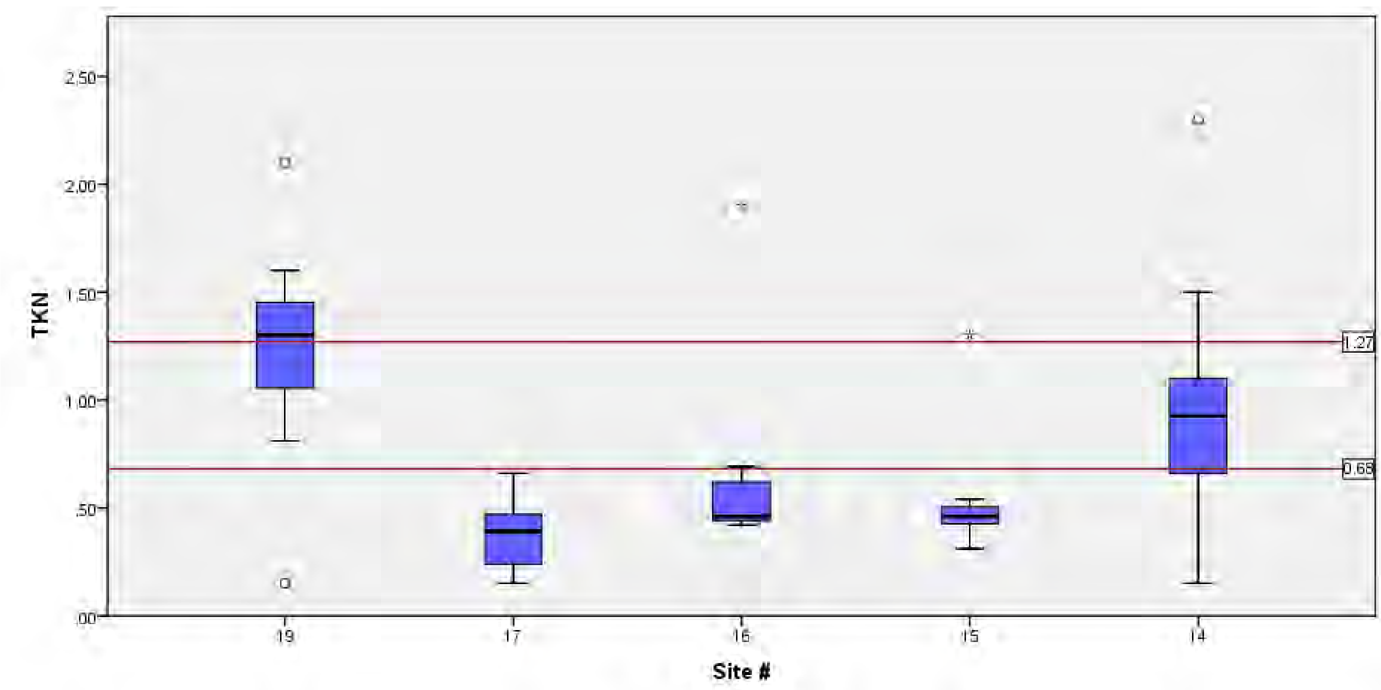


Figure 123 Box plot illustrating site total Kjehdahl nitrogen concentrations within the Deer Creek Subwatershed

Figure 124 shows that ammonia concentrations at Site 19 often exceeding the 0.21 mg/L threshold. The two highest concentrations observed 0.38 and 0.4 mg/L occurred during the summer. Ammonia concentration at the other sites were below the lab detection limit with one exception being Site 14 during the winter.

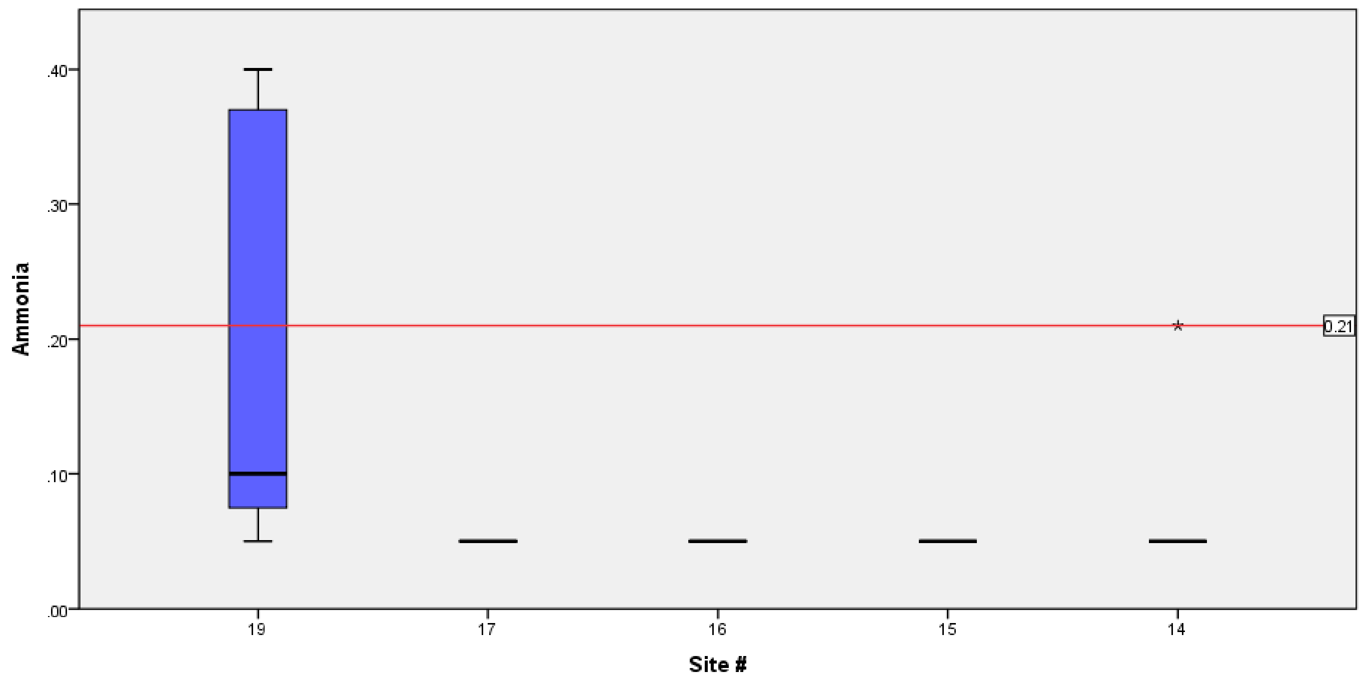


Figure 124 Box plot illustrating site ammonia concentrations within the Deer Creek Subwatershed

4.4.2.8 *Suspended Solids and Turbidity*

Figure 125 shows that total suspended solids median concentrations for all the subwatershed sights fell below the 30 mg/L threshold. Sites 14, 16 and 19 had occasional exceedances which corresponded to precipitation events and higher stream flows.

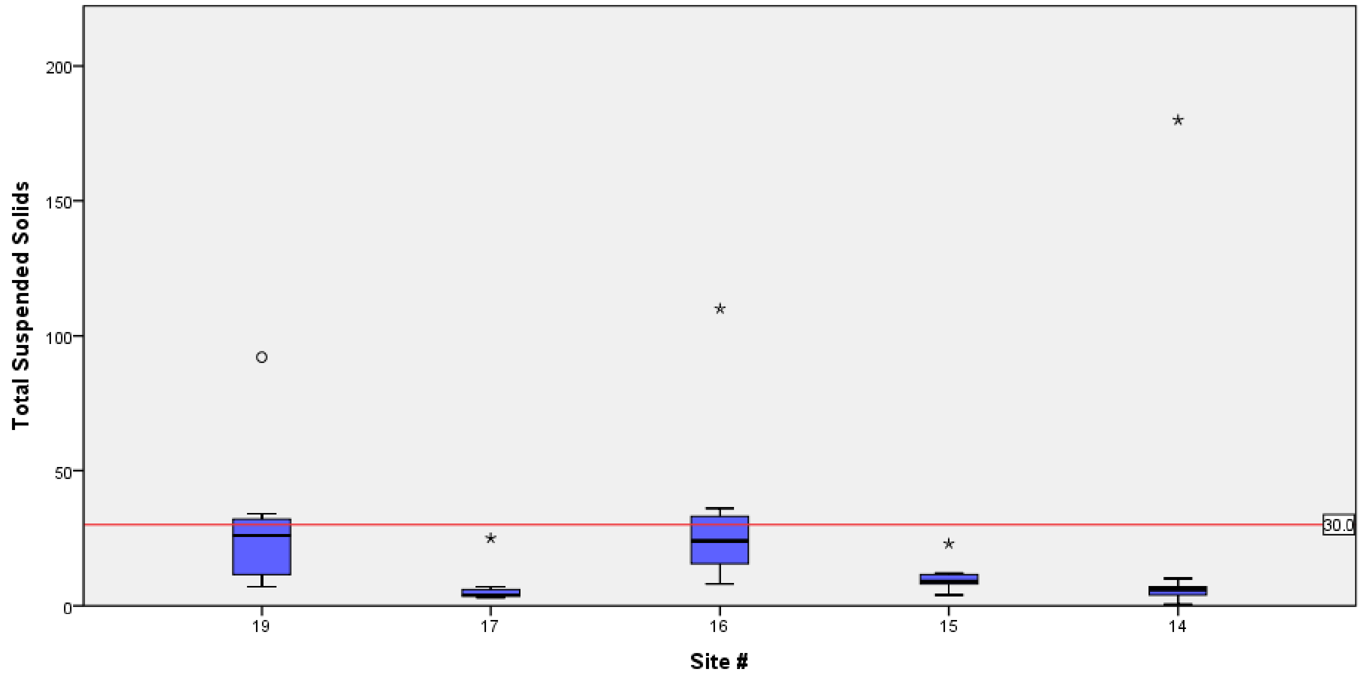


Figure 125 Box plot illustrating site total suspended solids concentrations within the Deer Creek Subwatershed

Figure 126 shows similar site patterns to those seen for total suspended solids. Sites 15, 16, and 19 frequently (40-75%) had turbidity levels higher than 10.4 NTU.

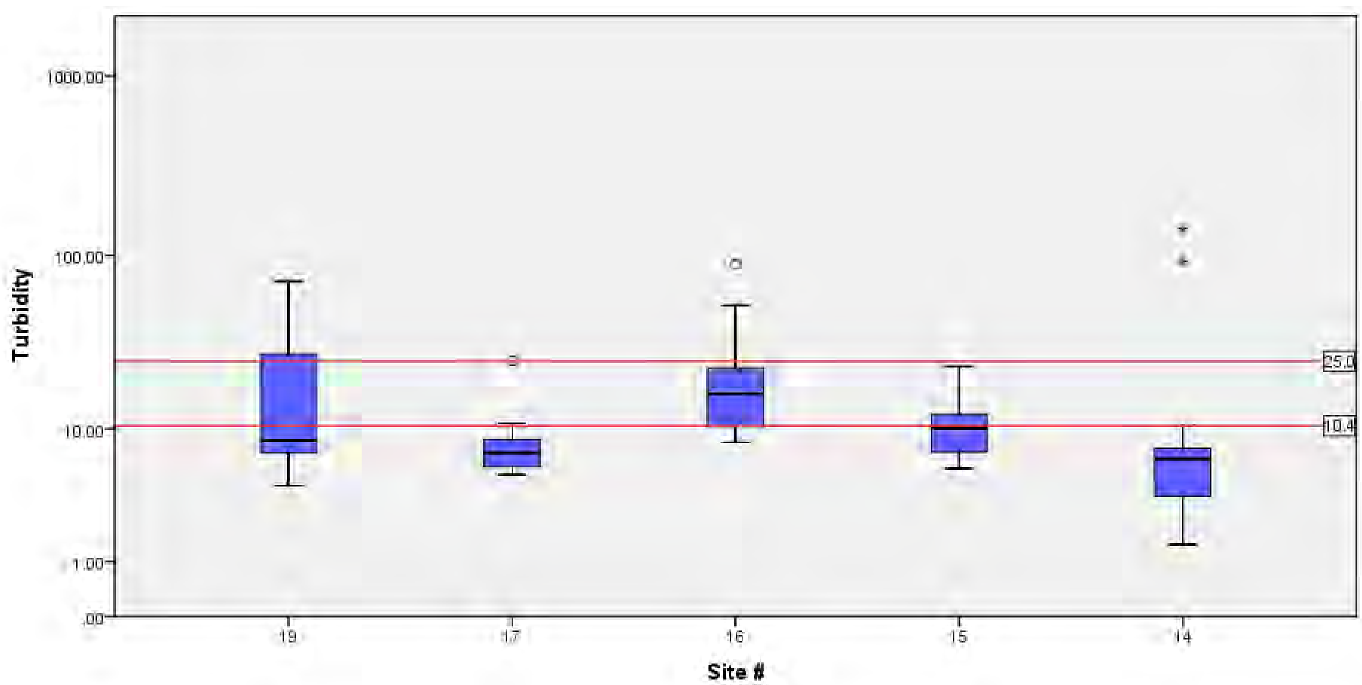


Figure 126 Box plot illustrating turbidity levels within the Deer Creek Subwatershed

4.4.2.9 *Habitat*

Figure 127 shows that Site 19 does not possess the habitat quality that is conducive of supporting a healthy warm water fishery (QHEI <51). Each habitat metric evaluated for this site scored very poorly. Habitat quality at Sites 16 and 17 is marginal in its ability to support a healthy fishery receiving QHEI scores of 52 and 51 respectively. Based on the individual metric scores, substrate quality stands out as a major habitat limitation for sites 16, 17, and 19. Substrates at Sites 16 and 19 are characterized by muck with moderate to heavy siltation and moderate embeddedness. These two sites are located in wetland areas. The substrate at Site 17 is characterized by hardpan (clay) with moderate siltation and embeddedness. The lower channel morphology scores at Sites 17 and 19 can be attributed to past channelization. Both sites had moderately low channel sinuosity with fair pool –riffle development. Site 17 was listed by IDEM as having recovered from channelization but Site 19 was still recovering. Only a small portion of Main Beaver Dam Ditch near the western boundary of the subwatershed is maintained as a county legal drain (Figure 129).

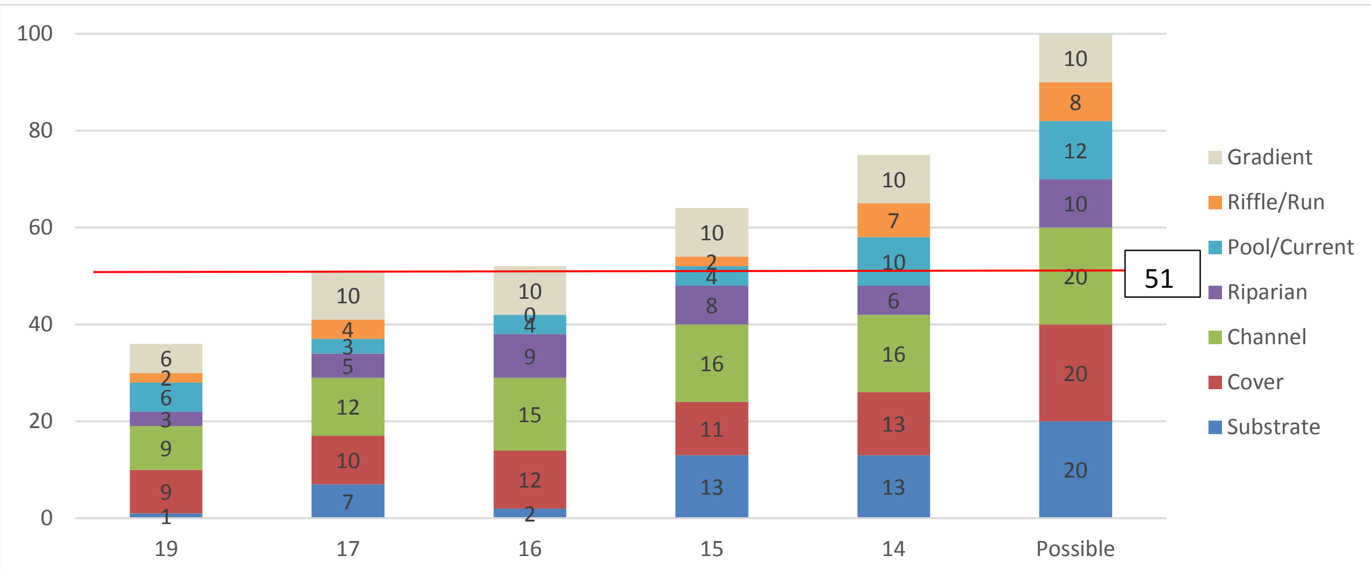


Figure 127 Site qualitative habitat evaluation index scores within the Deer Creek Subwatershed

4.4.3 Land Cover & Land Use

Overall, agriculture is the dominant land cover type within the subwatershed (Figure 128). Compared to the other watersheds, Deer Creek still retains a fair amount of natural land cover. The density of development in the subwatershed is sparse enough that almost all the developed areas, with the exception of Lakes of the Four Seasons, are unsewered and therefore rely on septic systems to treat waste water.

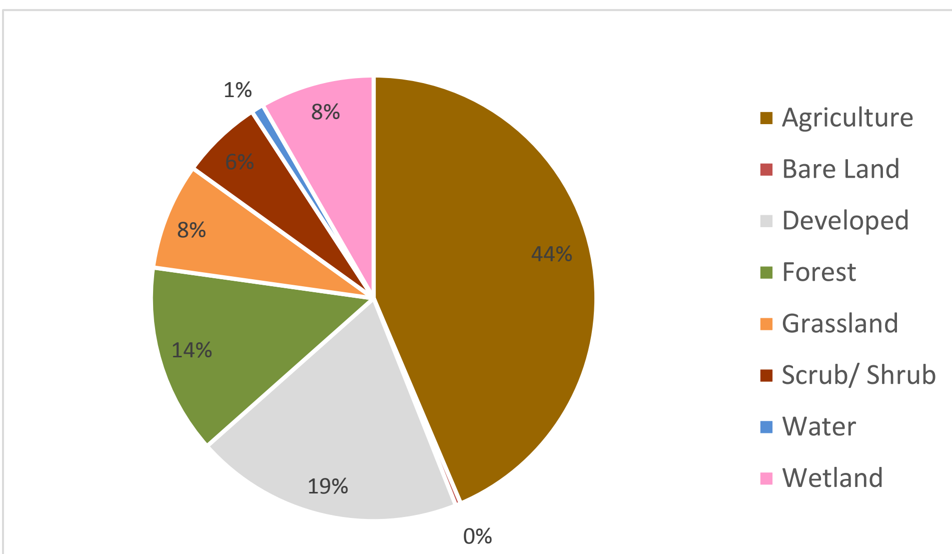


Figure 128 Percent land cover within the Deer Creek Subwatershed

Table 60 includes land cover information for each site's drainage area. Sites 17 and 19 have the highest percentage of developed land in the subwatershed, including portions of Winfield, Lakes of the Four Seasons, and Merrillville. Upstream of Site 19, wetland and forestland buffer stretches Deer Creek's mainstem from adjacent human land uses. Less natural land cover is appearent along the tributaries that drain to Site 17. Sites 16 and 15 have the highest percentage of natural land cover and least amount of development in the subwatershed (Figure 129). Site 14 is generally representative of the entire subwatershed. It's immediate surrounding land cover is forest and wetland. Site 14 is located within Deep River County Park.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
19	45.3	0.1	30.5	7.7	6.2	2.9	0.8	6.6
17	33.8	0.8	39.8	9.4	6.6	6.3	1.9	1.4
16	33.5	1.2	14.9	19.8	12.7	8.1	0.7	9.0
15	32.9	0.0	2.9	32.4	9.5	7.2	1.9	13.3
14	39.7	0.2	32.2	10.1	6.2	3.8	0.6	7.1

Table 60 Site percent land cover within the Deer Creek Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 61. Agricultural and developed land cover makes up a fairly large percentage of many of the riparian zones. Site 15 and 16's riparian zones have one of the highest percentages of natural land cover in the entire watershed.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
19	21.8	0.0	27.9	6.8	8.9	2.9	2.9	28.6
17	20.2	0.9	38.6	13.4	5.9	11.5	7.2	2.2
16	19.1	0.8	13.6	20.4	10.6	7.1	2.3	26.2
15	24.3	0.0	1.2	26.5	1.3	5.7	5.7	35.4
14	28.5	0.2	22.1	9.8	5.3	6.4	2.5	25.3

Table 61 Site percent riparian land cover within the Deer Creek Subwatershed

There are no NPDES permitted industrial facilities documented in the subwatershed. The TMDL identified four waste water treatment plants (Figure 129). The Winfield WWTP (IN0058343) had one 1 TSS violation in 2011 and inspections found violations in February 2010 and January 2012. The Deep River Water Park WWTP (IN0058378) had 11 violations between 2009 and 2014 primarily for ammonia but also for *E. coli* and chlorine. No inspections were shown to occur for Chicagoland Christian Village (IN0054470) or the Falling Waters Conservancy District (IN0062090) over this time period.

Nine potential livestock facilities were identified in the subwatershed (Figure 129). One facility is located in the drainage area of an intermittent tributary that enters Deep River from the north. At least two facilities are located in the Deer Creek drainage area. Two other facilities are very close to this area and may at least in part fall within the Deer Creek drainage. Another two facilities are located between the unnamed tributaries Sites 16 and 17 are located on. An additional facility is upstream of Site 16 near an intermittent, headwater tributary. Two facilities are located near an intermittent, headwater tributary upstream of Site 15. Another facility is located south of U.S. Hwy 30 in the eastern portion of the subwatershed.

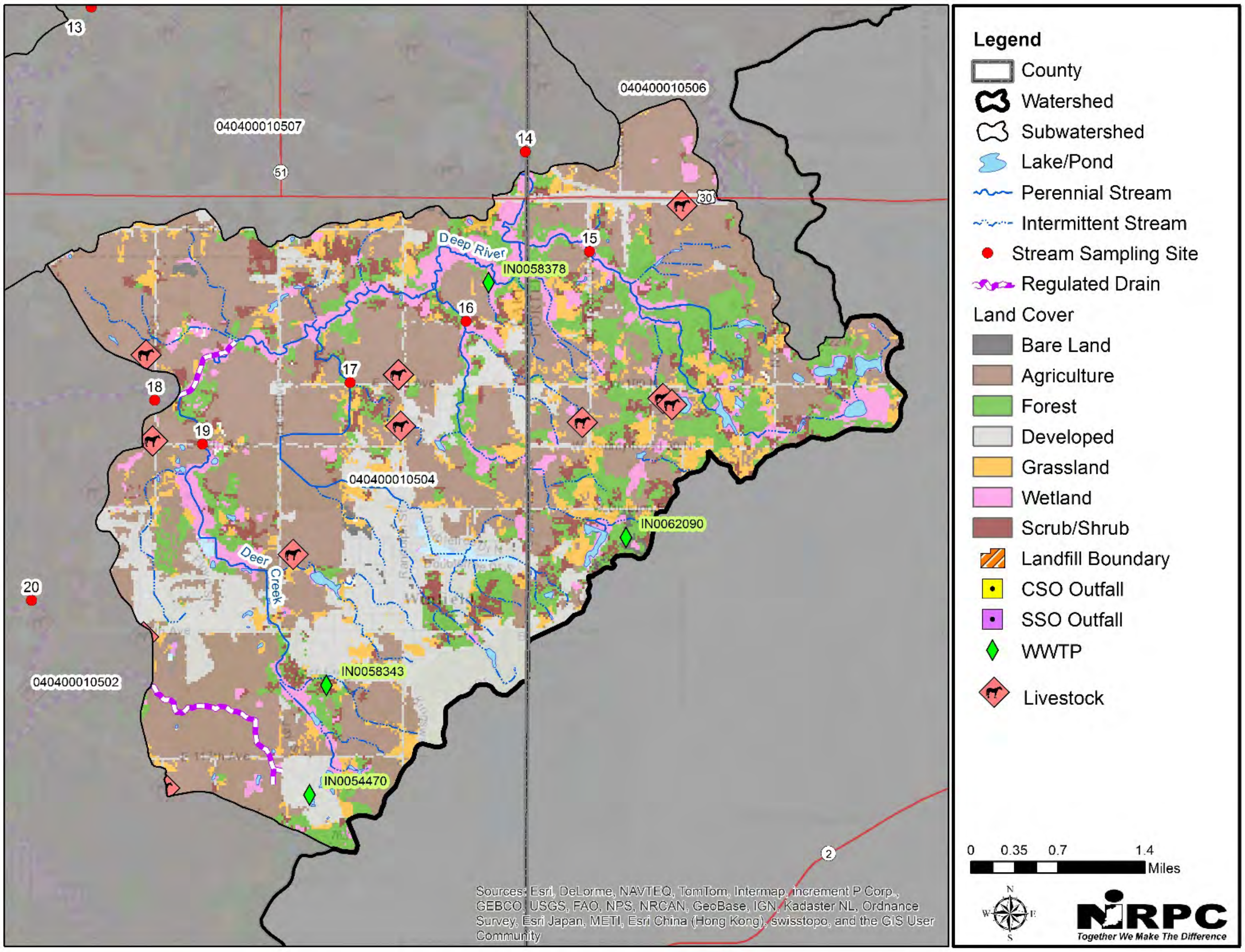


Figure 129 Land cover and land use within the Deer Creek Subwatershed

4.4.4 Soils

Like numerous other areas in the watershed, many of the soils that border the streams in the subwatershed are primarily rated as hydric. Many of these soils have been drained for agricultural production or development (Figure 56). The subwatershed has the third highest percentage of highly or potentially highly erodible soils in the watershed (Section 2.4.2). The largest concentration of these soils is located in the western and southern portion of the subwatershed (Figure 130). Steep slopes can be found adjacent to many of the tributaries entering Deep River from the south (Figure 130). The most prominent areas are located upstream of Sites 15 and 19.

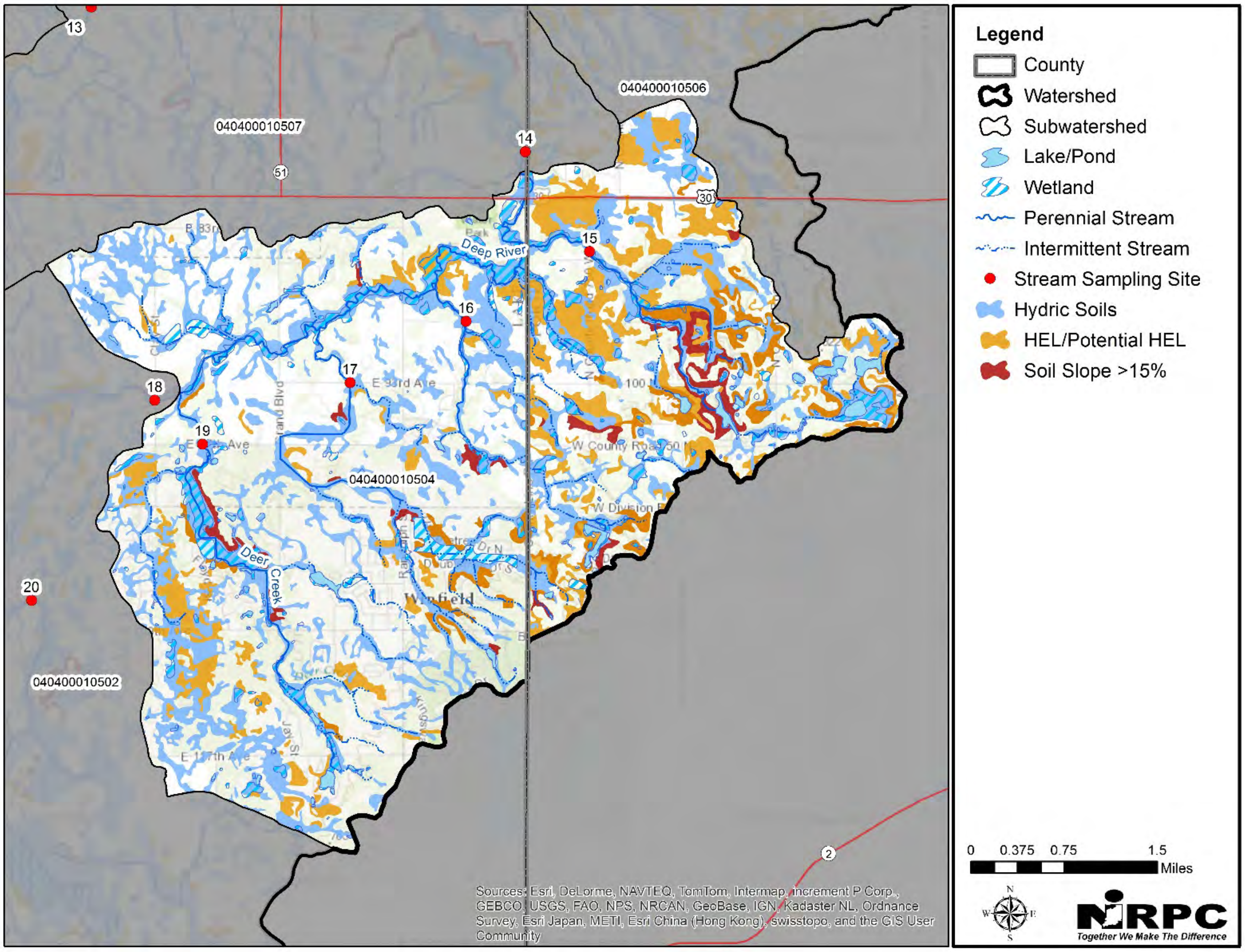


Figure 130 Soils within the Deer Creek Subwatershed

4.5 City of Merrillville Subwatershed (HUC 040400010505)

4.5.1 Overview

The City of Merrillville subwatershed is located in the central portion of the watershed. It drains approximately 19.5 mi² of primarily developed (63%) land. Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities and high E. coli and nutrient levels.

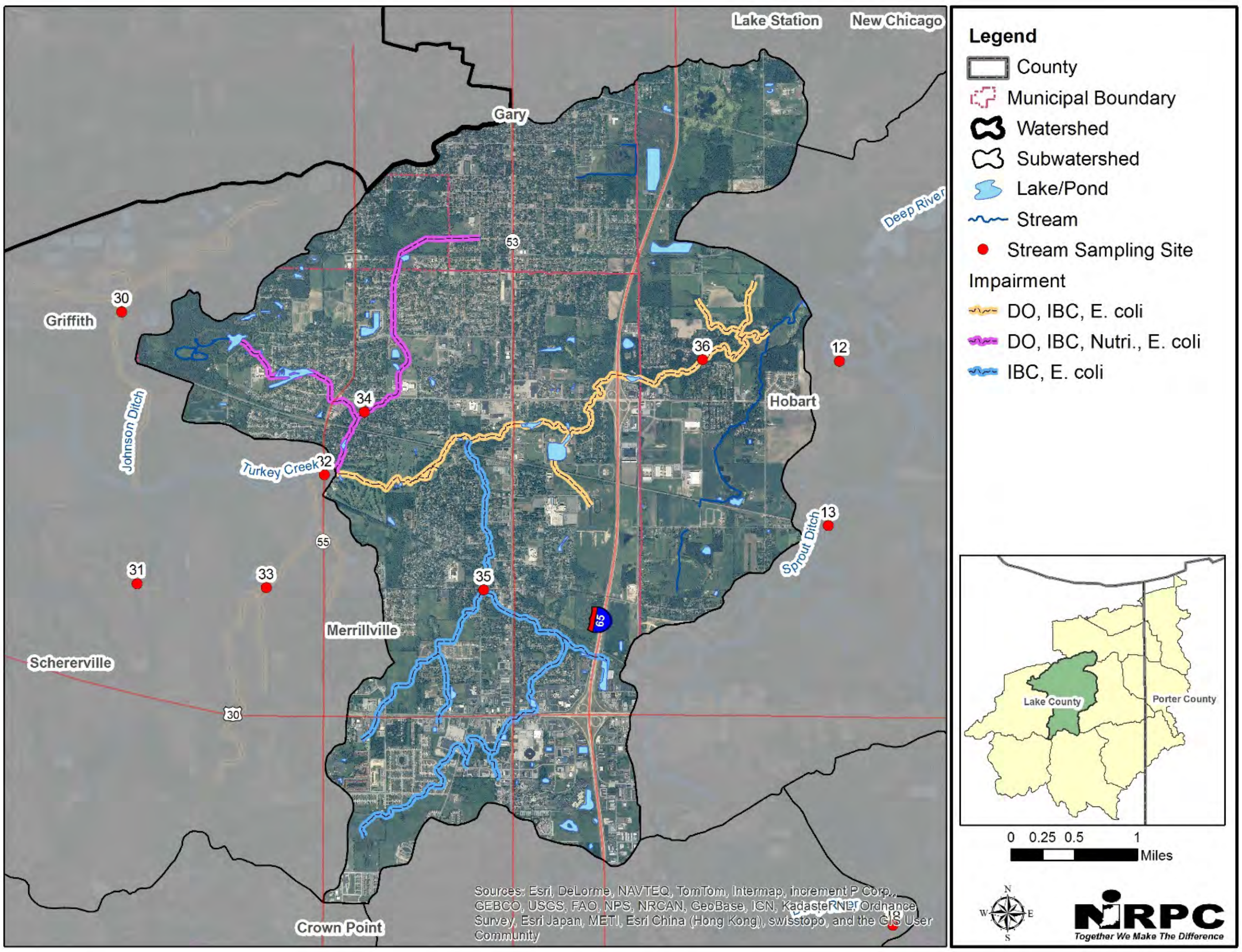


Figure 131 Impaired streams within the City of Merrillville Subwatershed

4.5.2 Water Quality

IDEM collected water quality data at three monitoring stations (Sites 34-36) within the Deer Creek subwatershed (Figure 131). Site 36 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.5.2.1 *Pathogens*

Figure 132 shows that full body contact recreational use would be threatened by elevated pathogen levels. Samples taken at Sites 35 and 36 always exceeded the single sample *E. coli* water quality standard of 235 CFU/100 mL. Site

34 also frequently exceeded the *E. coli* water quality standard. Exceedances occurred across dry to high flow stream flow conditions indicating input from point and nonpoint sources.

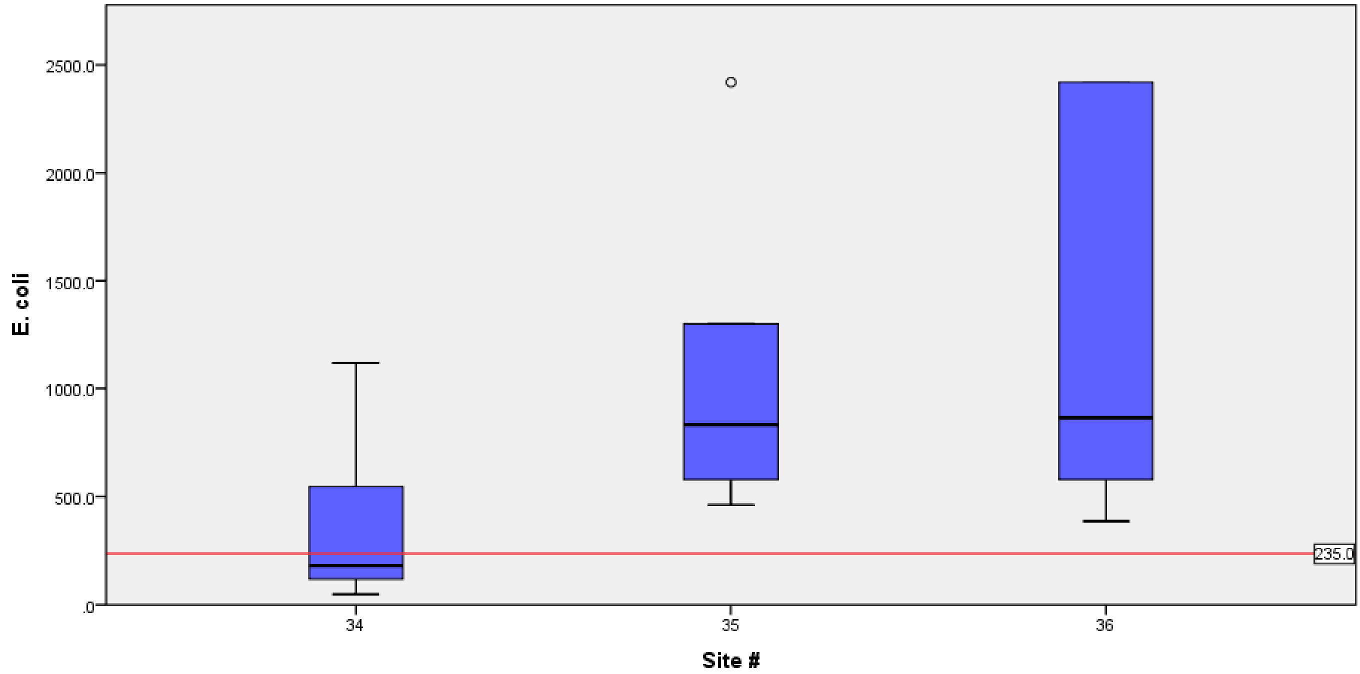


Figure 132 Box plot illustrating site E. coli concentrations within the City of Merrillville Subwatershed

4.5.2.2 *Fish*

An evaluation of each site's fish community structure revealed that none of the sites are supporting of their Aquatic Life Use designation, each receiving a "very poor" integrity class rating. Only seven fish, representing two species, were collected form Site 34. Site 36 faired only slightly better with 25 fish collected, representing three species. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
34	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
35	20	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
36	16	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant

Table 62 Site fish index of biotic integrity scores within the City of Merrillville Subwatershed

4.5.2.3 *Macroinvertebrates*

An evaluation of each site's macroinvertebrate community structure revealed that none of the sites are supporting of their Aquatic Life Use designation, each receiving a "poor" integrity class rating. Intolerant and sensitive macroinvertebrate species were generally absent and the species that were present are considered tolerant of disturbance.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
34	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
35	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
36	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 63 Site macroinvertebrate index of biotic integrity scores within the City of Merrillville Subwatershed

4.5.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. The average summer water temperature, typically the most stressful period for aquatic organisms, was 21°C, (70°F) for all sites.

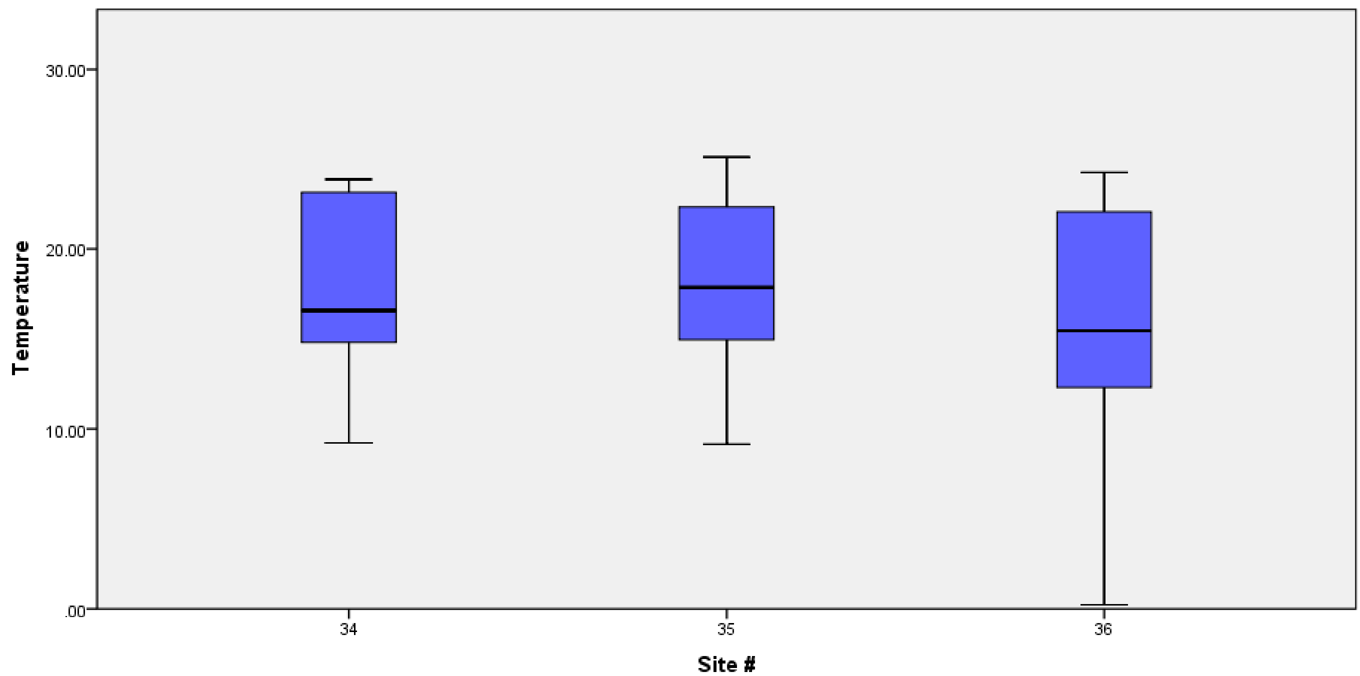


Figure 133 Box plot illustrating site water temparutre within the City of Merrillville Subwatershed

4.5.2.5 *Dissolved Oxygen*

Figure 134 shows severely depleted dissolved oxygen concentrations at Site 34. Over 75% of the observations fell below the 4 mg/L dissolved oxygen water quality standard.

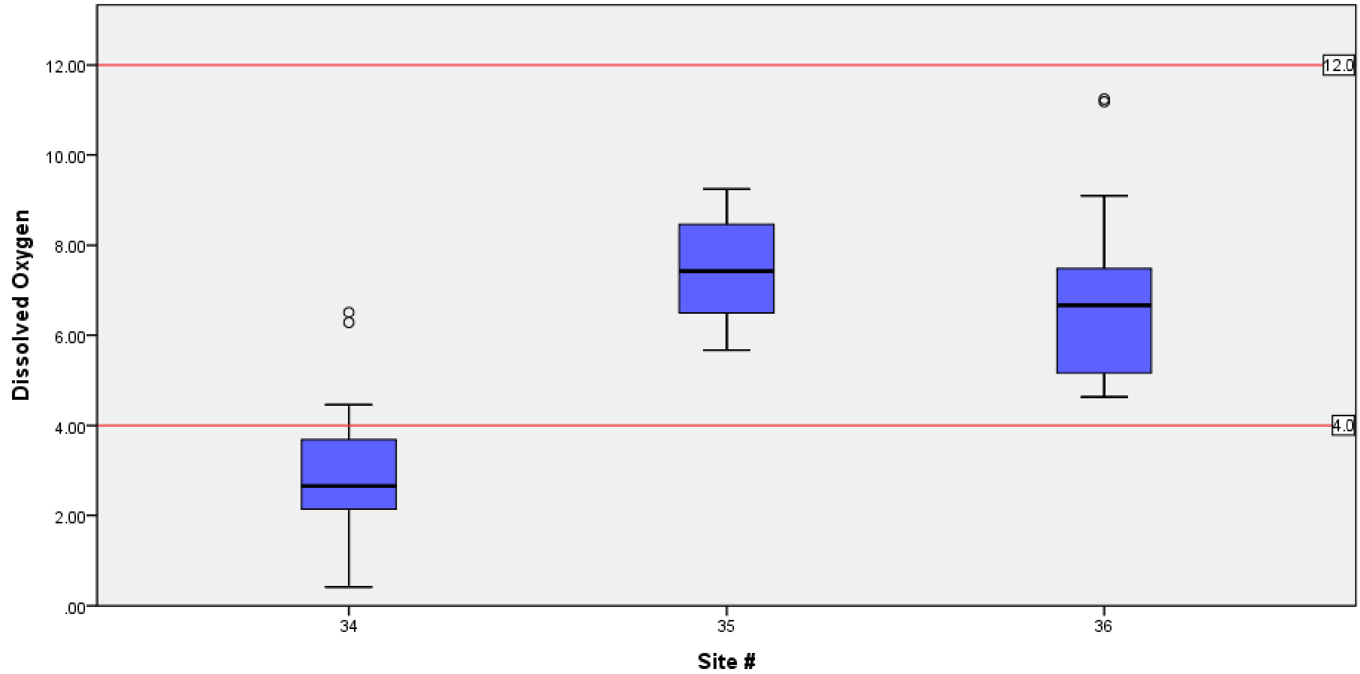


Figure 134 Box plot illustrating site dissolved oxygen concentrations within the City of Merrillville Subwatershed

4.5.2.6 *Total Organic Carbon*

Figure 135 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Site 34.

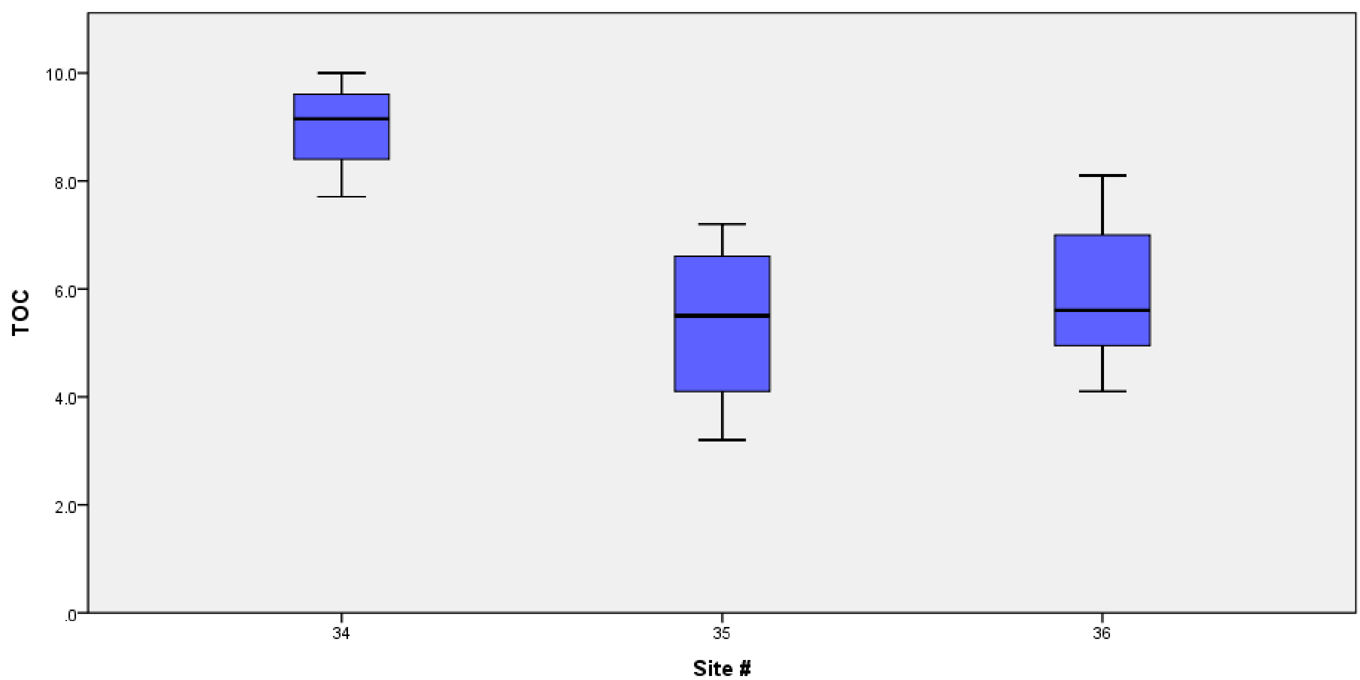


Figure 135 Box plot illustrating site TOC concentrations within the City of Merrillville Subwatershed

4.5.2.7 *Nutrients*

Figure 136 shows the highest total phosphorus levels occur at Site 34 with a median concentration in excess of the 0.07 mg/L threshold. Sites 35 and 36 had similar median concentrations, however nearly 50% of the samples from Site 36 exceeded 0.07 mg/L.

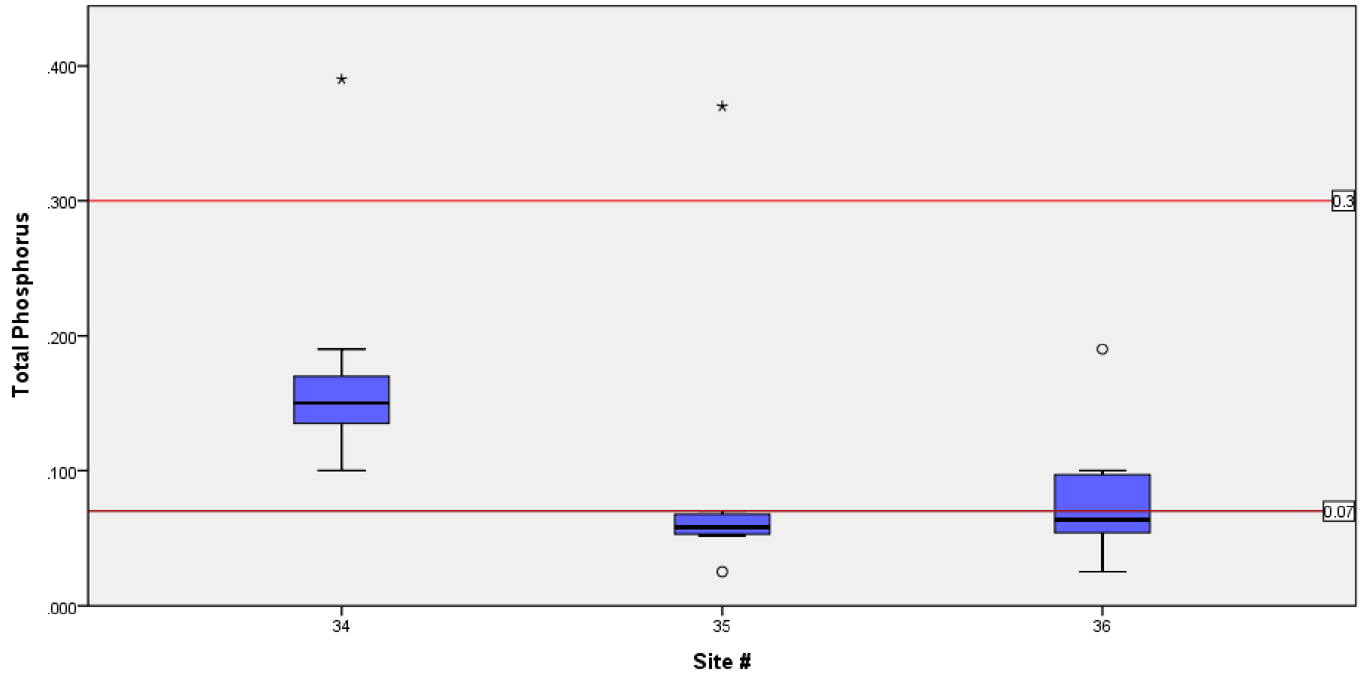


Figure 136 Box plot illustrating site total phosphorus concentrations within the City of Merrillville Subwatershed

Figure 137 shows that none of the sites had nitrate concentrations exceed the 1.09 mg/L threshold.

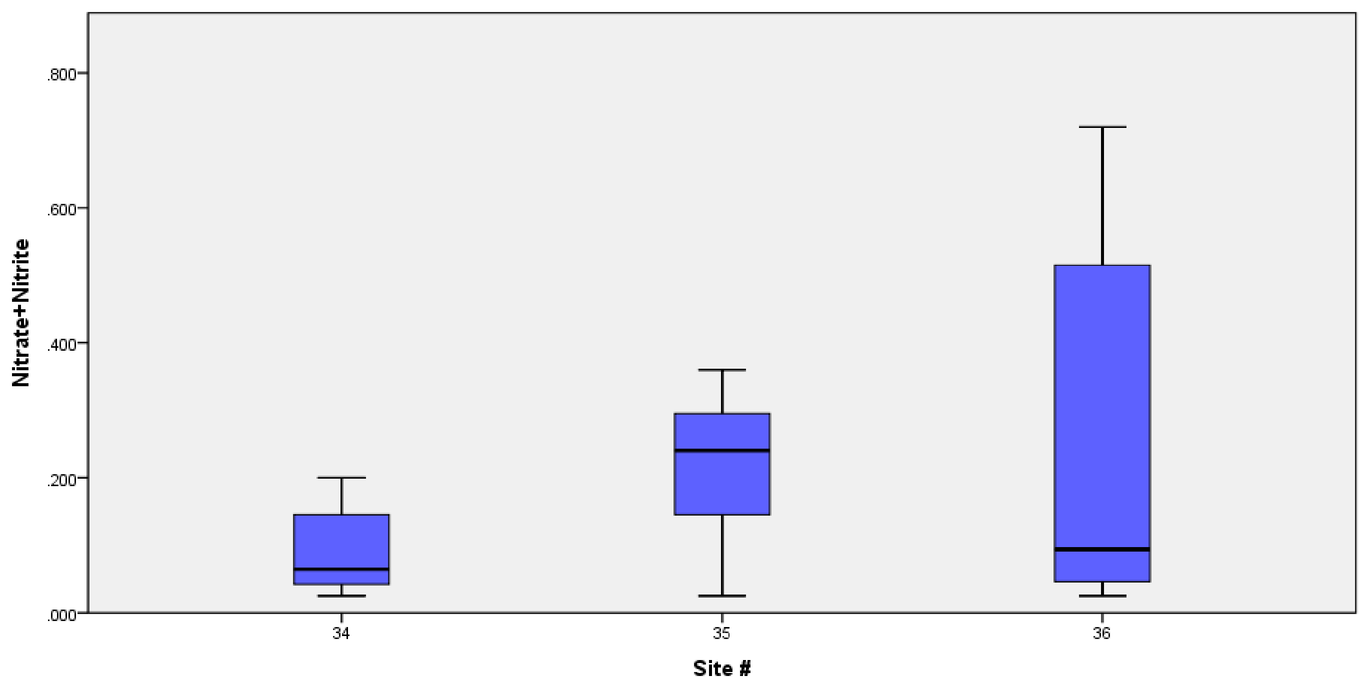


Figure 137 Box plot illustrating site nitrate concentrations within the City of Merrillville Subwatershed

Figure 138 shows that all sites had median total Kjeldahl nitrogen concentrations at or above the 0.68 mg/L threshold. Site 34 had the highest median and maximum concentration observed.

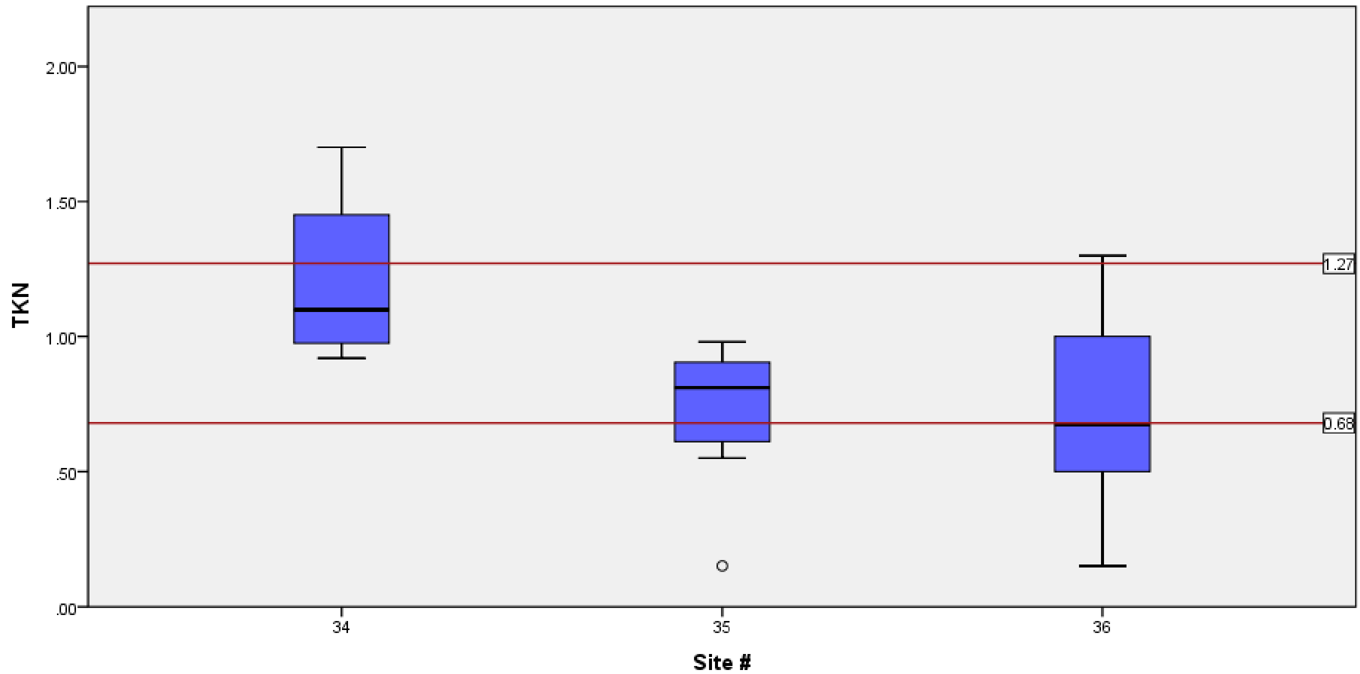


Figure 138 Box plot illustrating site total Kjeldahl nitrogen concentrations within the City of Merrillville Subwatershed

Figure 139 shows high ammonia levels at Site 34 with a median concentration near 0.21 mg/L and a maximum concentration of 0.59 mg/L. Sites 35 and 36 have median ammonia concentrations above 0.03 mg/L with maximum concentrations of 0.15 mg/L and 0.14 mg/L respectively.

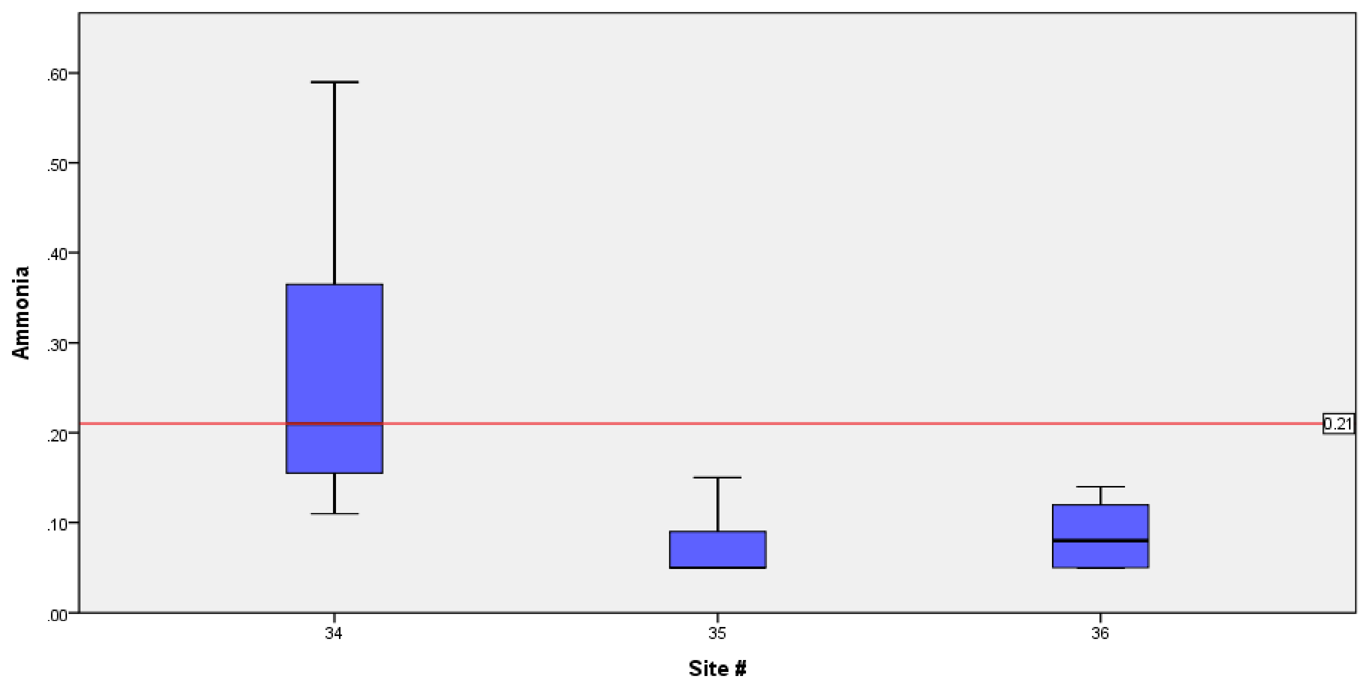


Figure 139 Box plot illustrating site ammonia concentrations within the City of Merrillville Subwatershed

4.5.2.8 *Suspended Solids & Turbidity*

Figure 140 shows that total suspended solid concentrations almost always fell below the 30 mg/L threshold and anything above this value was considered an outlier in the dataset. The exceedances at Sites 34 and 35 occurred during low stream flow conditions indicating a potential point source contribution. Site 36's exceedance occurred during high stream flows and is indicative of runoff and/or streambank erosion.

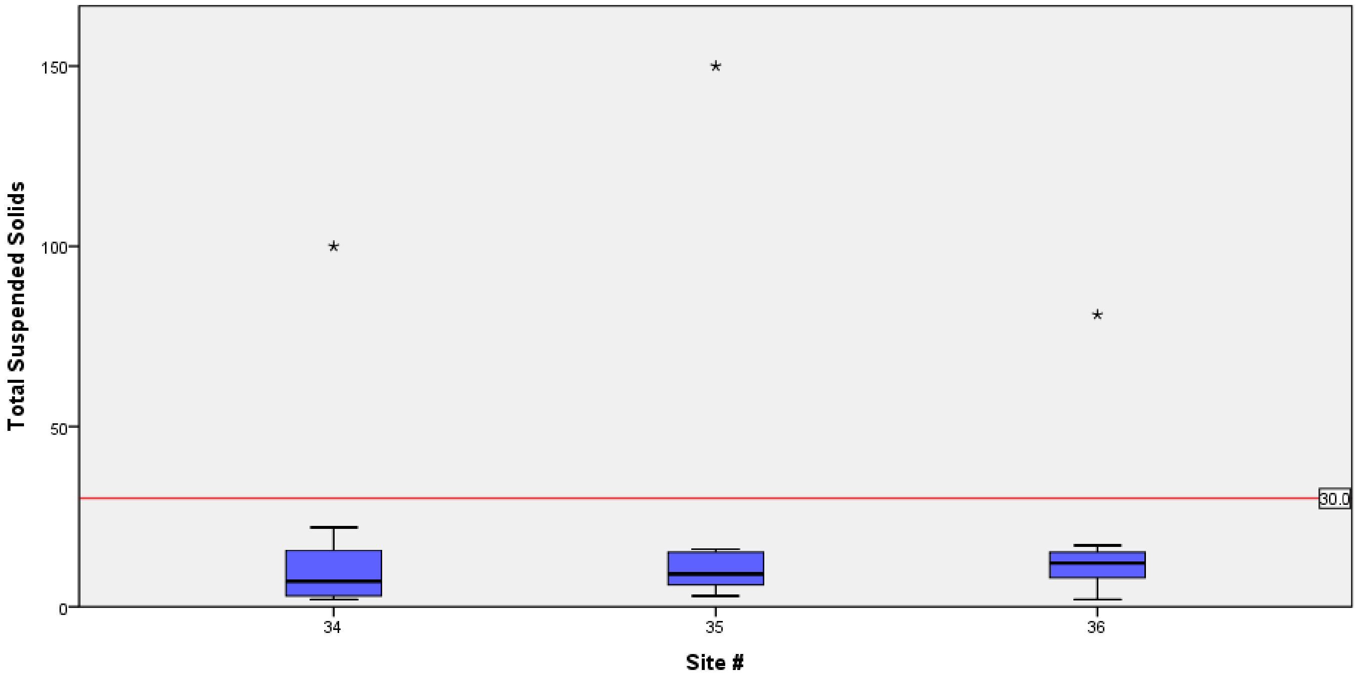


Figure 140 Box plot illustrating site total suspended solids concentrations within the City of Merrillville Subwatershed

While total suspended solid concentrations were relatively similar between sites, Figure 141 shows that Site 34 had much higher turbidity levels with a median level over 25 NTU. The discrepancy may be due to higher colored dissolved organic matter which would not be picked up by total suspended solids testing. Sites 35 and 36 also had median turbidity levels over the 10.4 NTU threshold.

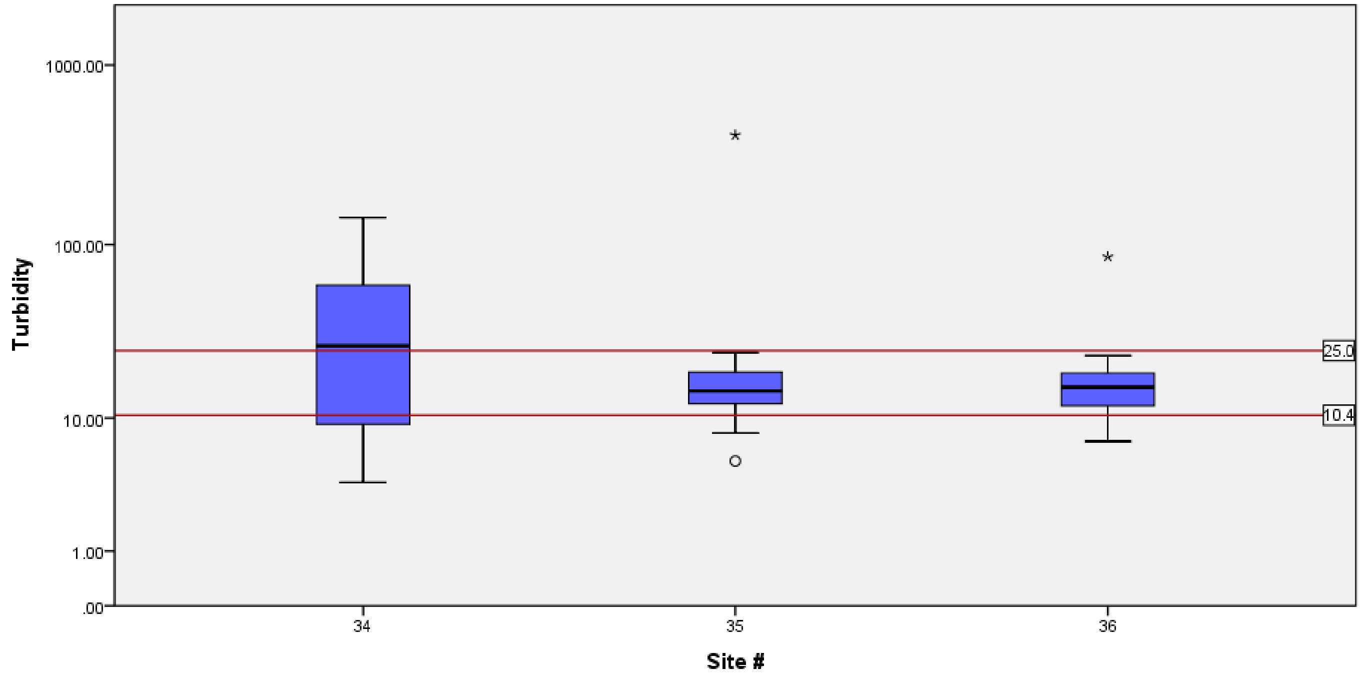


Figure 141 Box plot illustrating site turbidity levels within the City of Merrillville Subwatershed

4.5.2.9 *Habitat*

Figure 142 shows that none of the sites possess the habitat quality conducive to supporting a healthy warm water fishery (QHEI < 51). Poor substrate quality was a limiting factor at all sites. Substrates at Sites 34 and 36 were characterized by muck, heavy siltation and extensive embeddedness. Site 35's substrate was primarily characterized as artificial (riprap and concrete) with normal levels of siltation and embeddedness. Each site had low to no channel sinuosity, poor to fair riffle/pool development, and low to moderate channel stability.

Sites 34 and 35 are located on channels that are in essence urban drains. The channels have relatively trapezoidal cross-sections with minimal or no active floodplain and very narrow to no riparian buffers. In some areas, the stream channel has been piped and buried. Examples include the tributary of Turkey Creek adjacent to Merrillville Intermediate School on 61st Avenue, upstream of Site 34 and the tributary of Turkey Creek adjacent to what used to be Old Mill Pizza on 73rd Avenue and Madison Street at Site 35. Site 36 is located on a low gradient, sluggish flow reach of Turkey Creek surrounded by floodplain wetland.

The poor habitat quality at Sites 34 and 35 is symptomatic of the waterways being excavated into existence or modified to improve drainage. Each of sites in the subwatershed, except Site 35, are located on reaches that are maintained as county legal drains (Figure 144). Aerial imagery however shows that at least portions of this tributary to Turkey Creek were modified at some point to improve drainage.

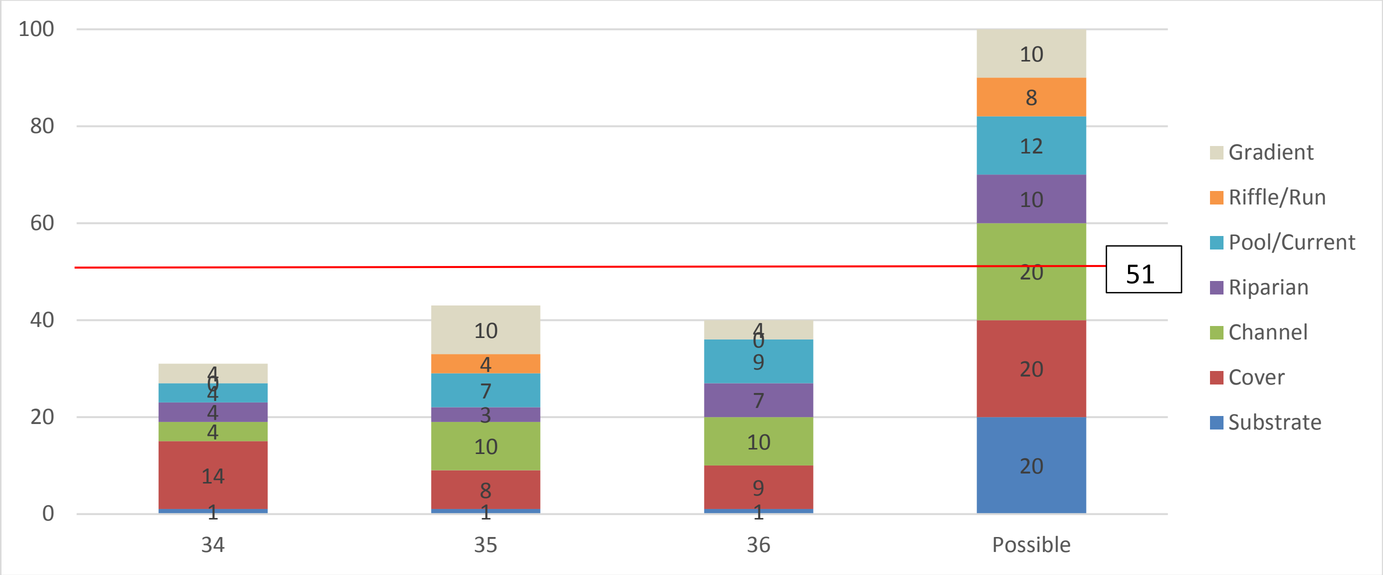


Figure 142 Site Qualitative Habitat Evaluation Index scores within the City of Merrillville Subwatershed

4.5.3 Land Use & Land Cover

Overall, the predominant land cover type within the subwatershed is developed lands (63%) lands (Figure 143). Agriculture is a relatively minor land use within the watershed only accounting for approximately 12% of the land area. Merrillville has the largest municipal footprint within the subwatershed but it also includes portions of Gary and Hobart. These unincorporated areas are mostly unsewered.

