# TREATY CREEK-WABASH RIVER WATERSHED MANAGEMENT PLAN
## MIAMI AND WABASH COUNTIES, INDIANA

**A PROJECT OF THE**
**WABASH RIVER DEFENDERS**
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# 1.0 WATERSHED INTRODUCTION

## 1.1 Watershed Community Initiative

A watershed is the land area that drains to a common point, such as a location on a river. All of the water that falls on a watershed will move across the landscape collecting in low spots and drainage ways until it moves into the waterbody of choice. All activities that take place in a watershed can impact the water quality of the river that drains it. What we do on the land, such as constructing new buildings, fertilizing lawns, or growing crops, affects the water and the ecosystem that lives in it. A healthy watershed is vital for a healthy river, and a healthy river can enhance the community and helps maintain a healthy local economy. Watershed planning is especially important in that it will help communities and individuals determine how best to preserve water functions, prevent water quality impairment, and produce long-term economic, environmental, and political health.

The Wabash River watershed includes all the land that drains into the Wabash River. The river starts in Ohio and drains about 1,024,382 acres by the time it passes through the current watershed project area (Figure 1). The Treaty Creek-Wabash River includes portions of Wabash and Miami Counties in north-central Indiana.

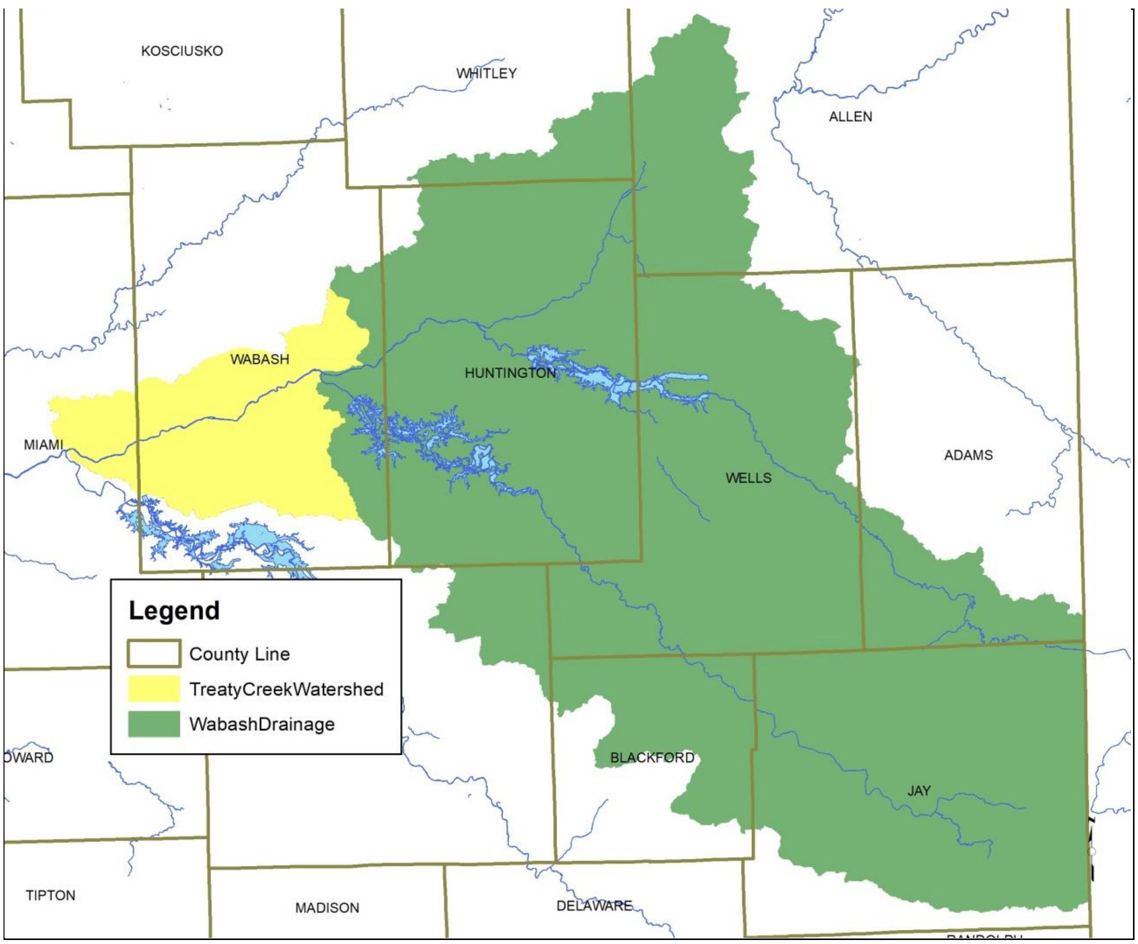


**Figure 1. Wabash River watershed highlighting the Treaty Creek-Wabash River Drainage.**

## 1.2 Project History

In the fall of 2015, the Wabash River Defenders submitted a grant request to the Indiana Department of Environmental Management (IDEM) with a focus on assessing and improving water quality within the Treaty Creek-Wabash River Drainage within Wabash and Miami Counties, Indiana. The Wabash River Defenders' goal is complete water quality planning for all waterbodies that drain to the Wabash River within Wabash County. The Wabash River Defenders selected the Treaty Creek-Wabash River Watershed as it contained most of the tributaries that drain to the Wabash River within Wabash County that have not already been included in a watershed planning process. They completed a brief inventory of the watershed identifying predominant land uses and potential associated water quality issues that could be associated with the predominantly row crop agriculture watershed. Additionally, the Wabash River Defenders identified several preliminary partners as well as concerns associated with the various practices and uses in the watershed. Specifically, the watershed includes the entire City of Wabash MS4 boundary, which requires the input and participation of the City of Wabash. The watershed is predominantly agricultural with 73% of the watershed covered by row crop agriculture or pasture land, 14% in forest or wetland and 9% in developed land uses including the City of Wabash and Town of Lagro. The engagement of the Miami and Wabash Soil and Water Conservation Districts (SWCD), Natural Resources Conservation District (NRCS), and Purdue Extension staff as well as producers across the watershed would be paramount. A majority of the land within the watershed is privately-owned and in a soybean-corn rotation. More than 30 active confined feeding operations are located within the Treaty Creek-Wabash River watershed. These operations house more than 10,000 head of cattle and more than 50,000 head of hogs. Between these animals and those housed on small, unregulated farms, more than 100 tons of manure are produced daily within the Treaty Creek-Wabash River watershed.

Additionally, the Wabash River Defenders completed an initial assessment of the watershed reviewing available water chemistry data and identified that it contains high nutrient, sediment and E. coli concentrations and limited biotic communities. Assessments completed via IDEM's monthly fixed station sampling (1991 to current) at the Wabash River at SR 105, which is upstream of this watershed, indicate that nutrient concentrations routinely exceed target nitrate-nitrogen (75% of samples measure greater than 2 mg/L) and total phosphorus (99% of samples measure greater 0.08 mg/L) concentrations. Additionally, IDEM-collected turbidities measured within the stream indicate higher than target levels (78% of samples measured higher than 25 NTU). In the Wabash River at Lagro, limited nutrient, sediment and E. coli data collected in rotational basin assessments (1990 to present) indicate that concentrations are typically higher than the state standard and targets. The source of these issues is currently unknown as only two watershed tributaries have been sampled by IDEM in the past. Sample results from historic sampling efforts completed by IDEM (1990 to present) indicate impaired biotic communities in Mill Creek, Ridgeway Creek and a tributary to Ridgeway Creek but provide little data for other watershed tributaries. The Wabash River Total Maximum Daily Load (TMDL) identifies the following load reductions from nonpoint sources at the Roush Lake sample point: 0% less nitrate, 20% less total phosphorus, and 95% less E. coli (TetraTech, 2008).

The Wabash River Defenders approached commuity groups and individuals throughout the watershed that might be interested in working with them to assess and improve water quality within the Wabash River. Identified potential partners include: The Community Foundation of Wabash County, Grow Wabash County, City of Wabash Utilities, Visit Wabash County, Indiana American Water, Miami County Soil and Water Conservation District and Natural Resources Conservation Service, Wabash County Surveyors office, Wabash County Soil and Water Conservation District and Natural Resources Conservation Service, Wabash County Purdue Extension, Wabash County Solid Waste Management District, Wabash County Area Plan Commission, Wabash County United Fund, and Wabash County

Emergency Management. This group formed a Steering Committee (Table 1), conducted windshield surveys of the watershed, and held several meetings open to the public in order to generate input in the development of a watershed management plan for the Treaty Creek-Wabash River Watershed. All of these efforts were guided by the following mission and vision developed by public participants and committee members:

***Mission:*** concerned citizens working together to improve water quality and habitat in the Wabash River and its tributaries for all generations.

***Vision:*** Improved water quality for humans and wildlife

## 1.3 Stakeholder Involvement

Development of a watershed management plan requires input from interested citizens, local government leaders, and water resource professionals. These individuals are required to not only buy into the project and the process but must also become an integral part of identifying the solution(s) which will result in improved water quality. We involved stakeholders in the watershed management planning process through a series of public meetings, and education and outreach events including windshield surveys, water quality monitoring opportunities, and meetings with local officials.

### 1.3.1 Steering Committee

Individuals representing the towns and counties within the watershed, environmental groups, natural resource professionals, agricultural and commercial representatives, and private citizens comprised the steering committee. The steering committee has met nearly every other month to develop the watershed management plan (WMP) starting in December 2017. Table 1 identifies the steering committee members and their affiliation.

**Table 1. Treaty Creek-Wabash River Watershed steering committee members and their affiliation.**

| Individual | Organization(s) Represented |
|---|---|
| Bob Gray | City of Wabash |
| Christine Flohr | Visit Wabash County |
| Keith Gillenwater | Economic Development Group |
| Brandon France | Indiana American Water |
| Mary Lou Musselman | Miami County SWCD |
| David Grant | Strauss Veal Feeds |
| Cheri Slee | Wabash County Surveyor |
| Mike Howard | Wabash County Area Plan |
| Tashina Lahr-Manifold | Wabash County SWCD |
| Steve Johnson | Wabash County United Fund |
| Adam Jones | Wabash County NRCS |
| Ed Sprunger | Miami County NRCS |
| Gregg Wilkinson | Miami County Surveyor |
| Curtis Campbell | Wabash County Purdue Extension |
| Kimberly Frazier | Miami County Purdue Extension |
| Jen Rankin | Wabash County Solid Waste |
| Keith Poole | Wabash River Defenders |

| Individual | Organization(s) Represented |
|---|---|
| Mike Beauchamp | Wabash River Defenders |
| Bob Brown | Wabash County Emergency Management |

### 1.3.2 Public Meetings

Public participation is necessary for the long-term success of any watershed planning and subsequent implementation effort. One component of public participation for this project was public meetings. There were two public meetings held in February 2018 and February 2020 to introduce the project and develop a concerns list, then review the plan's goals, strategies and actions and confirm that those meet the public's desire for the future of water quality within the Treaty Creek-Wabash River Watershed. The purpose of the public meetings was to provide information on the overall planning effort and its progress; solicit stakeholder input, opinions, and participation; create opportunities for the public to recommend programs, policies, and projects to improve water quality; and build support for future phases of the project.

The public meetings were advertised through press releases distributed to local newspapers in the watershed. The meetings were also advertised through word of mouth as staff from the Soil and Water Conservation District put together mailings that advertised the events and the Wabash River Defenders distributed information via their website and social media pages as well as through their email distribution list.

The first public meeting was held on February 13, 2018 at the Honeywell Center in Wabash, Indiana. Attendees represented citizens, farmers, and city officials. During this meeting, the Wabash River Defenders detailed the history of the project; described opportunities for individuals to volunteer as part of the project; and provided attendees with the opportunity to identify their concerns about the Treaty Creek-Wabash River Watershed and develop goals for the long-term vision of the stream.

A second public meeting was held on February 10, 2020 at the Honeywell Center in Wabash, Indiana. The meeting included an overview of water quality and watershed data, details of how critical areas were selected and goals created, and a review of practices selected and their timeframe for implementation. Attendees represented citizens, farmers, and city and county officials.

### 1.3.3 Educational Materials and Events

A Treaty Creek-Wabash River Watershed brochure was developed to highlight opportunities for individuals to get involved with the project, identify community partners, and provide general information and fun facts about the watershed, watershed management planning, and the project (Appendix A). The brochure will be distributed at committee, public, and group meetings and at education events throughout the lifetime of the project.

## 1.4 Public Input

Throughout the planning process, project stakeholders, the steering committee, and the general public listed concerns for the Treaty Creek-Wabash River Watershed including the Wabash River, its tributaries, and its watershed. Public and committee meetings were the primary mechanism of soliciting individual concerns. All comments were recorded and included as part of the concern documentation and prioritization process. Concerns voiced throughout the process are listed in Table 2. Similar stakeholder concerns were grouped roughly by topic and condensed by the committee. The order of concern listing does not reflect any prioritization by watershed stakeholders.

**Table 2. Stakeholder concerns identified during public input sessions, steering committee meetings, and watershed inventory process from February through June, 2018 as prioritized by the steering committee.**

| **Stakeholder Concerns** |
|---|
| River is muddy – where does sediment originate? |
| Flooding impacts from non-natural stream flows –Salamonie dam releases |
| Flooding impacts/topsoil loss/impacts from agricultural land |
| Fertilizers and pesticides flowing into the river |
| Livestock access to Wabash River and tributaries |
| Engaging local individuals with the river |
| Agricultural producer & landowner participation in existing conservation programs |
| Redside dace (ETR) occurs in Mill Creek- impacts of water quality/habitat on this species? |
| Landfill – is this impacting the Wabash River |
| Indiana American Water drinking water supply – Wabash River in wellhead protection area |
| Septic impacts |
| Habitat loss along the river and its tributaries |
| Invasive species impacts to water quality |
| Streambank erosion – mouth of Treaty Creek, areas along Mill Creek, island erosion, near Lagro, along River and tributary sharp bends |
| Hardscape impacts/water quantity impacts during stormwater runoff events |
| Industrial impacts to the Wabash River including materials from manufacturing process and/or inputs from runoff |
| Long-term efforts to remove trash –are there still sources and if so, where? |
| Preserving local high-quality areas |
| Impact of potential Riverwalk on wildlife |
| Gravel pits/gravel pit overflow as source of sediment |
| Potential for spills from the railroad |
| Miami County impact may be limited – land is largely owned/managed by one owner and is already in conservation programs |
| Impacts of impaired waterbodies on the watershed |
| Nutrient concentrations are elevated |
| Fertilizers and pesticides flowing into the river |
| E. coli concentrations are elevated |
| Livestock manure impacts to the river and its tributaries |
| Biodiversity is limited in the watershed |
| General public needs educated about agricultural practice use |
| Urban residents are unaware of their impacts to the Wabash River |
| Education is needed on watershed concepts, elevated nutrients, etc |

## 2.0 <u>WATERSHED INVENTORY I: WATERSHED DESCRIPTION</u>

### 2.1 <u>Watershed Location</u>

The Treaty Creek-Wabash River Watershed is part of the Middle Wabash-Little Vermilion watershed and covers portions of Miami and Wabash counties (Table 3). The watershed includes a number of tributaries to the Wabash River from immediately upstream of Lagro, Indiana to immediately upstream of Peru, Indiana. The Wabash River starts in Ohio and drains about 1,600 square miles by the time it gains water from the Treaty Creek-Wabash River Watershed project area.

## 2.2 Subwatersheds

### 2.2.1 Treaty-Creek-Wabash River Tributary Watersheds

In total, seven 12-digit Hydrologic Unit Codes are contained within the Treaty Creek-Wabash River Watershed (Figure 2; Table 3). The subwatersheds range in size from about 10,000 acres or 16 square miles to nearly 19,000 acres or 29 square miles. Each of these drainages will be discussed in further detail under *Watershed Inventory II*.

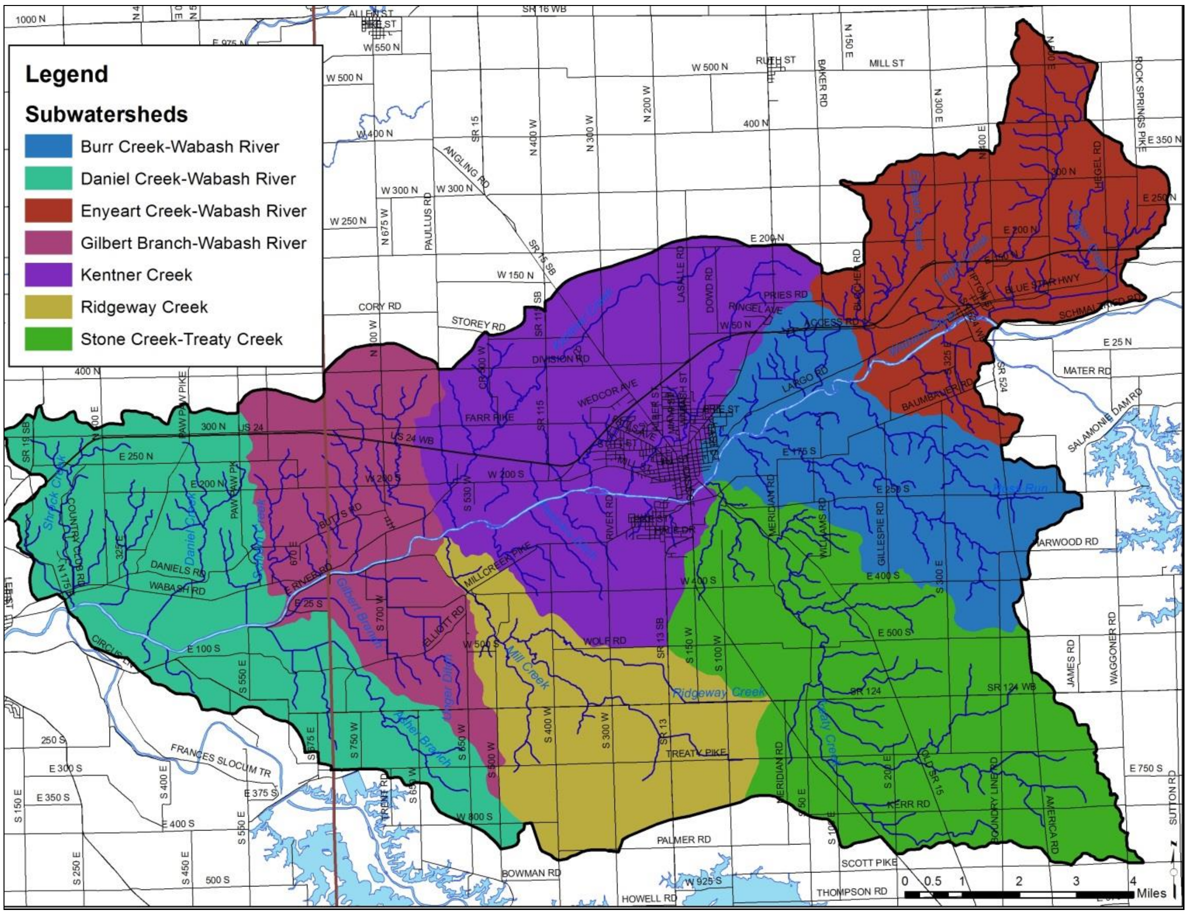


**Figure 2. 12-digit Hydrologic Unit Code Subwatersheds in the Treaty Creek-Wabash River Watershed.**

**Table 3. 12-digit Hydrologic Unit Code (HUC) watersheds in the Treaty Creek-Wabash River Watershed.**

| Subwatershed Name | Hydrologic Unit Code | Area (acres) | Percent of Watershed |
|---|---|---|---|
| Enyeart Creek-Wabash River | 051201011401 | 13,848.7 | 13.7% |
| Stone Creek-Treaty Creek | 051201011402 | 19,267.6 | 19.1% |
| Burr Creek-Wabash River | 051201011403 | 11,245.7 | 11.1% |
| Ridgeway Creek | 051201011404 | 10,324.6 | 10.2% |
| Kentner Creek | 051201011405 | 18,634.9 | 18.5% |
| Gilbert Branch-Wabash River | 051201011406 | 11,224.0 | 11.1% |
| Daniel Creek-Wabash River | 051201011407 | 16,314.1 | 16.1% |
| Watershed Total | | 100,859.6 | |

## 2.3 Climate

In general, Indiana has a temperate climate with warm summers and cool to cold winters. The Treaty Creek-Wabash River Watershed is no different. Climate in this watershed is characterized by four distinct seasons throughout the year. High temperatures measure approximately 84°F in August, while low temperatures measure near freezing (17°F/-8.3°C) in January. The growing season typically extends from early April through late October. On average, 40 inches of precipitation occur within the Treaty Creek-Wabash River Watershed with precipitation occurring as small, frequent rain events spread almost evenly throughout the year.

## 2.4 Geology and Topography

The geology of the Treaty Creek-Wabash River Watershed is directly influenced by the advance and retreat of the Huron and Erie Lobes of the Wisconsin glaciation. As the Michigan, Erie, and Saginaw lobes of the glaciers advanced and retreated, they laid thick material over two-thirds of the state. End moraines, such as the Mississinewa Moraine, ground moraines, and lake and outwash plains create a geologically diverse landscape across northern Indiana, including the Treaty Creek-Wabash River Watershed. Glacial drift, outwash plains, and ground moraines cover much of the area along the length of the Wabash River within the watershed creating large, flat areas. Much of the bedrock geology across the watershed is comprised of limestone (Figure 3). The Wabash River cuts through sand and gravel outwash plains known as the Lagro Formation. These materials are from the Silurian and Devonian age. Icy meltwater from the more recent Wisconsin Age glaciers swept through the Lagro Formation to create the broad flat valley called the Maumee Terrace leaving steep limestone and dolomite bluffs behind.

Surficial geology indicates that the Treaty Creek-Wabash River Watershed lies within silty clay loam to clay loam with till, while the Wabash River floodplain is mostly limestone and dolomite within outwash. Surficial geology within the Treaty Creek-Wabash River Watershed originates from silty clay loam and clay loam till materials (Figure 4). The Wabash Formation, which is comprised of limestone, dolomite and argillaceous dolomite, underlies the entire Treaty Creek-Wabash River Watershed. The underlying bedrock is comprised of Silurian rocks (Gutschick, 1966).

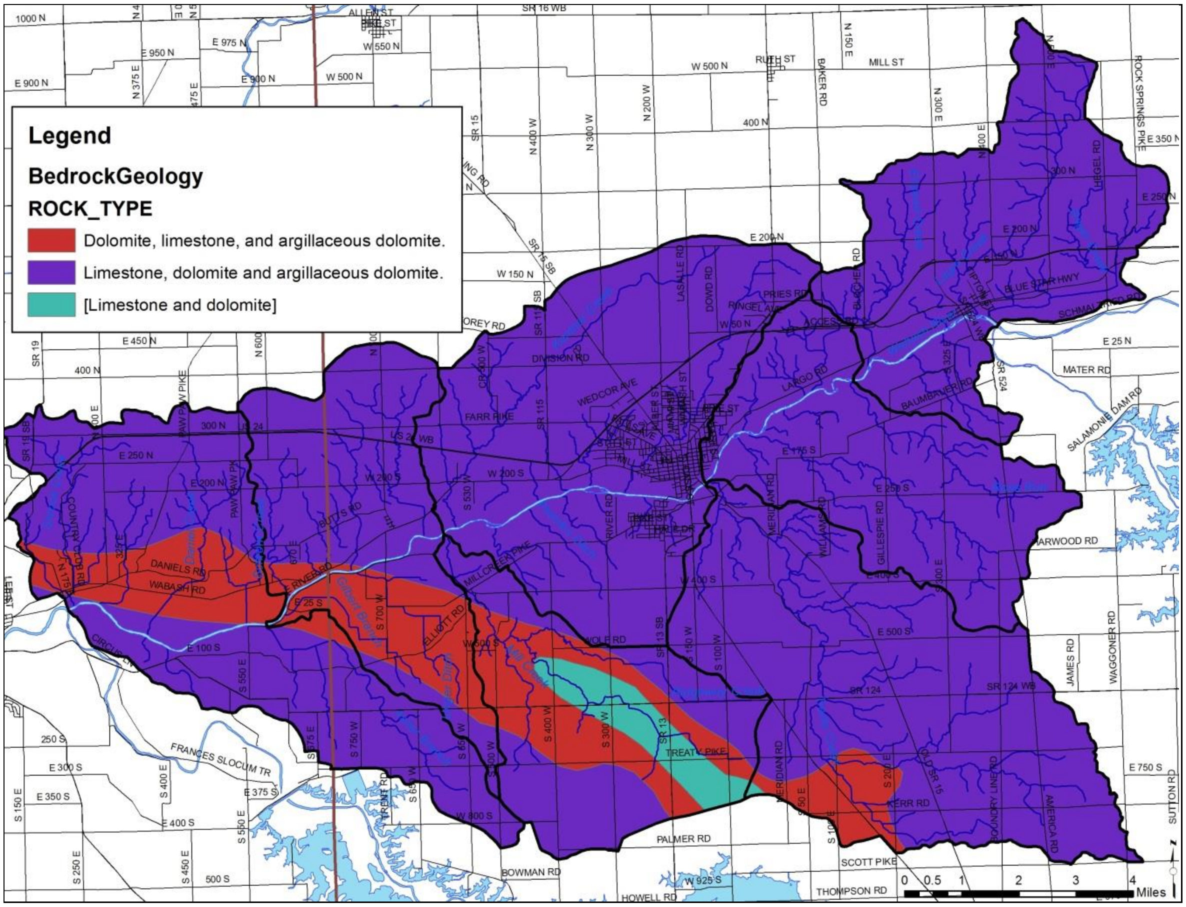


**Figure 3. Bedrock in the Treaty Creek-Wabash River Watershed.**

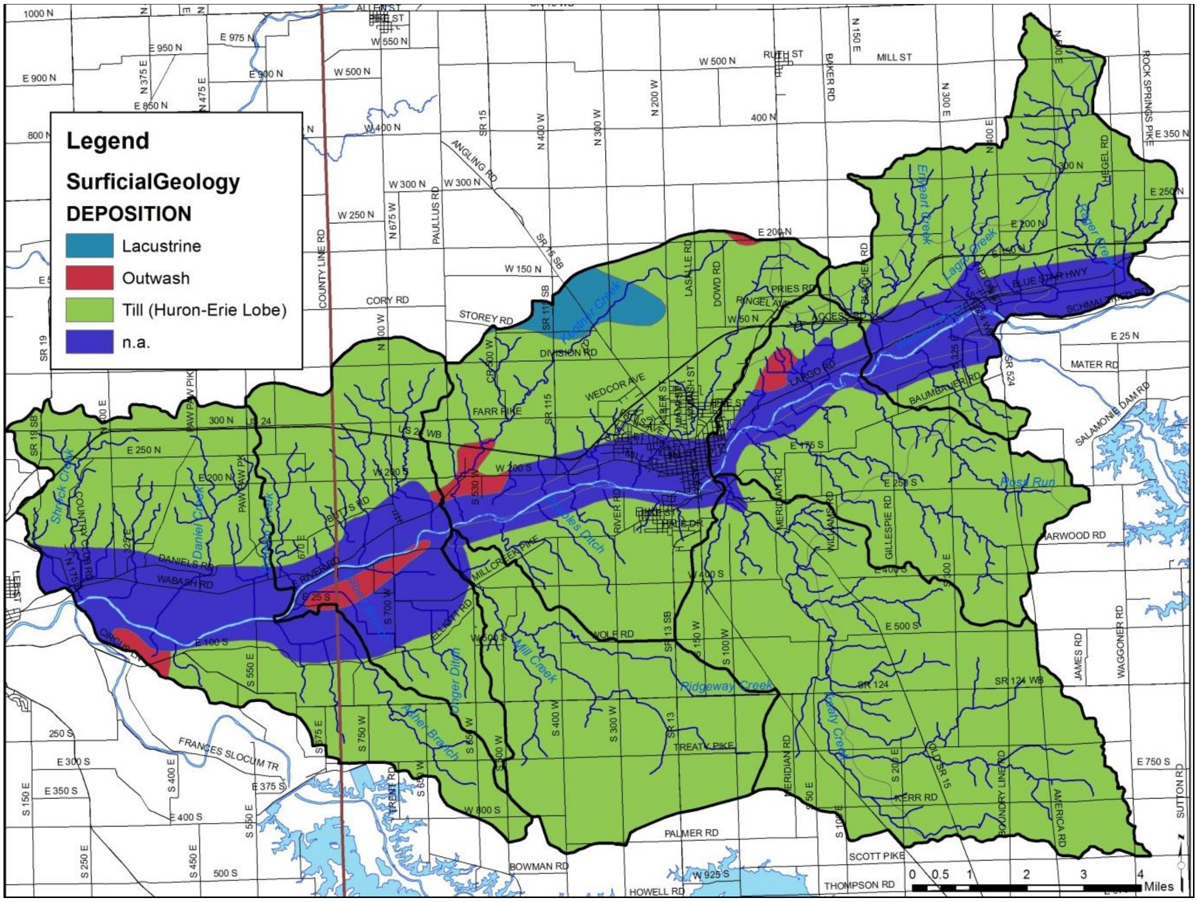


**Figure 4. Surficial geology throughout the Treaty Creek-Wabash River Watershed.**

The Treaty Creek-Wabash River Watershed has an average elevation of 760 feet mean sea level (msl; Figure 5). The watershed is relatively flat within the Wabash River floodplain; these flat areas extend one half to one full mile north and south of the Wabash River. The highest elevation of the watershed is nearly 890 feet above mean sea level (msl) occurring multiple times in the headwaters of Lagro and Treaty creeks. The lowest watershed elevation (640 ft msl) occurs at the Wabash River as it flows west out of the Treaty Creek-Wabash River Watershed. The steep limestone and dolomite bluffs occur north and south of the Wabash River throughout much of the river's length within the watershed.

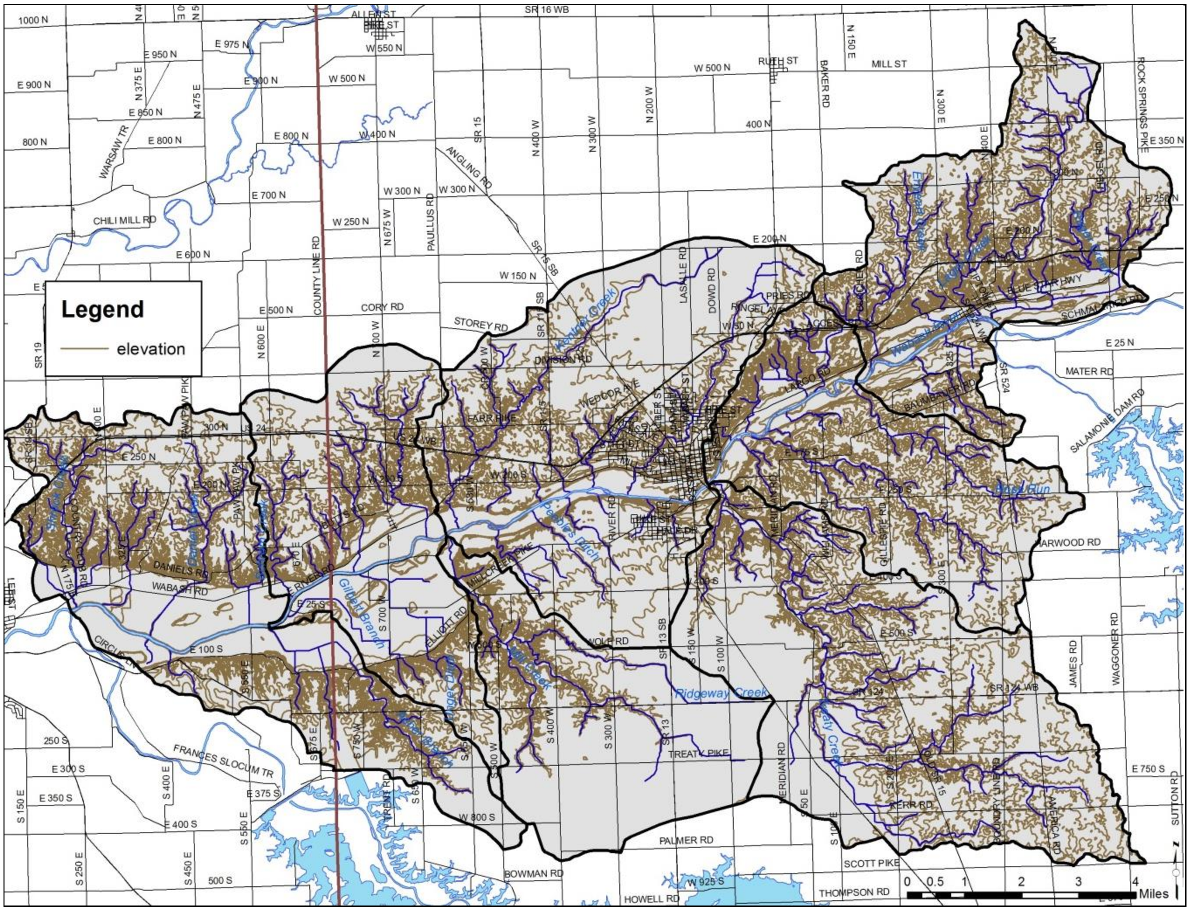


**Figure 5. Surface elevation in the Treaty Creek-Wabash River Watershed.**

## 2.5 Soil Characteristics

There are hundreds of different soil types located within the Treaty Creek-Wabash River Watershed. These soil types are delineated by their unique characteristics. The types are then arranged by relief, soil type, drainage pattern, and position within the landscape into soil associations. These associations provide overall characteristics across the watershed landscape. Soil associations are not used at the individual field level for decision making. Rather, the individual soil types are used for field-by-field management decisions. Some specific soil characteristics of interest, including septic limitations and soil erodibility, for watershed and water quality management are detailed below.