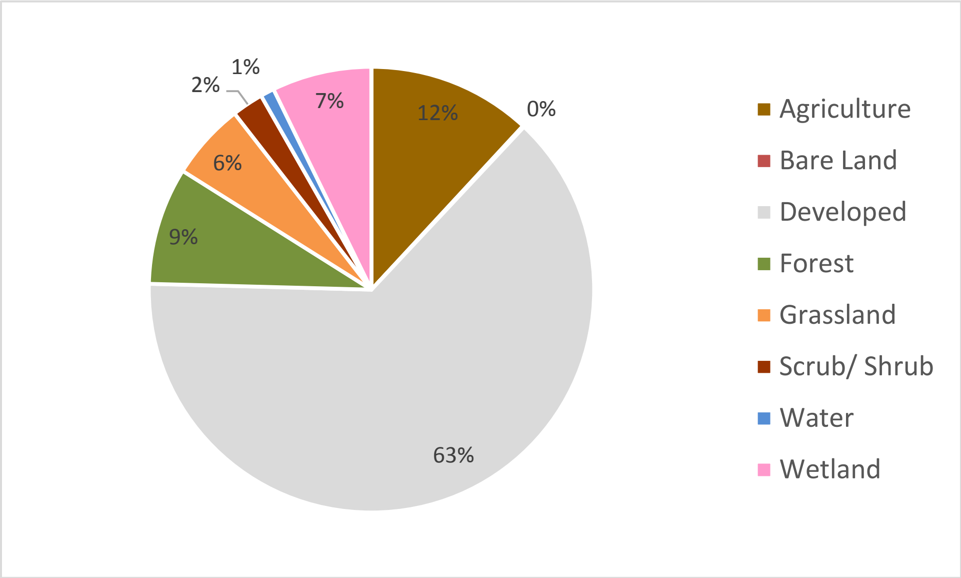


Figure 143 Percent land cover within the City of Merrillville Subwatershed

Table 64 includes land cover information for each site's drainage area. All sites have a high percentage of developed land within their drainage areas (62-73%). A majority of the natural land cover within the subwatershed is located within the city limits of Hobart and Oak Ridge Prairie County Park.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
34	4.2	0.0	72.5	7.3	3.7	2.2	1.0	9.1
35	13.6	0.2	72.6	3.2	6.6	1.9	0.3	1.5
36	12.5	0.1	61.9	9.2	5.0	3.3	0.8	7.1

Table 64 Site percent land cover within the City of Merrillville Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 65. Agricultural and developed land cover makes up the greatest percentage of the riparian zones in the subwatershed.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
34	0.6	0.0	67.6	5.5	3.7	4.0	0.0	18.7
35	11.1	0.0	74.3	5.5	1.0	2.8	0.1	5.1
36	12.3	0.0	55.2	7.6	2.9	4.3	1.7	16.0

Table 65 Site percent riparian land cover within the City of Merrillville Subwatershed

The TMDL reports two NPDES permitted industrial facilities located in subwatershed. (See TMDL for NPDES industrial facility location map.) The TMDL does not reference any permit violations for these facilities over the five year period between 2010 and 2014. There is one sanitary sewer overflow outfall located in the subwatershed upstream of Site 36 on Turkey Creek (Figure 144).

Four potential livestock facilities were identified in the subwatershed. All four are located east of I-65 in the drainage area of an intermittent stream that joins Turkey Creek downstream of Site 36(Figure 144).

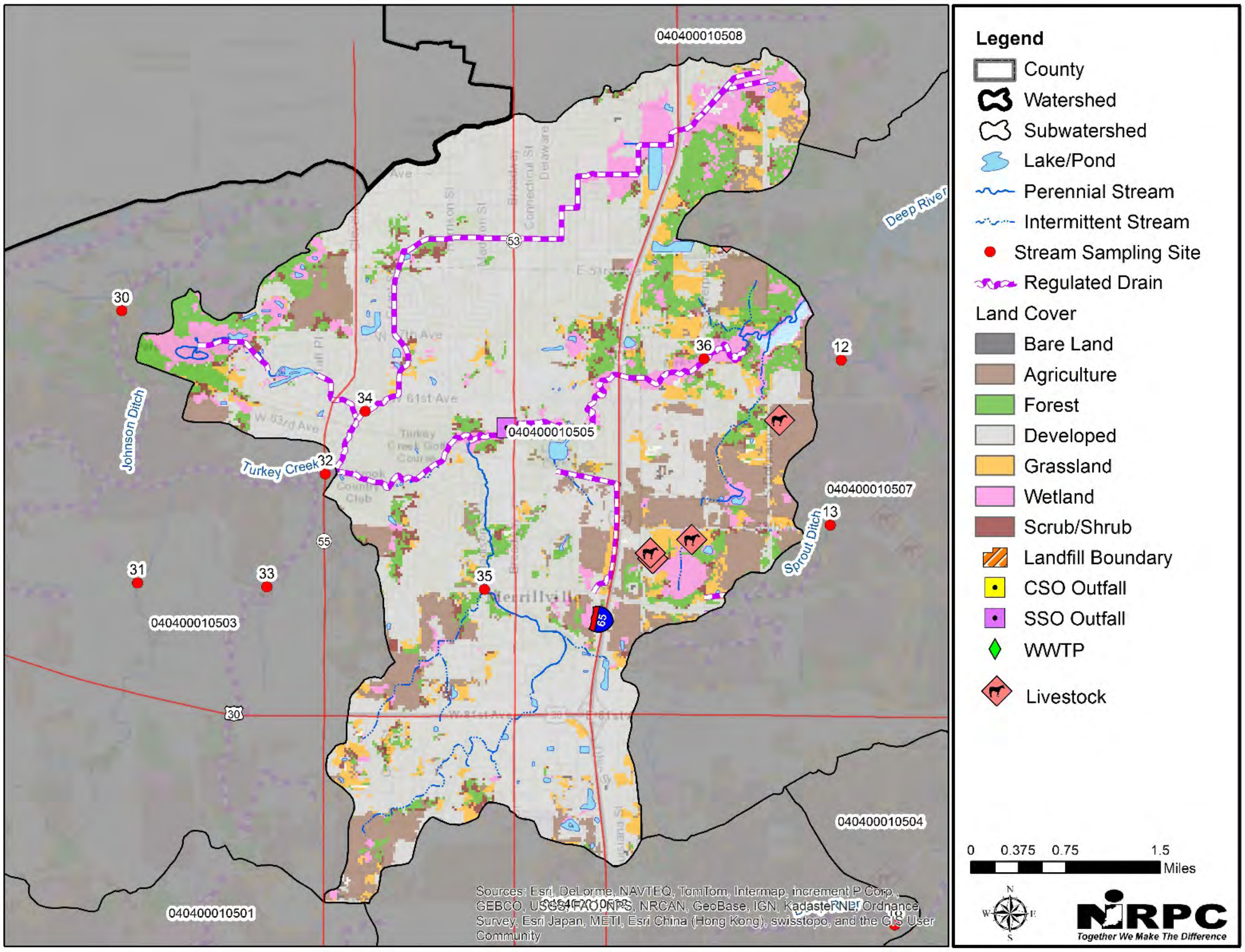


Figure 144 Land cover and land use within the City of Merrillville Subwatershed

4.5.4 Soils

A majority of the soils that border the streams in the subwatershed are classified as hydric. In most cases these areas were drained or filled for agricultural or development purposes. A very high concentration of highly erodible/ potentially highly erodible soils is located in the southern extent of the subwatershed within and surrounding Site 35's drainage area. A number of these areas remain in agricultural production. Soil surface texture in these areas are comprised of silt loam and silty clay loams especially surrounding the tributaries. This in part may help explain the poor substrate quality noted in the stream habitat assessments. There are small inclusions of steeply sloped soils along the unnamed tributary to Turkey Creek west of I-65.

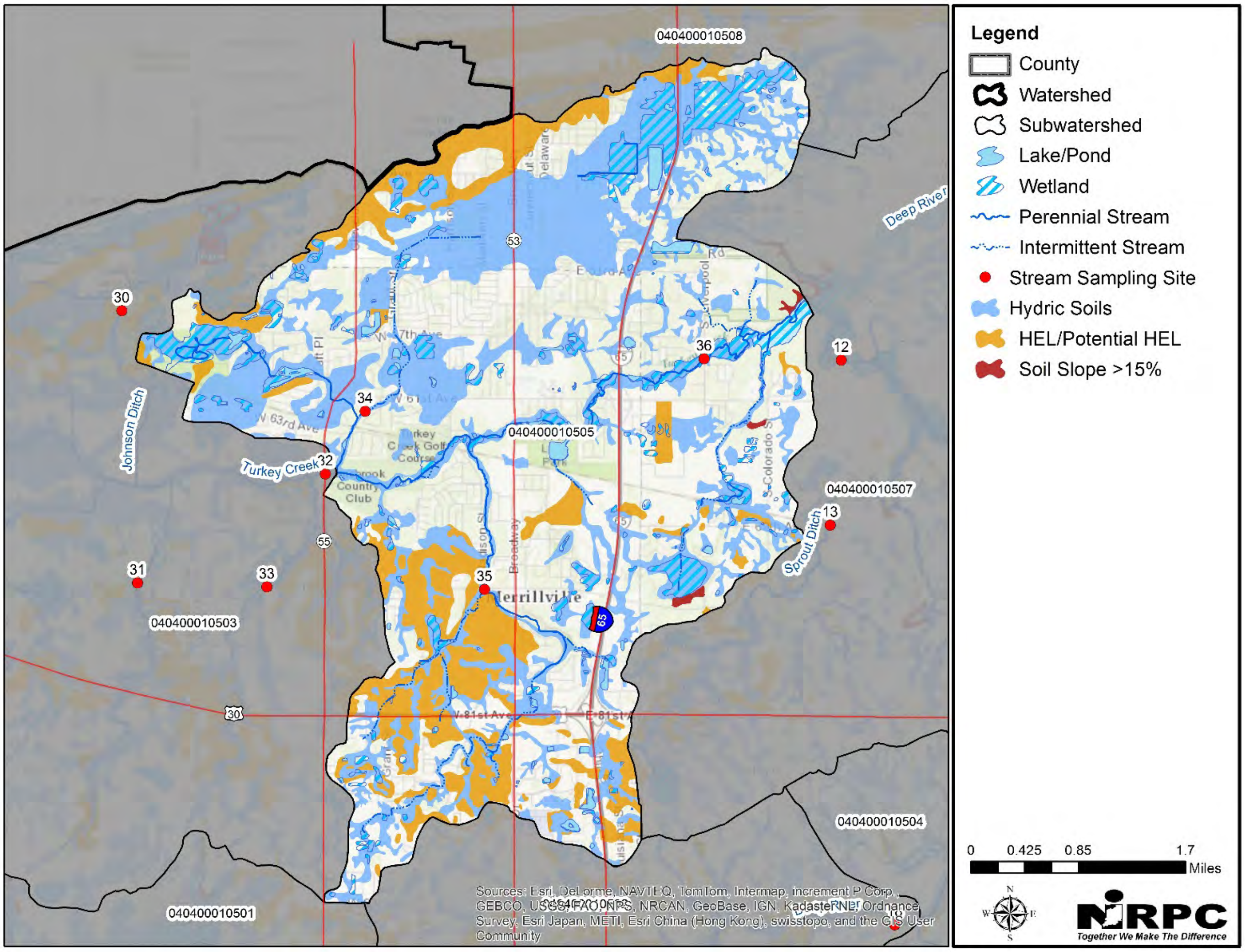


Figure 145 Soils within the City of Merrillville Subwatershed

4.6 Duck Creek Subwatershed (HUC 0404000106)

4.6.1 Overview

The Duck subwatershed is located in the east central portion of the watershed. It drains approximately 15.8 mi² of primarily agricultural (51%) and developed (23%) land. Based on the monitoring completed by IDEM, two stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities and high *E. coli* and nutrient levels.

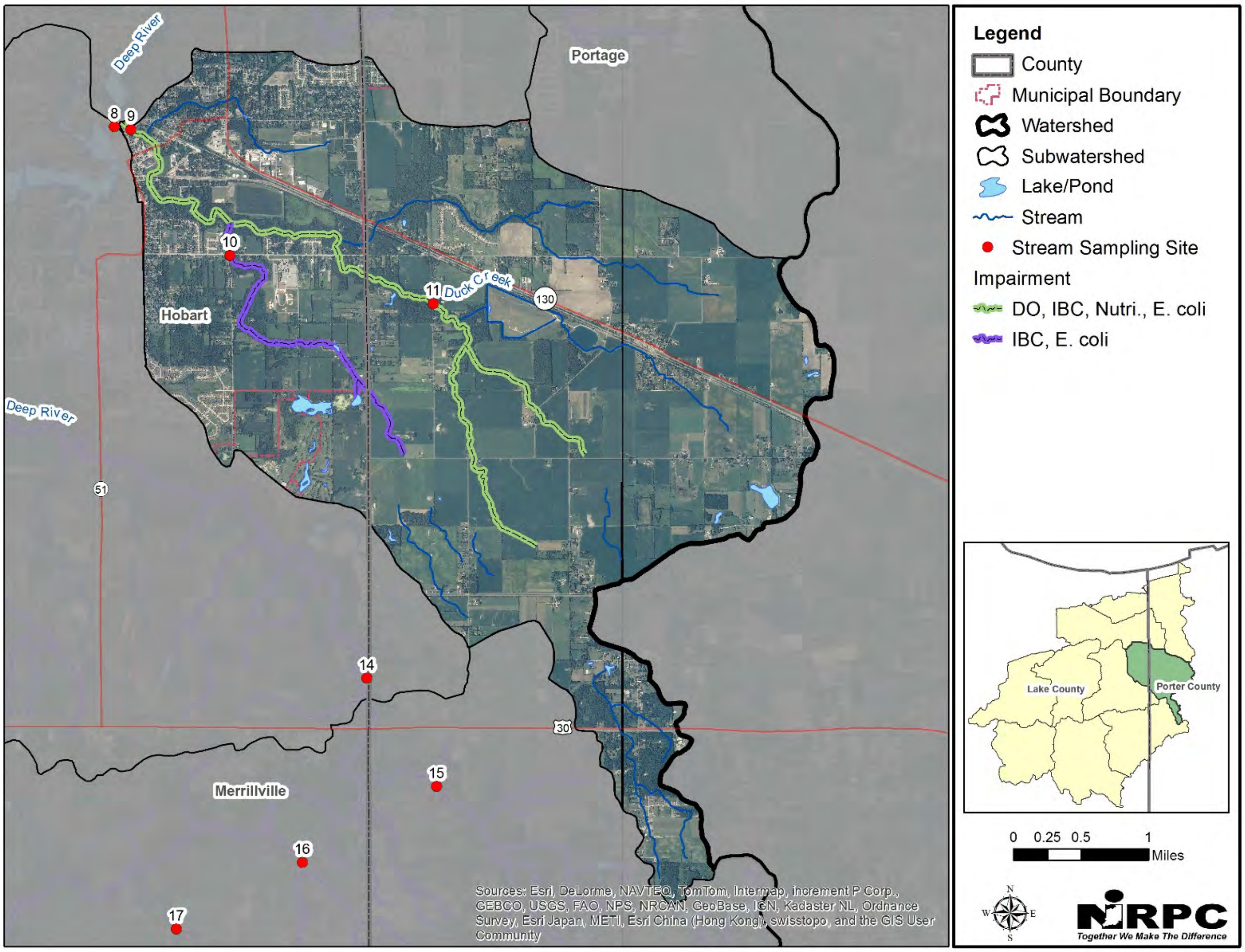


Figure 146 Impaired streams within the Duck Creek Subwatershed

4.6.2 Water Quality

IDEM collected water quality data at three monitoring stations (Sites 9-11) within the subwatershed (Figure 146). Site 9 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.6.2.1 *Pathogens*

Figure 147 shows that any full body contact recreational use would be threatened by elevated pathogen levels. Sites 11 and 10 consistently exceed the single sample *E. coli* water quality standard with median concentrations above 235 CFU/100 mL. Exceedances for Sites 10 and 11 occurred across dry to higher stream flow conditions indicating input from point and nonpoint sources. Site 9's exceedance were mostly limited to higher stream flows indicating a majority of the exceedances were attributed to nonpoint source inputs.

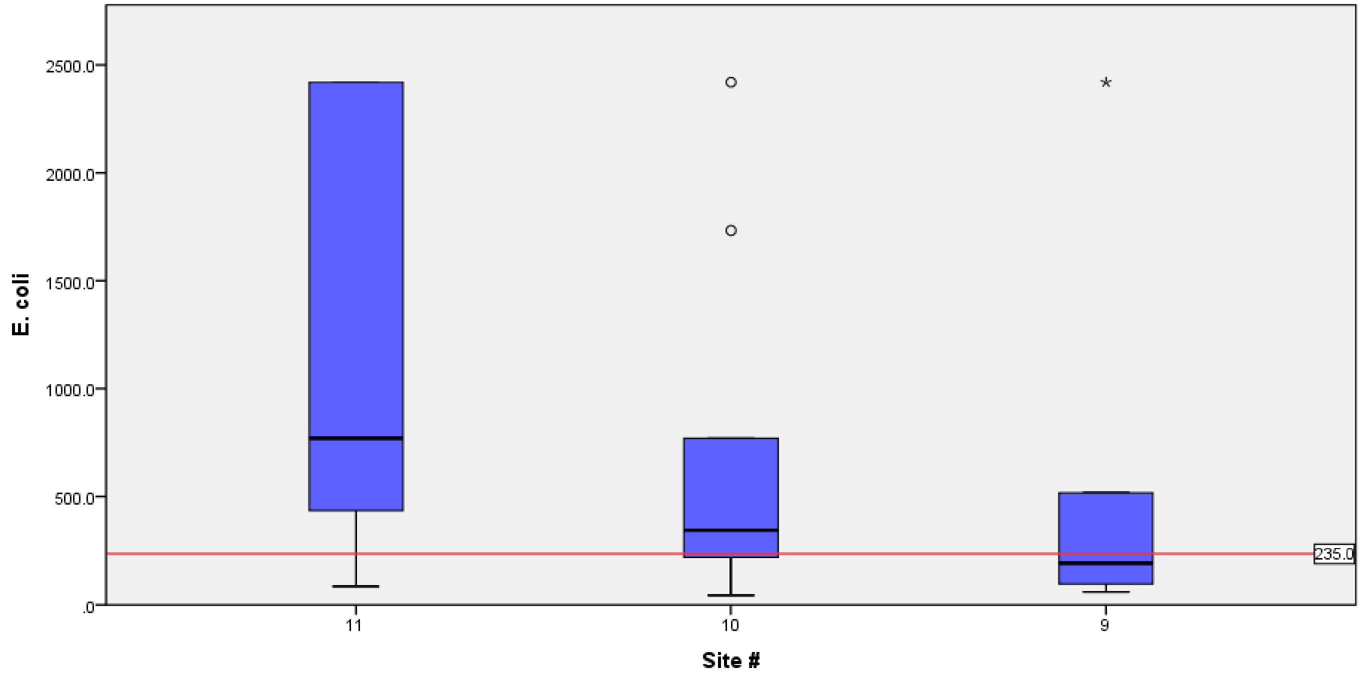


Figure 147 Box plot illustrating site E. coli concentrations within the Duck Creek Subwatershed

4.6.2.2 *Fish*

An evaluation of each site's fish community structure revealed that none of the sites are supporting of their Aquatic Life Use designation, either receiving a "very poor" or "poor" integrity class rating. Only one fish was collected from Site 10. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
11	24	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
10	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
9	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 66 Site fish index of biotic integrity scores within the Duck Creek Subwatershed

4.6.2.3 *Macroinvertebrates*

An evaluation of each site's macroinvertebrate community structure revealed that none of the sites are supporting of their Aquatic Life Use designation, each receiving a "poor" integrity class rating. Intolerant and sensitive macroinvertebrate species were generally absent and the species that were present are considered tolerant of disturbance.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes

11	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
10	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
9	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 67 Site macroinvertebrate index of biotic integrity scores within the Duck Creek Subwatershed

4.6.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. The average summer water temperature, typically the most stressful period for aquatic organisms, ranged from 18-21°C, (64-70°F) with Site 11 being the coolest.

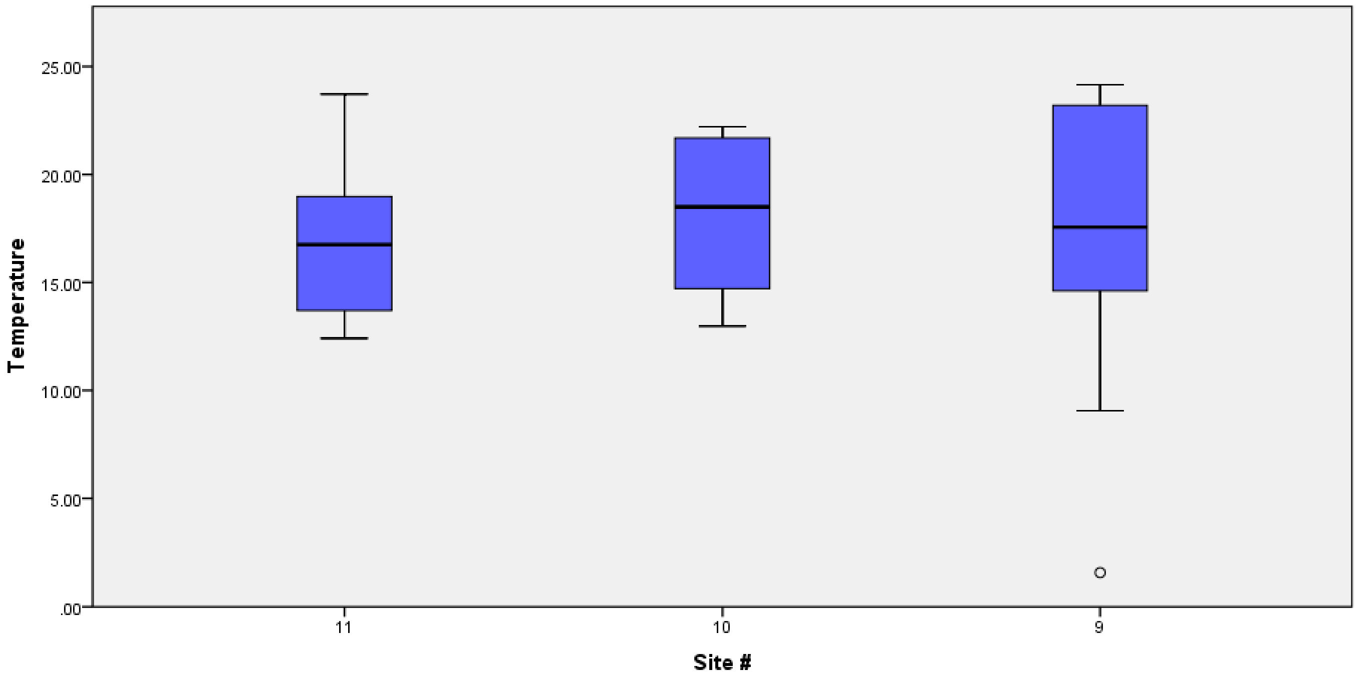


Figure 148 Box plot illustrating site water temperatures within the Duck Creek Subwatershed

4.6.2.5 *Dissolved Oxygen*

Figure 149 shows that all sites have median dissolved oxygen concentrations between 4-12 mg/L, however Site 11 frequently had dissolved oxygen concentrations that fell below the 4 mg/L water quality standard. The lowest concentration observed was less than 1 mg/L. These observations typically occurred during the summer when water temperatures were at their warmest. Dissolved oxygen concentrations higher than the 12 mg/L threshold all occurred in spring when water temperatures were still relatively cool.

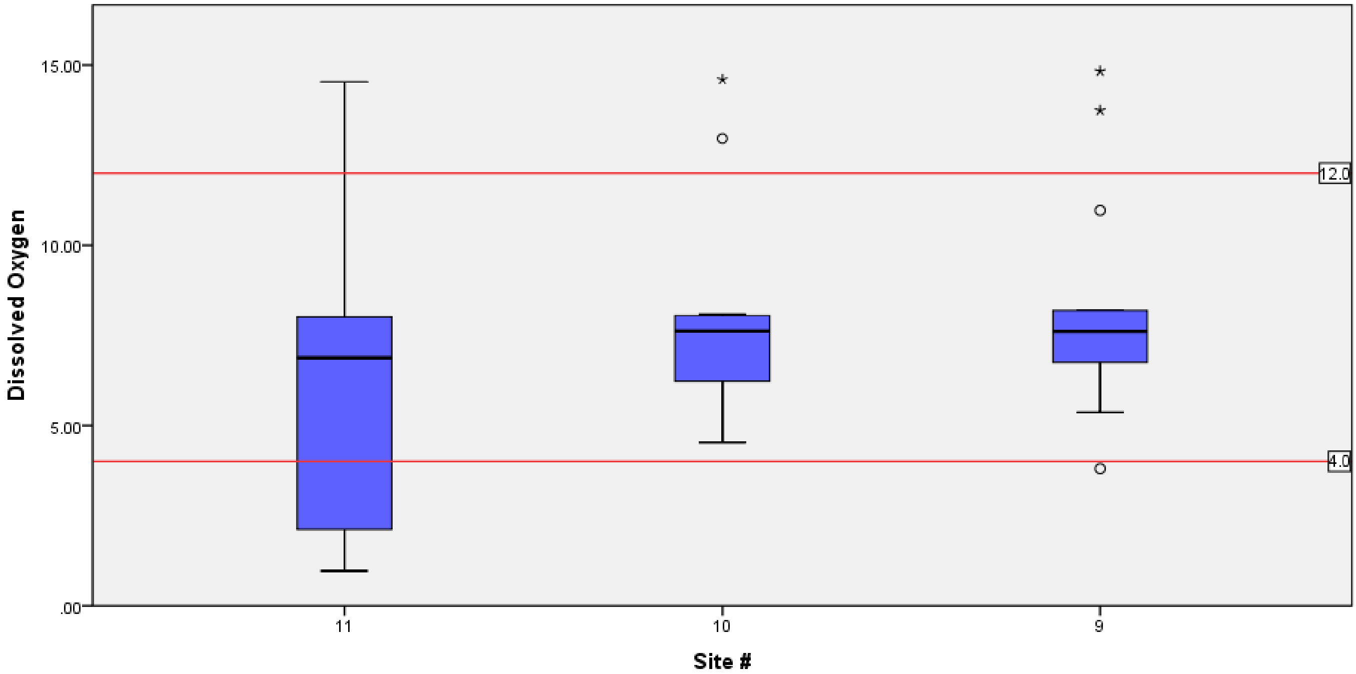


Figure 149 Box plot illustrating site dissolved oxygen concentrations within the Duck Creek Subwatershed

4.6.2.6 *Total Organic Carbon*

Figure 150 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Site 11.

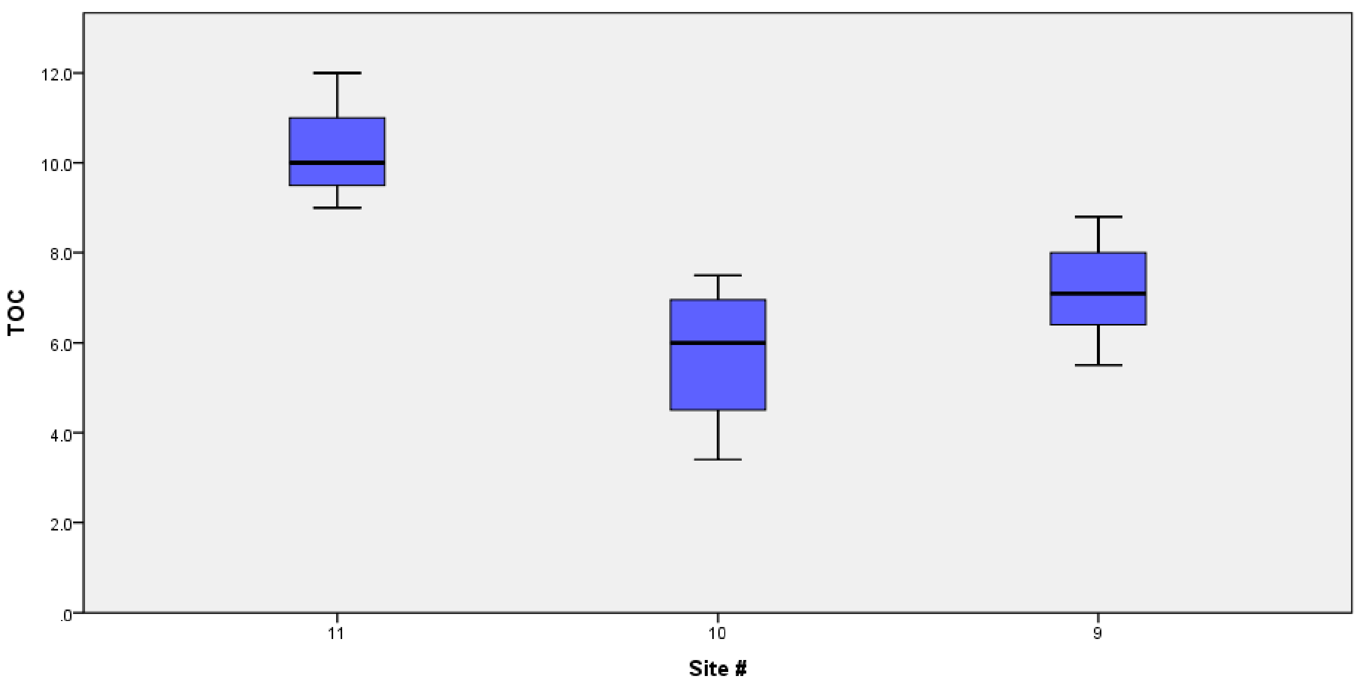


Figure 150 Box plot illustrating site TOC concentrations within the Duck Creek Subwatershed

4.6.2.7 *Nutrients*

Figure 151 shows that median total phosphorus concentrations fell between the 0.3 mg/L and 0.07 mg/L thresholds. Site 11 had the highest median and maximum total phosphorus concentration.

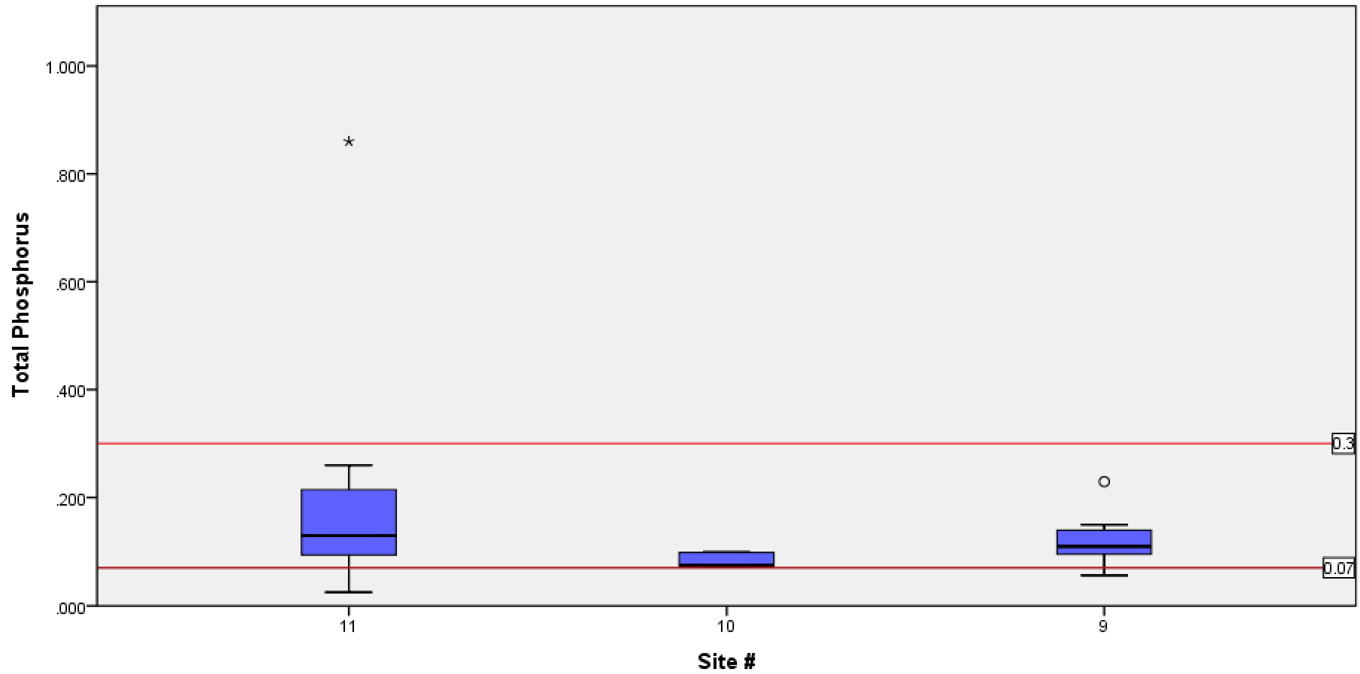


Figure 151 Box plot illustrating site total phosphorus concentrations within the Duck Creek Subwatershed

Figure 152 shows that none of the sites exceeded the 10 mg/L threshold. Site 11 was the only site to have a median nitrate concentration above the 1.09 mg/L threshold.

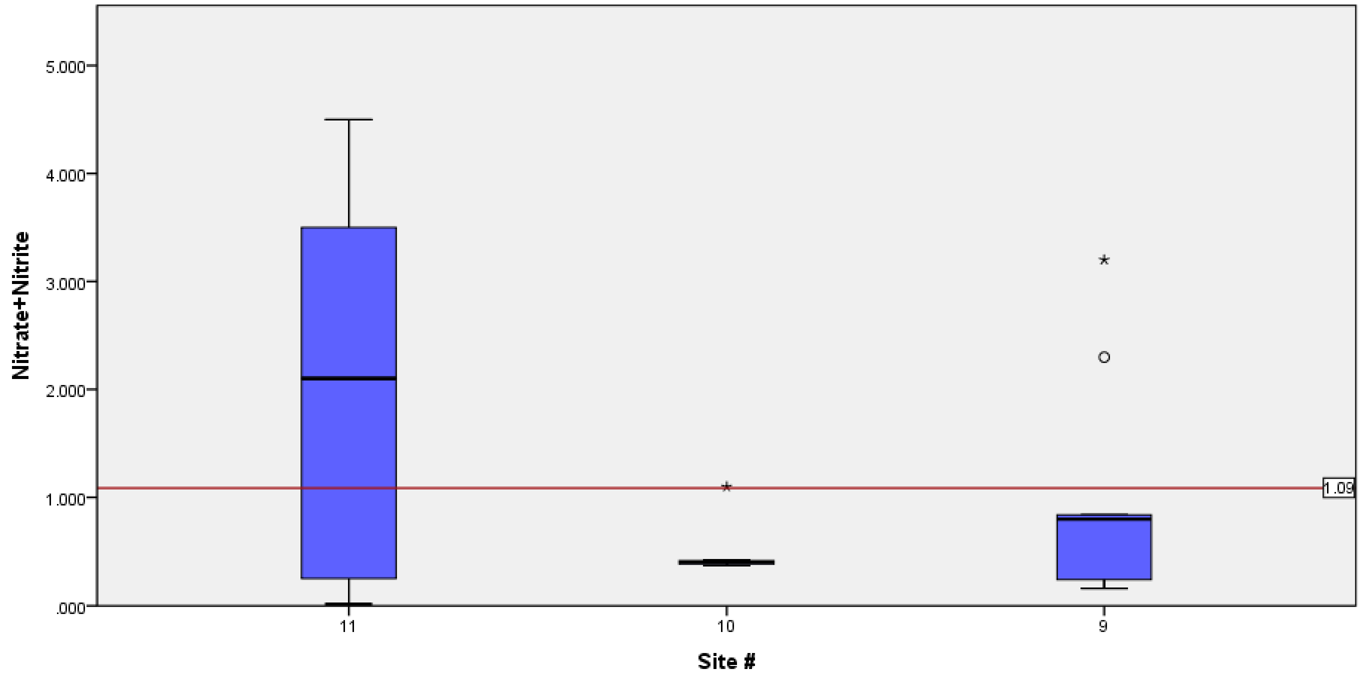


Figure 152 Box plot illustrating site nitrate concentrations within the Duck Creek Subwatershed

Figure 153 shows that Sites 9 and 11 have median total Kjeldahl nitrogen concentrations that fall between the 0.68 mg/L and 1.27 mg/L thresholds. The outlier at Site 11 occurred during the summer and coincides with other peaks.

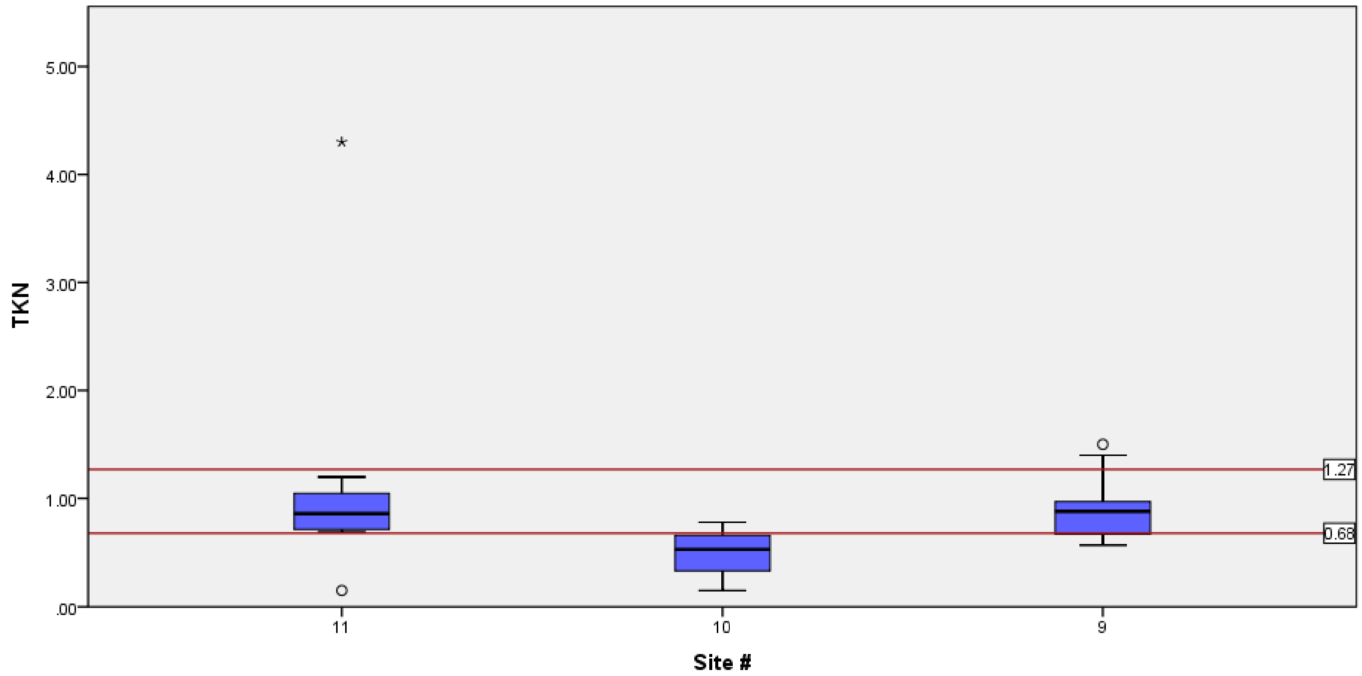


Figure 153 Box plot illustrating site total Kjeldahl nitrogen concentrations within the Duck Creek Subwatershed

Figure 154 shows that ammonia concentrations most typically fell below the lab detection limit except for a few outlier events observed at Sites 9 and 11. The maximum concentration observed at Site 9 was 0.21 mg/L during the spring and 2.6 mg/L at Site 11 during the summer.

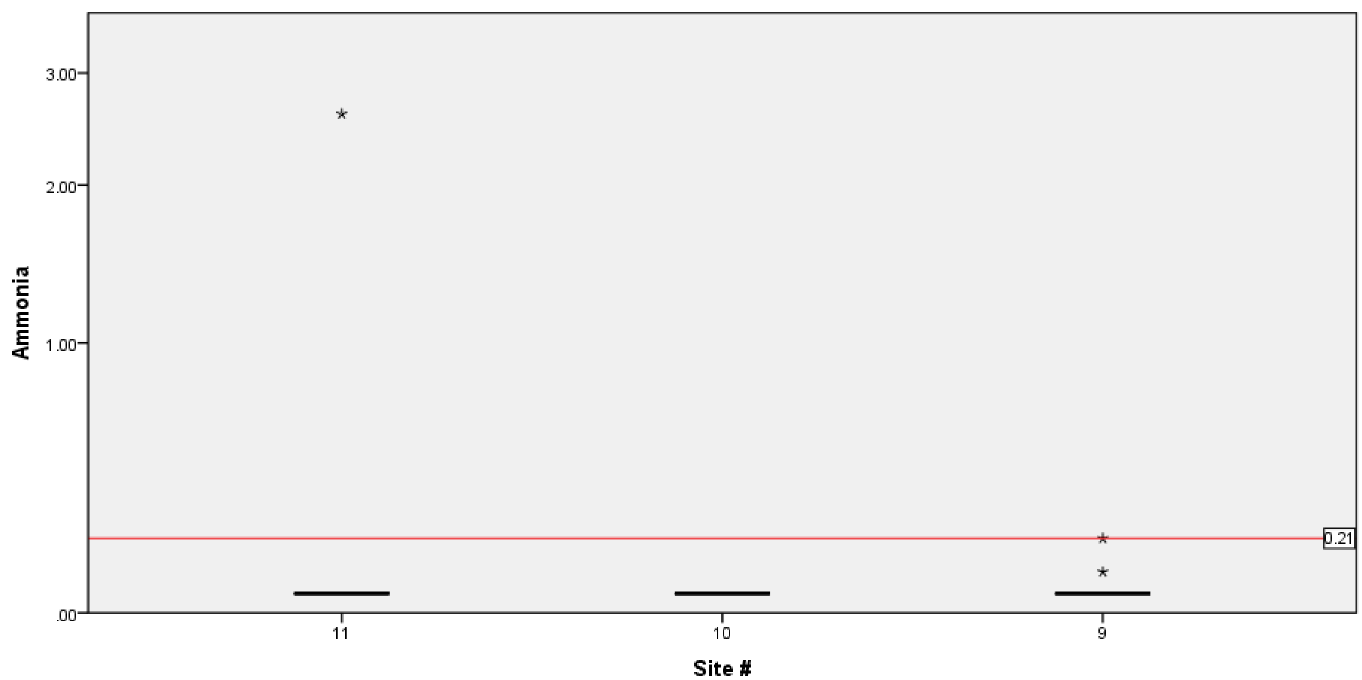


Figure 154 Box plot illustrating site ammonia concentrations within the Duck Creek Subwatershed

4.6.2.8 *Suspended Solids & Turbidity*

Figure 155 shows that all sites typically had maximum total suspended solids concentrations below the 30 mg/L threshold except for on occasion at Site 11. The exceedance at occurred during mid-range stream flow conditions indicating a likely nonpoint source contribution.

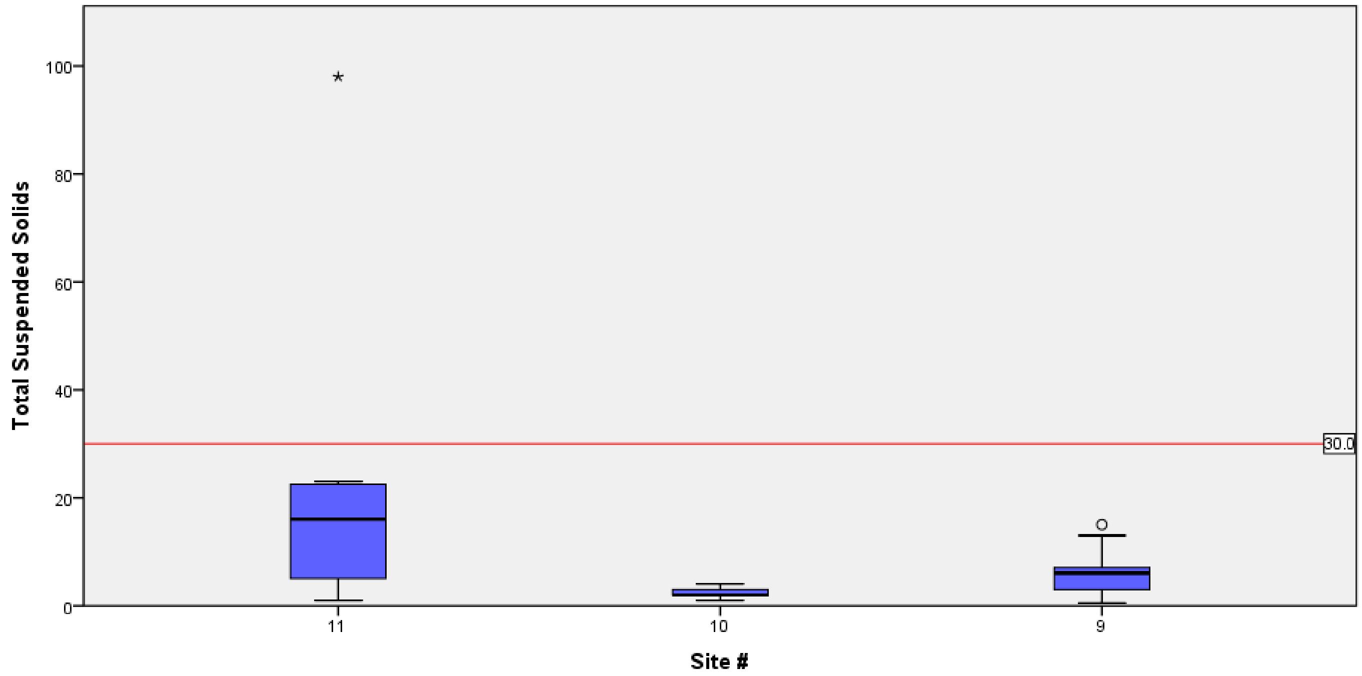


Figure 155 Box plot illustrating site total suspended solids concentrations within the Duck Creek Subwatershed

Figure 156 shows that Site 11 had a median turbidity level greater than 10.4 NTU. Turbidity levels at Sites 9 and 10 typically fell below 10.4 NTU.

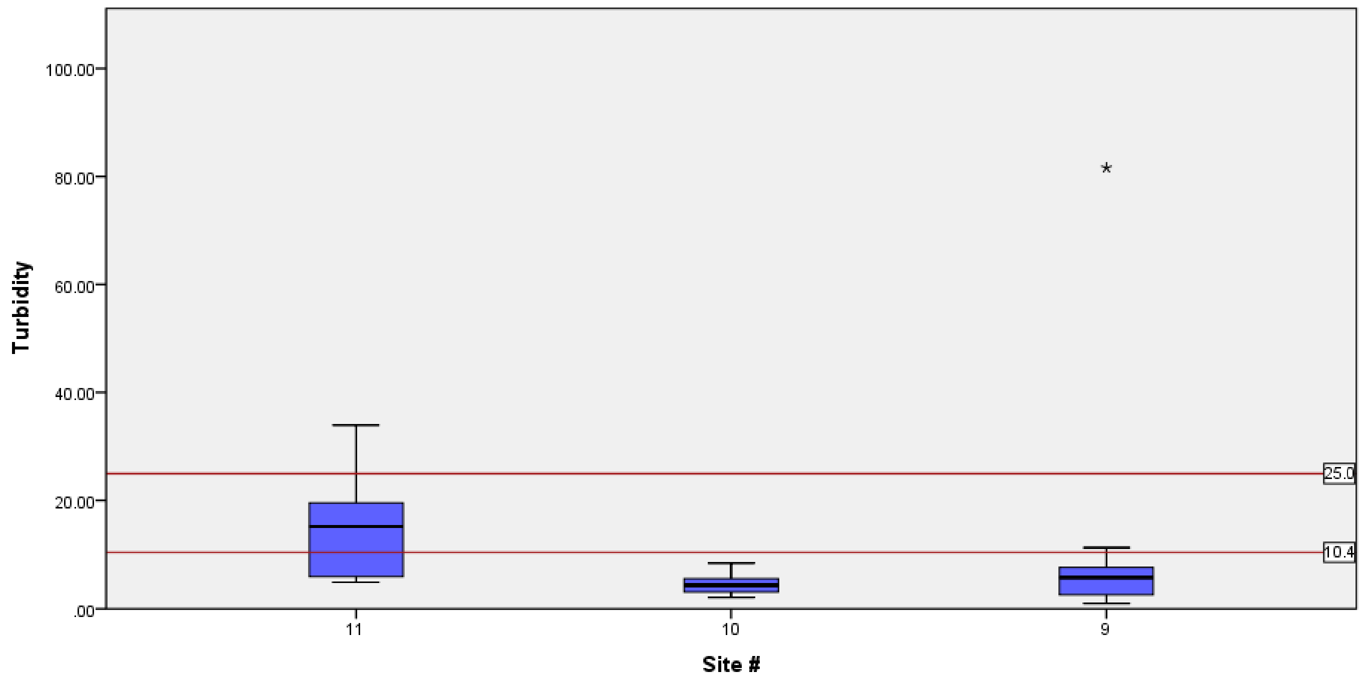


Figure 156 Box plot illustrating site turbidity levels within the Duck Creek Subwatershed

4.6.2.9 *Habitat*

Figure 157 shows that Sites 10 and 11 generally do not possess the habitat quality conducive to supporting a healthy warm water fishery (QHEI < 51). The QHEI for Site 9, just met this threshold with a score of 52.

The major habitat limitations for Site 10 are poor substrate quality and channel morphology. Substrates at Site 10 were characterized as predominately muck with moderate silt cover and embeddedness. The channel reach had low sinuosity, poor riffle/pool development, showed recent or no recovery from stream channelization and had low channel stability. Aerial imagery shows this small stream meandering within its floodplain upstream and downstream of the site on East 10th Street. Land cover data shows much of the streams length to be bordered by wetland, forest and grassland. The poor channel morphology at the site appears to be attributed to placement of fill in the floodplain to construct the roadway and clearing to maintain flow through the two large culverts that the stream passes through under the road.

The major habitat limitation at Site 11 is substrate quality and instream cover. Substrates at Site 11 were characterized as predominately muck with moderate silt cover and embeddedness. The channel reach had moderate sinuosity, good riffle/pool development, but showed signs of having recovered from past channelization. Instream habitat cover was documented as being sparse.

The primary habitat limitations at Site 9 include substrate quality, channel morphology and instream cover. Substrates were characterized as predominately sand with inclusions of gravel and muck. Silt cover was categorized as moderate and embeddedness was extensive. This stretch of Duck Creek has a low channel gradient and it meanders through a forested floodplain wetland which could explain the substrate quality. The stream channel sinuosity was categorized as low however there was no indication of past channelization. Channel stability was categorized as low. Once again this might be because of the fine substrates in addition to a moving bedload.

None of the sites in the subwatershed are located on reaches that are maintained as county regulated drains. However there are segments located upstream of Site 11 (Figure 159).

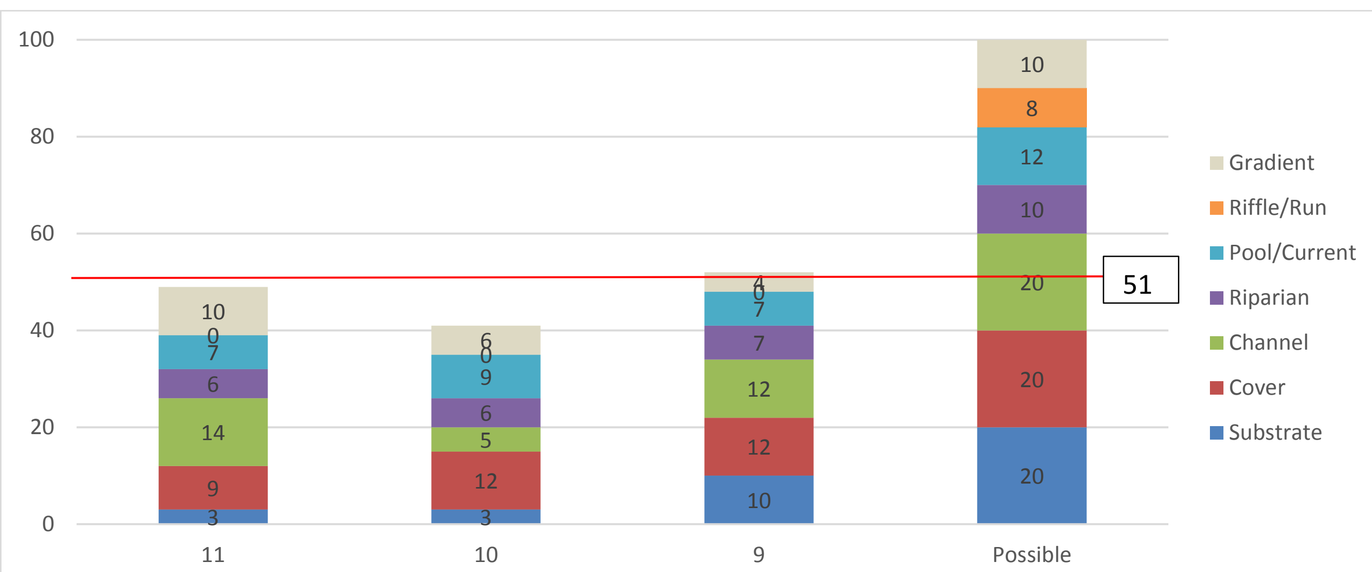


Figure 157 Site qualitative habitat evaluation index scores within the Duck Creek Subwatershed

4.6.3 Land Use & Land Cover

Overall, the predominant land cover type within the subwatershed is agricultural lands (51%) Figure 158). Most of the development occurring within the subwatershed is located within the boundaries of Hobart in Lake County. The Porter County portion of the subwatershed is almost entirely unincorporated except for a very small area to the north that fall within Portage. A majority of the subwatershed is unsewered except for some areas within Hobart (Figure 61).

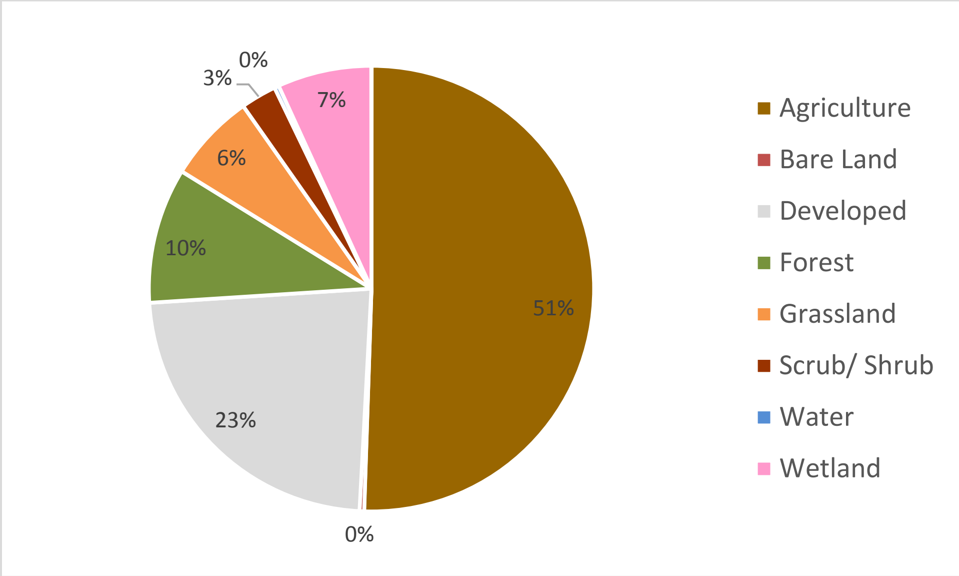


Figure 158 Percent land cover within the Duck Creek Subwatershed

Table 68 includes land cover information for each site's drainage area. Each sites drainage area is dominated by agricultural land uses. Sites 9 and 10 have the highest percentage of developed land, with portions of their drainage area falling near downtown Hobart. Long reaches of Duck Creek and its tributaries are buffered by floodplain wetlands and upland forest except within the headwater areas.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
11	69.0	0.3	9.5	7.5	6.2	2.2	0.5	4.8
10	56.4	0.1	19.3	8.1	5.5	1.8	0.5	8.2
9	50.4	0.3	23.2	9.8	6.4	2.6	0.3	6.8

Table 68 Site percent land cover within the Duck Creek Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 69. Overall, natural land cover makes up the largest percentage of cover in the riparian zone. However, human uses are still a significant component of the subwatershed's riparian zone. Agriculture is the most prevalent human land cover type especially within Site 10's drainage area.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
11	36.6	0.0	6.9	13.6	14.8	5.5	1.1	21.5
10	54.1	0.0	3.8	4.0	1.7	0.6	1.0	34.7
9	33.2	0.0	10.4	10.0	7.8	3.3	0.7	34.6

Table 69 Site percent riparian land cover within the Duck Creek Subwatershed

No NPDES permitted facilities were identified by the TMDL in the subwatershed. However, there is one landfill (Wheeler Landfill) located along State Highway 130. A tributary of Duck Creek runs adjacent to the landfill (Figure 159). This reach was recently cleaned to improve drainage and reduce flooding impacts observed upstream. This maintenance activity resulted in a deep channel profile with steep slopes. Erosion is already evident.

Ten potential livestock facilities were identified in the subwatershed. Three facilities are located in the drainage area of the unnamed tributary to Duck Creek that Site 10 is located on. The other facilities are located upstream of Site 11 on the Porter County portion of the subwatershed (Figure 159).

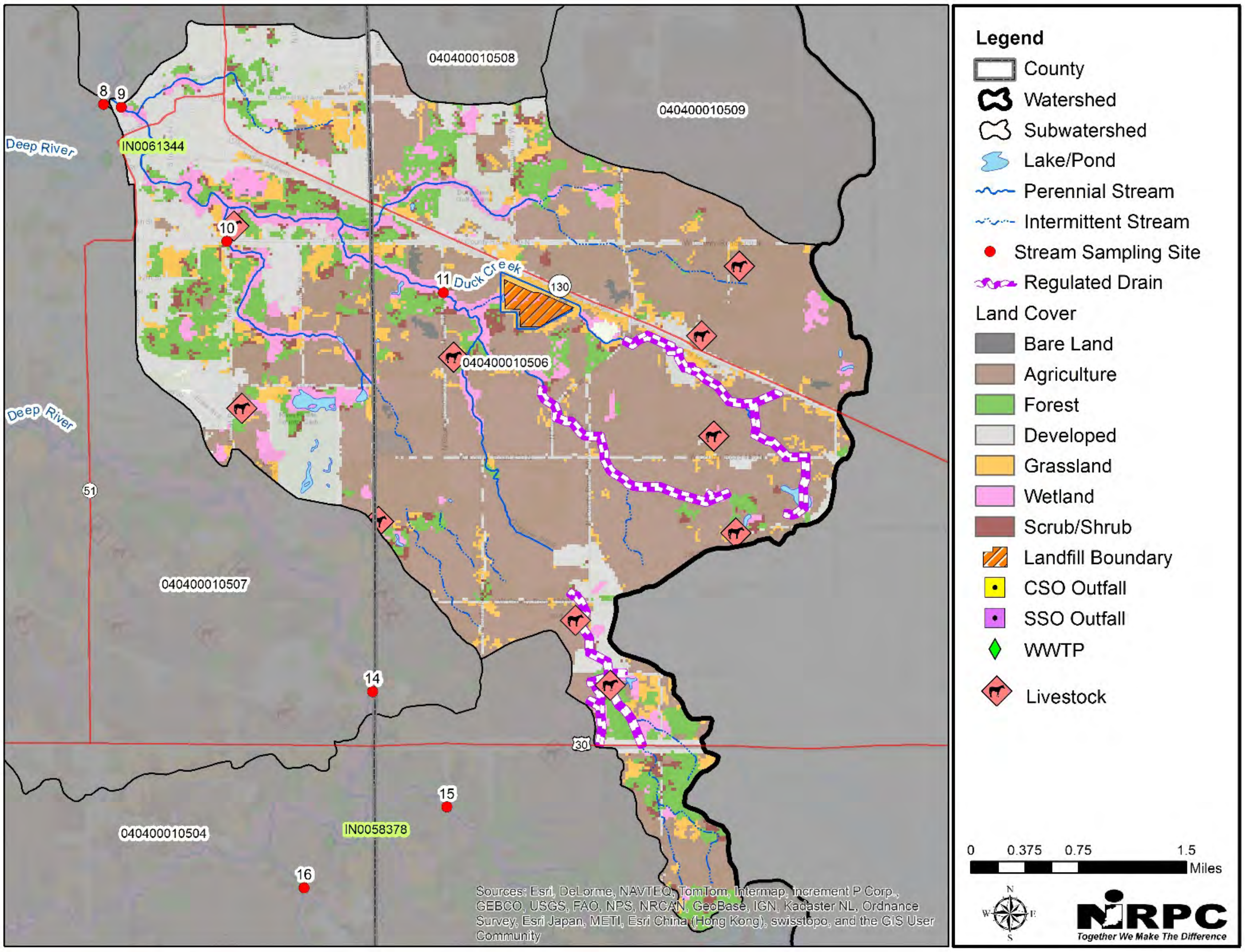


Figure 159 Land use and land cover within the Duck Creek Subwatershed

4.6.4 Soils

A majority of the soils that border the streams in the subwatershed are classified as hydric. The subwatershed is somewhat unique in that relatively long reaches of Duck Creek and its tributaries retain portions of their riparian wetlands (Figure 159). Despite this, the subwatershed has the second highest loss of wetland habitat (Table 35). Many areas of highly or potentially highly erodible soils are located adjacent or in proximity to Duck Creek and its tributaries, especially in the agricultural areas within Porter County. A high percentage of the soils in the subwatershed have moderate to high runoff potential. Soil surface texture in these areas are largely comprised of silt loam and silty clay loams. This in part may help explain the poor substrate quality noted in the stream habitat assessments. There is one small area around the landfill in which soil slope exceeds 15%.

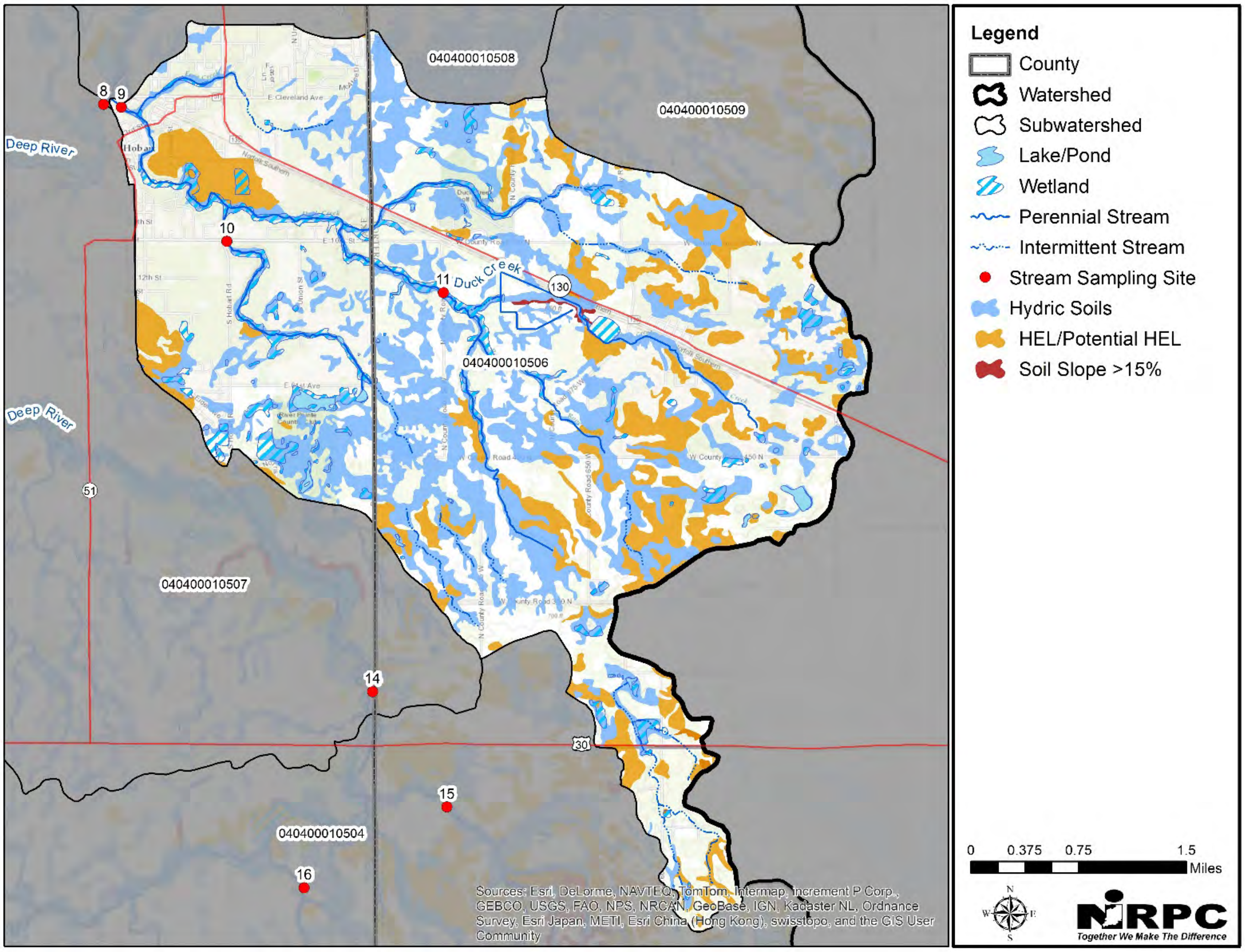


Figure 160 Soils within the Duck Creek Subwatershed

4.7 Lake George Subwatershed (HUC 0404000107)

4.7.1 Overview

The Lake George subwatershed is located in the central portion of the watershed. It drains approximately 17.3 mi² of primarily developed (35%) and agricultural (29%) land. Based on the monitoring completed by IDEM, two stream segments have been identified as impaired. Known water quality problems include impaired biotic communities and high *E. coli* levels.

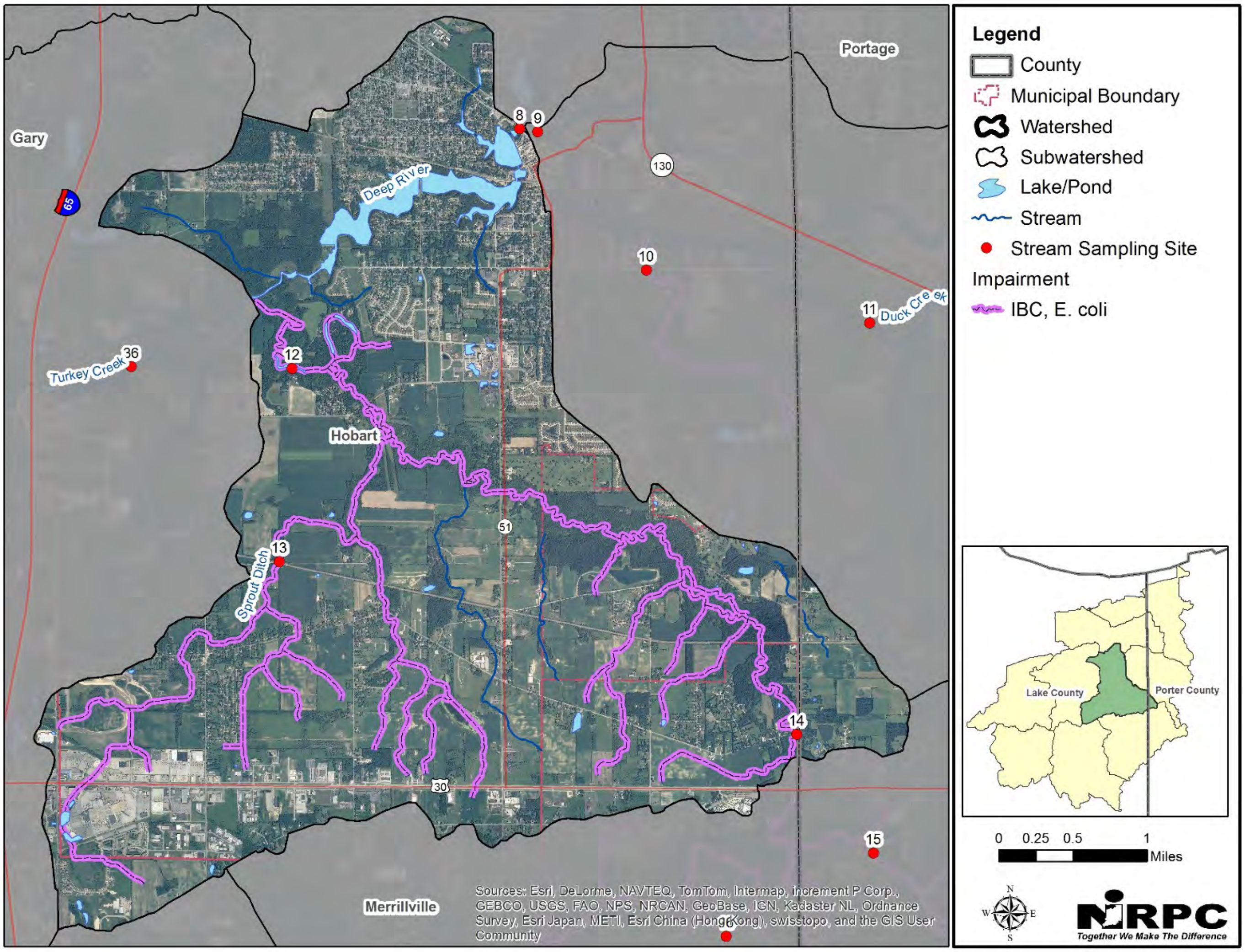


Figure 161 Impaired streams within the Lake George Subwatershed

4.7.2 Water Quality

IDEM collected water quality data at four monitoring stations (Sites 8, 12-14) within the Lake George subwatershed (Figure 161). Site 8 was used to represent the subwatershed and to assess its contribution to the overall Deep River-Portage Burns Waterway watershed.

4.7.2.1 *Pathogens*

Figure 162 shows that full body contact recreational use is threatened by elevated pathogen levels. Sites 8, 12, and 13 had median *E. coli* concentrations above the 235 CFU/100 mL single sample water quality standard. There is an increase in *E. coli* concentrations between Site 14 (downstream) and Site 12 (upstream) on Deep River. Site 13, located on Sprout Ditch, generally had the highest concentrations observed and may be contributing to the higher *E. coli* levels downstream at Site 12. There was a slight decrease in median *E. coli* concentrations between Sites 8 and 12 on Deep River. This decrease in part may be attributed to Lake George.