### 2.5.1 Soil Associations

The watershed is covered by 9 soil associations with three associations combining to cover more than two-thirds of the total watershed area. The Blount-Pewamo-Glynwood association is limited to the northern portion of the Lagro Creek drainage; the southern portion of the Treaty Creek, Burr Creek, and Ross Run drainages and the northern headwaters of the Miami County tributaries. These nearly level to moderately sloping, poorly drained soils are located on gently rolling topography where water ponds in depressions during wet periods. The Blount-Glynwood-Morley association covers a majority of the drainage east of the City of Wabash as well as the majority of Miami County tributaries north of the Wabash River, while the Fincastle-Brookston-Miamian association covers much of the Treaty Creek and Mill Creek drainages. These soils are located on mixed row crop agriculture, pasture land, and remnant forested areas. This association is comprised of moderately steep, moderately well drained to well drained soils that formed on clay loam glacial till. These areas are typically located on rolling topography with knobs, ridges, and ravines cutting across the land surface. The mainstem of the Wabash River, its floodplain, and the relatively wide, flat valley located north and south of the river are covered by Sawmill-Lawson-Genesee soils in the west and Millsdale-Newglarus-Randolph soils to the east. These nearly level, well drained soils formed in outwash and underlying sand and gravel are located on terraces and deep depressional areas like the old glacial river channel that surrounds the Wabash River.

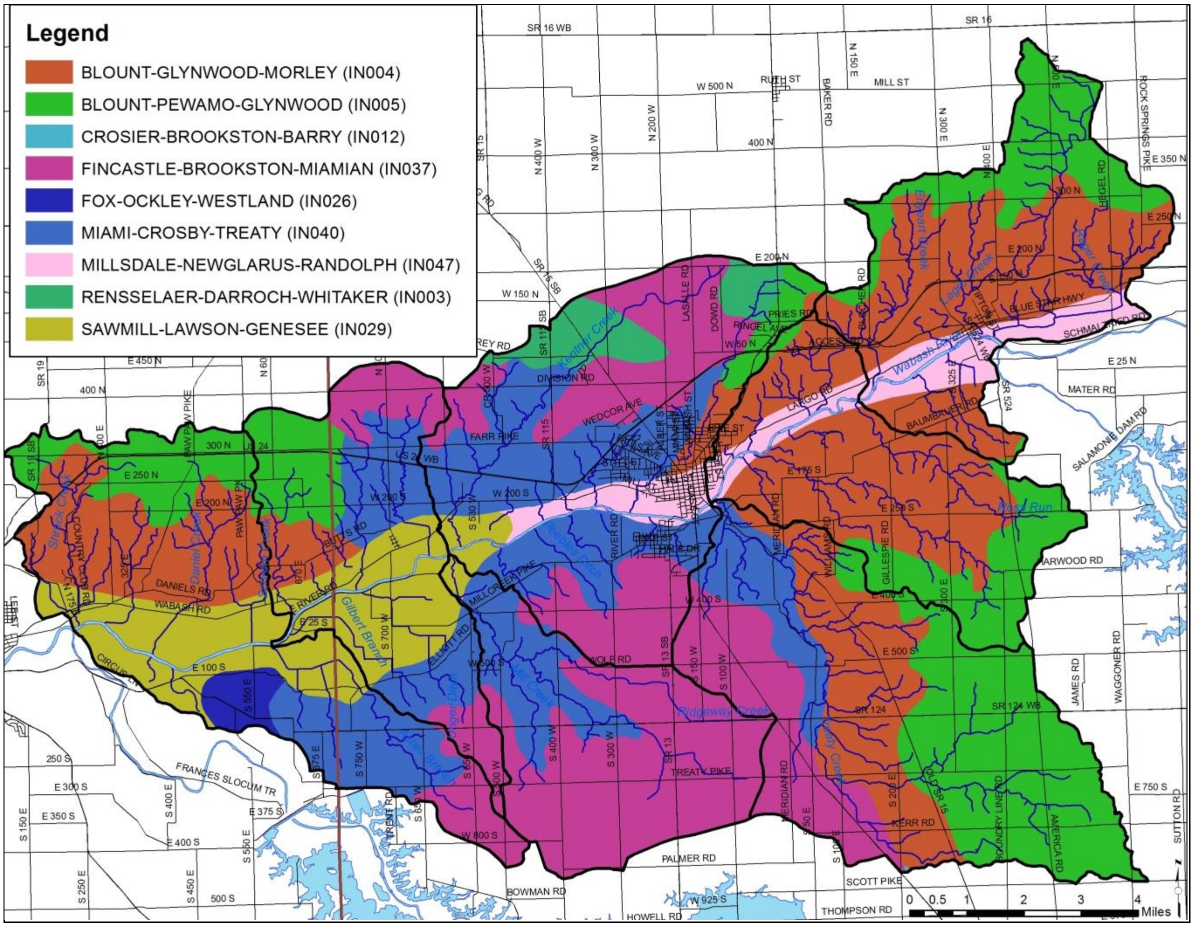


**Figure 6. Soil associations in the Treaty Creek-Wabash River Watershed.** Source: NRCS, 2018.

### 2.5.2 Soil Erodibility

Soils that move from the landscape to adjacent waterbodies result in degraded water quality, limited recreational use, and impaired aquatic habitat and health. Soils carry attached nutrients and pesticides, which can result in impaired water quality by increasing plant and algae growth or even killing aquatic life. The ability and/or likelihood for soils to move from the landscape to waterbodies are rated by the Natural Resources Conservation Service (NRCS). The NRCS uses soil texture and slope to classify soils into those that are considered highly erodible, potentially highly erodible, and not highly erodible. The classification is based on an erodibility index which is determined by dividing the potential average annual rate of erosion by the soil unit's soil loss T value or tolerance value. The T value is the maximum annual rate of erosion that can occur for a particular soil type without causing a decline in long-term productivity. Potentially highly erodible soil determinations are based on the slope steepness and length in addition to the erodibility index value.

Watershed stakeholders are concerned about soil erosion. As detailed above, soils which have high erodibility index values are those that are located on steep slopes and are easily moved by wind, water, or land uses. Figure 7 details locations of highly erodible and potentially highly erodible soils within the Treaty Creek-Wabash River watershed. Highly erodible soils cover 21% of the watershed or 21,532 acres, while potentially highly erodible soils cover an additional 15% of the watershed or approximately 14,639 acres. Highly erodible soils are found throughout the watershed but are concentrated on steep bluffs adjacent to the Wabash River and along tributaries east of the City of Wabash. Potentially highly erodible soils are located adjacent to highly erodible soils along the less steep areas of Treaty Creek-Wabash River drainages. The remaining 64% of watershed soils are not designated as highly or potentially highly erodible.

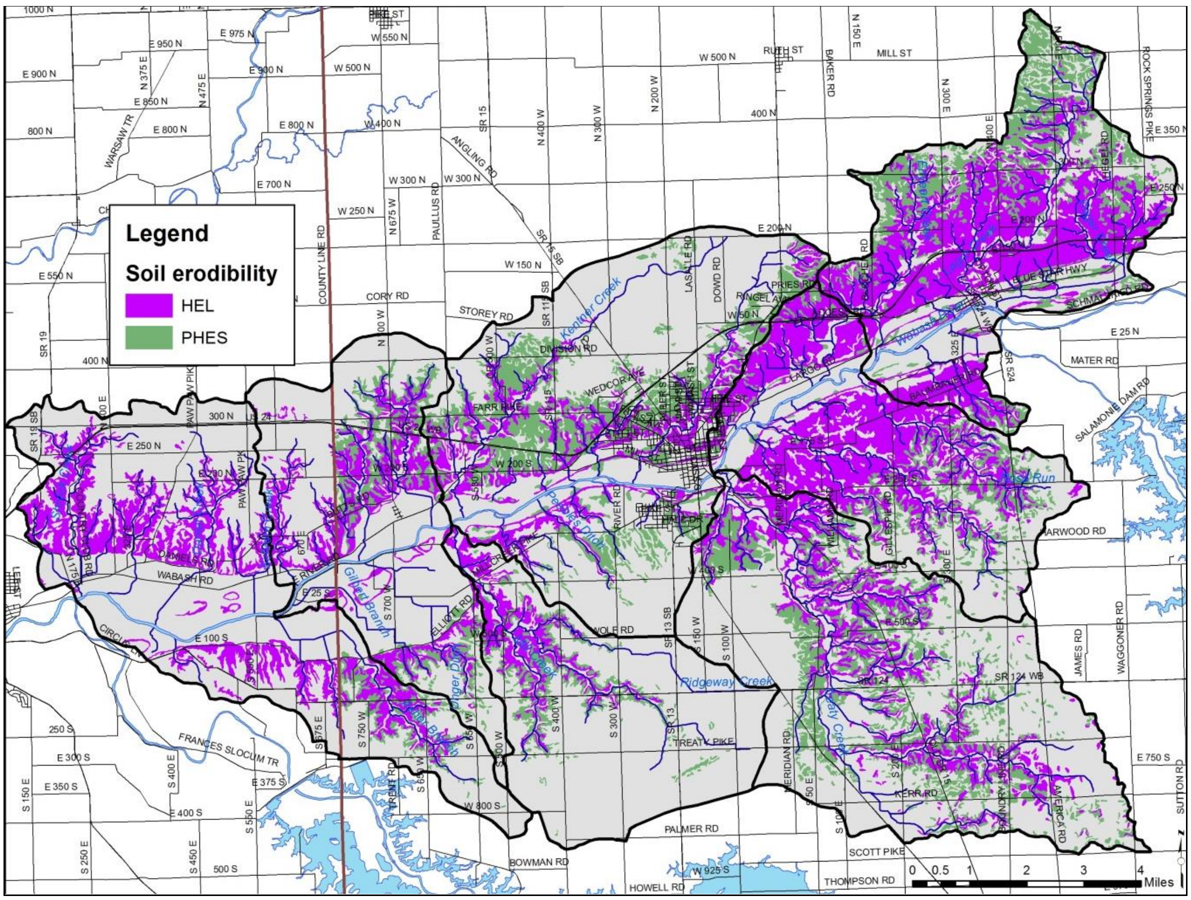


**Figure 7. Highly erodible (HES) and potentially highly erodible soils (PHES) in the Treaty Creek-Wabash River Watershed.** Source: NRCS, 2018.

### 2.5.3 Hydric Soils

Hydric soils are those which remain saturated for a sufficient period of time to generate a series of chemical, biological, and physical processes. The oxidation and reduction of iron in the soil, or "redox", causes color changes characteristic of prolonged fluctuations in the water table. After undergoing these processes, the soils maintain the resultant characteristics even after draining or use modification occurs. Watershed stakeholders are concerned about the conversion of wetlands into agricultural and urban land uses. Historically, approximately 19,619 acres (19%) of the watershed was covered by hydric soils (Figure 8). Hydric soils are found throughout the watershed, with the highest densities located on flat plains away from the watershed drainageways. As these soils are considered to have developed under wetland conditions, they are a good indicator of historic wetland locations and therefore will be revisited in the land use section.

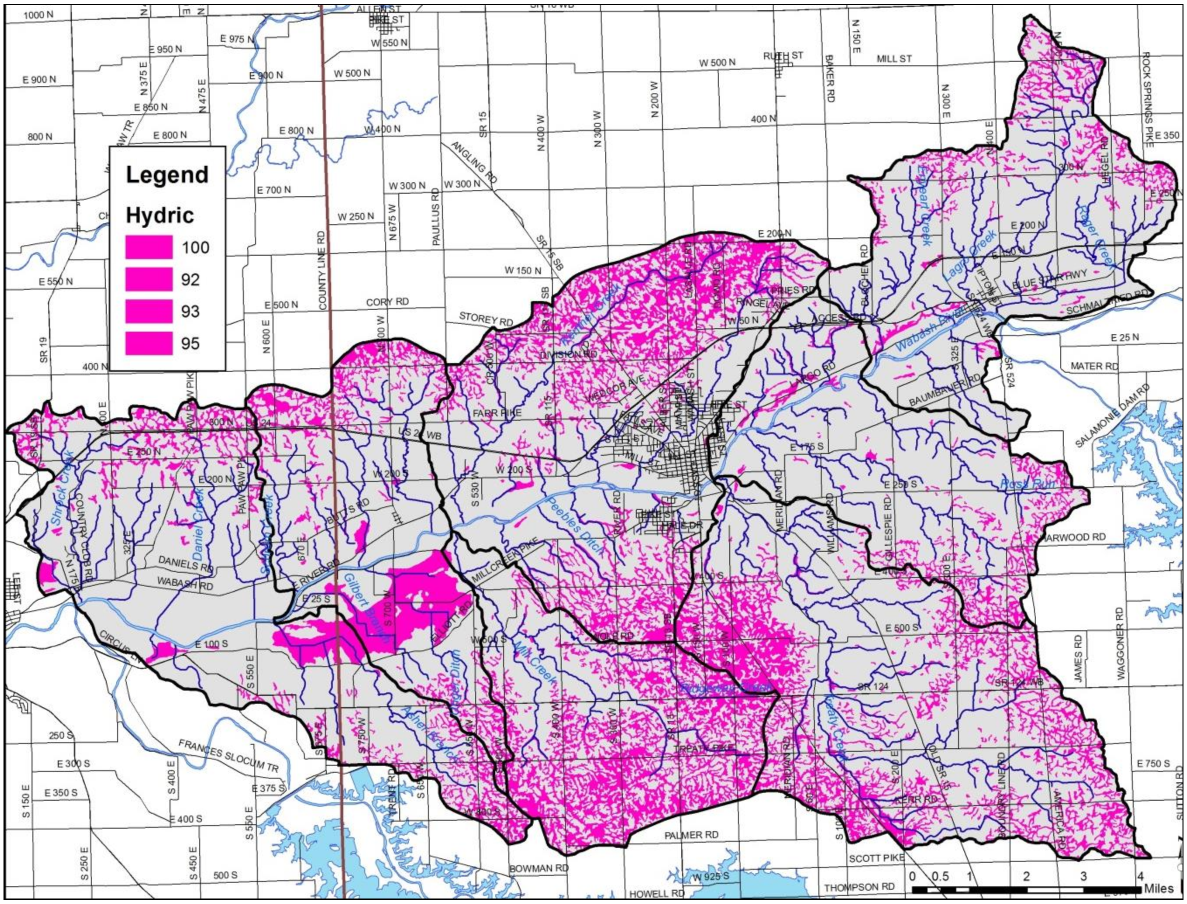


**Figure 8. Hydric soils in the Treaty Creek-Wabash River Watershed.** Source: NRCS, 2018.

### 2.5.4 Tile-Drained Soils

Soils drained by tile drains cover 64,288 acres or 64% of the Treaty Creek-Wabash River Watershed as estimated utilizing methods details in Sugg, 2007 (Figure 9). This method of drainage is widely used in row crop agricultural settings within the watershed, and anecdotal data indicate that tile drainages has become even more intensively used within the last ten years. This results in altered hydrology, allowing the water to drain from the landscape more quickly to improve conditions for farming, but also potentially exacerbating downstream flooding and incising streams which cuts them off from their natural floodplains. In these areas, materials such as nutrients applied to agricultural soils are directly transported downstream, bypassing natural features such as filter strips that might otherwise filter out or assimilate nutrients. Both counties represented in the Treaty Creek-Wabash River Watershed use extensive series of tile to drain their lands. As the demands of production on each acre of land increases more tile is put in, typically in a network or series as extensive as 30 to 50 foot spacing between tiles. Impacts to stream water quality can be reduced by the use of tile control structures and drainage water management. Most of these areas are relatively flat where drainage augmentation is required to move water from agricultural fields in order to produce row crops. In these areas, materials applied to agricultural soils are directly transported to downstream waterbodies.

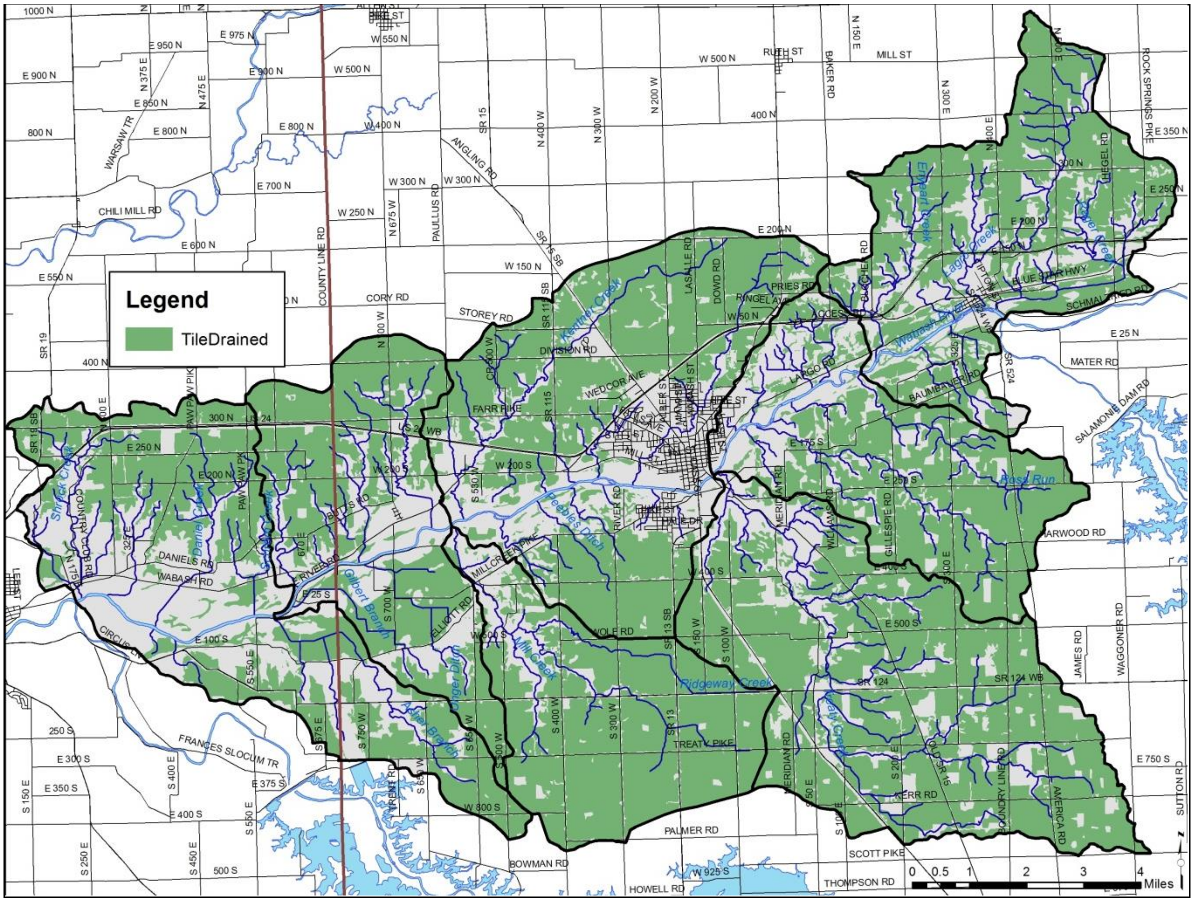


**Figure 9. Tile-drained soils in the Treaty Creek-Wabash River Watershed.** Source: NLCD, 2011 and NRCS, 2018.

## 2.6 Wastewater Treatment

### 2.6.1 Soil Septic Tank Suitability

Throughout Indiana, households depend upon septic tank absorption fields in order to treat wastewater. Seven soil characteristics, including position in the landscape, soil texture, slope, soil structure, soil consistency, depth to limiting layers, and depth to seasonal high water table, are utilized to determine suitability for on-site septic treatment. Septic tanks require soil characteristics that allow for gradual movement of wastewater from the surface into the groundwater. A variety of characteristics limit the ability for soils to adequately treat wastewater. High water tables, shallow soils, compact till, and coarse soils all limit soils abilities in their use as septic tank absorption fields. Specific system modifications are necessary to adequately address soil limitation; however, in some cases, soils are too poor for treatment and therefore prove inadequate for use in septic tank absorption fields.

Until 1990, residential homes located on 10 acres or more and occurring at least 1,000 feet from a neighboring residence were not required to comply with any septic system regulations. In 1990, a new septic code corrected this loophole. Current regulations address these issues and require that individual septic systems be examined for functionality. Additionally, newly constructed systems cannot be placed within the 100-year floodplain. Systems installed at existing homes must be placed above the 100-year flood elevation. However, many residences grandfathered into this code throughout the state have not upgraded or installed fully functioning systems (Krenz and Lee, 2005). In these cases, septic effluent discharges into field tiles or open ditches and waterways and will likely continue to do so due to the high cost of repairing or modernizing systems ($4,000 to $15,000; ISDH, 2001). Lee et al. (2005) estimates that 76,650 gallons of untreated wastewater per failing system is expelled in the state of Indiana annually. The true impact of these systems on the water quality in the Treaty Creek-Wabash River Watershed cannot be determined without a complete survey of systems.

The NRCS ranks each soil series in terms of its limitations for use as a septic tank absorption field. Each soil series is placed in one of three categories: severely limited, moderately limited, and slightly limited. Some soils are also unranked. Severe or very limited limitations delineate areas whose soil properties present serious restrictions to the successful operation of a septic tank tile disposal field. Using soils with a severe limitation increases the probability of the system's failure and increases the costs of installation and maintenance. Areas designated as having moderate or somewhat limited limitations have soil qualities which present some drawbacks to the successful operation of a septic system; correcting these restrictions will increase the system's installation and maintenance costs. Slight limitations delineate locations whose soil properties present no known complications to the successful operation of a septic tank tile disposal field. Use of soils that are rated moderately or severely limited generally require special design, planning, and/or maintenance to overcome limitations and ensure proper function.

Watershed stakeholders are concerned about the lack of maintenance associated with septic tanks, the use of soils that are not suited for septic treatment, and the presence of straight pipe systems within the watershed. These concerns are exacerbated by the fact that severely limited soils cover essentially the entire watershed (Figure 10). Nearly 97,939 acres or 97% of the watershed is covered by soils that are considered very limited for use in septic tank absorption fields. Nearly 1,253 (1.2%) acres are somewhat limited meaning that these soils are generally suitable for septic systems. The remaining 1,667 acres (1.7%) not rated for septic usage as it is not generally industry standard to install a septic system in these geographic locations.

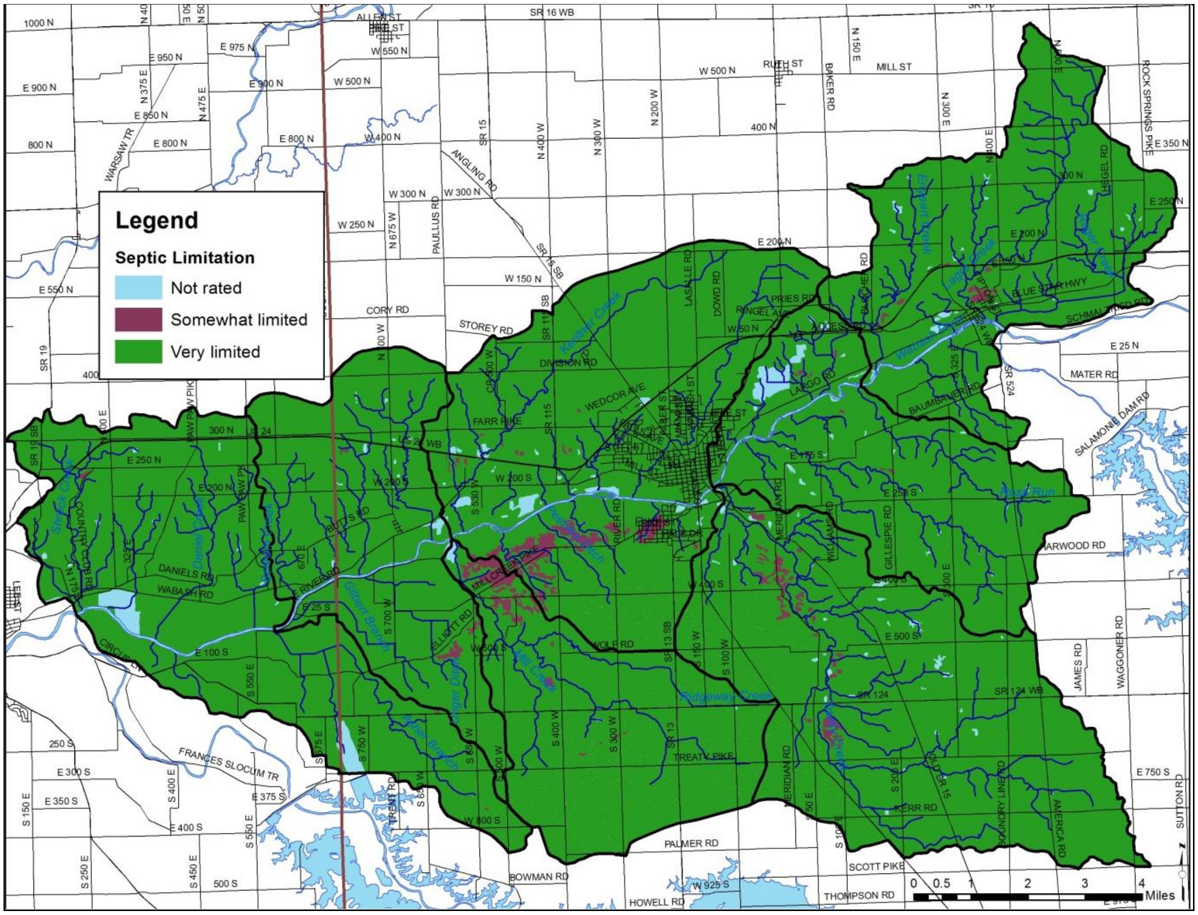


**Figure 10. Suitability of soils for septic tank usage in the Treaty Creek-Wabash River Watershed.** Source: NRCS, 2018.

### 2.6.2 Wastewater Treatment and Solids Disposal

Several facilities which treat wastewater and are permitted to discharge the treated effluent are located within the watershed. These facilities are regulated by National Pollution Discharge Elimination System (NPDES) permits. These include several wastewater treatment plants ranging in size from small, local plants to larger, publicly-owned facilities, and school facilities. In total, 8 NPDES-regulated facilities are located within the watershed (Figure 11). Table 4 details the NPDES facility name, activity, permit number, and designed flow in million gallons per day (MGD). More detailed information for each facility will be discussed on a subwatershed basis in subsequent sections.

**Table 4. NPDES-regulated facility information.**

| MapID | NPDES ID | Facility Name | Receiving Stream | Designed Flow (mgd) |
|---|---|---|---|---|
| 1 | IN0030635 | SOUTHWOOD ELEMENTARY SCHOOL | Treaty Creek | 0.011 |
| 2 | IN0039063 | WABASH ALLOYS, L.L.C. | Wabash River | 0.060 |
| 3 | IN0059510 | WABASH WATER TREATMENT/IAWC | Treaty Creek | 0.190 |
| 4 | IN0024741 | WABASH MUNICIPAL SEWAGE TR. PL | Wabash River | 4.000 |
| 5 | IN0045357 | LAKEVIEW TRAILER COURT & SUBDI | Kentner Creek | 0.010 |
| 6 | IN0054127 | LAKEVIEW MOBILE HOME WWTP | Kentner Creek | 0.012 |
| 7 | IN0003484 | CELOTEX CORP | Wabash River | 0.055 |
| 8 | IN0051861 | CARRIAGE HOUSE ESTATES MHP | Chamberlain Ditch | 0.006 |

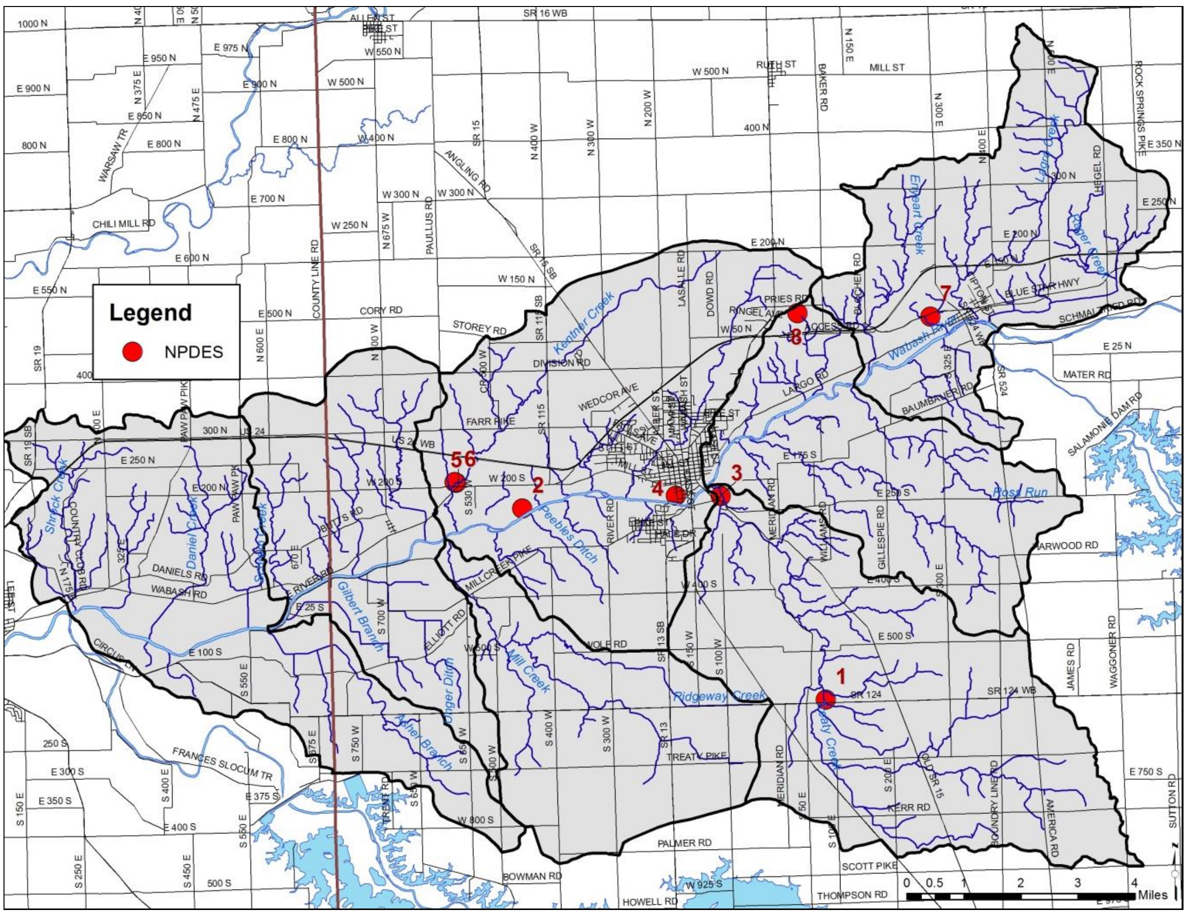


**Figure 11. NPDES-regulated facilities in the Treaty Creek-Wabash River Watershed.**

### 2.6.3 Municipal Wastewater Treatment and Combined Sewer Overflows

In the relatively rural Treaty Creek-Wabash River Watershed, there are two wastewater treatment facilities discharging to Kentner Creek, both are part of the Lakeview Mobile Home Park; one wastewater treatment plant discharging to Chamberlain Ditch from Carriage House Estates; one wastewater water facility discharging to the Wabash River from the City of Wabash; and the Southwood Elementary School wastewater facility and Indiana American Water, a drinking water facility, which discharges to Treaty Creek. Eight Combined Sewer Overflow (CSO) points are located within the City of Wabash discharging to Charley Creek and its tributary, Priser Ditch, or to the Wabash River (Figure 12). Sludge from municipal wastewater treatment plants is applied on 4,504 acres throughout the watershed. Much of this application occurs within the Stone Creek-Treaty Creek and Enyeart Creek Subwatersheds (Figure 12).

**City of Wabash WWTP**

The City of Wabash wastewater treatment plant treats effluent from the city's 8.65 square mile drainage servicing the cities 81 miles of sewer pipes (United Consulting, 2003). In 1960-1961, the City of Wabash constructed a 2.76 MGD activated sludge plant. In 1994, the wastewater plant was renovated and converted almost entirely to a sludge handling plant. Two submersible pumps with an 8 MGD capacity were installed to address combined sewer overflows. The current operation utilizes one screw pump, one submersible pump, and one submersible pump with across the line starting. As flows to the facility increase above the screw pump's capacity, the submersible VFD pump control is initiated which results in a greater than 10 MGD peak hourly rate. The system also includes a UV disinfection system which allows for nearly 100% kill of coliforms under normal, dry weather conditions. The system includes 8 CSOs, all of which are monitored by flow meters, which cover approximately 30% of the 81 sewer miles (Figure 12). The majority of the sewer system south of the Wabash River is more than 35 years in age and is generally in poor condition, which allows for stormwater and ground water infiltration. In 2002, the City of Wabash initiated a downspout disconnection program removing nearly 10,000,000 gallons of inflow annually from the sewer system.

### 2.6.4 Unsewered Areas

Three unsewered, dense housing areas covering 370 acres were identified within the watershed (Figure 12). Areas that have at least 25 houses within a square mile outside of the sanitary district boundaries were classified as unsewered, dense housing areas. These areas could be a source of nutrients and E. coli to adjacent streams.

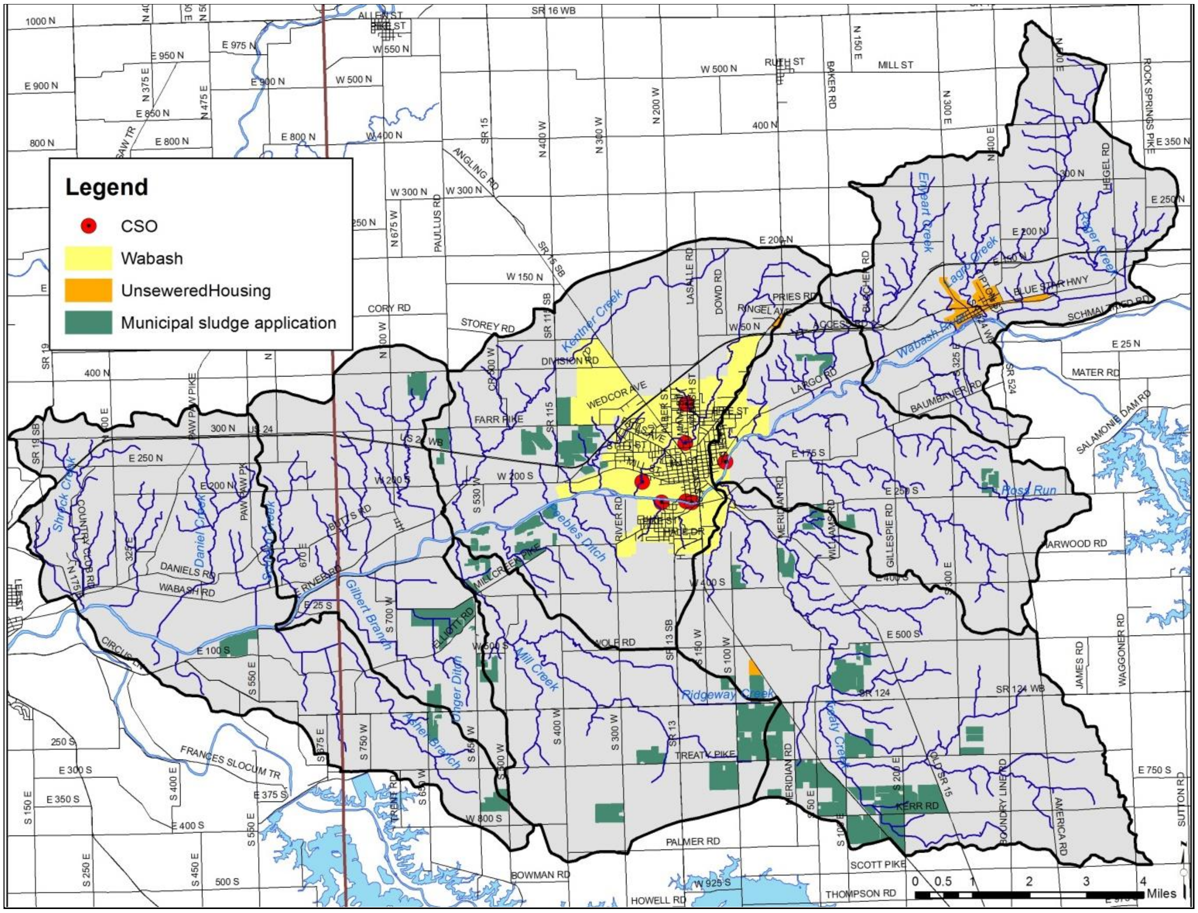


**Figure 12. Wastewater treatment plant service areas, municipal biosolids land application sites, dense unsewered housing, and combined sewer overflow outfalls within the Treaty Creek-Wabash River Watershed.** Sources: United Consulting, 2016; IDEM, 2018.

## 2.7 <u>Hydrology</u>

Watershed streams, reservoirs, legal drains, floodplains, wetlands, storm drains, groundwater, subsurface conveyances, and manmade drainage channels all contribute to the watershed's hydrology. Each component moves water into, out of, or through the system. Their contributions will be covered in further detail in subsequent sections.

### 2.7.1 Watershed Streams

The Treaty Creek-Wabash River Watershed contains approximately 297 miles of streams, regulated drains, and regulated tile drains. Of these, approximately 7.8 miles are regulated drains, including Koontz Drain, Peebles Ditch, Unger Ditch, and Stauffer Ditch. The majority of streams in the Treaty Creek-Wabash River Watershed are not regulated; however, drain status and locations should be confirmed on a case by case basis with the Wabash County Surveyor. It should be noted that regulated drains are maintained by the county surveyor's office and all of the regulated drains within the watershed have both a regular maintenance fund and a regular maintenance schedule. Maintenance practices can include dredging with large construction equipment to maintain flow, debris removal, and vegetation management both within the regulated drain and the riparian zone. As these waterbodies are subject to periodic cleaning, it is important to work with the county surveyor to establish priorities for these waterbodies in terms of water quality improvement and erosion control.

The major tributaries to the Wabash River within the Treaty Creek-Wabash River include Treaty Creek, Shrock Creek, Schrom Creek, Ross Run, Ridgeway Creek, Rager Creek, Mill Creek, Charley Creek, Lagro Creek, Kentner Creek, Helm Creek, Enyeart Creek, Gilbert Branch, Engleman Creek, Asher Branch, Daniel Branch, Burr Creek, and Daniel Creek (Figure 13). Treaty Creek and the Wabash River are used for recreational kayaking and canoeing, as well as fishing, swimming, and aesthetic enjoyment. Charley Creek and its waterfall are a common source of aesthetic enjoyment within the watershed. Stakeholders are concerned with maintaining the recreational value of the Wabash River and its tributaries and have some concerns because portions of the watershed have been designated as impaired by IDEM for *E. coli*, nutrients, and impaired biotic communities.

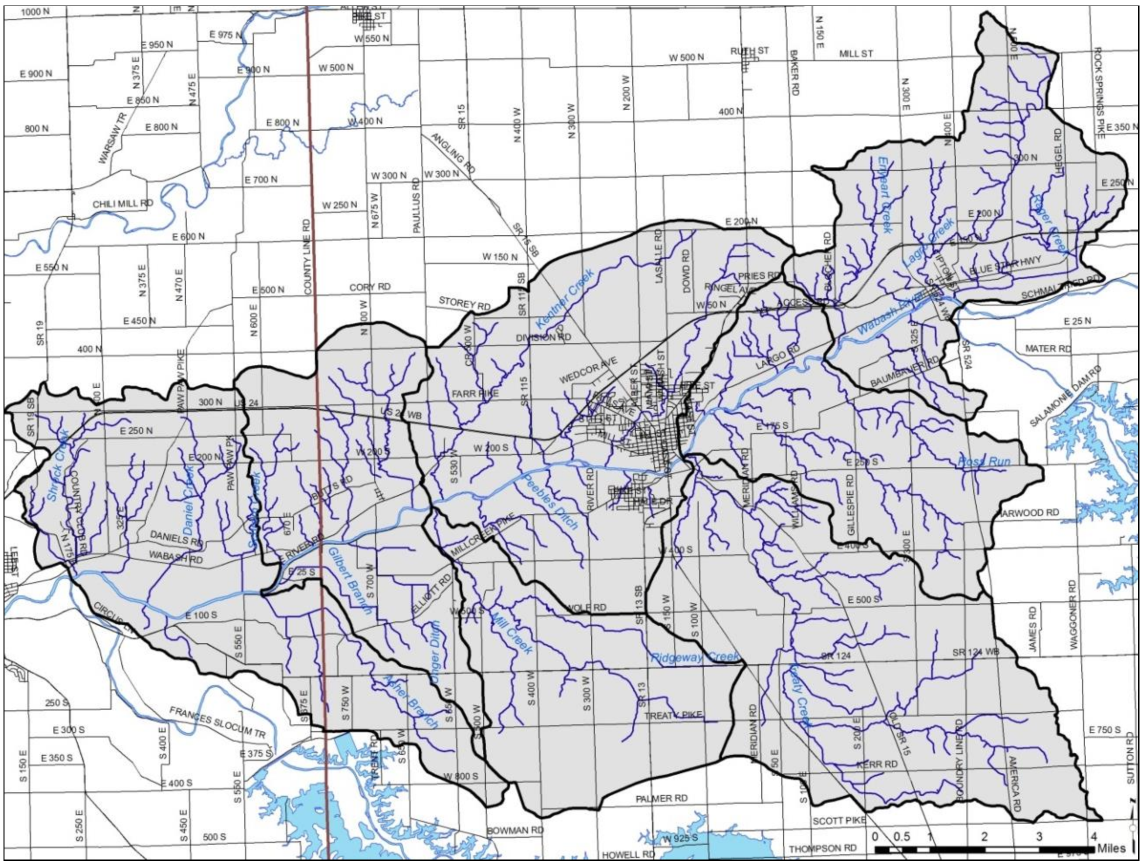

**Figure 13. Streams in the Treaty Creek-Wabash River Watershed.** Source: USGS, 2018.

### 2.7.2 Lakes, Ponds and Impoundments

More than 170 small lakes and farm ponds dot the Treaty Creek-Wabash River Watershed landscape covering a total of 270 acres. These provide local swimming holes, recreational boating options, and localized fishing as well as providing water storage and retention to assist with flooding. Many are located in tributary headwaters and offer some water retention; however, most are insignificant in size or water quality impact. Most recreational boating and fishing occur on the adjacent Salamonie or Mississinewa Reservoirs or on the Wabash River itself.

### 2.7.3 Impaired Waterbodies (303(d) List)

The impaired waterbodies, or 303(d), list is prepared biannually by the Indiana Department of Environmental Management. Waterbodies are included on the list if water quality assessments indicate that they do not meet their designated use. More information on the listing process is included in section 3.2.1. Seven stream segments within the Treaty Creek-Wabash River Watershed are included on the list of impaired waterbodies. Table 5 details the listings in the watershed, while Figure 14 maps the segments and their locations within the watershed. Waterbodies are listed as impaired for *E. coli* (19.2 miles), impaired biotic communities (13.1 miles), nutrients (19.2 miles), mercury and PCBs (19.2 miles). Based on the development of the Wabash River Nutrient and Pathogen TMDL Development (TetraTech, 2008), the *E. coli* and nutrient impaired segments are considered category 4 impaired waterbodies, or waterbodies for which a TMDL has been written, while impaired biotic community, and mercury and PCB impaired segments are considered category 5 impairments, or those for which a TMDL or other management plan has not yet been developed.

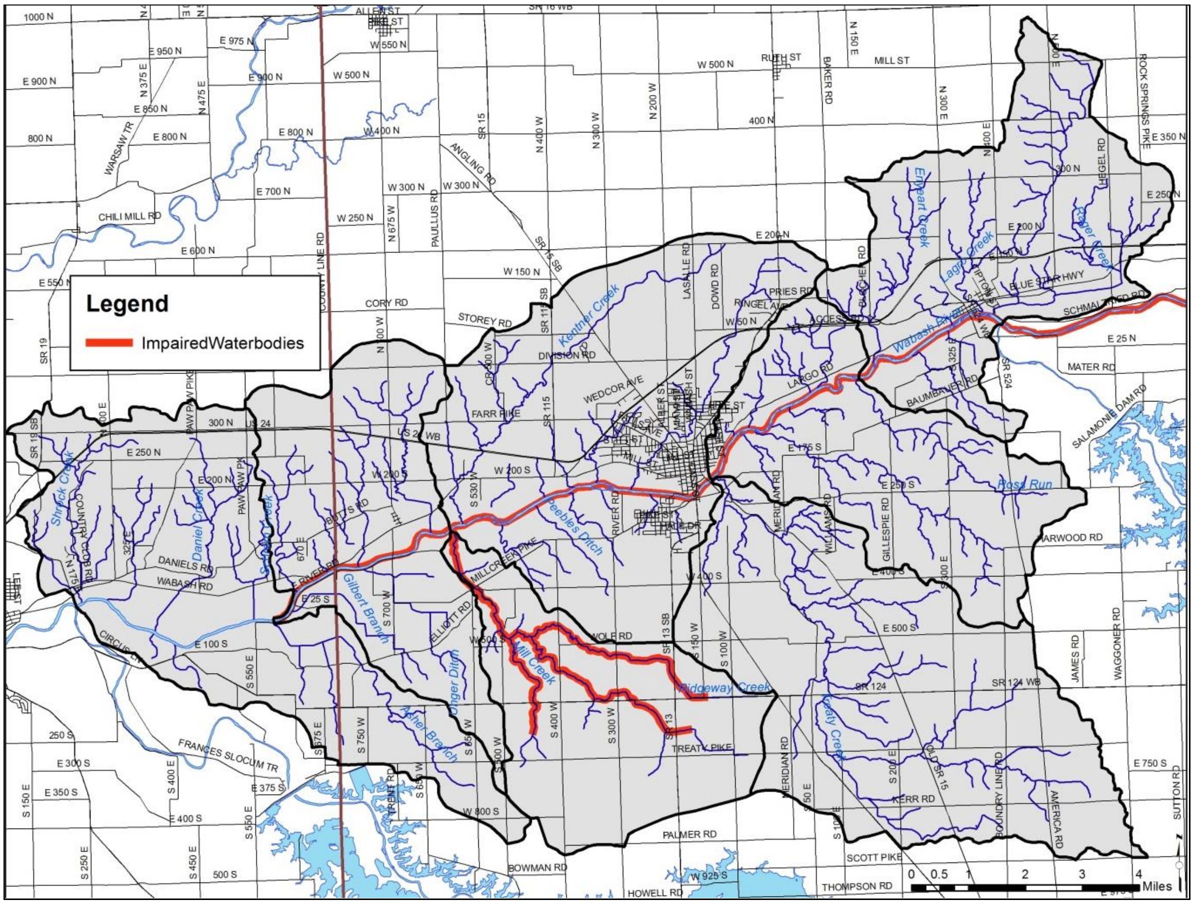


**Figure 14. Impaired waterbody locations in the Treaty Creek-Wabash River Watershed.**
Source: IDEM, 2013.

**Table 5. Impaired waterbodies in the Treaty Creek-Wabash River Watershed 2016 IDEM 303(d) list.**

| HUC | Waterbody | Assessment Unit | County | Impairment |
|---|---|---|---|---|
| 051201011401 | Wabash River | INB01E3_M1011 | Wabash | E.coli, nutrients, mercury, PCBs |
| 051201011401 | Wabash River | INB01F1_M1012 | Wabash | E.coli, nutrients, mercury, PCBs |
| 051201011403 | Wabash River | INB01F2_M1013 | Wabash | E.coli, nutrients, mercury, PCBs |
| 051201011405 | Wabash River | INB01F2_M1014 | Wabash | E.coli, nutrients, mercury, PCBs |
| 051201011406 | Wabash River | INB01F5_M1015 | Miami, Wabash | E.coli, nutrients, mercury, PCBs |
| 051201011406 | Wabash River | INB01F8_M1015 | Wabash | E.coli, nutrients, mercury, PCBs |
| 051201011404 | Mill Creek | INB01F7_00 | Wabash | Impaired biotic communities |

### 2.7.4 Floodplains

Flooding is a common hazard that can affect a local area or an entire river basin. Increased imperviousness, encroachment on the floodplain, deforestation, stream obstruction, tiling, or failure of a flood control structure all are mechanisms by which flooding occurs. Impacts of flooding include property and inventory damage, utility damage and service disruption, bridge or road impasses, streambank erosion, riparian vegetation loss, water quality degradation, and channel or riparian area modification.

Floodplains are lands adjacent to streams, rivers, and other waterbodies that provide temporary storage for water. These systems act as nurseries for wildlife, offer green space for humans and wildlife, improve water quality, and buffer the waterbody from adjacent land uses. Local stakeholders are concerned about impacts to floodplains from development, lack of landowner maintenance, and soil erosion and deposition within the floodplain.

Figure 15 details the locations of floodplains within the Treaty Creek-Wabash River Watershed. Extensive floodplains lie adjacent to the Wabash River with narrow floodplain areas adjacent to Mill Creek, Charley Creek, and Treaty Creek. Wabash River flooding, especially when the Salamonie Reservoir is releasing water into the river, has been noted as a historic issue and continues to be of concern to stakeholders. Approximately 7.6% (8,472 acres) of the Treaty Creek-Wabash River Watershed lies within the 100-year floodplain (Figure 15). This 100-year floodplain is composed of three regions:

- Zone A is the area inundated during a 100-year flood event for which no base flood elevations (BFE) have been established. Slightly more than half of the Treaty Creek-Wabash River Watershed floodplain is in Zone A or nearly 4,210 acres (3.8% of the watershed).
- Zone AE is the area inundated during a 100-year flood event for which BFEs have been determined. The chance of flooding in Zone AE is the same as the chance of flooding in Zone A; however, floodplain boundaries in Zone A are approximated, while those in Zone AE are based on detailed hydraulic models which allows Zone AE floodplains to be more accurate. Nearly half of the Treaty Creek-Wabash River Watershed floodplain is in Zone AE or 4,001 acres (3.6 % of the watershed).
- Zone X includes areas outside the 100-year and 500-year floodplains which have a 1% chance of flooding to a depth of one foot of water. No BFEs are available for these areas and no flood insurance is required. The remainder of the watershed is classified as Zone X. An additional 260 acres (0.2 %) of Treaty Creek-Wabash River Watershed floodplain lies in Zone X.

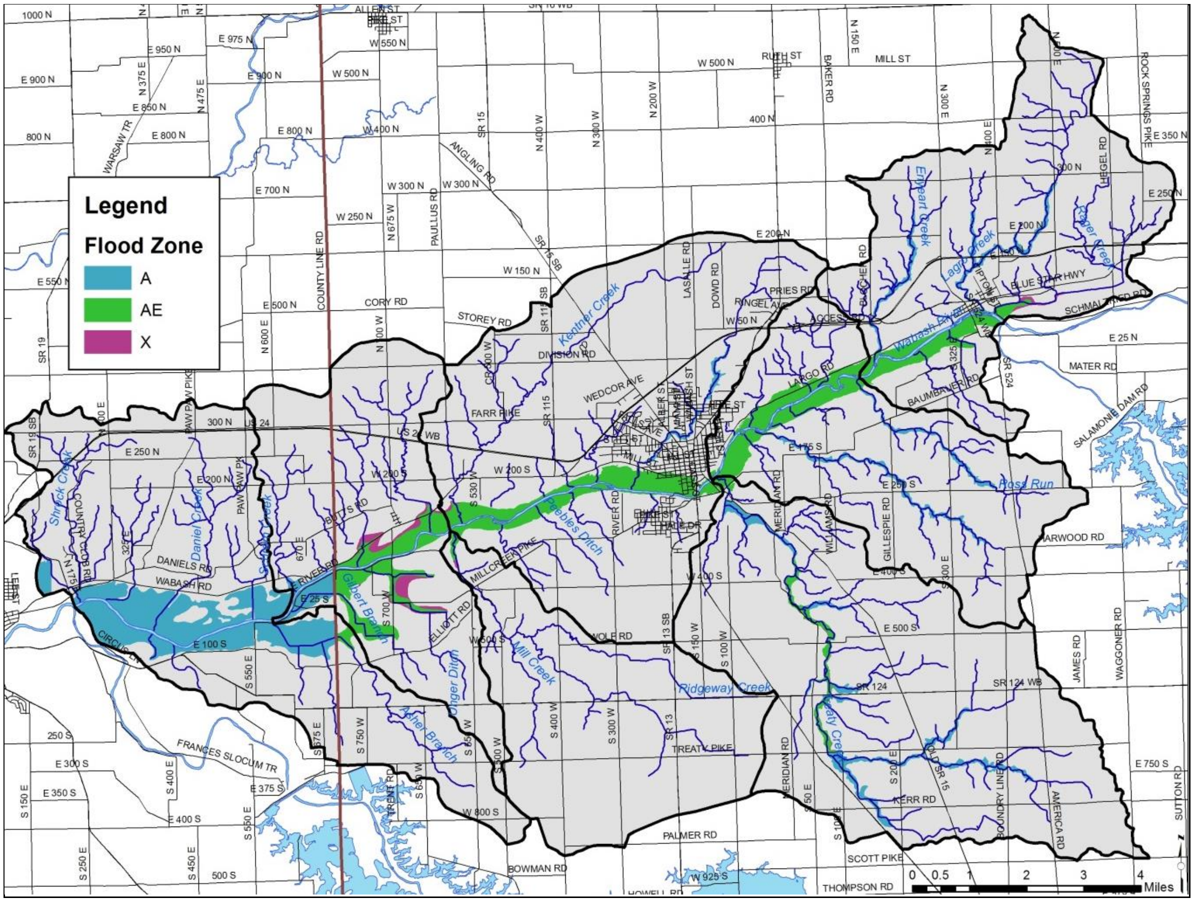


**Figure 15. Floodplain locations within the Treaty Creek-Wabash River Watershed.**

### 2.7.5 Wetlands

Approximately 25% of Indiana was covered by wetlands prior to European settlement (Clark, 1994). Overall, 85% of wetlands have been lost resulting in Indiana ranking fourth in the nation in terms of percentage of wetland loss. Wetlands provide numerous valuable functions that are necessary for the health of a watershed and waterbodies. Wetlands play critical roles in protecting water quality, moderating water quantity, and providing habitat. Wetland vegetation adjacent to waterways stabilizes shorelines and streambanks, prevents erosion, and limits sediment transport to waterbodies. Additionally, wetlands have the capacity to increase stormwater retention capacity, increase stormwater attenuation, and moderate low water levels or flow volumes by allowing groundwater to slowly seep back into waterbodies. These benefits help to reduce flooding and erosion. Wetlands also serve as high quality natural areas providing breeding grounds for a variety of wildlife. They are typically diverse ecosystems which can provide recreational opportunities such as fishing, hiking, boating, and bird watching. It should be noted that natural wetlands are regulated through the IDEM and the U.S. Army Corps of Engineers while USDA has jurisdiction over wetlands on agricultural fields. Any modification to wetlands requires permits from these agencies.

Wetlands cover 1,389 acres, or 1.3%, of the watershed. When hydric soil coverage is used as an estimate of historic wetland coverage, it becomes apparent that more than 85% of wetlands have been modified or lost over time. This represents 28.5 square miles of wetland loss within the Treaty Creek-Wabash River Watershed. As commodity prices continue to go up and down, area land values remain high and as a result individuals are spending a great deal of money to drain small natural wetlands in their fields in order to be able to farm that additional couple acres of land as it is cheaper to tile it than to buy ground already in production.

Figure 16 shows the current extent of wetlands within the Treaty Creek-Wabash River Watershed. Wetlands displayed in Figure 16 results from compilation efforts by the U.S. Fish and Wildlife Service as part of the National Wetland Inventory (NWI). The NWI was not intended to map specific wetland boundaries that would compare exactly with boundaries derived from ground surveys. As such, NWI boundaries are not exact and should be considered to be estimates of wetland coverage. Using this map will help us to identify which portions of the watershed would make ideal candidates for wetland restoration efforts which would reduce the amount of sediment and nutrients reaching the creek, as well as helping to restore the natural hydrology of the area which could help to reduce flooding impacts locally.

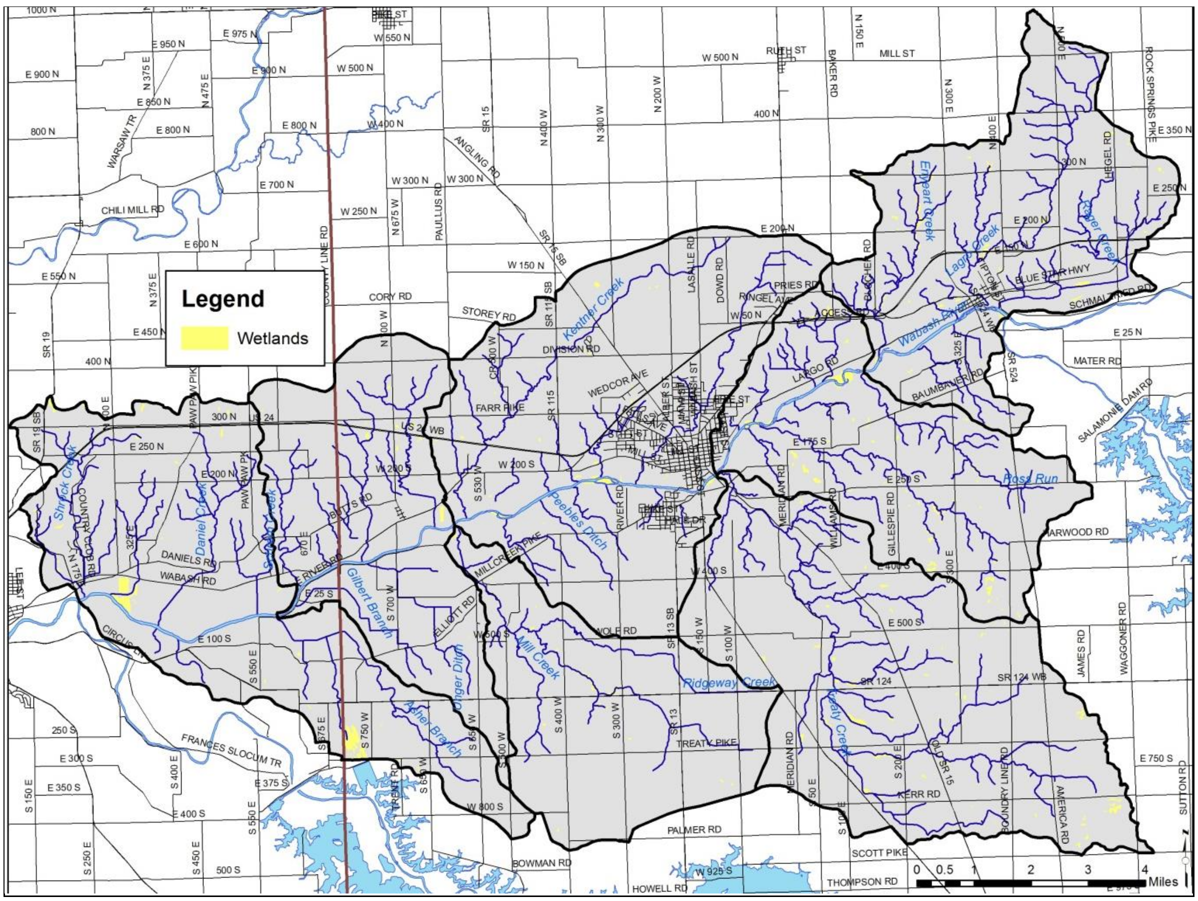


**Figure 16. Wetland locations within the Treaty Creek-Wabash River Watershed.** Source: USFWS, 2017.

### 2.7.6 Stormwater and Storm Drains

Under natural conditions, the majority of precipitation is allowed to infiltrate the soil and recharge groundwater resources. The volume of infiltration and groundwater recharge diminishes as development increases. To handle the large volume of precipitation falling in urban areas, stormwater systems have been constructed. Storm drain systems are present in most urban areas throughout the watershed. In total, more than 30 miles of storm drain pipe are present within the watershed. The City of Wabash works to mitigate stormwater impacts to the Treaty Creek-Wabash River watershed including Charley Creek and its tributaries, the most urban tributary in the watershed via its municipal separate storm sewer system (MS4) program (Figure 17).

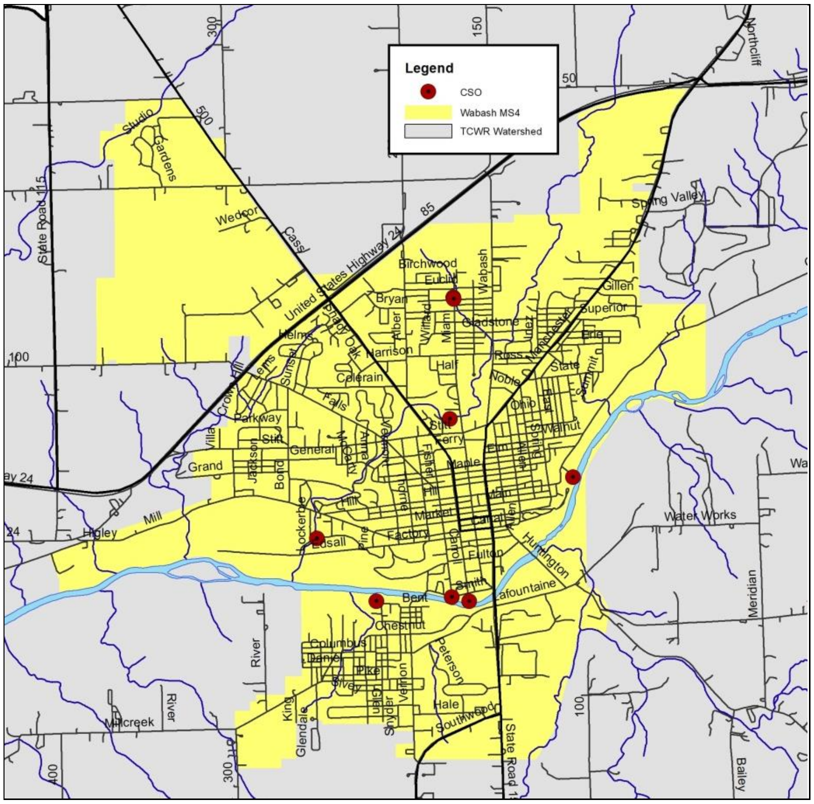


**Figure 17. City of Wabash MS4s boundary and CSO overflow locations.**

The City of Wabash has eight combined sewer overflows (CSOs) which discharge to three streams: an unnamed tributary to Charley Creek, locally known as Priser Ditch; Charley Creek; and the Wabash River (United Consulting, 2003). CSOs 007 and 008 discharge to Priser Dich, CSOs 005 and 006 discharge to Charley Creek, and CSOs 001, 002, 003, and 004 discharge directly to the Wabash River (Figure 17). The city's Stream Reach Characterization and Evaluation Report concluded that the CSO discharges negatively impact receiving streams. To address these impacts, the city enacted a best operation and maintenance plan including posting warning signs at all CSO outfalls, continued system inspection and maintenance, employee education, enacting a downspout disconnection program, and establishing a public education program including news releases.

### 2.7.7 Wellfields/Groundwater

In general, municipal water which supplies Lagro and Wabash, is taken from unconsolidated deposits of relatively clean, coarse-textured sand and gravel deposited in gravel outwash (Grove, 2007). In total, seven aquifers cover Wabash and Miami counties. Aquifer thickness varies from 50 to 125 feet in some areas and exceeds 400 feet near LaFontaine and trending northwest into Miami County along the Wabash River. The Till Veneer Aquifer System covers much of the Wabash River mainstem. This aquifer encompasses areas of unconsolidated material which is predominantly thin glacial till or alluvium overlying eroded bedrock (Grove, 2007). Much of the Treaty Creek-Wabash River Watershed is drained by the Bluffton Till and Bluffton Complex aquifer systems. These aquifers generally contain deposits of varying material and thickness but typically measure greater than 50 feet in thickness. Intratill sand and gravel lenses are overlain by thick deposits or separated from the surface by thick till layers within these aquifer systems (Grove, 2007).

Table 6 lists wellhead protection areas within and adjacent to the Treaty Creek-Wabash River Watershed. The wellhead protection areas and wellhead protection plans associated with each area will be discussed in additional detail in subsequent sections. Potential pollution from construction, sewage outfalls or overflows, illegal dumping, agriculture, and storm water runoff must be avoided or controlled due to the recharge of these aquifers from runoff and river water. The sensitivity to surface contamination is shown in Figure 18. While areas of aquifer within Wabash County north and south of Wabash and along the western Wabash County/eastern Miami County border are highly sensitive to contamination, much of the Treaty Creek-Wabash River Watershed possess low to moderate sensitivity to surface contamination. To determine if you are located within a wellhead protection area visit https://www.in.gov/idem/cleanwater/pages/wellhead/.