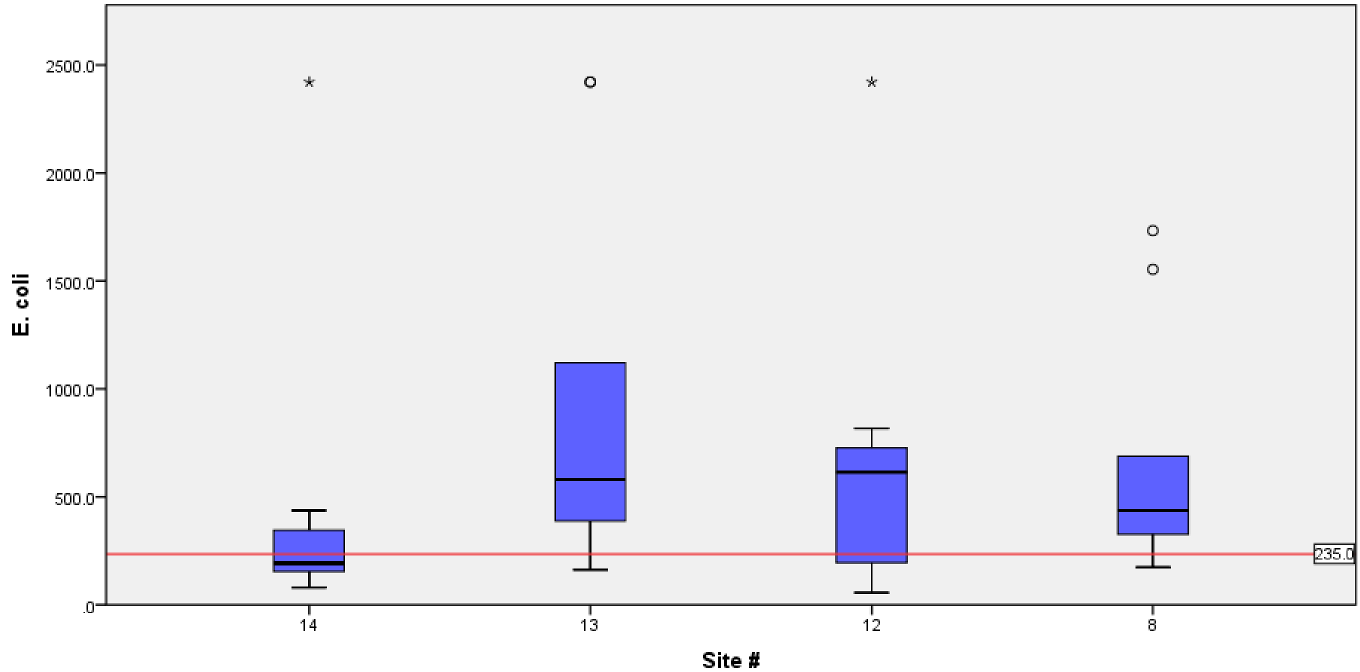


Figure 162 Box plot illustrating site E. coli concentrations within the Lake George Subwatershed

4.7.2.2 *Fish*

An evaluation of each site's fish community structure revealed that Sites 8 and 13 are not supporting of their Aquatic Life Use designation. Sites 12 and 14 are considered to be fully supporting however, they only received a "fair" integrity class rating. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were absent.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
14	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
13	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
12	42	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
8	32	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 70 Site fish index of biotic integrity scores within the Lake George Subwatershed

4.7.2.3 *Macroinvertebrates*

An evaluation of each site's macroinvertebrate community structure revealed that Sites 8 and 12 are not supporting of their Aquatic Life Use designation. Sites 13 and 14 are considered to be fully supporting however, they only received a "fair" integrity class rating. Intolerant and sensitive macroinvertebrate species were generally absent and the species that were present are considered tolerant of disturbance.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
14	40	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
13	42	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
12	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
8	28	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 71 Site macroinvertebrate index of biotic integrity scores within the Lake George Subwatershed

4.7.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. Average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 19-21°C, (66-70°F).

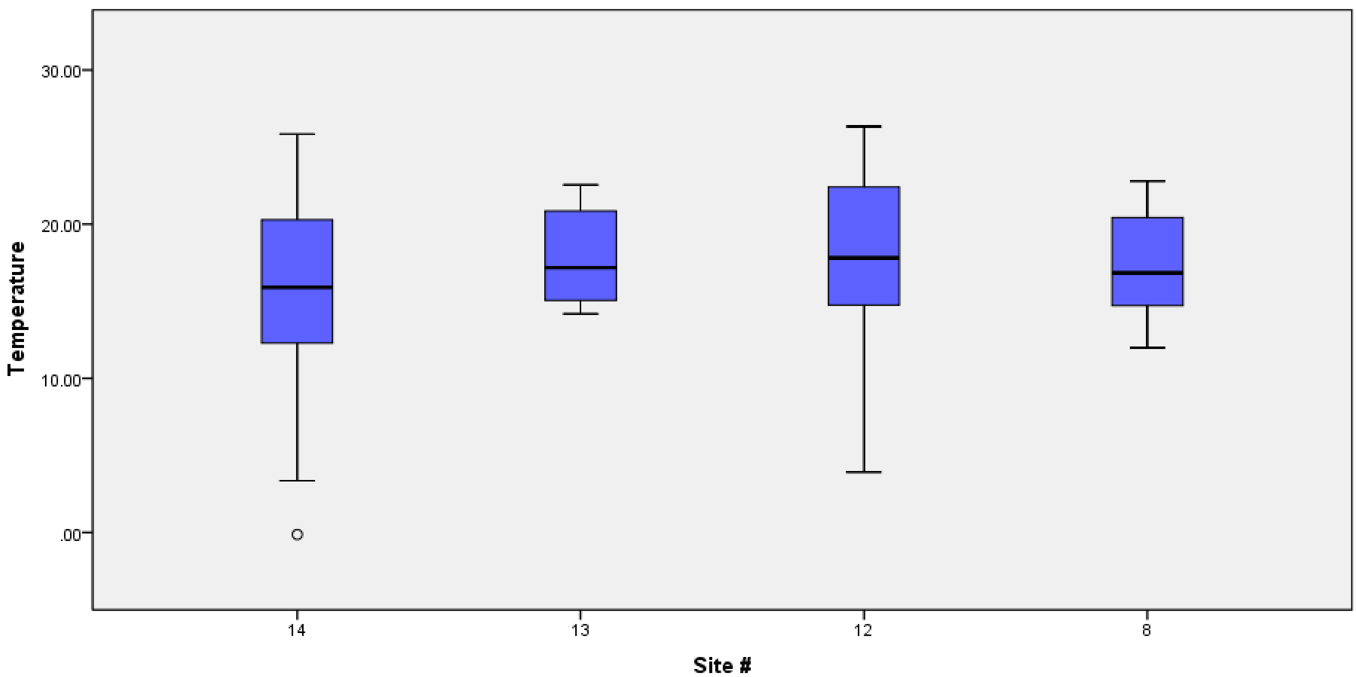


Figure 163 Box plot illustrating site water temperature within the Lake George Subwatershed

4.7.2.5 *Dissolved Oxygen*

Figure 164 shows that all sites typically met the dissolved oxygen water quality standard of 4-12mg/L. There were two occasions during the summer in which Site 8, located below the Lake George dam, had dissolved oxygen concentrations less than 4 mg/L. Sites 12-14 had dissolved oxygen concentrations that occasionally exceeded the 12 mg/L target. The exceedances at Sites 12 and 13 occurred during the spring while Site 14's exceedance occurred during the summer.

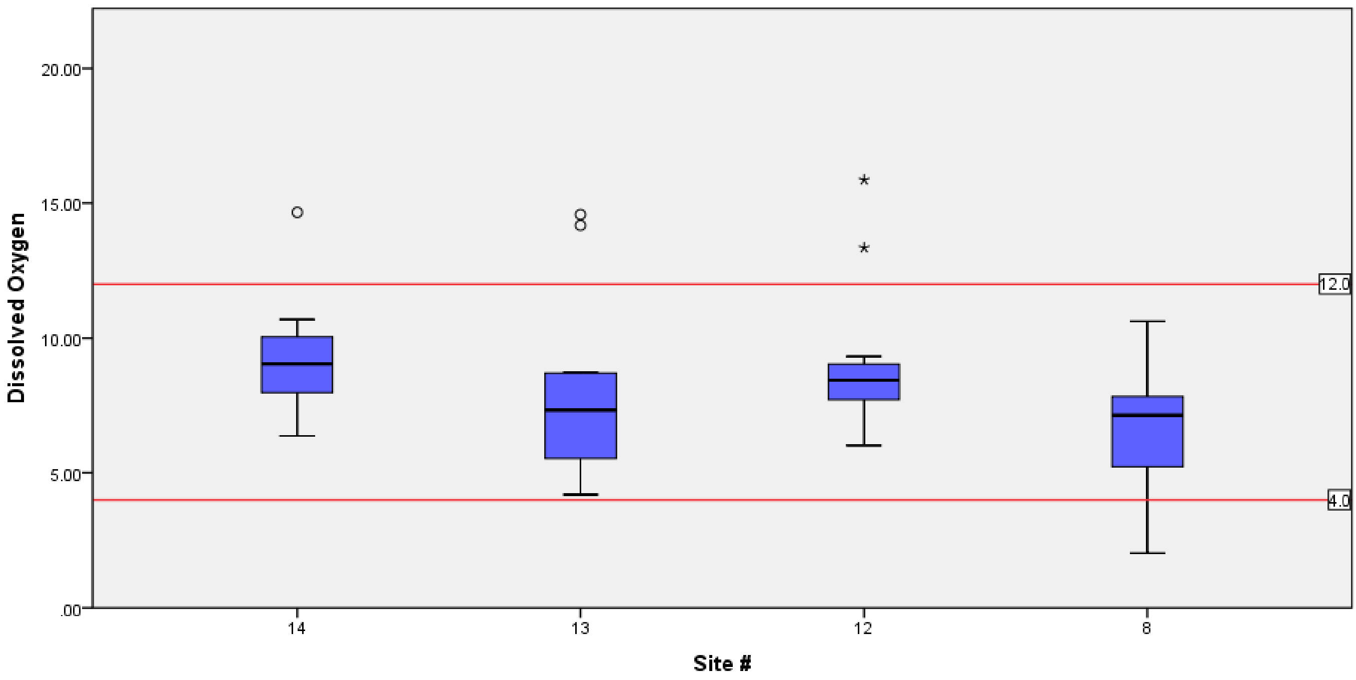


Figure 164 Box plot illustrating site dissolved oxygen concentrations within the Lake George Subwatershed

4.7.2.6 *Total Organic Carbon*

Organic material loading and decomposition doesn't appear to be the primary driver for the occasional dissolved oxygen problems observed at Site 8. Figure 165 shows a fairly sizable drop in total organic concentrations between Sites 12 and 8 indicating that organic materials carried by Deep River are settling out in Lake George.

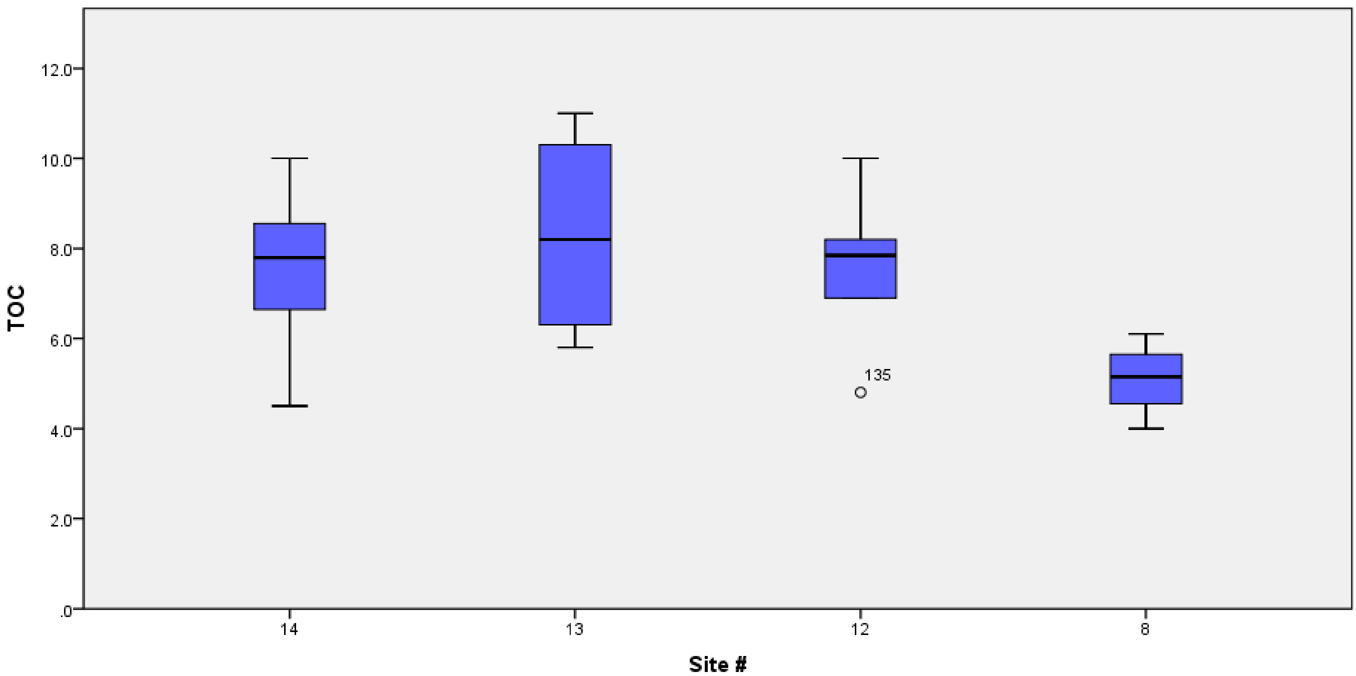


Figure 165 Box plot illustrating site TOC concentrations within the Lake George Subwatershed

4.7.2.7 *Nutrients*

Figure 166 shows that all sites had median total phosphorus concentrations between the 0.07 mg/L and 0.3 mg/L thresholds. Generally Site 14 had the highest observed concentrations but we can see a decreasing as we move from upstream to downstream along Deep River. Additionally the figure shows that median concentrations drop below the Lake George dam indicating the lake is acting a phosphorus sink within the system.

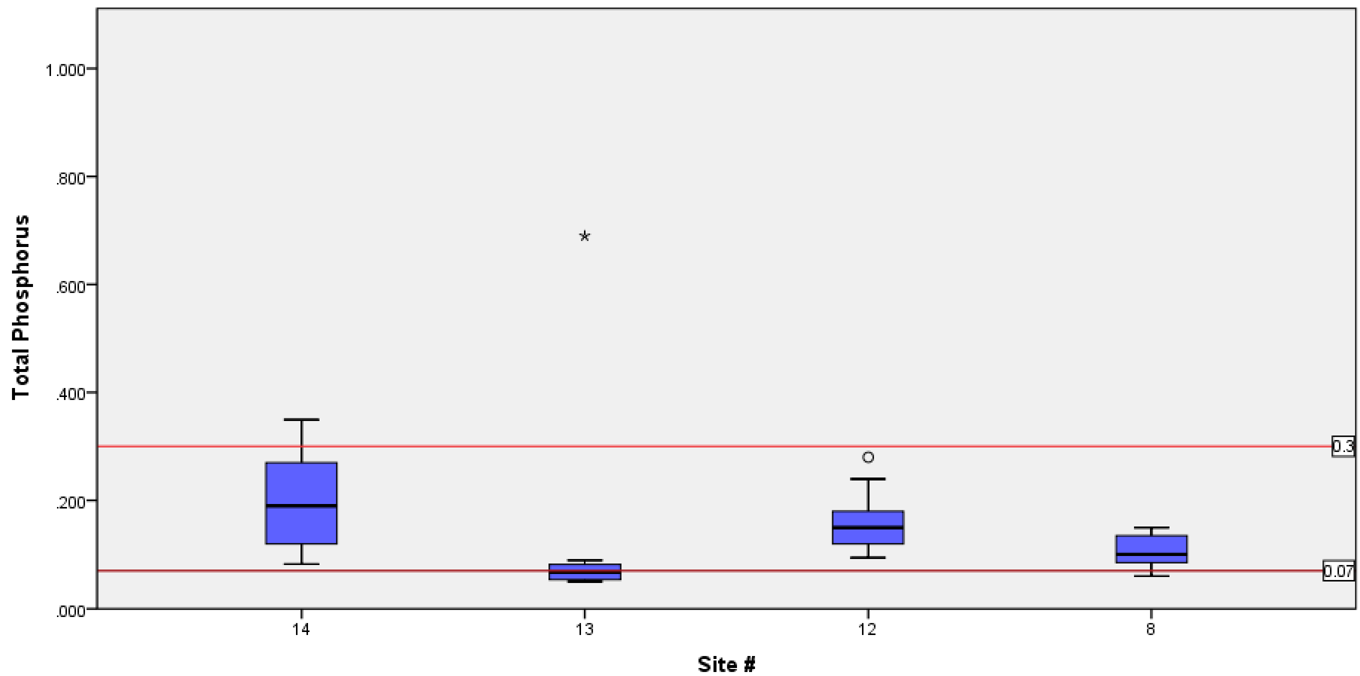


Figure 166 Box plot illustrating site total phosphorus concentrations within the Lake George Subwatershed

Figure 167 shows similar site patterns for nitrate concentrations as was observed for total phosphorus. Median nitrate concentrations decrease moving from upstream to downstream along Deep River. Nitrate concentrations show a large drop between Sites 12 and 8 indicating denitrification is occurring within Lake George. No sites exceeded the 10 mg/L threshold but Sites 12 and 14 have median nitrate concentrations above the 1.09 mg/L threshold.

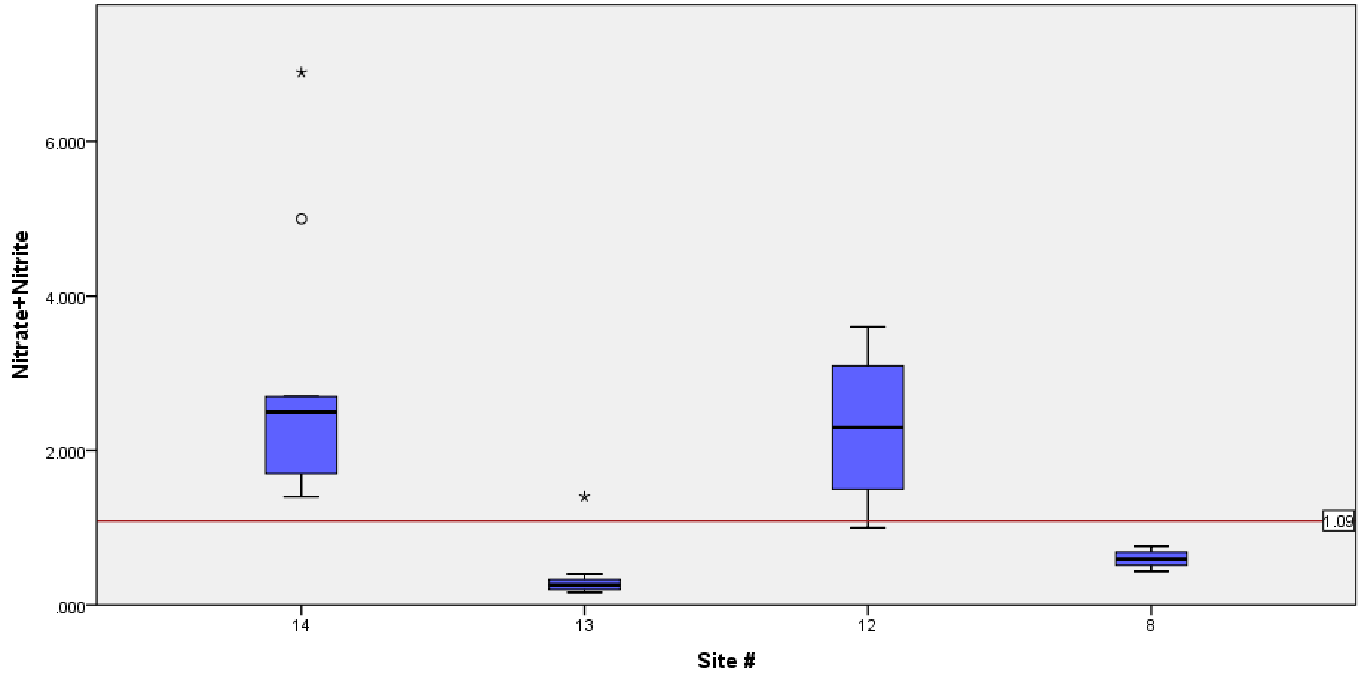


Figure 167 Box plot illustrating site nitrate concentrations within the Lake George Subwatershed

Figure 168 shows a decreasing trend in total Kjeldahl nitrogen levels from upstream to downstream on Deep River. Sites 14 and 12 have median concentrations between the 0.68 mg/L and 1.27 mg/L thresholds.

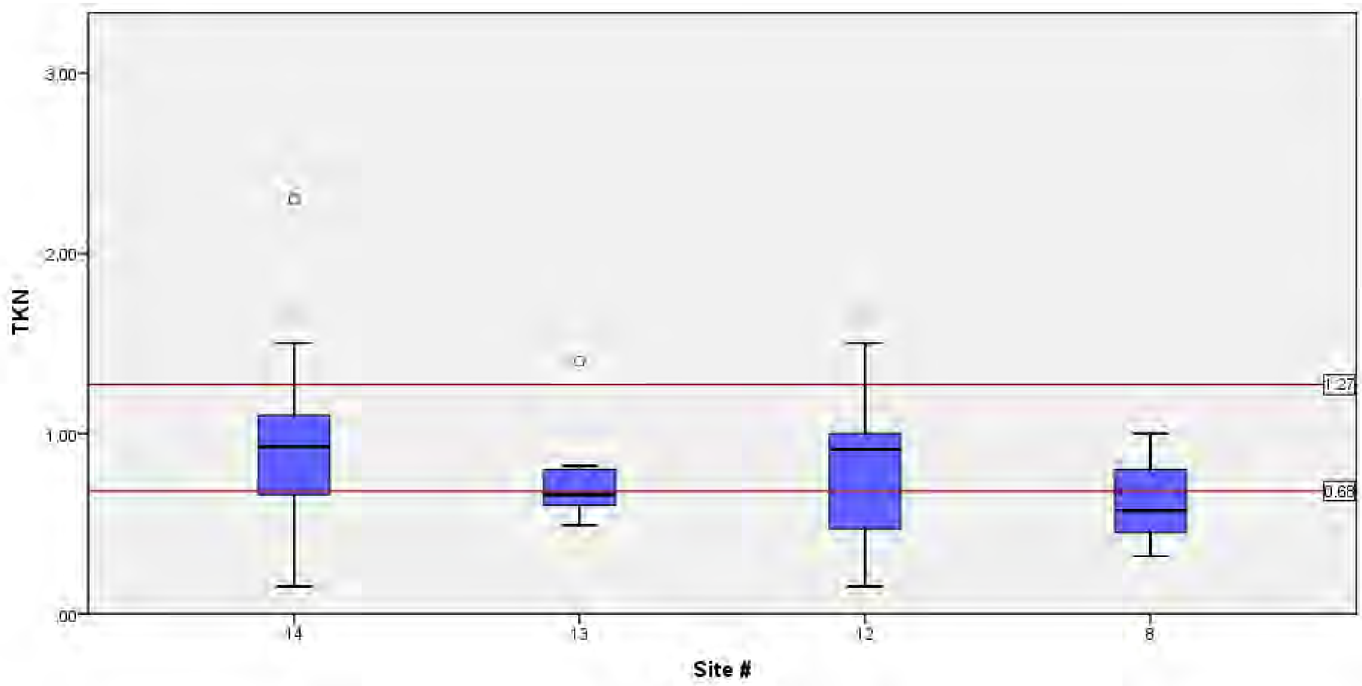


Figure 168 Box plot illustrating site total kjeldahl nitrogen concentrations within the Lake George Subwatershed

Figure 169 shows that ammonia concentrations at Sites 12-14 frequently fell below the laboratory detection limit. The highest maximum ammonia concentration was observed at Site 14 during the winter. Site 8 had the highest frequency of concentrations above 0.03 mg/L indicating excess organic material deposition in Lake George.

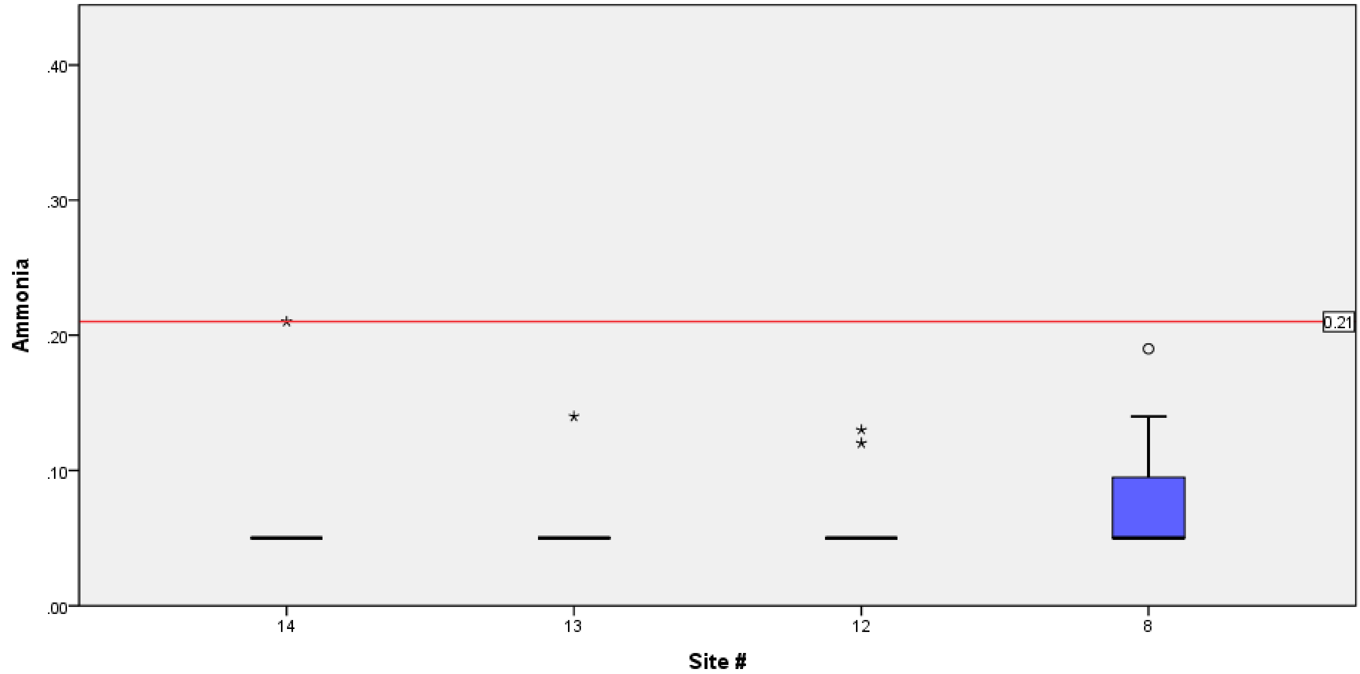


Figure 169 Box plot illustrating site ammonia concentrations within the Lake George Subwatershed

4.7.2.8 *Suspended Solids & Turbidity*

Figure 170 shows that very rarely did any site exceed the 30 mg/L total suspended solids threshold. There is an increasing trend in median total suspended solids concentrations from Site 14 downstream to Site 12. However, total suspended solid concentrations generally decline at Site 8 below the Lake George dam, indicating solids are falling out of suspension in the lake.

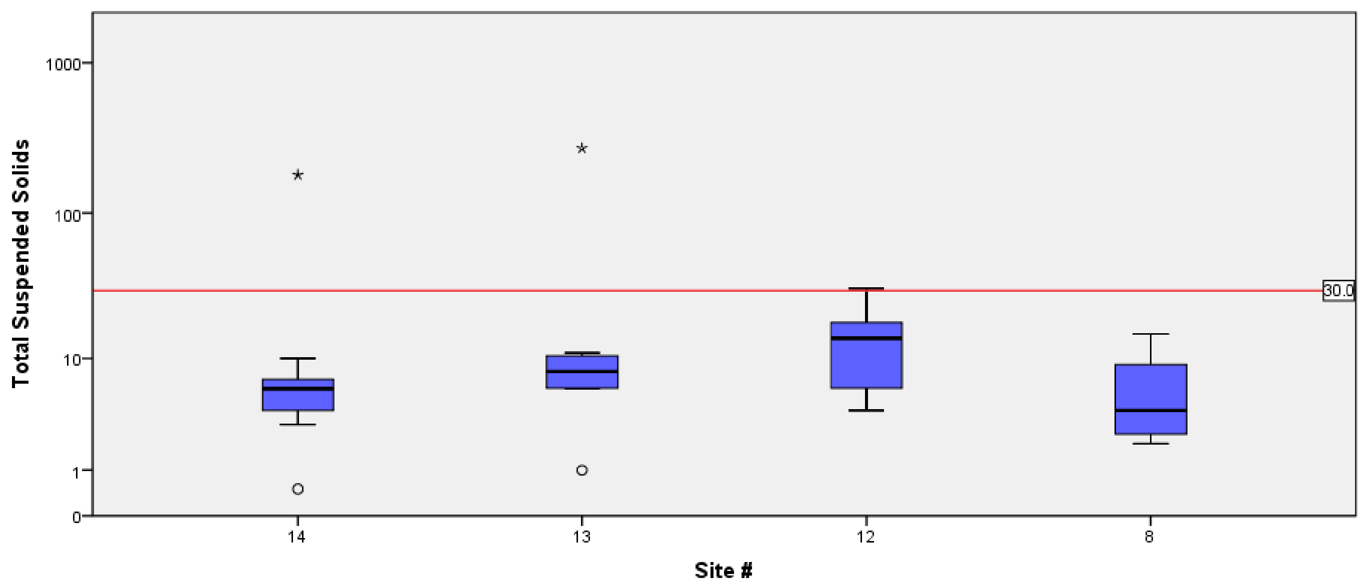


Figure 170 Box plot illustrating site total suspended solids concentrations within the Lake George Subwatershed

Figure 171 shows similar site patterns to those seen above for total suspended solids. Sites 12 and 13 had median turbidity levels slightly higher than the 10.4 NTU threshold. There is an increase in median turbidity concentrations moving from Site 14 downstream to Site 12. Turbidity concentrations fall at Site 8 indicating that suspended materials are settling out in Lake George.

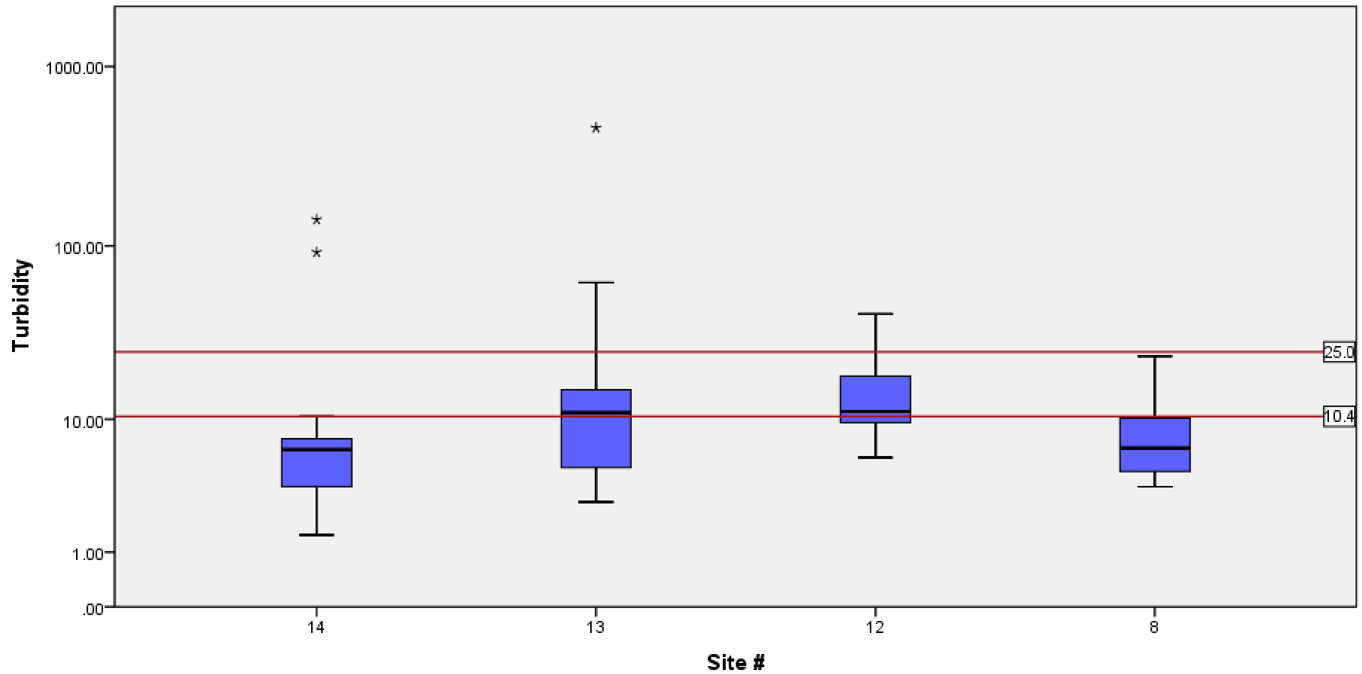


Figure 171 Box plot illustrating site turbidity levels within the Lake George Subwatershed

4.7.2.9 *Habitat*

Figure 172 shows habitat quality is generally conducive to supporting at healthy warmwater fishery at each of survey sites in the subwatershed (QHEI >51). A decline in habitat quality was observed moving downstream from Site 14 to Site 12 on Deep River. The decline appears to be primarily attributed to a decline in substrate quality and absence of riffle/run habitat. Site 12's substrate was characterized as primarily hardpan (clay) with inclusions of sand, detritus, muck and silt. Silt cover and embeddedness were classified as moderate. Site 14's substrate was characterized as primarily sand with inclusions of cobble, gravel, muck and artificial substrate (riprap). Siltation and embeddedness was classified as normal. The difference in substrate quality and riffle habitat may be partly explained by stream gradient between sites. Stream gradient and current velocity greater at Site 14 compared to Site 12.

Habitat quality at Site 8, located below the Lake George dam in Hobart, rebounded to a level similar to that observed at Site 14. Deep River widens out in this area below the dam into a bowl shaped basin. Substrates at Site 8 are characterized as primarily sand with moderate silt cover and embeddedness.

Site 13 is located on Sprout Ditch, a tributary to Deep River. Channel morphology was slightly poorer than the other sites in the subwatershed. Channel sinuosity as low and the reach was recovering from channelization. A portion of Sprout Ditch upstream of Site 13 is maintained as a county legal drain (Figure 174).

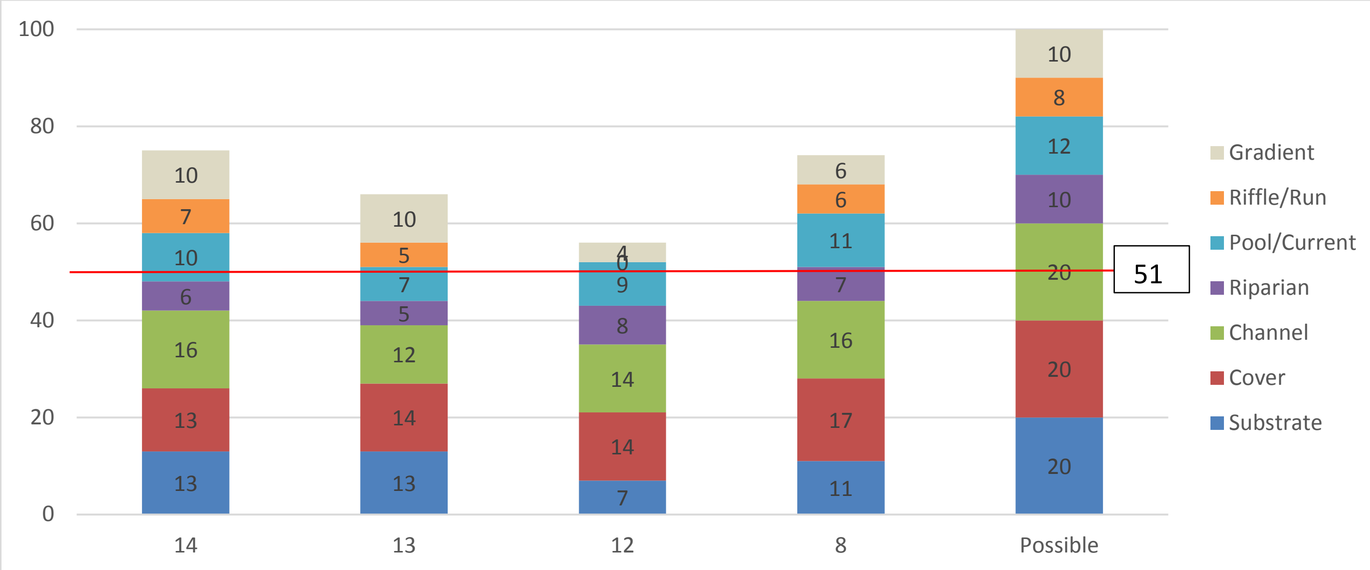


Figure 172 Site qualitative habitat evaluation idex scores within the Lake George Subwatershed

4.7.3 Land Cover & Land Use

Overall, the predominant land cover types within the subwatershed are developed (35%) and agricultural (29%) lands (Figure 173). The highest concentration of development is located in Hobart around Lake George and along the US 30 corridor. Most of the subwatershed's agricultural lands exist between these two higher density developed areas. Much of the low intesity development in this area is unsewered.

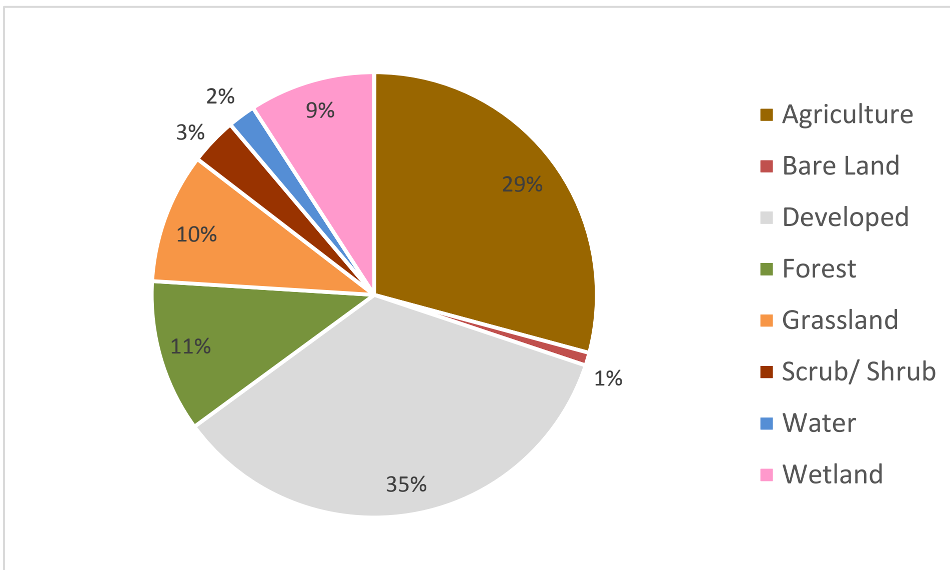


Figure 173 Percent land cover within the Lake George Subwatershed

Table 72 includes land cover information for each site's drainage area. Site 14 is located on Deep River adjacent to Deep River County Park. It's drainage area is primarily agricultural and developed land but the site itself is surrounded by wetland and forest. Site 13, located on Sprout Ditch, has the highest percentage of developed land within its drainage which includes a large portion of the retail business area along the US 30 corridor. Furhter downstream Sprout Ditch passes through primarily agricultural land. Site 12 shares a similar composition of land cover to that of Site 14 and is also bordered by wetland and forest that buffer Deep River from adjacent human land uses. Site 8 is located below the tailwaters of the Lake George dam on Deep River. The immediate surrounding land use is development near downtown Hobart.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland

14	39.7	0.2	32.2	10.1	6.2	3.8	0.6	7.1
13	29.8	0.3	46.1	6.3	9.9	3.8	0.7	3.1
12	39.1	0.4	31.4	10.0	6.9	3.8	0.6	7.6
8	29.7	0.3	41.6	10.1	6.4	3.6	0.9	7.5

Table 72 Site percent land cover within the Lake George Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 73. There's a relatively equal contribution of human and natural land cover types within the subwatershed's riparian zones. Generally, the mainstem of Deep River is buffered from adjacent human uses by forested floodplain wetland which is edged by upland forest along the river valley. Human uses are most prevalent along the tributaries flowing into Deep River (Figure 174).

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
14	28.5	0.2	22.1	9.8	5.3	6.4	2.5	25.3
13	31.8	0.0	25.9	9.5	14.2	7.3	3.0	8.2
12	28.1	0.4	19.5	10.1	5.8	6.3	2.2	27.6
8	22.9	0.3	27.9	9.9	5.0	5.6	3.4	25.2

Table 73 Site percent riparian land cover within the Lake George Subwatershed

There are no NPDES permitted industrial facilities documented in the subwatershed. However, the TMDL identified one waste water treatment plant (Figure 174). The Hobart WWTP (IN0061344) had three inspection violations reported between 2010 and 2011. They were referred to enforcement in June 2011.

There are 13 potential livestock facilities located within the subwatershed (Figure 174). All but one of the facilities fall within Site 12's drainage area. A majority of these are located in the rural area south of Deep River and north of U.S. Highway 30. This area is drained by a number of intermittent tributaries.

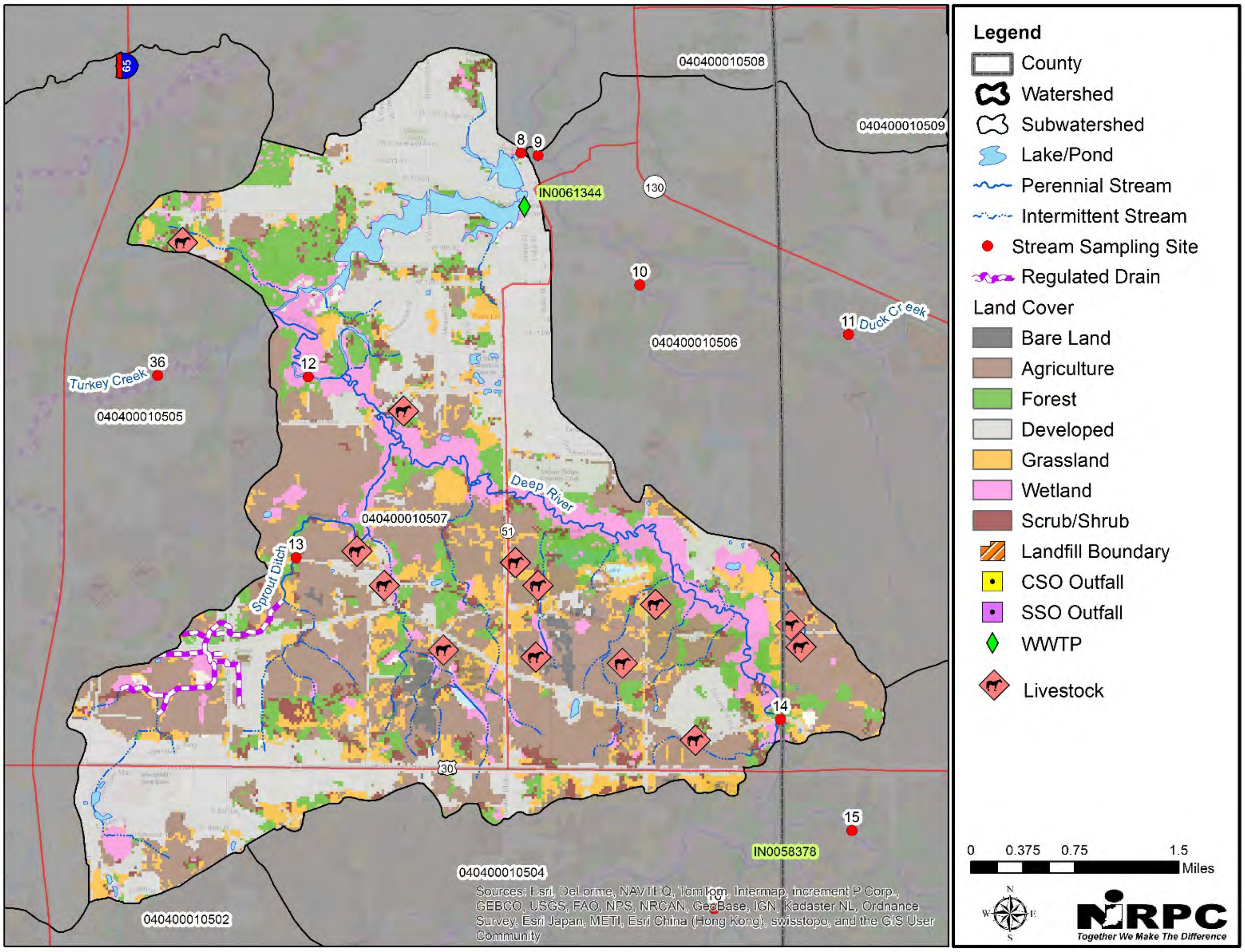


Figure 174 Land cover and land use within the Lake George Subwatershed

4.7.4 Soils

Deep River and many of its tributaries are bordered by hydric soils within the subwatershed. Most of the wetlands in which these soils developed have been drained for agricultural production and development except along Deep River (Figure 175). Areas of highly or potentially highly erodible soils are located within the Sprout Ditch drainage area and bordering Deep River to the east. There are a few locations in which soils with slopes greater than 15% occur within the subwatershed. A number of these locations are located directly adjacent to Deep River floodplain valley or intermittent tributaries.

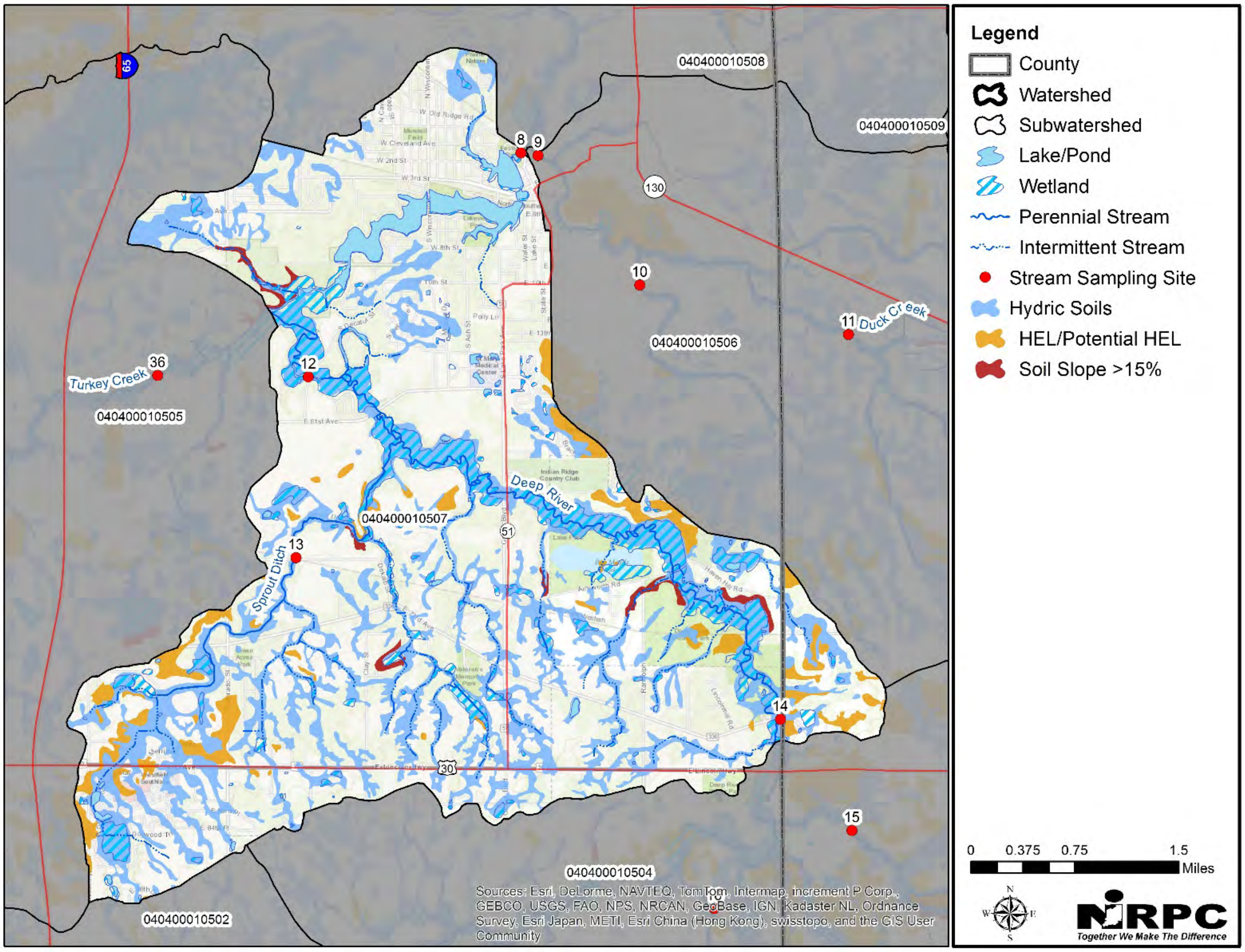


Figure 175 Soils within the Lake George Subwatershed

4.8 Little Calumet River-Deep River Subwatershed (HUC 040400010508)

4.8.1 Overview

The Little Calumet River-Deep River subwatershed is located in the northern tier of the watershed. It drains approximately 19 mi² of primarily developed land (71%). Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include impaired biotic communities and high *E. coli* levels.

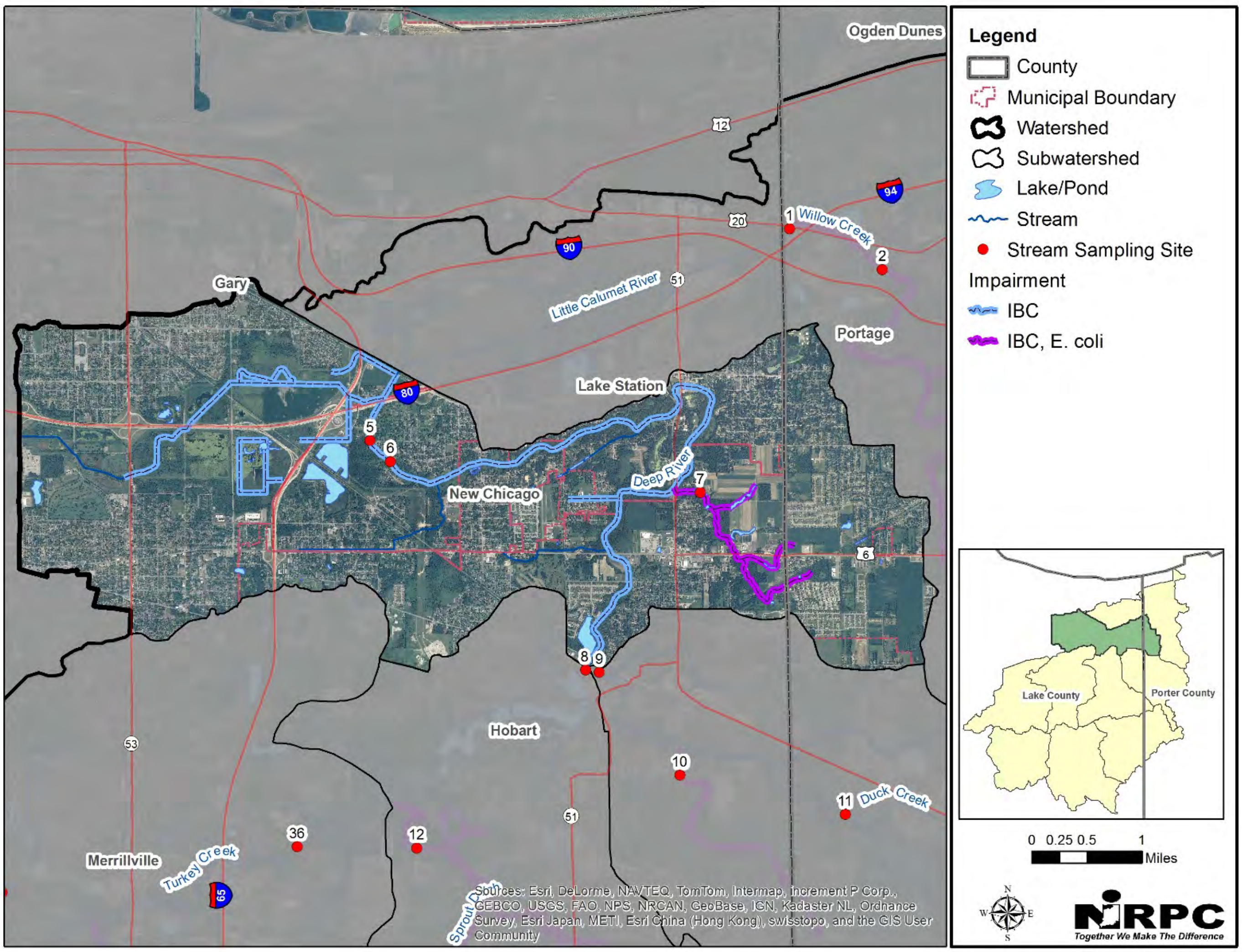


Figure 176 Impaired streams within the Little Calumet River Subwatershed

4.8.2 Water Quality

IDEM collected water quality data at three monitoring stations (Sites 5-7) within the subwatershed (Figure 176). Site 6 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed. It is also important to note that Sites 5 and 6 bracket a dam located on Deep River in Lake Station (See Section 2.5.4.3 for additional details about this dam). Site 5 was added as a targeted monitoring point during the baseline assessment to help evaluate the potential impacts associated with the dam.

4.8.2.1 *Pathogens*

Figure 177 shows that Site 7's median *E. coli* concentration is greater than the single sample water quality standard of 235 CFU/100mL indicating that full body contact recreational use is threatened by elevated pathogen levels. Exceedances at Site 7 occurred across low to moderately high flow conditions indicating inputs from point and nonpoint sources. Site 5 had two observations over 235 CFU/100mL while Site 6 only had a single observation. These exceedances occurred during mid-range to moderately high flow conditions indicating nonpoint source inputs.

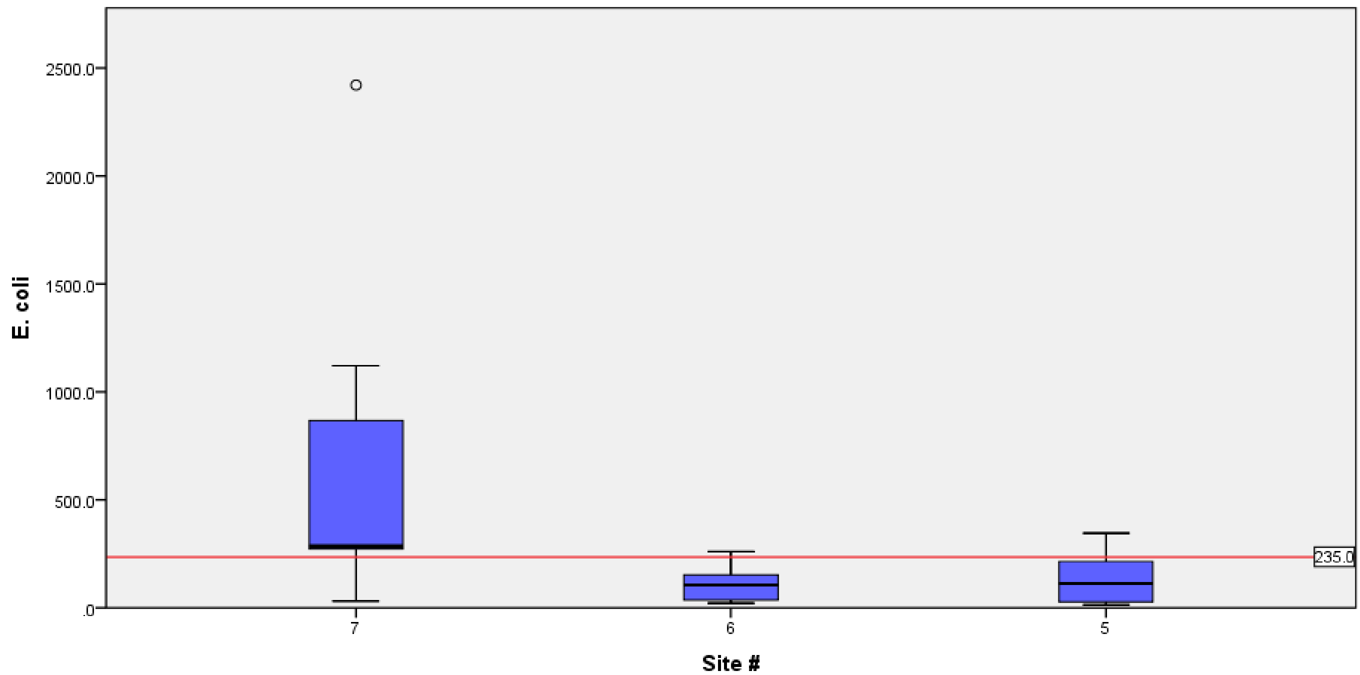


Figure 177 Box plot illustrating site E. coli concentrations within the Little Calumet River Subwatershed

4.8.2.2 *Fish*

An assessment of fish community structure showed that Sites 7 and 5 are not supporting of their Aquatic Life Use designation. While Site 6 was found to be fully supporting, it only received an integrity classification of "fair". The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were lacking. Only five fish were collected at Site 7. Metric scores that evaluated trophic structure, the position the fish occupies in the food chain (ex. carnivore or insectivore), indicated environmental degradation at Site 7 and to some degree at Site 5. Fish species that require clean gravel/cobble substrates to spawn were lacking from all sites.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
7	18	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
6	36	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure
5	34	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant

Table 74 Site fish index of biotic integriry scores within the Little Calumet River Subwatershed

4.8.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed that Site 7 was not supporting of its Aquatic Life Use designation. All sites were dominated by macroinvertebrates that are tolerant of pollution and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes
7	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
6	30	Fully Supporting	Poor	Many expected species absent or rare, tolerant species dominant
5	38	Fully Supporting	Fair	Intolerant and sensitive species absent, skewed trophic structure

Table 75 Site macroinvertebrate index of biotic integriry scores within the Little Calumet River Subwatershed

4.8.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. The average summer water temperature, typically the most stressful period for aquatic organisms, was 24°C, (75°F).

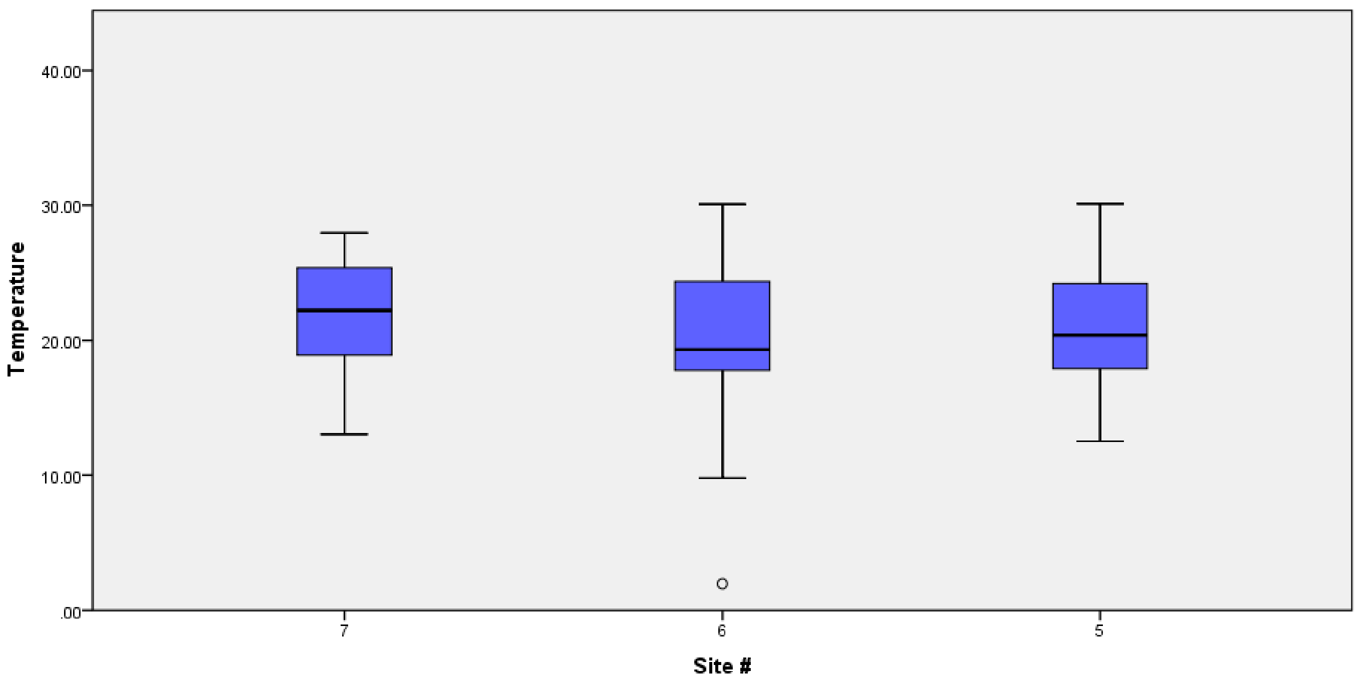


Figure 178 Box plot illustrating site water temperatures within the Little Calumet River Subwatershed

4.8.2.5 *Dissolved Oxygen*

Figure 179 shows that site median dissolved oxygen concentrations fell between 4-12 mg/L. Sites 5 and 7 each had one observation during the summer in which they failed to meet the water quality standard with dissolved oxygen concentrations of 3.3 mg/L and 3.9 mg/L respectively. Observations above 12 mg/L at Sites 6 and 7 occurred during the spring. The Deep River dam is located between Sites 6 (upstream) and 5 (downstream). The figure shows the influence of the dam as dissolved oxygen levels increase as water spills over and through the structure.

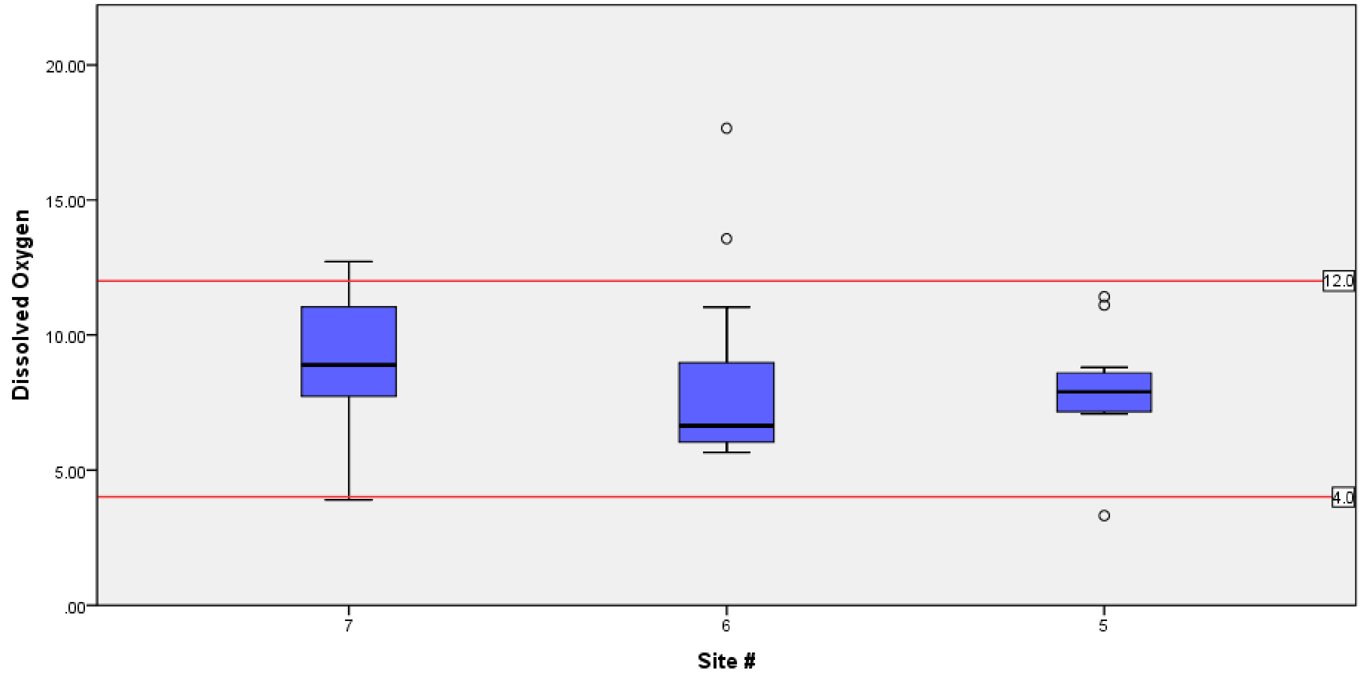


Figure 179 Box plot illustrating site dissolved oxygen concentrations within the Little Calumet River Subwatershed

4.8.2.6 *Total Organic Carbon*

Figure 180 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This indicates that organic material loading is influencing dissolved oxygen concentrations.

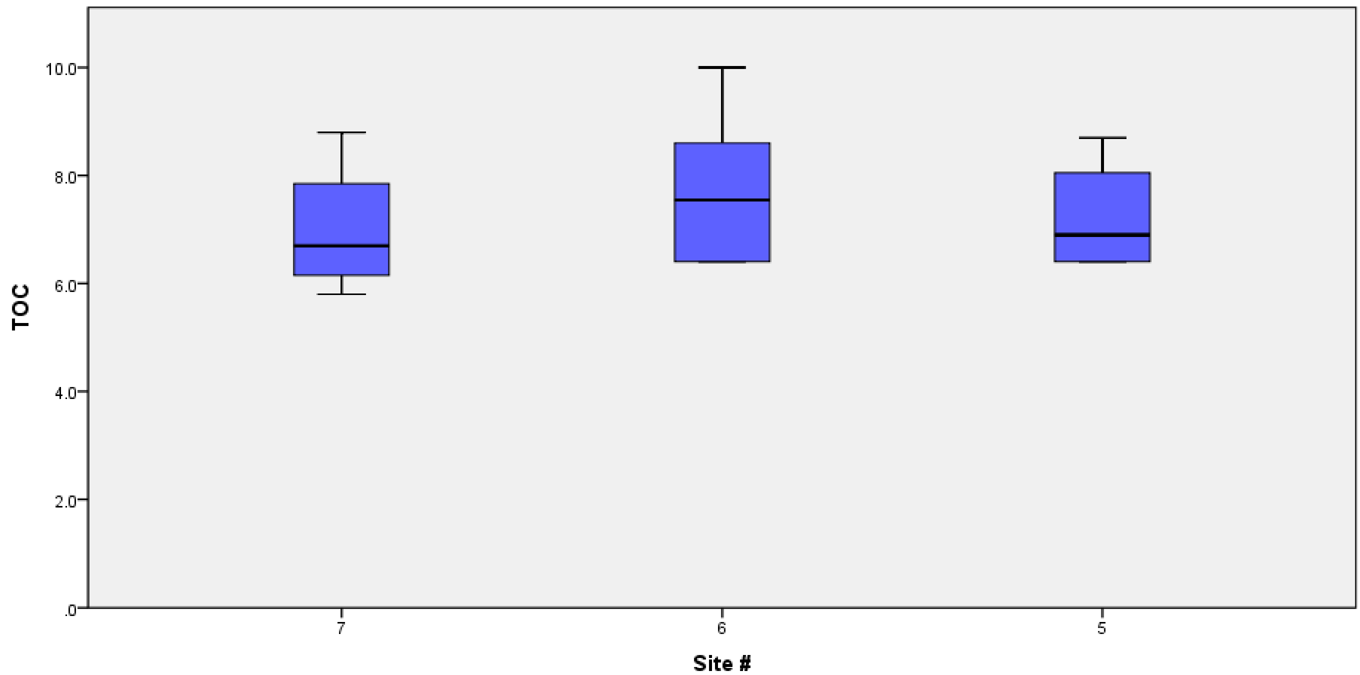


Figure 180 Box plot illustrating site TOC concentrations within the Little Calumet River Subwatershed

4.8.2.7 *Nutrients*

Figure 181 shows that none of the sites exceeded the 0.3mg/L total phosphorus threshold however, all sites had median concentrations exceeding the 0.07 mg/L threshold.

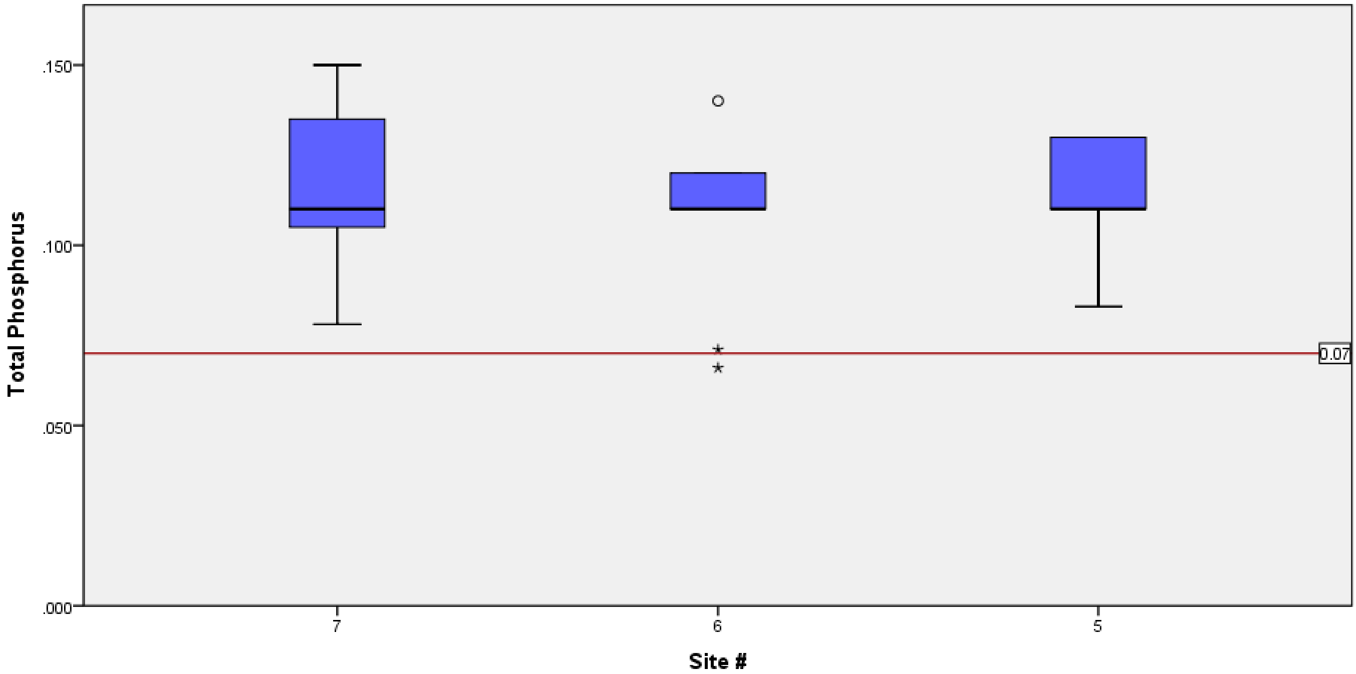


Figure 181 Box plot illustrating site total phosphorus concentrations within the Little Calumet River Subwatershed

Figure 182 shows that none of the sites exceeded the 10 mg/L nitrate threshold. Median nitrate concentrations fell below the 1.09 mg/L threshold for all sites.

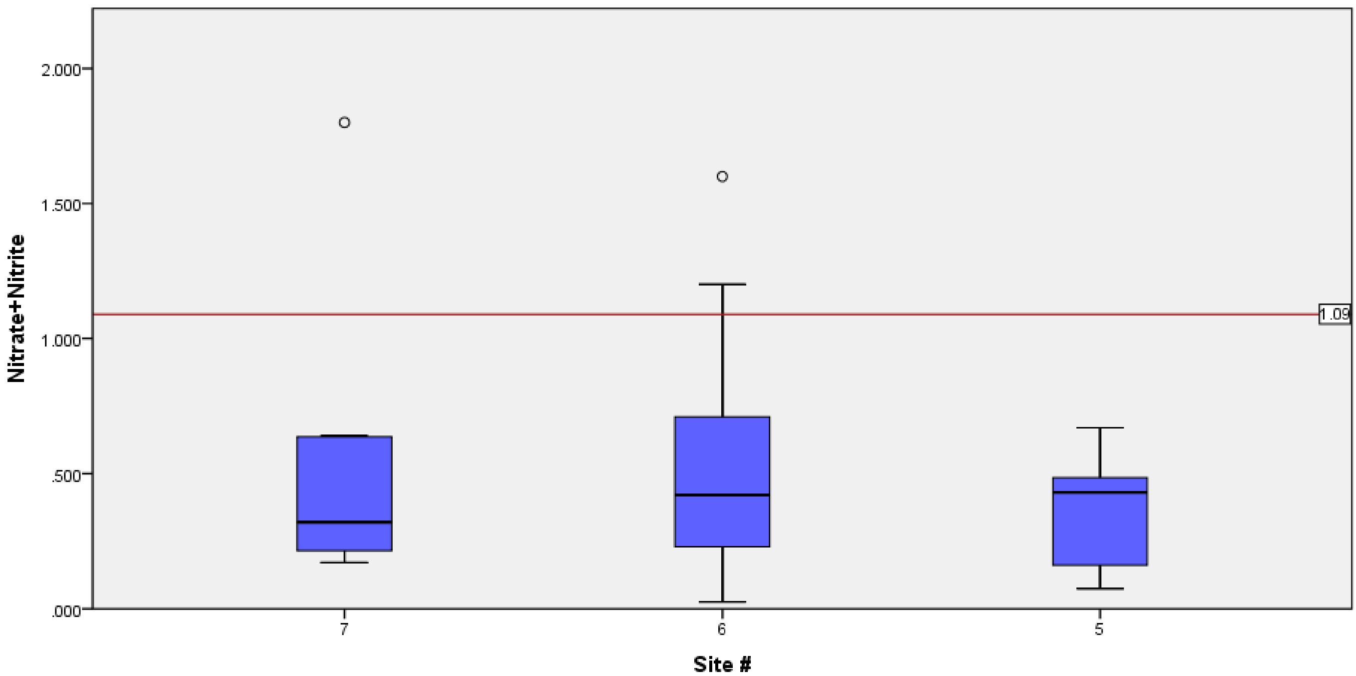


Figure 182 Box plot illustrating site nitrate concentrations within the Little Calumet River Subwatershed

Figure 183 shows that site median total Kjeldahl nitrogen concentrations fell between the 1.27 mg/L and 0.68 mg/L threshold. Since total Kjeldahl nitrogen is a measure of organic nitrogen and ammonia, looking at Figure 183 and Figure 184 we can see that Site 6, located upstream of the dam, has a higher organic nitrogen load.

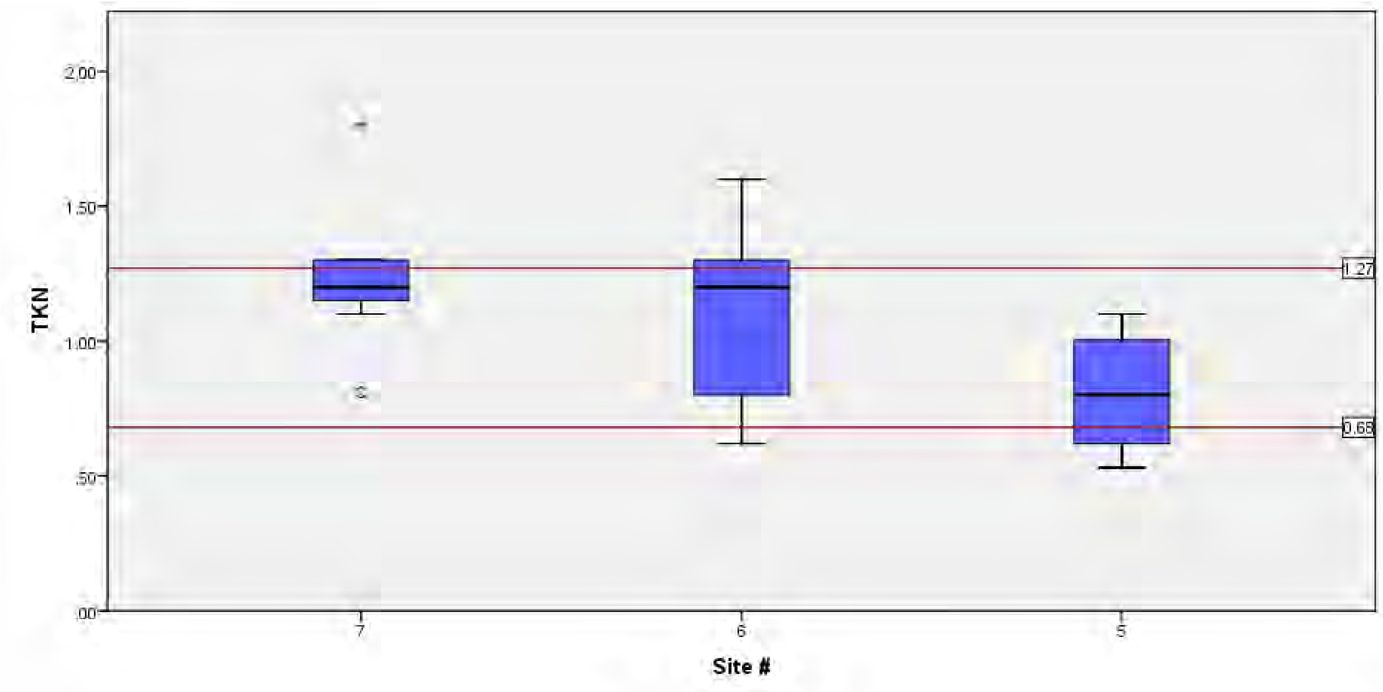


Figure 183 Box plot illustrating site total Kjeldahl nitrogen concentrations within the Little Calumet River Subwatershed

Figure 184 shows that ammonia concentrations typically fell below the lab detection limit for all sites. Each site had one or two outlier observations above 0.10 mg/L.

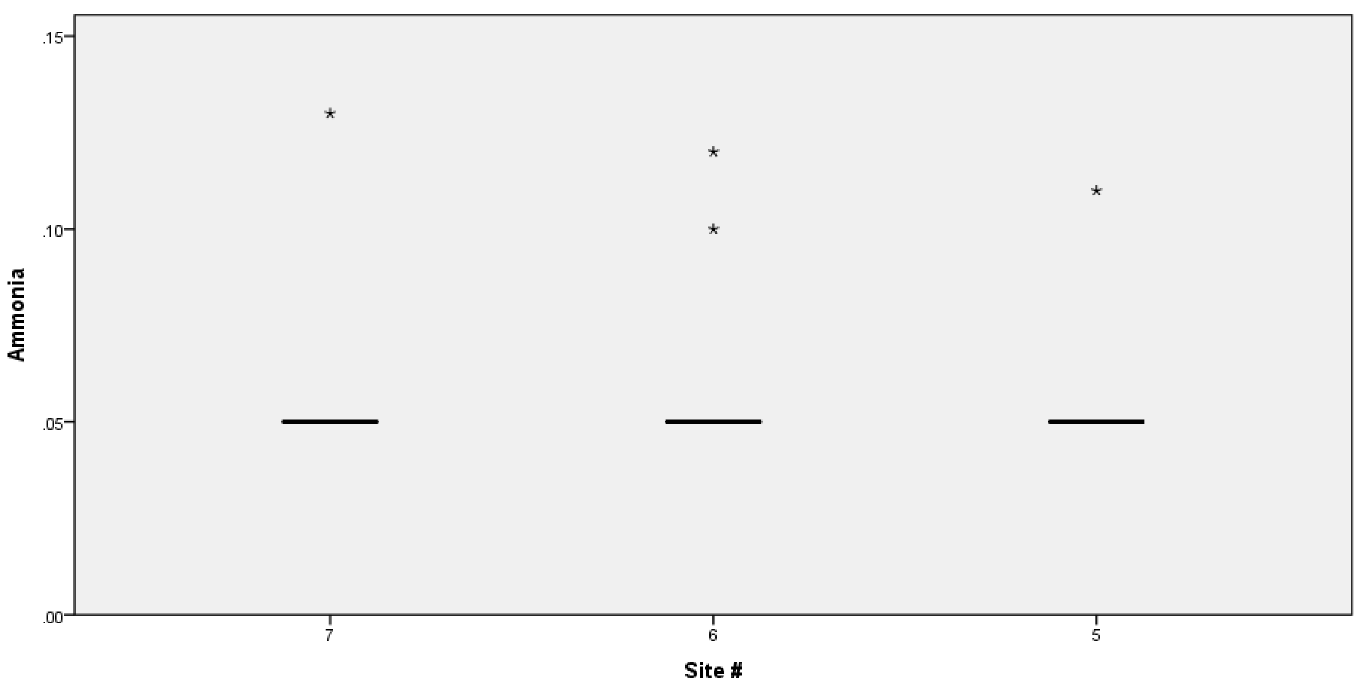


Figure 184 Box plot illustrating site ammonia concentrations within the Little Calumet River Subwatershed

4.8.2.8 *Suspended Sediment & Turbidity*

Figure 185 shows that all the sites had median total suspended solid concentration below the 30 mg/L threshold. We can see that median total suspended solids concentrations were lower on Deep River compared to the tributary represented by Site 7. An increase in median concentrations is apparent below the dam between Sites 6 and 7. This is likely due to the erosive energy of the water going over and through the dam structure.

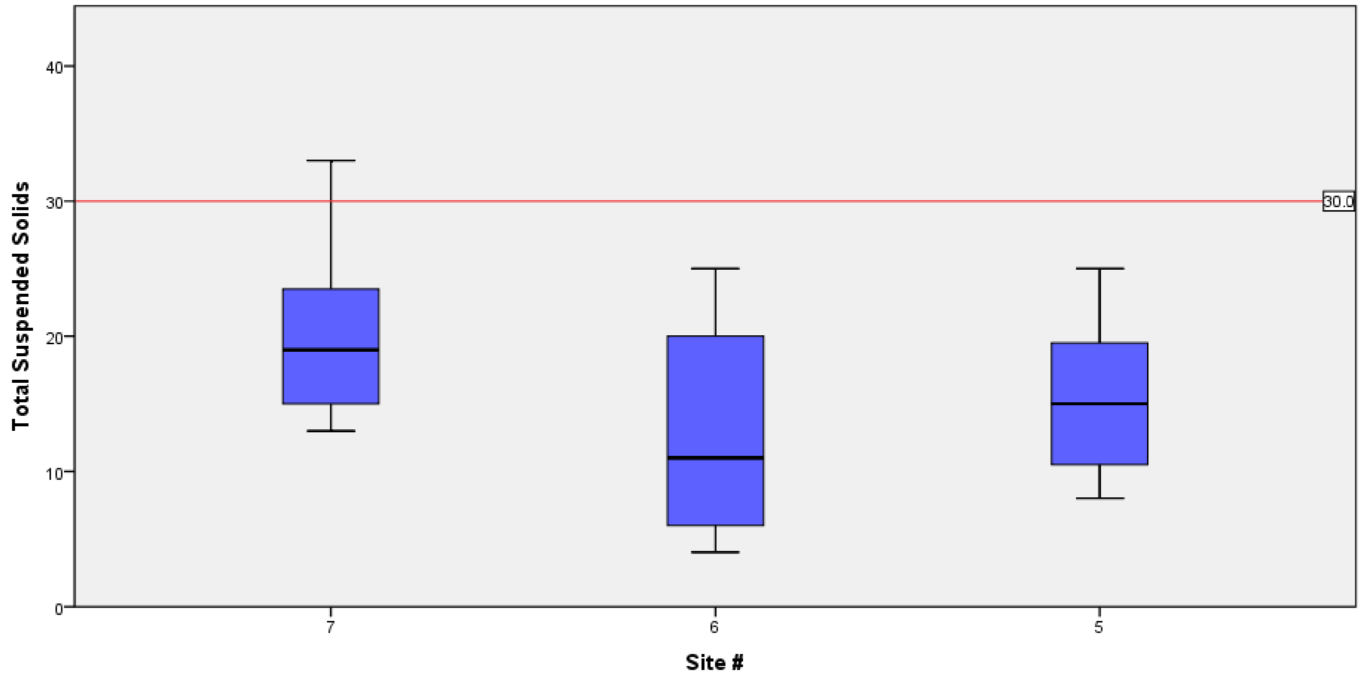


Figure 185 Box plot illustrating site total suspended solids concentrations within the Little Calumet River Subwatershed

Figure 186 shows similar site patterns as those observed above for total suspended solids. Sites 5 and 7 had median turbidity levels between 10.4 NTU and 25 NTU.

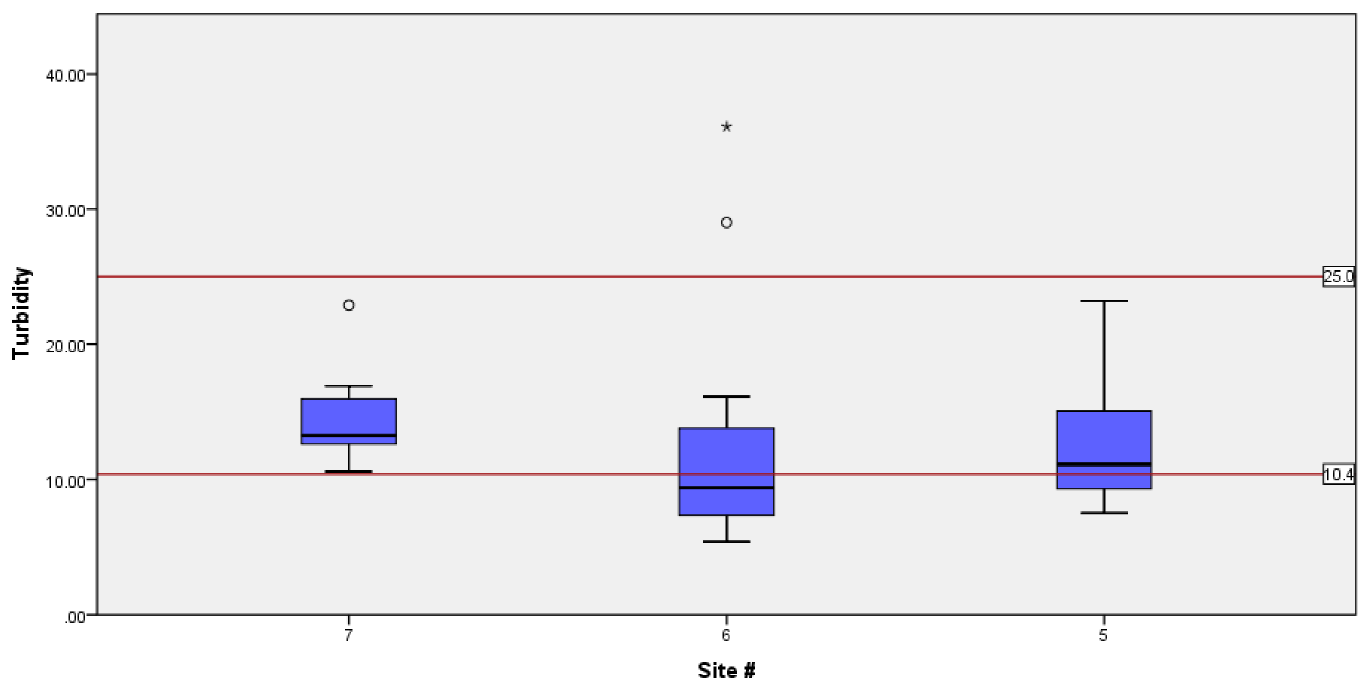


Figure 186 Box plot illustrating site turbidity levels within the Little Calumet River Subwatershed

4.8.2.9 *Habitat*

Habitat evaluations performed by IDEM revealed that Sites 5 and 7 generally do not possess the habitat quality that is conducive of supporting a healthy warm water fishery (QHEI <51). Site 6 was found to have habitat quality that was marginally capable of supporting a health warm water fishery with a QHEI score of 52.

Site 5 is located immediately downstream of the Deep River dam in Lake Station. Site 6 is located upstream of the dam. Site 6's reach on Deep River has a more lake-like appearance and function because of the dam. The river is nearly twice as wide upstream of the dam than downstream. Both sites had relatively poor substrate quality and channel morphology and instream cover. Muck and silt comprise a larger percentage of the substrate at Site 6 compared to downstream and aquatic macrophytes (plants) are the dominate instream cover.

The major habitat limitation at Site 7 was primarily substrate quality. Substrates at the site were characterized as muck with heavy silt cover and moderate embeddedness. Channel morphology and instream cover were also relatively poor. Channel sinuosity was moderate, pool/riffle development was poor and channel stability was low. There was no sign of past channelization.

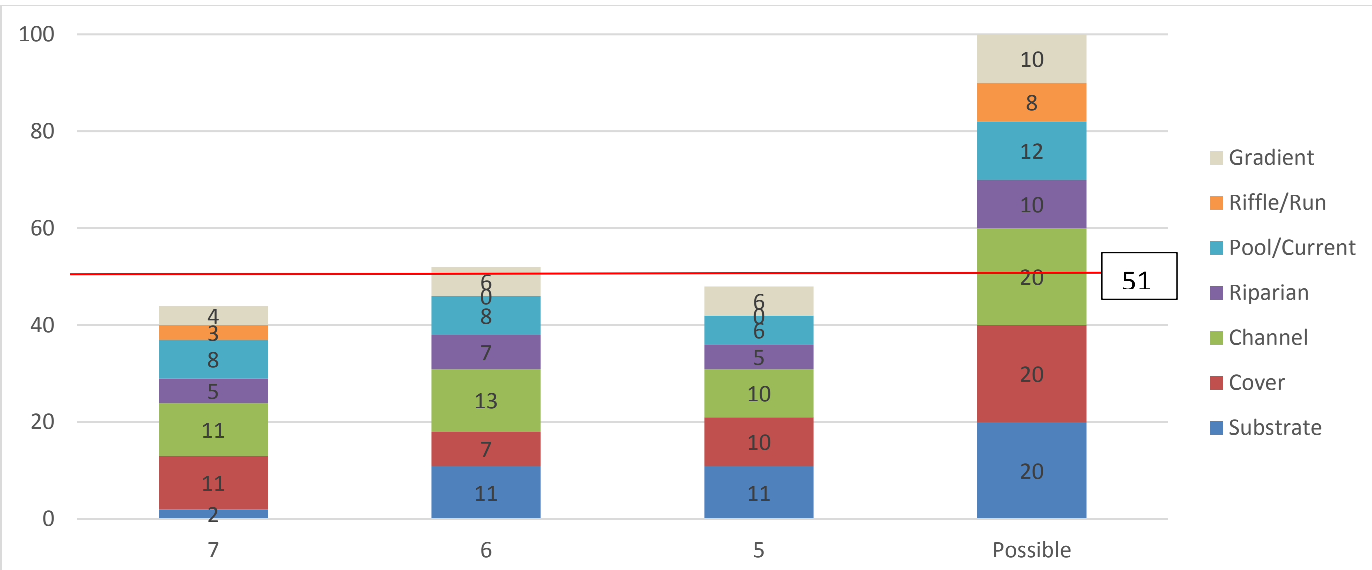


Figure 187 Site qualitative habitat evaluation index scores within the Little Calumet River Subwatershed

4.8.3 Land Cover & Land Use

Overall, the predominant land cover type within the subwatershed is developed lands (71%) (Figure 188). The subwatershed includes portions of Gary, Hobart, Lake Station, New Chicago, and Portage. There are three combined sewer overflows located on the West Branch of the Little Calumet River, west of Interstate 65, in Gary. Based on

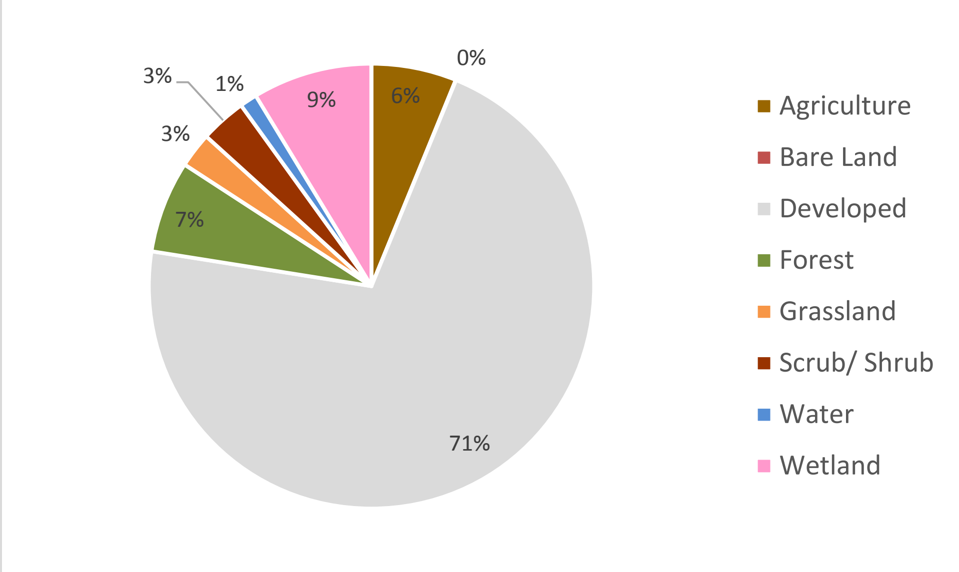


Figure 188 Percent land cover within the Little Calumet River Subwatershed

Table 76 includes information on the percentage of land types within each site's drainage area. Site 5 & 6 have identical percentages of land cover types within their respective drainage areas since they are located within 1/2 –mile of each other on Deep River. A majority of their drainage area is developed land. Most of the agricultural land that drains to these sites is located within Site 7's drainage area. Site 7 has the highest percentage of developed land in its drainage area including portions of Hobart and Portage. There are also several fields near the site where produce such as vegetables and blueberries are grown. Floodplain wetland and patches of upland forest border stretches of Deep River between US Highway 6 and Site 5. An extensive area of wetland is located in the western portion of the subwatershed south of Interstate 80/94.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
7	16.7	0.0	63.0	8.6	5.3	3.9	0.0	2.5
6	30.4	0.3	41.3	10.1	6.2	3.5	0.9	7.4
5	30.4	0.3	41.3	10.1	6.2	3.5	0.9	7.4

Table 76 Site percent land cover within the Little Calumet River Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 77. There's a relatively equal contribution of human and natural land cover types within the Site 5 and 6's riparian zones. Natural land cover is slightly more prevalent, at 60%, in Site 7's drainage area. Developed land accounts for a majority of the land cover. Generally, the large reaches of Deep River is buffered from adjacent human uses by floodplain wetland which is edged by upland forest in some areas along the river valley (Figure 174).

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
7	2.2	0.0	38.1	14.7	1.3	10.6	0.3	32.8
6	22.7	0.2	26.8	10.0	5.1	5.5	3.2	26.6
5	22.6	0.2	26.8	10.0	5.1	5.5	3.2	26.6

Table 77 Site percent riparian land cover within the Little Calumet River Subwatershed

There are no NPDES permitted industrial facilities or waste water treatment plants documented in the subwatershed. The TMDL identified five Gary Sanitary District waste water treatment plant combined sewer overflows in the subwatershed (Figure 189). Between 2009 and 2013 there were 260 combined sewer overflow events.

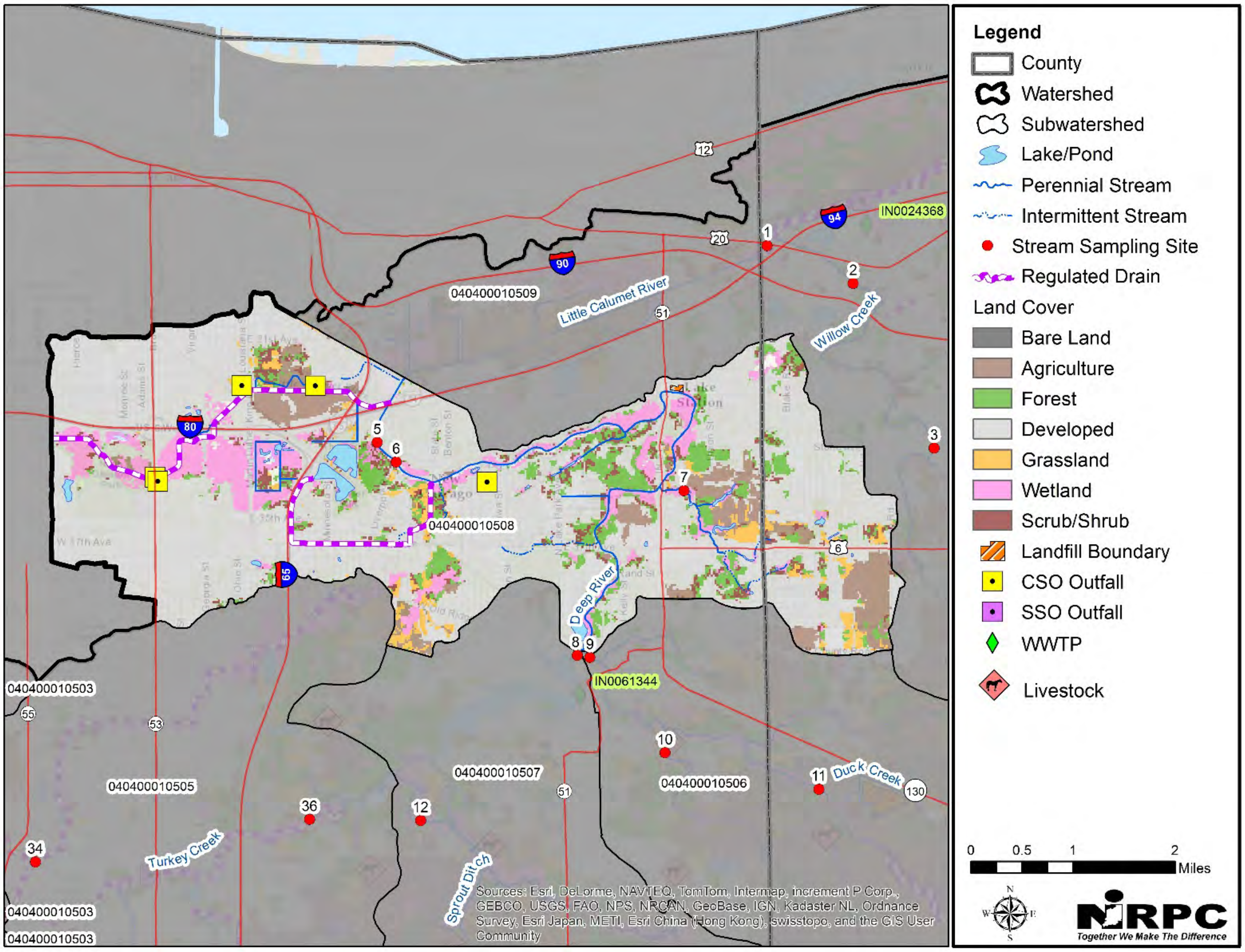


Figure 189 Land cover and land use within the Little Calumet River Subwatershed

4.8.4 Soils

Figure 190 shows an extensive amount of both hydric and highly/ potentially highly erodible soils within the subwatershed. Many of the hydric soils along the West Branch of the Little Calumet River were drained when the river was channelized sometime around the 1920's. Two wide bands of highly erodible/ potentially highly erodible soils run through the subwatershed. Many of these areas have been developed except for the agricultural land around Site 7. This could explain in part the poor substrate quality observed at the site.

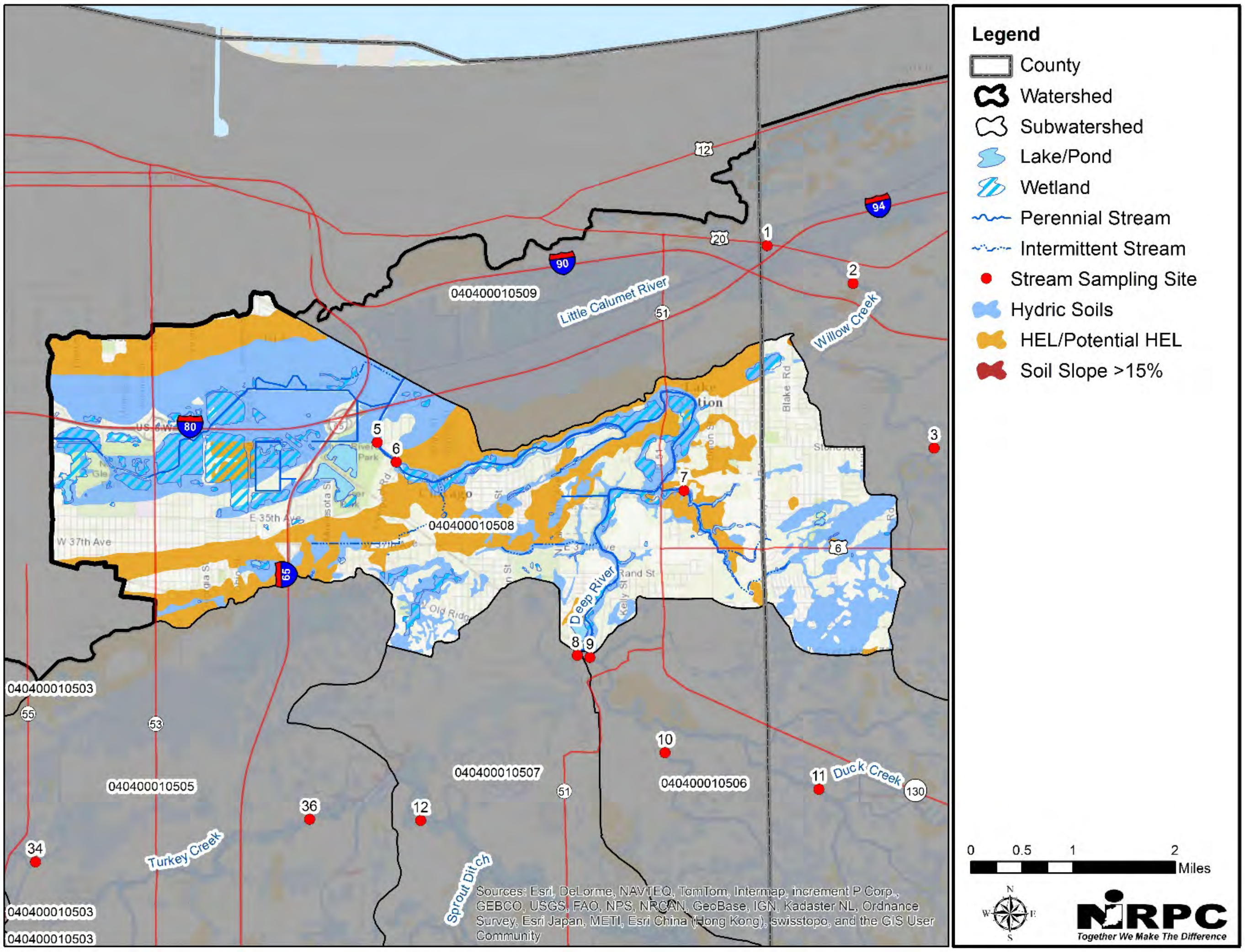


Figure 190 Soils within the Little Calumet River Subwatershed

4.9 Willow Creek-Burns Ditch Subwatershed (HUC 040400010509)

4.9.1 Overview

The Willow Creek-Burns Ditch subwatershed is located in the northern tier of the watershed. It drains approximately 20.9 mi² of primarily developed (56%) and agricultural land (20%). Based on the monitoring completed by IDEM, three stream segments have been identified as impaired. Known water quality problems include low dissolved oxygen levels, impaired biotic communities, high E. coli levels.

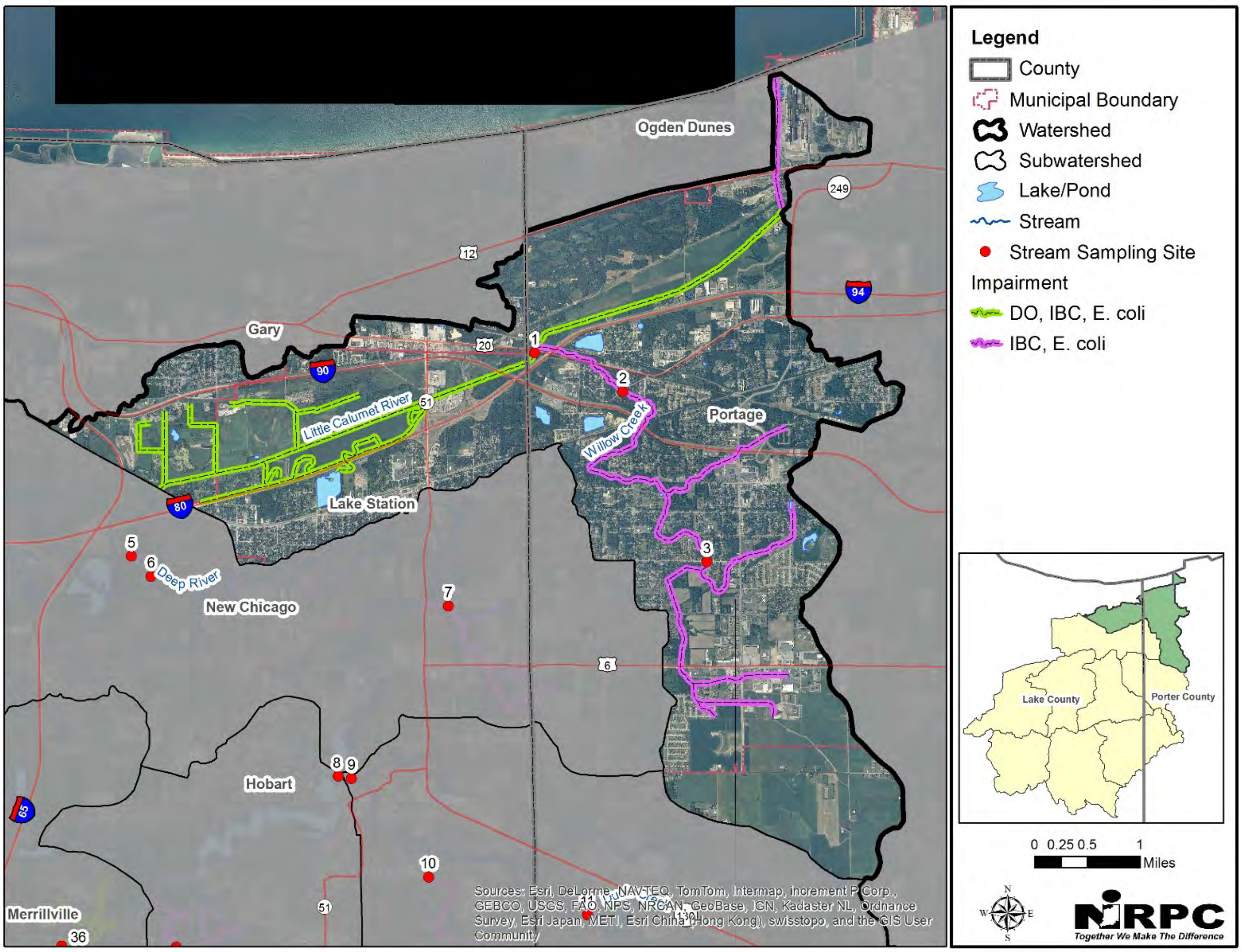


Figure 191 Impaired streams withing the Willow Creek Subwatershed

4.9.2 Water Quality

IDEM collected water quality data at three monitoring stations (Sites 1-3) within the subwatershed (Figure 191). Site 1 was used to represent the subwatershed and to assess its contribution to the overall Deep River- Portage Burns Waterway watershed.

4.9.2.1 *Pathogens*

Figure 192 shows that recreational use of the subwatershed's streams is threatened by elevated pathogen levels. All sites regularly violate the *E. coli* single sample water quality standard with median concentrations exceeding 235 CFU/100 mL. Sites 2 and 3, located on Willow Creek, had much higher *E. coli* levels than observed at Site 1 on the

Little Calumet River. There is a slight decrease in *E. coli* concentrations moving downstream from Site 3 to Site 2. Exceedances occurred across dry to high flow stream conditions indicating inputs from point and nonpoint sources.

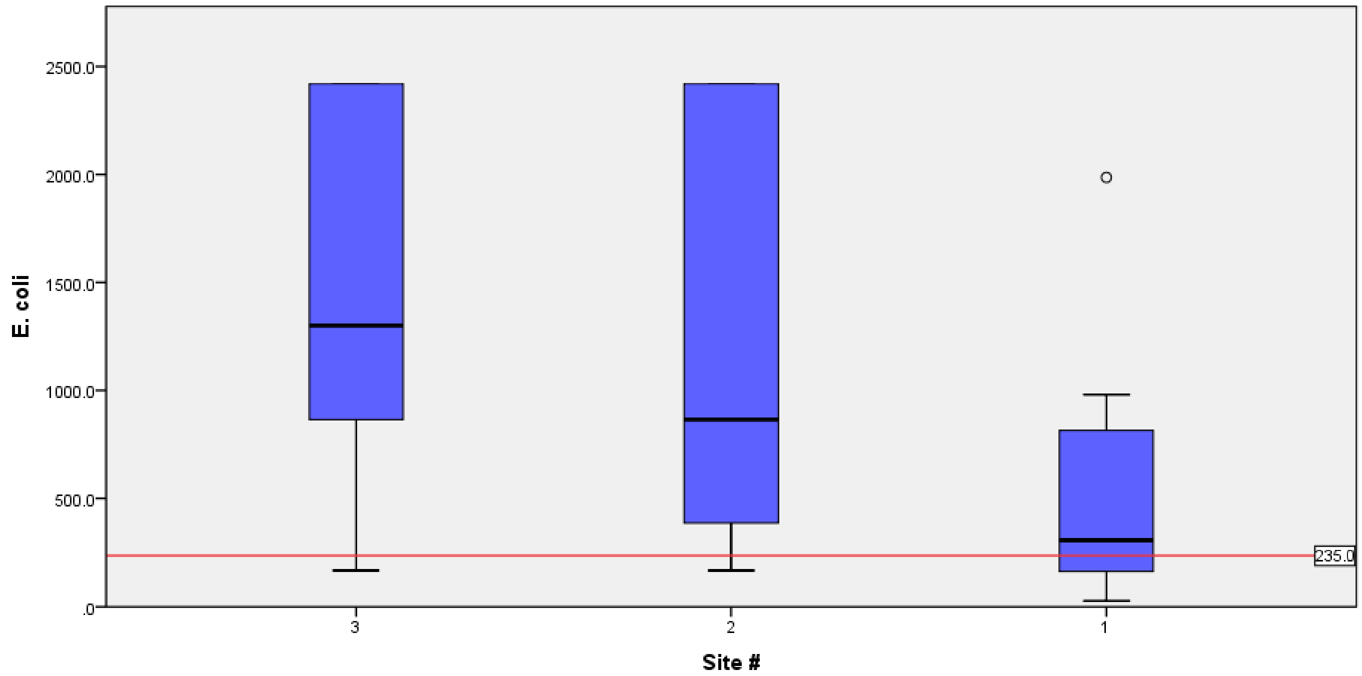


Figure 192 Box plot illustrating E. coli concentrations within the Willow Creek Subwatershed

4.9.2.2 *Fish*

An assessment of fish community structure shows that Sites 1-3 are not supporting of their Aquatic Life Use designation. The individual metrics used to evaluate the fish communities revealed that species sensitive to pollution and habitat degradation were lacking. Metric scores that evaluated trophic structure, the position the fish occupies in the food chain (ex. carnivore or insectivore), indicated environmental degradation at Sites 1- 2 and to some degree at Site 3.

Site	IBI Score	Aquatic Life Use Support	Integrity Class	Attributes
3	30	Not Supporting	Poor	Many expected species absent or rare, tolerant species dominant
2	12	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant
1	16	Not Supporting	Very Poor	Few species and individuals present, tolerant species dominant

Table 78 Site fish index of biotic integrity scores within the Willow Creek Subwatershed

4.9.2.3 *Macroinvertebrates*

An assessment of macroinvertebrate community structure showed that Sites 2-3 are not supporting of their Aquatic Life Use designation. While Site 1 was found to be fully supporting, it only received a "fair" integrity class rating. All sites were dominated by macroinvertebrates that are tolerant of pollution and habitat degradation. Metric scores that evaluated trophic structure indicated some degree of environmental degradation as well.

Site	mIBI Score	Aquatic Life Use Support	Integrity Class	Attributes

3	26	Not Supporting	Poor	Intolerant and sensitive species absent, skewed trophic structure
2	22	Not Supporting	Poor	Intolerant and sensitive species absent, skewed trophic structure
1	36	Fully Supporting	Fair	Many expected species absent or rare, tolerant species dominant

Table 79 Site macroivertebrate index of biotic integrity scores within the Willow Creek Subwatershed

4.9.2.4 *Water Temperature*

None of the stream temperatures observed in the subwatershed exceeded the state water quality standard maximum limit for any month. The average summer water temperatures, typically the most stressful period for aquatic organisms, ranged from 17-23°C, (63-73°F). Water temperatures on Willow Creek tended to be cooler downstream at Site 2 compared to Site 3 during much of the year.

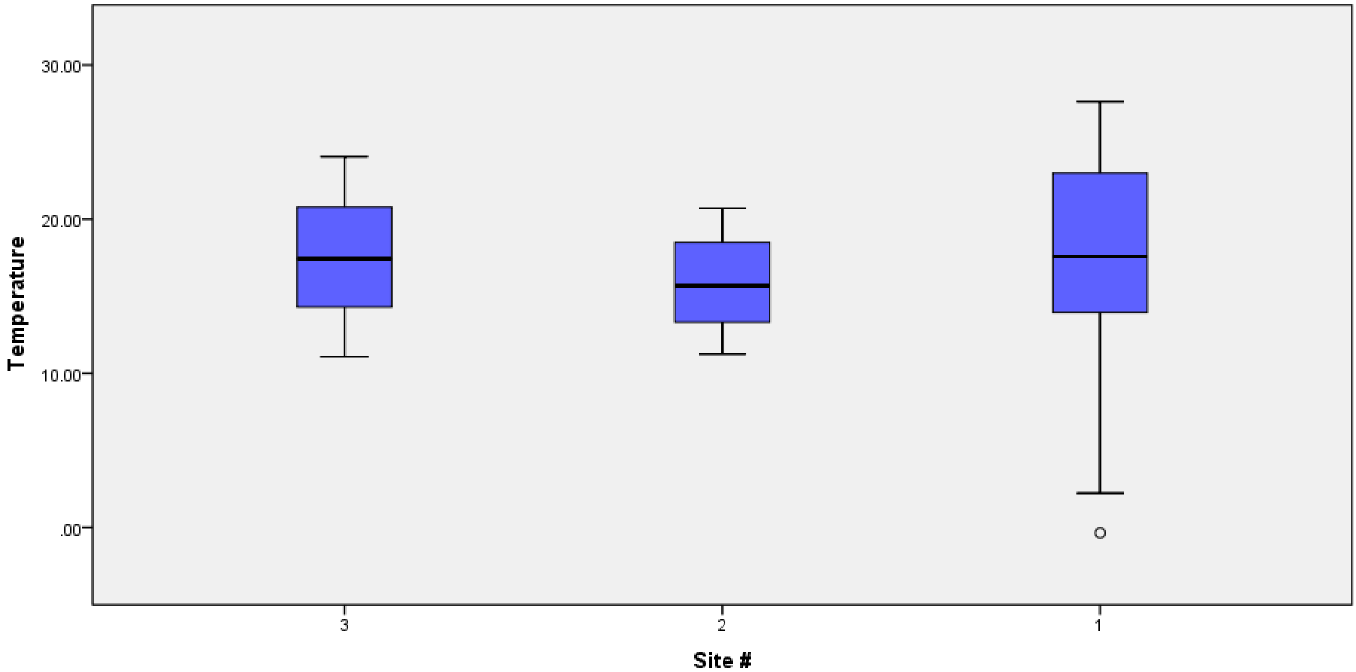


Figure 193 Box plot illustrating water temperatures within the Willow Creek Subwatershed

4.9.2.5 *Dissolved Oxygen*

Figure 194 shows that site dissolved oxygen concentrations typically met the state water quality standard with median values between 4 to 12 mg/L. Concentrations above 12 mg/L at Sites 1 and 2 occurred during late fall and early spring when water temperatures were cool. Site 1 had a single observation below 4 mg/L during the summer.

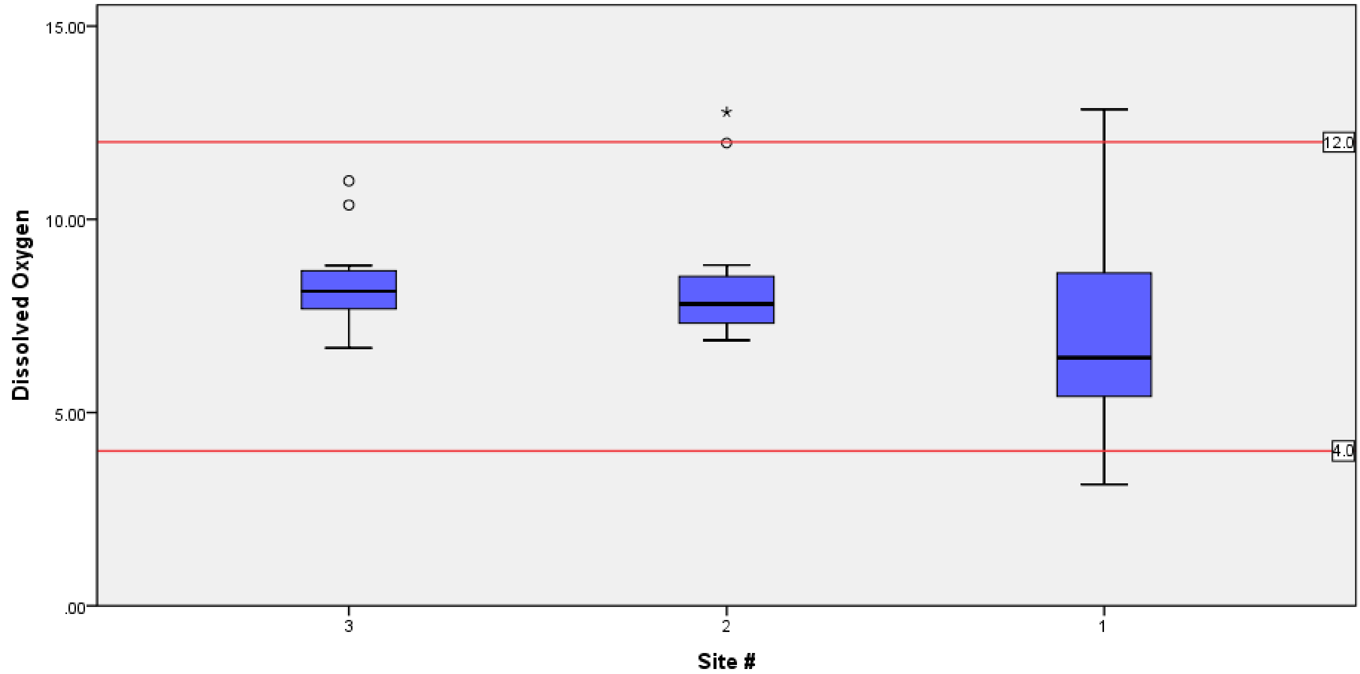


Figure 194 Box plot illustrating dissolved oxygen concentrations within the Willow Creek Subwatershed

4.9.2.6 *Total Organic Carbon*

Figure 195 generally shows an inverse trend to that observed for dissolved oxygen concentrations in the figure above. This is a good indication that organic material loading and subsequent decomposition is at least partially driving some of the dissolved oxygen issues observed at Site 1.

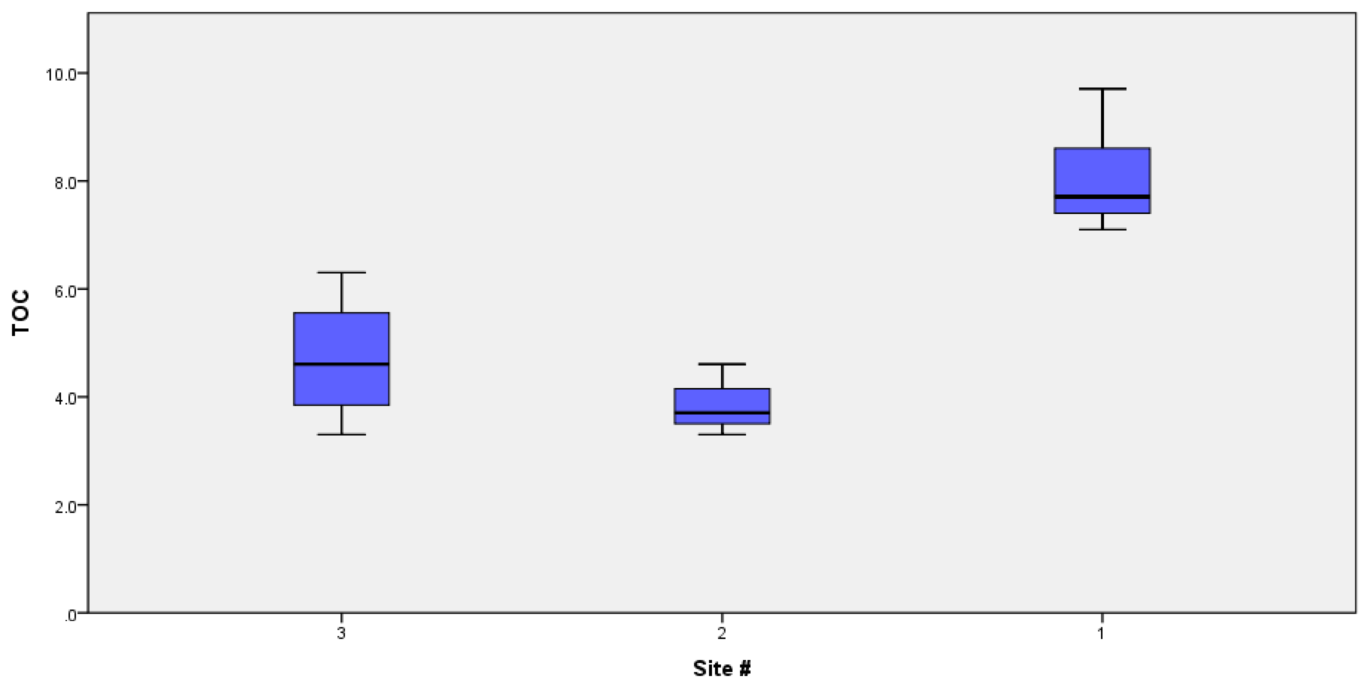


Figure 195 Box plot illustrating TOC concentrations within the Willow Creek Subwatershed

4.9.2.7 *Nutrients*

Figure 196 shows that none of the sites exceeded the 0.3 mg/L total phosphorus threshold. Site 1 had the highest median total phosphorus concentration which exceeded the 0.07 mg/L threshold. The median concentration at Sites 2 and 3 fell below the 0.07 mg/L threshold. There was a slight decrease in median concentrations from upstream at Site 3 to downstream at Site 2. Seasonally, total phosphorus concentrations were highest during the summer for Sites 2 and 3. However, statistically there was no significant difference observed across seasons.

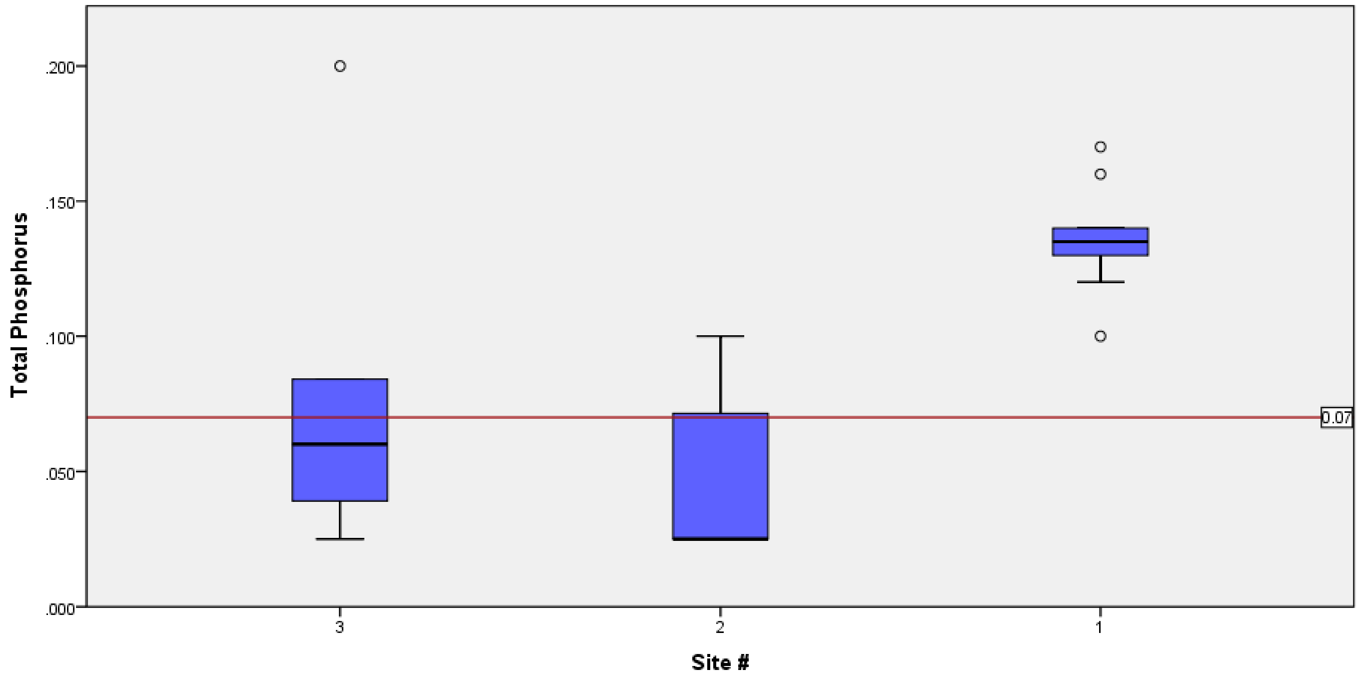


Figure 196 Box plot illustrating total phosphorus concentrations within the Willow Creek Subwatershed

Figure 197 shows that none of the sites exceeded the 10 mg/L nitrate threshold. However, Sites 2 and 3 had median concentration above the 1.09 mg/L threshold. The figure shows a decreasing trend in nitrate concentrations from Site 3 downstream to Site 2.

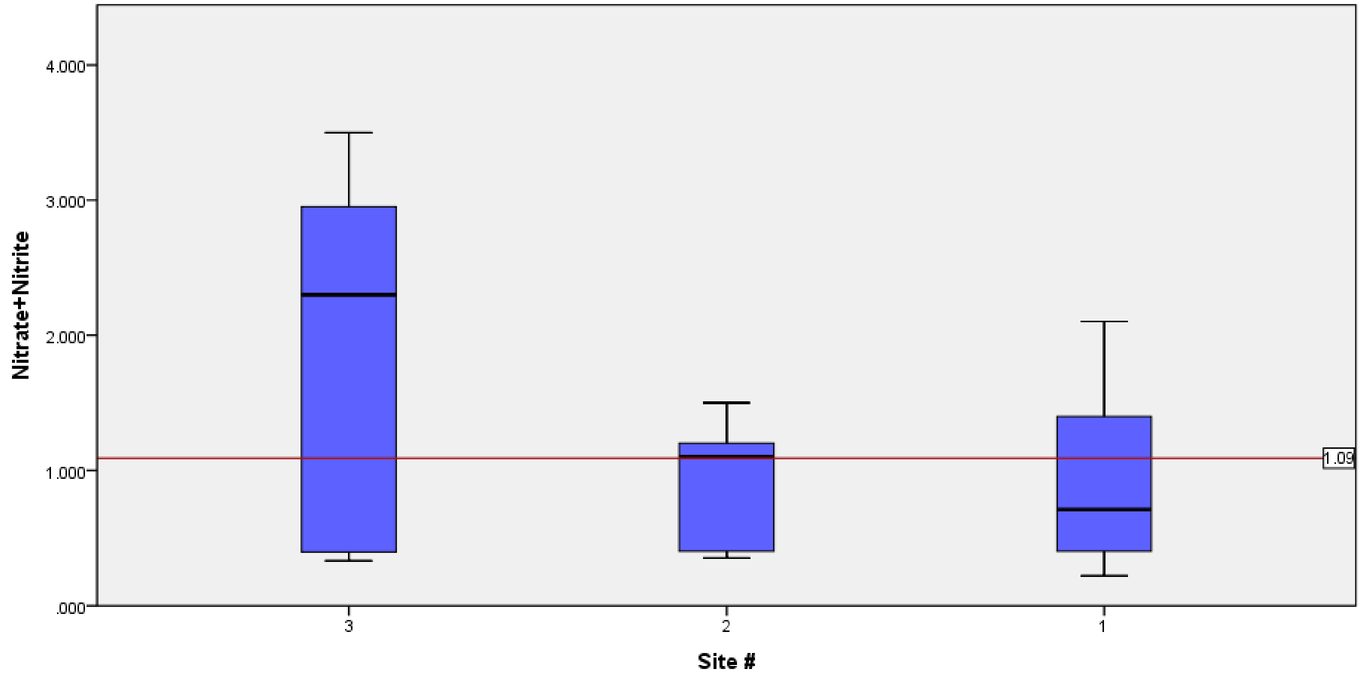


Figure 197 Box plot illustrating nitrate concentrations within the Willow Creek Subwatershed

Figure 198 shows that all site median total Kjeldahl nitrogen concentrations fell between the 1.27 and 0.4 mg/L thresholds. Site 1 consistently had the highest concentrations observed during the study period.

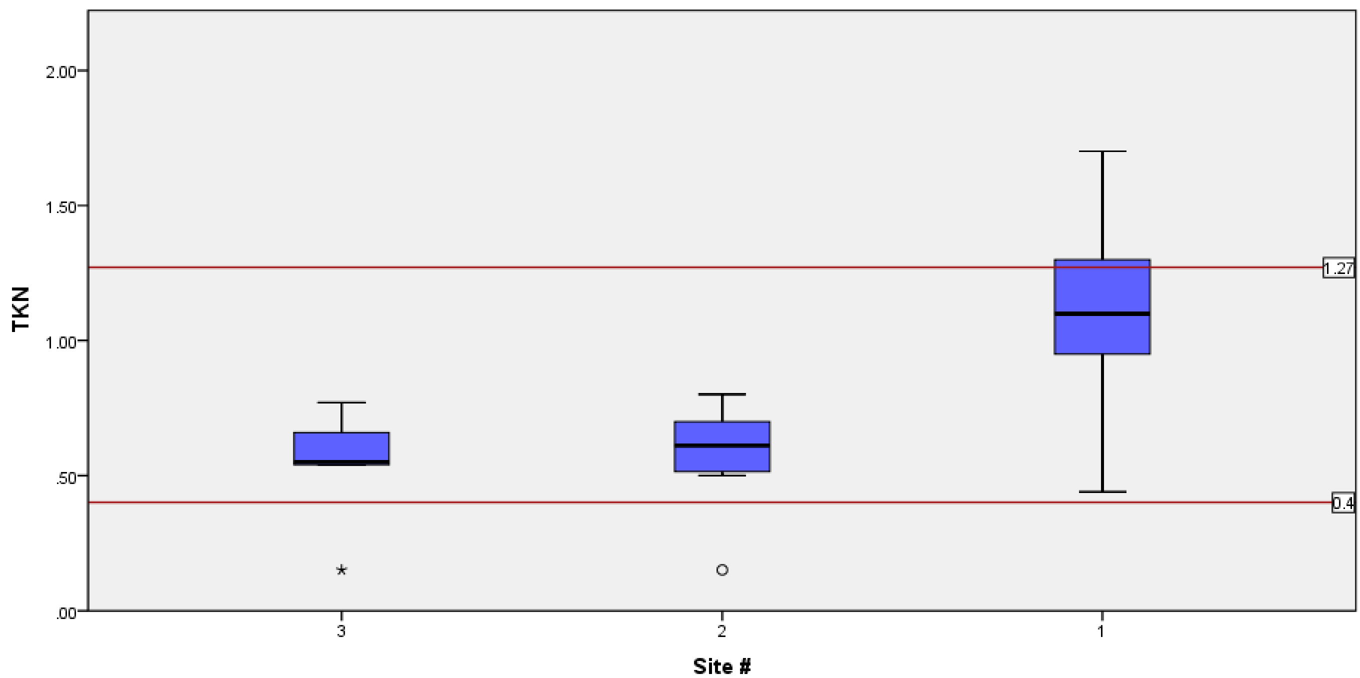


Figure 198 Box plot illustrating total Kjeldahl nitrogren concentrations within the Willow Creek Subwatershed

Figure 199 shows that none of the sites exceeded the maximum ammonia threshold of 0.21 mg/L. However Sites 1 and 3 have median concentrations above 0.03 mg/L threshold. Ammonia concentrations at Site 2 were typically below laboratory detection limits. The maximum concentrations observed were 0.17 mg/L at Site 1, 0.20 mg/L at Site 2, and 0.16 mg/L at Site 3.

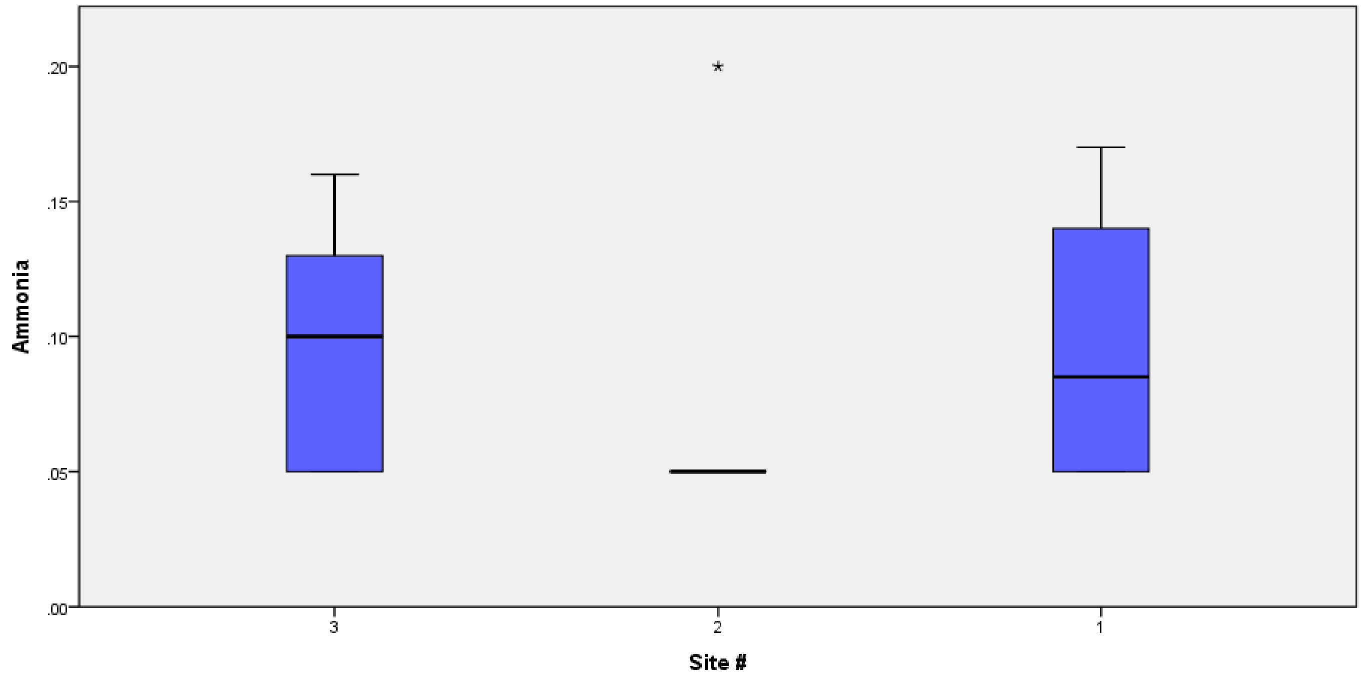


Figure 199 Box plot illustrating ammonia concentrations within the Willow Creek Subwatershed

4.9.2.8 *Suspended Sediment & Turbidity*

Figure 200 shows that site median total suspended solids concentrations fell below the 30 mg/L threshold.

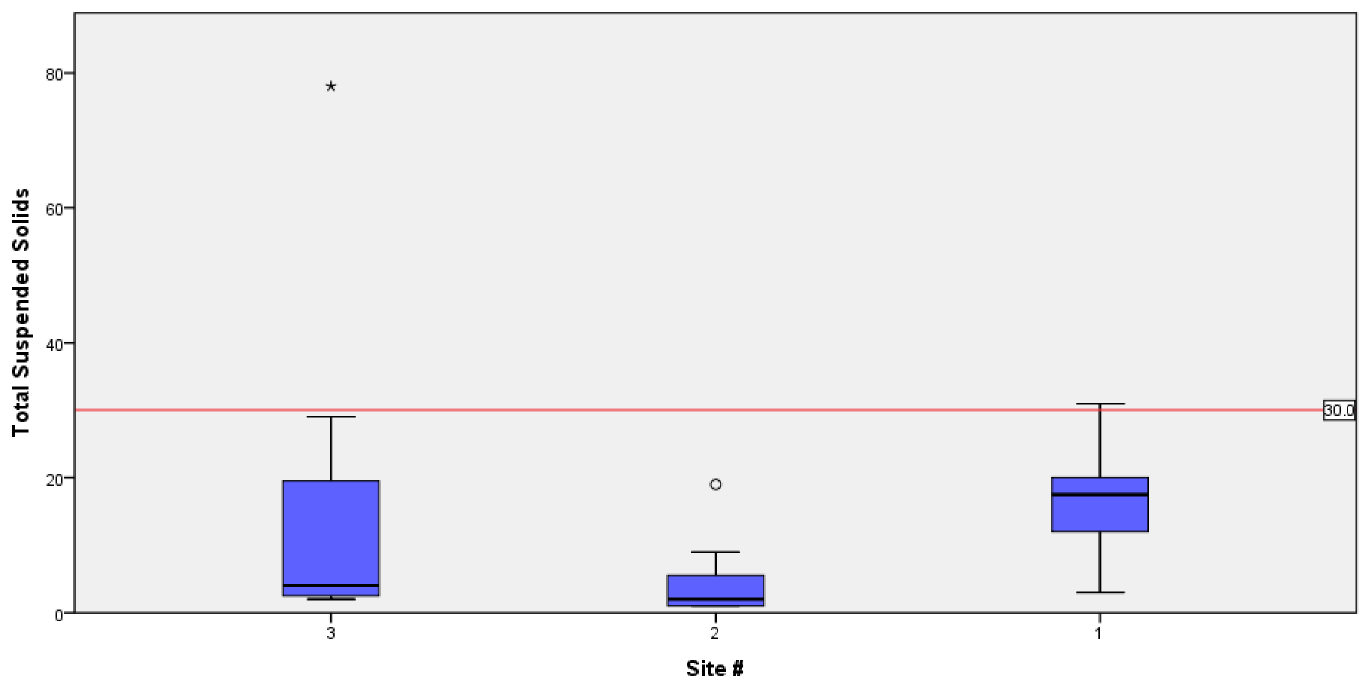


Figure 200 Box plot illustrating total suspended solids concentrations within the Willow Creek Subwatershed

Figure 201 shows similar site trends in turbidity levels to those observed for total suspended solids above. Median turbidity levels at Site 1 exceeded the 10.4 mg/L threshold.

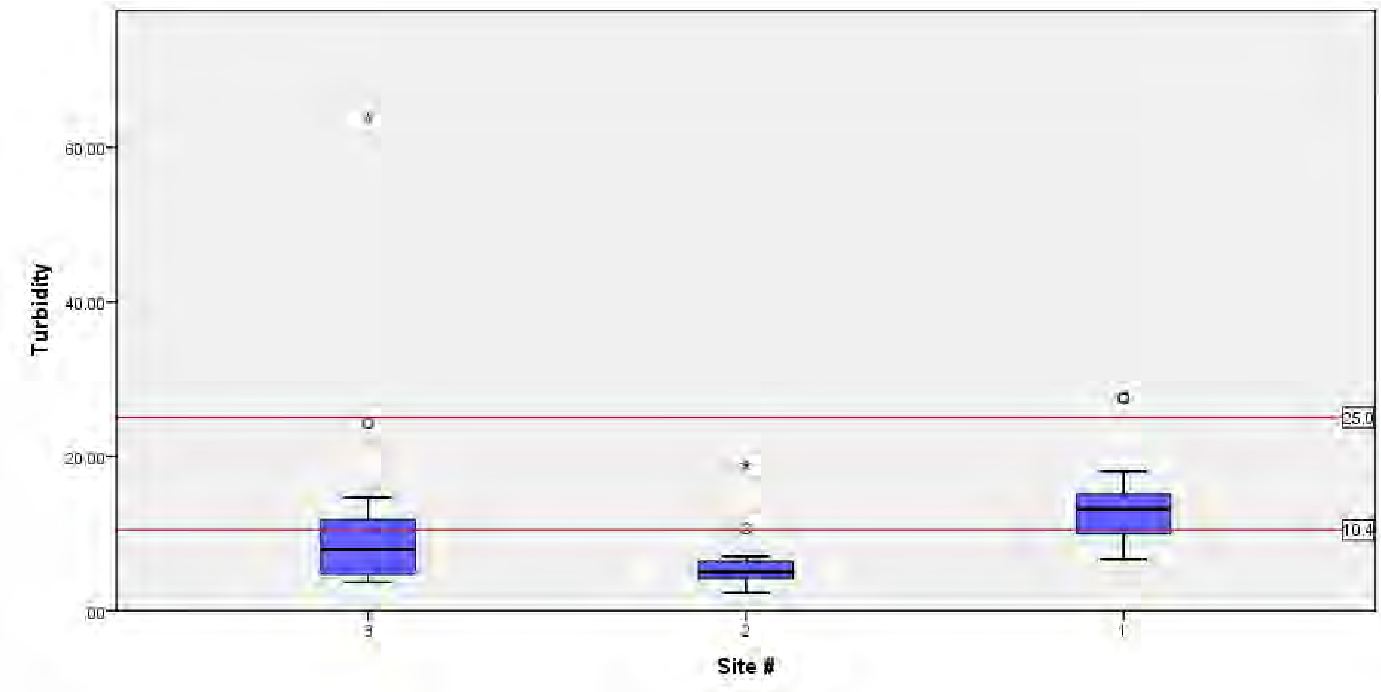


Figure 201 Box plot illustrating turbdity levels within the Willow Creek Subwatershed

4.9.2.9 *Habitat*

Figure 202 shows that Site 1 on Burns Ditch and Site 3 on Willow Creek generally do not possess habitat quality conducive of supporting a healthy warm water fishery (QHEI <51). The major habitat limitation at these sites include poor channel morphology and instream cover as well as relatively poor substrate quality. The habitat evaluation forms showed both of these stream reaches had been channelized in the past but were beginning to show some level of recovery. Upstream and downstream site photos at each site show the typical trapezoidal channel cross-section associated with drainage improvement. Channel stability was documented as moderate to low respectively. Substrates at Site 1 were primarily characterized as sand with strong inclusions of muck and silt. Silt cover and embeddedness were moderate. Substrates at Site 3 were characterized as sand with normal silt cover and embeddedness. Habitat complexity was low at each site and the amount of cover was sparse.