**Table 6. Wellhead protection areas in and adjacent to the Treaty Creek-Wabash River Watershed.**

| County | PWSID | System name | Population |
|---|---|---|---|
| Wabash | 5285003 | Indiana American Water - Wabash | 11,015 |
| Wabash | 5285005 | Lagro Municipal Water Department | 454 |
| Wabash | 5285006 | Lake View Mobile Home Park | 50 |
| Wabash | 5285011 | Rhoades Wheel In Mobile Home Park | 60 |
| Wabash | 5285019 | Carriage House Estates | 25 |

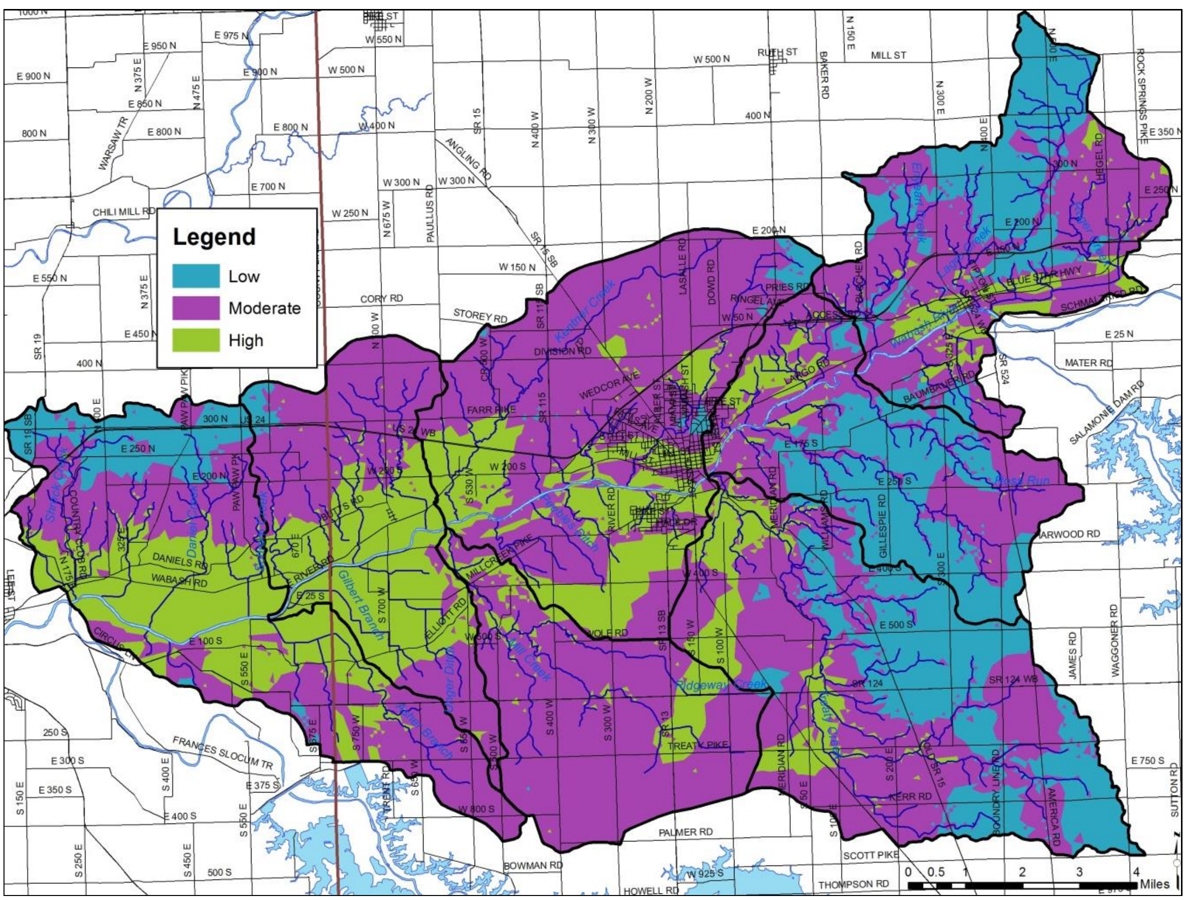

**Figure 18. Aquifer sensitivity within the Treaty Creek-Wabash River Watershed.** Source: IGS, 2015.

## 2.8 Natural History

Geology, climate, geographic location, and soils all factor into shaping the native flora and fauna which occurs in a particular area. Categorization of these floral and faunal communities has been completed by a number of ecologists since the earliest efforts by Coulter in 1886. Since this time, Petty and Jackson (1966) identified regional communities; Homoya et al. (1985) classified Indiana into natural regions, while Omernik and Gallant (1988) categorized Indiana into ecoregions. Homoya et al. (1985) note that prior to European settlement, much of Miami and Wabash counties were covered by a mix of wetland land uses, including bog, fen, marsh, sedge meadow, swamp, seep, and spring, as well as a mix of lakes and deciduous forest. Upland areas were likely covered by red, white, and black oak; maple, and shagbark and pignut hickory. More wet areas were covered by beech, sugar maple, black maple, and tulip poplar. Historically, wet habitat mixed with upland habitat throughout the watershed.

### 2.8.1 Natural and Ecoregion Descriptions

According to Homoya et al.'s (1985) classification of natural regions in Indiana, the Treaty Creek-Wabash River Watershed lies in Homoya's Central Till Plain Natural Region. The Treaty Creek-Wabash River Watershed also lies in the Clayey High Lime Till Plains within the Eastern Corn Belt Plains Ecoregion as defined by Omernik and Gallant (1988). Petty and Jackson (1966) indicate that the Treaty Creek-Wabash River Watershed is within the Beech-Maple Association.

### 2.8.2 Wildlife Populations and Pets

Individuals are concerned about local wildlife and pet populations, the impact that these have on pathogen levels, and the impact that changing land uses could have on these populations. These will be quantified in subsequent sections. With these concerns in mind, wildlife density can be estimated from a variety of sources. The Indiana Department of Natural Resources (IDNR) is tasked with managing wildlife populations throughout the state. In order to complete this task, the IDNR must have an idea of the population density within specific areas, counties, or regions. The most recent survey of wildlife populations for which data are publicly available occurred in 2005. Those densities are shown in Table 7 with deer, squirrels and turkey being the most common wildlife present within the region. It should be noted that these numbers could both underestimate and overestimate populations within the watershed. Densities are recorded based on animal observations per 1000 hours of overall observation. If observations areas are not equally spread throughout the region, over or underestimates of the populations could occur. Likewise, animals are not likely equally distributed throughout the region; therefore, the regional density may again over or underestimate the true density of the animal in question. Nonetheless, these estimates provide the best guess at wildlife densities.

**Table 7. Surrogate estimates of wildlife density in the IDNR northeast region, which includes the Treaty Creek-Wabash River Watershed.**

| Animal | 2005 Population Observation (per 1000 hrs of observation) |
|---|---|
| Beaver | 0.7 |
| Bobcat | 1.6 |
| Bobwhite | 8.1 |
| Coyote | 19.6 |
| Deer | 1112.5 |
| Fox squirrel | 640.3 |
| Gray fox | 2.0 |
| Gray squirrel | 89.1 |
| Grouse | 7.2 |
| Domestic cat | 26.8 |
| Muskrat | 6.3 |
| Opossum | 16.4 |
| Rabbit | 33.1 |
| Raccoon | 72.8 |
| Red fox | 1.7 |
| Skunk | 5.1 |
| Turkey | 15.4 |

Source: Plowman, 2006.

Pet populations can affect pathogen levels similar to the impacts provided by wildlife. While a count of pets for the Treaty Creek-Wabash River Watershed was not completed, dog and cat populations were estimated for the Watershed using statistics reported in the 2012 U.S. Pet Ownership & Demographics Sourcebook. Specifically, the Sourcebook reports that on average 37.4 percent of households own dogs and 32.9 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of E. coli in population centers. The estimated number of domestic pets in cities and towns in the Treaty Creek-Wabash River Watershed is based on the average number of pets per household multiplied by the population of the watershed resulting in a suggested population of 9,823 cats and 7,590 dogs.

### 2.8.3 Endangered Species

The Indiana Natural Heritage Data Center, part of the Indiana Department of Natural Resources, Division of Nature Preserves, maintains a database documenting the presence of endangered, threatened, or rare species; high quality natural communities; and natural areas in Indiana. The database originated as a tool to document the presence of special species and significant natural areas and to assist with management of said species and areas where high quality ecosystems are present. The database is populated using individual observations which serve as historical documentation or as sightings occur; no systematic surveys occur to maintain the database.

The state of Indiana uses the following definitions to list species:

- *Endangered*: Any species whose prospects for survival or recruitment with the state are in immediate jeopardy and are in danger of disappearing from the state. This includes all species classified as endangered by the federal government which occur in Indiana. Plants currently known to occur on five or fewer sites in the state are considered endangered.

- *Threatened*: Any species likely to become endangered within the foreseeable future. This includes all species classified as threatened by the federal government which occur in Indiana. Plants currently known to occur on six to ten sites in the state are considered threatened.
- *Rare*: Plants and insects currently known to occur on eleven to twenty sites.

In total, 47 observations of listed species and/or high quality natural communities occurred within the Treaty Creek-Wabash River Watershed (Figure 19; Clark, personal communication). These observations include one amphibian, five bird species, two mammals, nine mollusks, four plants, and four community types or geologic features. Many of these species were historically located adjacent to the Wabash River or a tributary or within their riparian habitats. State endangered species include mollusk species: round hickory nut (1989, 2008, 2009), eastern fanshell pearlymussel (1988), snuffbox (1988, 2008, 2009), rayed bean (1988, 2009); the greater redhorse (1989), redside dace (2008, 2010), and the cerulean warbler (1994). State threatened species include the prairie-rocket wallflower, while state rare species include the false hop sedge and Michaux's stitchwort. Species of special concern include the bald eagle, American badger, hooded warbler, broad-winged hawk, least weasel, Ohio pigtoe, kidneyshell, wavyrayed lampmussel, and four-toed salamander. High quality natural communities include the waterfall and cascade, central till plain mesic upland forest, central till plain dry-mesic upland forest, and limestone cliff and are located on high quality natural areas including the Asherwood Nature Preserve, Frances Slocum State Recreation Area, Hathaway Preserve at Ross Run Nature Preserve and Salamonie River State Forest. Appendix B includes the database results for the Treaty Creek-Wabash River Watershed, as well as county-wide listings for Miami and Wabash Counties.

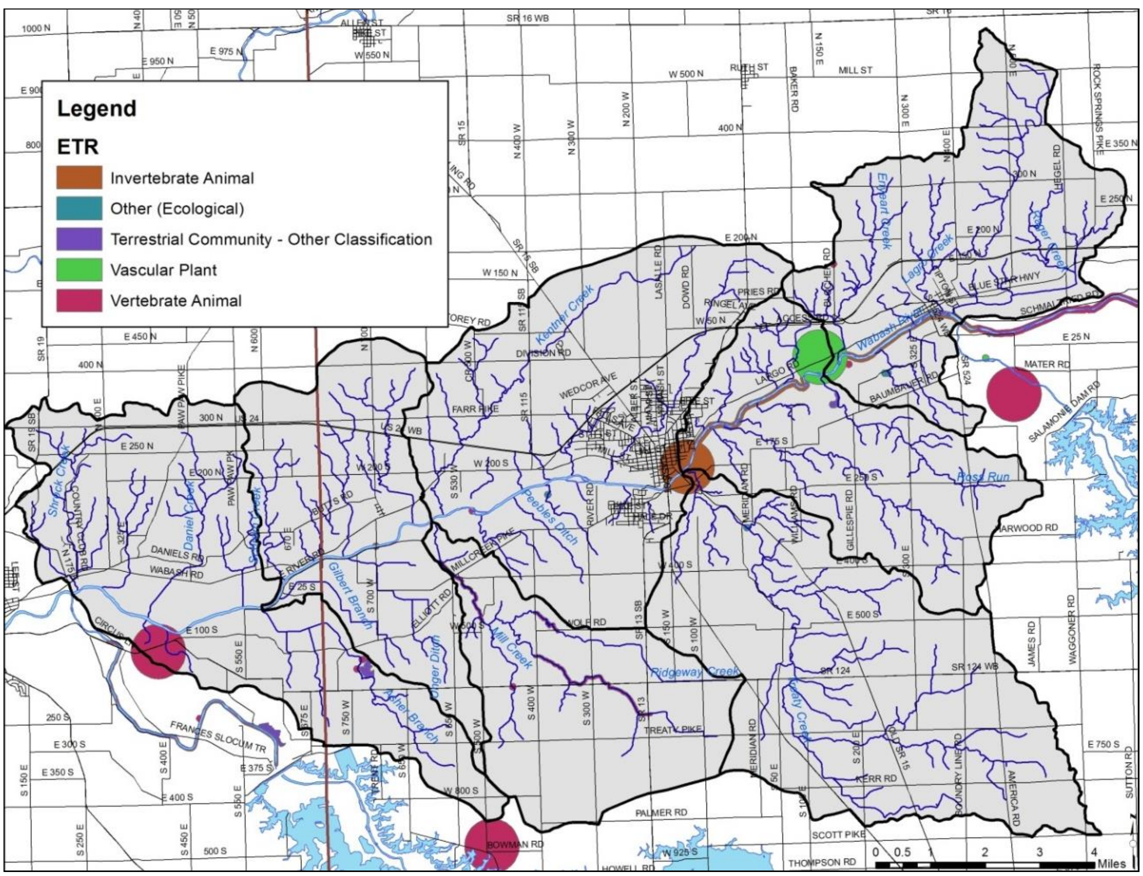


**Figure 19. Locations of special species and high quality natural areas observed in the Treaty Creek-Wabash River watershed.** Source: Clark, 2018.

### 2.8.4 Recreational Resources and Significant Natural Areas

A variety of recreational opportunities and natural areas exist within the Treaty Creek-Wabash Watershed. Recreational opportunities include parks, fish and wildlife areas, nature preserves, fairgrounds, golf courses, and school grounds (Figure 20). Portions of the Salamonie State Forest and Mississinewa Dam properties are located within the watershed. Additionally, Acres Land Trust owns and manages Ross Run and the Hanging Rock and Wabash Reef National Monument, a portion of which is located in the watershed, while City of Marion Schools manages Asherwood Nature Preserve. The City of Wabash maintains the Paradise Spring Historical Park and Riverwalk, Hanna Park, Erie Community Center, Charley Creek Park, and Broadmore Park, while the Town of Lagro manages the Lagro Park and Community Building. The Wabash River is also a popular stream with canoe and kayak enthusiasts at certain times of the year. Additional recreational opportunities exist at various schools, golf complexes and sporting clay facilities.

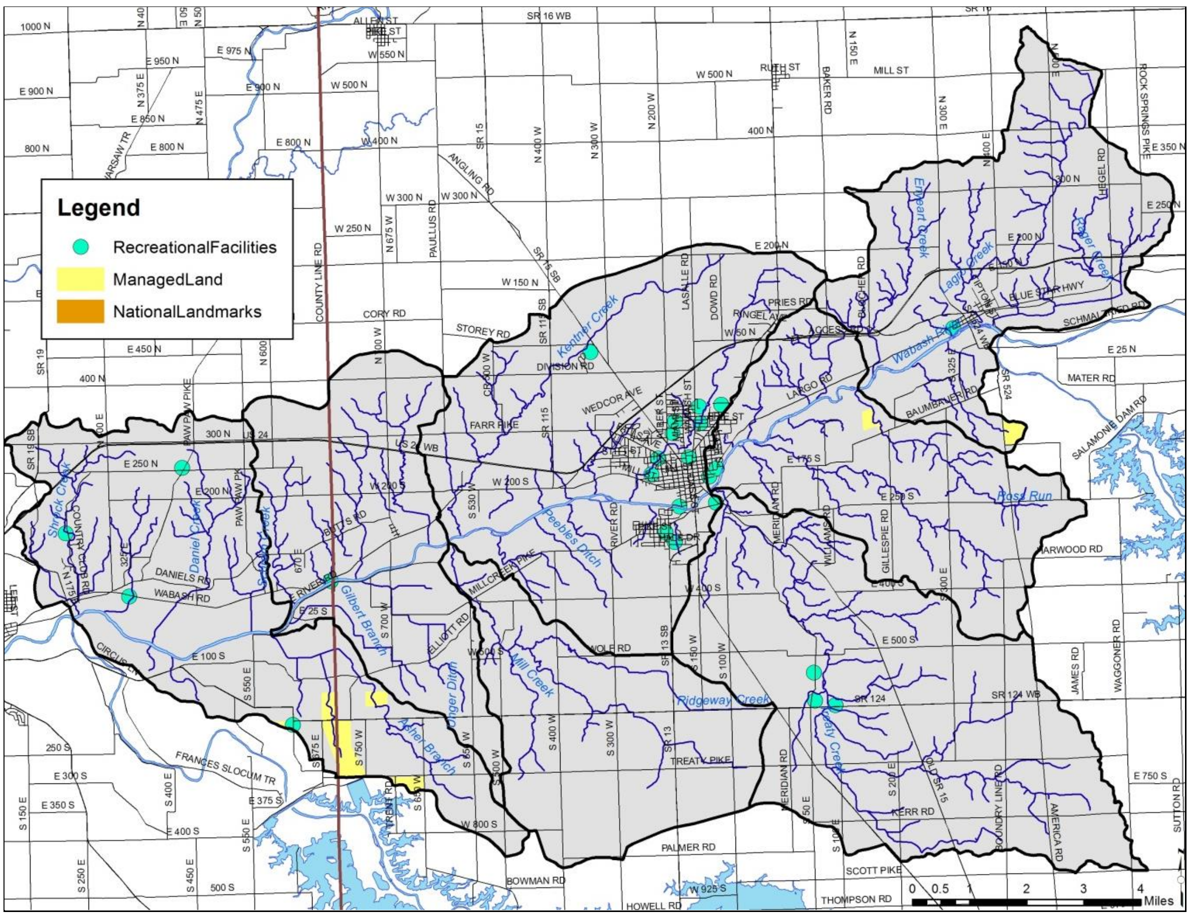


**Figure 20. Recreational opportunities and natural areas in the Treaty Creek-Wabash River Watershed.**

## 2.9 Land Use

Water quality is greatly influenced by land use both past and present. Different land uses contribute different contaminants to surface waters. As water flows across agricultural lands it can pick up pesticides, fertilizers, nutrients, sediment, pathogens, and manure, to name a few. However, when water flows across parking lots or from roof tops it not only picks up motor oil, grease, transmission fluid, sediment, and nutrients, but it reaches a waterbody faster than water flowing over natural or agricultural land. Hard or impervious surfaces present in parking lots or on rooftops create a barrier between surface and groundwater. This barrier limits the infiltration of surface water into the groundwater system resulting in increased rates of transport from the point of impact on the land to the nearest waterbody.

### 2.9.1 Current Land Use

Today, the Treaty Creek-Wabash River Watershed is dominated by row crop agriculture (71%) with an additional 2.5% of the watershed covered by pasture or hay (Table 8, Figure 21). Nearly 9% of the watershed is covered by developed open space or is in low, medium, or high intensity developed areas. Grassland, deciduous and evergreen forest, open water, and wetlands cover the remaining 17.5% of the watershed. Definitions for each land cover type are included in Appendix C.

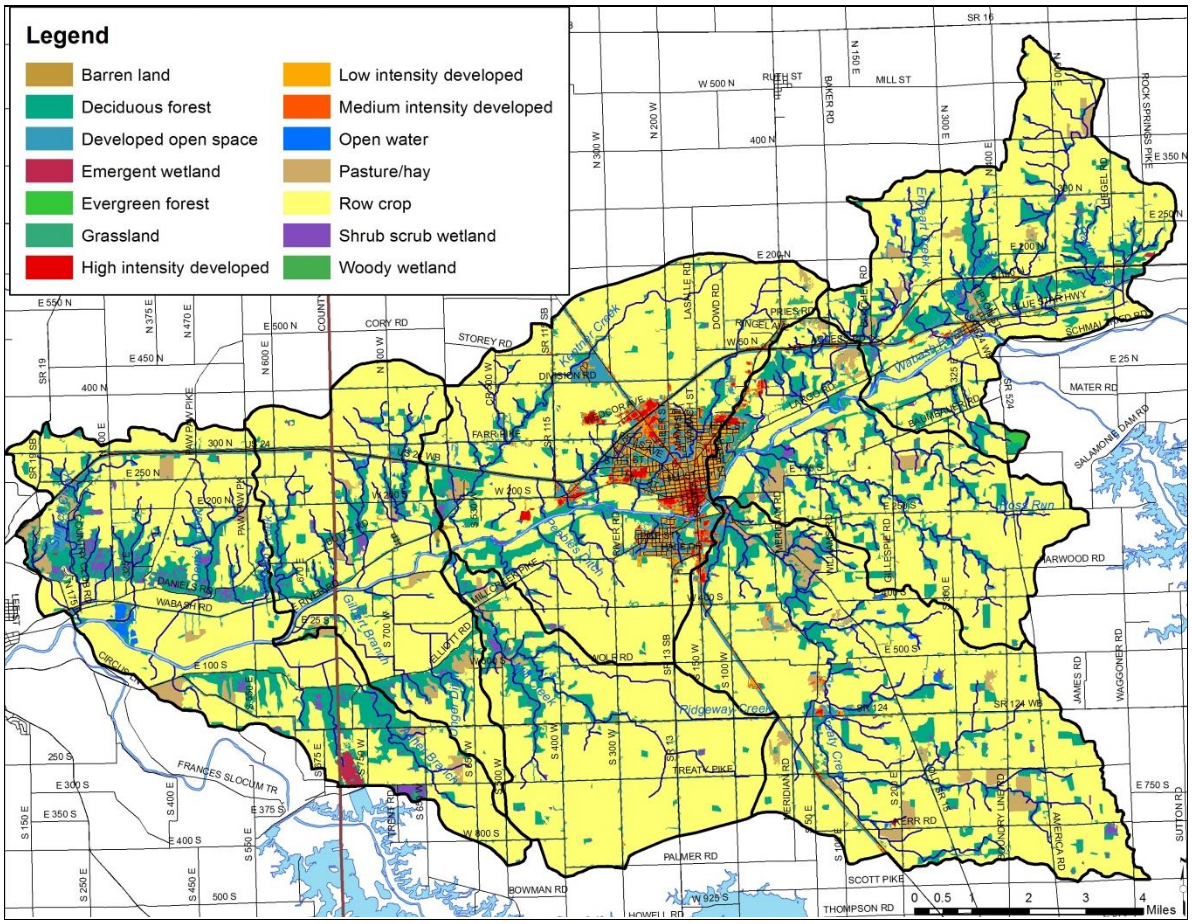


**Figure 21. Land use in the Treaty Creek-Wabash River Watershed.** Source: NLCD, 2011.

**Table 8. Detailed land use in the Treaty Creek-Wabash River Watershed.**

| Classification | Area (acres) | Percent of Watershed |
|---|---|---|
| Row crop | 79,250.5 | 70.9% |
| Deciduous forest | 15,804.2 | 14.1% |
| Developed open space | 7,313.9 | 6.5% |
| Pasture/hay | 2,780.5 | 2.5% |
| Low intensity developed | 2,227.2 | 2.0% |
| Shrub/scrub | 1,174.0 | 1.0% |
| Open water | 1,099.0 | 1.0% |
| Grassland | 1,044.5 | 0.9% |
| Medium intensity developed | 512.9 | 0.5% |
| High intensity developed | 303.9 | 0.3% |
| Emergent wetland | 221.9 | 0.2% |
| Evergreen forest | 65.0 | 0.1% |
| Woody wetland | 38.1 | 0.0% |
| Total | 111,835.7 | 100% |

Source: USGS, 2011

### 2.9.2 Agricultural Land Use

Individuals are concerned about the impact of agricultural practices on water quality. Specifically, the volume of exposed soil entering adjacent waterbodies, the prevalence of tiled fields and thus the transport of chemicals into waterbodies, the use of agricultural chemicals, and the volume of manure applied via small animal farms and through confined animal feeding operations are concerning to local residents. Each of these issues will be discussed in further detail below.

**Tillage Transect**

Tillage transect information data for Miami and Wabash counties was compiled for 2017 (Table 9; ISDA, 2017A-B). As reported by ISDA, members of Indiana's Conservation Partnership (ICP) conduct a field survey of tillage methods. A tillage transect is an on-the-ground survey that identifies the types of tillage systems farmers are using and long-term trends of conservation tillage adoption using GPS technology, plus a statistically reliable model for estimating farm management and related annual trends. Table 9 provides the number of acres and percent of acres on which conservation tillage was utilized for each county by corn and soybeans.

**Table 9. Conservation tillage data collected via tillage transect data by county for corn and soybeans (ISDA, 2017A-B).**

| County | Corn (acres) | Corn (%) | Soybeans (acres) | Soybeans (%) |
|---|---|---|---|---|
| Miami | 61,734 | 83% | 97,306 | 76% |
| Wabash | 73,315 | 78% | 98,926 | 64% |

**Agricultural Chemical Usage**

Agricultural pesticides and fertilizers are commonly applied to row crops in Indiana. These chemicals can be carried into adjacent waterbodies through surface runoff and via tile drainage. This is especially an issue if a storm occurs prior to the chemicals being broken down and used by the crops.

Data for chemical usage on an individual county or watershed level are not currently collected. Rather, data is collected for the state as a whole in two forms. First, the National Agricultural Statistics Survey

(NASS) collects information on chemical usage, number of applications per year, type of chemical applied, and the application rate. These data were last collected in 2006 (NASS, 2006). Additionally, NASS collects farmland data for the number of acres in agricultural production by type (i.e. corn, soybeans, grains) (NASS, 2017). These data indicate that corn (135,050 acres) and soybeans (196,230 acres) are the two primary crops grown in the watershed (Table 10).

Nitrogen is more typically applied to corn than to soybeans. Soybeans have symbiotic bacteria on their roots that act as nitrogen fixers, which means that they pull the nitrogen that they need from the atmosphere then convert it into a form which they can use. Corn does not fix nitrogen; therefore, nitrogen needs to be applied. Nitrogen is typically applied twice in Indiana – once at or before planting and a second time when corn reaches approximately one foot in height (NASS, 2007). Fall application of nitrogen also occurs and is particularly problematic. Agricultural data indicate that corn receives 98% of the nitrogen applied in the state and 87% of the phosphorus. For these reasons, nutrient calculations were only completed for corn as applications to soybeans are likely negligible. Based on these data, it is estimated that 9,953 tons of nitrogen and 4,923 tons of phosphorus are applied annually within Miami and Wabash counties (Table 10).

**Table 10. Agricultural nutrient usage for corn in the Treaty Creek-Wabash River Watershed counties.**

| Nutrient | Acres of Corn | % of Area Applied | Applications (#/year) | Rate/Application (lb/acre) | Total Applied/Year (tons) |
|---|---|---|---|---|---|
| Nitrogen | 135,050 | 100 | 2.2 | 67 | 9,953 |
| Phosphorus | 135,050 | 93 | 1.4 | 56 | 4,923 |

Source: NASS, 2007

Pesticides are also used on crops grown in Indiana. The Office of the Indiana State Chemist indicates that the two predominant herbicide active ingredients applied are atrazine and glyphosate. Atrazine is most commonly applied as a corn herbicide, while glyphosate is used on both corn and soybean fields as an herbicide. NASS indicates that in 2005, an average of 1.24 pounds of atrazine and 0.6 pounds of glyphosate were applied per acre of corn, and 0.73 pounds of glyphosate were applied per acre of soybeans (NASS, 2006). Using these rates, we estimated that a little over 83 tons of atrazine and approximately 112 tons of glyphosate are applied to cropland in Miami and Wabash Counties annually (Table 11).

**Table 11. Agricultural herbicide usage in the Treaty Creek-Wabash River Watershed counties.**

| Crop | Acres | Application Rate (lb/acre) | Total Applied (lbs) | Total Applied/Year (tons) |
|---|---|---|---|---|
| Corn (Atrazine) | 135,050 | 1.24 | 167,462 | 83.7 |
| Corn (Glyphosate) | 135,050 | 0.60 | 81,030 | 40.5 |
| Soybeans (Glyphosate) | 196,230 | 0.73 | 143,248 | 71.6 |

Source: NASS, 2006

**Confined Feeding Operations and Hobby Farms**

A mixture of small, unregulated and larger, regulated livestock operations (confined feeding operations) are found within the Treaty Creek-Wabash River Watershed. Small farms are those which house less than 300 animals. Larger farms that house large numbers of animals for longer than 45 days per year are regulated by IDEM. These regulations are based on the number and type of animals present. IDEM requires a permit, which document animal housing, manure storage and disposal, and nutrient management plans for farms which maintain 300 or more cows, 600 or more hogs, or 30,000 or more fowl. These facilities are considered confined feeding operations (CFO). There are 38 active and 10 voided confined feeding operations located in the watershed, none of which are large enough to be classified as a concentrated animal feeding operation (CAFO; Figure 22). The facilities house hogs, veal, and dairy and beef cattle with a combined total of 139 boars, 3,958 sows, 19,841 finishing hogs, 13,238 nursery hogs for a total of 37,016 hogs; 4,155 dairy cattle, 1,122 beef cattle, and 2,050 veal. In total, approximately 44,300 animals per year are housed in CFOs in the watershed, generating approximately 510,183,400 pounds of manure per year spread over more than 3,200 acres in the watershed. Note that acreage upon which manure is spread is based on maps provided in CFO permit applications. These fields are not necessarily used for manure produced by each applicant; however, they demonstrate that sufficient acreage is available for manure distribution that meets soil recommendations. Based on the number of permitted animals and the volume produced by each animal type (Barket and Walls, 2002), this volume of manure contains nearly 538,340 pounds of nitrogen and 392,490 pounds of phosphorus.

More than 60 small, unregulated animal farms housing more than 600 animals were identified during the windshield survey, which is most likely an underestimate of the actual number. These small "mini farms" contain small numbers of cattle, horses, or goats, which could be sources of nutrients and *E. coli* as these animals exist on small acreage lots with limited ground cover.

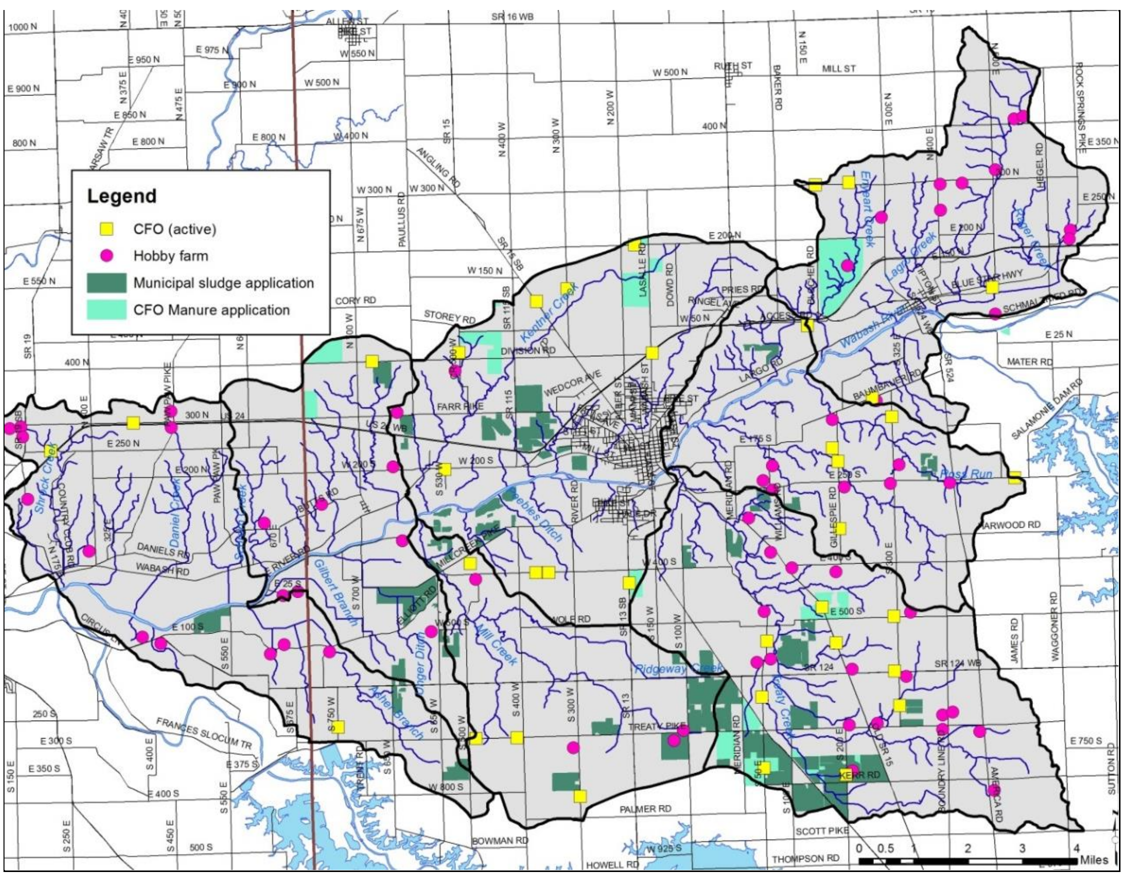


**Figure 22. Confined feeding operation and unregulated animal farm locations and associated farm fields for confined feeding operation manure and municipal wastewater treatment plant sludge spreading within the Treaty Creek-Wabash River Watershed.** Source: IDEM, 2015.

### 2.9.3 Natural Land Use

Natural land uses including forest, wetlands, and open water cover approximately 17.5% of the watershed. Forest cover occurs adjacent to waterbodies throughout the watershed, while wetland land uses are isolated throughout the watershed (Figure 21). Many forested tracts are contiguous and large lengths the Wabash River and smaller riparian forests lie adjacent to streams as intact riparian buffers.

### 2.9.4 Urban Land Use

Urban land uses cover nearly 12% of the watershed (Table 8). Although this is only a very small portion of the watershed, there are some significant issues related to the developed areas. Especially troublesome are issues related to failing septic systems, combined sewer overflows, impervious surfaces, flooding, and stormwater runoff that allow untreated sewage and stormwater to flow into the watershed during heavy rain events. Upgrades needed for facilities such as WWTP's can be cost-prohibitive. Ten combined sewer overflow (CSO) locations are present in the City of Wabash. The City is working to remediate these via their long-term control plan.

**Impervious Surfaces**

Impervious surfaces are hard surfaces which limit surface water from infiltrating into the land surface to become groundwater thereby creating high overland flow rates. Hard surfaces include concrete, asphalt, compacted soils, rooftops, and buildings or structures. In developed areas like Wabash and Lagro, land which was once permeable has been covered by hard, impervious surfaces. This results in rain which once absorbed into the soil running off of rooftops and over pavement to enter the stream with not only higher velocity but also higher quantities of pollutants.

Overall, the watershed is covered by low levels of impervious surfaces. However, high impervious densities are present in Lagro and Wabash and along roads throughout the watershed. Estimates indicate that 8,130 acres (7%) of the watershed are 25% or more covered by hard surfaces. Elvidge et al. (2004) indicated that streams in watersheds with greater than 10% impervious surfaces clearly exhibited degradation. The Center for Watershed Protection (CWP) identified similar impacts from impervious surface density on water quality. The CWP study indicates that stream ecology degradation begins with only 10% impervious cover in a watershed. Higher impervious surface coverage results in further impairments including water quality problems, increased bacteria concentrations, higher levels of toxic chemicals, high temperatures, and lower dissolved oxygen concentrations (CWP, 2003). The Treaty Creek-Wabash River does not meet this 10% threshold.

**Remediation Sites**

Remediation sites are areas that could include remnant or leftover industrial waste, leaking underground storage tanks (LUST), open dumps, and brownfields. These remediation sites are present throughout the Treaty Creek-Wabash River Watershed (Figure 23). Most of these sites are located within the developed areas of Wabash and along US Highway 24. In total, 13 industrial waste sites, 43 LUST facilities, 3 solid waste facilities, one restricted waste site, and seven brownfields are present within the watershed. There are no Superfund sites within the watershed.

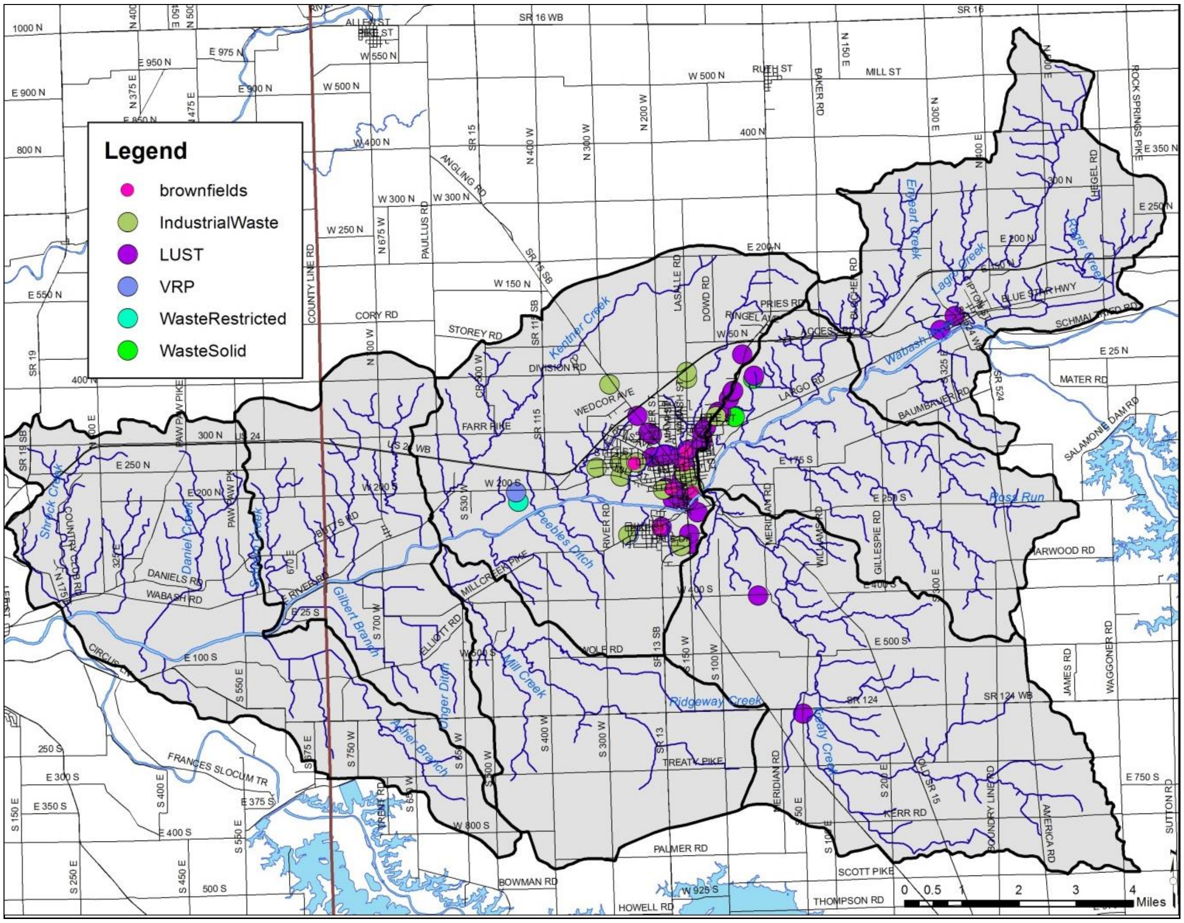


**Figure 23. Industrial remediation and waste sites within the Treaty Creek-Wabash River Watershed.** Source: IDEM, various.

## 2.10 Population Trends

The Treaty Creek-Wabash River Watershed is relatively a sparsely populated area in general and includes the entirety of the Town of Lagro and City of Wabash. Tracking population changes within a watershed is challenging as data is published by counties and townships rather than watershed boundaries. Estimates of the population of the watershed are derived by calculating percentage of the watershed within a county and extrapolating from county-wide data. The Treaty Creek-Wabash River Watershed lies within two counties. It drains nearly 13% of Miami County and 3% of Wabash County. Population trends for these counties derived from the most recently completed census (2010) are shown in Table 12, while Table 13 displays estimated populations for the portion of each county located within the watershed (StatsIndiana, 2018). These data indicate modest growth in both counties over the past decade; however, most of that growth is associated with Wabash and the immediate area.

**Table 12. County demographics for counties within Treaty Creek-Wabash River Watershed.**

| County | Area (sq. mi) | Population (2010) | Population Growth (2000-2010) | Pop. Density (#/sq. mi) |
|---|---|---|---|---|
| Miami | 373.8 | 35,862 | -1063 | 95.8 |
| Wabash | 412.4 | 32,885 | -1442 | 76.2 |

**Table 13. Estimated watershed demographics for the Treaty Creek-Wabash River Watershed.**

| County | Acres of County in Watershed | Percent of County in Watershed | Population |
|---|---|---|---|
| Miami | 239,232 | 6.9% | 1,781 |
| Wabash | 263,936 | 32.9% | 10,513 |
| **Total Estimated Population** | | | **12,294** |

## 2.11 Planning Efforts in the Watershed

While no one single plan has been dedicated to the Treaty Creek-Wabash River Watershed until the development of this one, several larger plans have encompassed portions of the Treaty Creek-Wabash River Watershed or areas which it drains or outlets into. Planning efforts include those by the Wabash River Heritage Corridor Commission along the length of the Wabash River, into which Treaty Creek-Wabash River drains, the Miami and Wabash County SWCD Master Plans and the Miami and Wabash county-wide master plans.

### 2.11.1 Wabash County Area Plan

The Wabash County initiated an update to the comprehensive plan in 2009 (Wabash County, 2011). The plan identifies the counties resources and provides guidance for their protection and improvement. Resources identified and mechanisms for protection and improvement include the following:

- Agricultural land: The consumption of agricultural land for non-related purposes, including a loss of farmland acres and overall loss of total farmland in Wabash County, will have a negative economic impact on Wabash County in the long-term. Since 1945, the number of farms in Wabash County decreased by 60% from 2,097 farms in 1945 to 850 farms in 2007. Farmland loss of 17% was observed with acreage decreasing from 240,542 aces in 1945 to 200,689 in 2007. The protection of productive agricultural land from development and the regulation of develop on marginally productive land were highlighted as future goals during the area planning process.
- Environmental areas: Protection of the counties' reservoirs, lakes, rivers, wetlands, and other features were recognized as part of the planning process. Specifically, the plan recognizes the goal for balancing development with the protection of environmental features. Several goals and objectives were identified including:
    - Protecting today's environment and natural resources for our benefit and the benefit of future generations through strategic development practices.
    - Working with federal, state and local environmental groups to meet regulations for sewage processing in rural communities with focused development where infrastructure already exists.
    - Protecting underground aquifers from contaminants from improper development or use of land.
    - Maintaining community floodways, floodplains and spillways as natural spaces for flood and erosion control, water quality management and ground water recharge.
    - Providing incentives for the agricultural community to incorporate best practices in agricultural-related operations.
    - Using zoning and ordinances to preserve natural wooded areas and wetlands.
    - Initiating a program in which community members are provided the opportunity to earn their solid waste fee back through obedient recycling.
    - Developing positive relationships with the industrial interests and working together to protect the environment.

  - Holding environmental impacts on recreational areas in check, which is essential in implementing high quality life, good health, and favorable community spirit.

#### 2.11.2 City of Wabash CSO Long-Term Control Plan

The City of Wabash submitted their Combined Sewer Overflow (CSO) Long-term Control Plan (LTCP) in 2003. An addendum to the LTCP was submitted to IDEM in 2010 (United Consulting, 2016). This, in cooperation with the city's CSO operational plan and issued NPDES permit outline the wet weather operating procedures and design capabilities of the wastewater treatment plant and its collection system. Specifically the plan identifies that all flows received by the wastewater treatment plant will receive full treatment, and that during conditions where wet weather discharges from CSO outfalls 001, 003, 004, 005, 006, 007, or 008 result from a storm event, those conditions will be documented.

Prior to approval of the long-term control plan, the City of Wabash implemented several early action projects. These included:

- Stormwater and sanitary improvements and sewer separation along Vernon Street, Fairfield Drive, Snyder Street, Linlawn Drive, Sivey Stree, and Glenn Avenue;
- Sanitary sewer interceptor replacement from Chestnut and Vernon streets to Hutchens and Middle streets;
- Drainage improvements along LaFountain Avenue; and
- Lift station improvements on Lift Station 10.

The cities LTCP alternative combines several controls that will be constructed over a 17 year period with an approximate cost of $13 million (Figure 24). Once implemented, the LTCP is expected to result in capture and full treatment of flows up to and including a 10 year, 1-hour storm. LTCP projects include the following:

- Construction of various street-specific projects
- Construction of various storm and sanitary sewer improvements
- Construction of lift station 2/CSO 003 improvements.
- Construction of lift station 4 area improvements.
- Installation of mechanical fine screening at the wastewater plant.
- Evaluation of possible elimination of some remaining CSOs after a sufficient post-construction monitoring period.

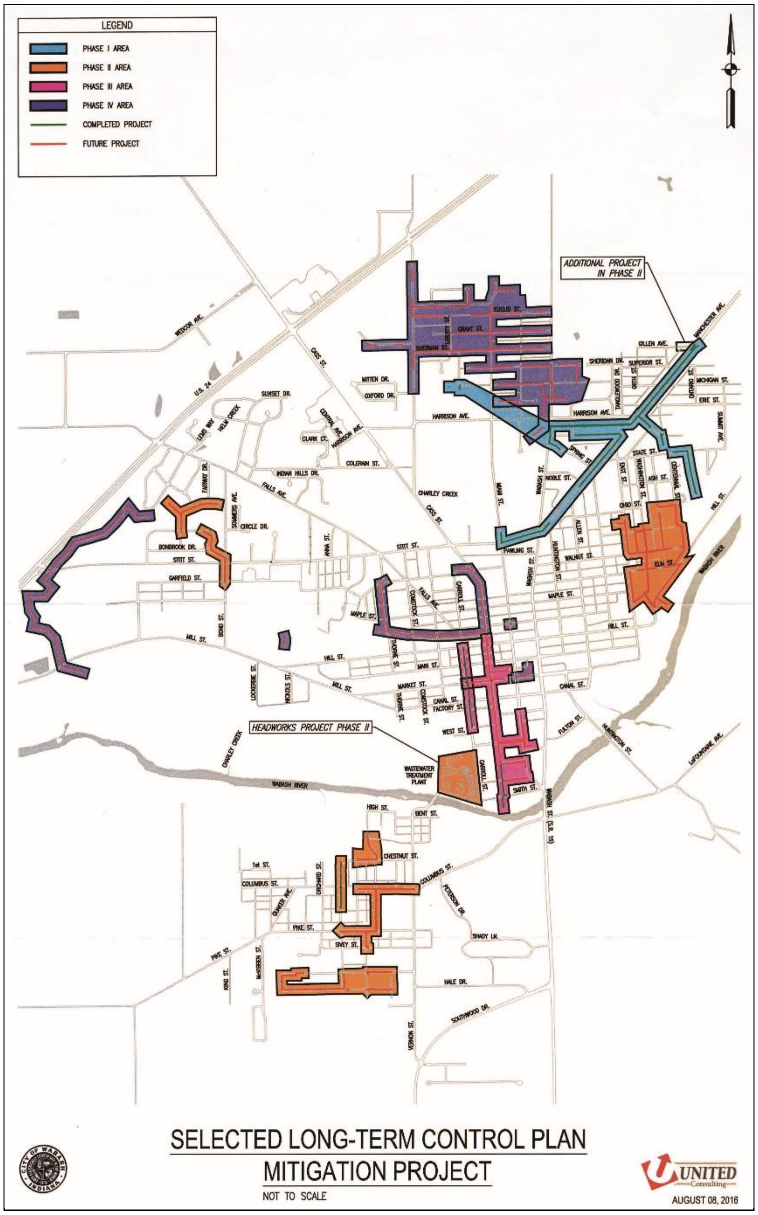


**Figure 24. Selected long-term control plan mitigation projects to address combined sewer overflows in the City of Wabash.**

### 2.11.3 Silver Creek-Hanging Rock Watershed Diagnostic Study

The Wabash River Defenders completed the Silver Creek-Hanging Rock Watershed Diagnostic Study in 2017. While the Silver Creek-Hanging Rock Watershed is not located within the Treaty Creek-Wabash River Watershed, it is adjacent to the watershed lying immediately upstream. The completion of this watershed diagnostic study was the first phase in the Wabash River Defenders' efforts to understand and subsequently, protect and improve, water quality within the Wabash River in Wabash County.

The Silver Creek Hanging Rock Watershed Diagnostic Study is a comprehensive examination of Silver Creek and several minor tributaries to the Wabash River in Huntington and Wabash counties and their surrounding watershed. In 2017, with funding from the Indiana Department of Natural Resources Lake and River Enhancement (LARE) Program, the Wabash River Defenders hired the team of Arion

Consultants and Commonwealth Biomonitoring to conduct the study. The scope of the study included the following:

- Data review and mapping current conditions: Collection and review of historic studies, water quality and fisheries reports, and base mapping of watershed conditions.
- Public engagement and outreach: Completion of watershed walking and driving tours and landowner and public meetings.
- Watershed assessment: Completion of stream water quality sampling, macroinvertebrate and fish community assessments, and habitat scoring.
- Analysis and data interpretation: Review of historic and current conditions, assessment of collected water quality data, and compilation of results and recommendations.

The Silver Creek-Hanging Rock Watershed encompasses 25,487 acres (10,314.2 ha) of Huntington and Wabash counties, Indiana. The watershed is 75% row crop agriculture. Forested lands and wetlands account for 17% of the watershed land use, while urban land uses, including urban open space and low, medium, and high intensity developed areas, account for 6% of the watershed.

The study documented high levels of soluble and total phosphorus during base and storm flow conditions and elevated total suspended solids and *E. coli* concentrations during storm flow conditions. Four of the Silver Creek-Hanging Rock Watershed sites, Silver Creek Outlet (Site 1), Silver Creek Headwater (Site 5), Hamilton-Satterthwaite Drain (Site 9) and Kaehr (Site 10), generally possessed poorer water quality conditions than the other stream reaches. The Rapid Bioassessment Protocol (RBP), an index which utilizes invertebrate community structure to measure water quality, documented a range of moderately impacted to non-impaired macroinvertebrate communities. The Index of Biotic Integrity indicates that the fish community in the Silver Creek-Hanging Rock Watershed rates as fair to very poor. Habitat as assessed using the Qualitative Habitat Evaluation Index (QHEI) rated as good to poor. Overall, the Silver Creek-Hanging Rock Watershed provides adequate habitat to maintain good quality fish communities and only moderately impaired macroinvertebrate communities.

Observers identified nearly 14 miles of streambank erosion and an additional 12 miles of streams with narrow buffers throughout the Watershed. Nearly 4,000 acres of row crop agriculture would benefit from soil health-focused projects to reduce soil erosion and improve the biological, chemical, and physical condition of streams throughout the study area. Load reduction calculations were estimated for nitrogen, phosphorus and sediment based on the potential best management practices to be implemented within the Silver Creek-Hanging Rock Watershed. If the Silver Creek-Hanging Rock Watershed is blanketed with the proposed projects, pollutant loading will be reduced as follows: 3,141 lb. nitrogen (84%), 1,033 lb. phosphorus (80%), and 66,601 lb. sediment (84%).

#### 2.11.4 Lower Salamonie River Watershed Management Plan

In 2010, meetings concerning issues within the Salamonie River and reservoir were held to generate stakeholder involvement. The project area included the lower section of the Salamonie River in Blackford, Grant, Wells, Huntington and Wabash counties. Excess nutrient runoff, failing septic systems, endangered species protection, streambank erosion and the need for agricultural BMP usage were identified. In 2013, the Huntington County SWCD received IDEM Section 319 funds to produce a watershed management plan for the Lower Salamonie (Kroeker Consulting, 2016). While this area is located upstream of the Treaty Creek-Wabash River Watershed, stakeholders identified water quantity releases from the Salamonie as one of their concerns. Additionally, water quality issues from the Salamonie directly impact the Treaty Creek-Wabash River Watershed. Goals identified as part of the Salamonie River Watershed Management Plan are as follows:

- Less than 60% of samples will exceed pathogen targets within 5 years with less than 75% of samples exceeding targets in 10 year and only outliers exceeding targets in 30 years.
- Achieve a 10% reduction in nitrogen and phosphorus within 5 years, a 15% reduction in nitrogen and a 20% reduction in phosphorus in 10 years and a 20% reduction in nitrogen and 53-70% reduction in phosphorus in 30 years.
- Reduce sediment by 10% in 5 years, 20% in 10 years and 55% in 30 years.
- Improve mIBI scores in 5 years, mIBI scores match with QHEI scores in 10 years and remove impairments on all stream segments that are listed on the 303(d) list in 30 years.
- Create new access points to rivers and streams; increase walking and riding trails along waterways; educate stakeholders about the values of the river and reservoir; improve riparian areas, aquatic habitats and the fishery; and help organize river clean ups within 30 years.

### 2.11.5 Wabash River Heritage Corridor Commission Master Plan

In 1990, the Indiana Department of Natural Resources created the Wabash River Heritage Corridor Fund to provide assistance with conservation and recreational development projects along the Wabash River. In 1991, the Wabash River Heritage Corridor Commission (WRHCC) was created by House Enrolled Act 1382. The WRHCC protects and enhances the natural, cultural, historical and recreational resources of the Wabash River within the nineteen counties through which the river runs. This includes Warren and Tippecanoe counties, which are part of the current planning project. Since 1990, approximately 60 projects received funding totaling more than $13 million through the corridor fund (WRHCC, 2004). Additional efforts by the WRHCC include maintenance of a visible presence within the corridor counties, provision of interaction along the length of the corridor, and promotion of the Wabash River and its historical and recreational opportunities.

In 2004, the WRHCC updated its master plan via a series of public meetings along the Wabash River corridor. Since 2010, the WRHCC has updated the master plan as part of their regular bimonthly meeting efforts. The 2004 master plan focused on eight main areas including land use, natural resources, historic resources, recreational resources, corridor connection and linkages, scenic by-way linkages, thematic connections, and tourism. The updated plan includes these same foci. As portions of the watershed are contained within the Wabash River Heritage Corridor, it is important that the goals, strategies, and actions developed as part of this plan be in line with those developed as part of the WRHCC master plan. The 2004 master plan identified the following action items:

- Maintain and enhance the natural diversity of the corridor.
- Restore natural landscapes of the Wabash River Heritage Corridor.
- Ensure that mineral extraction is environmentally sensitive.
- Stabilize the riverbank.
- Re-establish riparian forests and wetlands along the Wabash River.
- Develop and implement set-back programs to reduce surface runoff and non-point source pollution.
- Enforce existing regulations regarding point source pollution related to wastewater treatment plants and septic systems and explore the need for new regulations.
- Promote monitoring of water quality and public education about water quality.
- Preserve large regional natural areas.
- Fish stocking and wildlife reintroduction in and along the Wabash River.
- Conduct a historic resource inventory of the corridor resource and nominate eligible properties for National Register designation within the corridor.

- Develop a prioritized list of historic and cultural resources that are threatened for focused preservation effort by county.
- Identify long-term funding opportunities for historic preservation along the corridor.
- Acquire and develop more recreational areas and opportunities.
- Promote and enhance hunting and fishing opportunities.
- Promote and enhance birding opportunities in the corridor.
- Promote and enhance bicycling opportunities in the corridor.
- Develop trail connections along the river linking corridor communities.
- Increase access to the Wabash River for recreational use, boating, fishing, and enjoyment of the river. Increase overnight facilities access.
- Establish designation of scenic by-way along the river.
- Install directional or identification signs for scenic by-ways along the river.
- Create an image to connect and interpret significant resources.
- Develop a Wabash River Heritage Corridor Center that would introduce and interpret the significance of the Wabash River and the Heritage Corridor and serve as a central repository or records center for Wabash studies.
- Develop a Wabash River and Heritage Corridor education curriculum for teacher training opportunities.
- Create corridor identification.
- Promote and market corridor resources and events.
- Develop and coordinate corridor events as part of the Heritage Corridor identity.
- Provide information to promote local and corridor recreational resources and facilities.
- Develop a natural resource guide specific to the Wabash River Heritage Corridor that will be site specific including river and public access information.

In 2009 legislation was revised to allow a new source of dedicated money to be placed in the fund, derived from royalties of oil and mineral rights beneath the Wabash River. This fund will be used to once again fund projects in the Wabash River Corridor.

The grants have been awarded every other year, in 2012 and 2014 so far, and total approximately $300,000 every two years. Both Treaty Creek-Wabash River Watershed counties are eligible to apply for funding.

## 2.12 <u>Watershed Summary: Parameter Relationships</u>

Several relationships among watershed parameters become apparent when watershed-wide data are examined. These relationships are discussed here in general, while relationships within specific subwatersheds are discussed in more detail in subsequent sections.

### 2.12.1 Topography, Soils, Septic Suitability, and Hydrology

Much of the topography and terrain characteristics within the Treaty Creek-Wabash River Watershed have a direct correlation to water quality. Approximately 36% of the Treaty Creek-Wabash River Watershed are mapped in highly erodible or potentially highly erodible soils. Highly erodible and potentially highly erodible soils are very susceptible to erosion. Nutrients, such as phosphorus, and sediment erode easily when these soils are not covered. Sediments and nutrients that reach Treaty Creek-Wabash River Watershed waterbodies are likely to degrade water quality. Highly erodible and potentially highly erodible soils that are used for animal production or are located on cropland are more susceptible to soil erosion.

Most of the soils in the watershed are rated as very limited for septic system suitability. Sewers are utilized within the City of Wabash. All other residences utilize septic systems. This is a concern because adequate filtration may not occur, and this water may easily reach water sources and groundwater. With a lack of natural filtration of septic fields to groundwater, degradation of water quality is likely if septic systems are not maintained. Septic maintenance is a concern of Treaty Creek-Wabash River Watershed stakeholders.

### 2.12.2 Soils, Topography and Land Form

Topography within the watershed is generally flat away from the Wabash River, especially in the northern and southern portions of the watershed. Soils in these areas formed on till deposits, are somewhat poorly drained to moderately well drained, and are well suited to agriculture. As a result, approximately 75% of the watershed is in a corn-soybean rotation. Because of the low slope and poor drainage, tile drains are extensively used throughout the watershed. It will be important to address the impacts of row crop agriculture and tile-drained systems, by promoting practices to reduce nutrients transported through tiles and to repair and prevent streambank erosion, in order to improve water quality in the watershed.

The steepest terrain in the watershed occurs along the Wabash River itself where steep cliffs along the river provide dramatic scenery. The steepness of the terrain in this area likely made it very difficult to remove timber, making this portion of the watershed one of the most heavily forested areas today. This area is also where the highest concentration of highly erodible and potentially highly erodible soils is found. Protecting and restoring the forested riparian buffer in this area will be important to reducing streambank erosion and in-stream sediment levels.

### 2.12.3 High Quality Habitat and ETR Species

In general, most of the higher quality upland habitat in the watershed occurs along the Wabash River and in the steep topography associated with the river's riparian area. The topography, bedrock and soils in this area support spectacular ravines and mature forest habitats, including areas owned by the DNR and Acres Land Trust. The tributary streams and Wabash River provide rare habitat that is home to many species of wildlife, fish, and plants. The topography here made this area less suitable for farming and so more of the natural community and habitat has been preserved here. Many of the endangered, threatened and rare species and high-quality natural communities in the watershed are found along this stretch of the stream corridor, making this an important area to focus habitat preservation and restoration efforts.

## 3.0 WATERSHED INVENTORY II-A: WATER QUALITY AND WATERSHED ASSESSMENT

In order to better understand the watershed, an inventory and assessment of the watershed and existing water quality studies conducted within the watershed is necessary. Examining previous efforts allowed the project participants to determine if sufficient data was available or if additional data needed to be collected in order to characterize water quality problems. Once the water quality data assessment occurred, the watershed was then characterized to determine potential sources of any water quality issues identified by the data review. Subsequently, pollutant sources could then be tied to stakeholder concerns and collected data could be used to estimate pollutant loads from each identified source location. The following sections detail the water quality and watershed assessment efforts on both the broad, watershed-wide scale and in a focused manner looking at each subwatershed within the Treaty Creek-Wabash River Watershed.

### 3.1 Water Quality Targets

Many of the historic water quality assessments occurred using different techniques or goals. Several sites were sampled only one time and for a limited number of parameters. Monitoring committee members were reluctant to draw too many conclusions based on a single sampling event. Nonetheless, the available data are detailed below and compared in general with water quality targets. In order to compare the results of these assessments, the monitoring committee identified a standard suite of parameters and parameter benchmarks. Table 14 details the selected parameters and the benchmark utilized to evaluate collected water quality data.

**Table 14. Water quality benchmarks or targets used to assess water quality from historic and current water quality assessments.**

| Parameter | Water Quality Benchmark | Source |
|---|---|---|
| Dissolved oxygen | 4-12 mg/L | Indiana Administrative Code |
| pH | 6-9 | Indiana Administrative Code |
| Temperature | Monthly standard | Indiana Administrative Code |
| *E. coli* | <235 colonies/100 mL | Indiana Administrative Code |
| Conductivity | 1050 µmhos/cm | Indiana Administrative Code |
| Nitrate-nitrogen | <1.5 mg/L | Ohio EPA (1999) |
| Total phosphorus | <0.07 mg/L<br><0.30 mg/L | Ohio EPA (1999)<br>IDEM TMDL Target |
| Total suspended solids | <30 mg/L | IDEM TMDL Target |
| Turbidity | <25 NTU | Minnesota TMDL Target |
| Qualitative Habitat Evaluation Index | >51 points | IDEM (2008) |
| Index of Biotic Integrity | >36 points | IDEM (2008) |
| Macroinvertebrate Index of Biotic Integrity | >36 points | IDEM (2008) |

### 3.2 Historic Water Quality Sampling Efforts

A variety of water quality assessment projects have been completed within the Treaty Creek-Wabash River Watershed (Figure 25). Statewide assessments and listings include the integrated water monitoring assessment, the impaired waterbodies assessment, and fish consumption advisories. Additionally, the Indiana Department of Environmental Management (IDEM) and Indiana Department of Natural Resources (IDNR) have both completed assessments within the watershed. Corridor-wide assessments of the fish community along the length of the Wabash River were completed by DePauw University, Ball State University, and The Nature Conservancy. Regional water quality assessments completed as part of the City of Wabash Wastewater Utility, Indiana American Water routine sampling, and assessments of fish community completed by Manchester University as well as volunteer-based sampling of water quality through the Hoosier Riverwatch program all provide additional water quality data with which the watershed can be characterized. A summary of each assessment methodology and general results are discussed below. Specific data results are detailed within subwatershed discussions in subsequent section.

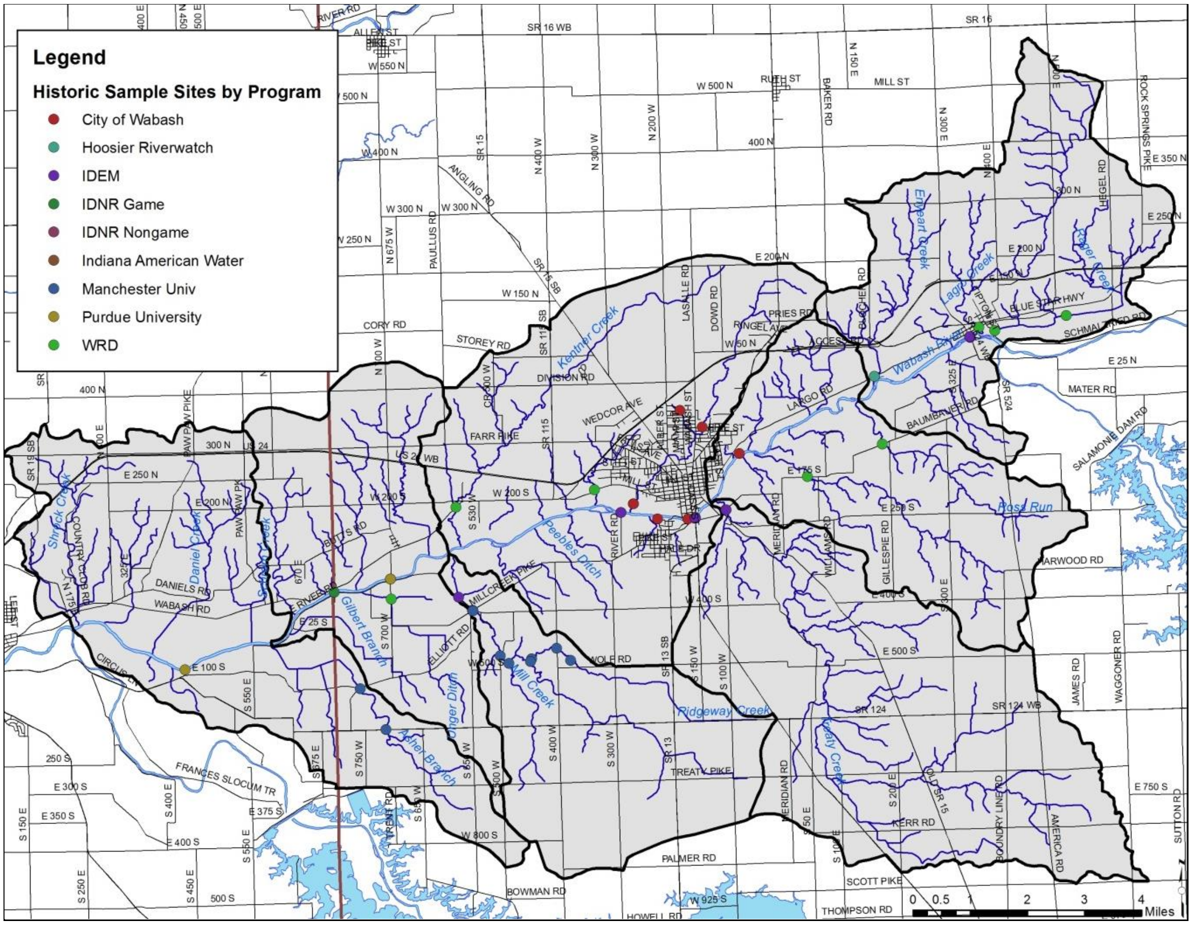


**Figure 25. Historic water quality assessment locations.**

### 3.2.1 Integrated Water Monitoring Assessment (305(b) Report)

The Indiana Department of Environmental Management (IDEM) is the primary agency tasked with monitoring surface water quality within the state of Indiana. Section 305(b) of the Clean Water Act requires that the state report on the quality of waterbodies throughout the state on a biennial basis. These assessments are known as the Integrated Water Monitoring Assessment (IWMA) or the 305(b) Report. The most recent draft report was delivered to the USEPA and underwent public comment in 2016 (IDEM, 2016). To complete this report, the 305(b) coordinator reviews all data collected by IDEM and selected high-quality data collected by other organizations on a waterbody basis. Each assessed waterbody is then assigned a water quality rating based on its ability to meet Indiana's water quality standards (WQS). WQS are set at a level to protect Indiana waters' designated uses of swimmable, fishable, and drinkable. Waterbodies that do not meet their designated uses are proposed for listing on the impaired waterbodies list, which is discussed in more detail below. The 2016 IWMA includes 56 waterbody reaches in the Treaty Creek-Wabash River Watershed (IDEM, 2016). Listings include the following:

- Ridgeway Creek and an unnamed tributary are listed as impaired for aquatic life use but with insufficient data to assess fish consumption or recreational uses.
- Six segments of the Wabash River are listed as impaired for fish consumption, aquatic life use, and recreational impairments; however, a TMDL was written for the aquatic life use and recreational impairments.
- Rager Creek is listed for insufficient data to assess impairments.
- Enyeart Creek is listed for insufficient data to assess impairments.
- Treaty Creek and ten unnamed tributary segments are listed for insufficient data to assess impairments.
- Stone Creek is listed for insufficient data to assess impairments.
- Ross Run is listed for insufficient data to assess impairments.
- Burr Creek is listed for insufficient data to assess impairments.
- Charley Creek is listed for insufficient data to assess impairments.
- Helm Creek is listed for insufficient data to assess impairments.
- Koontz Ditch is listed for insufficient data to assess impairments.
- Peebles Ditch is listed for insufficient data to assess impairments.
- Stauffer Ditch is listed for insufficient data to assess impairments.
- Kentner Creek is listed for insufficient data to assess impairments.
- Carlin Branch and an unnamed tributary are listed for insufficient data to assess impairments.
- Unger Ditch is listed for insufficient data to assess impairments.
- Engleman Creek and an unnamed tributary are listed for insufficient data to assess impairments.
- Schrom Creek is listed for insufficient data to assess impairments.
- Gilbert Branch is listed for insufficient data to assess impairments.
- Asher Branch is listed for insufficient data to assess impairments.
- Daniel Creek is listed for insufficient data to assess impairments.
- Mill Creek is listed for insufficient data to assess impairments.
- Eleven unnamed tributaries to the Wabash River are listed for insufficient data to assess impairments.

### 3.2.2 Impaired Waterbodies (303(d) List)

Waterbodies in the Treaty Creek-Wabash River Watershed which are included on the Impaired Waterbodies list are detailed in section 2.7.3 above.

### 3.2.3 Fish Consumption Advisory (FCA)

Three state agencies collaborate annually to compile the Indiana Fish Consumption Advisory (FCA). The Indiana Department of Natural Resources, Indiana Department of Environmental Management, and Indiana State Department of Health have worked together since 1972 on this effort. Samples are collected through IDEM's rotating basin assessment for bottom feeding, mid-water column feeding, and top feeding fish. Fish tissue samples are then analyzed for heavy metals, PCBs, and pesticides. Table 15 details the advisories for the Treaty Creek-Wabash River Watershed from the from the 2017 report (ISDH, 2017). Advisories listings are as follows:

- Level 3 – limit consumption to one meal per month for adults with pregnant or breastfeeding women, women who plan to have children, and children under 15 consuming zero volume of these fish.