While Site 2 was found to have habitat quality that is generally conducive to supporting a healthy warm water fishery, the stream reach may be atypical in the Willow Creek system. Fish and macroinvertebrate assessments indicate that the reach is biologically impaired. The number of species and individuals collected were some of the lowest in the entire watershed. There does not appear to be a clear link between the biotic impairment and water quality. An inquiry to the DNR about any reported or documented fish kills came back negative which helped eliminate an episodic event. Further investigation points more towards a biotic response to a habitat stressor. Site visits conducted with City of Portage staff upstream and downstream of Site 2 showed areas of channel instability (slumping banks, unvegetated mid-channel and side bars, and leaning trees) and limited to no access to floodplain.

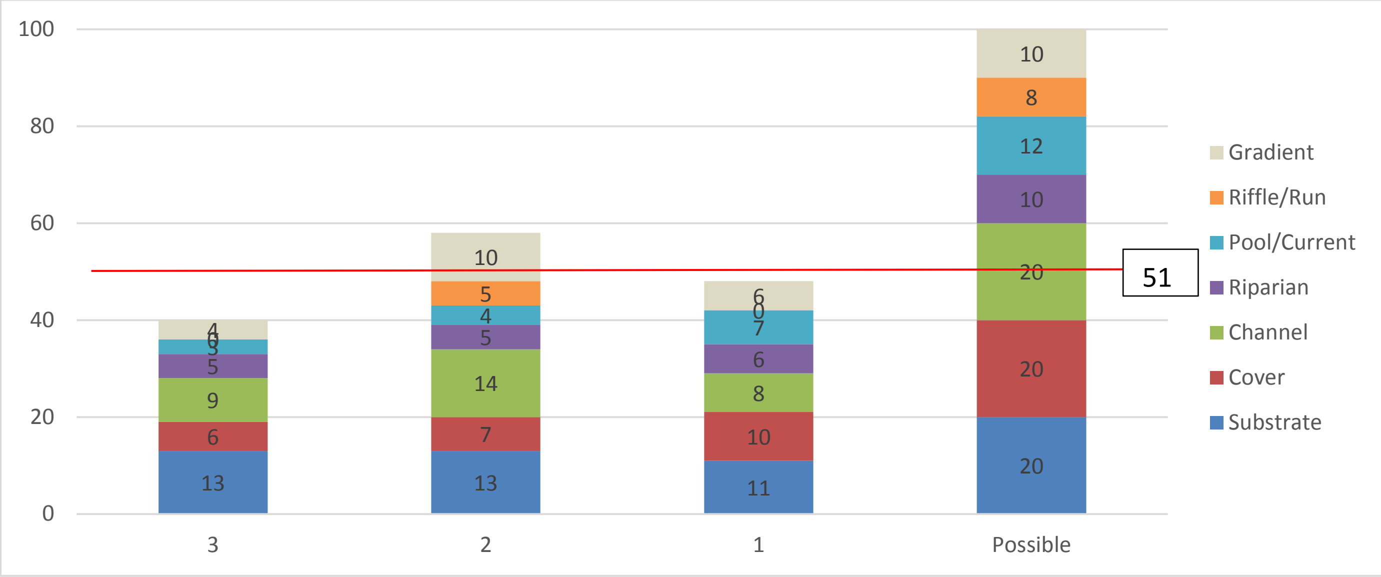


Figure 202 Site qualitative habitat evaluation index scores within the Willow Creek Subwatershed

The poor habitat quality is symptomatic of the waterways being excavated into existence or modified to improve drainage. Site 1 located on Burns Ditch is maintained as a county legal drain as are two of the tributaries to Willow Creek (Figure 204). Willow Creek is not a county legal drain, however, the City of Portage maintains it to improve drainage.

4.9.3 Land Use & Land Cover

Overall, the predominant land cover type within the subwatershed is developed lands (56%) followed distantly by agriculture (20%) (Figure 203). Portions of Gary, Lake Station, New Chicago, and Portage are located within the subwatershed. Almost the entirety of Willow Creek's drainage area is located within Portage. There is one combined sewer overflow located on a ditch that feeds into the Little Calumet River in Gary. Most of the urbanized areas within the subwatershed are sewered.

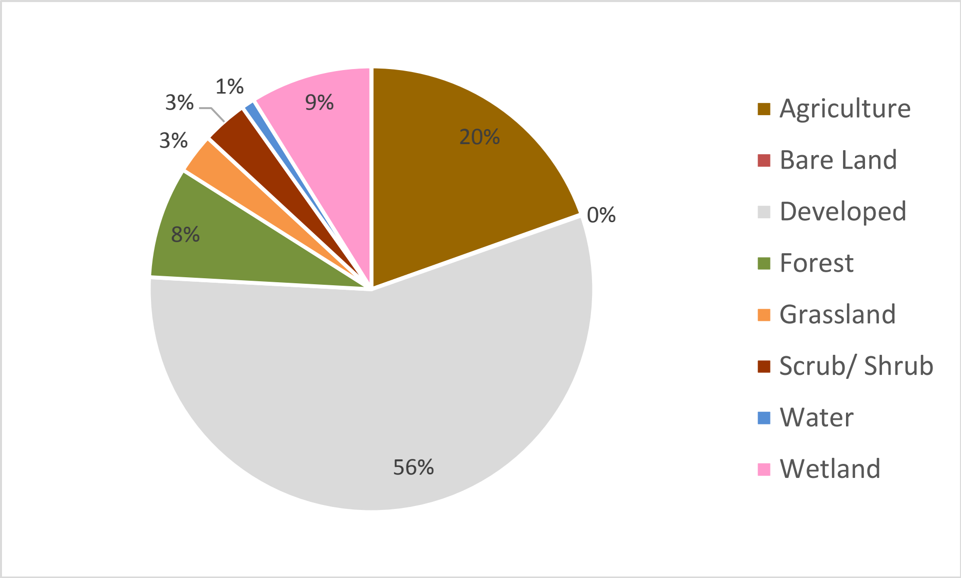


Figure 203 Percent land cover within the Willow Creek Subwatershed

Table 80 includes land cover information for each site's drainage area. Site 1 has nearly an equal mix of agricultural and developed land within its drainage area. Most of its agricultural land lies directly adjacent to the Little Calumet River between Interstate 80-94 and Interstate 90. Site 2 and 3's drainage areas are primarily developed except for the southernmost extent which is agricultural. No substantial natural cover is apparent along the Little Calumet River buffering it from adjacent land uses, however patches of forest and scrub/shrub habitat can be observed along portions of Willow Creek (Figure 204).

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
3	46.7	0.0	45.4	1.8	2.5	1.8	0.2	1.6
2	29.3	0.0	56.4	6.2	1.7	3.1	0.1	3.1
1	28.5	0.3	43.8	9.5	5.9	3.5	0.9	7.7

Table 80 Site percent land cover within the Willow Creek Subwatershed

Riparian land cover information for each site's drainage area is provided in Table 81. There's a relatively equal contribution of human and natural land cover types within Site 1 and 3's riparian zones. The riparian zone in Site 2's drainage area is predominately developed with agriculture making a very small contribution.

Site	% Agriculture	% Bare Land	% Developed	% Forest	% Grassland	% Scrub/ Shrub	% Water	% Wetland
3	22.4	0.2	27.6	9.8	4.9	5.7	3.1	26.2
2	1.6	0.0	56.6	15.0	3.3	12.7	0.3	10.5
1	22.4	0.2	27.6	9.8	4.9	5.7	3.1	26.2

Table 81 Site percent riparian land cover within the Willow Creek Subwatershed

The TMDL identifies six NPDES industrial facilities that discharge to a waterway in the subwatershed. See TMDL for facility locations map). The TMDL does not reference any permit violations for these facilities over the five year period between 2010 and 2014. The Portage WWTP and a SSO outfall are located on Burns Ditch downstream of Site 1 (Figure 204). The TMDL documents four inspections occurred between 2010 and 2013. Violations were observed in 2013.

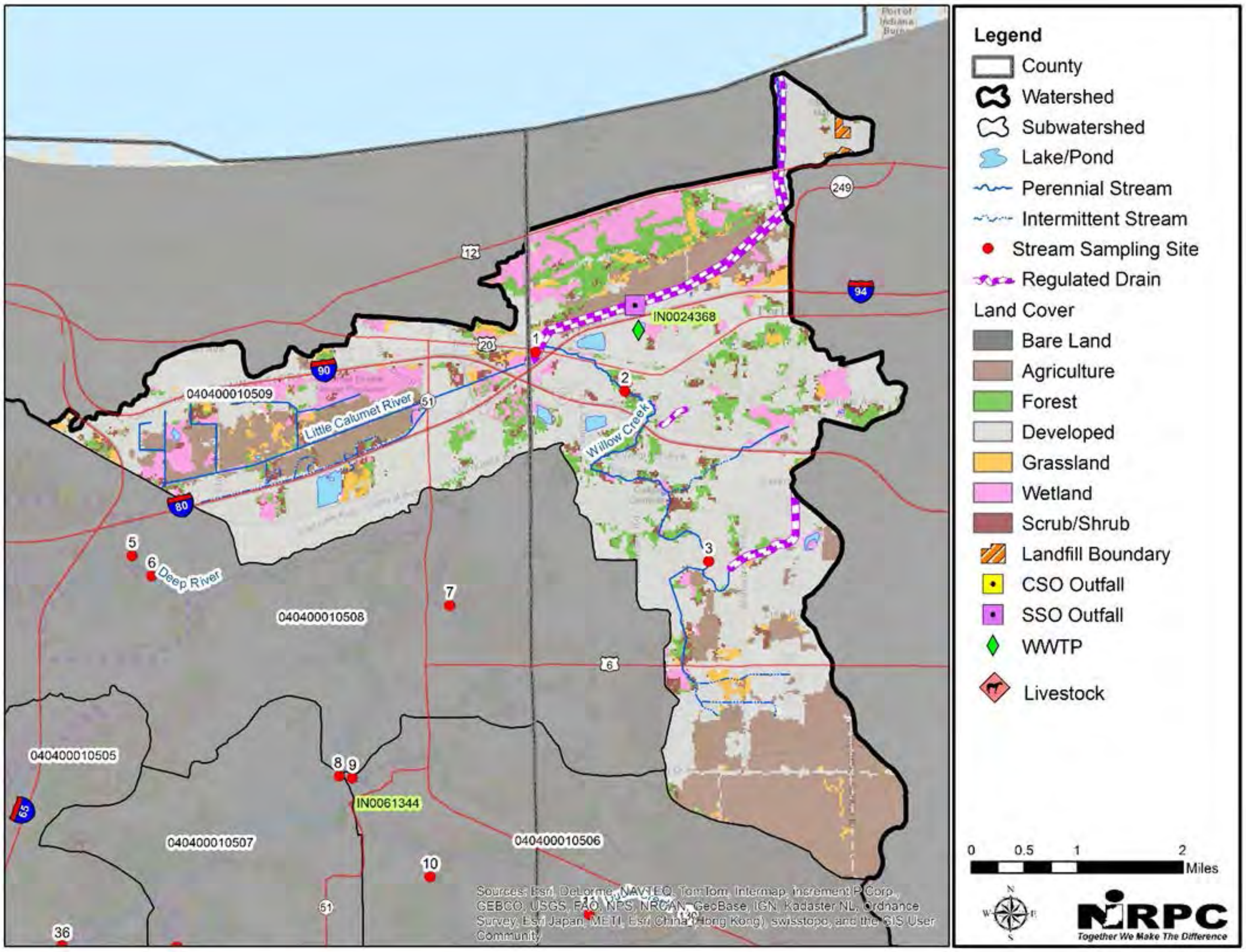


Figure 204 Land cover and land use within the Willow Creek Subwatershed

4.9.4 Soils

Figure 205 shows an extensive amount of both hydric and highly/ potentially highly erodible soils within the subwatershed. Most of the wetlands that these hydric soils developed in along the Little Calumet River were drained sometime around the 1920's when the river was channelized. Today many of these soils are either in agricultural production or have been developed on. The soils classified as highly erodible/ potentially highly erodible have also been developed on to a large extent except for the agricultural lands south of US Highway 6.

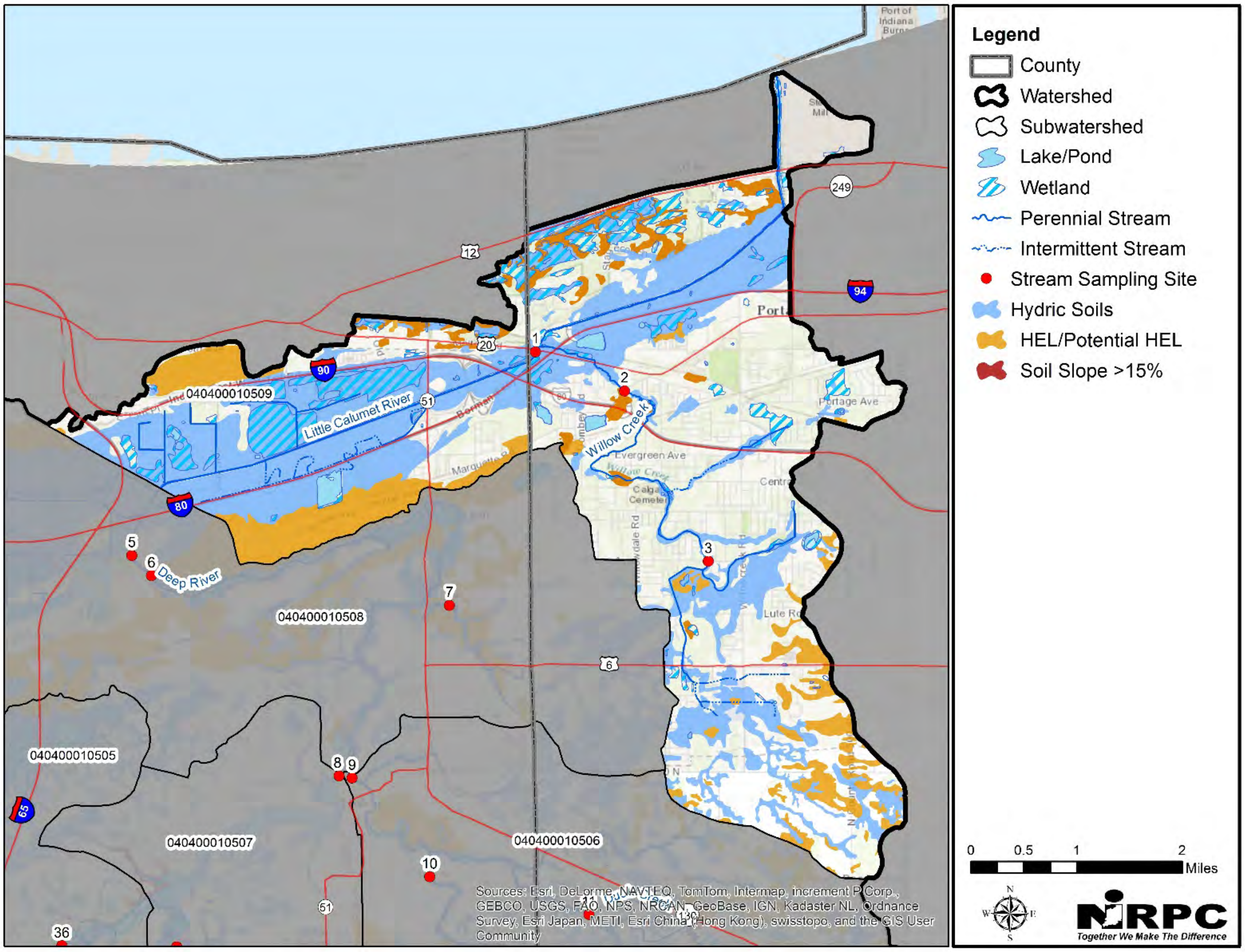


Figure 205 Soils within the Willow Creek Subwatershed

5 Watershed Inventory- Part III

5.1 Watershed Inventory Summary

Thirty five (35) stream sites were monitored over a one year period beginning in April 2013 by IDEM to support the development of our watershed plan and a Total Maximum Daily Load (TMDL) study. IDEM field crews collected *E. coli*, fish, macroinvertebrate, habitat, and water chemistry data to help determine if the streams were meeting their designated uses (i.e. are they swimmable and fishable). *E. coli* samples were collected to evaluate full body contact recreational use while fish and macroinvertebrate communities were assessed to evaluate aquatic life uses. Habitat and water chemistry data were collected to help identify potential biotic community stressors. Through this process, IDEM identified 210 miles of stream that do not support full body contact recreational use and 225 miles of stream that do not support aquatic life use.

5.1.1 Patterns & Trends Affecting Full Body Contact Recreational Use

Figure 206 shows the location of the stream segments that will be included on the draft 2016 303d List of Impaired Waterbodies for *E. coli* and the median site concentrations. Figure 207 summarizes *E. coli* concentrations for all sites in the watershed. It's apparent from these figures that full body contact recreational use is threatened throughout much the watershed.

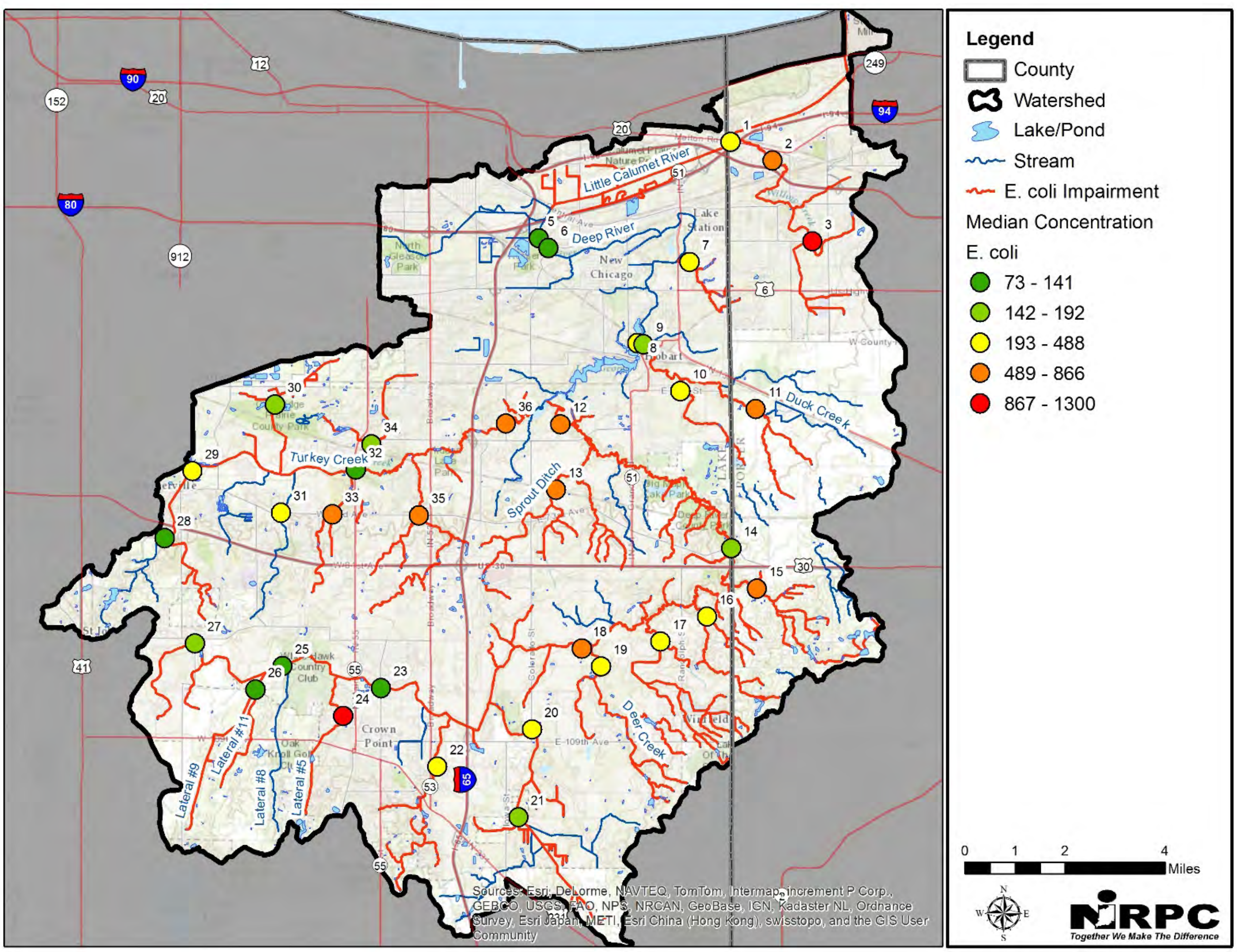


Figure 206 E. coli impaired stream reaches and sites with elevated E. coli concentrations

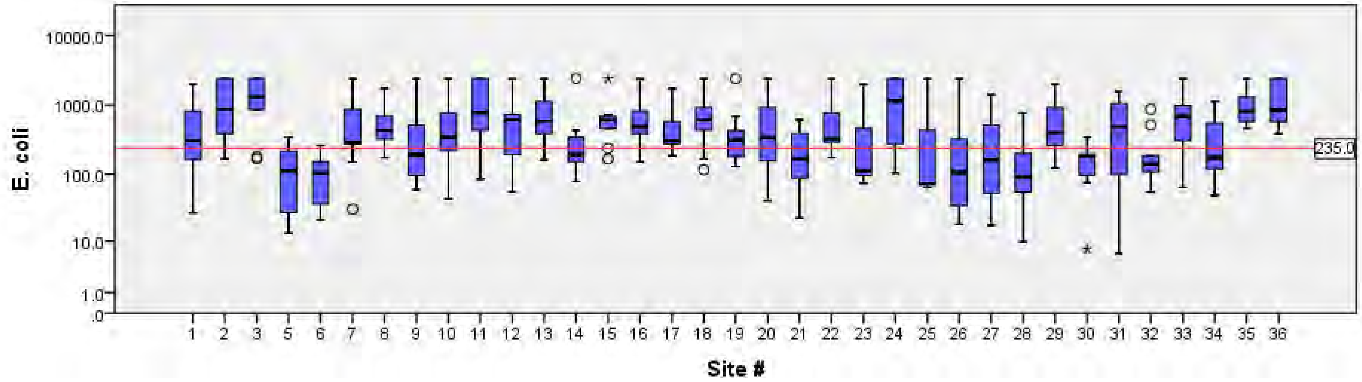


Figure 207 Box plot illustrating site E. coli concentrations within the watershed

Load duration curves for *E. coli* in the TMDL report show that many sites exceed the water quality standard across low to moderately high stream flow conditions indicating the contribution of nonpoint and at least periodic point sources. There is a strong positive correlation between *E. coli* and other water quality parameters including total solids, total dissolved solids, conductivity, and chloride (Table 83) indicating sewage as a likely source. *E. coli* is also positively correlated, although not as strongly, to riparian deciduous forest indicating wildlife sources. *E. coli* observations followed monthly/seasonal variations associated with water temperature. Median concentrations increased throughout the spring, peaking in July, before declining in the cooler fall months (Figure 208).

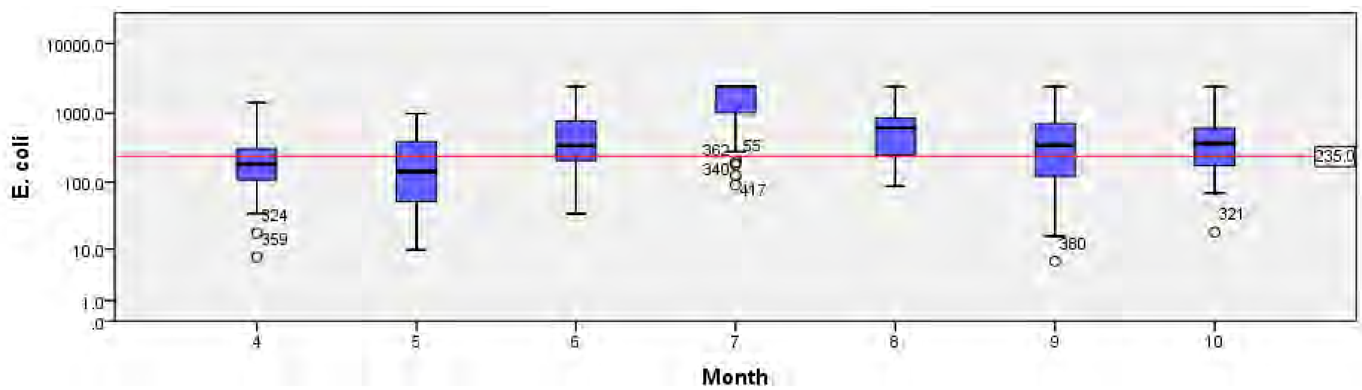


Figure 208 Box plot illustrating monthly E. coli concentrations within the watershed

5.1.2 Patterns & Trends Affecting Aquatic Life Use

Figure 209 shows the location of stream segments that will be included on the draft 2016 303d List for impaired biotic communities and stressors identified at each sampling site (i.e. failure to meet water quality and habitat targets, see Table 38). Impaired biotic communities is largely a watershed wide issue. Figure 210 summarizes dissolved oxygen, sediment and nutrient concentrations for all sites in the watershed and Figure 211 summarizes habitat data.

Since none of the streams in our watershed are designated as limited use by the State, they are required to be capable of supporting a well-balanced, warm water aquatic community whether the streams are naturally occurring or manmade systems (i.e. ditches). The water quality regulatory definition of a “well-balanced aquatic community” is “an aquatic community which is diverse in species composition, contains several different trophic levels, and is not composed mainly of strictly pollution tolerant species”. Even the best water quality monitoring sites in our watershed are characterized as lacking sensitive fish/macroinvertebrate species and having skewed trophic structures. Expected species are often absent and tolerant species dominate. The most heavily impacted reaches have few species and individuals present.

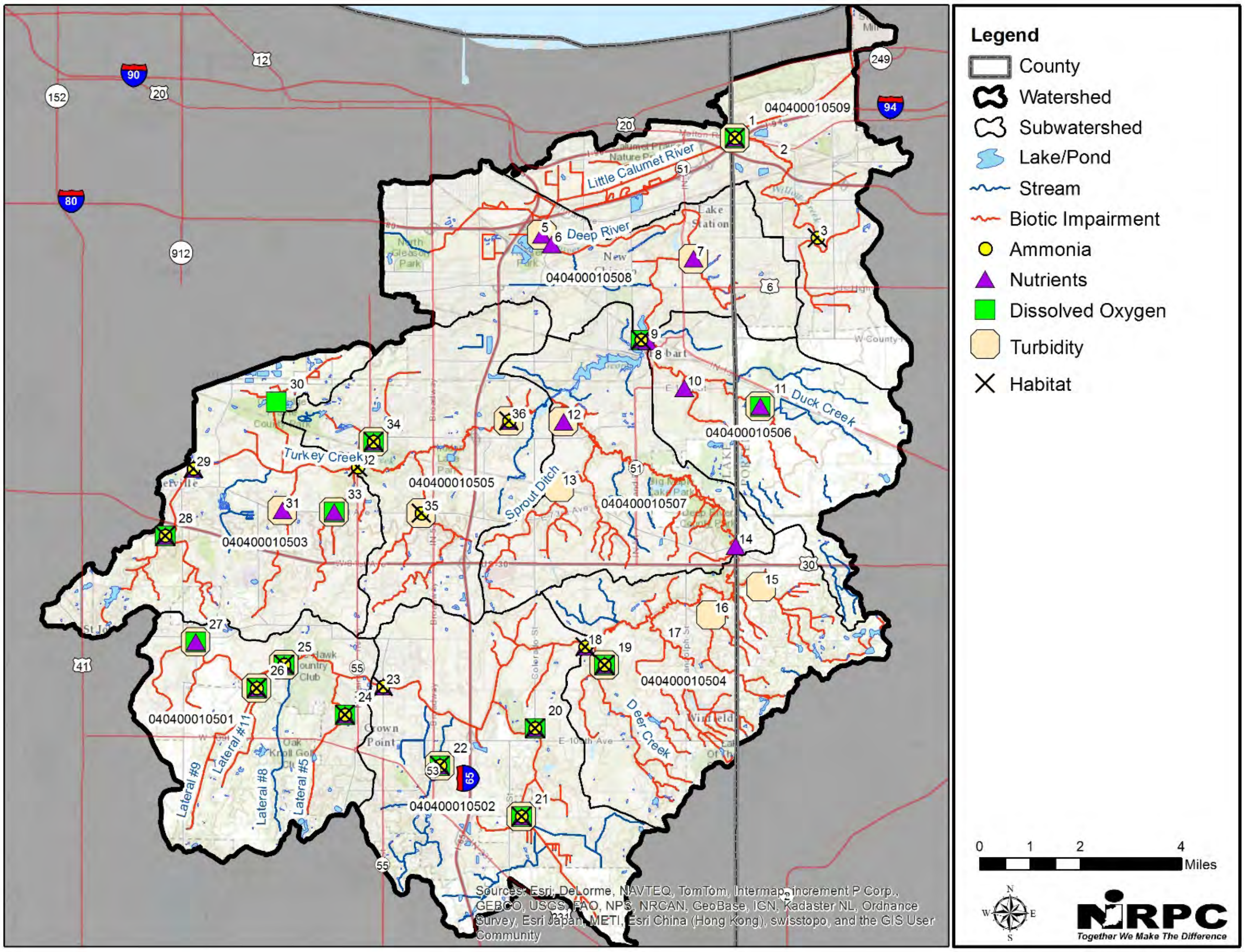
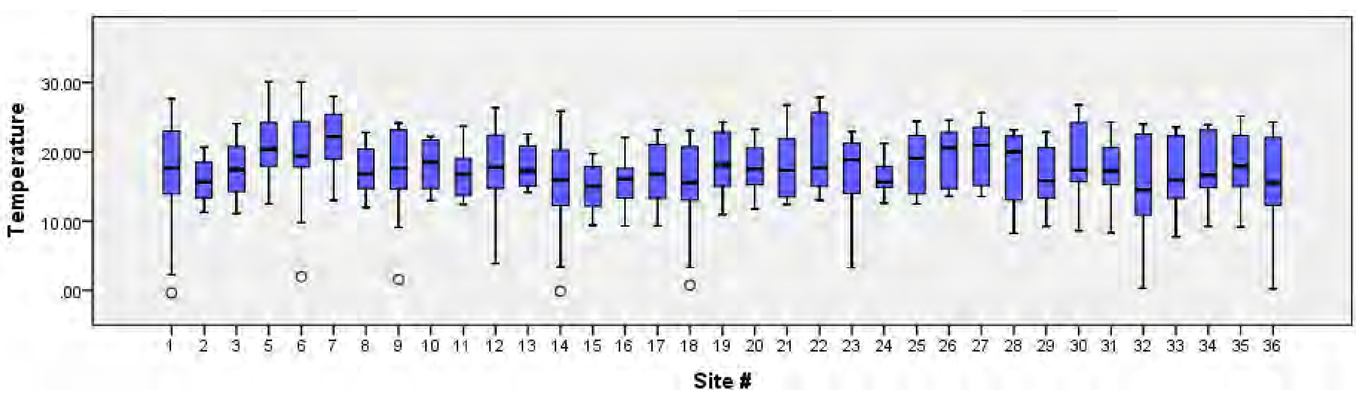
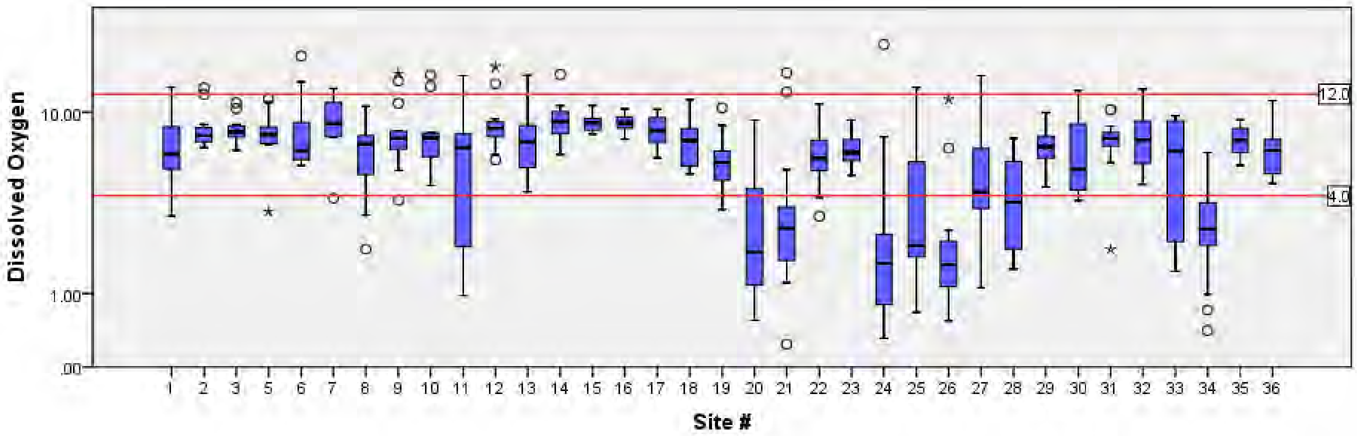
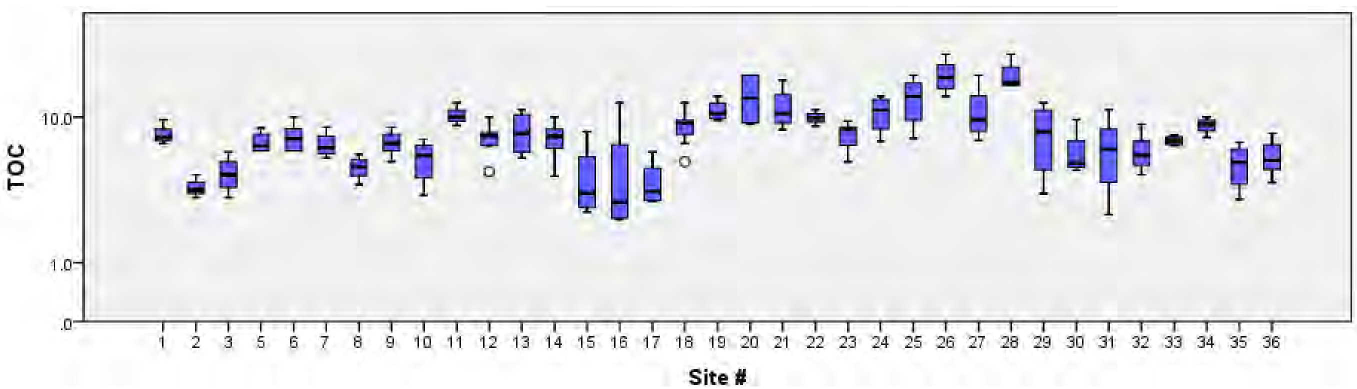


Figure 209 Biotic impairment and stressor co-occurrences




Dissolved Oxygen
10.00
1.00
.00
12.0
4.0
1 2 3 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Site #


TOC
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1 2 3 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
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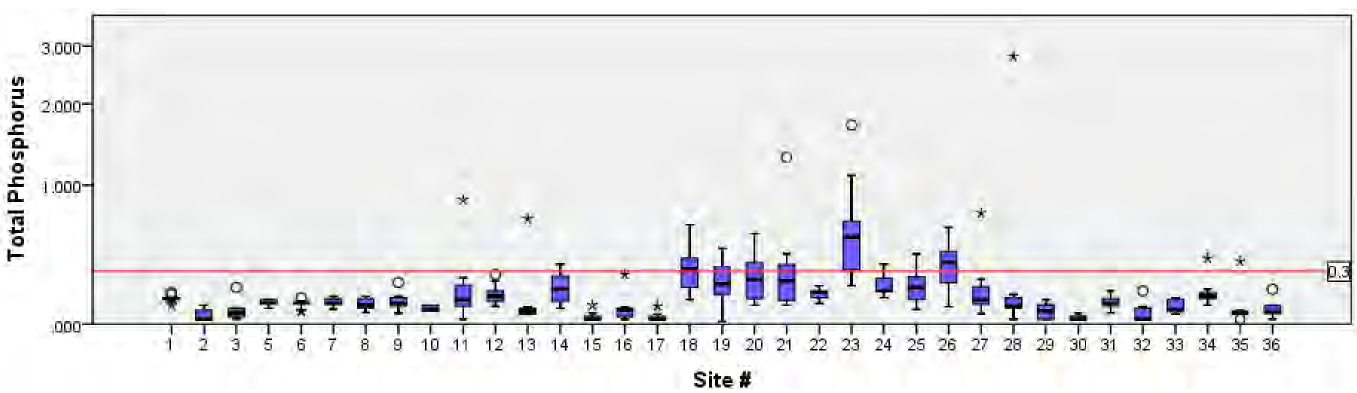
Total Phosphorus
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1 2 3 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
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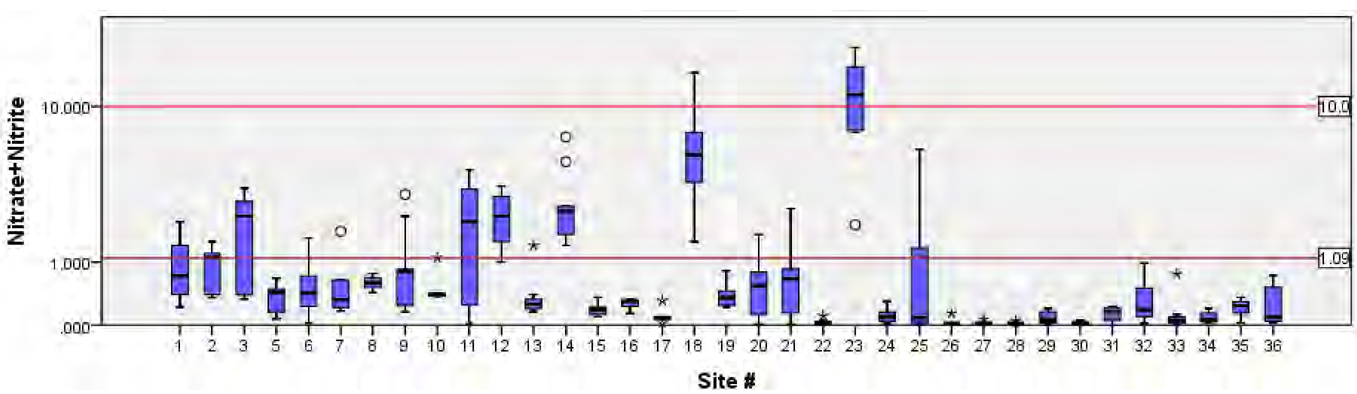
Nitrate+Nitrite
10.000
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Site #

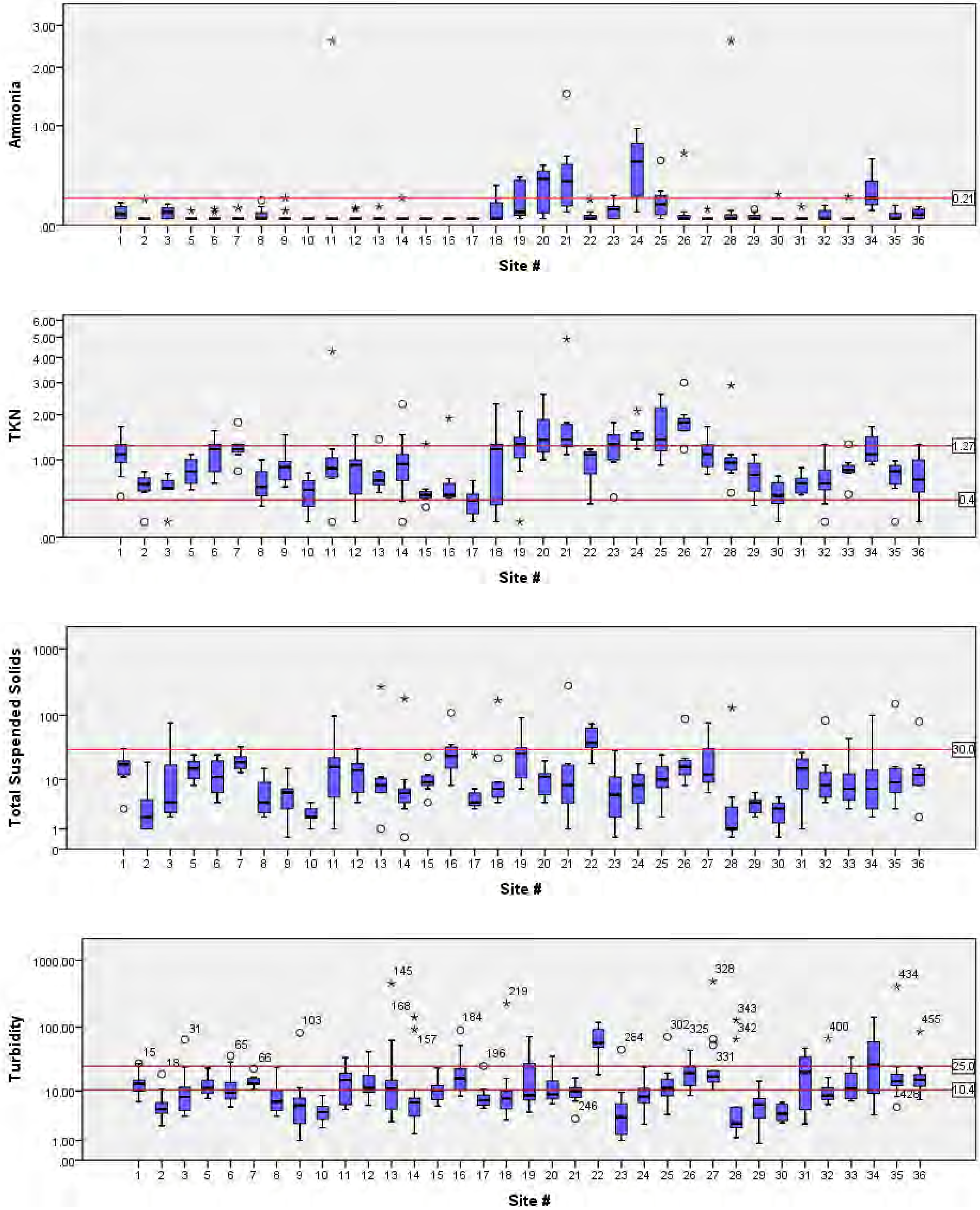


Figure 210 Box plots illustrating site temperature, dissolved oxygen, total organic carbon, sediment, and nutrient concentrations within the watershed

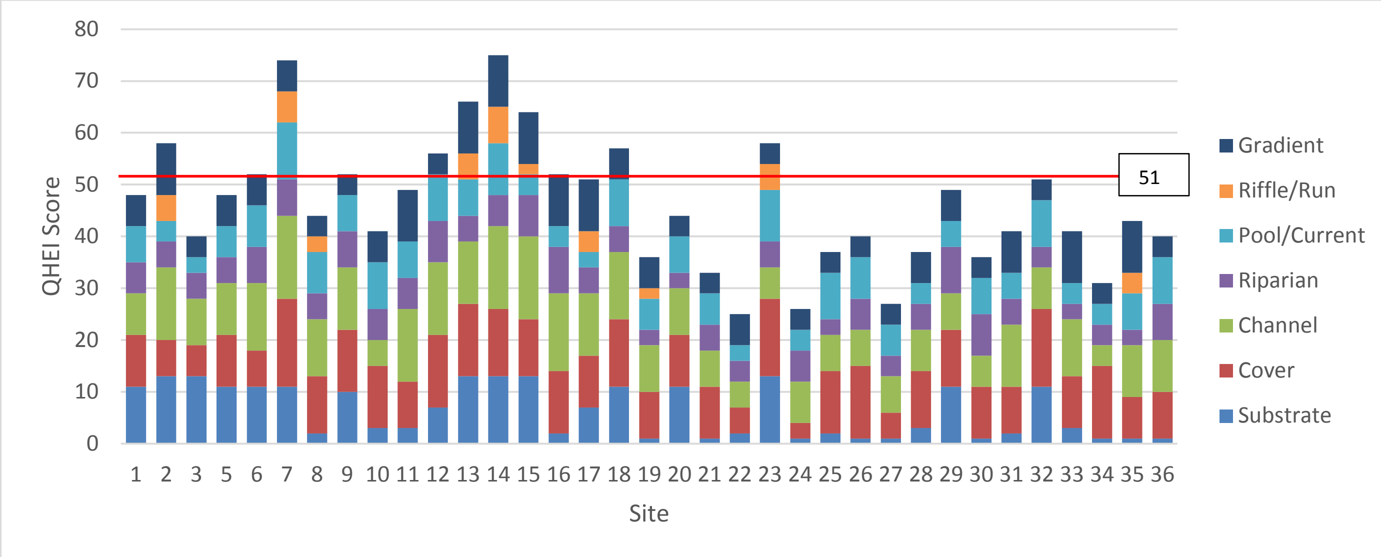


Figure 211 Site Qualitative Habitat Evaluation Index scores within the watershed

Several candidate causes (stressors) have been identified as potential contributors to the observed fish and/or benthic macroinvertebrate community impairments. These include elevated water temperatures, low dissolved oxygen levels, excess nutrient loading, ammonia toxicity, excess sediment loading, and habitat degradation. Table 82 provides a summary and initial evaluation of where the candidate causes co-occur with biotic impairments. This information is also spatially represented in Figure 209. Site 2 is the only site in which potential stressors are not readily apparent.

Low dissolved oxygen levels, excess nutrient loading, ammonia toxicity and habitat degradation are the stressors that most often co-occur with biotic impairments. The connection between water temperature and impaired biotic communities is ambiguous at this point. Additional data would be useful to explore the relationship further.

Site	Biotic Impairment		Candidate Causes/ Stressors											
			↑Temp	↓DO	↑ Nutrients			Toxicity	↑ Sediment		↓Habitat Quality			
	Fish	Macros	Temp	DO	TP	NO3	TKN	NH3	TSS	Turb	QHEI	Emb	Chan	Grad
1	Yes	No	0	0	+	0	0	0	-	+	+	+	+	0
2	Yes	Yes	0	-	-	0	0	-	-	-	-	-	-	-
3	Yes	Yes	0	-	+	0	0	0	-	0	+	-	+	+
5	Yes	No	0	-	+	-	0	-	-	+	+	+	+	0
6	No	Yes	0	-	+	-	0	-	-	0	-	+	+	0
7	Yes	Yes	0	-	+	-	0	-	-	+	-	+	-	0
8	Yes	Yes	0	0	+	-	0	0	-	0	+	+	+	0
9	Yes	Yes	0	-	+	-	0	-	-	-	+	+	+	+
10	Yes	Yes	0	-	+	-	0	-	-	-	+	+	+	0
11	Yes	Yes	0	+	+	0	0	-	-	+	+	+	-	-
12	No	Yes	0	-	+	0	0	-	-	+	-	+	-	+
13	Yes	No	0	-	-	-	0	-	-	+	-	+	+	-
14	No	No	0	-	+	0	0	-	-	-	-	-	-	-
15	Yes	Yes	0	-	-	-	-	-	-	+	-	-	-	-
16	No	Yes	0	-	+	-	-	-	0	+	-	+	-	-
17	Yes	No	0	-	-	-	-	-	-	-	+	+	+	-
18	No	No	0	-	+	0	0	0	-	-	-	+	+	0
19	Yes	Yes	0	+	+	-	+	+	0	+	+	+	+	0
20	No	No	0	+	+	-	+	+	-	0	+	+	+	+

Site	Biotic Impairment		Candidate Causes/ Stressors											
			↑Temp	↓DO	↑ Nutrients			Toxicity	↑ Sediment		↓Habitat Quality			
	Fish	Macros	Temp	DO	TP	NO3	TKN	NH3	TSS	Turb	QHEI	Emb	Chan	Grad
21	Yes	Yes	0	+	+	-	+	+	-	+	+	+	+	+
22	No	No	0	+	+	-	0	-	+	+	+	+	+	0
23	No	Yes	0	-	+	+	+	0	-	0	-	-	+	+
24	Yes	Yes	0	+	+	-	+	0	-	0	+	+	+	+
25	Yes	Yes	0	+	+	0	+	0	-	+	+	+	+	+
26	Yes	Yes	0	+	+	-	+	-	-	+	+	+	+	+
27	No	Yes	0	+	+	-	0	-	0	+	+	+	+	+
28	Yes	NA	0	+	+	-	0	-	-	-	+	+	+	0
29	No	Yes	0	-	+	-	0	-	-	-	+	+	+	0
30	Yes	Yes	0	+	-	-	-	-	-	-	+	+	+	+
31	Yes	Yes	0	-	+	-	0	-	-	+	+	+	+	-
32	No	Yes	0	-	-	-	0	0	-	0	+	+	+	+
33	Yes	Yes	0	+	+	-	0	-	-	+	+	+	+	-
34	Yes	Yes	0	+	+	-	+	+	-	+	+	+	+	+
35	Yes	Yes	0	-	-	-	0	-	-	+	+	-	+	-
36	Yes	Yes	0	-	+	-	0	0	-	+	+	+	+	+

"+" Candidate cause co-occurs with biotic impairment.
"0" Uncertain or ambiguous if the candidate cause co-occurs with biotic impairment.
"-" Candidate cause does not co-occur with biotic impairment.

Table 82 Biotic impairment and candidate cause co-occurrence scoring

In most cases, multiple stressors co-occur where biotic impairments are observed. Having multiple stressors co-occur where there are biotic impairments is not uncommon as was shown in the conceptual causal pathway diagrams included in Section 3.2. A correlation analysis was completed to explore the degree of relationships between these stressors. The results are shown below in Table 83. Red equals a statistically significant negative correlation and green a statistically significant positive correlation.

Correlation values are interpreted as follows:

- A coefficient of 0 indicates that the variables are not related.
- A negative coefficient indicates that as one variable increases, the other decreases.
- A positive coefficient indicates that as one variable increases the other also increases.
- Larger absolute values of coefficients indicate stronger associations.

		DO	DO % Sat	NH3	NO3	TKN	TP	TSS	Turb	TS	TDS	E coli	pH	Cond	Chl	TOC	COD
DO	Corr.	1.000	.981**	-.730**	.373*	-.581**	-.539**	-.146	-.179	-.294	-.055	.190	.845**	-.253	-.178	-.719**	-.632**
	Sig.	.	.000	.000	.027	.000	.001	.401	.303	.087	.753	.275	.000	.143	.305	.000	.000
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
DO % Sat	Corr.	.981**	1.000	-.762**	.347*	-.562**	-.521**	-.143	-.162	-.332	-.090	.137	.872**	-.299	-.194	-.693**	-.593**
	Sig.	.000	.	.000	.041	.000	.001	.413	.353	.051	.607	.432	.000	.081	.265	.000	.000
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
NH3	Corr.	-.730**	-.762**	1.000	.139	.637**	.612**	.174	.051	.407*	.205	-.026	-.727**	.373*	.385*	.622**	.520**
	Sig.	.000	.000	.	.426	.000	.000	.318	.773	.015	.238	.881	.000	.027	.022	.000	.001
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
NO3	Corr.	.373*	.347*	.139	1.000	.152	.216	-.067	-.211	-.052	-.019	.198	.158	.003	.101	-.090	-.054
	Sig.	.027	.041	.426	.	.384	.212	.704	.224	.767	.914	.254	.363	.986	.563	.607	.756
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TKN	Corr.	-.581**	-.562**	.637**	.152	1.000	.864**	.381*	.258	.150	.008	-.270	-.539**	.095	.161	.865**	.876**
	Sig.	.000	.000	.000	.384	.	.000	.024	.135	.389	.962	.117	.001	.587	.357	.000	.000
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TP	Corr.	-.539**	-.521**	.612**	.216	.864**	1.000	.452**	.374*	.151	-.029	-.241	-.587**	.100	.261	.852**	.873**
	Sig.	.001	.001	.000	.212	.000	.	.006	.027	.385	.867	.163	.000	.567	.131	.000	.000

		DO	DO % Sat	NH3	NO3	TKN	TP	TSS	Turb	TS	TDS	E coli	pH	Cond	Chl	TOC	COD
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TSS	Corr.	-.146	-.143	.174	-.067	.381*	.452**	1.000	.814**	.309	.201	.020	-.017	.151	.133	.388*	.486**
	Sig.	.401	.413	.318	.704	.024	.006	.	.000	.071	.247	.907	.921	.387	.445	.021	.003
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Turb	Corr.	-.179	-.162	.051	-.211	.258	.374*	.814**	1.000	.178	.050	.068	-.037	.096	.163	.354*	.425*
	Sig.	.303	.353	.773	.224	.135	.027	.000	.	.305	.774	.698	.832	.585	.349	.037	.011
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TS	Corr.	-.294	-.332	.407*	-.052	.150	.151	.309	.178	1.000	.931**	.449**	-.412*	.931**	.757**	.200	.087
	Sig.	.087	.051	.015	.767	.389	.385	.071	.305	.	.000	.007	.014	.000	.000	.249	.618
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TDS	Corr.	-.055	-.090	.205	-.019	.008	-.029	.201	.050	.931**	1.000	.469**	-.181	.899**	.680**	.017	-.065
	Sig.	.753	.607	.238	.914	.962	.867	.247	.774	.000	.	.004	.298	.000	.000	.923	.711
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
E coli	Corr.	.190	.137	-.026	.198	-.270	-.241	.020	.068	.449**	.469**	1.000	.074	.467**	.373*	-.330	-.303
	Sig.	.275	.432	.881	.254	.117	.163	.907	.698	.007	.004	.	.672	.005	.028	.053	.076
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
pH	Corr.	.845**	.872**	-.727**	.158	-.539**	-.587**	-.017	-.037	-.412*	-.181	.074	1.000	-.382*	-.369*	-.655**	-.562**
	Sig.	.000	.000	.000	.363	.001	.000	.921	.832	.014	.298	.672	.	.023	.029	.000	.000
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Cond	Corr.	-.253	-.299	.373*	.003	.095	.100	.151	.096	.931**	.899**	.467**	-.382*	1.000	.771**	.132	.018
	Sig.	.143	.081	.027	.986	.587	.567	.387	.585	.000	.000	.005	.023	.	.000	.448	.917
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Chl	Corr.	-.178	-.194	.385*	.101	.161	.261	.133	.163	.757**	.680**	.373*	-.369*	.771**	1.000	.183	.091
	Sig.	.305	.265	.022	.563	.357	.131	.445	.349	.000	.000	.028	.029	.000	.	.293	.604
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TOC	Corr.	-.719**	-.693**	.622**	-.090	.865**	.852**	.388*	.354*	.200	.017	-.330	-.655**	.132	.183	1.000	.892**
	Sig.	.000	.000	.000	.607	.000	.000	.021	.037	.249	.923	.053	.000	.448	.293	.	.000
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
COD	Corr.	-.632**	-.593**	.520**	-.054	.876**	.873**	.486**	.425*	.087	-.065	-.303	-.562**	.018	.091	.892**	1.000
	Sig.	.000	.000	.001	.756	.000	.000	.003	.011	.618	.711	.076	.000	.917	.604	.000	.
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 83 Water quality correlation analysis results

Strong negative relationships exist between dissolved oxygen (DO) and ammonia (NH3), total Kjeldahl nitrogen (TKN), total phosphorus (TP), total organic carbon (TOC), and chemical oxygen demand (COD). The breakdown of organic materials and chemical compounds, measured by TOC and COD respectively, consumes dissolved oxygen. Excess nutrient loading, measured by TKN and TP, accelerates plant and algal growth. Bacterial breakdown of dead plant material consumes oxygen. Nitrification, the conversion of ammonia to nitrate (NO3), requires oxygen. Low oxygen levels suppress this process and therefore ammonia levels build up. The correlation analysis also showed a strong positive relationship between total suspended solids (TSS) and total phosphorus and chemical oxygen demand indicating these pollutants are sediment related.

A correlation analysis was also completed to explore the degree of relationships between water quality parameters and land cover types. The results are shown below in Table 84. Red equals a statistically significant negative correlation and green a statistically significant positive correlation.

		HID	MID	LID	OSD	Cult.	Past.	Grass.	Decid. For.	Evergr. For.	Mix For.	Scrub / Shrub	For. Wet.	Scrub / Shrub Wet.	Emerg. Wet.	Bare Land	Open Water
Temp	Corr.	.121	.098	.079	.181	.044	-.274	-.114	-.079	-.113	-.222	-.198	.047	.021	.103	.015	-.116
	Sig.	.489	.576	.652	.297	.801	.112	.514	.654	.517	.200	.255	.791	.903	.556	.931	.508
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
DO	Corr.	-.006	.022	-.204	.064	.106	.201	.331	.052	.215	.446**	.316	-.004	-.214	-.514**	.229	-.191
	Sig.	.973	.901	.240	.713	.545	.247	.052	.767	.215	.007	.064	.980	.218	.002	.186	.271
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
DO % Sat	Corr.	.017	.035	-.173	.076	.086	.176	.351*	.062	.218	.430**	.314	.001	-.208	-.504**	.276	-.188
	Sig.	.921	.842	.322	.662	.622	.311	.039	.722	.209	.010	.067	.994	.231	.002	.109	.278
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35

		HID	MID	LID	OSD	Cult.	Past.	Grass.	Decid. For.	Evergr. For.	Mix For.	Scrub / Shrub	For. Wet.	Scrub / Shrub Wet.	Emerg. Wet.	Bare Land	Open Water
NH3	Corr.	.020	-.016	.125	-.220	.016	-.074	-.318	-.041	-.276	-.321	-.332	-.015	.219	.501**	-.377*	.066
	Sig.	.908	.927	.475	.204	.929	.674	.063	.815	.109	.060	.051	.933	.205	.002	.025	.707
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
NO3	Corr.	-.129	-.262	-.409*	-.397*	.633**	.359*	.033	-.121	-.357*	-.060	-.160	-.041	.105	.079	.111	-.430**
	Sig.	.461	.128	.015	.018	.000	.034	.852	.489	.035	.731	.359	.816	.548	.651	.526	.010
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TKN	Corr.	-.276	-.165	-.079	-.269	.205	.092	-.210	.009	-.329	-.413*	-.221	-.026	.235	.542**	-.114	-.121
	Sig.	.109	.344	.651	.119	.238	.601	.225	.961	.053	.014	.202	.883	.174	.001	.516	.487
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TP	Corr.	-.243	-.218	-.143	-.238	.273	.155	-.192	-.014	-.381*	-.401*	-.252	-.080	.312	.623**	.030	-.116
	Sig.	.159	.209	.414	.168	.113	.373	.269	.934	.024	.017	.145	.648	.068	.000	.865	.508
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TSS	Corr.	-.069	.047	-.108	-.199	.090	.027	-.054	-.148	-.337*	-.336*	-.123	-.165	-.111	.144	.179	-.202
	Sig.	.694	.788	.539	.251	.606	.878	.758	.396	.048	.048	.480	.342	.524	.410	.304	.245
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Turbidity	Corr.	.056	.206	.098	-.052	-.085	-.165	-.110	-.166	-.246	-.304	-.112	-.121	-.206	.035	.326	-.181
	Sig.	.749	.235	.575	.768	.629	.344	.529	.341	.154	.076	.522	.488	.235	.844	.056	.298
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TS	Corr.	.381*	.412*	.241	-.051	-.107	-.266	-.243	-.295	-.413*	-.060	-.292	-.394*	-.268	.059	-.235	-.211
	Sig.	.024	.014	.163	.771	.540	.122	.160	.086	.014	.734	.088	.019	.120	.738	.174	.224
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TDS	Corr.	.395*	.450**	.212	-.005	-.130	-.218	-.155	-.248	-.312	.086	-.172	-.435**	-.324	-.064	-.200	-.212
	Sig.	.019	.007	.221	.978	.456	.209	.375	.150	.068	.623	.322	.009	.058	.714	.249	.221
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
E coli	Corr.	.099	.249	-.006	-.258	.043	-.056	-.060	-.459**	-.306	.145	-.304	-.356*	-.465**	-.540**	-.066	-.402*
	Sig.	.572	.149	.975	.135	.804	.749	.734	.006	.074	.407	.076	.036	.005	.001	.705	.017
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
pH	Corr.	.048	.009	-.183	-.004	.018	.148	.444**	.047	.239	.377*	.362*	.023	-.252	-.524**	.290	-.057
	Sig.	.783	.959	.293	.982	.917	.397	.008	.788	.166	.026	.033	.896	.144	.001	.092	.745
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Cond	Corr.	.430**	.445**	.271	-.075	-.091	-.283	-.265	-.355*	-.400*	.018	-.373*	-.440**	-.355*	-.037	-.166	-.258
	Sig.	.010	.007	.116	.671	.603	.100	.124	.036	.017	.918	.027	.008	.036	.832	.341	.135
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Chl	Corr.	.542**	.494**	.350*	.146	-.101	-.364*	-.278	-.391*	-.351*	.084	-.466**	-.272	-.370*	-.077	-.038	-.180
	Sig.	.001	.003	.039	.403	.564	.031	.106	.020	.039	.630	.005	.114	.029	.659	.827	.300
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
TOC	Corr.	-.213	-.185	-.046	-.143	.138	.058	-.164	.064	-.284	-.352*	-.179	-.011	.322	.674**	-.078	.032
	Sig.	.218	.288	.792	.412	.429	.742	.346	.715	.099	.038	.303	.952	.059	.000	.656	.854
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
COD	Corr.	-.278	-.176	-.085	-.146	.218	.051	-.287	-.004	-.353*	-.405*	-.240	-.041	.253	.547**	-.013	-.122
	Sig.	.106	.310	.629	.401	.209	.770	.094	.982	.038	.016	.164	.817	.142	.001	.940	.484
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35

Table 84 Water quality land cover correlation analysis results

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

From this analysis we can see some of the negative impacts associated with human land uses and the water quality benefits provided by natural land cover. For example strong positive correlations were observed between the percentage of agriculture land cover and nitrates and the percentage of development showed strong positive correlations with total solids (TS), total dissolved solids (TDS), conductivity, and chlorides (chl). The water quality benefit associated with forest cover was observed with a strong positive relationship with dissolved oxygen, and negative correlations with *E. coli*, conductivity, nitrate, total phosphorus, turbidity, chlorides, total organic carbon and chemical oxygen demand. Similarly there was a strong negative correlation observed between wetlands and *E. coli*.

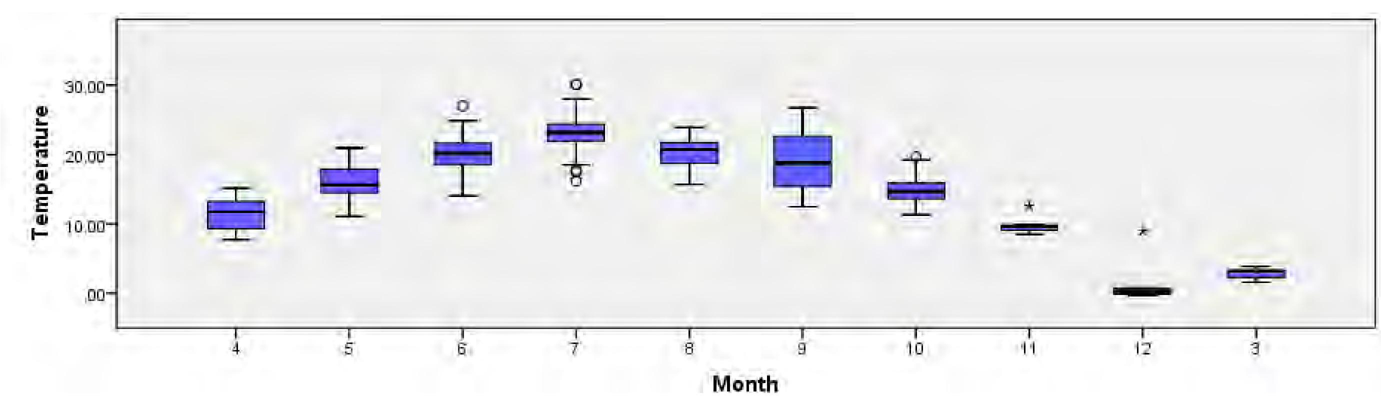
The correlation analysis indicates that wetlands in our watershed can act as sinks or sources. For example there is a strong positive correlation between the percentage of emergent wetlands and total phosphorus (source) and a strong negative correlation with E. coli concentrations (sink). A number of factors influence how the wetland will "behave" in this capacity such as wetland type, hydrologic conditions, season, and length of time the wetland has been subjected to loading. Human impacts can lead to considerable changes in chemical cycling in wetlands and their ability to assimilate these often increased inputs is not limitless.

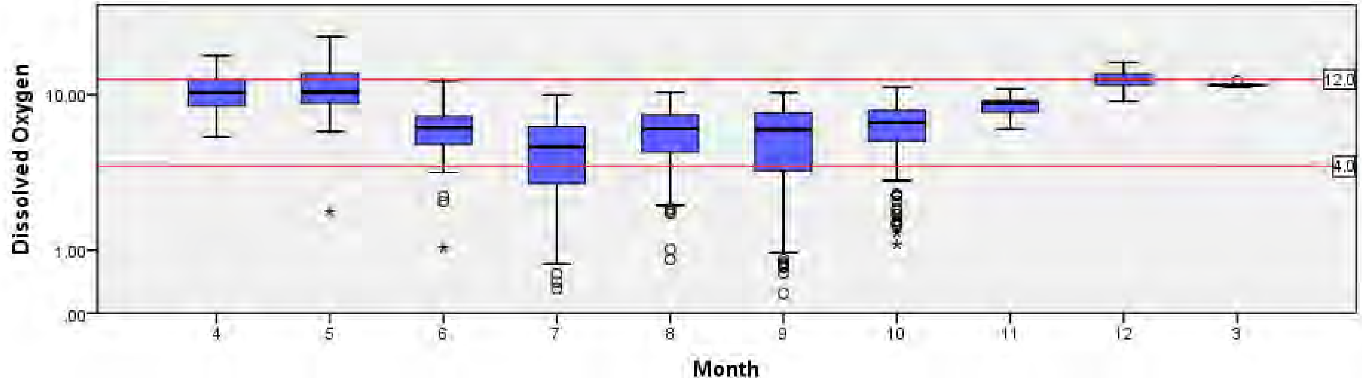
<u>Hydrologic Condition Variability</u>

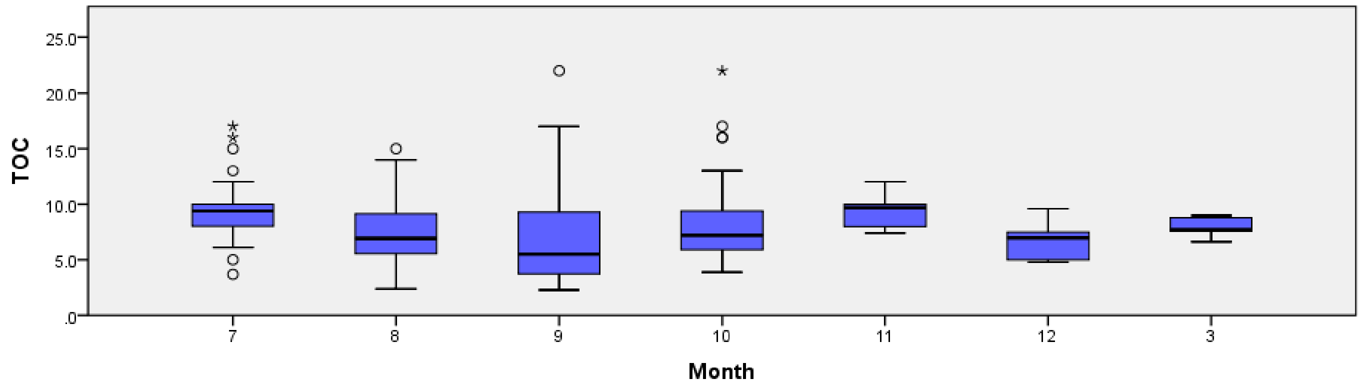
Site load duration curves for nutrients and sediment (TSS) show that water quality target values are most often exceeded during midrange to high flow conditions indicating the primary sources are runoff and streambank erosion related. Occasionally, target values are exceeded during dry stream flow conditions indicating pollutant loading from upland impervious areas and within the riparian zone. Load duration curves for each site are included in Appendix B of the Deep River-Portage Burns Waterway TMDL study http://www.in.gov/idem/nps/3893.htm.

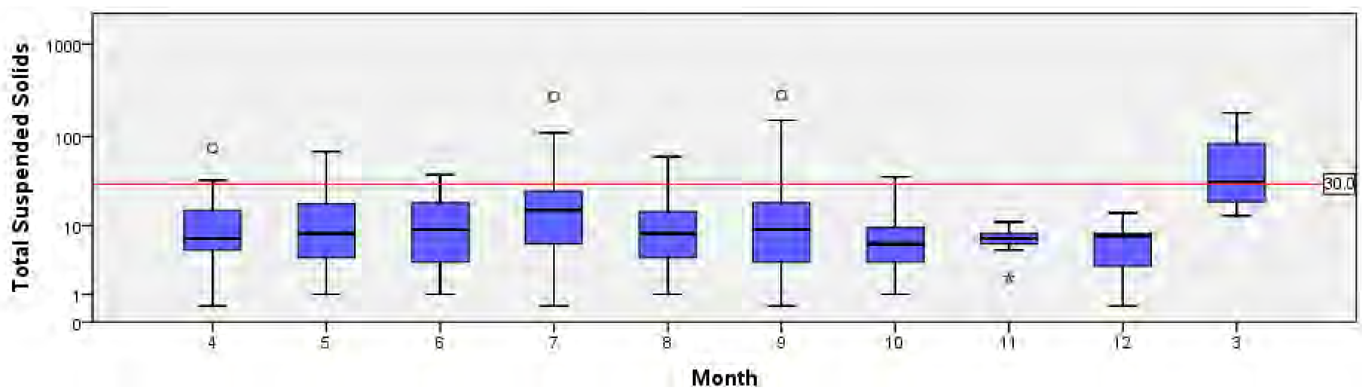
<u>Temporal Variability</u>

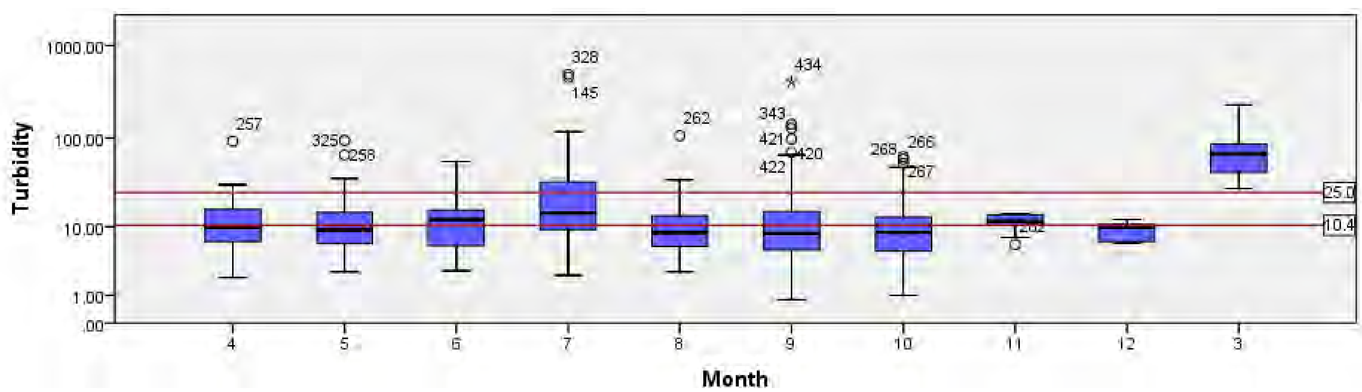
Statistically significant monthly/seasonal variations were observed in dissolved oxygen, total organic carbon, sediment, and nutrient concentrations (Figure 212). Dissolved oxygen concentrations most frequently fell below the 4 mg/L water quality standard during the summer months with warmer water temperatures and lower stream flows. Total suspended solids (TSS) and turbidity levels most frequently exceeded target values during March. This observation generally corresponds to the melting and subsequent runoff of the nearly 60 inches of snow that fell on the region between November 2013 and March 2014 (Table 5). Total phosphorus showed a small peak in July, with larger peaks being observed in September and December. Nitrate concentrations were at the highest during the fallow months of November and December. Ammonia concentration were generally highest in June and September. No water quality monitoring occurred in January or February because of ice cover at the stream sites.




Dissolved Oxygen
10.00
1.00
.00
4
5
6
7
8
9
10
11
12
3
12.0
4.0
Month


TOC
25.0
20.0
15.0
10.0
5.0
.0
7
8
9
10
11
12
3
Month


Total Suspended Solids
1000
100
10
1
0
4
5
6
7
8
9
10
11
12
3
30.0
Month


Turbidity
1000.00
100.00
10.00
1.00
.00
257
325
258
328
145
262
434
343
421
420
422
268
266
267
25.0
10.4
4
5
6
7
8
9
10
11
12
3
Month

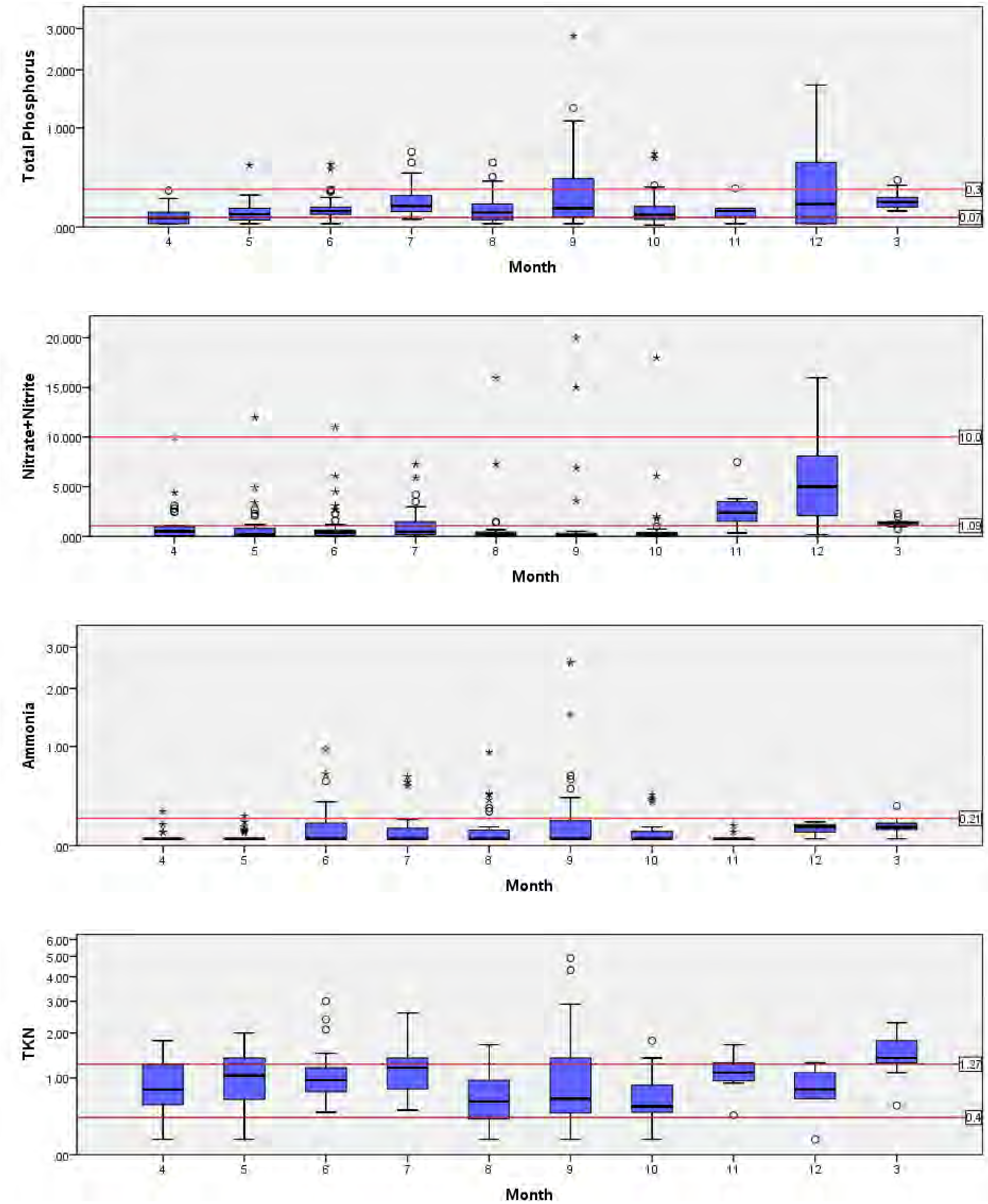


Figure 212 Box plots illustrating monthly dissolved oxygen, sediment and nutrient concentrations within the watershed

<u>Stressor Linkage Analysis</u>

A statistical analysis following methodologies outlined by Morris et al (2005) was used to further evaluate and identify the key stressors and linkages that could better explain the observed biotic impairments. The first step was to conduct a cluster analysis, grouping sites with similar fish and macroinvertebrate community structures (i.e. species and percent composition). Assuming that these community structures are the result of external driving forces and that those forces are identifiable, these groupings were used to evaluate physical and chemical variables (stressors) relative to the identified groupings. The resulting clusters (Figure 213 and Figure 214) were used as grouping variables in a Kruskal-Wallis analysis of variance (ANOVA) by ranks test to evaluate the water chemistry, habitat and land cover variables.

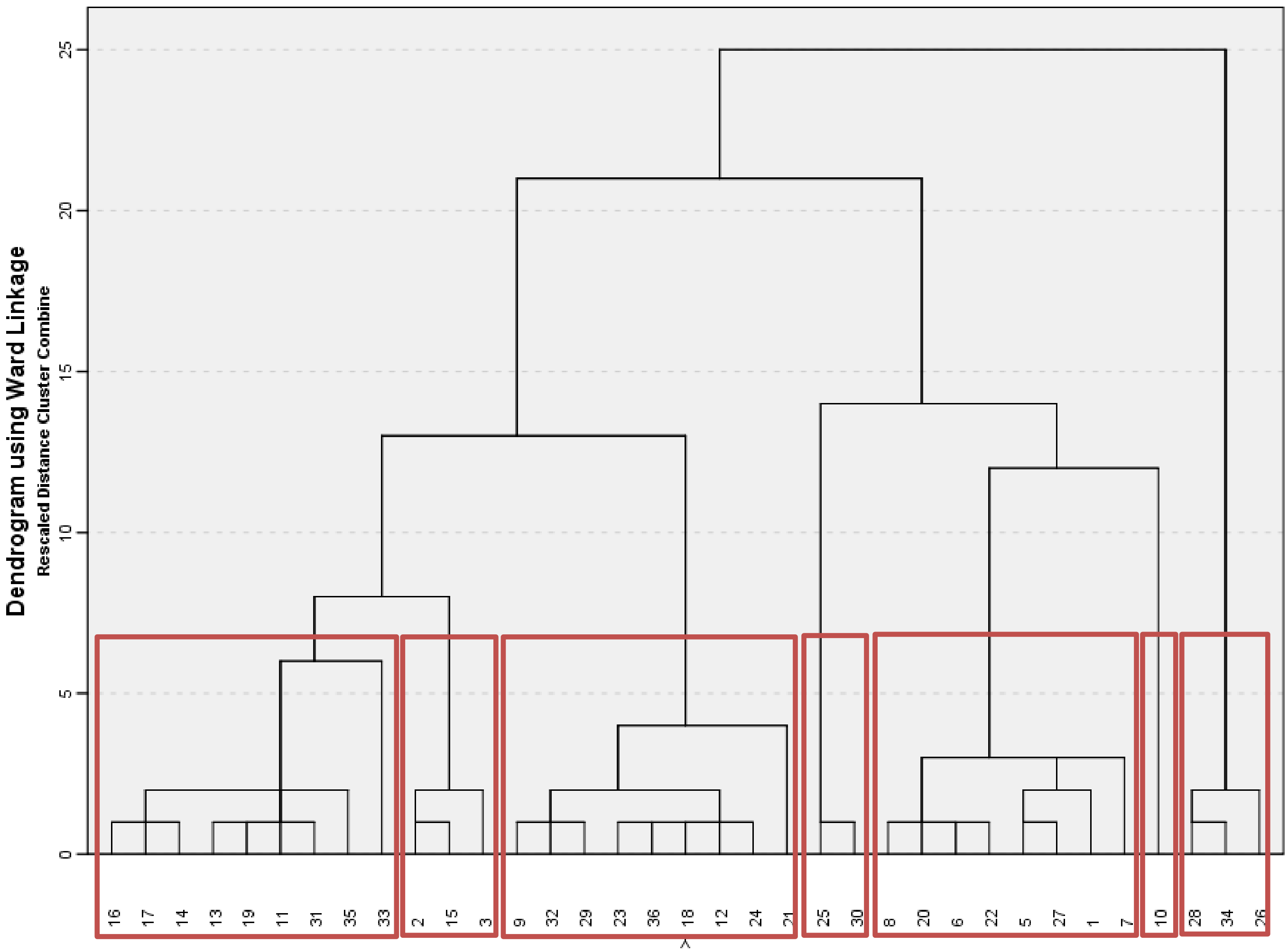


Figure 213 Fish Community Cluster Analysis

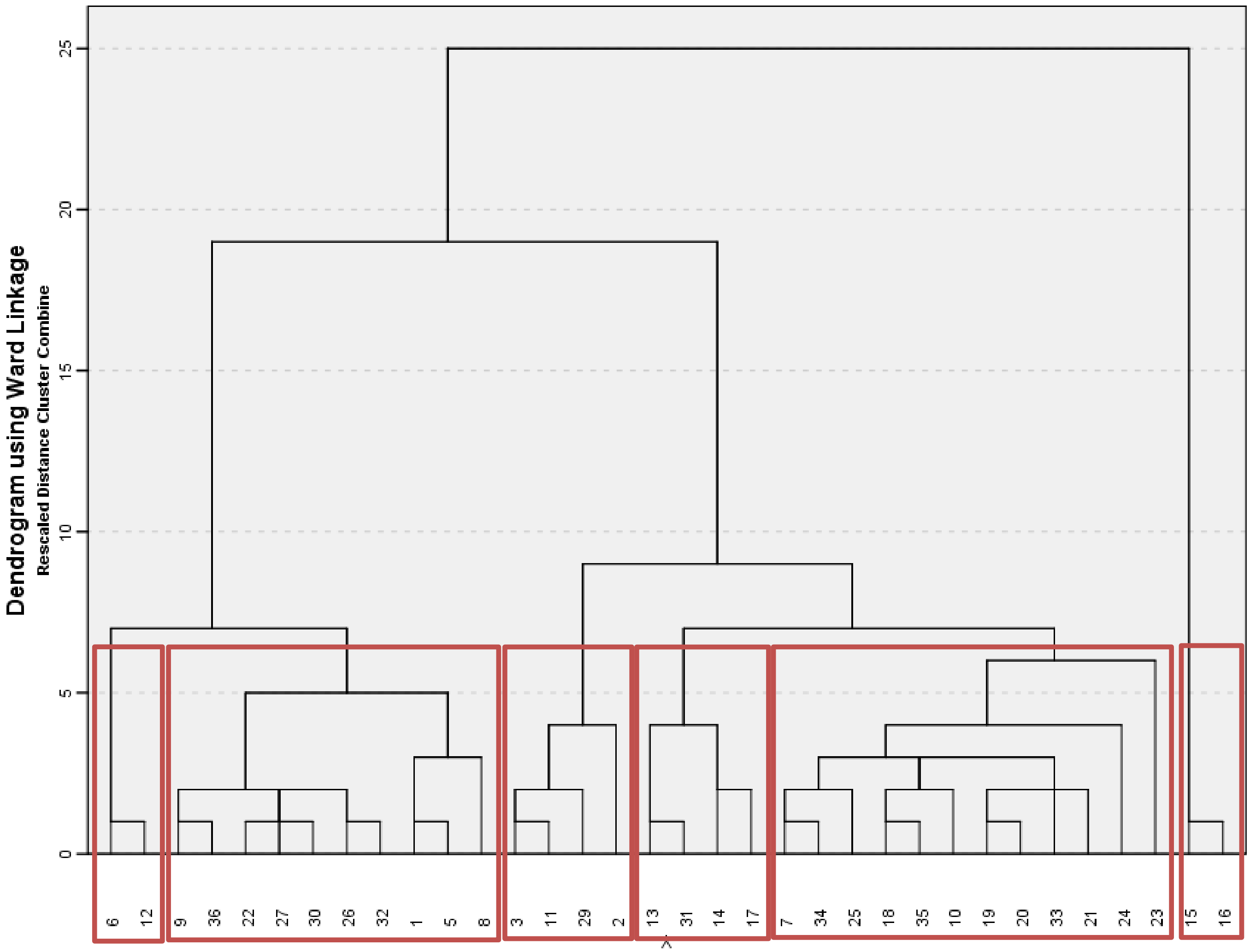


Figure 214 Macroinvertebrate community cluster analysis

The results of the Kruskal-Wallis ANOVA test (Table 85) showed that six water chemistry, one land cover, and three habitat variables (stressors) were significantly predictive of fish community structure. Four water chemistry, five land cover, and three habitat variables were significantly predictive of benthic macroinvertebrate community structure. The habitat variables effectively capture the influence of channelized streams/regulated drains on biotic communities within the watershed.

Variable	Fish Significance (α=0.05, CL=95%)	Macroinvertebrate Significance (α=0.05, CL=95%)
Water Chemistry		
Temperature	.014	
Dissolved Oxygen (DO)	.036	.019
Dissolved Oxygen % Saturation		.024
Ammonia		.019
Turbidity	.036	
E. coli	.026	
pH		.017
Total Organic Carbon (TOC)	.028	

Variable	Fish Significance (α=0.05, CL=95%)	Macroinvertebrate Significance (α=0.05, CL=95%)
Chemical Oxygen Demand (COD)	.046	
Land Cover		
Wetland	.022	.026
Forest		.040
Scrub/Shrub		.021
Riparian Deciduous Forest		.003
Riparian Scrub/Shrub		.015
Physical Habitat		
Channel Morphology	.019	.018
Riparian		.027
Gradient	.001	.010
Embeddedness	.022	

Table 85 Variables significantly predictive of the fish and macroinvertebrate community structure

The variables found to be significantly predictive of community structures were further evaluated using a Principle Components Analysis (PCA). This type of analysis is often used to identify which factors explain most of the variance observed within a larger set of variables and to generate hypotheses regarding causal mechanisms. Variables were normalized and standardized (z-scores) and evaluated for strong correlations ($r > 0.8$) using Spearman's correlation before conducting this analysis. Chemical oxygen demand was dropped from further consideration due to its strong correlation to total organic carbon for fish while pH and dissolved oxygen percent saturation were dropped due to their strong correlation to dissolved oxygen.

The result of the principal components analysis explaining fish community structure is shown in Figure 215. Three statistically significant dimensions were identified which collectively describe 68% of the variability. Loading values greater than 0.75 signify a "strong" correlation, while values between 0.75 and 0.50 indicate "moderate" correlation and values between 0.50 and 0.30 denote "weak" correlation.

Component 1 explains 34% of the variation and shows a strong positive correlation with dissolved oxygen (DO) and a strong negative correlation with total organic carbon (TOC). Moderate, positive correlations were observed with three habitat related metrics including channel morphology, stream gradient and substrate embeddedness (inverse metric). A moderate, negative correlation was observed with emergent wetland (LC15) habitat. Component 2 explains an additional 18% of the variation and shows a strong negative correlation with wetland habitat. Moderate, positive correlations where observed with *E. coli* and turbidity and a moderate, negative correlation was observed with emergent wetland (LC15) habitat. Component 3 explains an additional 15% of the variation with a strong positive correlation with water temperature and moderate negative correlation with *E. coli*.

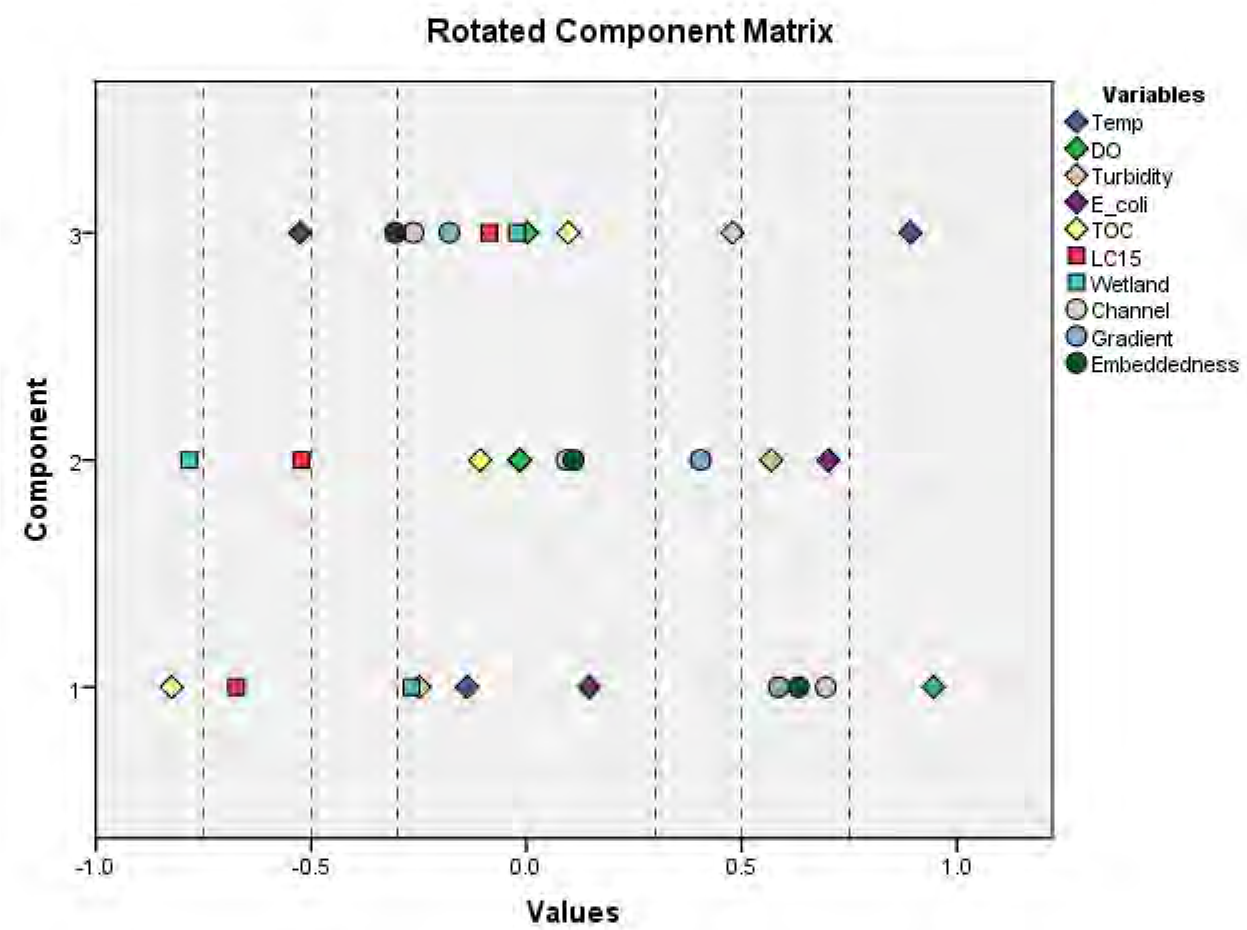


Figure 215 Fish community principle component analysis results

Results of the principal components analysis used to evaluate which factors are most influential in macroinvertebrate community structure are shown in Figure 216. Two statistically significant dimensions were identified which collectively describe 67% of the variability.

Component 1 explains 40% of the variation and shows a strong positive correlation with dissolved oxygen (DO), channel morphology, and riparian deciduous forest (Rip9). Moderate, positive correlations were observed with stream gradient and riparian scrub/shrub habitat (Rip12). A moderate, negative correlation was observed with ammonia. Component 2 explains an additional 27% of the variation and shows a strong positive correlation with forest and wetland habitat. Moderate, positive correlations where observed with forest and riparian deciduous forest (Rip9) habitat.

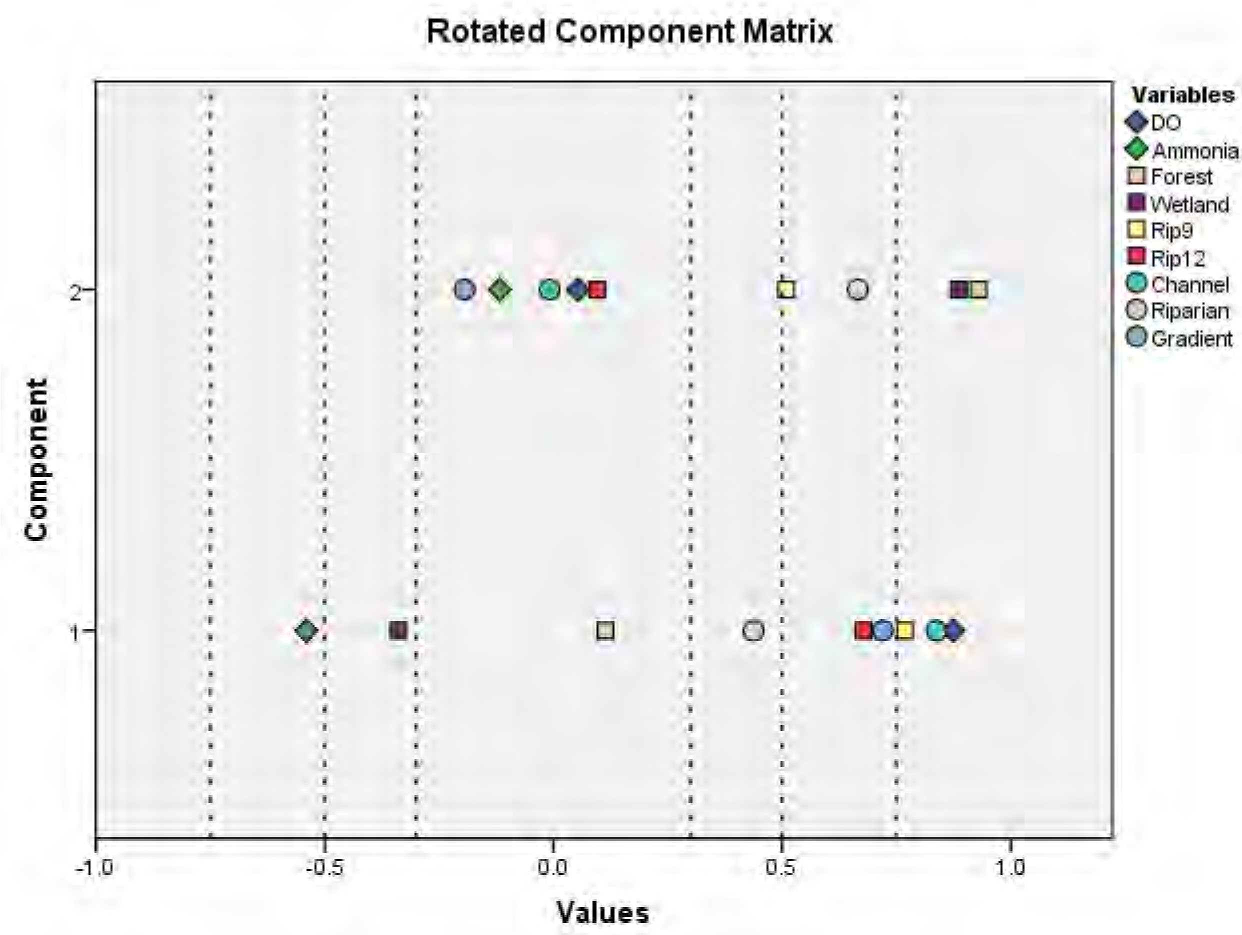


Figure 216 Macroinvertebrate community principal component analysis results

The linkage analysis shows that dissolved oxygen, channel morphology, and riparian forest are the most significant factors in explaining fish and macroinvertebrate community structure in the watershed. Restoration actions should focus heavily on these parameters. Sites that maintained good dissolved oxygen levels throughout the year (4-12 mg/L), had good channel morphology (i.e. good sinuosity, pool/riffle/run development, not channelized or had recovered, and were stable), and forested riparian zone typically had healthier fish and macroinvertebrate communities.

Healthy, functioning fish and macroinvertebrate communities occurs when the following conditions are present (Harman et al, 2012):

1. Continuous upstream streamflow sources, as removal of impoundments and excessive water consumption for human activities will provide adequate streamflow throughout the year;
2. Floodplain connectivity and bankfull channel, which dissipate energy of large storm events to prevent excessive scouring of substrates used for reproduction, and prevent sediment inundation of substrate habitat;
3. Healthy hyporheic zones (the region where shallow groundwater and surface water mix along the streambed) , which provide habitat and food resources;

4. Bed form diversity and in-stream structures, which create diverse habitats for feeding and reproduction, dissipate stormflow energy; provides opportunities for organic carbon storage and retention, provide substrates such as large woody debris, and provide scour pools for reproduction, feeding and shelter;
5. Channel stability, which prevents sediment inundation of habitat and excessive turbidity that is contributed from channel erosion;
6. Riparian community, which provides inputs for food resources, provides shade for cooler temperatures and provides vegetative roots for available habitat; and
7. Adequate dissolved oxygen, which is required for survival and health.

Based on the data that has been collected and presented, issues with conditions 1-2 and 4-7 are readily apparent, to varying degrees in watershed.

Also, when all factors are considered together an interrelated or hierarchical cause-and-effect relationship is apparent. The “stream functions pyramid” shown in Figure 217 is provided as a visual representation to help explain these relationships. The pyramid is based on a framework adopted by the US Army Corps of Engineers (USACE) for evaluating stream restoration projects. The pyramid simplifies a suite of 15 functions that the USACE determined to be critical to the health of a stream and riparian ecosystem (Harman et al, 2012).

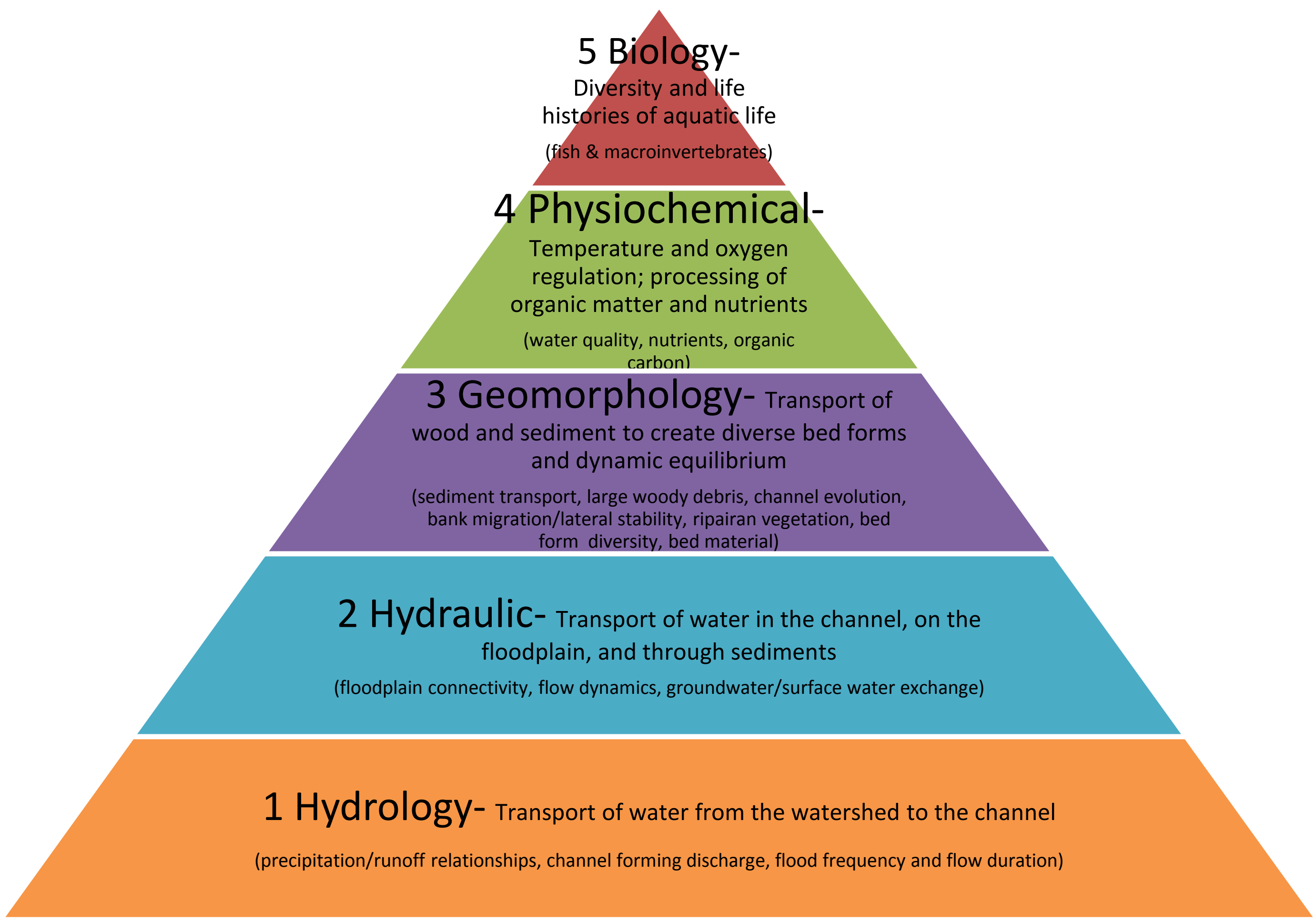


Figure 217 Stream functions pyramid

This functional based framework infers that restoration activities that occur at lower levels will provide a functional lift at higher levels. The pyramid also infers that the likelihood of restoring aquatic communities or water quality without also addressing lower level functions is problematic at best.

The principal components analysis results indicate that geomorphology related measures such as channel morphology, bed material, and riparian vegetation explain a significant portion of variability observed in aquatic communities. Hydraulic function parameters such as floodplain connectivity were not evaluated directly in the field during the baseline assessment. However, given the extent of stream channelization and impervious cover in the watershed it is reasonable to assume that floodplain connectivity is an issue along at least some stream reaches in the watershed such as Willow Creek and Main Beaver Dam Ditch. At the hydrology level, the shape of the flow-duration curve presented in Figure 19 indicates variable stream flows as a result of increased surface runoff and reduced watershed storage.

5.2 Analysis of Stakeholder Concerns

Stakeholder concerns generated through the public/ steering committee meetings are listed in Table 86. The steering committee helped evaluate whether the available data and evidence supported each concern. The steering committee also determined whether or not it was a concern they wished to focus. The only concern that the steering committee chose not to focus on at this time was the loss of cropland to development. This can be a complex issue with both positives (ex. less natural area converted) and negatives (ex. loss of productive farmland).

Concerns	Supported by Data?	Evidence	Able to Quantify?	Within Project Scope?	Steering Committee Wants to Focus On?
Stream Habitat Loss and Riparian Encroachment	Yes	24 of the 35 stream sites (69%) assessed by IDEM had QHEI scores <51 indicating that habitat quality in these reaches was generally not conducive to supporting a healthy warm water fish community. The average "riparian quality" metric score from the QHEI was 5.5 with a range of 3 to 9 (12 possible points). An analysis of land cover types within a 30-meter buffer adjacent to streams showed that human land uses account for 35 to 65% of the area with an average of 52%.	Yes	Yes	Yes
Wetland Habitat Loss and Degradation	Yes	Based on hydric soils data, nearly 28,000 acres (75%) of wetland habitat has been converted to developed or agricultural land uses.	Yes	Yes	Yes
Species Loss	Yes	Species metric scoring (# species) for the Index of Biotic Integrity indicates that 26 sites fall below expectations for the ecoregion.	Yes	Yes	Yes
Need for Conserved	Yes	The Chicago Wilderness Green Infrastructure Vision 2.1 identified	Yes	Yes	Yes

Concerns	Supported by Data?	Evidence	Able to Quantify?	Within Project Scope?	Steering Committee Wants to Focus On?
Open Spaces, Riparian Corridor Acquisition, Recreational Access		37,622 acres (58 mi²) of land as a priority for preservation. Approximately 17,000 acres (27 mi²) of land is currently protected according to DNR managed lands data.			
		Overall, human land uses account for approximately 57% of the riparian land cover in the watershed.			
Habitat Restoration and Long-Term Management of Natural Areas	Yes	Aquatic and terrestrial invasive species have been documented in the watershed by various agencies and non-government organizations.	Yes	Yes	Yes
		High quality natural areas and ETR species are documented in the watershed by Indiana Natural Heritage Data Center			
		Local land trusts and managers such as Shirley Heinze, The Nature Conservancy, Save the Dunes, DNR and Lake County Parks Department have invested significant resources in managing natural areas.			
Terrestrial and Aquatic Invasive Species	Yes	Round goby and alewife collected by IDEM assessment crews at three sites below Deep River dam in Lake Station.	Yes	No	Yes
		At least 13 terrestrial, invasive plant species have been identified in the watershed. Several others have been identified as probable.			
Negative Impact of Impaired Waterways to Recreational Use, Property Values, and Economic Development	Yes	All 35 monitoring sites have median *E. coli* concentrations that exceed the 235 CFU/100 mL single sample water quality standard.	Yes	Yes	Yes
		24 of the 35 (69%) monitoring sites have impaired fish communities.			
		Seven (20%) sites had seven or fewer fish collected.			
		Signs posted inside the Portage Lakefront and Riverwalk warn the public not to swim inside the harbor due to high bacteria levels.			
Coordination Between Municipalities, Business, and Residents	No	As a general observation, the level of coordination is highly variable and dependent on many factors.	Uncertain	Yes	Yes

Concerns	Supported by Data?	Evidence	Able to Quantify?	Within Project Scope?	Steering Committee Wants to Focus On?
Enforcement of Existing Regulations Protective of Stream Health	Yes	Over 160 unauthorized wetland impact violations have been investigated by the U.S. Army Corps of Engineers between 2000 and March 2015 in the watershed.	Yes	Yes	Yes
Reconciling Need for Drainage While Also Protecting Water Quality and Aquatic Life	Yes	Of the approximate 112 miles of regulated drain within the watershed, 110 miles are listed with an impairment. Significantly negative correlations exist between regulated drains and: • dissolved oxygen • pH • QHEI, channel quality, riffle/run, and gradient metrics • Silt and embeddedness QHEI sub-metrics • Simple lithophils IBI metric • Intolerant species and sprawler mIBI metrics Significantly positive correlations exist between regulated drains and: • Ammonia • Total Kjeldahl nitrogen • Total phosphorus • Total organic carbon • Chemical oxygen demand • Insectivore IBI metric	Yes	Yes	Yes
Maintenance of Existing Plans	Yes	No organizational structure was put in place to implement the Deep River-Turkey Creek and West Branch Little Calumet River WMP's once they were completed. Projects were largely independent of group effort.	Yes	Yes	Yes
Loss of Cropland to Development	Yes	Between 1985 and 2010, 6,644 acres of agricultural land (-17%) was converted to other uses while development expanded by nearly 10,578 acres (26%).	Yes	Yes	No
Some Absentee Agricultural Landowners Seem to be Land Speculators with Less	No	Agricultural parcels posted/listed for sale near prime development areas. However due to privacy requirements associated with the Farm Bill program, operator or site information is restricted to the general public so	No	Uncertain	Yes

Concerns	Supported by Data?	Evidence	Able to Quantify?	Within Project Scope?	Steering Committee Wants to Focus On?
Interest in Investing in BMPs to Protect Water Quality		there is a degree of uncertainty associated with BMP implementation.			
Ability of Watershed to Store and Filter Storm Water Runoff While Providing Habitat	Yes	In a Wisconsin DNR publication that focused on small wetlands and wetland loss, Trochlell and Bernthal (1998) compiled research that showed there was a threshold in which watersheds with less than 10% wetland area often experienced pronounced negative hydrological and water quality impacts, including deceased stream stability, higher peak flows, lower base flows and increased suspended solid loading rates. Only 8% of the land area in our watershed is wetland habitat. Historically it would have been closer to 32%. The approximate value of ecosystem services provided by the Green Infrastructure Vision within our watershed is: • $31 million in water purification • $493 million in water flow regulation/ flood control • $126 million in groundwater recharge	Yes	Yes	Yes
Excessive Sediment and Nutrient Loading from Urban and Agricultural Land Uses	Yes	Biotic impairments co-occur where the data indicates sediment and nutrients are at an intensity and duration that could result in a change in the ecological condition. Median concentrations of sediment and nutrient target values protective of fish and macroinvertebrate communities exceeded. • TSS- 1 site (2.9% of sites) • Turbidity- 16 sites (45.7% of sites) • TP- 24 sites (68.6% of sites) • Nitrate- 6 sites (17.1% of sites) • TKN- 23 sites (65.7% of sites)	Yes	Yes	Yes

Concerns	Supported by Data?	Evidence	Able to Quantify?	Within Project Scope?	Steering Committee Wants to Focus On?
		• Ammonia- 10 sites (28.6% of sites) There is a significant correlation between nutrient concentrations and agricultural land uses. There is a significant correlation between chloride concentrations and developed land uses.			
Increased Storm Water Runoff Volume Causing Streambank and Shoreline Erosion	Yes	USGS stream gage at Lake George outlet indicates increasing trends for annual peak discharge and precipitation. However, annual peak discharge is increasing at a much higher rate (57%) than annual total precipitation (11%) over period of record (1947-2009). The flow-duration curve suggests a system influenced by increased runoff and loss of storage. Impervious surface cover analysis shows that seven of the nine subwatersheds are impacted by impervious cover, exceeding the 10% threshold classification for a sensitive stream. 31 of the 34 (91%) monitoring sites had moderate levels of streambank erosion documented on the QHEI	Yes	Yes	Yes
Sedimentation of Lake George and Burns Ditch	Yes	In 1993 the U.S. Army Corps of Engineers (USACE), Chicago District, initiated an extensive evaluation of Lake George and its major tributaries and later published a 1995 Planning/ Engineering feasibility report for the dredging of Lake George. In 2000, the City of Hobart proceeded with a limited dredging of Lake George that removed 590,000 cubic yards of sediment at a cost of over two million dollars. In 2003, the USACE released the Burns Ditch/ Waterway Sediment Transport Modeling Phase I Report with the following findings: • Sediment reduced the average depth of water in Lake George	Yes	Yes	Yes

Concerns	Supported by Data?	Evidence	Able to Quantify?	Within Project Scope?	Steering Committee Wants to Focus On?
		from approximately 6-8 ft. to 1-3 ft. • Sediment in the lake is mostly from intensive agriculture and development construction in the upstream watershed. • Sediment on the lake bottom is formed by fine silt and clay (90-98%). • Channel erosion on the river reach downstream of Lake George appears to be an important source of sediment that ultimately settles at mouth of Burns Ditch.			
		Bathymetric mapping of Lake George for the Deep River Flood Risk Management Plan shows that 70,000 cubic yards of sediment have accumulated over the past 14 years (2001-2014). This translates to approximately 5,000 cubic yards/year.			
		Median TSS concentrations drop from 14 mg/L at Site 12 on Deep River upstream of Lake George to 4 mg/L at Site 8 immediately downstream of the Lake George dam (71% reduction) indicating sediment deposition in the lake.			
Failing Septic Systems	Yes	City of Hobart and Indiana State Department of Health confirm several houses have failed septic systems with absorption fields located within Deep River floodplain.	Yes	Yes	Yes
		Strong positive correlation observed between *E. coli* and total dissolved solids, conductivity and chloride median concentrations indicating presence of human sources.			
Flooding, Floodplain Encroachment, and Stream Flashiness	Yes	Analysis of land cover types within the 100-yr. floodplain show that agriculture accounts for 22% of the floodplain land area, development 21%, and developed open space 9%.	Yes	Yes	Yes
		Impervious surface cover analysis shows that seven of the nine			

Concerns	Supported by Data?	Evidence	Able to Quantify?	Within Project Scope?	Steering Committee Wants to Focus On?
		subwatersheds are impacted by impervious cover.			
		USGS stream gage data shows a steady increase in annual peak flows.			
		Flow duration curve points towards a system influenced by runoff and loss of storage.			
Negative Impacts Associated with Dams	Yes	Streambank erosion downstream of Lake George and Deep River dams documented in IDEM habitat assessments.	Yes	Yes	Yes
		Findings from the USACE Burns Ditch/ Waterway Sediment Transport Modeling Phase I Report state that channel erosion on the river reach downstream of Lake George appears to be an important source of sediment due to rapid fluctuation in discharge.			
		Impaired biotic impairments in upstream and downstream reaches of the Lake George and Deep River dams.			
		Deep River dam is an obstacle for recreational use of the river as a water trail.			
Public Involvement	No	Attendance at public/stakeholder meeting.	Yes	Yes	Yes, as overall stakeholder awareness and collaboration
		Participation in Hoosier Riverwatch training workshops.			
Soil Health	Yes	In 2103, approximately 45% of the acreage in corn production in Lake and Porter Counties still used conventional tillage.	Yes	Yes	Yes
		In 2013, no-till was only used on 20% of the acreage in corn production in Lake County and 5% in Porter County.			
Combined Sewer and Sanitary Sewer Overflows	Yes	Crown Point WWTP CSO Events • 2009- 10 events • 2010- 10 events • 2011- 20 events • 2012- 5 events • 2013- 15 events Gary Sanitary District WWTP CSO Events	Yes	Yes	Yes

Concerns	Supported by Data?	Evidence	Able to Quantify?	Within Project Scope?	Steering Committee Wants to Focus On?
		• 2009- 64 events • 2010- 80 events • 2011- 44 events • 2012- 24 events • 2013- 48 events			
Litter Left Behind After Floodwaters Recede	Yes	Litter deposited in floodplains after floodwaters receded. Litter accumulated in woody debris within stream channel.	Yes	Yes	Yes
		Litter collected by volunteers during stream clean up (NWI Paddlers Association event on Deep River below Lake George).			
		Litter accumulated on beach inside Burns Waterway harbor.			

Table 86 Analysis of stakeholder concerns

6 Problems & Causes

The stakeholder concerns which the steering committee has chosen to focus on have been carried forward into Table 87 which relates concerns to problems in the watershed. Problems are conditions or actions that need to be changed, improved or investigated further.

Concern	Problem
• Need for Conserved Open Spaces, Riparian Corridor Acquisition, Recreational Access Stream Habitat Loss and Riparian Encroachment • Wetland Habitat Loss and Degradation • Ability of Watershed to Store and Filter Storm Water Runoff While Providing Habitat • Habitat Restoration and Long-Term Management of Natural Areas	The degradation and loss of upland and riparian habitats is negatively affecting our watershed's ability to store and filter storm water runoff while also providing important habitat and recreation opportunities.
• Negative Impact of Impaired Waterways to Recreational Use, Property Values, and Economic Development	Some of our streams are frequently turbid and have nuisance levels of aquatic plant growth and algal blooms.
• Negative Impact of Impaired Waterways to Recreational Use, Property Values, and Economic Development • Failing Septic Systems • Combined Sewer and Sanitary Sewer Overflows	Elevated pathogens levels pose a health risk to full body contact recreational use of our streams.
• Negative Impact of Impaired Waterways to Recreational Use, Property Values, and Economic Development	Poor quality fish community structure and numbers limit recreational use of our streams and lakes.

Concern	Problem
• Coordination Between Municipalities, Business, and Residents • Enforcement of Existing Regulations Protective of Stream Health • Maintenance of Existing Plans • Public Involvement • Litter Left Behind After Floodwaters Recede • Some Absentee Agricultural Landowners Seem to be Land Speculators with Less Interest in Investing in BMPs to Protect Water Quality • Soil Health	Awareness of watershed issues and collaboration need to be increased to protect our streams, lakes and natural areas.
• Reconciling Need for Drainage While Also Protecting Water Quality and Aquatic Life • Negative Impacts Associated with Dams	Hydromodification is negatively affecting aquatic life and recreational use of our streams and lakes.
• Excessive Sediment and Nutrient Loading from Urban and Agricultural Land Uses • Sedimentation of Lake George and Burns Ditch	Excessive sediment and nutrient loading threaten aquatic life and recreational use of our streams and lakes.
• Increased Storm Water Runoff Volume Causing Streambank and Shoreline Erosion • Flooding, Floodplain Encroachment, and Stream Flashiness	Losses of upland, riparian and wetland habitats, and increases in impervious surface cover exacerbate streambank erosion and downstream flooding.

Table 87 Problems reflecting stakeholder concerns

Table 88 relates problems to potential causes. A cause is considered an event or actions that produce an effect which in this case is the problem statement.

Problem	Potential Cause(s)
The degradation and loss of upland and riparian habitats is negatively affecting our watershed's ability to store and filter storm water runoff while also providing important habitat and recreation opportunities.	Encroachment on and conversion of upland, riparian and wetland habitat for development and agricultural land uses.
Some of our streams and lakes are frequently turbid and have nuisance levels of aquatic plant growth and algal blooms.	• Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan. • Sediment concentrations often exceed the protective water quality target values established by this watershed restoration plan.
Elevated pathogens levels pose a health risk to full body contact recreational use of our streams.	*E. coli* concentrations often exceed state water quality standards.
Poor quality fish community structure and numbers limit recreational use of our streams and lakes.	• Streams lack the habitat quality that is conducive to supporting a healthy warm water fishery as indicated by QHEI scores.

Problem	Potential Cause(s)
	• Dissolved oxygen concentrations fall below state water quality standards. • Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan. • Ammonia concentrations often exceed the protective water quality target values established by this watershed restoration plan. • Sediment concentrations often exceed the protective water quality target values established by this watershed restoration plan.
Awareness of watershed issues and collaboration need to be increased to protect our streams, lakes and natural areas.	• Limited resources and/or awareness of need. • Communities/organizations have other issues that are a higher priority than water quality and aquatic habitats
Hydromodification activities are negatively affecting aquatic life and recreational use of our streams and lakes.	Hydromodification activities disrupts hydraulic, geomorphic, physiochemical, and biotic stream functions.
Excessive sediment and nutrient loading threaten aquatic life and recreational use of our streams and lakes.	• Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan. • Sediment concentrations often exceed the protective water quality target values established by this watershed restoration plan. • Channelized streams disassociated the stream from their floodplain.
Losses of upland, riparian and wetland habitats, and increases in impervious surface cover exacerbate streambank erosion and downstream flooding.	• Conversion of forest, grassland and wetland habitats for human land uses such as development and agriculture. • Development siting and implementation of post-development practices not sufficiently protective of environmental features and ecosystem functions.

Table 88 Potential causes for identified problems

7 Pollutant Sources and Pollutant Loads

The following section provides information on potential pollutant sources in the watershed and an approximation of existing pollutant loads and reductions needed based on pollutant thresholds/target values.

7.1 Potential Pollutant Sources

Information about watershed problems and potential causes listed above in Table 88 have been linked to potential sources in the following tables. The Indiana Department of Environmental Management defines a sources as an activity, material, or structure that results in a cause of nonpoint source pollution.

Problem	The degradation and loss of upland, wetland and riparian habitats is negatively affecting our watershed's ability to store and filter storm water runoff while also providing important habitat and recreation opportunities.

Potential Cause(s)	Encroachment on and conversion of upland, riparian and wetland habitat for development and agricultural land uses.
Potential Sources	• Between 1985 and 2010 approximately 759 acres of forest, 2,430 acres of grassland, 1,079 acres of scrub/shrub, and 563 acres of wetland habitat has been converted. • Nearly 220 acres (3%) of core forest habitat was lost between 1996 and 2006. • Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60% City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds. • Subwatershed wetland loss: Headwaters Main Beaver Dam Ditch 75%, Main Beaver Dam Ditch 86%, Headwaters Turkey Creek 76%, Deer Creek 71%, City of Merrillville 76%, Duck Creek 81%, Lake George 61%, Little Calumet River 69%, and Willow Creek 74%. • Subwatershed drainage area 10% or less wetland: Headwaters Main Beaver Dam Ditch 10% , Main Beaver Dam Ditch 5%, Headwaters Turkey Creek 9%, Deer Creek 7%, City of Merrillville 8%, Duck Creek 5%, Lake George 10%, Little Calumet River 10%, and Willow Creek 9% subwatersheds.

Table 89 Potential causes and sources of habitat degradation

Problem	Some streams and lakes are frequently turbid and have nuisance levels of aquatic plant growth and algal blooms.
Potential Cause(s)	• Nutrient concentrations often exceed the protective water quality target values established by this watershed plan. • Sediment concentrations often exceed the protective water quality target values established by this watershed plan. • Streams are disassociated from their floodplains
Potential Sources	• CSO communities: Crown Point and Gary (4 Headwaters Main Beaver Dam Ditch subwatershed, 1 Main Beaver Dam Ditch subwatershed, 5 Little Calumet River subwatershed). • SSOs: Merrillville and Portage (1 Headwaters Turkey Creek subwatershed, 1 City of Merrillville subwatershed and 1 Willow Creek subwatershed). • Pasture and livestock operations (# animal units/subwatershed: 208 Headwaters Main Beaver Dam Ditch, 299 Main Beaver Dam Ditch, 242 Headwaters Turkey Creek, 420 Deer Creek, 325 City of Merrillville, 311 Duck Creek, 290 Lake George, 328 Little Calumet River, 411 Willow Creek). • 26,000 acres of row crop production in the watershed • Approximately 2,600 acres (10%) of row crop production occur on HEL soils • Approximately 18,500 acres (71%) of row crop are tile drained • Approximately 45% of row crop in corn is conventional tillage • There are approximately 23,000 septic systems in the watershed based on number of rural households. The highest densities are located in the Headwaters Main Beaver Dam Ditch (402 households/mi^2), Headwaters Turkey Creek (280 households/mi^2), and Duck Creek (243 households/mi^2). • Domestic pets in population centers (# dogs/subwatershed: 8,500 Headwaters Main Beaver Dam Ditch, 13,000 Main Beaver Dam Ditch, 19,000 Headwaters Turkey Creek, 5,000 Deer Creek, 29,000 City of Merrillville, 6,000 Duck Creek, 13,000 Lake George, 37,000 Little Calumet River, 20,000 Willow Creek). • MS4 entities (#/subwatershed: 6 Headwaters Main Beaver Dam Ditch, 3 Main Beaver Dam Ditch, 6 Headwaters Turkey Creek, 5 Deer Creek, 4 City of Merrillville, 4 Duck Creek, 4 Lake George, 7 Little Calumet River, 4 Willow Creek).

	• Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60 City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds. • Moderate to high levels of streambank erosion was documented at 28 of the 35 stream monitoring sites. • 24 of the 35 stream monitoring sites are located on stream reaches that have been channelized. • Streams that are disassociated from there floodplain or ditches that were not designed with benchs. • Approximately 112 miles of stream are maintained as regulated drains. • Flow-duration curves point to streams flows being strongly influenced by runoff and as a result are flashy.

Table 90 Potential causes and sources of turbid streams and algal blooms

Problem	Elevated pathogens levels pose a health risk to full body contact recreational use of streams.
Potential Cause(s)	*E. coli* concentrations often exceed state water quality standards.
Potential Sources	• NPDES permitted WWTPs (1 Headwaters Main Beaver Dam Ditch subwatershed, 4 Deer Creek subwatershed, 1 Little Calumet River subwatershed, 1 Willow Creek subwatershed). • CSO communities: Crown Point and Gary (4 Headwaters Main Beaver Dam Ditch subwatershed, 1 Main Beaver Dam Ditch subwatershed, 5 Little Calumet River subwatershed). • SSOs: Merrillville and Portage (1 Headwaters Turkey Creek subwatershed, 1 City of Merrillville subwatershed and 1 Willow Creek subwatershed). • Pasture and livestock operations (# animal units/subwatershed: 208 Headwaters Main Beaver Dam Ditch, 299 Main Beaver Dam Ditch, 242 Headwaters Turkey Creek, 420 Deer Creek, 325 City of Merrillville, 311 Duck Creek, 290 Lake George, 328 Little Calumet River, 411 Willow Creek). • There are approximately 23,000 septic systems in the watershed based on number of rural households. The estimated failure rate is somewhere between 1-2% which equates to 230 to 460 failing systems. The highest densities of systems are located in the Headwaters Main Beaver Dam Ditch (402 households/mi2), Headwaters Turkey Creek (280 households/mi2), and Duck Creek (243 households/mi2). • Domestic pets in population centers (# dogs/subwatershed: 8,500 Headwaters Main Beaver Dam Ditch, 13,000 Main Beaver Dam Ditch, 19,000 Headwaters Turkey Creek, 5,000 Deer Creek, 29,000 City of Merrillville, 6,000 Duck Creek, 13,000 Lake George, 37,000 Little Calumet River, 20,000 Willow Creek). • An estimated 20% of dog owners do not pick up their pet's waste. • Nuisance level urban goose populations because of suitable habitat and feeding (ex. below Lake George dam) • MS4 entities (#/subwatershed: 6 Headwaters Main Beaver Dam Ditch, 3 Main Beaver Dam Ditch, 6 Headwaters Turkey Creek, 5 Deer Creek, 4 City of Merrillville, 4 Duck Creek, 4 Lake George, 7 Little Calumet River, 4 Willow Creek).

Table 91 Potential causes and sources of pathogens

Problem	Poor quality fish community structure and numbers limit recreational use of streams and lakes.
Potential Cause(s)	• Streams lack the habitat quality that is conducive to supporting a healthy warm water fishery as indicated by QHEI scores. • Dissolved oxygen concentrations fall below state water quality standards.

	• Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan. • Ammonia concentrations often exceed the protective water quality target values established by this watershed plan. • Sediment concentrations often exceed the protective water quality target values established by this watershed plan.
Potential Sources	• Sites 1, 3, 5, 8, 10, 11, 17, 19-22, and 24-36 have habitat quality that is generally not conducive of supporting a healthy warm water fishery (QHEI <51). • There are seven dams located in the watershed. • There are 112 miles of channel that are managed as regulated drains, representing approximately 39% of the total stream miles, in the watershed. • 24 of the 35 stream monitoring sites are located on stream reaches that have been channelized. • Flow-duration curves point to streams flows being strongly influenced by runoff and as a result are flashy. • Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60% City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds.

Table 92 Potential causes and sources resulting in poor quality fish communities

Problem	Hydromodification activities are negatively affecting aquatic life and recreational use of streams and lakes.
Potential Cause(s)	Hydromodification activities disrupts hydraulic, geomorphic, physiochemical, and biotic stream functions
Potential Sources	• Seven dams located in the watershed. • There are 112 miles of channel that are managed as county regulated drains, representing approximately 39% of the total stream miles, in the watershed. • 24 of the 35 stream monitoring sites are located on stream reaches that have been channelized. • Flow-duration curves point to streams flows being strongly influenced by runoff and as a result are flashy.

Table 93 Potential causes and sources of hydromodication negatively affecting aquatic life and recreational use

Problem	Excessive sediment and nutrient loading threaten aquatic life and recreational use of streams and lakes.
Potential Cause(s)	• Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan. • Sediment concentrations often exceed the protective water quality target values established by this watershed restoration plan.
Potential Sources	• CSO communities: Crown Point and Gary (4 Headwaters Main Beaver Dam Ditch subwatershed, 1 Main Beaver Dam Ditch subwatershed, 5 Little Calumet River subwatershed). • SSOs: Merrillville and Portage (1 Headwaters Turkey Creek subwatershed, 1 City of Merrillville subwatershed and 1 Willow Creek subwatershed). • Pasture and livestock operations (# animal units/subwatershed: 208 Headwaters Main Beaver Dam Ditch, 299 Main Beaver Dam Ditch, 242 Headwaters Turkey Creek, 420 Deer Creek, 325 City of Merrillville, 311 Duck Creek, 290 Lake George, 328 Little Calumet River, 411 Willow Creek).

	• 26,000 acres of row crop production in the watershed • Approximately 2,600 acres (10%) of row crop production occur on HEL soils • Approximately 18,500 acres (71%) of row crop are tile drained • Approximately 45% of row crop in corn is conventional tillage • There are approximately 23,000 septic systems in the watershed based on number of rural households. The highest densities are located in the Headwaters Main Beaver Dam Ditch (402 households/mi^2), Headwaters Turkey Creek (280 households/mi^2), and Duck Creek (243 households/mi^2). • Domestic pets in population centers (# dogs/subwatershed: 8,500 Headwaters Main Beaver Dam Ditch, 13,000 Main Beaver Dam Ditch, 19,000 Headwaters Turkey Creek, 5,000 Deer Creek, 29,000 City of Merrillville, 6,000 Duck Creek, 13,000 Lake George, 37,000 Little Calumet River, 20,000 Willow Creek). • MS4 entities (#/subwatershed: 6 Headwaters Main Beaver Dam Ditch, 3 Main Beaver Dam Ditch, 6 Headwaters Turkey Creek, 5 Deer Creek, 4 City of Merrillville, 4 Duck Creek, 4 Lake George, 7 Little Calumet River, 4 Willow Creek). • Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60 City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds. • Moderate to high levels of streambank erosion was documented at 28 of the 35 stream monitoring sites. • 24 of the 35 stream monitoring sites are located on stream reaches that have been channelized. • Flow-duration curves point to streams flows being strongly influenced by runoff and as a result are flashy.

Table 94 Potential causes and sources of sediment and nutrient loading

Problem	Losses of upland, riparian and wetland habitats, and increases in impervious surface cover exacerbate streambank erosion and downstream flooding.
Potential Cause(s)	• Conversion of forest, grassland and wetland habitats for human land uses such as development and agriculture. • Development siting and implementation of post-development practices not sufficiently protective of environmental features and ecosystem functions.
Potential Sources	• Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60% City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds. • Impervious surface cover exceeds 10% in the Headwaters Main Beaver Dam Ditch (16%), Main Beaver Dam Ditch (15%), Headwaters Turkey Creek (21%), City of Merrillville (26%), Lake George (18%), Little Calumet River (28%) and Willow Creek subwatersheds (25%). • Subwatershed wetland loss: Headwaters Main Beaver Dam Ditch 75%, Main Beaver Dam Ditch 86%, Headwaters Turkey Creek 76%, Deer Creek 71%, City of Merrillville 76%, Duck Creek 81%, Lake George 61%, Little Calumet River 69%, and Willow Creek 74%. • Subwatershed drainage area 10% or less wetland: Headwaters Main Beaver Dam Ditch 10% , Main Beaver Dam Ditch 5%, Headwaters Turkey Creek 9%, Deer Creek 7%, City of Merrillville 8%, Duck Creek 5%, Lake George 10%, Little Calumet River 10%, and Willow Creek 9% subwatersheds.

Table 95 Potential sources streambank erosion and downstream flooding related to habitat loss

7.2 Current Runoff Volume & Pollutant Loads

Storm water runoff is the volume of water generated by a storm that does not infiltrate into the ground or is not retained in storage as surface water. A pollutant load is the mass of a pollutant (ex. pounds of sediment or nutrients) that passes a particular point (ex. monitoring station) of a river in specific amount of time (ex. annually). *E. coli* has no mass and its "load" is expressed as a concentration of colony forming units (CFU) or most probable number (MPN).

7.2.1 Pollutant Load Modeling

A number of models were considered and used during the development of this watershed plan to estimate pollutant loads and storm water runoff volume. The models included the Spreadsheet Tool for Estimating Pollutant Loads (STEPL), Region 5, Hydrologic Simulation Program- FORTRAN (HSPF), Nonpoint Source Pollution & Erosion Comparison Tool (NSPECT), and the Kentucky Nutrient models. STEPL and Region 5 are both fairly simple spreadsheet based models that were run by NIRCP. Because of the complexity and time intensity, NIRPC contracted with Purdue University Calumet- Department of Mechanical Engineering to setup and run the HSPF, NSPECT and Kentucky Nutrient models.

The STEPL model was used to estimate annual runoff volume and nutrient and sediment pollutant loads for each site catchment area. The Kentucky Nutrient Model was used to estimate nitrate and total phosphorus loads. The nitrate data was incorporated in the HSPF model as well. Later, NIRPC decided to also use HSPF to estimate nutrient loading with data processed using the Kentucky Nutrient Model. The Region 5 model was used to estimate load reductions anticipated through best management practice implementation (See Section 11.6). The NSPECT model was setup to evaluate landscape scale restoration activities such as reforestation and future land use/land cover changes.

Ultimately the STEPL model was selected to estimate the load reductions needed (Section 7.3) because data was calculated and available at the smaller catchment scale as opposed to the subwatershed scale with HSPF.

Additional information about the models used is available from the following websites.

STEPL & Region 5: http://it.tetratech-ffx.com/steplweb/default.htm
HSPF: http://water.usgs.gov/software/HSPF/
Kentucky Nutrient
Model: https://www.uky.edu/WaterResources/assets/docs/pdf/The%20Kentucky%20Nutrient%20Model%20Report%2010-06-14.pdf
NSPECT: https://coast.noaa.gov/digitalcoast/tools/opennspect.html

7.2.2 HSPF Modeling Results

Failing septic systems, livestock and CSO were identified as specific sources in the HSPF model. General nonpoint sources were allocated between permeable and impermeable land cover types (Table 96). Permeable land use-land cover includes some urban development, agriculture, forest, wetlands, and barren land. Impermeable land is solely urban development.

The HSPF model indicated that the highest E. coli loads occur in the Little Calumet-Deep River and Headwaters Main Beaver Dam Ditch subwatersheds followed by the Headwaters Turkey Creek subwatershed.

The HSPF model indicated that CSOs are a major contributor of *E. coli* loading where they exist and when CSO events occur in the watershed. CSOs contribute at least an order of magnitude more to *E. coli* loading than failing septic systems or livestock. The largest loads originate from CSOs located in the Little Calumet-Deep River subwatershed.

The HSPF model also indicates that livestock is a slightly greater contributor to *E. coli* loads than failing septic systems in 7 of the 9 subwatersheds. However, it is important to note that the numbers and locations of either is an approximation based on agricultural census data from 2007 and populated unsewered areas respectively. A failure rate of 1.5% was assumed in estimating the contribution from failing septic systems.

Subwatershed	Failing Septic Systems (counts/day)	Livestock (counts/day)	Combined Sewer Overflow (counts/day)	Average NPS Load Permeable (counts/ac./day)	Average NPS Load Impermeable (counts/ac./day)
Headwaters Main Beaver Dam Ditch	2.86E+10	4.19E+10	2.55E+11	3.84E+11	4.8E+08
Main Beaver Dam Ditch-Deep River	1.85E+10	5.34E+10	0	3.84E+11	4.8E+08
Headwaters Turkey Creek	2.86E+10	4.19E+10	0	3.84E+11	4.8E+08
Deer Creek-Deep River	1.63E+10	5.03E+10	0	3.84E+11	4.8E+08
City of Merrillville-Turkey Creek	4.94E+10	3.86E+10	0	3.84E+11	4.8E+08
Duck Creek	3.27E+10	3.33E+10	0	3.84E+11	4.8E+08
Lake George-Deep River	4.18E+10	3.55E+10	0	3.84E+11	4.8E+08
Little Calumet River-Deep River	2.37E+09	3.62E+10	1.59E+12	3.84E+11	4.8E+08
Willow Creek-Burns Ditch	4.79E+10	5.22E+10	0	3.84E+11	4.8E+08

Table 96 Estimated E. coli loads by subwatershed (HSPF)

Agricultural land was shown to have an average *E. coli* load two orders of magnitude greater than the next highest land use type which was urban land uses (Table 97).

Land Use Type	Average E. coli Load (counts/ac./day)
Urban or Built-up Land	1.61E+11
Agricultural Land	2.37E+13
Forest Land	1.31E+11
Wetlands/Water	4.82E+07
Barren Land	4.82E+07

Table 97 Estimated E. coli load by land use (HSPF)

The HSPF model indicated that the highest nitrate loads occur in the Headwaters Main Beaver Dam Ditch and Little Calumet-Deep River subwatersheds followed by the Main Beaver Dam Ditch-Deep River subwatershed (Table 98).

As with *E. coli*, the HSPF model indicated that CSOs are a major contributor of nitrate loading where they exist in the watershed. The largest nitrate loads originate from CSOs located in the Headwaters Main Beaver Dam Ditch subwatershed. The HSPF model also indicates that failing septic systems are another important contributor of nitrate loading.

Subwatershed	Failing Septic Systems (lbs./day)	Livestock (lbs./day)	Combined Sewer Overflow (lbs./day)	Average NPS Load Permeable (lbs./ac./day)	Average NPS Load Impermeable (lbs./ac./day)
Headwaters Main Beaver Dam Ditch	0.0048	0.0066	49.3326	0.0011	0.0012
Main Beaver Dam Ditch-Deep River	0.2429	0.0084	0	0.0011	0.0012
Headwaters Turkey Creek	0.0040	0.0074	0	0.0011	0.0012
Deer Creek-Deep River	0.0277	0.0079	0	0.0011	0.0012
City of Merrillville-Turkey Creek	0.0840	0.0061	0	0.0011	0.0012
Duck Creek	0.0556	0.0053	0	0.0011	0.0012
Lake George-Deep River	0.0711	0.0056	0	0.0011	0.0012
Little Calumet River-Deep River	0.0045	0.0057	6.7875	0.0011	0.0012
Willow Creek-Burns Ditch	0.0815	0.0082	0	0.0011	0.0012

Table 98 Estimated nitrate loads by subwatershed (HSPF)

7.2.3 STEPL Modeling Results

Urban land cover contributes approximately 66% of the annual runoff volume in the watershed (Figure 218). Table 99 presents runoff volume, expressed in acre-feet, by land cover type for each site's catchment area. No BMPs were applied to the model for these estimates.

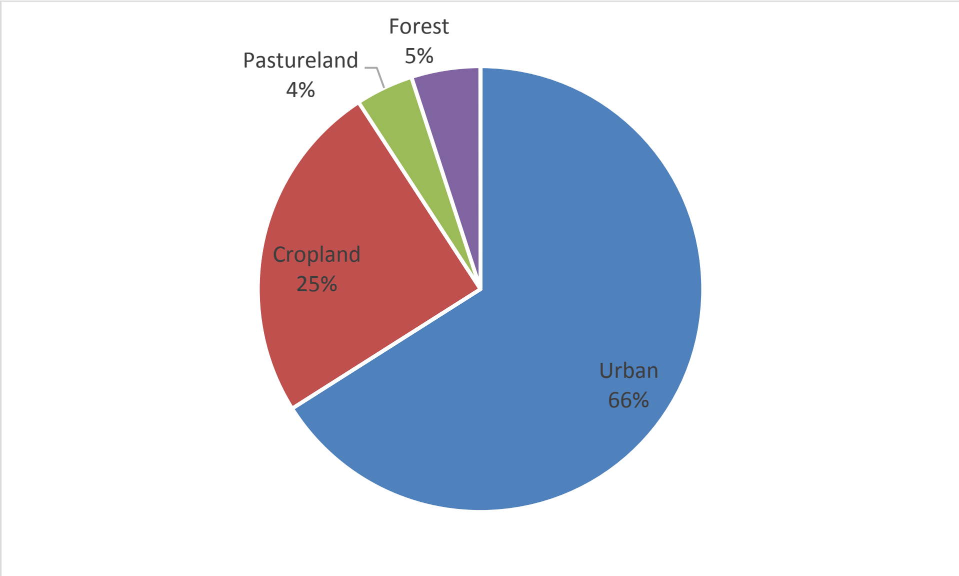


Figure 218 Percent land cover contribution to runoff volume (STEPL)

Site #	Urban (ac-ft)	Cropland (ac-ft)	Pastureland (ac-ft)	Forest (ac-ft)	Tot Runoff Vol (ac-ft)
1	3,930	243	5	29	4,208
2	926	1	-	28	955
3	1,643	1,003	48	24	2,717
5	32	-	-	3	35
6	1,675	19	6	47	1,748
7	1,649	258	14	80	2,001
8	2,225	491	41	269	3,026
9	1,090	982	322	227	2,620
10	1,131	388	58	55	1,632
11	472	1,491	195	200	2,358
12	54	151	194	228	627
13	239	149	141	113	642
14	941	363	109	80	1,492
15	3,881	1,908	198	71	6,058
16	1,204	946	150	111	2,411
17	141	631	129	61	961
18	372	1,749	251	154	2,525
19	1,341	33	19	100	1,492
20	2,741	177	36	162	3,116
21	1,515	4	14	43	1,577
22	302	647	36	19	1,005
23	535	506	144	277	1,463
24	774	437	5	2	1,218
25	3,254	228	36	165	3,682

26	2,824	738	79	166	3,806
27	1,130	53	70	74	1,326
28	1,173	1	31	107	1,312
29	384	2	1	30	417
30	1,174	118	24	53	1,369
31	935	226	11	31	1,203
32	2,734	88	11	100	2,933
33	1,953	197	25	31	2,205
34	1,658	602	109	196	2,566
35	435	827	98	79	1,438
36	449	1,962	371	153	2,935

Table 99 Estimated annual runoff (STEPL)

Estimated annual pollutant loads for nitrogen, phosphorus, biological oxygen demand, and sediment for each site's catchment area is provided in Table 100. No BMPs were applied to the model for these estimates. Annual loading was also calculated on a per acre basis to help identify which catchments were contributing a higher proportion of pollutant loads.