- Level 4 – limit consumption to one meal every 2 months for adults with women and children detailed above having zero consumption.
- Level 5 – zero consumption or do not eat.

Based on these listings, the following conclusions can be drawn:
- The Wabash River is under a fish consumption advisory for selected fish of select size within the length of the river in Miami and Wabash counties.
- No carp or carpsuckers be consumed from any waterbody within the watershed.

**Table 15. Fish Consumption Advisory listing for the Treaty Creek-Wabash River Watershed.**

| Waterbody | Fish Species | Fish Size | Advisory |
|---|---|---|---|
| All | Carp | 15-20 inches | 3 |
| | | 20-25 inches | 4 |
| | | 25+ inches | 5 |
| Wabash River | Black redhorse | > 19 inches | 3 |
| | Blue sucker | 21-26 inches | 3 |
| | | > 26 inches | 4 |
| | Carpsucker | all | 3 |
| | River carpsucker | <14 inches | 3 |
| | Channel catfish | >15 inches | 3 |
| | Freshwater drum | >16 inches | 4 |
| | Shorthead redhorse | >15 inches | 3 |
| | White crappie | <8 inches | 3 |
| | Sauger | 13+ inches | 3 |
| | Smallmouth buffalo | < 20 inches | 3 |
| | | 20+ inches | 4 |

### 3.2.4 Wabash River Total Maximum Daily Load (TMDL) Study

Water quality data collected from the Wabash River indicated that the Wabash River did not consistently comply with the state's water quality standards. Based on these determinations, segments of the Wabash River have been included on the state's 303(d) list since its inception. The 2002 listing included segments of the Wabash River in non-compliance for pathogens (*E. coli* and fecal coliform), nutrients, pH, dissolved oxygen, and impaired biotic communities. Subsequent lists prepared in 2004, 2006, and 2008 replicate these listings. In order to cohesively address impairments, one TMDL was written for the entire length of the Wabash River including the 30 miles in Ohio and the 475 miles in Indiana and Illinois (Tetra Tech, 2006). Within the Treaty Creek-Wabash River Watershed, the TMDL addresses nutrient, dissolved oxygen, and *E. coli* impairments.

Data collected by several agencies was obtained for water quality model development and TMDL calculation. The following conclusions were drawn with regards to water quality in the Wabash River:
- Nitrate+nitrite concentrations routinely exceeded the Indiana benchmark (10 mg/L); however, median concentrations measured 5 mg/L.
- Median dissolved oxygen concentrations generally exceeded 8 mg/L with only a few stations measuring below the minimum benchmark (4 mg/L). However, several stations routinely exceeded the upper benchmark (12 mg/L).
- Phosphorus concentrations routinely exceeded the phosphorus benchmark (0.3 mg/L) used for impaired waterbody listing by the IDEM.

- Most station impairments resulted from a combination of phosphorus and nitrate+nitrite or dissolved oxygen exceedances.

Due to the routine nature of the listings, one TMDL was developed for the entire Wabash River. The TMDL was calibrated at six locations along the river where sufficient data was available for calculation. The location relevant to Treaty Creek-Wabash River Watershed is the Wabash River at J. Edward Roush Lake. Although this station is located upstream of the watershed, it more closely resembles conditions present along the Wabash River within the watershed than the downstream segment (Wabash River at Lafayette) and is therefore used as the base assessment regarding necessary reductions (Figure 26). Based on the Wabash River TMDL, the following conclusions have been drawn:

- A monthly reduction in *E. coli* from nonpoint sources from April to October of 94-95% is needed in the Wabash River at J. Edward Roush Lake. No reduction in point source generated *E. coli* is necessary. This percent reduction results in a reduction of 5,664,700,000,000 *E. coli* colonies per day or 15,500,000,000 colonies per 100 ml per year (TetraTech, 2007).
- Monthly reductions of total phosphorus from nonpoint sources ranging from 12 to 23% are needed in the Wabash River at J. Edward Roush Lake. No reduction in point sources is necessary. This results in an overall reduction of 0.16 lb of phosphorus per day or just less than 57 lb of phosphorus per year.
- No nitrate reductions are required upstream of Lafayette from either point or nonpoint sources.

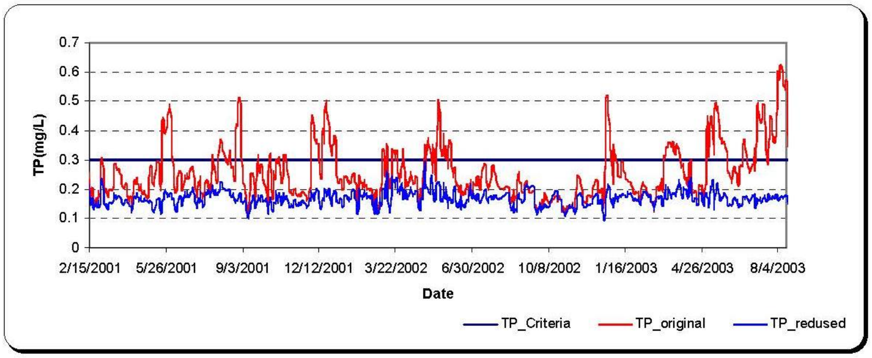


**Figure H-5. TP at Upstream J. Edward Roush**

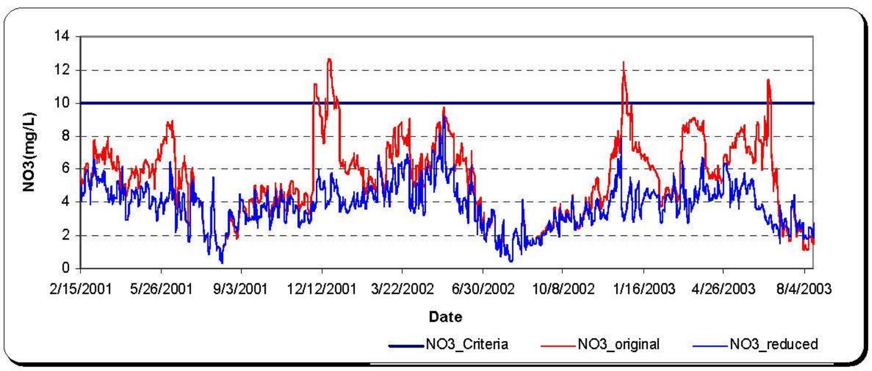


**Figure H-6. NO3 at Upstream J. Edward Roush**

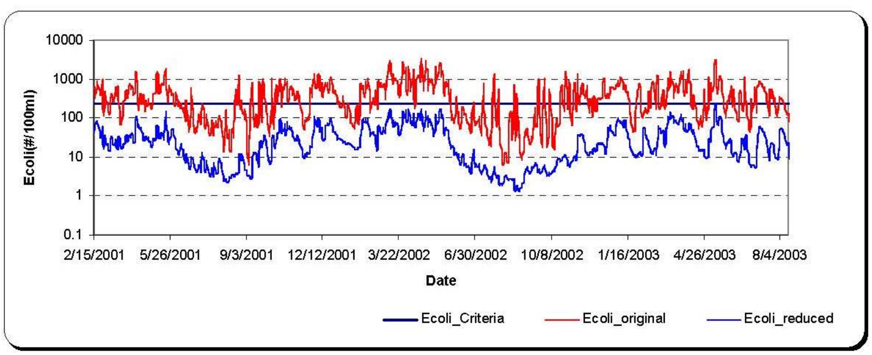


**Figure H-7. *E. coli* (instantaneous) at Upstream J. Edward Roush**

**Figure 26. Total phosphorus (TP), nitrate (NO3), and *E. coli* load reductions identified in the Wabash River TMDL for the J. Edward Roush Lake portion of the Wabash River. Source: TetraTech, 2006.**

### 3.2.5 IDEM Fixed Station (1990-2009) and Rotational Basin Assessments

Through IDEM's fixed station water quality monitoring program, IDEM scientists collect water quality samples once per month at 160 stream and river sample sites throughout the state. One sample site is located on the Wabash River upstream of the Treaty Creek-Wabash River Watershed at Andrews (SR 105). Although the location is upstream of the upper end of the Treaty Creek-Wabash River Watershed, these data provide details as to the quality of water entering the watershed. Based on the fixed station sampling data, the following conclusions can be drawn:

- Total phosphorus concentrations exceeded the recommended criteria during a majority (>99%) of months sampled. Samples routinely exceeded 0.3 mg/L resulting in this reach of the Wabash River being listed on Indiana's impaired waterbodies list.
- Total Kjeldahl nitrogen and nitrate-nitrogen concentrations routinely exceeded the recommended criteria with more than 75% of samples measuring above target levels.
- Total suspended solids concentrations and turbidity levels were elevated with more than 75% of samples exceeding target concentrations in a majority of the samples collected in from the Wabash River at Andrews.
- *E. coli* concentrations varied over time but generally exceeded the state standard.

In 1991, 1998, 2003, 2008, IDEM sampled water chemistry at several locations in the Treaty Creek-Wabash River Watershed via their rotational basin assessment program. Sampling occurred in Mill Creek, Treaty Creek, and the Wabash River. A majority of the assessments which occurred via the rotational basin program included a single sample event with some assessments including up to three sample events; however, the Wabash River was assessed at River Road, Lagro Road, SR 15 and at SR 524 as part of E. coli assessments which included five samples collected over 30 days and at SR 15 as part of the pesticide assessment program. Based on the rotational basin water chemistry assessments, the following conclusions can be drawn:

- *E. coli* concentrations exceeded the state standard in the Wabash River during a majority of assessments at all sites.
- Nitrate-nitrogen concentrations exceeded the recommended criteria; however, only three total samples were collected thus conclusions cannot be drawn at this time.
- Total phosphorus concentrations exceeded the recommended criteria in the Wabash River during all assessments at Lagro Road, State Road 15, and State Road 524.
- Turbidity levels exceed target concentrations in the Wabash River at State Road 15, State Road 524, Lagro Road and at River Road.
- Pesticide monitoring in the Wabash River occurred in 1998. Results indicate that pesticide concentrations are low with the exception of atrazine. Atrazine concentrations measured as high as 18 mg/L. Note that EPA recommends limiting atrazine consumption in drinking water to 3 mg/L.

IDEM completed biological and habitat assessments at two watershed sites in 1991, 1998, 2008, 2011, and 2015. Fish sampling occurred in the Wabash River at Lagro Road in 2008, in Mill Creek in 2011, and in Treaty Creek in 2015. Macroinvertebrate sampling occurred in the Treaty Creek in 1991 and 1998; in Mill Creek, in 1991, 1998 and 2011; and in the Wabash River in 2008. Both fish and macroinvertebrate samples were collected and habitat was also assessed using the QHEI. Based on these assessments, the following conclusions can be drawn:

- Habitat assessed at all sites rated well with all scores measuring above aquatic life use designated level (51). Scores ranged from 66 to 88 with all sites receiving high substrate, morphology, and riffle/run development scores.
- Macroinvertebrate communities rated as severely impaired in Mill Creek in 1998, while all other sites rated as moderately impaired. Specifically, high numbers of chironomids, low number and diversity of EPT taxa, and high HBI scores indicate limited macroinvertebrate communities within Mill Creek.

- Fish communities in the Wabash River and Mill Creek rated as poor, while the Treaty Creek fish community rated as fair.

### 3.2.6 Wabash River Defenders 2015 Monitoring

The Wabash River Defenders initiated water quality sampling in 2015 to better understand water quality within the Treaty Creek-Wabash River tributaries. Sampling occurred one time at 12 locations throughout the watershed under storm flow conditions. The following conclusions can be drawn:

- Under storm flow conditions, all sampled tributaries exceeded target concentrations for nitrate-nitrogen (1.5 mg/L) with Kentner Creek measuring 10 mg/L or the state water quality standard for drinking water.
- A majority of sites sampled exceeded target TP concentrations with Treaty Creek and Burr Creek samples measuring approximately 0.2 mg/L.
- One quarter of sample sites exceeded target TSS concentrations with Burr Creek measuring 60 mg/L.
- Additionally, 75% of sites sampled contained E. coli concentrations in excess of state standards (235 col/100 mL) with Treaty Creek measuring nearly five times the state standard concentration.

### 3.2.7 Stream Reach Characterization and Evaluation Report (2003)

The City of Wabash is required to complete a Stream Reach Characterization Evaluation Report (SRCER) as a component of the city's Combined Sewer Overflow (CSO) permit. The purpose of the SRCER was to provide the city with water quality information which assesses the potential impacts of the CSOs on water quality and to enable technically sound evaluation and planning. The SRCERs included evaluation of historically collected and current water quality data (United Consulting, 2003).

In 2003, United Consultants completed a SRCER for the City of Wabash. As part of this project, the City of Wabash assessed stormwater impacts from two CSO locations (CSO 002 and CSO004) as these are representative of the north of Wabash River and south of Wabash River systems, respectively, as well as the resulting impact of these overflows on the Wabash River. Samples were collected at 15-minute intervals for the first hour of discharge and 30-minute intervals for the next three hours if discharge occurred. During the final sampling event, samples were taken every 30 minutes until discharge ceased. Samples were analyzed for *E. coli*, BOD, pH, total suspended solids, dissolved oxygen, and temperature. Additionally, three receiving streams were sampled during three wet weather and three dry weather periods. Stream samples were analyzed for heavy metals, cyanide, BOD, pH, total suspended solids, dissolved oxygen, temperature, and *E. coli*. Based on the City of Wabash's SRCER, the following conclusions have been drawn:

- *E. coli* concentrations are elevated in Priser Ditch, Charley Creek, and the Wabash River with higher concentration observed during wet weather events than during dry weather events.
- Priser Ditch contained *E. coli* concentrations ranging from 1,000-39,000 col/100 mL during wet weather events.
- Charley Creek contained *E. coli* concentrations ranging from 10 to 1,100 col/100 mL at the upstream site and from 600 to 2,600 col/100 mL at the downstream site during dry weather to 9,200 to 190,000 col/100 mL at the upstream site and 30,000 to 170,000 col/100 mL at the downstream site during wet weather events.
- The Wabash River contained *E. coli* concentrations which ranged from 130 to 900 col/100 mL at the upstream site and from 350 to 1000 col/100 mL at the downstream site during dry weather and from 2,800 to 3,800 col/100 mL at the upstream site and 26,000 to 160,000 col/100 mL at the downstream site during wet weather events.

- CSO002 samples contained elevated BOD concentrations ranging from 12 to 82 mg/L during wet weather sampling. *E. coli* concentrations were also elevated with concentrations ranging from 120,000 to 5,900,000 col/100 mL. TSS concentrations ranged from 28 to 650 mg/L during the three storm events.
- CSO004 samples contained elevated BOD concentrations ranging from 14 to 120 mg/L during wet weather sampling. *E. coli* concentrations were also elevated with concentrations ranging from 130,000 to 3,300,000 col/100 mL. TSS concentrations ranged from 2 to 640 mg/L during the three storm events.

### 3.2.8 Manchester University Redside Dace Assessment (2008-2012)

Manchester University, via a State Wildlife Grant, completed a monitoring project to determine the distribution, abundance, habitat, prey selectivity and spawning habits of the state endangered redside dace in the Mill Creek drainage from 2008 through 2012 (Sweeten, 2009; Sweeten, 2010; Sweeten, 2011; Sweeten, 2012; Sweeten et al., 2013). As part of this project, Manchester University determined the genetic makeup of the Mill Creek redside dace population, developed a mechanism to model suitable redside dace release sites for population augmentation, and developed redside dace rearing protocols and tested the habitat selection model via release trials. In 2008, Manchester University established baselines for physical, biological and chemical parameters in Mill Creek through the completion of pebble counts, QHEI assessment, and IBI scoring as well as collection of nitrate, phosphorus, dissolved oxygen, conductivity and suspended sediment concentrations measured weekly. In 2010, redside dace were relocated from Mill Creek to Asher Branch and physical and habitat parameter monitoring occurred within both streams. Based on the Manchester University redside dace study, the following conclusions have been drawn:

- At the start of the study period, redside dace was found in only two streams: Mill Creek in the Treaty Creek-Wabash River Watershed and Hannah Creek in Wayne County.
- Redside dace are widely distributed throughout Mill Creek where they are limited to pools measuring approximately 1 meter deep in areas of heavy shade from adjacent riparian vegetation.
- IBI scores ranged from 36 to 52 with the fish community rating as good to excellent in Mill Creek and Asher Branch.
- QHEI scores ranged from 80 to 90 suggesting good quality habitat within some reaches in the Mill Creek and Asher Branch drainages.
- In 2010 and 2011, approximately 500 redside dace were moved from Mill Creek to the Asher Branch. Early results verify limited spawning in Asher Branch with young of the year1 and 2 juveniles observed.

### 3.2.9 Indiana American Water Assessment

Indiana American Water monitors the Wabash River at State Road 15 as part of their wellhead protection plan.

### 3.2.10 IDNR Non-Game Assessment (2008)

In 2008, the Indiana Department of Natural Resource assessed freshwater mussel communities within three reaches of the Wabash River within the Treaty Creek-Wabash River Watershed (IDNR, unpublished). Sampling occurred at CR 700 West, at CR 100 North, and at CR 350 East. In total, 46 species were identified. The deertoe and pimpleback were the common species identified. Three state endangered species including round hickory nut, eastern fanshell pearlymussel, snuffbox, and rayed bean were identified during this assessment.

### 3.2.11 Wabash River Fishery Assessment: Ball State University (2001-2017)

Ball State University continued Jim Gammon's Wabash River assessment efforts starting in 2001 and continuing with an annual assessment through present day (Pyron and Lauer, 2009; Pyron, unpublished). The most recently reported effort included assessment of the fish community and field water chemistry in 500 feet reaches throughout the Middle Wabash. Sampling occurred along four reaches within the Treaty Creek-Wabash River Watershed. Data collected throughout the Middle Wabash indicate relatively similar numbers of individuals (113 in 2017; 116.2 average) and numbers of species per collection (2001 to 2017). Based on these data, the following conclusions can be drawn:

- pH and dissolved oxygen concentrations were elevated along the Wabash River; however, none of the concentrations exceeded the target value.
- The highest species diversity occurred in the below City of Wabash sampling reach with this same reach containing the highest density.
- The lowest density and diversity occurred in the Salamonie reach. Pyron and Lauer (2004) noted that habitat is likely a contributing factor to both high and low densities and diversities.
- All sites possessed IBI scores which exceeded the score at which IDEM indicates streams are not meeting their aquatic life use designation.

### 3.2.12 IDNR Fisheries Assessment (2008)

In July 1999, the Indiana Department of Natural Resources (IDNR) surveyed the length of the Wabash River in 48 one-half to one-mile segments. Habitat and general chemistry data were collected concurrent with the fish community assessment. Three segments were located within the watershed; these occurred downstream of the Salamonie Dam outlet, at the City of Wabash, and at the Wabash-Miami County line. During the assessment, between 26 and 34 species and 393 and 396 individuals were collected. In total, 117 species were identified during the assessment. Common carp, river carpsucker, and shorthead redhorse were collected in highest numbers within these reaches. Based on these data, the following conclusions can be drawn:

- Habitat is readily available within these three reaches score between 63 and 75. Water clarity was also low measuring between 11 and 18 inches. Dissolved oxygen concentrations were elevated measuring greater than 11.5 mg/L in each reach.
- Stefanavage (2007) indicated that distribution of species was most explained by individual species biology and its habitat preference rather than any impact from upstream dams or water quality impacts.

### 3.2.13 The Nature Conservancy Wabash River Study

The Nature Conservancy compiled a database of biological, stressor, and threat data for the Wabash River and its tributaries (Armitage and Rankin, 2009). The data were then used to analyze water quality and fish community information on an 11-digit watershed level. Although no new data were collected as part of this study, their analysis methods allow conclusions to be drawn which can be used to compare this watershed with others along the length of the Wabash River. Based on data collected, the following conclusions can be drawn:

- An ideal habitat (QHEI) score for this portion of the Wabash River based on 1800s conditions is 93.5. At that time, habitat would have rated as excellent to near maximum scores for most metrics.
- This segment of the Wabash River was historically home to riffles. TNC hypothesized that increased flashiness, increased peak flows, and modifications in meander patterns occur within the Wabash River in the Treaty Creek-Wabash River Watershed.

- The fish community in this reach is generally lacking in sensitive species with common carp and river redhorse dominating the population.
- Total phosphorus and nitrate-nitrogen concentrations are elevated within the mainstem and tributaries in this reach. The elevated nutrient concentrations present in the tributaries, coupled with the lack of buffers, increased delivery of nutrients via drainage systems and tile drains, and degradation of instream habitat due to altered hydrology.

### 3.2.14 Purdue University Sturgeon Sampling (2003-2004)

Shovelnose sturgeon populations within the Wabash River were assessed by Kennedy et al. (2006) from April 2003 through November 2004. Sturgeon were assessed in two reaches of the Wabash River: near Richvalley and near Peru to determine relative abundance, size, age structure, growth, mortality rate, condition, and gender ratio. Based on these data, the following conclusions can be drawn:

- Relative abundance of shovelnose sturgeon measured greater in the upper reach during the spring than abundances measured in the lower reach. This is likely due to upstream migration associated with spawning activities. This migration suggests that the upper reach contains suitable shovelnose sturgeon spawning habitat that may significantly contribute to sustaining the overall shovelnose sturgeon population.
- Population characteristics observed by Kennedy et al. (2006) indicate that the Wabash River shovelnose sturgeon population is similar to populations reported in other river systems. However, despite shovelnose sturgeon attaining larger body sizes, reaching older age classes, and experiencing lower mortality rates, growth rates and relative weights were lower than those observed in other river systems.

### 3.2.15 Hoosier Riverwatch Sampling (2001-2011)

In 2009 and again in 2018-2019, volunteers trained through the Hoosier Riverwatch program assessed stream sites within the Treaty Creek-Wabash River Watershed. Assessments occurred sporadically with some sites assessed only once during the reporting period, while others were monitored more often. Volunteers monitored stream stage, flow rate, and discharge; collected water chemistry samples for analysis using HACH test kits; assessed instream habitat using the Citizen's QHEI; and surveyed the stream's macroinvertebrate community. Using the chemical data, the Water Quality Index (WQI) was calculated. Volunteers calculated a Pollution Tolerance Index (PTI) using the biological data. Based on these data, the following conclusions can be drawn:

- Ross Run was analyzed once in 2009 with all parameters falling within standard concentration. Habitat score 68, which rates as good.

## 3.3 <u>Current Water Quality Assessment</u>

### 3.3.1 Water Quality Sampling Methodologies

As part of the current project, the Wabash River Defenders implemented a one-year water quality monitoring program. The program included biweekly water chemistry monitoring and biological (fish and macroinvertebrate) and habitat assessments once during the first year of the planning project. Additionally, the project implemented a volunteer monitoring program to assess water chemistry and macroinvertebrate communities. The program is detailed below and in the Quality Assurance Project Plan for Treaty Creek-Wabash River Watershed Management Plan approved on January 22, 2018. Sites sampled through this program are displayed in Figure 27. Sample sites were selected based on the largest tributary drainage areas to the Wabash River and included high priority drainages including those that are known to receive combined sewer overflows or are suspected to be home to high quality natural communities or ETR species. The biweekly sampling regimen was enacted to create a baseline of water quality data.

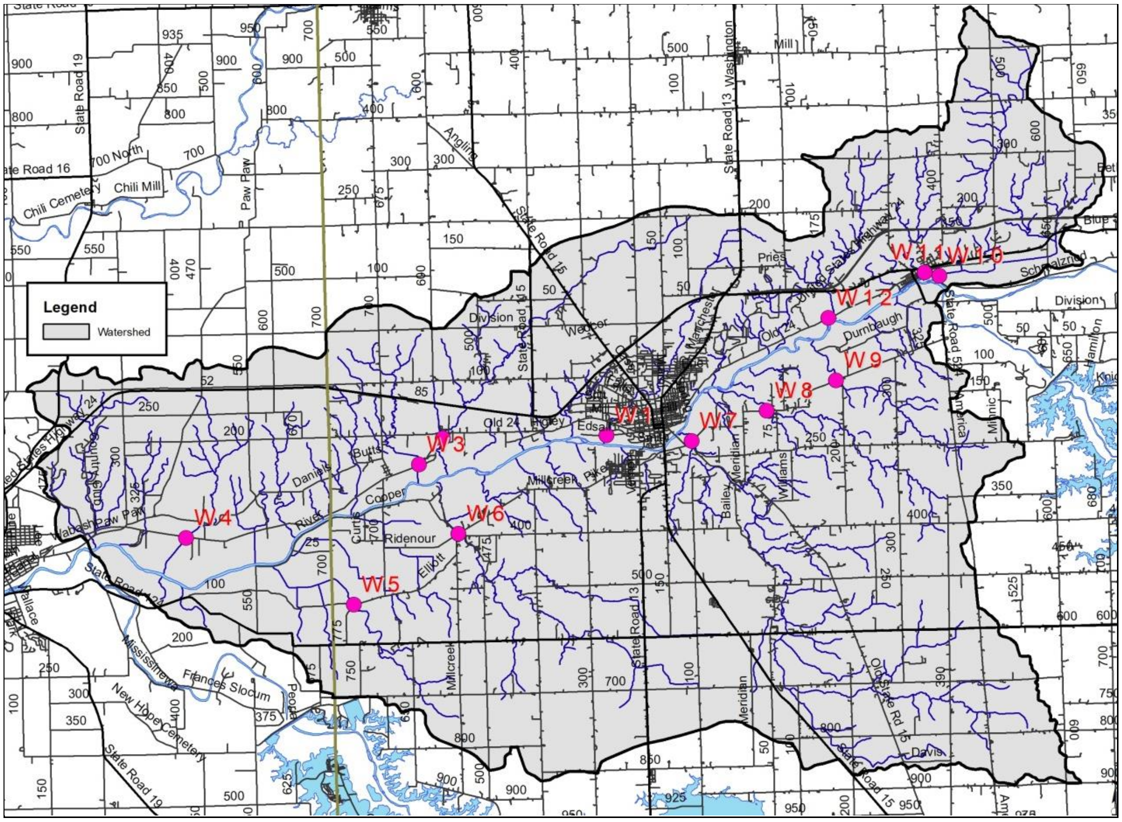


**Figure 27. Sites sampled as part of the Treaty Creek-Wabash River Watershed Management Plan.**

## Stream Flow

Stream flow was measured *in situ* when grab samples were collected. Stream flow was calculated by scaling stream flow measured at the U.S. Geological Survey (USGS) Wabash River near Wabash, Indiana (USGS Gage 03325000) to subwatershed drainage area during high flow events and for creation of flow duration curves.

## Field Chemistry Parameters

The Treaty Creek-Wabash River project established twelve chemistry monitoring stations as part of the monitoring program. Stations are located at the outlets of major tributaries including Charley Creek, Kentner Creek, Harlan Branch, Daniel Creek, Asher Branch, Mill Creek, Treaty Creek, Burr Creek, Ross Run, Ruger Creek, Lagro Creek, and Enyeart Creek. Dissolved oxygen, temperature, pH, turbidity, and conductivity were measured biweekly at the sampling stations from March 2018 to March 2019. Appendix D details the parameters measured and potential impacts to particular parameters.

## Laboratory Chemistry Parameters

Like the field parameters, biweekly laboratory sample collection and analysis occurred throughout the one-year sampling program. Samples were analyzed for nitrate-nitrogen, total phosphorus, total suspended solids, and *E. coli*. Appendix D details the parameters measured and potential impacts to particular parameters.

**Macroinvertebrate Community Assessment**
Macroinvertebrates were collected during base flow conditions using the multihabitat approach detailed in IDEM Protocols for the collection and calculation of the macroinvertebrate Index of Biotic Integrity. The macroinvertebrate samples were processed using the laboratory processing protocols detailed in the IDEM protocol. Organisms were identified to the genus level.

**Fish Community Assessment**
Data from fish community sampling at each of the sites in the Treaty Creek-Wabash River Watershed were used to calculate the Index of Biological Integrity for the Central Corn Belt Plains (Simon, 1991). Owen and Karr (1978) found that natural streams support fish communities of high species diversity. Fish communities in natural streams are seasonally more stable than the fish communities of modified streams. "Structurally diverse natural streams typically have a great deal of buffering capacity: meanders tend to moderate the effect of floods, pools offer excellent refuges for fishes during dry periods, and tree shade decreases heat loads and minimizes the oxygen-robbing effect of decomposing and extensive algal blooms" (Karr and Schlosser, 1977). Many endangered species are restricted to specific habitat complexes within streams and have become endangered as a result of habitat loss, fragmentation, or pollution.

**Habitat**
The physical habitat at each of the biological sample sites was evaluated using the Qualitative Habitat Evaluation Index (QHEI). The Ohio EPA developed the QHEI for streams and rivers in Ohio (Rankin, 1989, 1995) and the IDEM adapted the QHEI for use in Indiana. Commonwealth Biomonitoring assessed habitat at all twelve sites in the summer of 2018. Appendix D details the QHEI and its individual metrics.

### 3.3.2 Field Chemistry Results

**Temperature**

Figure 28 illustrates the biweekly temperature measurements in Treaty Creek-Wabash River Watershed stream. As shown, temperatures measure approximately the same at each of the stream sites with seasonal changes in temperature creating major differences in temperature throughout the sampling period. Temperatures measured near 0°C in all streams from January through March 2018 and again in November 2018 through March 2019 sampling events. The highest temperatures occurred during the June, July and August assessments depending on riparian cover and stream depth present at each location.

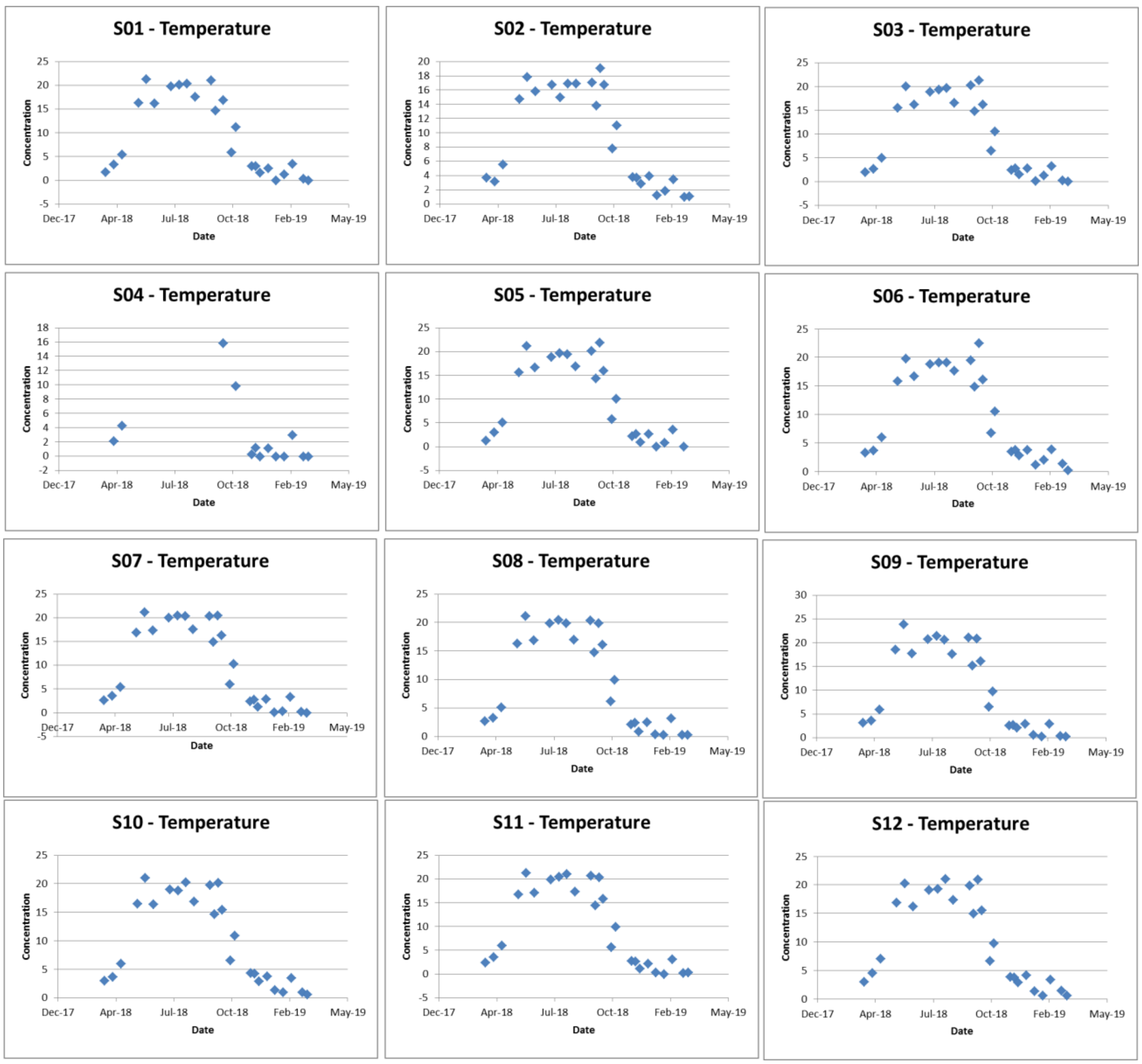


**Figure 28. Temperature measurements in Treaty Creek-Wabash River samples sites from March 2018-March 2019.** Note differences in scale along the concentration (y) axis.