Site #	Nitrogen Load		Phosphorus Load		BOD Load		Sediment Load	
	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)	(t/yr)	(lb/ac/yr)
1	27,827	3.0	5,532	0.6	95,185	10.2	630	135.7
2	5,334	0.6	847	0.1	20,085	2.2	122	26.2
3	27,034	2.9	6,914	0.7	64,140	6.9	404	87.1
5	191	0.0	32	0.0	721	0.1	4	0.9
6	10,529	1.1	1,860	0.2	39,195	4.2	229	49.3
7	13,559	1.5	2,915	0.3	42,597	4.6	245	52.8
8	20,988	2.3	4,707	0.5	61,733	6.6	363	78.3
9	27,392	2.9	6,833	0.7	64,137	6.9	342	73.6
10	13,801	1.5	3,267	0.4	37,740	4.1	214	46.1
11	31,976	3.4	8,990	1.0	61,711	6.6	379	81.6
12	5,308	0.6	1,146	0.1	12,893	1.4	43	9.3
13	5,627	0.6	1,221	0.1	14,772	1.6	62	13.3
14	13,035	1.4	3,062	0.3	35,338	3.8	188	40.4
15	56,826	6.1	14,011	1.5	142,545	15.3	857	184.6
16	25,589	2.8	6,618	0.7	60,014	6.5	344	74.1
17	13,681	1.5	3,773	0.4	26,386	2.8	154	33.1
18	36,623	3.9	10,332	1.1	68,789	7.4	423	91.1
19	7,865	0.8	1,387	0.1	29,527	3.2	162	34.8
20	18,030	1.9	3,433	0.4	63,488	6.8	354	76.2
21	8,167	0.9	1,337	0.1	31,811	3.4	175	37.6
22	13,800	1.5	3,914	0.4	26,922	2.9	174	37.6
23	13,970	1.5	3,586	0.4	32,510	3.5	175	37.6
24	12,099	1.3	3,122	0.3	29,380	3.2	183	39.3
25	21,095	2.3	3,947	0.4	73,405	7.9	423	91.2

26	28,915	3.1	6,577	0.7	82,470	8.9	484	104.3
27	7,598	0.8	1,325	0.1	27,234	2.9	142	30.6
28	6,413	0.7	1,023	0.1	24,924	2.7	136	29.3
29	2,523	0.3	470	0.1	9,448	1.0	52	11.2
30	8,343	0.9	1,618	0.2	27,803	3.0	160	34.5
31	8,943	1.0	2,009	0.2	25,707	2.8	156	33.6
32	15,773	1.7	2,774	0.3	58,547	6.3	333	71.7
33	13,638	1.5	2,640	0.3	45,418	4.9	266	57.3
34	20,954	2.3	4,951	0.5	56,450	6.1	322	69.4
35	18,180	2.0	4,788	0.5	36,802	4.0	194	41.7
36	41,786	4.5	11,196	1.2	80,366	8.7	416	89.6
Total	603,411		142,153		1,610,195		9,310	

Table 100 Estimated annual pollutant loading by catchment (STEPL)

Estimated total annual pollutant loads by source are present in Table 101 and Figure 219. Table 101 also includes area loads which show that cropland contributes higher nutrient and sediment loads on a per acre basis.

Sources	N Load (lb/yr)	N Load (lb/ac/yr)	P Load (lb/yr)	P Load (lb/ac/yr)	BOD Load (lb/yr)	BOD Load (lb/ac/yr)	Sed Load (t/yr)	Sed Load (t/ac/yr)
Urban	239,763	4.86	37,188	0.75	942,489	19.12	5,478	0.11
Cropland	318,784	12.36	97,011	3.76	516,213	20.02	3,735	0.14
Pastureland	32,845	5.59	2,846	0.48	106,199	18.07	55	0.01
Forest	2,280	0.22	1,294	0.13	5,530	0.54	43	0.00
Septic	9,738	-	3,814	-	39,765	-	-	-
Total	603,411	-	142,153	-	1,610,195	-	9,310	-

Table 101 Estimated total annual pollutant load by source

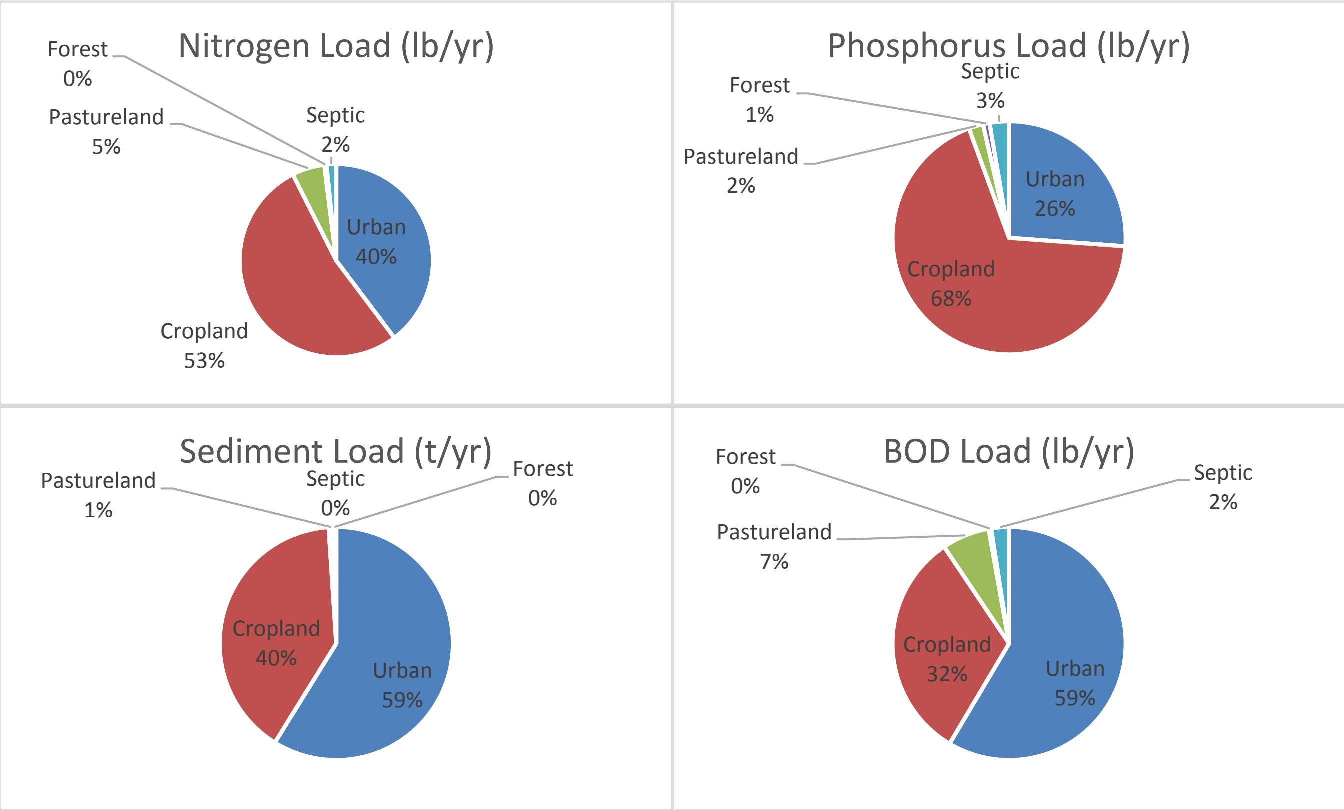


Figure 219 Estimated total annual pollutant load by source (STEPL)

The following table provides a summary of *E. coli* data from the Deep River-Portage Burns Waterway TMDL.

Site	# of Samples	% Samples Violating Target	Maximum MPN/100mL	Average MPN/100mL
1	10	60%	1986.3	551.9
2	10	90%	2419.6	1340.4
3	10	80%	2419.6	1240.2
5	10	20%	344.8	132.6
6	10	10%	260.3	107.3
7	10	90%	1732.9	656.1
8	10	80%	2419.6	612.9
9	10	40%	2419.6	622.2
10	10	60%	2419.6	661.2
11	10	80%	2419.6	1216
12	10	70%	2419.6	669.7
13	10	80%	2419.6	957.8
14	10	40%	2419.6	438.5
15	10	90%	2419.6	699.3
16	10	80%	2419.6	720
17	10	80%	1732.9	501.6

Site	# of Samples	% Samples Violating Target	Maximum MPN/100mL	Average MPN/100mL
18	10	80%	2419.6	785.8
19	10	50%	2419.6	511.5
20	10	60%	2419.6	629.9
21	10	40%	613.1	233.2
22	10	80%	>2419.6	687.6
23	10	30%	1986.3	372
24	10	80%	>2419.6	1,297.50
25	10	40%	2419.6	414.3
26	10	29%	770.1	207.6
27	10	50%	1413.6	360
28	7	29%	770.1	207.6
29	10	80%	1986.3	668.9
30	10	20%	344.8	168.8
31	10	60%	1553.1	564.9
32	10	20%	866.4	238
33	10	80%	2419.6	810.9
34	10	40%	1119.9	351.8
35	10	100%	2419.6	1001.3
36	10	100%	2419.6	1301.9

Table 102 Summary of E. coli site data from TMDL

7.3 Pollutant Load Reductions Needed

The US EPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL) model was also used to estimate pollutant loads reductions needed for each catchment area and the watershed as a whole. The watershed restoration plan targets listed below were used as STEPL model inputs. The steering committee ultimately decided to use more stringent nutrient targets than chosen by IDEM for the TMDL study. Total suspended solids and *E. coli* targets from the TMDL were retained. The watershed plan water quality targets are the same or more stringent than those used for the TMDL. Therefore meeting the reductions listed in the tables below would also meet the load reductions called for in the TMDL.

Parameter	TMDL Target Value	Watershed Plan Target Value
Total Phosphorus	No value should exceed 0.30 mg/L	No value should exceed 0.07 mg/L
Total Nitrogen	NA	No value should exceed 3.3 mg/L
Biological Oxygen Demand	NA	No value should exceed 2 mg/L
Total Suspended Solids	No value should exceed 30.0 mg/L	No value should exceed 30.0 mg/L
E. coli	No value should exceed 125 counts/100 mL (geometric mean)	No value should exceed 125 counts/100 mL (geometric mean)

Table 103 TMDL water quality targets compared to the watershed restoration plan targets

The following four tables show the overall reductions needed to meet the water quality targets for total nitrogen, total phosphorus, biological oxygen demand, and sediment as measured by total suspended solids.

Site #	N Current Load (lb/year)	N Target Load (lb/year)	N Load Reduction (lb/year)	% N Load Reduction
1	27,827	34,676	NA	NA
2	5,334	7,627	NA	NA
3	27,034	23,594	3,439	13
5	191	282	NA	NA
6	10,529	14,071	NA	NA
7	13,559	15,903	NA	NA
8	20,988	24,625	NA	NA
9	27,392	23,596	3,796	14
10	13,801	13,608	193	1
11	31,976	23,043	8,932	28
12	5,308	5,834	NA	NA
13	5,627	5,675	NA	NA
14	13,035	12,615	421	3
15	56,826	51,738	5,088	9
16	25,589	21,469	4,120	16
17	13,681	9,509	4,172	30
18	36,623	25,132	11,491	31
19	7,865	11,419	NA	NA
20	18,030	24,114	NA	NA
21	8,167	11,852	NA	NA
22	13,800	9,676	4,124	30
23	13,970	13,226	744	5
24	12,099	10,505	1,594	13
25	21,095	28,471	NA	NA
26	28,915	31,137	NA	NA
27	7,598	10,280	NA	NA
28	6,413	9,991	NA	NA
29	2,523	3,373	NA	NA
30	8,343	10,696	NA	NA
31	8,943	9,753	NA	NA
32	15,773	22,306	NA	NA
33	13,638	17,134	NA	NA
34	20,954	21,561	NA	NA
35	18,180	13,592	4,588	25
36	41,786	28,775	13,011	31
Total	603,411	600,857	2,554	<1

Table 104 Nitrogen load reductions needed by catchment (STEPL)

Site #	P Current Load (lb/year)	P Target Load (lb/year)	P Load Reduction (lb/year)	% P Load Reduction
1	5,532	1,942	3,590	65
2	847	245	602	71
3	6,914	2,310	4,604	67
5	32	9	22	70
6	1,860	513	1,347	72
7	2,915	900	2,015	69
8	4,707	1,550	3,156	67
9	6,833	2,313	4,520	66
10	3,267	1,036	2,231	68
11	8,990	3,091	5,899	66
12	1,146	448	698	61
13	1,221	427	794	65
14	3,062	973	2,089	68
15	14,011	4,613	9,398	67
16	6,618	2,169	4,448	67
17	3,773	1,301	2,472	66
18	10,332	3,562	6,770	66
19	1,387	409	978	71
20	3,433	1,029	2,403	70
21	1,337	371	966	72
22	3,914	1,323	2,591	66
23	3,586	1,235	2,351	66
24	3,122	1,011	2,111	68
25	3,947	1,243	2,704	69
26	6,577	2,133	4,443	68
27	1,325	407	918	69
28	1,023	317	706	69
29	470	118	352	75
30	1,618	517	1,101	68
31	2,009	658	1,351	67
32	2,774	827	1,947	70
33	2,640	837	1,804	68
34	4,951	1,632	3,319	67
35	4,788	1,451	3,337	70
36	11,196	3,534	7,662	68
Total	142,153	46,453	95,699	67

Table 105 Phosphorus load reductions needed by catchment (STEPL)

Site #	BOD Current Load (lb/year)	BOD Target Load (lb/year)	BOD Load Reduction (lb/year)	% BOD Load Reduction
1	95,185	22,433	72,752	76
2	20,085	4,660	15,425	77
3	64,140	16,749	47,392	74
5	721	173	549	76
6	39,195	8,687	30,507	78
7	42,597	10,304	32,294	76
8	61,733	16,187	45,547	74
9	64,137	16,744	47,393	74
10	37,740	9,215	28,526	76
11	61,711	17,601	44,110	71
12	12,893	3,948	8,946	69
13	14,772	3,831	10,941	74
14	35,338	8,559	26,780	76
15	142,545	36,048	106,496	75
16	60,014	15,337	44,677	74
17	26,386	7,301	19,085	72
18	68,789	19,484	49,305	72
19	29,527	7,042	22,485	76
20	63,488	15,122	48,366	76
21	31,811	7,232	24,580	77
22	26,922	7,431	19,492	72
23	32,510	9,291	23,219	71
24	29,380	7,432	21,948	75
25	73,405	17,895	55,510	76
26	82,470	20,730	61,740	75
27	27,234	6,397	20,837	77
28	24,924	6,100	18,825	76
29	9,448	2,074	7,374	78
30	27,803	6,799	21,005	76
31	25,707	6,478	19,229	75
32	58,547	13,801	44,746	76
33	45,418	10,904	34,514	76
34	56,450	14,583	41,867	74
35	36,802	9,822	26,980	73
36	80,366	21,483	58,882	73
Total	1,610,195	407,876	1,202,319	75

Table 106 BOD load reductions needed by catchment (STEPL)

Site #	Sed Current Load (t/year)	Sed Target Load (t/year)	Sed Load Reduction (t/year)	% Sed Load Reduction
1	630	263	367	58
2	122	35	86	71
3	404	272	132	33
5	4	1	3	70
6	229	72	157	68
7	245	113	133	54
8	363	185	179	49
9	342	254	88	26
10	214	123	91	42
11	379	341	38	10
12	43	39	4	10
13	62	43	19	31
14	188	112	76	40
15	857	545	312	36
16	344	247	97	28
17	154	142	11	7
18	423	393	30	7
19	162	54	108	67
20	354	133	220	62
21	175	53	122	70
22	174	150	24	14
23	175	132	43	25
24	183	120	62	34
25	423	162	262	62
26	484	257	227	47
27	142	51	91	64
28	136	42	94	69
29	52	16	36	69
30	160	66	94	59
31	156	81	75	48
32	333	113	220	66
33	266	109	157	59
34	322	189	133	41
35	194	157	37	19
36	416	378	38	9
Total	9,310	5,444	3,866	42

Table 107 Sediment load reductions needed by catchment (STEPL)

Site	# of Samples	% Samples Violating Target	Maximum MPN/100mL	Average MPN/100mL	% Reduction
1	10	60%	1986.3	551.9	57.40%
2	10	90%	2419.6	1340.4	82.50%
3	10	80%	2419.6	1240.2	81.10%
5	10	20%	344.8	132.6	0%
6	10	10%	260.3	107.3	0%
7	10	90%	1732.9	656.1	64.20%
8	10	80%	2419.6	612.9	61.70%
9	10	40%	2419.6	622.2	62.20%
10	10	60%	2419.6	661.2	64.50%
11	10	80%	2419.6	1216	80.70%
12	10	70%	2419.6	669.7	64.90%
13	10	80%	2419.6	957.8	75.50%
14	10	40%	2419.6	438.5	46.40%
15	10	90%	2419.6	699.3	66.40%
16	10	80%	2419.6	720	67.40%
17	10	80%	1732.9	501.6	53.20%
18	10	80%	2419.6	785.8	70.10%
19	10	50%	2419.6	511.5	54.10%
20	10	60%	2419.6	629.9	62.70%
21	10	40%	613.1	233.2	0%
22	10	80%	>2419.6	687.6	65.80%
23	10	30%	1986.3	372	36.80%
24	10	80%	>2419.6	1,297.50	81.90%
25	10	40%	2419.6	414.3	43.30%
26	10	29%	770.1	207.6	69.50%
27	10	50%	1413.6	360	34.70%
28	7	29%	770.1	207.6	69.50%
29	10	80%	1986.3	668.9	64.90%
30	10	20%	344.8	168.8	0%
31	10	60%	1553.1	564.9	58.40%
32	10	20%	866.4	238	1.20%
33	10	80%	2419.6	810.9	71.00%
34	10	40%	1119.9	351.8	33.20%
35	10	100%	2419.6	1001.3	76.50%
36	10	100%	2419.6	1301.9	81.90%

Table 108 E. coli load reductions needed by catchment (TMDL)

The following table summarizes the current loads, target loads, load reductions, and percent reductions for the watershed. In order to calculate the overall watershed geomean (average) for *E. coli*, the site geomeans were averaged together and then an overall percent reduction was calculated from this value.

Pollutant	Current Load	Target Load	Load Reduction	% Reduction
Nitrogen (lb/year)	603,411	600,857	2,554	<1
Phosphorus (lb/year)	142,153	46,453	95,699	67
BOD (lb/year)	1,610,195	407,876	1,202,319	75
Sediment (t/year)	9,310	5,444	3,866	42
	Average	**Target Value**	**-**	**% Reduction**
E. coli (CFU/100mL)	627	125	-	80

Table 109 Overall current and target loads and load reductions needed for the watershed

8 Watershed Restoration Goals

The following goals and supporting objectives have been developed based on public concerns, watershed inventory and pollutant loading data, and guidance from steering committee members.

8.1 Recreational Use

Existing Condition:

Water quality data collected during the baseline assessment shows that 60% of the 327 samples collected for *E. coli* exceeded the single sample water quality standard of 235 CFU/100 mL with a median concentration of 344 CFU/100mL and a maximum >2,419 CFU/100 mL.

Goal 1: Reduce watershed *E. coli* loads by 80% so that all waterways meet the state water quality standard of 235 CFU/100 mL (single sample) and 125 CFU/100mL (geomean) during the recreational season (April 1 – October 31) by 2050.

- 10-years: Reduce E. coli loading by 20%
- 20-years: Reduce E. coli loading by 50%
- 30-years: Reduce *E. coli* loading by 70%

Indicators: Water quality will be used as the indicator towards meeting this goal. The environmental indicator will be *E. coli* testing conducted at each impaired site at least monthly during the recreational season following 5 years of implementation.

8.2 Aquatic Life Use

Existing Condition: Biological monitoring data collected during the baseline assessment indicate that the overall biological integrity of the watershed is poor to very poor. More than 94% of the 35 sample sites failed established criteria for aquatic life support during each sampling event with a median Index of Biotic Integrity score of 30 for fish and 28 for macroinvertebrates.

Goal 2: Restore warmwater fish and macroinvertebrate communities so that all waterways meet their aquatic life use designations with natural waterways maintaining at least a "good" integrity class rating and modified waterways maintaining at least a "fair" integrity class rating by 2050.

To achieve this goal, functional lifts are necessary at the hydrology, hydraulic, geomorphology, and physiochemical levels. The following supporting objectives are anticipated to provide this lift. <u>Lower function levels must be addressed to realize functional lift of higher levels.</u>

Indicators: Biological monitoring will be used as the indicator towards meeting this goal. The environmental indicator will be a macroinvertebrate assessment (Hoosier Riverwatch methodology). Ideally, both the fish and macroinvertebrate communities can revaluated by IDEM using their methodologies. Monitoring will be conducted annually at each impaired site once the implementation phase is complete.

Objective 2.1: Improve dissolved oxygen levels so that all waterways are capable of supporting a well balance, warm water community.

- All waterways should maintain a daily average dissolved oxygen concentration >5 mg/L and no less than 4 mg/L at any time.

Indicators: Water quality and streamflow will be used as the indicators towards meeting this goal. The environmental indicators will include dissolved oxygen, temperature, BOD testing and stream flow (Hoosier Riverwatch methodologies) conducted at each impaired site at least monthly following 5 years of implementation.

Objective 2.2: Reduce nutrient and sediment loads from urban and agricultural land uses.

- All waterways should maintain a median total phosphorus concentration of <0.08 mg/L, nitrate concentration <1.09 mg/L, and total suspended solids concentration <30 mg/L.
  - Reduce phosphorus loading from 142,153 lb/year to 46,453 lb/year (67%) and nitrogen loading from 603,411 lb/year to 600,857 lb/year.
    - 10-Years: Reduce nitrogen loading by 128 lb/year (0.02%) and phosphorus loading by 4,785 lb/year (3%).
    - 20-Years: Reduce nitrogen loading by 638 lb/year (0.11%) and phosphorus loading by 23,925 lb/year (17%).
    - 30-Years: Reduce nitrogen loading by 1,915 lb/year (0.32%) and phosphorus loading by 71,774 lb/year (50%).
  - Reduce sediment loads from 9,310 t/year to 5,444 t/year (42%).
    - 10-Years: Reduce sediment loading by 193 t/year (2%).
    - 20-Years: Reduce sediment loading by 966 t/year (10%).
    - 30-Years: Reduce sediment loading by 2,899 t/year (31%).

Indicators: Water quality and pollutant load modeling will be used as the indicators towards meeting this goal. The environmental indicators will include orthophosphate, nitrate and turbidity testing (Hoosier Riverwatch methodologies) at each impaired site at least monthly following 5 years of implementation. Pollutant load models will be run on a project by project basis.

Objective 2.3: Restore riparian vegetation to improve channel stability, nutrient processing, sediment capture, and landscape habitat connectivity.

Indicators: Physical measurement and qualitative measures will be used as the indicators towards meeting this goal. The environmental indicators will be buffer width and length and qualitative visual assessments to assess functioning condition (ex. IDEM QHEI and NRCS SVA). Buffer length and width restored/enhanced will be determined following practice installation. Qualitative visual assessments will be conducted annually for 5 years thereafter.

Objective 2.4: Improve bed form diversity within channelized/incised or dammed stream reaches to increase depth variability and substrate quality.

Indicator: Physical measurement and qualitative measures will be used as the indicators towards meeting this goal. The environmental indicators will be bed material characterization (material size), pool-to-pool spacing and depth variability, and qualitative visual assessments to assess functioning condition (ex. IDEM QHEI and NRCS SVA). Bed material, pool-to-pool spacing and depth variability will be characterized and qualitative visual assessments will be conducted prior to any in-channel implementation activity and continued annually over a total of 5 years.

Objective 2.5: Improve channel stability to reduce suspended and bedded sediments.

Indicators: Physical measurement and qualitative measures will be used as the indicators towards meeting this goal. The environmental indicators will be channel evolution stage/stream succession type and channel profile and cross sections. Channel stage/type and channel profile and cross section will be assessed prior to any in-channel implementation activity and ideally will be reevaluated annually over a total of 5 years.

Objective 2.6: Provide floodplain connectivity for channelized/incised stream reaches to improve channel stability and facilitate sediment storage and nutrient processing outside of the channel.

Indicators: Physical measurement qualitative measures will be used as the indicators towards meeting this goal. The environmental indicators will be bank height and entrenchment ratios and qualitative visual assessments to assess channel condition (ex. NRCS SVA). Bank height and entrenchment ratios will be characterized and qualitative visual assessments will be conducted prior to any in-channel implementation activity and continued annually over a total of 5 years.

Objective 2.7: Reduce storm water runoff volume and rates to improve flow-duration conditions and flow dynamics.

Indicators: Models and flow-duration curves will be used as indicators towards meeting this goal. The environmental indicators will include volume reduction from practice implementation and flow-duration curves. Models that evaluate runoff volume and reductions will be run on a project by project basis. Flow-duration curves will be evaluated after 5 years of implementation.

9 Watershed Critical Areas

IDEM identifies “Critical Areas” as areas where watershed management plan implementation can remediate nonpoint pollution sources in order to improve water quality and/or can mitigate the impact of future sources in order to protect water quality. Because storm water delivers additional pollutants and flow to streams, and excess flow has been shown to destabilize stream banks and add to pollutant loads, the reduction of flow may be designated as a critical activity if that reduction will reduce a nonpoint source pollutant in a critical area. IDEM requires the use of inventoried data, current pollutant loads, and potential sources to identify critical areas.

9.1 Identification Process

Site catchment drainage areas were used as the geographical extent in evaluating critical areas. The decision to use catchment areas over the larger HUC-12 subwatersheds was based on the fact that there are 35 sites in the watershed with water chemistry, biological, and habitat monitoring data available from IDEM’s baseline assessment in 2013. A two-step process was used in the evaluation:

1. The first step was to consider data that was shown to be statistically significant in describing the reasons behind existing stream impairments.

2. The second step was to consider data that represented stakeholder concerns.

A "weight of evidence" approach was used to prioritize which catchments would be deemed the most critical for implementation actions. Water quality data was prioritized over data that represented stakeholder concerns since that data captured real conditions.

9.1.1 Loads & Stressors

The first step of the critical area identification process was to consider data from the stressor linkage analysis completed in Section 5: Watershed Inventory- Part III and STEPL pollutant loading data from Section 7.2: Current Pollutant Loads. Based on this review, eighteen different indicators were chosen for consideration (Table 110).

Site data for each indicator were sorted and ranked from worst to best. The top nine worst sites (upper 25%) were recorded. In the instance of a tie, site selection was inclusive of all tie values. These data were combined to come up with a cumulative score which was used to rank sites based on number of occurrences documented.

STEPL Loads (adjusted for catchment area)
• Nitrogen load • Phosphorus load • Biological oxygen demand load • Sediment load • Runoff volume
Water Chemistry (% observations exceeding target value or water quality standard)
• Dissolved oxygen • Ammonia • Nitrate • Total Kjeldahl nitrogen • Total phosphorus • Total suspended solids • Turbidity • E. coli
Habitat Quality
• Qualitative Habitat Evaluation Index scores
Fish & Macroinvertebrate Community Health
• Index of biotic integrity scores • Macroinvertebrate Index of Biotic Integrity scores
Land Cover (% of land cover in catchment area)
• Forest • Agriculture

Table 110 Pollutant load and stressor indicators used in critical area identification process

9.1.2 Stakeholder Concerns

The second step considered stakeholder concerns identified in Section 6: Problems and Causes that could be measured and were not captured by the previous step. Based on this review, seven different indicators were chosen for consideration (Table 111).

Stakeholder Concerns
• Percent wetland loss • Percent Green Infrastructure Vision lands not protected • Recreational sites located on or adjacent to impaired waterways • Approximate percentage of impaired streams that are regulated drains

- Percent human land cover
- Percent riparian human land cover
- Percent impervious cover

Table 111 Stakeholder concern indicators used in critical area identification process

Data for each indicator was evaluated and the top 25% worst values for each indicator were identified. In the instance of a tie, the data was inclusive of all tie values.

Site	% Exceedance DO	% Exceedance Ammonia	% Exceedace Nitrate	% Exceedance TKN	% Exceedance TP	% Exceedance TSS	% Exceedance Turbidity	% Exceedance E coli	QHEI Score	IBI Score	mIBI Score	STEPL N Load	STEPL P Load	STEPL BOD Load	STEPL Sed Load	STEPL Runoff Volume	% Ag Land Cover	% Forest Cover
1	7	50	30	90	100	10	67	67	48	16	36	3.00	0.60	10.25	135.71	0.45	29	9
2	0	14	57	29	29	0	17	89	58	12	22	0.57	0.09	2.16	26.24	0.47	29	6
3	0	57	57	17	43	14	25	78	40	30	26	2.91	0.74	6.91	87.08	0.80	47	2
5	8	14	0	14	100	0	50	22	48	34	38	0.02	0.00	0.08	0.93	0.33	30	10
6	0	22	22	89	89	0	43	11	52	36	30	1.13	0.20	4.22	49.26	0.42	30	10
7	8	14	14	100	100	14	100	78	74	18	30	1.46	0.31	4.59	52.78	0.81	17	9
8	17	29	0	33	71	0	25	89	44	32	28	2.26	0.51	6.65	78.27	0.64	30	10
9	7	22	22	67	89	0	14	33	52	30	30	2.95	0.74	6.91	73.57	0.48	50	10
10	0	0	14	29	100	0	17	33	41	12	28	1.49	0.35	4.06	46.07	0.70	56	8
11	33	14	57	86	86	14	67	78	49	24	30	3.44	0.97	6.65	81.62	0.49	69	7
12	0	22	89	56	100	11	64	67	56	42	28	0.57	0.12	1.39	9.27	0.34	39	10
13	0	14	14	43	43	14	58	78	66	30	42	0.61	0.13	1.59	13.35	0.43	30	6
14	0	10	100	60	100	10	13	44	75	36	40	1.40	0.33	3.81	40.42	0.67	40	10
15	0	0	0	14	14	0	50	89	64	30	28	6.12	1.51	15.35	184.58	0.76	33	32
16	0	0	0	29	57	29	75	78	52	40	30	2.76	0.71	6.46	74.08	0.64	34	20
17	0	0	0	0	14	0	17	78	51	34	38	1.47	0.41	2.84	33.11	0.54	34	9
18	0	40	100	60	100	10	20	78	57	36	40	3.94	1.11	7.41	91.12	0.55	38	8
19	8	71	0	86	86	29	45	56	36	32	28	0.85	0.15	3.18	34.82	0.79	45	8
20	75	71	14	100	100	0	33	67	44	38	38	1.94	0.37	6.84	76.16	0.76	67	9
21	77	100	14	100	100	14	42	40	33	12	20	0.88	0.14	3.43	37.63	0.88	67	9
22	17	29	0	71	100	71	100	80	25	38	38	1.49	0.42	2.90	37.55	0.62	5	14
23	0	70	100	90	100	0	6	33	58	36	26	1.50	0.39	3.50	37.60	0.46	25	11
24	85	100	100	100	100	0	25	80	26	14	24	1.30	0.34	3.16	39.32	0.81	2	6
25	62	71	38	100	100	0	62	40	37	28	26	2.27	0.43	7.90	91.15	0.80	43	13
26	85	29	0	100	100	14	77	30	40	12	26	3.11	0.71	8.88	104.30	0.70	33	23
27	46	14	0	100	86	29	92	50	27	40	28	0.82	0.14	2.93	30.59	0.73	44	0
28	56	29	0	86	86	14	22	29	37	12	0	0.69	0.11	2.68	29.25	0.73	4	16
29	0	29	0	67	43	0	8	80	49	36	26	0.27	0.05	1.02	11.17	0.31	8	13
30	15	14	0	29	0	0	0	20	36	28	34	0.90	0.17	2.99	34.55	0.81	1	22
31	8	14	0	29	86	0	69	60	41	12	28	0.96	0.22	2.77	33.60	0.84	13	8
32	0	40	0	40	30	10	31	20	51	44	30	1.70	0.30	6.30	71.67	0.82	16	11
33	38	14	0	86	71	14	54	80	41	30	28	1.47	0.28	4.89	57.33	0.87	25	6
34	77	100	0	100	100	14	69	40	31	12	30	2.26	0.53	6.08	69.43	0.65	4	7
35	0	86	0	57	14	14	85	100	43	20	30	1.96	0.52	3.96	41.74	0.73	14	3
36	0	50	0	40	40	10	88	100	40	16	30	4.50	1.21	8.65	89.63	0.71	13	9

Table 112 Top 25% worst values for each water quality indicator highlighted in red

Site	% Wetland Loss	Ratio Managed Lands / GIV	Recreational Sites on 303d Stream	% 303d Streams Regulated Drains	% Human Land Cover	% Impervious Cover	% Human Riparian Land Cover
1	85	100	0	0	76	39	82
2	93	100	1	75	86	23	80
3	89	100	0	100	71	17	70
5	81	84	0	75	71	5	65
6	86	100	0	100	82	5	63
7	92	60	0	0	76	6	57
8	82	99	0	25	50	28	56
9	93	88	1	0	87	24	56
10	87	96	2	75	79	24	55
11	90	67	0	50	93	31	55
12	83	100	1	50	77	20	54
13	83	100	0	100	75	15	53
14	64	61	0	100	48	21	53
15	78	61	0	100	76	10	50
16	93	72	0	0	74	16	49
17	91	98	3	100	79	21	47
18	80	100	0	50	68	25	46
19	72	98	0	50	49	17	45
20	95	100	1	100	92	19	45
21	95	93	1	100	75	13	45
22	75	83	3	100	62	17	44
23	75	100	0	75	79	18	44
24	78	85	0	0	72	12	44
25	61	99	4	0	70	17	43
26	0	100	4	0	51	17	43
27	76	94	0	0	36	13	43
28	71	97	0	25	63	5	42
29	63	98	0	0	60	9	41
30	85	100	0	25	82	23	37
31	50	99	0	0	75	22	36
32	82	76	1	100	65	22	31
33	81	100	1	100	73	7	28
34	85	94	0	0	76	7	26
35	92	65	0	0	87	5	25
36	97	91	0	0	80	24	25

Table 113 Top 25% worst values for each stakeholder concern indicator highlighted in red

In order to better understand where the worst problems existed throughout the watershed, the number of times a site was identified as having a value in the top 25% worst was recorded (Table 114). Thirty-two out of the thirty-five sites had at least one data record in the top 25% worst values for water quality, loads, and stressors. Twenty-eight out of the thirty-five sites had at least one data record in the top 25% worst values relating to stakeholder concerns.

Site	Pollutant Load & Stressor Indicators # of Times Site Identified	Stakeholder Concern Indicator # of Times Site Identified	Site	Pollutant Load & Stressor Indicators # of Times Site Identified	Stakeholder Concern Indicators # of Times Site Identified
1	7	2	**20**	6	1
2	5	0	**21**	10	4
3	11	5	**22**	4	3
5	0	2	**23**	5	0
6	0	1	**24**	11	3
7	5	3	**25**	11	1
8	2	2	**26**	11	3
9	4	0	**27**	7	3
10	2	2	**28**	5	2
11	7	0	**29**	2	1
12	1	0	**30**	2	3
13	2	2	**31**	3	5
14	1	3	**32**	1	2
15	5	2	**33**	5	6
16	4	0	**34**	9	2
17	0	1	**35**	5	3
18	5	2	**36**	7	3
19	4	0			

Table 114 Number of times site identified

The information on number of times a site was identified (Table 114) was used to populate an attribute table in GIS so that the data could be expressed spatially. GIS shapefile layers were created to display the Pollutant Load & Stressor Indicators data and Stakeholder Concern Indicators data (Figure 220). An "equal interval" classification scheme with four classes was chosen to classify the dataset for priority ranking. Equal interval classification divides the range of attribute values into equal-sized subranges. This allows the user to specify the number of intervals, four in this case, and ArcGIS automatically determines the class breaks based on the value range (Table 115). Equal interval is best applied to familiar data ranges, such as percentages. This method emphasizes the amount of an attribute value relative to other values. Additionally, the data was linear in distribution and had no outliers that would skew the results, thereby making equal interval classification an appropriate method.

Load & Stressor Indicators	Rank	Stakeholder Indicators	Rank
0 - 2.750000	4 - Low Priority	0 – 1.500000	4 - Low Priority
2.750001 – 5.500000	3 – Moderately Low Priority	1.500001 – 3.00000	3 – Moderately Low Priority
5.500001 – 8.250000	2 – Moderately High Priority	3.00001 – 4.500000	2 – Moderately High Priority

8.250001 - 11	1 – High Priority	4.500001 - 6	1 – High Priority

Table 115 Classification scoring breaks

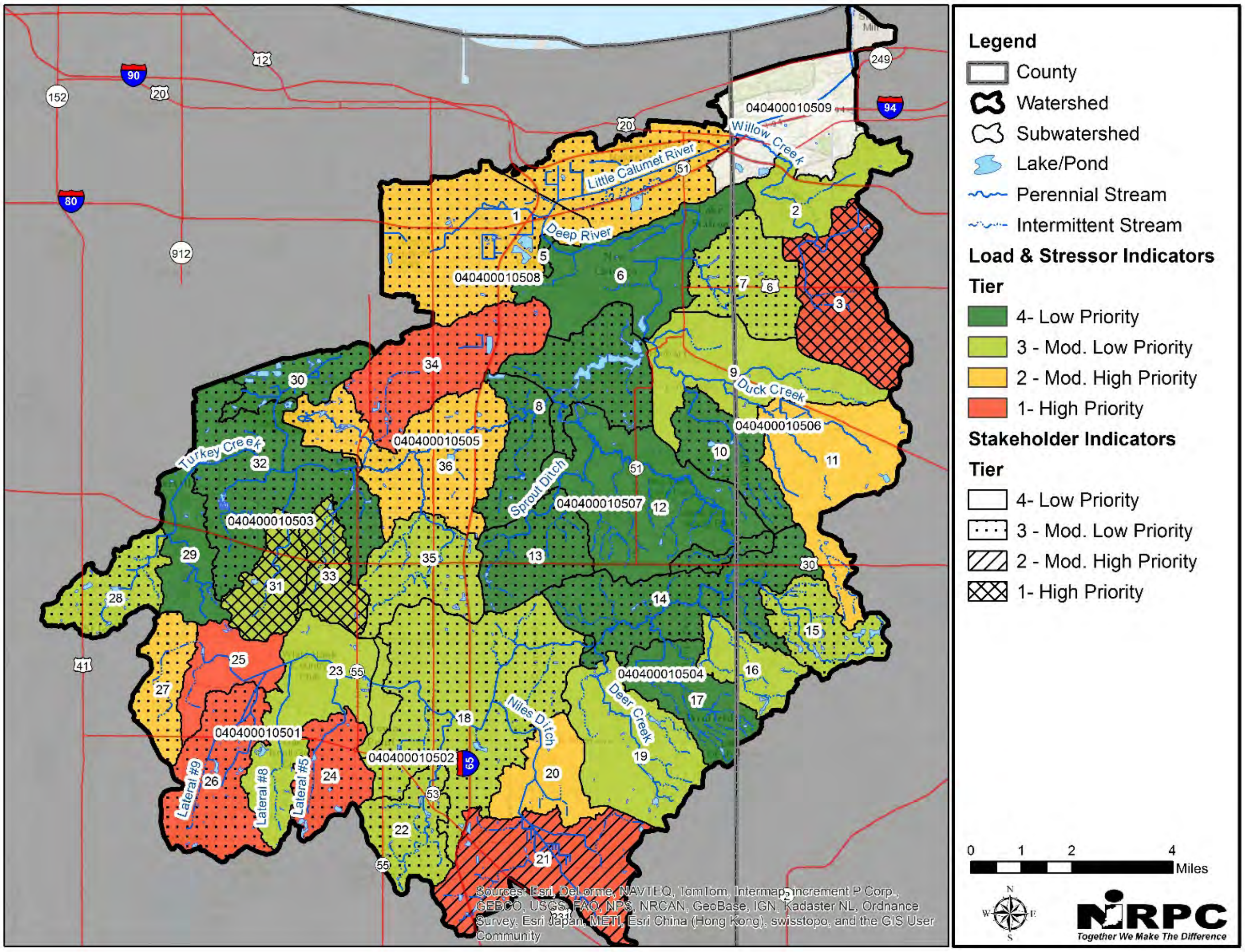


Figure 220 Pollutant load and stressor indicators with stakeholder indicators overlay

Since further prioritization is necessary, we counted the number of times each site had at least one data record in the top 25% worst values for the water quality, loads, and stressors and at least one data record in the top 25% worst values related to stakeholder concerns.

9.1.3 Final Determination

As previously stated, water quality data was prioritized over data that represented stakeholder concerns since that data captured real conditions. However, one last step was taken to further prioritize critical areas. Any site that had an occurrence of five or more stakeholder concerns received a higher priority ranking. In Table 116, below, note that both sites 33 and 31 are considered moderately low priority for water quality. However, since the data shows that there are a lot of stakeholder concerns that need to be addressed in these areas, they are moved from moderately low priority to moderately high priority critical areas.

Site	Water Quality Indicator # of Times Site Identified	Stakeholder Concern Indicator # of Times Site Identified	Site	Water Quality Indicator # of Time Site Identified	Stakeholder Concern Indicator # of Times Site Identified
3	11	5	23	5	0
24	11	3	22	4	3
26	11	3	9	4	0
25	11	1	16	4	0
21	10	4	19	4	0
34	9	2	31	3	5
27	7	3	30	2	3
36	7	3	8	2	2
1	7	2	10	2	2
11	7	0	13	2	2
20	6	1	29	2	1
33	5	6	14	1	3
7	5	3	32	1	2
35	5	3	12	1	0
15	5	2	5	0	2
18	5	2	6	0	1
28	5	2	17	0	1
2	5	0			

Table 116 Final step in critical area determination

The results of this last step are a shown in Figure 221 . Catchments identified as Tier 1 critical areas will be a priority for 319 grant cost-share program implementation at this time. This includes catchments areas 3, 21, 24, 25, 26, 27 and 36.

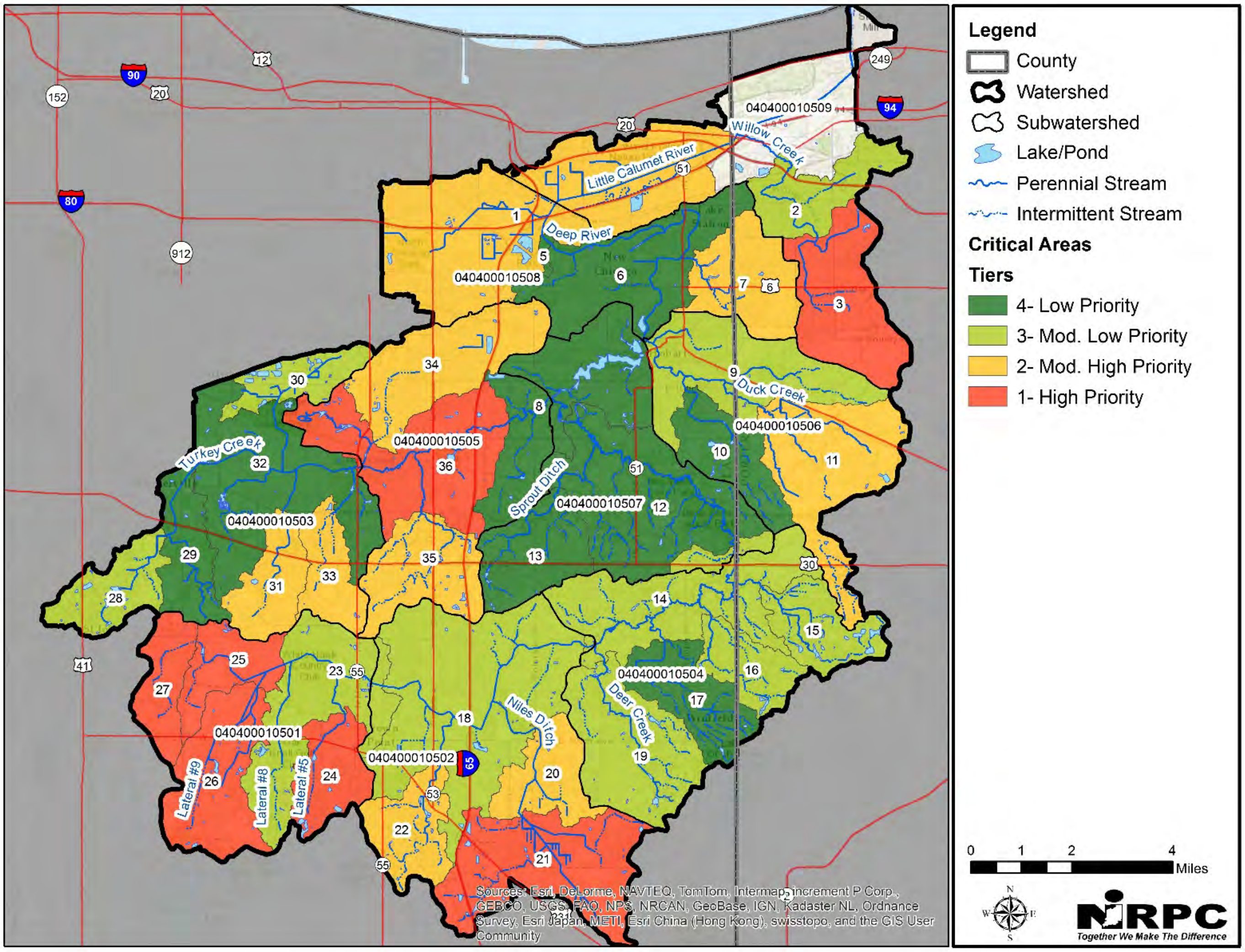


Figure 221 Critical areas

9.2 Critical Area Summary of Potential Problems & Sources

Table 117 lists the water quality, physical habitat, and aquatic life problems documented for the Tier 1 critical areas. These are the issues that will need to be addressed through implementation actions.

Tier 1- High Priority Critical Areas							
Catchment Area	*E. coli*	Dissolved Oxygen	Nutrients	Sediment	Ammonia Toxicity	Physical Habitat	Aquatic Life
3	X		X	X		X	X
21	X	X	X	X	X	X	X
24	X	X	X	X	X	X	X
25	X	X	X	X	X	X	X
26	X	X	X	X		X	X
27	X	X	X	X		X	X
36	X		X	X		X	X

Table 117 Tier 1 critical area problems

The following four tables are based on the conceptual diagrams presented earlier in Section 3.2. They outline the casual pathways, from sources to the observed biotic impairments. Multiple stressors exist in each critical area and contribute to the observed impairment in most of the catchments. Each table includes information on the human activities, sources, and site evidence contributing to the biotic impairment. Human activity and source information included in the tables was gathered from a desktop GIS assessment using data such as aerial imagery, land cover, and NPDES facility (point source) outfalls. Information on site evidence was gathered from IDEM's field notes, data sheets and site pictures.

	Human Activity			Source						Site Evidence						
Site	Agriculture	Urbanization	Channel Alteration	Impoundments	Septic Systems	Point Sources	Agricultural & Urban Runoff	Devegetated Riparian Areas	Channel Alteration	High Plant Abundance	Slow Moving Water	Reduced Water Volume	Organic Wastes	Turbidity	Color	Embedded Substrate
21	X		X		X		X	X	X	X	X		X	X	X	X
24		X	X	X		X	X		X	X	X			X	X	X
25	X	X	X		X		X	X	X	X	X			X	X	X
26	X	X	X		X		X		X	X	X			X	X	X
27	X	X	X		X		X	X	X	X	X			X	X	X

Table 118 Human activities, sources and site evidence tied to dissolved oxygen problems in tier 1 critical areas

	Human Activity			Source						Site Evidence		
Site	Agriculture	Urbanization	Channel Alteration	Waste Water Treatment Plants/CSO/SSO	Landfills & Waste Disposal Sites	Confined Animal Feeding Operations	Agricultural & Urban Runoff	Pasture Runoff	Septic Systems	Proliferation of Filamentous or Algae Mats	Phytoplankton Blooms (Green Water)	High Plant Abundance
3	X	X	X				X		X	X		
21	X		X			X	X	X	X	X	X	X
24	X	X	X	X			X	X	X	X	X	X
25	X	X	X				X	X	X	X	X	X
26	X	X	X		X		X	X	X	X	X	X
27		X	X				X	X	X	X		X
36	X	X	X	X			X		X			X

Table 119 Human activities, sources and site evidence tied to nutrient problems in tier 1 critical areas

	Human Activity	Source	Site Evidence

Site	Land Cover Alteration	Riparian Alteration	Channel Alteration	Autumn Plowing	Road Maintenance	Channel Modification	Eroding Streambanks	Impoundments	Impervious Surfaces	Turbid Water	Deposited or Embedded Substrate	Slow Moving Water
3	X	X	X		X	X	X		X	X		X
21	X	X	X	X	X	X	X			X	X	X
24	X	X	X		X	X	X		X	X	X	X
25	X	X	X	X	X	X				X	X	X
26	X	X	X	X	X	X				X	X	X
27	X	X	X	X	X	X				X	X	X
36	X	X	X	X	X	X			X	X	X	X

Table 120 Human activities, sources and site evidence tied to sediment problems in tier 1 critical areas

	Human Activity			Source									Site Evidence			
Site	Agriculture	Urbanization	Channel Alteration	Impoundments	Septic Systems	Point Sources	Agricultural & Urban Runoff (Fertilizer)	Manure Application	Concentrated Animal Feeding Operations	Piped/Buried Streams	Devegetated Riparian Areas	High Plant Production	Slow Moving or Stagnant Water	Organic Wastes	Suspended Solids	Alkaline, Anoxic, or Warm Water
21	X		X		X		X	X	X		X	X	X	X	X	X
24		X	X	X		X	X					X	X			X
25	X	X	X		X		X				X	X	X			X

Table 121 Human activities, sources and site evidence tied to ammonia toxicity problems in tier 1 critical areas

	Human Activity		Source							Site Evidence							
Site	Agriculture	Urbanization	Channelization	Impervious Surfaces	Levees or Walls	Agricultural Drainage	Devegetated Riparian Areas	Dredging	Buried/ Piped Stream	Concrete or Rip-Rap	Embedded Substrates	Bridge or Culvert	Channelization	Predominance of Runs, Glides, or Pools	Eroded Streambanks	Lack or Alteration of Riparian Vegetation	Lack of Habitat Features

3	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X
21	X	X	X			X	X	X			X	X	X	X	X	X	X
24		X	X	X			X	X		X	X	X	X	X		X	X
25	X	X	X			X	X	X			X	X	X	X	X	X	
26	X	X	X			X	X	X			X	X	X	X	X	X	
27	X	X	X	X		X	X	X			X	X	X	X	X	X	X
36	X	X	X	X		X	X	X			X	X	X	X	X	X	X

Table 122 Human activities, sources and site evidence tied to physical habitat problems in tier 1 critical areas

10 Watershed Priority Preservation Areas

Priority preservation areas have been identified for our watershed because these areas were shown to have:

- higher water quality compared to other locations
- healthier fish and macroinvertebrate assemblages
- higher quality stream and riparian habitat
- land area included in the Green Infrastructure Vision ecological network
- concentrations of natural habitat features that provide important ecosystem functions (ex. water purification, groundwater recharge, and stream flow regulation)
- concentrations of high quality natural areas and Heritage Database species
- habitats most at risk to invasive species

Data analysis shows that the Deep River Outstanding River reach is generally healthier than any of the other streams assessed in our watershed. Monitoring sites located on this reach had significantly (statistically) higher IBI scores; greater number of fish species; lower number of tolerant species; better QHEI channel morphology sub-metric scores; higher dissolved oxygen concentrations and lower *E. coli* and ammonia concentrations. The higher quality of this reach can likely be attributed to its natural, meandering river channel upstream of Lake George and the contiguous tracts of forest, wetland and floodplain buffering it from adjacent human land uses.

The Hobart Marsh Area encompasses nearly 750 acres of permanently protected land, which includes, wet forest, oak woodland, tall grass prairie, emergent marsh, savanna, and fens. A preliminary review of the Indiana Natural Heritage Database shows that 79 unique element occurrences exist within this area. The site provides critical habitat for nine state threatened or rare plant species, Blanding's turtle (state endangered), over 40 state endangered, threatened and rare insect species, four state endangered bird species, and five high quality natural communities. Several different entities (federal, state, municipal and NGO) own conservation lands within this area.

A half-mile buffer was established around the Deep River outstanding river reach using GIS to identify the Deep River Outstanding River Corridor. This buffer width effectively captured a high percentage of natural land cover areas, core forests, documented high quality natural communities and ETR species, and managed lands along Deep River. The boundary used for the Hobart Marsh Area was the same boundary identified in the Hobart Marsh Plan.

These preservation areas will also be a priority for 319 grant cost-share program implementation at this time in order to protect and maintain the higher quality natural resources.

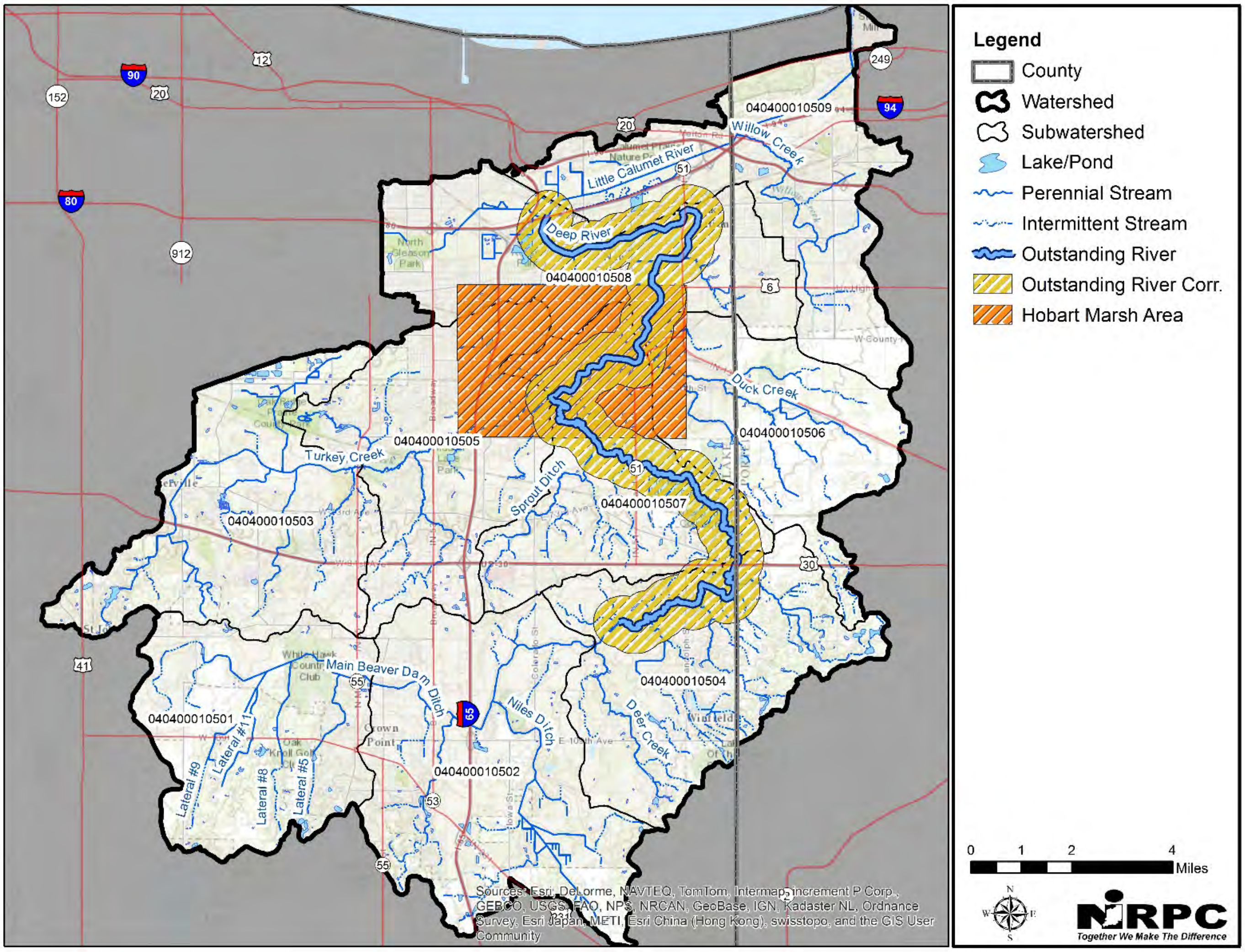


Figure 222 Deep River-Hobart Marsh Conservation Corridor

11 Best Management Practices

A wide variety of structural and non-structural implementation practices exist that we can select to help us protect and restore our watershed. A list of potential strategies was reviewed by the steering committee to help identify which practices were deemed the most appropriate and likely to succeed in addressing the watershed goals. The list of implementation strategies is not meant to be static or exhaustive as new approaches or practices may come to our attention over time and evaluation may show that certain practices were not as effective as we originally thought they would be.

11.1 Urban Area BMPs

Urban development is the most common human land use in the watershed, accounting for nearly 45% of its land area. The highest concentrations of development are located in the north western half of the watershed around Crown Point, Gary, Hobart, Merrillville and Portage. Urban development contributes an estimated 66% of the runoff volume, 40% of the nitrogen loads, 26% of the phosphorus loads, 59% of the biological oxygen demand loads, and 59% of the sediment loads in the watershed.

The following list of BMPs have been identified for implementation in the watershed. Descriptions of the individual practices are included in the appendices. The focus is to 1) Encourage the use of Low Impact Development (LID) design principles with new development or redevelopment; 2) Retrofit existing sites or practices to provide or improve water quality benefits and enhance storage for downstream channel protection (i.e. erosion) using LID practices; and 3) restore riparian corridors and native vegetation in upland areas to improve storage, water quality and habitat benefits.

- Bioretention (Rain Gardens)
- Capture Reuse (Rain Barrels & Cisterns)
- Constructed Filter
- Detention Basin
- Infiltration Practices
- Low Impact Development Site Design
- Native Revegetation
- Pervious Pavement w/ Infiltration
- Planter Boxes
- Riparian Buffer Restoration
- Vegetated Filter Strip
- Vegetated Roof (Green Roof)
- Vegetated Swale
- Water Quality Devices

Two resources were primarily consulted in identifying urban BMP list above and BMP selection considerations below: The Center for Watershed Protection's URBAN SUBWATERSHED RESTORATION MANUAL SERIES and the LOW IMPACT DEVELOPMENT MANUAL FOR MICHIGAN. Low Impact Development (LID) is a comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds. Low Impact Development mimics a site's pre-development hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Because LID utilizes a variety of useful techniques for controlling runoff, designs can be customized according to local regulatory and resource protection requirements, as well as site constraints.

11.1.1 LID Best Management Practice Selection Considerations

Selecting which BMPs accomplish as many storm water functions as possible is important. At the same time, meeting a certain function or level of pollution or storm water volume control can require multiple BMPs integrated at the site, creating a "treatment train." Treatment trains direct storm water to or through multiple BMPs in order to achieve quantity and/or quality storm water management objectives. Additionally, implementing BMPs as part of a treatment train can also provide a level of backup, which provides additional assurance if one BMP does not work as designed (e.g., maintenance problems, large storm event).

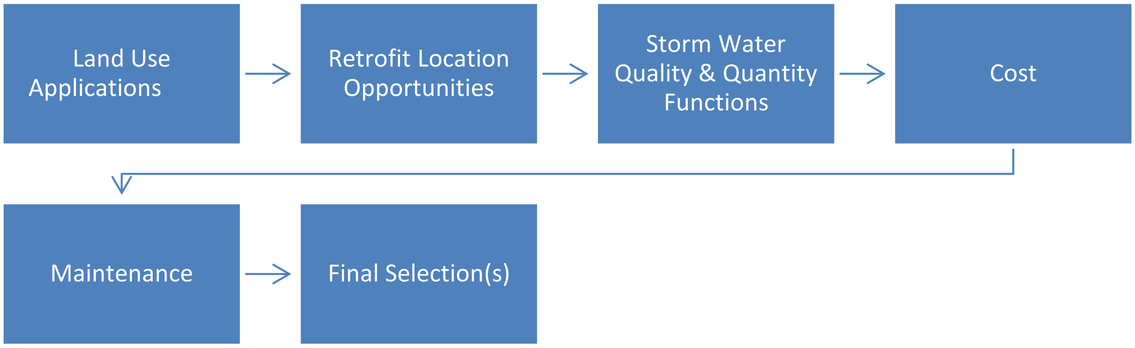


Figure 223 Decision making process for BMP selection

The following table, adapted from the LID Manual for Michigan, is intended to help identify which BMP(s) would be most suitable for a given land use. In many instances a combination of BMPs can be used at a site to improve pollutant removal and storm water volume reduction efficiency. Typical applications include modifying existing detention ponds, storage in transportation rights-of-way, parking lot retrofits, and landscapes/hardscapes.

Best Management Practice	Residential	Commercial	Ultra-Urban	Industrial	Transportation Rights-of-Way	Recreational	Retrofit
Bioretention	Yes	Yes	No	No	Yes	Yes	Yes
Capture Reuse	Yes	Yes	Yes	Yes	No	Yes	Yes
Constructed Filter	Limited	Yes	Yes	Yes	Yes	Yes	Yes
Detention- Dry Pond	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Detention- Wet Pond	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Detention- Constructed Wetland	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Infiltration- Dry Well	Yes	Yes	Yes	Limited	No	No	Yes
Infiltration- Basin	Yes	Yes	Limited	Yes	Limited	No	Limited
Infiltration- Berm	Yes	Yes	Limited	Yes	Yes	Yes	Yes
Infiltration- Trench	Yes	Yes	Yes	Yes	Yes	No	Yes
Infiltration- Subsurface Bed	Yes	Yes	Yes	Yes	Limited	No	Yes
Native Revegetation	Yes	Yes	No	Yes	Limited	Yes	Yes
Pervious Pavement	Yes	Yes	Yes	Yes	Limited	Yes	Yes
Planter Box	Yes	Yes	Yes	Limited	No	Limited	Yes
Riparian Buffer Restoration	Yes	Yes	Yes	Yes	Limited	Yes	Yes
Vegetated Filter Strip	Yes	Yes	Limited	Limited	Yes	Yes	Yes

Vegetated Roof	Limited	Yes	Yes	Yes	No	Yes	Yes
Vegetated Swale	Yes	Yes	Limited	Yes	Yes	Yes	Yes
Water Quality Device	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 123 Suitability of LID practices in various urban land uses

The following list of retrofit opportunities comes from the Center for Watershed Protection's URBAN SUBWATERSHED RESTORATION MANUAL SERIES- 3. URBAN STORMWATER RETROFIT PRACTICES. Opportunities can be broadly categorized as either storage or onsite retrofits. In general storage retrofits treat larger drainage areas, typically are constructed on public land, and tend to be more cost effective.

Retrofit location opportunities:

- Existing storm water ponds (SR-1)
- Storage above roadway crossings (SR-2)
- New storage below outfalls (SR-3)
- Treatment in conveyance system (SR-4)
- Transportation rights-of-way (SR-5)
- Large parking lots (SR-6)
- Hotspot operations (OS-7)
- Small parking lot retrofits (OS-8)
- Individual streets (OS-9)
- Individual rooftops (OS-10)
- Little retrofits (OS-11)
- Landscapes-hardscapes (OS-12)

SR = storage retrofit, treat drainage areas ranging from 5-500 acres
OS = onsite retrofit, treat drainage areas < 5 acres

Table 125 , primarily adapted from the LID Manual for Michigan, compares storm water quantity and quality functions, cost and maintenance for the various structural LID BMPs recommended. The ability of a practice to treat pathogens is based on a literature review conducted by Schueler (2000). As noted previously a combination of BMPs can be used at a site to improve pollutant removal and storm water volume reduction efficiency.

Best Management Practice	Volume	Peak Rate	Sediment	Phosphorus	Nitrogen	Pathogens*	Cost	Maintenance
Bioretention	M/H	M	H	M	M	X	M	M
Capture Reuse	H	L	M	M	M		L/M	M
Constructed Filter	L	L	H	M	M		M/H	H
Detention- Dry Pond	L	H	M	M	L		H	L/H
Detention- Wet Pond	L	H	H	M	M	X	H	L/M
Detention- Constructed Wetland	L	H	H	M	M	X	H	L/M
Infiltration- Dry Well	M	M	H	M/H	L/M	X	M	L/M
Infiltration- Basin	H	H	H	M/H	M	X	L/M	L/M

Infiltration- Berm	L/M	M	M/H	M	M	X	L/M	L/M
Infiltration- Trench	M	L/M	H	M/H	L/M	X	M	L/M
Infiltration- Subsurface Bed	H	H	H	M/H	L	X	H	M
Native Revegetation	L/M/H	L/M	H	H	M/H		L/M	L
Pervious Pavement	H	M/H	H	M/H	L		M	H
Planter Box	L/M	M	M	L/M	L/M		M	M
Riparian Buffer Restoration	L/M	L/M	M/H	M/H	M/H		L/M	L
Vegetated Filter Strip	L	L	M/H	M/H	M/H		L	L/M
Vegetated Roof	M/H	M	H	H	H		H	M
Vegetated Swale	L/M	L/M	M/H	L/H	M		L/M	L/M
Water Quality Device	NA	NA	Varies	Varies	Varies		Varies	Varies

Table 124 Function, cost, and maintenance of LID practices

L= Low, M= Medium, H= High, X= Yes

11.2 Agricultural Area BMPs

Agriculture is the second common human land use in the watershed, accounting for nearly 28% of its land area. The highest concentrations of agricultural land are located in the southeastern portion of the watershed. An estimated 53% of the nitrogen loads, 68% of the phosphorus loads, 32% of the biological oxygen demand loads, and 40% of the sediment loads in the watershed originate from agricultural production.

The following best management practices have been identified from the NRCS Field Office Technical Guide (FOTG) for Indiana to control sediment, nutrients, and pathogens from row crop production and livestock operations on agricultural lands. The selection of which BMPs are most appropriate for a field or site is based on a Conservation Plan which is developed between the NRCS district conservationist and landowner. A Conservation Plan must be in place for a landowner to eligible for Farm Bill programs or Section 319 Cost-Share program funding.

- Access Control
- Alternative Watering Systems
- Conservation Cover
- Cover Crops
- Critical Area Planting
- Denitrifying Bioreactor
- Drainage Water Management
- Fencing
- Field Border
- Filter Strips
- Forage and Biomass Planting
- Stabilization Structures
- Grassed Waterway
- Manure Management Planning
- Manure Storage Facilities
- Nutrient Management
- Open Channel (Two-Stage Ditch)
- Prescribed Grazing
- Riparian Herbaceous Cover
- Riparian Forest Cover
- Residue and Tillage Management, No Till
- Residue and Tillage Management, Reduced Till
- Saturated Buffer

11.3 Priority Preservation Areas BMPs

The priority preservation area includes a mix of urban and agricultural land uses adjacent to or near sensitive natural areas. All of the BMPs referenced above for urban and agricultural areas still apply to the priority preservation area. However there are some additional measures that are very important and specific to this area.

Conservation Planning

Conservation planning includes identifying key natural areas within the landscape, assessing the conservation value of each parcel identified, establishing conservation targets for the parcel, landowner education on the value of land preservation, and identifying conservation options to landowners.

Dam Removal or Modification

Dam removal or modification can help restore fish passage, sediment and nutrient transport, riverine habitat characteristics, and stream flows.

Natural Area Preservation

Natural area preservation can include acquisition, conservation easements, or land donation of key natural area parcels.

Natural Area Restoration

Natural area restoration can vary greatly depending on the level of disturbance at a site. For more heavily disturbed sites, or portions of sites, restoration activities may include more intensive measures such as conversion back to natural land cover (ex. agricultural to forest or grassland) or restoring hydrology (ex. wetland or floodplain restoration). Natural area restoration can also include ongoing activities such as invasive species control, fire reintroduction for fire-dependent communities (ex. prairies), or opening the tree canopy (ex. oak savanna).

11.4 Watershed-Wide BMPs

These practices can be used throughout the watershed.

- Education and Outreach
- Floodplain Reconnection/Two-Stage Ditch
- Native Revegetation
- Riparian Buffer Restoration
- Septic system maintenance
- Streambank Stabilization & Shoreline Protection
- Wetland Restoration

11.5 BMP Recommendations for Critical Areas

The following table includes recommended BMPs for Tier 1 critical areas in the watershed. The table also includes information on why the catchment area was critical and the human land cover area potentially available for treatment by the BMPs. The recommendations are not intended to be exhaustive or prescriptive. Any number or combination of implementation activities might contribute to water quality improvement, whether applied at sites where the actual impairment was noted or other locations where sources contribute indirectly to the water quality impairment.

Catchment Area	Reasons for Being Critical	Urban (ac.)	Cropland (ac.)	Pasture (ac.)	Suggested BMP
3	E. coli Nutrients Sediment Physical Habitat Aquatic Life	1,556	1,490	97	Floodplain reconnection
					Streambank stabilization
					Riparian buffer restoration
					Native revegetation
					Bioretention
					Capture Reuse
					Infiltration practices
					Vegetated swale
					Constructed wetland
					Wet pond
					Pervious pavement
					Cover crop
					Conservation tillage
					Grassed waterway
					Filter strips/Field border
					Nutrient management
					Septic system maintenance

Catchment Area	Reasons for Being Critical	Urban (ac.)	Cropland (ac.)	Pasture (ac.)	Suggested BMP
					Education and outreach
21	E. coli Dissolved Oxygen Nutrients Sediment Ammonia Physical Habitat Aquatic Life	351	2,605	509	Floodplain reconnection
					Streambank stabilization
					Riparian buffer restoration
					Native revegetation
					Wetland restoration
					Bioretention
					Capture Reuse
					Cover crop
					Conservation tillage
					Grassed waterway
					Filter strips/Field border
					Conservation cover
					Nutrient management
					Manure management
					Drainage water management
					Septic system maintenance
					Education and outreach
24	E. coli Dissolved Oxygen Nutrients Sediment Ammonia Physical Habitat Aquatic Life	1,437	6	29	Floodplain reconnection
					Streambank stabilization
					Riparian buffer restoration
					Native revegetation
					Bioretention
					Capture reuse
					Detention basin
					Pervious pavement
					Planter boxes
					Dry wells
					Infiltration trenches
					Subsurface infiltration beds
					Septic system maintenance
					Education and outreach
25	E. coli Dissolved Oxygen Nutrients Sediment Ammonia Physical Habitat Aquatic Life	282	964	73	Floodplain reconnection
					Streambank stabilization
					Riparian buffer restoration
					Native revegetation
					Wetland restoration
					Detention basin
					Cover crop
					Conservation tillage

Catchment Area	Reasons for Being Critical	Urban (ac.)	Cropland (ac.)	Pasture (ac.)	Suggested BMP
					Grassed waterway
					Filter strip/Field border
					Conservation cover
					Nutrient management
					Manure management
					Drainage water management
					Saturated buffer
					Septic system maintenance
					Education and outreach
26	E. coli Dissolved Oxygen Nutrients Sediment Physical Habitat Aquatic Life	513	745	291	Floodplain reconnection
					Streambank stabilization
					Riparian buffer restoration
					Native revegetation
					Wetland restoration
					Detention basin
					Cover crop
					Conservation tillage
					Grassed waterway
					Filter strip/Field border
					Conservation cover
					Nutrient management
					Manure management
					Drainage water management
					Saturated buffer
					Septic system maintenance
					Education and outreach
27	E. coli Dissolved Oxygen Nutrients Sediment Physical Habitat Aquatic Life	733	651	11	Floodplain reconnection
					Streambank stabilization
					Riparian buffer restoration
					Native revegetation
					Wetland restoration
					Detention basin
					Cover crop
					Conservation tillage
					Grassed waterway
					Filter strip/Field border
					Conservation cover
					Nutrient management
					Manure management
					Drainage water management

Catchment Area	Reasons for Being Critical	Urban (ac.)	Cropland (ac.)	Pasture (ac.)	Suggested BMP
					Saturated buffer
					Septic system maintenance
					Education and outreach
36	E. coli Dissolved Oxygen Nutrients Sediment Ammonia Physical Habitat Aquatic Life	3,081	338	73	Floodplain reconnection
					Streambank stabilization
					Riparian buffer restoration
					Wetland restoration
					Native revegetation
					Bioretention
					Capture reuse
					Detention basin
					Pervious pavement
					Planter boxes
					Dry wells
					Infiltration trenches
					Subsurface infiltration beds
					Cover crop
					Conservation tillage
					Grassed waterway
					Filter strip/Field border
					Conservation cover
					Septic system maintenance
					Education and outreach

Table 125 BMP recommendations for tier 1 critical areas

11.6 Estimated Load Reductions from BMPs

The following table provides a general overview of the load reductions anticipated from implementing some of the various practices recommended in the previous sections. These load reductions were estimated using the EPA Region 5 spreadsheet model. This model likely be used the most frequently in assessing site specific load reductions during implementation.