## Dissolved Oxygen

The dissolved oxygen meter consistently malfunctioned measuring dissolved oxygen at all sites as less than 3 mg/L throughout summer 2018 sampling. The meter probe was replaced by the manufacturer. Dissolved oxygen concentrations also display seasonal changes like those observed for temperature. However, as shown in Figure 29, dissolved oxygen concentrations are opposite those measured for temperature. This is as expected as colder water holds more dissolved oxygen than warmer water; therefore, when water temperatures are low, dissolved oxygen concentrations are high and vice-versa. As such, the dissolved oxygen graph shows a general pattern where dissolved oxygen concentrations are higher in winter and lower in summer. All streams display variation in dissolved oxygen concentration due to individual conditions present within each system. The lowest dissolved oxygen concentrations occurred at all sites during October 2018 where all sites' dissolved oxygen levels measured below the state standard (5 mg/L). Highest concentrations were recorded when streams were near or below freezing temperatures in January to March 2019.

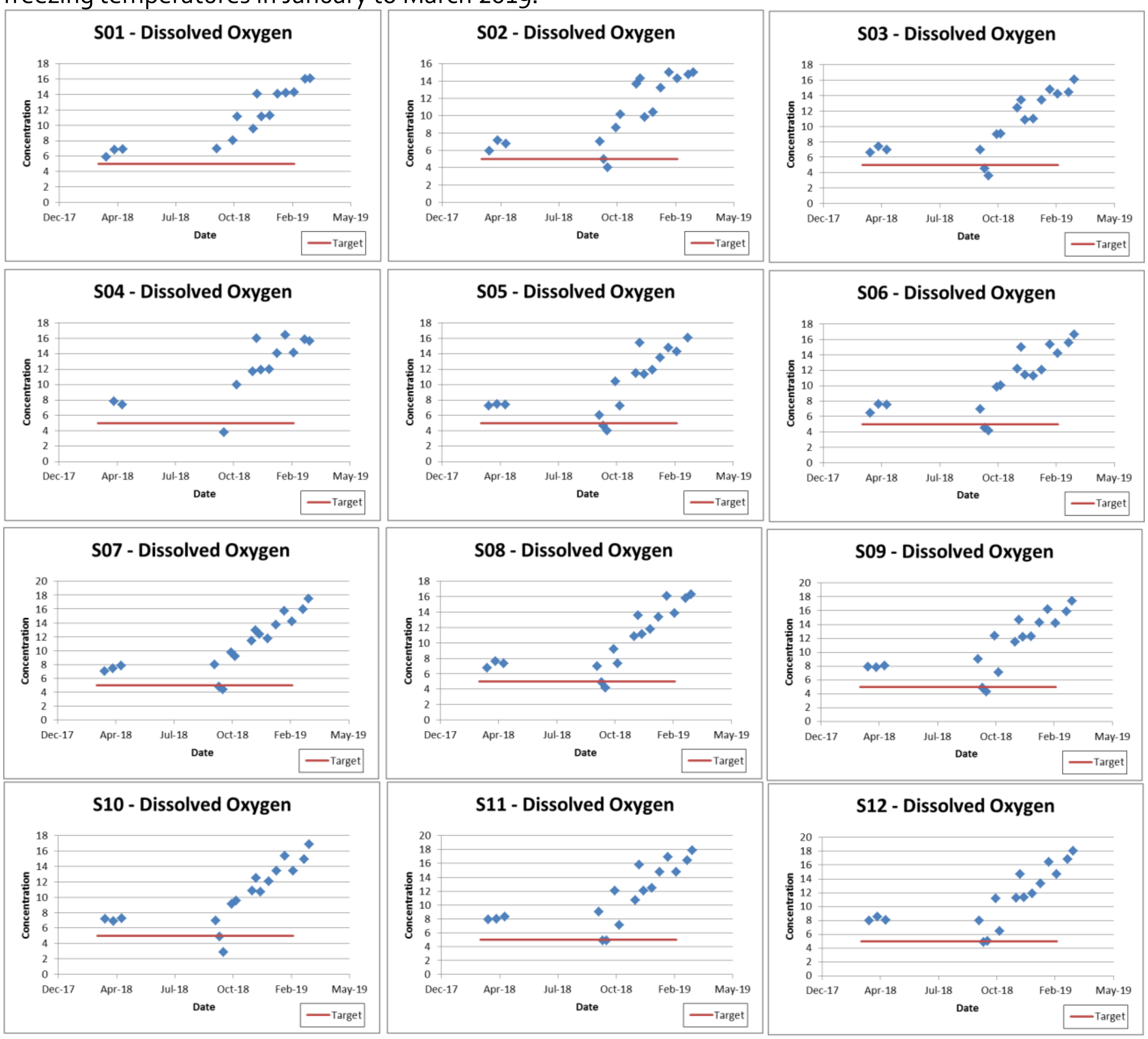


**Figure 29. Dissolved oxygen measurements in Treaty Creek-Wabash River samples sites from March 2018-March 2019.** Note differences in scale along the concentration (y) axis.

## pH

Throughout the sampling period, pH generally remained in an acceptable range in all watershed streams. No discernible pattern can be found in pH levels in any of the monitored streams (Figure 30). In March and April, pH levels measured below the lower pH target (6.0), while pH never measured above the upper pH target (9.0). Low pH levels occurred at all sites during the June 24 and October 4 sampling events when stream conditions were at their lowest flow conditions.

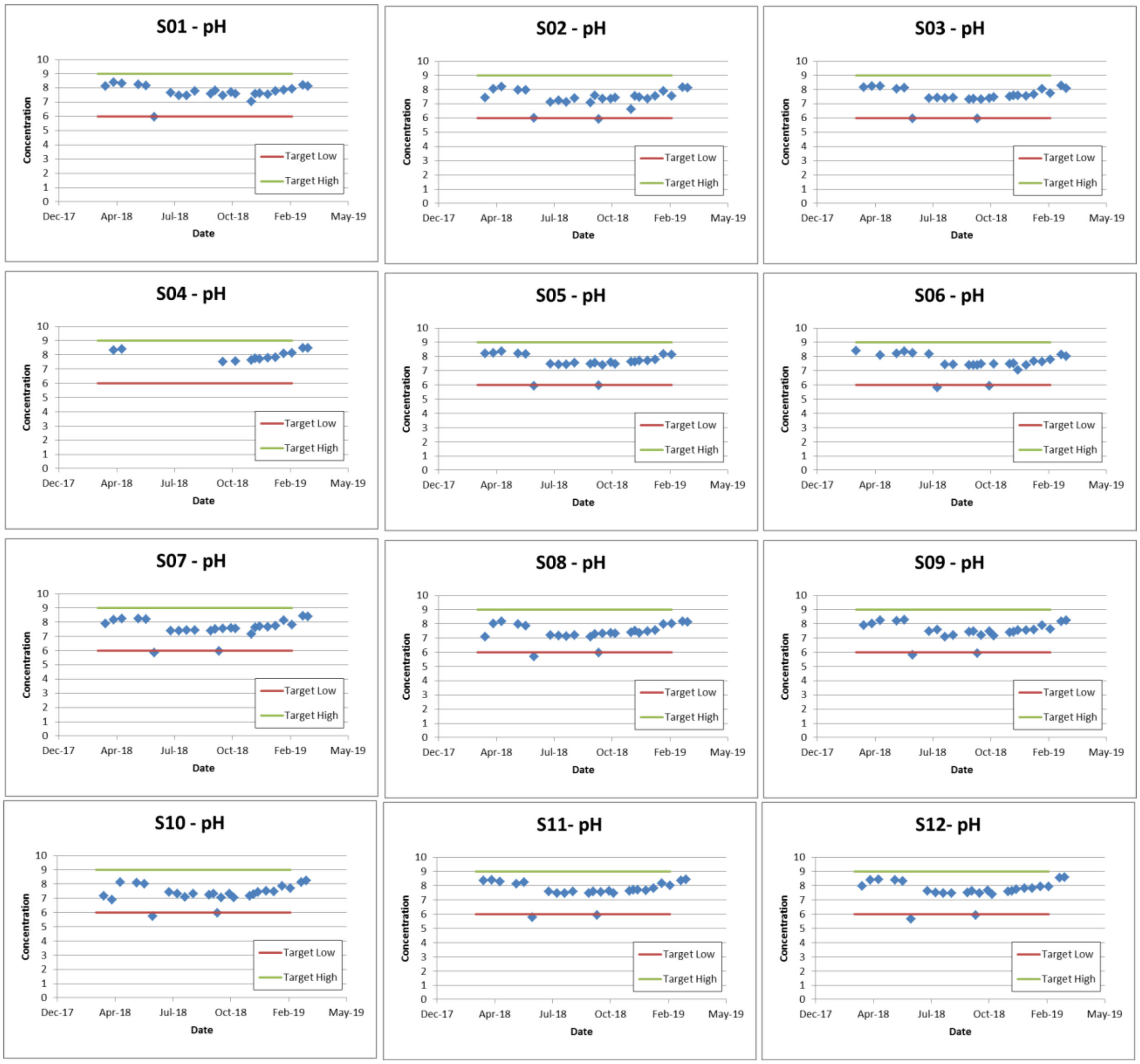


**Figure 30. pH measurements in Treaty Creek-Wabash River samples sites from March 2018-March 2019.** Note differences in scale along the concentration (y) axis.

**Specific Conductivity**

Figure 31 displays conductivity measurements in Treaty Creek-Wabash River Watershed streams. Conductivity measurements varied greatly over the sampling period but never exceeded state standards.

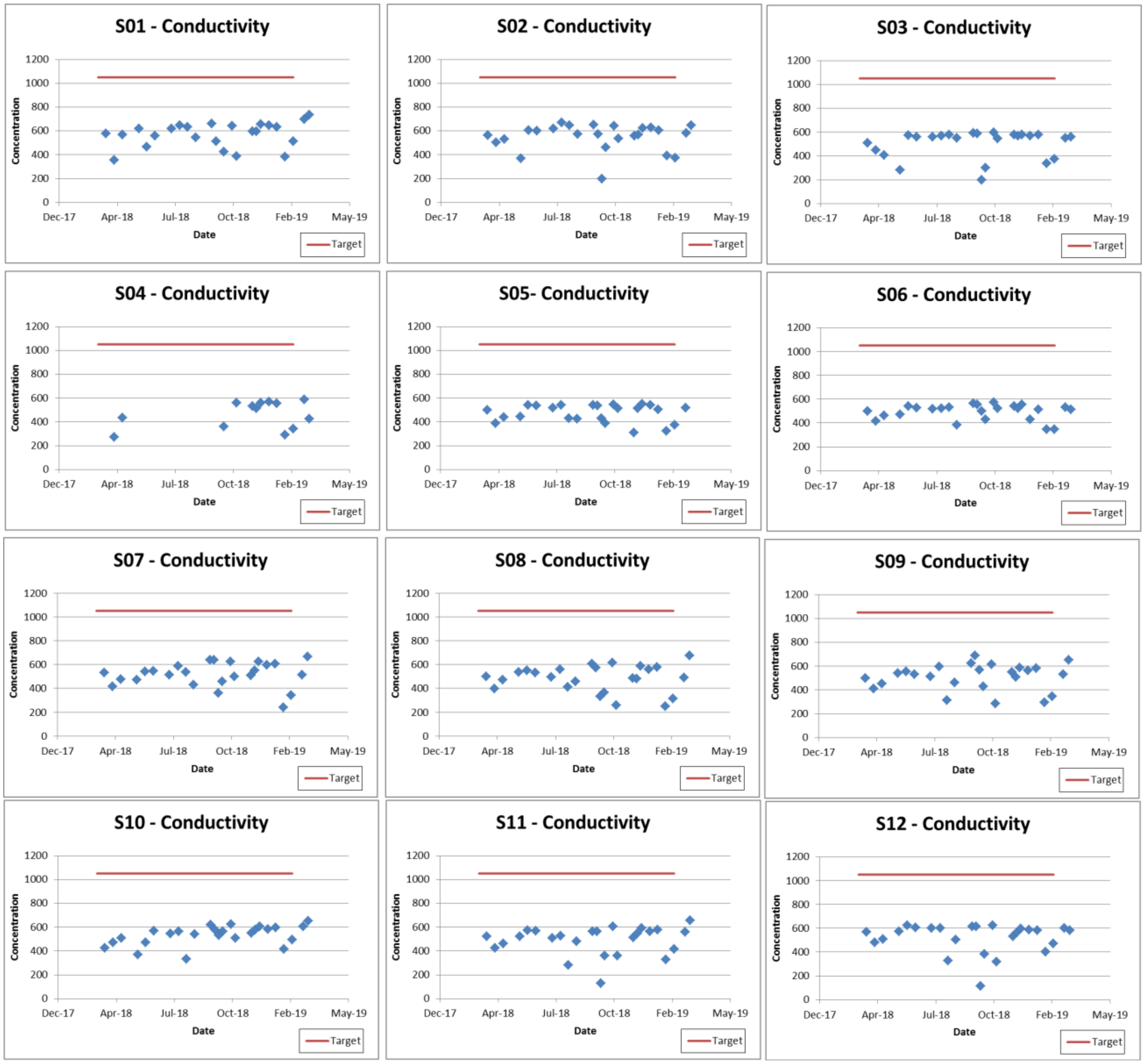


**Figure 31. Conductivity measurements in Treaty Creek-Wabash River samples sites from March 2018-March 2019.** Note differences in scale along the concentration (y) axis.

### Turbidity

Turbidity measurements for Treaty Creek-Wabash River Watershed streams are displayed in Figure 32. Turbidity concentrations exceeded the target in 32% of collected samples. Turbidity tends to spike during high flow events and this can be observed at several sites throughout the sampling season. Most exceedances in the Treaty Creek-Wabash River Watershed measured just above the target (25 NTU). The highest turbidity levels occurred in Site 8 with turbidities as high at 144 NTU observed in March 2018.

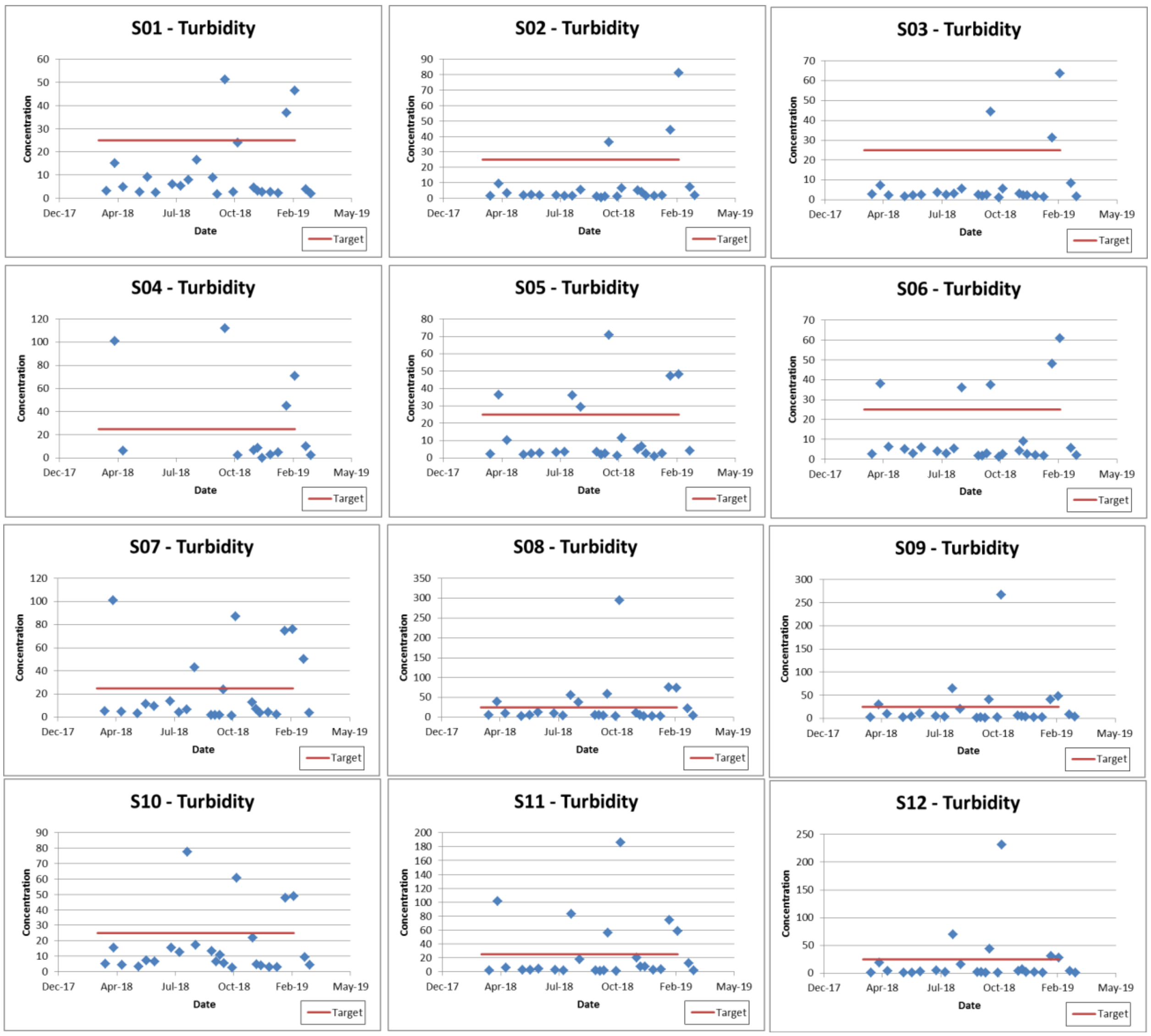


**Figure 32. Turbidity measurements in Treaty Creek-Wabash River samples sites from March 2018-March 2019. Note differences in scale along the concentration (y) axis.**

### 3.3.3 Water Chemistry Results

Figure 33 to Figure 40 display results for nitrate-nitrogen, total phosphorus, total suspended solids, and E. coli collected biweekly from twelve locations in the Treaty Creek-Wabash River Watershed. Data are displayed in comparison to target concentration and on load duration curves during the sample period. Appendix D details individual measurements collected throughout the sampling period.

## Nitrate-nitrogen

Figure 33 displays nitrate-nitrogen concentrations compared to target levels (1.5 mg/L). Nitrate-nitrogen concentrations generally measured the highest during the spring, falling throughout the summer and increasing again in the fall. Elevated nitrate-nitrogen concentrations were observed during peak flows during the summer as well. The highest concentrations occurred in March and November 2018. Nitrate-nitrogen concentrations exceeded targets in 69% of collected samples suggesting that flow condition does not impact sources of nitrate-nitrogen in the Treaty Creek-Wabash River Watershed. The highest average concentrations occurred in Sites 02, 03 and 06, Kentner Creek, Carlin Branch and Mill Creek, respectively with average concentrations measuring above 3 mg/L at each site. All sites except Burr Creek (08) and Ross Run (09) averaged nitrate-nitrogen concentrations higher than the median concentration at which biological communities are impaired.

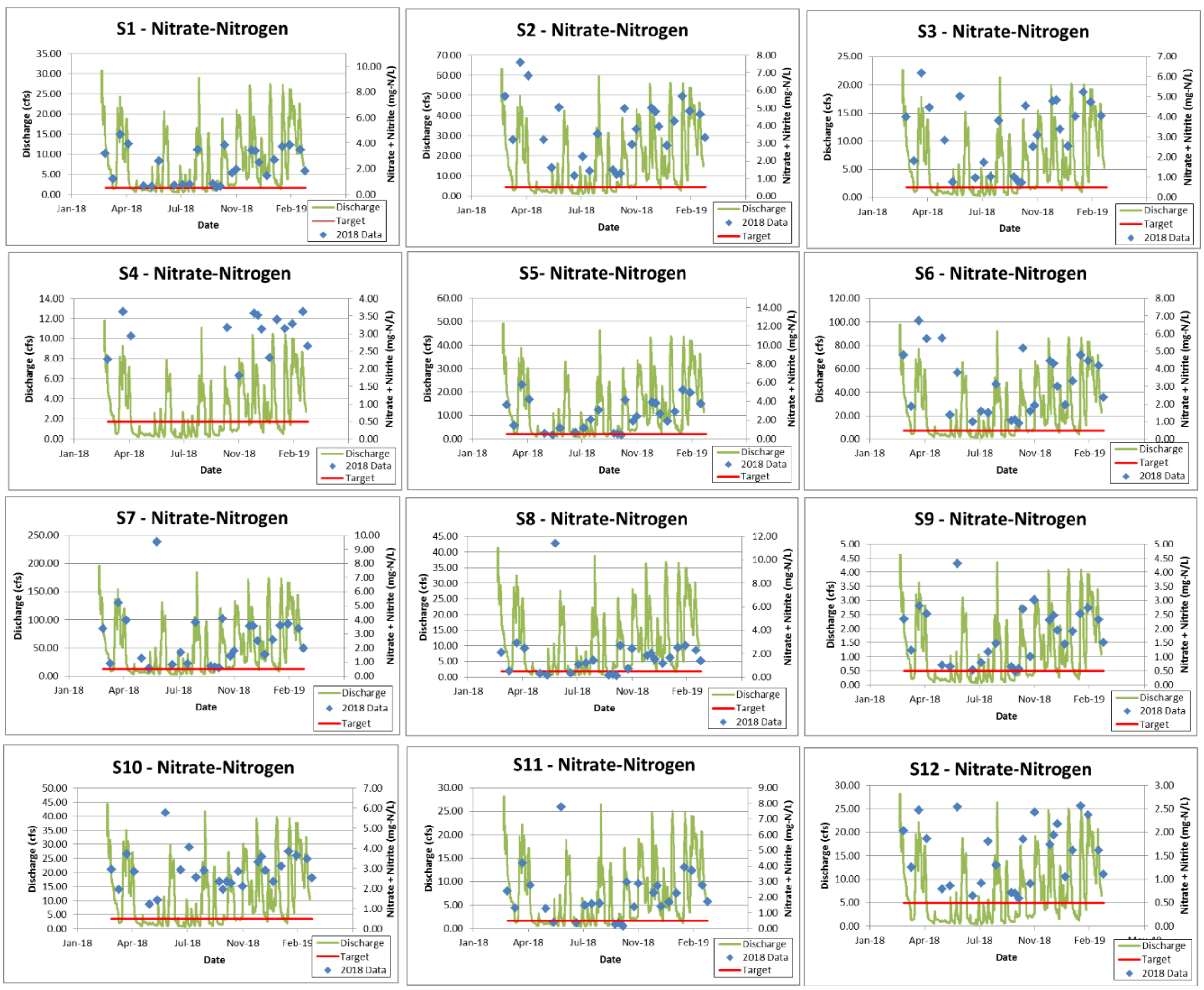


**Figure 33. Nitrate-nitrogen concentrations measured in Treaty Creek-Wabash River sample sites March 2018-March 2019.** Note differences in scale along the concentration (y) axis.

### Total Phosphorus

Total phosphorus concentrations exceed target concentrations in 45% of samples (Figure 34). The highest concentrations occurred during high flow events – each site contained high total phosphorus concentrations during different sampling events. Concentrations measured throughout the watershed measured in excess of the level at which total phosphorus concentrations impair biological communities (0.07 mg/L) with most exceedances occurring in concert with high flow events. Sites 11, 08 and 09, Lagro Creek, Burr Creek and Ross Run, contain the highest average concentration (0.46, 0.42 and 0.32 mg/L, respectively).

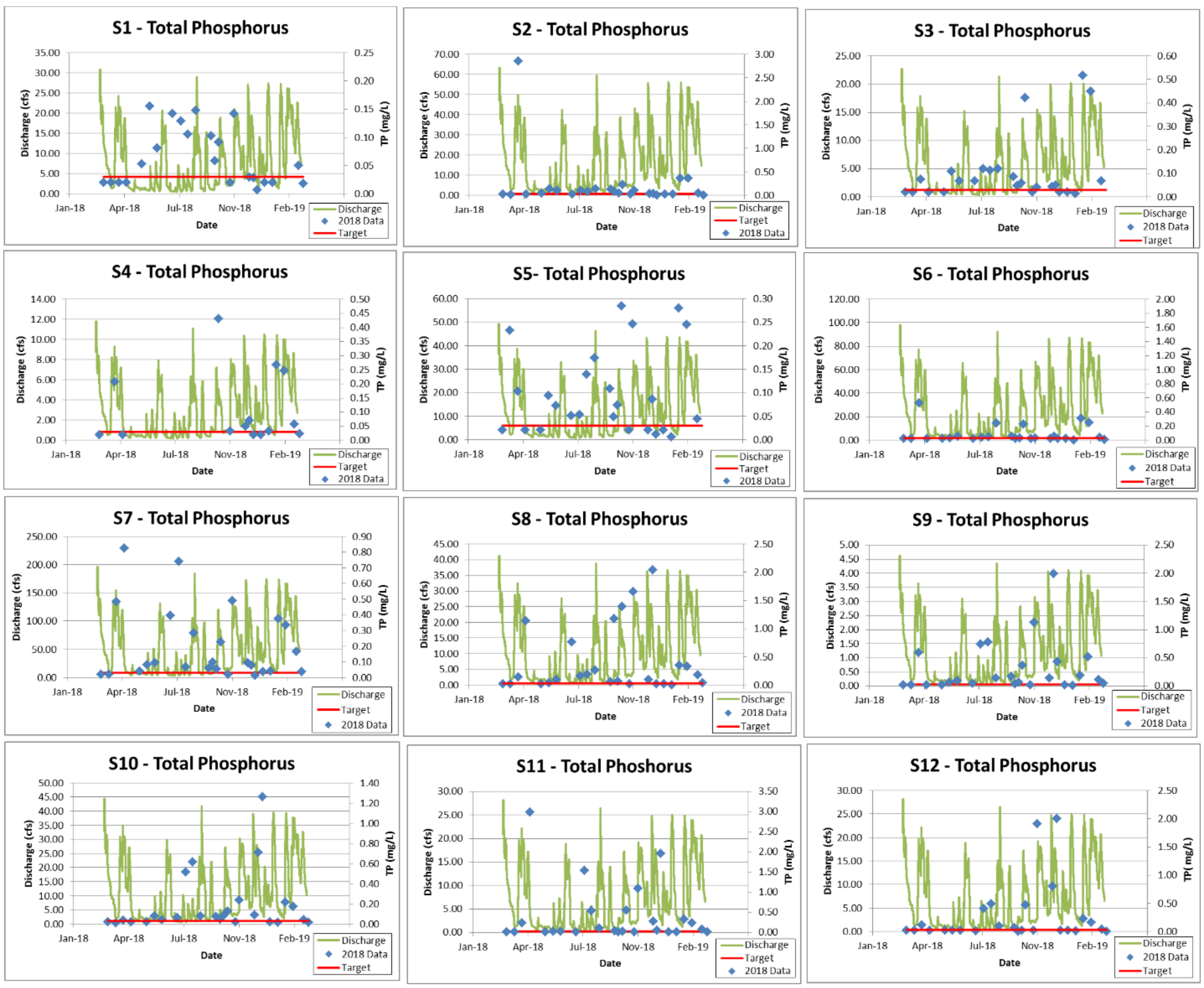


**Figure 34. Total phosphorus concentrations measured in Treaty Creek-Wabash River samples sites from March 2018-March 2019.** Note differences in scale along the concentration (y) axis.

## Total Suspended Solids

Total suspended solids (TSS) levels measured above target levels during high flow events (Figure 35) with 12% of samples exceeding target concentrations. Sites 04 and 09 contained the highest average concentrations measuring over 21 mg/L on average and exceeding targets in 25% or more collected samples. It should be noted that Site 04 was typically dry with samples collected during less than half of the monitoring events.

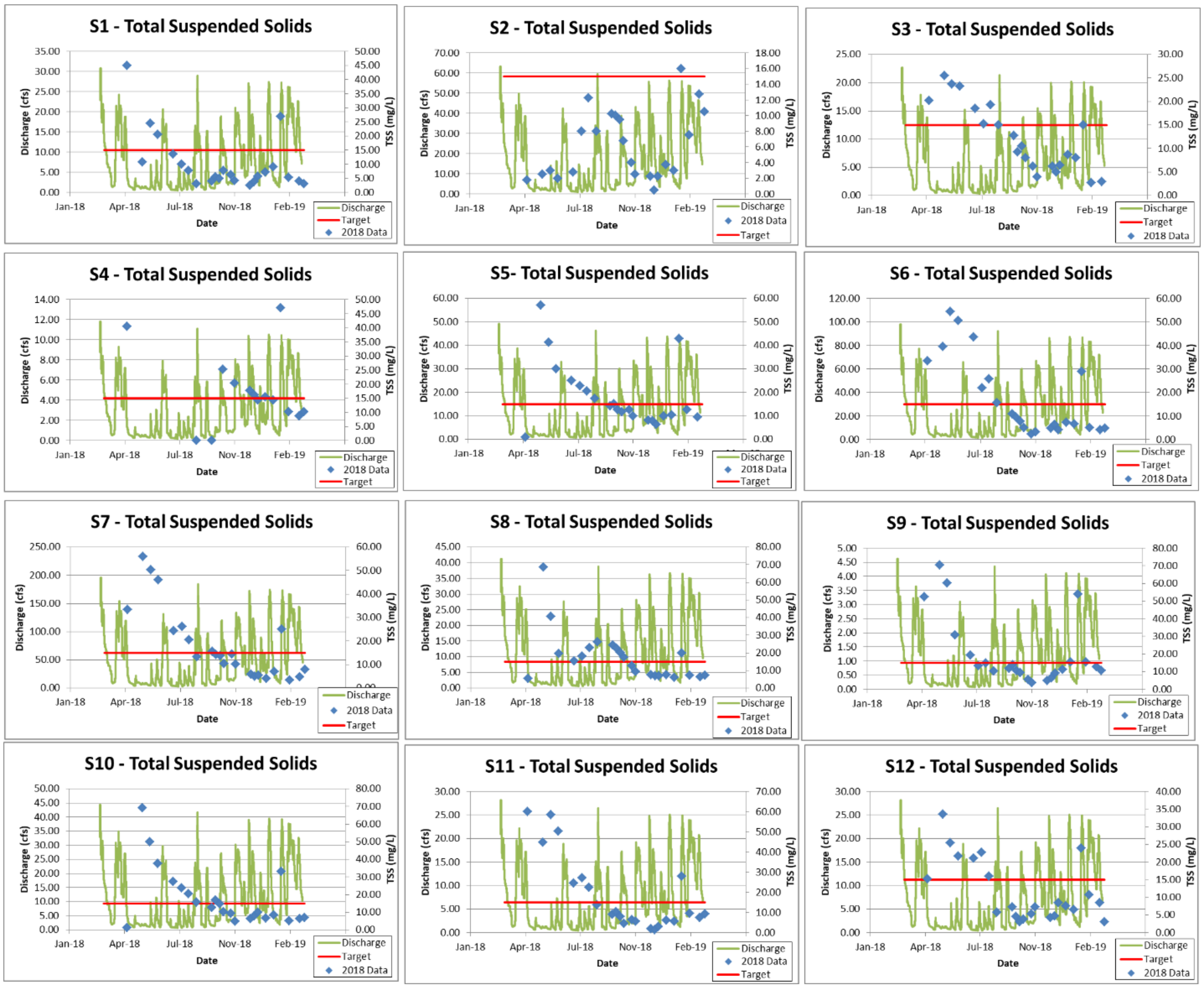


**Figure 35. Total suspended solids concentrations measured in Treaty Creek-Wabash River samples sites from March 2018-March 2019.** Note differences in scale along the concentration (y) axis.

### E. coli

E. coli concentrations observed at Treaty Creek-Wabash River Watershed sites are shown in Figure 36. E. coli concentrations exceed state standards in 75% of collected samples. Site 11, 08 and 05 contained E. coli concentrations where were elevated during various flow conditions and contained the highest average E. coli concentrations measuring 896, 858 and 803, respectively. All Treaty Creek-Wabash River Watershed sites possessed average E. coli concentrations in excess of state standards (235 col/100 mL). Sites 01 and 12 contained the lowest average E. coli concentrations with concentrations greater than 263 col/100 mL. E. coli exceedances at most sites appear to coincide with flow conditions with many sites containing elevated E. coli concentrations under elevated flow conditions.

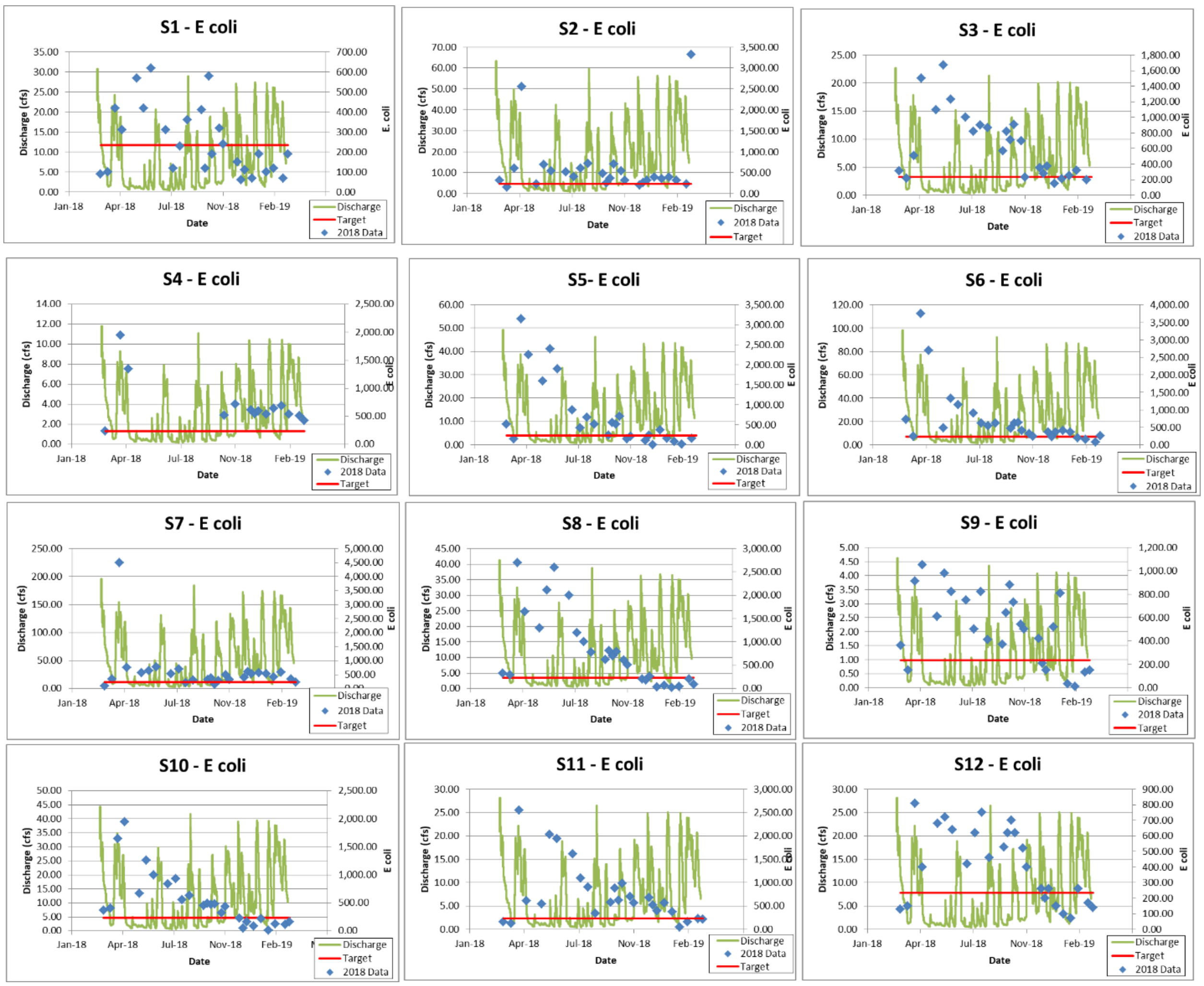


**Figure 36. E. coli concentrations measured in Treaty Creek-Wabash River samples sites from March 2018-March 2019.** Note differences in scale along the concentration (y) axis.