Practice (Contributing Area)	Estimated Load Reduction			
	Nitrogen (lb/year)	Phosphorus (lb/year)	BOD (lb/year)	Sediment (t/year)
Urban/Rural Development Areas				
Bioretention	179	44	2,274	31
Detention- Dry Pond (100 ac.)	269	26	975	23
Detention- Wet Pond	492	69	2,599	34
Detention- Constructed Wetland (100 ac.)	179	44	2,274	31
Infiltration- Basin	537	66	NA	30
Infiltration- Trench	492	60	NA	30

Pervious Pavement	761	66	NA	36
Vegetated Filter Strip (100 ac.)	358	46	1,823	29
Vegetated Swale (100 ac.)	90	25	1,083	26
Water Quality Device	NA	NA	NA	NA
Agricultural Areas				
No-Till/Strip-Till (100 ac.)	435	218	NA	167
Cover Crops (100 ac.)	271	136	NA	94
Filter Strips (100 ac.)	340	171	NA	110
Grassed Waterway (100 ft.)	34	17	NA	17
Critical Area Planting (100 ac.)	324	162	NA	107
Watershed-Wide				
Conservation Cover	324	162	NA	107
Two-Stage Ditch	46	23	NA	23
Wetland Restoration (10 ac.)	252	126	NA	89
Riparian Forest Buffer (100 ac.)	148	74	NA	56
Riparian Herbaceous Cover (100 ac.)	324	162	NA	107
Streambank Stabilization (100 ft.)	46	23	NA	23

Table 126 Summary of load reductions anticipated with each BMP

The STEPL model was used to approximate load reductions and progress towards meeting load reduction goals anticipated from a few of the key recommend BMPs watershed wide and within each catchment area. The BMPs selected for this general analysis were considered to have broad applicability throughout the watershed and their pollutant removal efficiencies were readily available in the model. The following tables are formatted to show progress (increasing rates) in implementation over time. For example, the first table shows increasing adaptation of cover crops on cultivated land. Rows highlighted in red correspond to the Tier 1 critical areas.

		10% Coverage (~2,500 ac)			25% Coverage (~6,500 ac)			50% Coverage (~13,000 ac)			75% Coverage (~19,500)		
Site	Row Crop	N	P	S	N	P	S	N	P	S	N	P	S
	Acres	lb/year	lb/year	t/year	lb/year	lb/year	t/year	lb/year	lb/year	t/year	lb/year	lb/year	t/year
1	825	198	79	5	495	197	12	989	395	24	1,484	592	36
2	5	2	1	0	6	2	0	12	4	0	18	5	0
3	1,499	731	243	9	1,828	607	22	3,656	1,214	43	5,483	1,821	65
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	66	16	6	0	40	16	1	79	32	2	119	48	3
7	384	187	62	2	469	156	6	937	311	11	1,406	467	17
8	729	356	118	4	889	295	11	1,778	590	21	2,666	886	32
9	898	438	145	5	1,095	364	13	2,190	727	26	3,285	1,091	39
10	968	472	157	6	1,180	392	14	2,360	784	28	3,540	1,176	42
11	2,289	1,116	371	13	2,791	927	33	5,582	1,854	66	8,373	2,781	99
12	1,456	710	236	8	1,775	589	21	3,549	1,179	42	5,324	1,768	63
13	576	281	93	3	703	233	8	1,405	467	17	2,108	700	25
14	2,215	1,080	359	13	2,700	897	32	5,401	1,794	64	8,101	2,691	96
15	221	108	36	1	270	90	3	540	179	6	809	269	10
16	222	108	36	1	270	90	3	540	179	6	810	269	10
17	541	264	88	3	660	219	8	1,320	438	16	1,980	658	24
18	2,840	1,385	460	16	3,463	1,150	41	6,926	2,300	82	10,389	3,450	123
19	1,403	684	227	8	1,710	568	20	3,421	1,136	41	5,131	1,704	61
20	938	457	152	5	1,143	380	14	2,287	760	27	3,430	1,139	41
21	2,605	1,270	422	15	3,176	1,055	38	6,352	2,110	75	9,528	3,164	113
22	49	24	8	0	60	20	1	120	40	1	181	60	2
23	262	128	42	2	319	106	4	639	212	8	958	318	11
24	6	4	1	0	10	3	0	20	6	0	30	9	0
25	964	470	156	6	1,175	390	14	2,350	780	28	3,525	1,171	42
26	745	363	121	4	908	302	11	1,816	603	22	2,724	905	32
27	651	317	105	4	793	263	9	1,587	527	19	2,380	790	28
28	2	2	1	0	6	2	0	12	3	0	17	5	0
29	78	19	7	0	47	19	1	94	37	2	140	56	3
30	6	6	2	0	15	4	0	29	8	0	44	12	0
31	176	86	28	1	214	71	3	428	142	5	643	213	8
32	1,096	534	178	6	1,336	444	16	2,672	888	32	4,009	1,331	48
33	336	164	54	2	410	136	5	820	272	10	1,230	408	15
34	130	63	21	1	158	53	2	317	105	4	475	158	6
35	292	178	57	2	444	142	4	888	283	8	1,331	425	13
36	338	206	66	2	514	164	5	1,028	328	10	1,542	492	15
Total	25,810	12,428	4,138	149	31,071	10,344	374	62,142	20,688	747	93,213	31,033	1,121
Reduction Needed		2,554	95,699	3,866	2,554	95,699	3,866	2,554	95,699	3,866	2,554	95,699	3,866
% Meet		>100%	4%	4%	>100%	11%	10%	>100%	22%	19%	>100%	32%	29%

Table 127 Anticipated load reductions from cover crops

		10% Coverage (~2,500 ac)			25% Coverage (~6,500 ac)			50% Coverage (~13,000 ac)			75% Coverage (~19,500)		
Site	Row Crop	N	P	S	N	P	S	N	P	S	N	P	S
	Acres	lb/year	lb/year	t/year	lb/year	lb/year	t/year	lb/year	lb/year	t/year	lb/year	lb/year	t/year
1	825	291	111	9	728	277	22	1,455	554	45	2,183	830	67
2	5	3	1	0	8	2	0	17	5	0	25	7	0
3	1,499	1,040	301	16	2,600	751	41	5,200	1,503	81	7,800	2,254	122
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	66	23	9	1	58	22	2	117	44	4	175	67	5
7	384	267	77	4	666	193	10	1,333	385	21	1,999	578	31
8	729	506	146	8	1,264	365	20	2,529	731	40	3,793	1,096	59
9	898	623	180	10	1,557	450	24	3,115	900	49	4,672	1,350	73
10	968	671	194	11	1,679	485	26	3,357	970	53	5,036	1,455	79
11	2,289	1,588	459	25	3,970	1,147	62	7,941	2,295	124	11,911	3,442	186
12	1,456	1,010	292	16	2,524	730	40	5,049	1,459	79	7,573	2,189	119
13	576	400	116	6	999	289	16	1,999	578	31	2,998	866	47
14	2,215	1,536	444	24	3,841	1,110	60	7,682	2,220	120	11,524	3,330	180
15	221	154	44	2	384	111	6	768	222	12	1,151	333	18
16	222	154	44	2	384	111	6	768	222	12	1,152	333	18
17	541	376	109	6	939	271	15	1,878	543	29	2,816	814	44
18	2,840	1,970	569	31	4,926	1,424	77	9,852	2,847	154	14,779	4,271	231
19	1,403	973	281	15	2,433	703	38	4,866	1,406	76	7,299	2,109	114
20	938	651	188	10	1,626	470	25	3,253	940	51	4,879	1,410	76
21	2,605	1,807	522	28	4,518	1,306	71	9,035	2,611	141	13,553	3,917	212
22	49	34	10	1	86	25	1	171	49	3	257	74	4
23	262	182	53	3	454	131	7	909	263	14	1,363	394	21
24	6	6	1	0	14	4	0	28	7	0	42	11	0
25	964	668	193	10	1,671	483	26	3,342	966	52	5,014	1,449	78
26	745	517	149	8	1,292	373	20	2,583	747	40	3,875	1,120	61
27	651	451	130	7	1,129	326	18	2,257	652	35	3,386	978	53
28	2	3	1	0	8	2	0	16	4	0	24	5	0
29	78	28	10	1	69	26	2	138	52	4	207	79	6
30	6	8	2	0	20	4	0	41	9	0	61	13	0
31	176	122	35	2	305	88	5	609	176	10	914	264	14
32	1,096	760	220	12	1,901	549	30	3,801	1,099	59	5,702	1,648	89
33	336	233	67	4	583	169	9	1,166	337	18	1,750	506	27
34	130	90	26	1	225	65	4	450	130	7	676	195	11
35	292	251	68	3	627	170	8	1,254	340	16	1,882	509	24
36	338	291	79	4	727	197	9	1,453	393	18	2,180	590	28
Total	25,810	17,687	5,132	280	44,217	12,829	701	88,435	25,658	1,401	132,652	38,487	2,102
Reduction Needed		2,554	95,699	3,866	2,554	95,699	3,866	2,554	95,699	3,866	2,554	95,699	3,866
% Meet		>100%	5%	7%	>100%	13%	18%	>100%	27%	36%	>100%	40%	54%

Table 128 Anticipated load reductions from reduced tillage

		1% Coverage			5% Coverage			10% Coverage			15% Coverage		
Site	Commercial	N	P	S	N	P	S	N	P	S	N	P	S
	Acres	lb/year	lb/year	t/year	lb/year	lb/year	t/year	lb/year	lb/year	t/year	lb/year	lb/year	t/year
1	524	5	1	704	24	5	3,518	48	11	7,035	7	2	1,082
2	92	1	0	135	5	1	676	8	2	1,218	13	3	1,894
3	186	3	1	391	12	3	1,760	24	5	3,520	38	8	5,475
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	221	2	0	271	10	2	1,488	20	5	2,976	31	7	4,465
7	47	1	0	98	3	1	391	7	1	978	9	2	1,369
8	84	1	0	196	5	1	782	11	2	1,564	17	4	2,542
9	109	1	0	196	7	1	978	15	3	2,151	22	5	3,129
10	103	1	0	196	7	1	978	13	3	1,955	20	4	2,933
11	32	0	0	59	2	0	293	4	1	587	7	1	978
12	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-
15	10	0	0	20	1	0	98	1	0	196	1	0	196
16	5	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-
18	1,948	26	6	3,715	131	29	18,967	261	57	37,933	393	86	57,095
19	11	0	0	20	1	0	98	1	0	196	2	0	293
20	5	-	-	-	0	0	59	1	0	98	1	0	98
21	11	0	0	20	1	0	98	1	0	196	1	0	196
22	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-
25	34	0	0	59	2	0	293	4	1	587	7	1	978
26	15	0	0	20	1	0	147	2	0	293	3	1	391
27	37	0	0	59	3	1	391	5	1	704	7	1	978
28	78	1	0	156	5	1	782	10	2	1,525	16	4	2,346
29	-	-	-	-	-	-	-	-	-	-	-	-	-
30	26	0	0	39	2	0	244	3	1	489	5	1	782
31	155	2	0	293	10	2	1,515	20	4	2,933	31	7	4,497
32	54	1	0	98	4	1	518	7	2	1,036	11	2	1,564
33	425	5	1	782	28	6	4,106	57	12	8,212	86	19	12,514
34	26	0	0	39	2	0	244	3	1	489	4	1	587
35	-	-	-	-	-	-	-	-	-	-	-	-	-
36	31	0	0	64	2	0	320	4	1	640	7	1	960
Total	25,810	52	12	7,626	267	59	38,744	533	117	77,509	739	163	107,340
Reduction Needed		2,554	95,699	3,866	2,554	95,699	3,866	2,554	95,699	3,866	2,554	95,699	3,866
% Meet		2%	<1%	>100%	10%	<1%	>100%	21%	<1%	>100%	29%	<1%	>100%

Table 129 Anticipated load reductions from bioretention

		1% Coverage			5% Coverage			10% Coverage			15% Coverage		
Site	Row Crop	N	P	S	N	P	S	N	P	S	N	P	S
	Acres	lb/year	lb/year	t/year	lb/year	lb/year	t/year	lb/year	lb/year	t/year	lb/year	lb/year	t/year
1	825	34	13	1	171	65	4	341	130	8	512	195	12
2	5	0	0	0	2	1	0	4	1	0	6	2	0
3	1,499	127	40	1	635	201	7	1,271	402	14	1,906	603	21
5	-	-	-	-	-	-	-	-	-	-	-	-	-
6	66	3	1	0	14	5	0	27	10	1	41	16	1
7	384	33	10	0	163	52	2	326	103	4	489	155	5
8	729	62	20	1	309	98	3	618	195	7	927	293	10
9	898	76	24	1	381	120	4	761	241	8	1,142	361	13
10	968	82	26	1	410	130	5	820	259	9	1,231	389	14
11	2,289	194	61	2	970	307	11	1,941	614	22	2,911	921	32
12	1,456	123	39	1	617	195	7	1,234	390	14	1,851	585	21
13	576	49	15	1	244	77	3	488	154	5	733	232	8
14	2,215	188	59	2	939	297	10	1,877	594	21	2,816	891	31
15	221	19	6	0	94	30	1	188	59	2	281	89	3
16	222	19	6	0	94	30	1	188	59	2	282	89	3
17	541	46	15	1	229	73	3	459	145	5	688	218	8
18	2,840	241	76	3	1,204	381	13	2,408	762	27	3,612	1,142	40
19	1,403	119	38	1	595	188	7	1,189	376	13	1,784	564	20
20	938	79	25	1	397	126	4	795	251	9	1,192	377	13
21	2,605	221	70	2	1,104	349	12	2,208	698	25	3,312	1,048	37
22	49	4	1	0	21	7	0	42	13	0	63	20	1
23	262	22	7	0	111	35	1	222	70	2	333	105	4
24	6	1	0	0	3	1	0	7	2	0	10	3	0
25	964	82	26	1	408	129	5	817	258	9	1,225	388	14
26	745	63	20	1	316	100	4	631	200	7	947	300	11
27	651	55	17	1	276	87	3	552	174	6	827	262	9
28	2	0	0	0	2	1	0	4	1	0	6	2	0
29	78	3	1	0	16	6	0	32	12	1	48	18	1
30	6	1	0	0	5	1	0	10	3	0	15	4	0
31	176	15	5	0	74	24	1	149	47	2	223	71	2
32	1,096	93	29	1	464	147	5	929	294	10	1,393	441	15
33	336	29	9	0	143	45	2	285	90	3	428	135	5
34	130	11	3	0	55	17	1	110	35	1	165	52	2
35	292	31	9	0	154	47	1	309	94	3	463	141	4
36	338	36	11	0	179	54	2	358	109	3	537	163	5
Total	25,810	2,160	685	24	10,800	3,424	121	21,600	6,849	243	32,400	10,273	364
Reduction Needed		2,554	95,699	3,866	2,554	95,699	3,866	2,554	95,699	3,866	2,554	95,699	3,866
% Meet		85%	1%	1%	>100%	4%	3%	>100%	7%	6%	>100%	11%	9%

Table 130 Anticipated load reductions from conservation cover

	1/4-Mile	1-Mile	3-Miles	5-Miles
Site	S	S	S	S
	t/year	t/year	t/year	t/year
1	38	151	453	755
2	34	137	412	686
3	29	117	350	583
5	34	137	412	686
6	34	137	412	686
7	31	124	371	618
8	29	117	350	583
9	29	117	350	583
10	29	117	350	583
11	29	117	350	583
12	29	117	350	583
13	29	117	350	583
14	29	117	350	583
15	29	117	350	583
16	29	117	350	583
17	29	117	350	583
18	29	117	350	583
19	29	117	350	583
20	29	117	350	583
21	29	117	350	583
22	29	117	350	583
23	29	117	350	583
24	29	117	350	583
25	29	117	350	583
26	29	117	350	583
27	29	117	350	583
28	29	117	350	583
29	38	151	453	755
30	29	117	350	583
31	29	117	350	583
32	27	110	329	549
33	29	117	350	583
34	31	124	371	618
35	31	124	371	618
36	29	117	350	583
Total	1,057	4,228	12,685	21,141
Reduction Needed	3,866	3,866	3,866	3,866
% Meet	27%	>100%	>100%	>100%

Table 131 Anticipated load reductions from streambank stabilization

12 Watershed Restoration Action Register

Goal and objectives were developed based on stakeholder concerns and information collected through the watershed characterization process. Each action register table, presented below, identifies the strategies, target audiences, timeframes, milestones, estimated costs, possible partners, and technical assistance to reach these goals. The action register is set up as five year work plan. Progress will be evaluated, modifications considered, and new work plans developed in subsequent 5-year cycles. The greatest focus over the next five to ten years will occur in the Tier 1 critical areas and priority preservation areas.

Goal 1: Reduce *E. coli* concentrations by 80% so that all waterways meet the state water quality standard of 235 CFU/100 mL (single sample) and 125 CFU/100mL (geomean) during the recreational season (April 1 – October 31).

Goal 2: Restore warmwater fish and macroinvertebrate communities so that all waterways meet their aquatic life use designations with natural waterways maintaining at least a "good" integrity class rating and modified waterways maintaining at least a "fair" integrity class rating.

Objectives:

- Improve dissolved oxygen levels so that all waterways maintain a concentration > 4 mg/L.
- Reduce nutrient and sediment loads from urban and agricultural land uses.
- Restore riparian vegetation to improve channel stability, nutrient processing, sediment capture, and landscape habitat connectivity.
- Improve bed form diversity within channelized/incised or dammed stream reaches to increase depth variability and substrate quality.
- Improve channel stability to reduce suspended and bedded sediments.
- Provide floodplain connectivity for channelized/incised stream reaches to improve channel stability and facilitate sediment storage and nutrient processing outside of the channel.
- Reduce storm water runoff volume and rates to improve flow-duration conditions and flow dynamics.

12.1 Recreational Use

12.1.1 Reduce E. coli Loads

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Restrict livestock access to streams and reduce runoff from pastures Long-term target: 75% of livestock owners & facility operators will have and implement provisions of conservation plan	Livestock Owners & Facility Operators	2016-2017	Coordinate with NRCS and ISDA to do site visits at identified facilities to determine if livestock have unrestricted livestock access to waterway or if pastures are in near proximity to potential conveyances.	*See Note	Watershed Group, SWCD, ISDA, NRCS	TSPs, SWCD, NRCS, ISDA, Purdue Extension
		2016-2020	Market conservation programs to owners and operators.	**See Note		
		2016-2020	Develop individual conservation plans as needed. Plans may include provisions for alternate water systems, livestock fencing, conservation buffers, and rotational grazing.	**See Note		
		2016	Develop a 319 cost-share program.	*See Note		
		2016-2020	Install alternate water systems, livestock fencing and conservation buffers as needed			
Implement manure management and application BMPs Long-term target: 75% owners and operators that have fields to which manure is applied will have and implement provisions of conservation plan	Livestock Owners & Facility Operators	2016-2017	Coordinate with NRCS and ISDA to do site visits at identified facilities to determine if manure from facilities is being field applied.	*See Note	Watershed Group, SWCD, ISDA, NRCS	TSPs, SWCD, NRCS, ISDA, Purdue Extension
		2016-2020	Market conservation programs to owners and operators.	**See Note		
		2016-2020	Develop individual conservation plans as needed. Plans may include provisions for manure management, nutrient management, cover crops, and conservation buffers.	**See Note		
		2016	Develop a 319 cost-share program.	*See Note		
		2016-2020	Install cover crops, conservation buffers as needed. Implement manure and nutrient management practices as needed.			

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Increase public awareness of proper septic system maintenance	Septic system owners	2016-2020	Collaborate with NWI Septic System Working Group in promoting SepticSmart Week.	*See Note	Watershed Group, NWI Septic System Working Group	ISDH, County Health Department
		2016-2017	Collaborate with NWI Septic System Working Group to develop outreach program strategy and materials	*See Note		
		2018-2020	Implement outreach program	*See Note		
Support the adoption of ordinances that improve county health department oversight of septic system operation and maintenance Long-term target: Lake & Porter Counties will have an O&M program and/or point-of-sale inspection ordinance	County Health Departments	2016-2020	Collaborate with NWI Septic System Working Group to support development of an operation and maintenance program ordinance and/or point-of-sale inspection ordinance	*See Note	Watershed Group, NWI Septic System Working Group	ISDH, County Health Department
Increase use of LID practices	Municipalities & Urban Landowners	2016-2020	See 12.2.2 Reduce Nutrient & Sediment Loads	--	Municipalities Watershed Group	MS4 Communities, IDEM, Consulting Firms

Table 132 Action register to reduce pathogen loading from agricultural areas

12.2 Aquatic Life Use

12.2.1 Improve Dissolved Oxygen Levels

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Reduce nutrient and sediment loads	--	2016-2020	See 12.2.2 Reduce Nutrient & Sediment Loads	--	--	--
Restore riparian vegetation	--	2016-2020	See 12.2.3 Restore Riparian Vegetation	--	--	--

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Improve bed form diversity	--	2016-2020	See 12.2.4 Improve Bed Form Diversity	--	--	--
Improve channel stability	--	2016-2020	See 12.2.5 Improve Channel Stability	--	--	--
Provide floodplain connectivity	--	2016-2020	See 12.2.5 Provide Floodplain Connectivity	--	--	--
Reduce storm water runoff volume & rates	--	2016-2020	See 12.2.6 Reduce Storm Water Runoff Volume & Rates	--	--	--

Table 133 Action register to improve dissolved oxygen levels

12.2.2 Reduce Nutrient & Sediment Loads

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Increase awareness of lawn and yard care pollution prevention practices	Urban/ Rural Landowners	2016-2018	Distribute Lawn to Lake & NWI Rain Garden Manuals at public events	$1,000/ event	Watershed Group, IL-IN Sea Grant	IL-IN Sea Grant, Purdue Extension
		2016-2017	Include information on DRPBWI webpage	$500		
		2016-2020	Occasionally post information on DRPBWI Facebook page	$1,000 annually		
Increase use of conservation cropping system (no-till, cover crops, adaptive nutrient and pest management, and precision farming) Long-term target: 75% of row crop fields	Agricultural Landowners & Operators	2016-2020	Host/promote regional conservation cropping system workshops and field day events.	$3,000 annually	Watershed Group	SWCD, NRCS, ISDA, Purdue Extension
		2016	Develop 319 cost-share program.	*See Note		
		2016-2020	Annually identify additional funding options.	*See Note		
		2016-2020	Market conservation cropping systems to owners and operators.	**See Note		
		2016-2020	Continue to develop conservation plans as needed.	**See Note		
		2016-2020	Annually implement 500 acres of conservation cropping system.	No-till: $20/ac Cover crop: $35/ac Nutr./Pest mgt.: $20/ac		
		2016	Develop 319 cost-share program.	*See Note		

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Increase use of conservation cover and critical area planting on areas retired from agricultural production Long-term target: 1% of agricultural fields	Agricultural Landowners & Operators	2016-2020	Annually identify additional funding options.	*See Note	Watershed Group	SWCD, NRCS, ISDA, Purdue Extension
		2016-2020	Market conservation cover and critical area planting to owners and operators.	**See Note		
		2016-2020	Continue to develop conservation plans as needed.	**See Note		
		2016-2020	Annually implement 50 acres of conservation cover and critical area planting.	$2,250		
Increase the use of conservation buffers (ex. filter strips, riparian buffer, field borders)	Agricultural Landowners & Operators, Urban/ Rural Landowners	2016	Develop 319 cost-share program.	*See Note	Watershed Group	SWCD, NRCS, ISDA, Purdue Extension
		2016-2020	Annually identify additional funding options.	*See Note		
		2016-2020	Market conservation buffers to landowners and operators.	*See Note **See Note		
		2016-2020	Continue to develop conservation plans as needed.	**See Note		
		2017-2018	Host conservation buffer workshop and field day event for urban areas.	$5,000/ event		
		2016-2020	Host/promote regional conservation buffer workshops and field day events for agricultural areas.	$5,000		
		2016-2020	Annually implement 50 acres of conservation buffers	$10,000-$25,000		
Increase use of grassed waterways	Agricultural Landowners & Operators	2016	Develop 319 cost-share program.	*See Note	Watershed Group	SWCD, NRCS, ISDA, Purdue Extension
		2016-2020	Annually identify additional funding options.	*See Note		
		2016-2020	Market grassed waterways to landowners and operators.	**See Note		
		2016-2020	Continue to develop conservation plans as needed.	**See Note		
		2016-2020	Annually implement 1,000 feet of grassed waterway	$10,000		
		2016-2017	Develop an education plan including promotional materials and	$5,000-$10,000	Watershed Group	

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Increase awareness of drainage water management practices	Agricultural Landowners & Operators		demonstration day for drainage water management			SWCD, NRCS, ISDA, Purdue Extension
		2016	Develop 319 cost-share program.	*See Note		
		2016-2017	Identify a drainage water management highlight project location. Installation target by 2020.	*See Note		
		2017-2020	Annually identify additional funding options.	*See Note		
		2017-2020	Market drainage water management to landowners and operators.	**See Note		
Restrict livestock access to streams and reduce runoff from pastures	Livestock Owners & Facility Operators	2016-2020	See 12.1.1 Reduce E. coli Loads	--	Watershed Group, SWCD, ISDA, NRCS	TSPs, SWCD, NRCS, ISDA, Purdue Extension
Implement manure management and application BMPs	Livestock Owners & Facility Operators	2016-2020	See 12.1.1 Reduce E. coli Loads	--	Watershed Group, SWCD, ISDA, NRCS	TSPs, SWCD, NRCS, ISDA, Purdue Extension
Increase use of LID practices and development Long-term target: 5% of existing developed lands treated	Municipalities & Urban Landowners	2016	Develop 319 cost-share program.	*See Note	Municipalities Watershed Group	MS4 Communities, IDEM, Consulting Firms
		2016-2020	Annually identify additional funding options.	*See Note		
		2016-2020	Market LID to municipalities and landowners.	*See Note		
		2016-2020	Host an LID development workshop.	$5,000-$10,000		
		2017-2020	Develop a web-based LID tour and update at least annually. (See Nashville LID Tour on ArcGIS.com for example)	$5,000-$10,000 initial, $2,500 annually thereafter		
		2016-2020	Annually retrofit and treat an additional 100 acres of urban land uses with LID practices.	$300,000-$500,000		

Table 134 Action register to reduce nutrient and sediment loading

12.2.3 Restore Riparian Vegetation

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Increase conservation buffers area along waterways Long-term target: 75% of waterway length	Riparian Landowners	2016	Develop 319 cost-share program	*See Note	MS4 Communities, County Surveyors Office, Watershed Group	SWCD, NRCS, ISDA, Purdue Extension
		2016-2020	Annually identify additional funding options.	*See Note		
		2016-2020	Market riparian restoration to municipalities and landowners.	*See Note **See Note		
		2016-2020	Continue to develop conservation plans as needed.	**See Note		
		2016-2020	Restore 20 acres of conservation buffer annually.	$19,000 - $50,000		

Table 135 Action register to restore riparian vegetation

12.2.4 Improve Bed Form Diversity

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Remove/modify the Deep River dam located in Lake Station	Property Owners	2016-2018	Complete engineering feasibility study for dam's removal or modification.	$30,000	City of Lake Station, School Corporation of Gary, Little Calumet River Basin Development Commission, Watershed Group	DNR LARE, Consulting Firms
		2017-2018	Identify funding options for construction.	*See Note		
		2018-2020	Begin construction once funding and permits have been secured.	TBD		
Re-meander formerly channelized/incised streams through excavated floodplain	Landowners, County Surveyors Office, Municipalities	2016-2017	Identify potential reaches where re-meandering stream channel and excavating a new floodplain is possible.	*See Note	County Surveyors Office, Municipalities, Little Calumet River Basin Development Commission, Watershed Group	NRCS, DNR, IDEM, USACE, Consulting Firms
		2017-2018	Meet with landowners to discuss willingness	*See Note **See Note		
		2018-2020	Conducted engineering feasibility study as sites are identified.	$30,000-$50,000		
		2020	Identify funding options for construction	*See Note		

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
		--	Construct as possible	TBD		
Incorporate large woody debris and/or other in-stream structures into restoration designs where feasible	Project designers, permitting agencies	2016-2020	Coordinate with project designers and permitting agencies.	*See Note	County Surveyors Office, Municipalities	NRCS, DNR, IDEM, USACE, Consulting Firms

Table 136 Action register to improve bed form diversity

12.2.5 Improve Channel Stability

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Remove or modify the Deep River dam located in Lake Station	Property Owners	2016-2020	See 12.2.4 Improve Bed Form Diversity	--	City of Lake Station, School Corporation of Gary, Little Calumet River Basin Development Commission, Watershed Group	DNR LARE, Consulting Firm
Stabilize eroding streambanks downstream impacted by in-channel infrastructure or where infrastructure is threatened	Lake County Parks Department	2017-2018	Complete an engineering design study for the severely eroding streambank on Deep River in Deep River County Park adjacent to County Line Road	$20,000-30,000	Lake County Parks, Lake County Highway Dept., Watershed Group	DNR LARE Program, Consulting Firms
		2019-2020	Stabilize project reach based on recommendations from engineering design study.	TBD		
	Landowners	2016-2018	Coordinate with partners to identify additional opportunities and create list of sites where stabilization is most needed	*See Note	County Surveyors Office, Municipalities	NRCS, DNR LARE, Consulting Firms

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
		2018	Identify funding options for construction	*See Note		
		2016-2020	Stabilize streambanks and shorelines as possible	$22 - $100 / foot		
Reconstruct conventional drainage ditches/incised channels to include floodplain benches or terraces.	Landowners	2016-2020	See 12.2.6 Provide Floodplain Connectivity	--	County Surveyors Office, Municipalities, Little Calumet River Basin Development Commission	NRCS, ISDA, SWCD, DNR LARE Program, TNC, Consulting Firms
Incorporate channel protection standards into storm water ordinances	Municipalities	2016-2020	Update municipal storm water ordinances to incorporate channel protection standards	$5,000-$10,000	MS4 Communities	MS4 Communities, Consulting Firms
Increase conservation buffers area along waterways	Riparian Landowners	2016-2020	See 12.2.3 Restore Riparian Vegetation	--	MS4 Communities, County Surveyors Office, Watershed Group	SWCD, NRCS, ISDA, Purdue Extension

Table 137 Action register to improve channel stability

12.2.6 Provide Floodplain Connectivity

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Reconstruct conventional drainage ditches/incised channels to include floodplain benches or terraces.	Landowners	2016-2017	Create a priority list and GIS layer of conventional drainage ditch reaches that could be reconstructed with floodplain benches or terraces.	*See Note	County Surveyors Office, Municipalities, Little Calumet River Basin	NRCS, ISDA, SWCD, DNR LARE Program, TNC, Consulting Firms
		2017-2018	Conduct geomorphic surveys and hydrologic surveys of priority project reaches.	$5,000 - $10,000 per reach		

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
		2016-2017	Identify funding options for construction	*See Note	Development Commission	
		2017-2018	Install ½- mile of two-stage ditch along Turkey Creek (previously identified project) or other appropriate location as a showcase project in the watershed.	$55,000		
		2019-2020	Host workshop highlighting the benefits of two-stage ditches.	$5,000		
		2017-2018	Conduct an engineering feasibility study for floodplain connectivity along Willow Creek south of Stone Avenue.	$30,000-$50,000		
		2018	Identify funding options for construction.	*See Note		
		2018-2020	Begin construction once funding and permits have been secured.	TBD		

Table 138 Action register to increase floodplain connectivity

12.2.7 Reduce Storm Water Runoff Volume & Rates

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
Reestablish natural upland habitats Long-term target additional 2,300 acres for 30% watershed coverage	Landowners	2016	Develop 319 cost-share program.	*See Note	MS4 Communities, DNR, Land Trusts, Watershed Group	NRCS, ISDA, SWCD, DNR, Land Trusts
		2016-2020	Annually identify additional funding options.	*See Note		
		2016-2020	Market upland habitat reestablishment to landowners.	*See Note **See Note		
		2016-2020	Continue to develop conservation plans as needed for agricultural owners and operators.	**See Note		
			Develop conservation & coordinated management plan for the Hobart Marsh Area & Develop long-term vision and strategy for the Deep River Conservation Corridor	$60,000		

Strategy	Target Audience	Time Frame	Milestone	Cost	Potential Partners	Technical Assistance
		2016-2020	Annually convert 25 acres of turf grass or row crop to natural upland habitat.	$125,000-$625,000		
Reestablish depressional wetlands and rehabilitate hydraulic function of wetland drained by ditches Long-term target additional 2,300 acres for 10% watershed coverage	Landowners	2016	Develop 319 cost-share program.	*See Note	Watershed Group	NRCS, ISDA, SWCD, DNR, USACE, IDEM, Consulting Firms
		2016-2020	Annually identify additional funding options.	*See Note		
		2016-2020	Market wetland restoration to landowners	*See Note **See Note		
		2016-2020	Continue to develop conservation plans as needed.	**See Note		
		2016-2020	Annually implement 5 acres of wetland restoration.	$10,000-$50,000		
Increase use of LID practices and development	Municipalities & Urban Landowners	2016-2020	See 12.2.2 Reduce Nutrient & Sediment Loads	--	Watershed Group, Municipalities	MS4 Communities, IDEM, Consulting Firms
Increase urban tree canopy density Long-term target 30% average UTC	Municipalities & Landowners	2016	Develop 319 cost-share program.	*See Note	Watershed Group, Municipalities	Urban Waters Partnership, USFS, DNR, NIPSCO
		2016-2020	Annually identify additional funding options.	*See Note		
		2016-2020	Market urban forestry and promote Tree City USA program to municipalities.	*See Note		
		2017-2018	Host urban forestry workshop and field day event.	$5,000		
		2016-2020	Public tree inventory completed by two municipalities.	$90,000		
		2016-2020	Urban forestry master plan completed by one municipality.	$5,000-$10,000		
		2017-2018	Develop one community engagement program.	$30,000 annually		
		2016-2020	Plant 1,000 native trees annually.	$200,000-$300,000 annually		

Table 139 Action register to reduce storm water runoff volume and rates

Notes:

* Annual salary of watershed coordinator

** Personnel from NRCS/SWCD/ISDA

13 Tracking Effectiveness

The success of this watershed plan depends upon the implementation of the strategies outlined above. Periodic adjustments to the strategies will need to be made as restoration targets are met or unforeseen challenges dictate a different approaches. The following indicators that will be used to track overall effectiveness of plan implementation and stream function functional-lift over time.

13.1 Pollutant Load Modelling

Pollutant load reductions anticipated through BMP implementation will be estimated using STEPL, Region 5 or other appropriate models. Modeling will be conducted prior to any 319 funded project implementation to evaluate and maximize cost-benefit. Modeling will also be done for partner projects that do not use Section 319 funding to greatest extent possible (ex. projects funded through Farm Bill programs).

13.2 Water Quality & Biological Assessment

Water quality and biological monitoring will begin following five years of implementation at the critical area sampling points. Water quality monitoring will occur at least monthly over a one year period to capture seasonal variability. Biological monitoring will occur once during the sampling year. Monitoring will follow Hoosier Riverwatch methodologies. Parameters to be monitored include benthic macroinvertebrates, temperature, pH, DO, BOD, orthophosphate, nitrate, and turbidity. Flow data will either be collected in the field using Hoosier Riverwatch methodologies or estimated using the Deep River USGS gaging station. The estimated cost is $1,000-$2,000 for supplies. Monitoring will be completed by trained partners and/or NIRPC.

13.3 Hydrologic & Geomorphology Assessment

Hydrology, hydraulics, and geomorphology assessments will be conducted as part of stream restoration design to help evaluate pre- and post- restoration functional lift. Hydrology parameters such as precipitation/runoff relationship, flood frequency, and flow duration will be assessed. Hydraulic parameters such as floodplain connectivity and flow dynamics will be evaluated. Geomorphology parameters such as channel evolution, bank stability, riparian vegetation, and bed form diversity, and bed material characterization will also be evaluated.

13.4 Administrative Indicators

Administrative indicators provide information that water quality data cannot. These indicators are used to track program participation, strategy completion, and goal attainment. Administrative indicators will be used to track the following:

- Funds secured and leveraged
- Attendance at workshops and field day events.
- Conservation practice installation and anticipated load reduction.
- Acres of natural area conserved.
- Photo monitoring of installed practices.
- Media coverage.
- Number and types of educational materials distributed.
- Number of goals met.
- Delisting of streams included on the 303d List (impairment type, # of segments, miles of stream)

13.5 Implementation Tracking

Implementation strategies will be tracked on a quarterly basis. Work completed towards each strategy will be documented in a spreadsheet which will include scheduled and completed activities, numbers of individuals attending or efforts completed toward each objective, and load calculations or monitoring results for each goal, objective, and strategy. Overall project progress will be tracked by measureable items such as workshops held, BMPs installed, meetings held, etc. Load reductions will be calculated for each BMP installed. These values and associated project details including BMP type, location, length of conservation commitment, easement, size, cost, installer, and more will be tracked over time using spreadsheets and GIS where appropriate.

14 Future Considerations

Watershed plans are intended to be living documents that require updates as water quality and land use change and BMPs are implemented.

The steering committee will continue to meet on a regular basis for the purpose of plan implementation. Annually, this committee will review findings of any subcommittees that have been formed to help implement the watershed restoration plan. The action register, which serves as a work plan, will be updated every five years. The steering committee will review project efforts according to the management plan's goals, objectives, and strategies no less than every five years. The Northwestern Indiana Regional Planning Commission will be responsible for holding and revising the Deep River-Portage Burns Waterway Watershed Restoration Plan as appropriate based on stakeholder feedback. The plan may be adapted or blended with other watershed management plans to effectively create living documents which cover larger-scale projects and capitalize on potential shared resources.

Questions pertaining to the Deep River-Portage Burns Waterway Watershed Plan can be directed to:

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Appendices

Best Management Practices

Urban Area Practices

Bioretention (Rain Gardens)

Bioretention areas (often called rain gardens) are shallow surface depressions planted with specially selected native vegetation to capture and treat stormwater runoff from rooftops, streets, and parking lots. Variations for this practice inlcude subsurface storage, use of underdrain, and use of impervious liner.

Capture Reuse

Structures designed to intercept and store runoff from rooftops allow for its reuse, reducing volume and overall water quality impairment. Storm wateris contained in the structures and typically reused for irrigation or other water needs. Variations for this practice include rain barrels and cisterns.

Constructed Filter

Constructed filters are structures or excavated areas containing a layer of sand, compost, organic material, peat, or other media that reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants. Constructed filters are suitable for sites without sufficient surface area available for bioretention. Variations for this pactice inlcude vegetated, infiltration, contained, linear perimiter, and subsurface.

Detention Basin

Detention basins are temporary stormwater storage structures that help prevent downstream flooding. The primary purpose of detention basins is the attenuation of stormwater runoff peaks. Variations can inlcude dry ponds, wet ponds, constructed wetlands, an bioretention.

Infiltration Practices

Infiltration practices are natural or constructed land areas located in permeable soils that capture, store, and infiltrate the volume of stormwater runoff into surrounding soil. Variations include dry wells, infiltration basins, infiltration berms, infitration trenches, subsurface infiltration beds, and bioretention.

LID Site Design

The LID site design process builds on the traditional approach to site design. It begins with analysis of the site, and incorporates steps to involve local decision makers early in the process. An essential objective of the site design process is to minimize storm water runoff by preventing it from occurring. This can be accomplished through the use of nonstructural BMPs in the site design (LID Manual for Michigan- Chapter 6). Once prevention is maximized, some amount of mitigation is needed to address storm water peak rate, volume, and water quality from increased impervious surfaces. These storm water management objectives can be met with the following structural BMPs (also see LID Manual for Michigan- Chapter 7).

Pervious Pavement w/ Infiltration

Pervious pavement is an infiltration technique that combines stormwater infiltration, storage, and structural pavement consisting of a permeable surface underlain by a storage reservoir. Pervious pavement is well suited for parking lots, walking paths, sidewalks, playgrounds, plazas, tennis courts, and other similar uses. Variations include porous asphalt, pervious concrete, permeable paver blocks, reinforced turf/gravel.

Planter Boxes

Planter boxes receive runoff from multiple impervious surfaces, which is used for irrigation of the vegetation in the planter box preventing storm water from directly draining into nearby storm sewers. They also play an important role in urban areas by minimizing storm water runoff, reducing water pollution, and creating a greener and healthier appearance of the built environment by providing space for plants and trees near buildings and along streets. Variations of planter boxes which can be used on sidewalks, plazas, rooftops, and other impervious areas include contained, infiltration, and flow-through.

Sanitary Sewer Hookup

Municipalities which operate a sanitary sewer system can require properties that use septic systems for wastewater treatment to connect to sanitary if the affected property line is within 300 feet of the sanitary line under Indiana Code 36-9-23-30.

Septic System Operation & Maintenance Program Ordinance

The purpose of a septic system operation and maintenance program is to establish requirement for the inspection, maintenance and repair of septic systems. Maintenance of septic systems is crucial for their operation, particularly the removal of accumulated sludge.

Stream Daylighting

Stream daylighting restores stream channels that have been piped/buried to an open channel. This type of restoration practice can restore a variety of ecosystem functions which benefit fish and wildlife and people. Examples include reduction in pathogen concentrations, increased habitat, nutrient uptake and sediment deposition, floodwater storage, recreation, scenic beauty.

Vegetated Filter Strip

A vegetated filter strip is a permanent, maintained strip of vegetation designed to slow runoff velocities and filter out sediment and other pollutants from urban stormwater. Filter strips require the presence of sheet flow across the strip, which can be achieved through the use of level spreaders. Frequently, filter strips are designed where runoff is directed from a parking lot into a stone trench, a grass strip, and a longer naturally vegetative strip. Variations include turf grasses, prairies grasses, shrubs and trees.

Vegetated Roof (Green Roof)

Green roofs are rooftops that include a thin covering of vegetation allowing the roof to function more like a natural vegetated surface. The overall thickness of the vegetated roof may range from 2 to 6 inches, typically containing multiple layers consisting of waterproofing, synthetic insulation, non-soil engineered growth media, fabrics, synthetic components, and foliage.

Vegetated Swale

A vegetated swale (or bioswale) is a shallow stormwater channel that is densely planted with a variety of grasses, shrubs, and/or trees designed to slow, filter, and infiltrate stormwater runoff. Check dams can be used to improve performance and maximize infiltration, especially in steeper areas. Vairations for this practice include vegetated swale with infiltration trench, linerar wetland swale and grass swale.

Water Quality Devices

Various proprietary, commercially available BMPs have been designed to remove nonpoint source pollutants from the conveyance system for stormwater runoff. These structural BMPs vary in size and function, but all utilize some form of filtration, settling, or hydrodynamic separation to remove particulate pollutants from overland or piped flow. The devices are generally configured to remove pollutants including coarse sediment, oil and grease, litter, and debris. Some filtration devices employ additional absorbent/adsorbent material for removal of toxic pollutants. Pollutants attached to sediment such as phosphorus, nitrates, and metals may be removed from stormwater by effective filtration or settling of suspended solids.

Agricultural Area Practices

Access Control

Access control is used to for the temporary or permanent exclusion of animals, people, vehicles and/or equipment from and area. The purpose of the measure is to achieve and maintain desired resource conditions by managing the intensity of use as specified in the conservation plan.

Alternative Watering Systems

Alternative watering systems provide an alternate location for livestock to seek water rather than using a surface water source. This removes the negative impacts of livestock access to streams including direct deposit of manure and bank erosion and destabilization, while improving the health of livestock by providing a clean water source and better footing while drinking. Alternative watering systems may include pump systems or gravity systems connected to a well, or running pipe from a pond or spring.

Conservation Cover

Conservation cover establishes and maintains permanent vegetative cover to reduce erosion and water quality degradation, improve soil health, and enhance wildlife and pollinator habitat.

Cover Crops

Cover crops include legumes and non-legumes which are planted prior to or following crop harvest. Cover crops typically grow for one season to one year and are typically grown in non-cropping seasons. Cover crops are used to improve soil quality and future crop harvest by improving soil tilth, reducing wind and water erosion, increasing available nitrogen, reducing phosphorus transport, suppressing weed cover, and encouraging beneficial insect growth.

Critical Area Planting

Critical area planting is the planting of grasses, legumes, or other vegetation to stabilize slopes in small, severely eroding areas. The permanent vegetation stabilizes areas such as gullies, over-grazed hillsides and terraced backslopes. Although the primary goal is erosion control, the vegetation can also provide nesting cover for birds and small animals.

Denitrifying Bioreactor

A denitrifying bioreactor is a structure containing a carbon source, installed to reduce the concentration of nitrate nitrogen in subsurface agricultural drainage flow via enhanced denitrification.

Drainage Water Management

Drainage water management is the process of managing water discharges from surface and/or subsurface agricultural drainage systems to reduce nutrient and pathogen loading; improve plant productivity, health and vigor; reduce oxidation of organic matter in soils; and provide seasonal wildlife habitat.

Fencing

Fencing is used to help accomplish conservation objectives by controlling the movement of animals, people and vehicles. For the purposes of this watershed restoration plan, fencing is identified as strategy to exclude livestock access for pasture management and access control.

Field Border

A field border is a strip of permanent vegetation established at the edge or around the perimeter of a field. The practice can be applied to reduce wind and water erosion, provide wildlife habitat, and connect other buffer practices on cropland and grazing lands.

Filter Strips

A filter strip is a strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater before they reach water bodies or water sources, including wells.

Forage and Biomass Planting

This practice is for establishing herbaceous species suitable for pasture, hay or biomass production to improve or maintain livestock nutrition and/or health; provide or increase forage supply; reduce soil erosion, improve soil and water quality; and produce feedstock for biofuel or energy production

Stabilization Structures

A grade stabilization structure is a structure used to control the grade in natural or constructed channels to reduce erosion and improve water quality.

Grassed Waterway

Grassed waterways are natural or constructed channels established for transport of concentrated flow at safe velocities using adequate channel dimensions and proper vegetation. They are generally broad and shallow by design to move surface water across farmland without causing soil erosion. Grassed waterways are used as outlets to prevent rill and gully formation. The vegetative cover slows the water flow, minimizing channel surface erosion, and uptakes nutrients. The waterways can also function as wildlife corridors.

Manure Management Planning

Manure management planning includes consideration of the volume and type of manure produced annually, crop rotations by field, the volume of manure and nutrients needed for each crop, field slope, soil type, and manure collection, transportation, storage, and distribution methods. Manure management planning uses similar techniques to nutrient management planning with regards to nutrient budgets. Proper management of animal waste can be done by implementing BMPs, through safe storage, by application as a fertilizer, and through composting. Manure management can also be addressed in education and outreach to encourage farmers to participate in this BMP.

Manure Storage Facilities

Waste storage facilities are one component of agricultural waste management systems, designed to temporarily store manure, wastewater, and contaminated runoff. Storage facilities include impoundments created by building an embankment or excavating a pond, or by building a structure such as a tank. Facilities should be constructed, operated and maintained in such a way that they do not pollute water resources. Facilities must be located outside of floodplains and with a minimum 300 foot setback from surface waters and drainage inlets, or a 100 foot setback if the facility is for solids storage only. In addition, facilities should be located so as to minimize the potential impacts from breach of embankment, accidental release and liner failure

Nutrient Management

Nutrient management is the management of the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments to minimize the transport of applied nutrients into surface water or groundwater. Nutrient management seeks to supply adequate nutrients for optimum crop yield and quantity, while also helping to sustain the physical, biological, and chemical properties of the soil. A nutrient budget for nitrogen, phosphorus, and potassium is developed considering all potential sources of nutrients including, but not limited to, animal manure, commercial fertilizer, crop residue, and legume credits.

Prescribed Grazing

This practice may be applied on all lands where grazing and/or browsing animals are managed. Removal of herbage by the grazing animals is in accordance with production limitations, plant sensitivities and management goals. Frequency of defoliations and season of grazing is based on the rate of growth and physiological condition of the plants. Duration and intensity of grazing is based on desired plant health and expected productivity of the forage species to meet management objectives. The practice minimizes concentrated livestock areas to enhance nutrient distribution and improve or maintain ground cover and riparian/floodplain plant community structure and functions.

Residue and Tillage Management, No Till

Conservation tillage refers to several different tillage methods or systems that leave at least 30% of the soil covered with crop residue after planting. This practice includes planting methods commonly referred to as no-till, quality no till, never-till, zero till, slot plant, zone till, strip till, or direct seed. The purpose of conservation tillage is to reduce sheet and rill erosion, maintain or improve soil organic matter content, conserve soil moisture, reduce plant damage, and provide habitat and cover for wildlife. The remaining crop residue helps reduce soil erosion and run-off volume.

Residue and Tillage Management, Reduced Till

This practice includes tillage methods commonly referred to as mulch tillage where a majority of the soil surface is disturbed by tillage operations such as vertical tillage, chiseling and disking and also includes tillage/planting systems with relatively minimal soil disturbance but which do not meet the criteria for Indiana (IN) Field Office Technical Guide (FOTG) Standard Residue and Tillage Management, No-Till. It applies to stubble mulching on summer-fallowed land, to tillage for annually planted crops and to tillage for planting perennial crops. Also included is the use of a "modified no-till" system (Indiana definition) that uses full width tillage but leaves as much as 85% of the initial residue on the soil surface.

Saturated Buffer

A saturated buffer is a riparian buffer in which the water table is artificially raised by diverting subsurface drainage along the buffer accomplished by installing a water control structure in the main drainage outlet. The purpose of the practice is to hydrologically reconnect a subsurface drainage outlet with an edge-of-field buffer. This practice takes advantage of both the denitrification and plant nutrient uptake opportunities that are known to exist in buffers with perennial vegetation as a way to remove nutrients from the drainage water.

WATERSHED-WIDE PRACTICES

Floodplain Reconnection

Floodplain reconnection restores the interactions between the stream and its floodplain, resulting in a regaining of hydrologic and ecological function. This may be accomplished by lowering of the floodplain terrace through benching, excavation to create lower floodplains, or raising the stream through bankfull channel restoration.

Native Revegetation

Native revegetation includes the restoration of forest and/or prairie. Revegetation should primarily use native vegetation due to the numerous benefits, including lower long-term maintenance needs, storm water runoff volume reduction, improved water quality, and habitat. Variations inlcude prairie, no-mow lawn areas, woodland (trees), constucted wetlands, buffer areas, and turfgrass replacement.

Riparian Buffer Restoration

Restores herbaceious and tree/shrub cover between waterbodies and upland human land uses. Riparian buffers create shade to lower or maintain water temperatures; improve habitat for terrestrial and aquatic organisms; reduce excess sediment and nutrients in surface runoff; and reduce runoff volume and velocity.

Streambank Stabilization & Shoreline Protection

Used to stabilize and protect streambanks, constructed channels, and shorelines for the purposes of preventing the loss or damage of land, land uses, or facilities; maintaining flow capacity; reducing offsite or downstream effects of sediment from bank erosion; and improving or enhancing the stream corridor for fish and wildlife habitat, aesthetics, recreation.

Two-Stage Ditch

The open channel practice applies to constructing or improving a channel, either natural or artificial, in which water flows with a free surface to provide discharge capacity required for flood prevention, drainage, other authorized water management purposes, or any combination of these purposes.

Wetland Restoration

This practice returns a wetland and its functions to a close approximation of its original condition as it existed prior to disturbance on a former or degraded wetland site.

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Natural Heritage Data

High quality natural communities & endangered, threatened, rare species located within the watershed.

Scientific Name	Common Name	Natural Communities
Achalarus lyciades	The Hoary Edge Skipper	Savanna or Prairie
Aethes patricia	--	Prairie
Agalinis auriculata	Earleaf Foxglove	Prairie
Agalinis skinneriana	Pale False Foxglove	Prairie
Agrotis stigmosa	--	Savanna or Prairie
Agrotis vetusta	A Moth	Prairie
Amblyscirtes vialis	Common Roadside-skipper	Prairie
Ambystoma laterale	Blue-spotted Salamander	Savanna or Woodlands
Ammodramus henslowii	Henslow's Sparrow	Prairie
Anas clypeata	Northern Shoveler	Marsh
Ancylis semiovana	--	Prairie or Savanna
Anepia capsularis	The Starry Campion Capsule Moth	Savanna
Apamea burgessi	A Noctuid Moth	Prairie
Apamea indocilis	The spastic apamea	Prairie
Apamea nigrior	Black-dashed Apamea	Prairie
Aralia hispida	Bristly Sarsaparilla	Savanna
Arctostaphylos uva-ursi	Bearberry	Dune or Sand Prairie
Arethusa bulbosa	Swamp-pink	Bog or Swamp
Aristida intermedia	Slim-spike Three-awn Grass	Savanna or Dry Sand Prairie
Aristida tuberculosa	Seabeach Needlegrass	Sand Prairie or Dunes
Armoracia aquatica	Lake Cress	Pond or Marsh
Aster borealis	Rushlike Aster	Sedge Meadow or Wet Prairie
Aster furcatus	Forked Aster	Perched Fen
Aster sericeus	Western Silvery Aster	Sand Savanna
Atrytonopsis hianna	Dusted Skipper	Prairie
Betula papyrifera	Paper Birch	Forest
Boloria selene myrina	Silver-bordered Fritillary	Prairie or Sedge Meadow
Botaurus lentiginosus	American Bittern	Marsh or Sedge Meadow
Botrychium matricariifolium	Chamomile Grape-fern	Forest
Botrychium simplex	Least Grape-fern	Prairie
Bruchomorpha dorsata	--	Prairie
Bruchomorpha extensa	The Long-nosed Elephant Hopper	Prairie
Bruchomorpha oculata	--	Prairie
Callophrys irus	Frosted Elfin	Savanna or Sand Prairie
Capis curvata	A Noctuid Moth	Prairie or Sedge Meadow
Carex aurea	Golden-fruited Sedge	Prairie or Sedge Meadow
Carex conoidea	Prairie Gray Sedge	Prairie
Carex crawei	Crawe Sedge	Prairie or Sedge Meadow
Carex echinata	Little Prickly Sedge	Prairie

Carex richardsonii	Richardson Sedge	Sand Prairie
Carex straminea	Straw Sedge	Prairie or Savana
Catocala gracilis	Graceful Underwing	Prairie
Catocala praeclara	Praeclara Underwing	Prairie
Chlidonias niger	Black Tern	Marsh
Chloealtis conspersa	Sprinkled Locust	Savanna
Chlorotettix fallax	A Leafhopper	Prairie
Chrysanympha formosa	The Huckleberry Looper Moth	Savanna
Cicadula straminea	--	Prairie
Cirsium hillii	Hill's Thistle	Prairie
Cirsium pitcheri	Dune Thistle	Dune
Cistothorus palustris	Marsh Wren	Marsh or Sedge Meadow
Cistothorus platensis	Sedge Wren	Marsh or Sedge Meadow
Clemmys guttata	Spotted Turtle	Fen or Sedge Meadow
Clintonia borealis	Clinton Lily	Fen or Seep
Coenochroa bipunctella	Sand Dune Panic Grass Moth	Sand Prairie
Coenochroa illibella	Dune Panic Grass Moth	Sand Prairie
Conocephalus saltans	Prairie Meadow Katydid	Prairie
Cornus amomum ssp. amomum	Silky Dogwood	Savanna
Cornus rugosa	Roundleaf Dogwood	Dunes, Woodlands, or Forest
Corydalis sempervirens	Pale Corydalis	Prairie or Savanna
Cosmotettix bilineatus	Two-lined cosmotettix	Prairie
Crambus bidens	--	Marsh or Sedge Meadow
Crambus girardellus	Orange-striped Sedge Moth	Marsh or Sedge Meadow
Crambus murellus	Prairie Sedge Moth	Prairie
Croesia curvalana	--	Savanna or Prairie
Croesia semipurpurana	--	Savanna
Cyclophora penduliniaria	Sweetfern Geometer	Savanna
Cycnia inopinatus	The Unexpected Milkweed Moth	Savanna or Sand Prairie
Cyperus houghtonii	Houghton's Nutsedge	Dune or Sand Prairie
Cypripedium calceolus var. parviflorum	Small Yellow Lady's-slipper	Savanna
Dichanthelium sabulorum var. thinium	Hemlock Panic-grass	Prairie
Dichomeris aleatrix	Aleatrix dichomeris	Prairie
Diervilla lonicera	Northern Bush-honeysuckle	Savanna
Drosera intermedia	Spoon-leaved Sundew	Bog or Sedge Meadow
Eleocharis melanocarpa	Black-fruited Spike-rush	Sedge Meadow or Wet Prairie
Eleocharis microcarpa	Small-fruited Spike-rush	Marsh or Sedge Meadow
Eleocharis wolfii	Wolf Spikerush	Wet Prairie
Emydoidea blandingii	Blanding's Turtle	Marsh or Sedge Meadow
Epigaea repens	Trailing Arbutus	Dune or Woodland
Epipaschia zelleri	--	Savanna
Eriophorum angustifolium	Narrow-leaved Cotton-grass	Sedge Meadow or Wet Prairie
Erynnis martialis	Mottled Duskywing	Savanna
Erynnis persius persius	Persius Dusky Wing	Savanna

Eubaphe meridiana	A Moth	Savanna
Euchloe olympia	Olympia Marble	Dune or Sand Prairie
Eucoptocnemis fimbriaris	A Noctuid Moth	Sand Prairie or Dunes
Eucosma bilineana	--	Prairie
Eucosma bipunctella	A Moth	Prairie
Eucosma fulminana	--	Prairie
Eucosma giganteana	--	Prairie
Euphydryas phaeton	Baltimore	Fen or Sedge Meadow
Euphyes bimacula	Two-spotted Skipper	Prairie
Euphyes dion	Sedge Skipper	Wet Prairie or Sedge Meadow
Euxoa albipennis	White-striped Dart	Savanna
Euxoa aurulenta	Dune Cutworm	Dune
Fagitana littera	The Marsh Fern Moth	Marsh or Wet Prairie
Faronta rubripennis	The Pine Streak	Sand Prairie or Dunes
Fimbristylis puberula	Carolina Fimbry	Wet Prairie
Flexamia pyrops	The Long-nose Three-awn Leafhopper	Interdunal Wetlands
Flexamia reflexus	Indiangrass Flexamia	Prairie
Forest - floodplain wet	Wet Floodplain Forest	Forest
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest	Floodplain Forest
Forest - upland dry	Dry Upland Forest	Forest
Forest - upland dry-mesic	Dry-mesic Upland Forest	Forest
Forest - upland mesic	Mesic Upland Forest	Forest
Formica glacialis	--	Wet Prairie or Sedge Meadow
Fuirena pumila	Dwarf Umbrella-sedge	Marsh or Sedge Meadow
Gabara pulverosalis	--	Prairie
Gabara subnivosella	A Noctuid Moth	Prairie
Gentiana puberulenta	Downy Gentian	Prairie
Geranium bicknellii	Bicknell Northern Crane's-bill	Prairie or Savanna
Graminella mohri	--	Prairie or Savanna
Grammia anna	Anna's tiger moth	Prairie or Savanna
Grammia figurata	The Figured Grammia	Prairie or Savanna
Grammia phyllira	The Sand Barrens Grammia	Prairie
Grammia virguncula	--	Prairie
Hemaris gracilis	The Blueberry Clearwing Sphinx	Savanna
Hemicarpha drummondii	Drummond Hemicarpha	Sedge Meadow or Wet Prairie
Hesperia leonardus	Leonard's Skipper	Prairie
Hesperotettix viridis pratensis	A Grasshopper	Prairie or Savanna
Holomelina opella	The Smokey Holomelina	Prairie or Savanna
Hudsonia tomentosa	Sand-heather	Dune or Sand Prairie
Hydrastis canadensis	Golden Seal	Forest
Hypericum kalmianum	Kalm St. John's-wort	Marsh or Wet Prairie
Ixobrychus exilis	Least Bittern	Marsh or Wet Prairie
Juncus articulatus	Jointed Rush	Sedge Meadow or Wet Prairie

Juncus balticus var. littoralis	Baltic Rush	Sedge Meadow or Interdunal Wetlands
Juncus scirpoides	Scirpus-like Rush	Sedge Meadow or Wet Prairie
Lanius ludovicianus	Loggerhead Shrike	Prairie
Lasiurus borealis	Eastern Red Bat	Savanna or Forest
Lasiurus cinereus	Hoary Bat	Savanna or Forest
Lasius minutus	--	Wet Prairie or Sedge Meadow
Laterallus jamaicensis	Black Rail	Marsh or Sedge Meadow
Lathyrus venosus	Smooth Veiny Pea	Savanna
Lesmone detrahens	A Moth	Savanna or Prairie
Leucania inermis	A Moth	Prairie
Leucania linita	Salt Marsh Wainscot	Marsh
Liatris pycnostachya	Cattail Gay-feather	Prairie or Sedge Meadow
Limotettix divaricatus	--	Prairie
Liochlorophis vernalis	Smooth Green Snake	Prairie
Loxagrotis acclivis	A Noctuid Moth	Prairie
Ludwigia sphaerocarpa	Globe-fruited False-loosestrife	Marsh or Pond
Lycaeides melissa samuelis	Karner Blue	Savanna
Lycaena helloides	Purplish Copper	Marsh or Sedge Meadow
Lycopodiella inundata	Northern Bog Clubmoss	Bog or Sedge Meadow
Macrochilo absorptalis	A Moth	Prairie
Macrochilo hypocritalis	A Noctuid Moth	Prairie
Macrochilo louisiana	--	Prairie
Melanomma auricinctaria	Huckleberry Eye-spot Moth	Savanna
Melanoplus viridipes viridipes	Green-legged Spur-throated Grasshopper	Prairie
Meropleon diversicolor	A Noctuid Moth	Prairie
Mesamia nigridorsum	A Leafhopper	Prairie
Metanema determinata	Dark Metanema	Savanna or Prairie
Metanema inatomaria	Pale Metanema	Savanna or Prairie
Myosotis laxa	Smaller Forget-me-not	Fen or Sedge Meadow
Myrmica lobifrons	--	Wet Prairie or Sedge Meadow
Neoconocephalus exiliscanorus	A Katydid	Prairie
Neoconocephalus nebrascensis	A Katydid	Prairie
Nola cilicoides	--	Prairie or Savanna
Nola pustulata	Sharp-blotched Nola	Prairie or Savanna
Nycticorax nycticorax	Black-crowned Night-heron	Marsh or Pond
Odontosia elegans	Elegant Prominent	Sedge Meadow or Fen
Oenothera perennis	Small Sundrops	Prairie
Ophisaurus attenuatus attenuatus	Western Slender Glass Lizard	Sand Prairie
Orphulella pelidna	Green Desert Grasshopper	Sand Prairie or Dunes
Paectes abrostolella	The Barrens Paectes Moth	Prairie or Savanna
Panax quinquefolius	American Ginseng	Forest
Panicum boreale	Northern Witchgrass	Prairie, Marsh or Fen

Panicum leibergii	Leiberg's Witchgrass	Prairie
Papaipema cerina	Golden Borer Moth	Prairie
Papaipema leucostigma	Columbine Borer	Savanna
Papaipema lysimachiae	The St. John'Swort Borer Moth	Sedge Meadow or Wet Prairie
Papaipema maritima	The Giant Sunflower Borer Moth	Prairie
Papaipema rigida	A Borer Moth	Prairie
Papaipema sciata	The Culver's Root Borer	Prairie
Papaipema silphii	Silphium Borer Moth	Prairie
Papaipema speciosissima	The Royal Fern Borer Moth	Wet Prairie or Interdunal Wetlands
Paraphlepsius lobatus	--	Prairie
Parasa indetermina	A Moth	Prairie or Fen
Peoria gemmatella	Gemmed Cordgrass Borer	Prairie
Peoria tetradella	--	Prairie or Savanna
Perideridia americana	Eastern Eulophus	Prairie or Savanna
Phaneta ochroterminana	--	Prairie or Savanna
Phaneta olivaceana	--	Prairie
Phaneta ornatula	--	Prairie
Phaneta raracana	--	Prairie
Phaneta striatana	--	Prairie
Phaneta umbrastriana	--	Prairie
Philaenarcys killa	Great Lakes dune spittlebug	Dune
Pinus banksiana	Jack Pine	Dune or Savanna
Plantago cordata	Heart-leaved Plantain	Seeps or Springs
Platanthera ciliaris	Yellow-fringe Orchis	Bog or Savanna
Platanthera flava var. herbiola	Pale Green Orchis	Prairie
Platanthera psycodes	Small Purple-fringe Orchis	Wet Prairie or Floodplain Forest
Platyperigea meralis	The Rare Sand Quaker	Savanna
Platyperigea multifera	Dune rustic	Dune
Poanes viator viator	Big Broad-winged Skipper	Marsh and Sedge Meadow
Polyamia caperata	Little Bluestem Polyamia	Prairie
Polyamia herbida	The Prairie Panic Grass Leafhopper	Prairie
Polyamia obtectus	Sand Panic Grass Leafhopper	Prairie
Polygonella articulata	Eastern Jointweed	Dune and Sand Prairie
Polygonum careyi	Carey's Smartweed	Prairie or Savanna
Polygonum hydropiperoides var. opelousanum	Northeastern Smartweed	Wet Prairie or Sedge Meadow
Prairiana kansana	The Kansas Prairie Leafhopper	Prairie
Prairie - dry-mesic	Dry-mesic Prairie	Prairie
Prairie - mesic	Mesic Prairie	Prairie
Prairie - sand dry	Dry Sand Prairie	Prairie
Prairie - sand dry-mesic	Dry-mesic Sand Prairie	Prairie
Prairie - sand mesic	Mesic Sand Prairie	Prairie
Prairie - sand wet	Wet Sand Prairie	Prairie

Prairie - sand wet-mesic	Wet-mesic Sand Prairie	Prairie
Prenanthes aspera	Rough Rattlesnake-root	Prairie and Savanna
Problema byssus	Bunchgrass Skipper	Prairie
Procambarus gracilis	Prairie Crayfish	Marsh and Wet Prairie
Prosapia ignipectus	Red-legged Spittle Bug	Prairie or Savanna
Protorthodes incincta	Saturn quaker	Prairie or Savana
Prunus pensylvanica	Fire Cherry	Dune or Sand Savanna
Pseudopomala brachyptera	Bunch Grass Locust	Savanna
Psilocarya scirpoides	Long-beaked Baldrush	Marsh or Sedge Meadow
Psinidia fenestralis	Sand Locust	Sand Prairie or Sand Savanna
Pygarctia spraguei	Sprague's Pygartic	Sand Prairie or Sand Savanna
Pyrausta laticlavia	The Southern Purple Mint Moth	Sand Prairie or Sand Savanna
Rallus elegans	King Rail	Marsh or Sedge Meadow
Rallus limicola	Virginia Rail	Marsh or Sedge Meadow
Rana pipiens	Northern Leopard Frog	Marsh or Prairie
Rhus aromatica var. arenaria	Beach Sumac	Dune and Sand Prairie
Rhynchospora macrostachya	Tall Beaked-rush	Marsh or Sedge Meadow
Rhynchospora recognita	Globe Beaked-rush	Sedge Meadow or Wet Prairie
Rubus setosus	Small Bristleberry	Prairie
Savanna - mesic	Mesic Savanna	Savanna
Savanna - sand dry	Dry Sand Savanna	Savanna
Savanna - sand dry-mesic	Dry-mesic Sand Savanna	Savanna
Schinia indiana	Phlox Moth	Prairie or Savanna
Schinia septentrionalis	A Noctuid Moth	Savanna or Sand Prairie
Schoenoplectus hallii	Hall's Bulrush	Sedge Meadow or Marsh
Scirpophaga perstrialis	--	Savanna
Scleria reticularis	Reticulated Nutrush	Sedge Meadow or Wet Prairie
Selaginella rupestris	Ledge Spike-moss	Dune or Savanna
Semiothisa eremiata	The Goat's Rue Looper	Prairie or Savanna
Semiothisa mellistrigata	A Geometrid Moth	Prairie
Semiothisa multilineata	--	Prairie
Sitochroa dasconalis	Pearly Indigo Borer	Prairie
Solidago ptarmicoides	Prairie Goldenrod	Prairie
Spartiniphaga inops	Spartina Borer Moth	Marsh or Wet Prairie
Spermophilus franklinii	Franklin's Ground Squirrel	Prairie or Savanna
Speyeria aphrodite	Aphrodite Fritillary	Prairie or Savanna
Sphinx luscitiosa	The Luscious Willow Sphinx	Prairie
Spiranthes lucida	Shining Ladies'-tresses	Fen or Sedge Meadow
Spiranthes magnicamporum	Great Plains Ladies'-tresses	Prairie
Strophostyles leiosperma	Slick-seed Wild-bean	Prairie or Savanna
Sturnella neglecta	Western Meadowlark	Prairie
Talinum rugospermum	Prairie Fame-flower	Sand Savanna
Tampa dimediatella	Red-striped Panic Grass Moth	Prairie
Thamnophis proximus proximus	Western Ribbon Snake	Sand Prairie

Thorybes pylades	Northern Cloudywing	Prairie or Savanna
Tricholita notata	Marked Noctuid	Prairie
Trichosilia manifesta	The Record Keeper Moth	Prairie
Trichostema dichotomum	Forked Bluecurl	Savanna or Dry Sand Prairie
Trimerotropis maritima	The Dune Locust	Dunes
Utricularia purpurea	Purple Bladderwort	Pond or Marsh
Utricularia subulata	Zigzag Bladderwort	Sedge Meadow or Wet Prairie
Utricularia subulata	Zigzag Bladderwort	Sedge Meadow or Wet Prairie
Venustaconcha ellipsiformis	Ellipse	River or Stream
Viburnum opulus var. americanum	Highbush-cranberry	Fen or Seep
Wetland - fen	Fen	Fen
Wetland - marsh	Marsh	Marsh
Wetland - marsh	Marsh	Marsh
Wetland - meadow sedge	Sedge Meadow	Sedge Meadow
Wetland - swamp shrub	Shrub Swamp	Shrub Swamp
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	Marsh
Zomaria interruptolinea	--	Savanna