### 3.3.4 Load Duration Curves

Load duration curves allows for comparison of instream loading with stream flow so that conditions of concern can be identified. The load duration curves present the flow characteristics for the twelve systems during the time of study from March 2018 to March 2019. Data used for the curves were calculated by scaling flow measured at Wabash River near Wabash, Indiana. Wabash River stream flow measured at the U.S. Geological Survey gauge was scaled to watershed size for each of the twelve monitoring stations as follow:

observed flow (cfs)) x (conversion factor) x (target concentration or state criteria) = total load /day

The individual load duration curves, also known as the allowable load curves, are displayed below (Figure 37 to Figure 40). In the graphs, the total daily load of each contaminant sample result (points) is plotted against the "percent time flow is exceeded" for the day of sampling (curve). Those points above the curve exceed the state criterion or target concentration. Values on a load duration curve can be grouped by hydrologic condition to help identify possible sources and conditions that result in the material being present in the system under those flow conditions. Most often, the flow ranges fall in High (0 to 10), Moist (10-40), Mid-Range (40-60), Wet (60-90), and Low (90-100). Exceedances falling in the moist range (10-40) are typically associated surface runoff or stormwater loads, while exceedances associated with the dry zone are most often associated with dry conditions. These exceedances are suggested to result from point sources that are the most likely source.

## Nitrate + Nitrite-nitrogen Load Duration Curves

Nitrate + Nitrite loads tend to measure higher than target concentrations at most sites during all conditions (Figure 37). S09, S11 and S12 nitrate-nitrogen loading rates measured above target levels more than 75% of the time. This suggests that a steady stream of nitrate-nitrogen is available within these subwatersheds. S01, S02, S03, S07, and S08 typically contain elevated nitrate-nitrogen during high flow conditions only. This suggests that under normal flow conditions, nitrogen is washed into the stream and that it may enter when sediment enters.

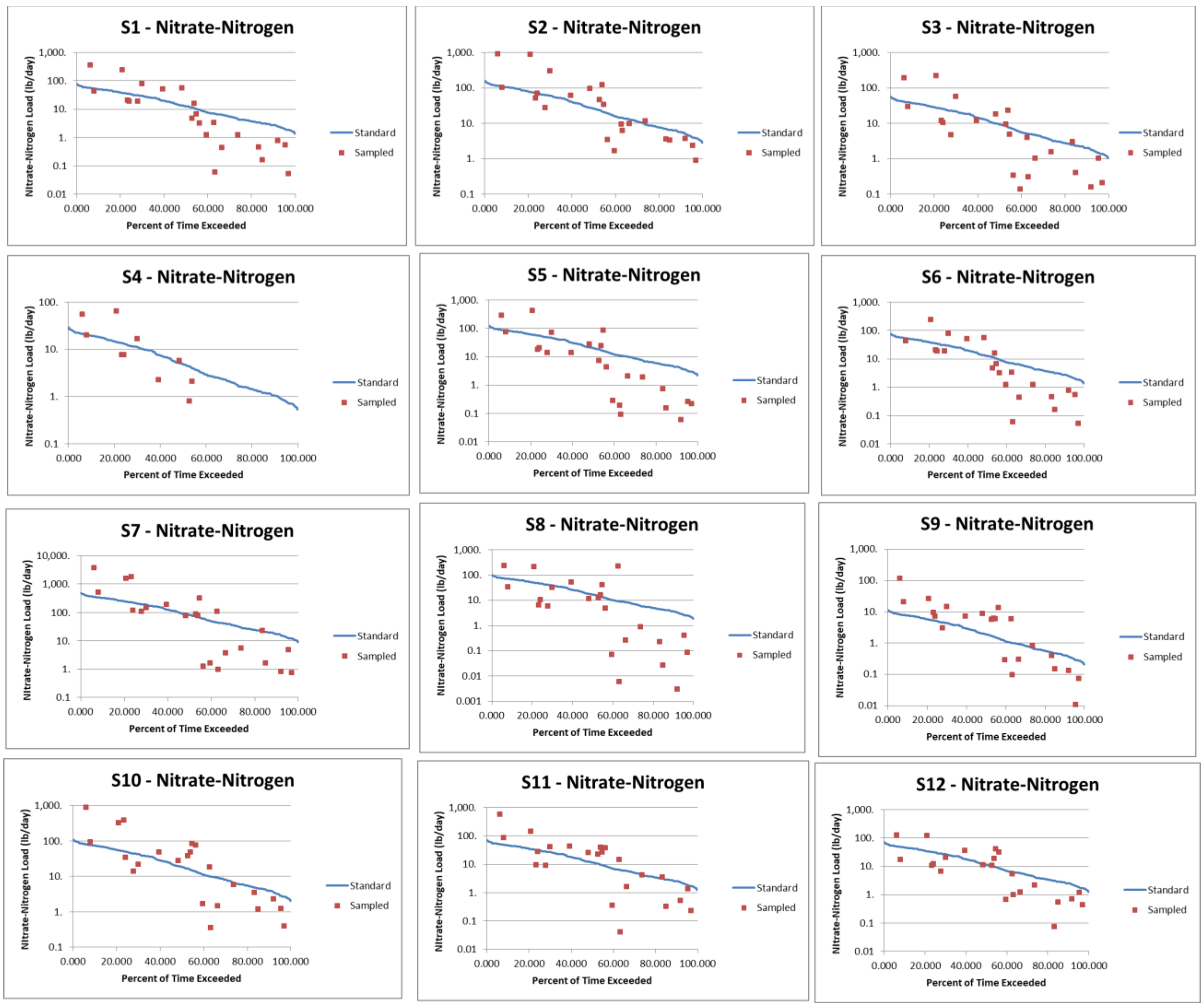


**Figure 37. Nitrate-nitrogen load duration curves for Treaty Creek-Wabash River samples sites from March 2018-March 2019.**

### Total Phosphorus Load Duration Curves

Total phosphorus (TP) levels generally measured above target levels under all flow conditions (Figure 38). This is somewhat surprising considering that most total phosphorus enters streams attached to suspended solids. Exceedances of the target levels occurred under storm flow conditions at all sites; however, exceedances were more prevalent under storm flow conditions at sites S01, S02 and S06 suggesting erosion or runoff is the cause of these values. S07, S09, S08, S11 and S12, exceeded target levels under both low flow conditions and high flow conditions. This suggests that a steady stream of total phosphorus is present in much of the Treaty Creek-Wabash River Watershed under all conditions.

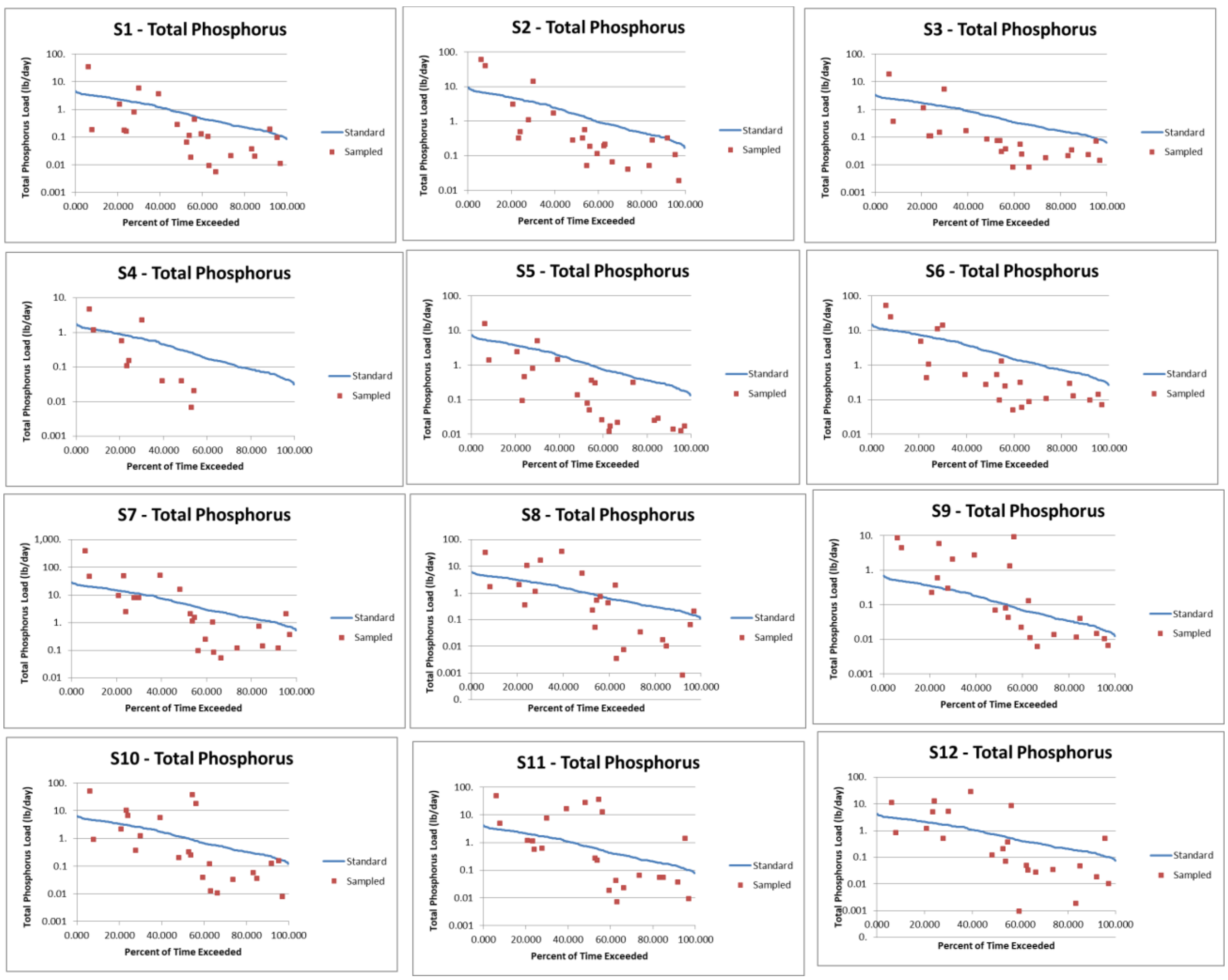


**Figure 38. Total phosphorus load duration curves for Treaty Creek-Wabash River samples sites from March 2018-March 2019.**

### Total Suspended Solids Load Duration Curves

Total suspended solids (TSS) levels generally measured below target levels during most flow events (Figure 39). Most exceedances occurred in the Treaty Creek-Wabash River Watershed during storm flow events suggesting erosion or runoff is the cause of these values. Site 09, S10 and S11 exhibited several exceedances during lower flow conditions as well. Possible sources of total suspended solids include the livestock access or stream bank erosion, both of which can provide a continuous source of total suspended solids.

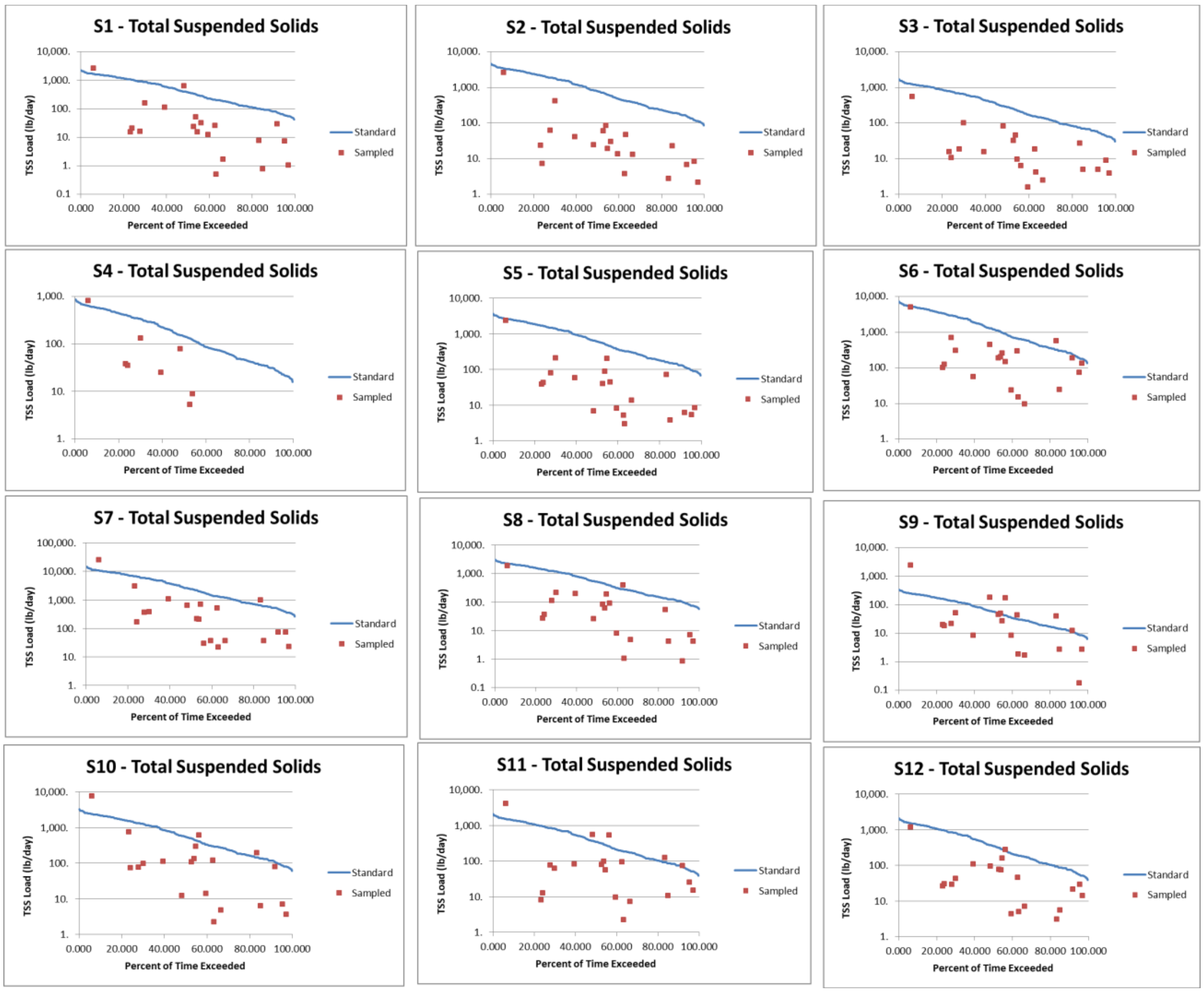


**Figure 39. Total suspended solids load duration curves for Treaty Creek-Wabash River samples sites from March 2018-March 2019.**

**E. coli Load Duration Curves**

E. coli load duration curves display completely different conditions than those presented by nitrate-nitrogen, total phosphorus and total suspended solids curves (Figure 40). E. coli curves indicate that E. coli levels exceed targets in Sites S06, S09, S10 and S11 during all flow conditions. These data suggest a nearly continuous source of E. coli within these streams. When flows are at their lowest, most of these sites contain E. coli concentrations below target levels suggesting that during wet or low exceedance conditions (60-100), there are limited sources of E. coli within these streams. Sites 02, 03 and S05 and 10 load duration curves indicate that E. coli concentrations exceed targets only during high flow conditions.

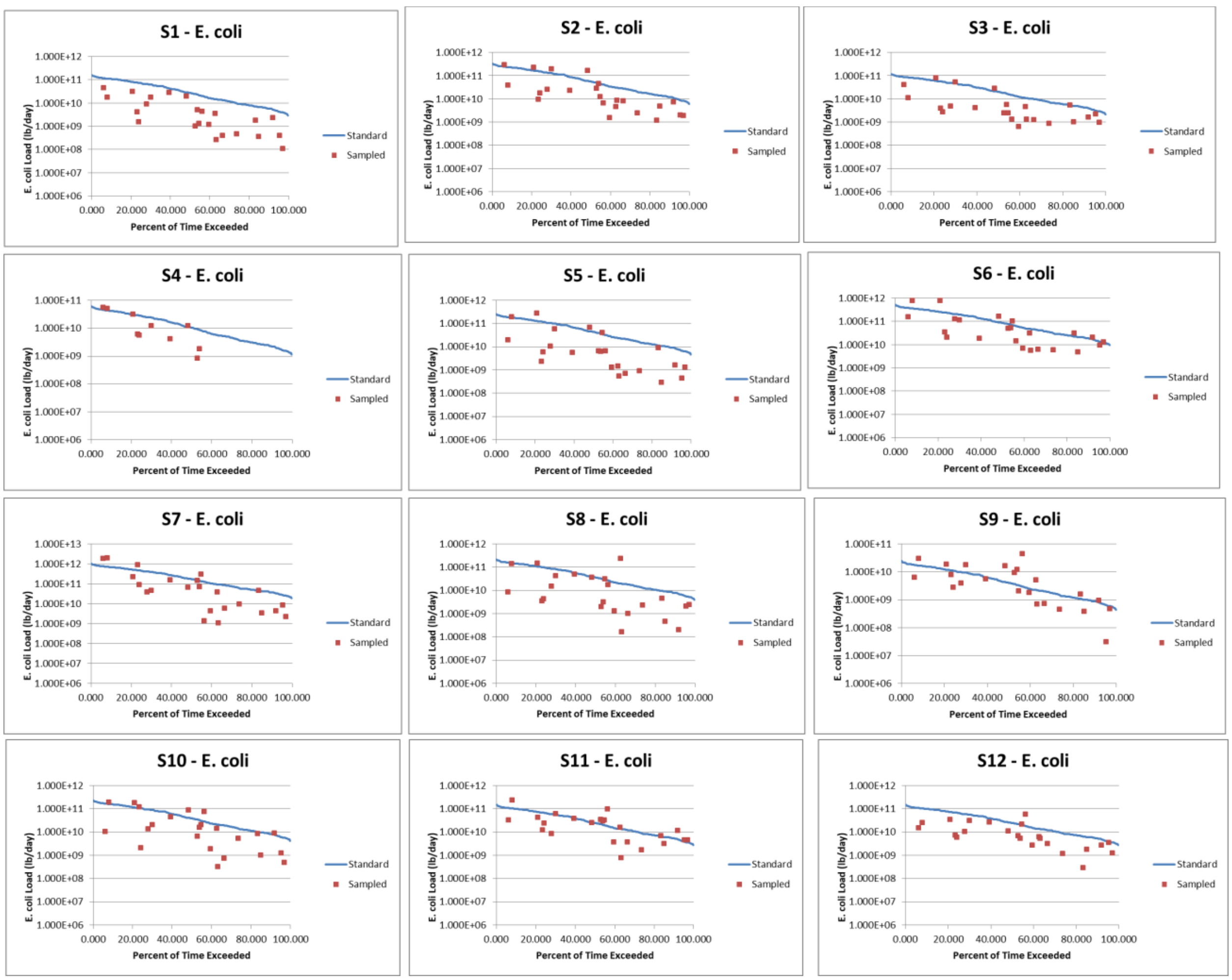


**Figure 40. E. coli concentrations load duration curves for Treaty Creek-Wabash River samples sites from March 2018-March 2019.**

### 3.3.5 Macroinvertebrate Community Assessment Results

In general, Asher Branch (S05) and Kentner Creek (S02) supported more diverse communities than other sites in the Treaty Creek-Wabash River Watershed (Figure 41, Table 16). Daniel Creek did not contain any macroinvertebrates at the time of sample collection. Burr Creek (S08) contained the most pollution intolerant community, while Mill Creek, Treaty Creek, and Lagro Creek contained the most pollution tolerant communities. Mayflies and caddisflies are considered to be aquatic insect groups that are intolerant of poor habitat and water quality. These two groups were abundant at most sites. However, overall diversity was somewhat low and the percentage of intolerant species was low at most sites.

Several species which would be expected to be abundant in high-quality streams, including the mayfly *Isonychia* and the mayflies *Stenonema femoratum* and *Stenonema vicarium*, were absent or present in very low numbers. Kentner Creek (S02), Asher Branch (S05), and Rager Creek (S10) possessed high numbers of individuals from the Dipteran genera, a high pollution tolerant genus. Ross Run (S09), Charley Creek (S01), Harlan Ditch (S03), and Lagro Creek (S11) contained low numbers of the more sensitive EPT families. Ross Run (S09) and Lagro Creek (S11) contained the lowest number of taxa (11 and 12, respectively). Overall, Asher Branch (S05), Charley Creek (S01), and Ross Run (S08) rated the highest macroinvertebrate index of biotic integrity with all three rating as fully supporting for aquatic life use designation based on IDEM guidance. All other sites rated as partially supporting for aquatic life based on the macroinvertebrate index of biotic integrity. Appendix D details the macroinvertebrate species collected at each sample site.

**Table 16. Metric classification scores and mIBI score for the Treaty Creek-Wabash River Watershed sample sites as sampled in 2018.**

| Metrics | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of taxa | 1 | 3 | 1 | -- | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Number of individuals | 3 | 3 | 3 | -- | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Number EPT taxa | 3 | 3 | 5 | -- | 5 | 5 | 5 | 5 | 3 | 5 | 3 | 5 |
| % Orthocladinae+Tanytarsini | 5 | 3 | 5 | -- | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 |
| % non-insects minus crayfish | 5 | 5 | 5 | -- | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 |
| Number Dipteran taxa | 3 | 3 | 3 | -- | 3 | 1 | 1 | 3 | 1 | 3 | 1 | 3 |
| % Intolerant | 1 | 1 | 1 | -- | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 |
| %Tolerant | 3 | 5 | 5 | -- | 5 | 3 | 1 | 5 | 5 | 1 | 3 | 3 |
| % Predators | 1 | 1 | 1 | -- | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 |
| %Shredders+Scrapers | 5 | 1 | 5 | -- | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 1 |
| %Collectors-Filterers | 5 | 1 | 1 | -- | 1 | 1 | 1 | 1 | 5 | 1 | 1 | 1 |
| % Sprawlers | 3 | 5 | 3 | -- | 5 | 3 | 1 | 5 | 5 | 5 | 5 | 3 |
| **Total** | **38** | **34** | **38** | **--** | **40** | **32** | **28** | **38** | **34** | **34** | **30** | **32** |

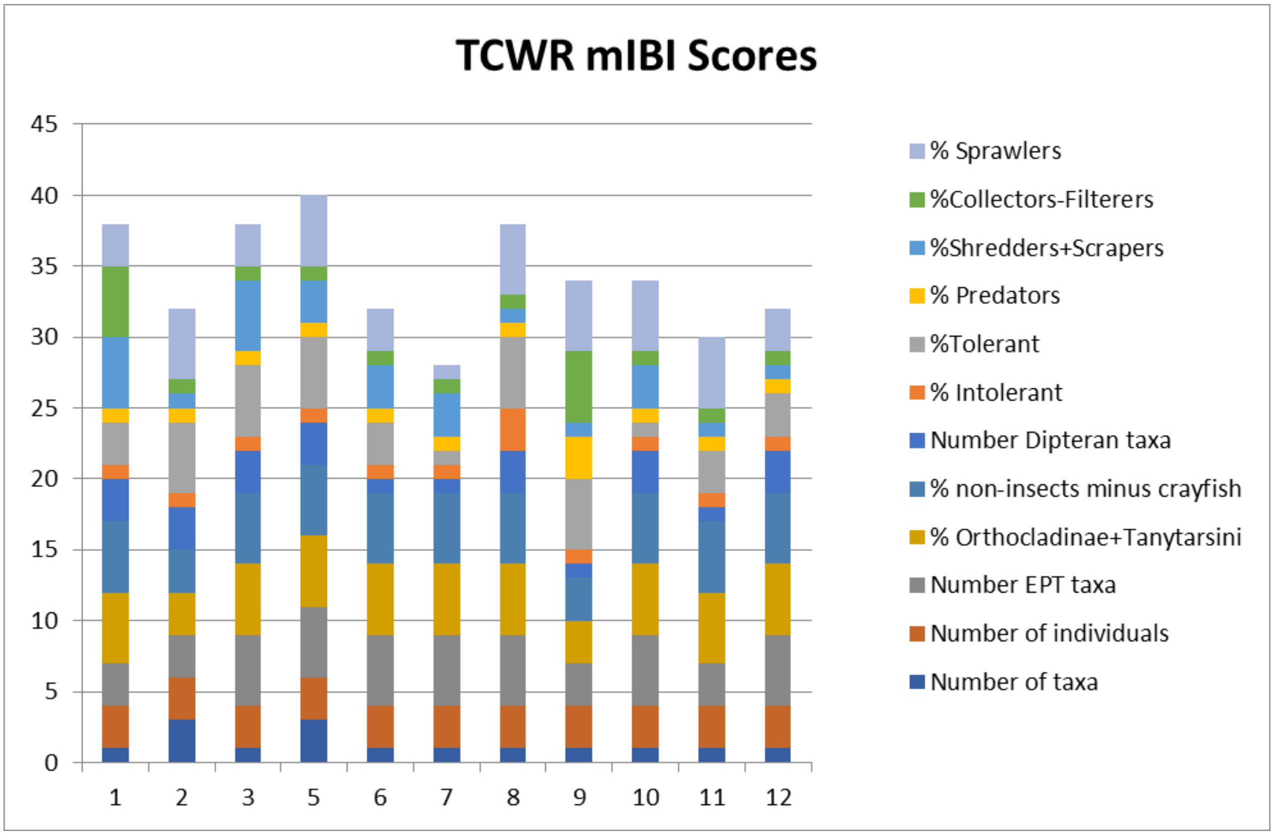


**Figure 41. Cumulative metrics used to calculate mIBI scores for Treaty Creek-Wabash River Watershed streams in 2018.**

### 3.3.6 Fish Community Assessment Results

Fish community data collected during sampling indicate that Treaty Creek-Wabash River streams generally rate as fair to good (average score of 46; Table 17). A total of 27 fish species were collected from Treaty Creek-Wabash River streams during 2018. The most common fish were the tolerant minnow species creek chub, bluntnose minnow, blacknose dace and central stoneroller. However, other species known to be more intolerant to water quality degradation, including certain darters and mottled sculpins, were also common. The abundance of sculpins indicates that many of these streams contain relatively low temperatures, likely due to groundwater inflows. One fish species, the redside dace, was present in Mill Creek and Asher Branch. This species is quite rare and is known from only one other stream in Indiana. Daniel Creek (S04) rates as very poor (12) with only eight individuals representing five families identified during the fish community assessment. The highest IBI score occurred at Kentner Creek (S02; Figure 42), which rated as good-excellent (54). Charley Creek, Carlin Branch, and Mill Creek all scored good (50, Sites 01, 03 and 06). These sites represent streams with a high density and diversity comprised of a solid mix of sensitive species and a diversity of trophic guilds. Appendix D details the fish species collected at each sample site.

**Table 17. Metric classification scores and IBI scores for the Treaty Creek-Wabash River Watershed sample sites sampled during 2018.**

| IBI Metrics | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total species | 5 | 5 | 5 | 1 | 5 | 5 | 5 | 5 | 3 | 3 | 5 | 3 |
| #of DMS | 5 | 5 | 5 | 1 | 5 | 5 | -- | 5 | 5 | 5 | 5 | 5 |
| # of darters | -- | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| % Headwater species | 3 | 5 | 5 | 1 | 3 | 3 | | 3 | 3 | 3 | 3 | 5 |
| # of sunfish | -- | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| # of minnows species | 5 | 5 | 5 | 1 | 5 | 5 | -- | 3 | 5 | 3 | 3 | 5 |
| # of suckers | -- | -- | -- | -- | -- | -- | 3 | -- | -- | -- | -- | -- |
| % Pioneer | 3 | 5 | 1 | 1 | 1 | 3 | | 1 | 1 | 1 | 1 | 3 |
| # of sensitive species | 5 | 3 | 5 | 1 | 3 | 5 | 5 | 3 | 3 | 1 | 3 | 1 |
| % of tolerance | 3 | 1 | 1 | 1 | 1 | 3 | 5 | 1 | 1 | 3 | 5 | 5 |
| % omnivores | 5 | 5 | 5 | 1 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| % insectivores | 5 | 5 | 5 | 1 | 5 | 5 | 5 | 3 | 3 | 5 | 5 | 5 |
| % Carnivores | -- | -- | -- | -- | -- | -- | 1 | -- | -- | -- | -- | -- |
| CPUE | 3 | 5 | 5 | 1 | 5 | 3 | 3 | 3 | 5 | 1 | 3 | 3 |
| % Simple Lithophils | 3 | 5 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| %DELTS score | 5 | 5 | 5 | 1 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| **Total IBI <= 20 sq. mi.** | 50 | 54 | 50 | 12 | 46 | 50 | -- | 40 | 42 | 38 | 46 | 48 |
| **Total IBI > 20 sq. mi.** | -- | -- | -- | -- | -- | -- | 46 | -- | -- | -- | -- | -- |

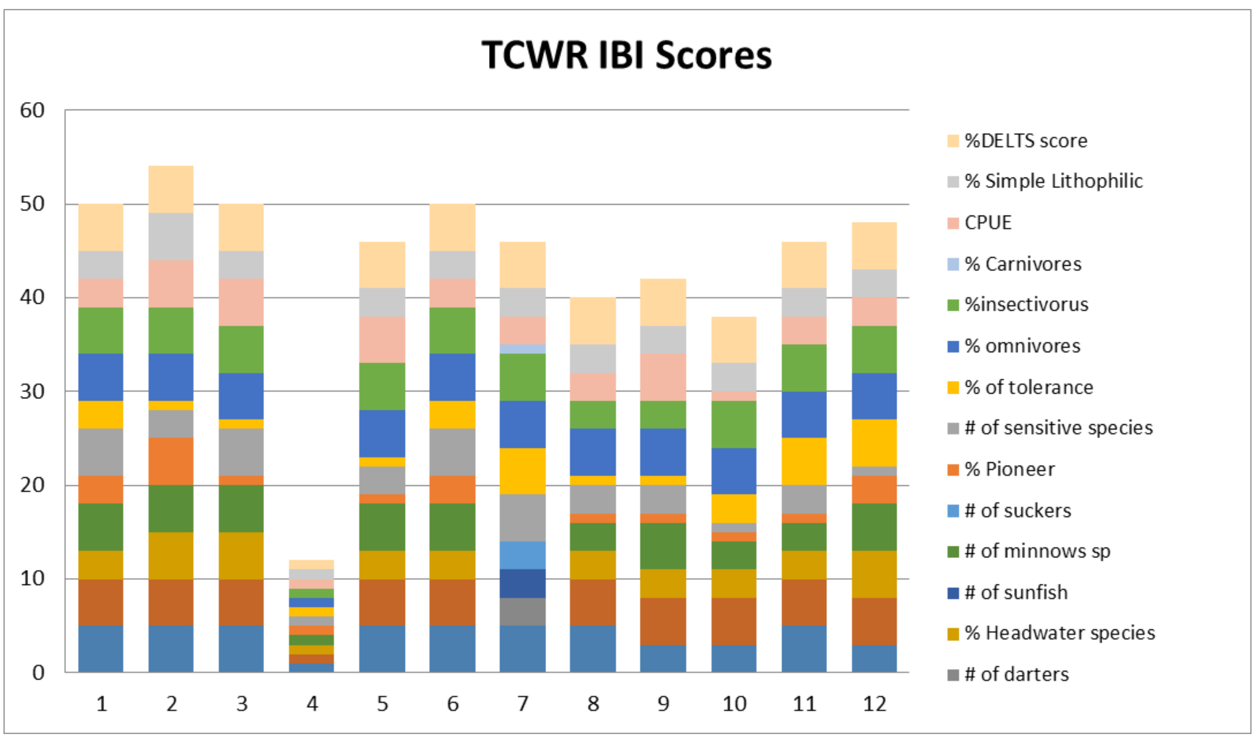


**Figure 42. Cumulative metrics used to calculate IBI scores for Treaty Creek-Wabash River Watershed streams.**

### 3.3.7 Habitat Results

Stream water quality and available habitat influence the quality of a biological community in a stream, and it is necessary to assess both factors when reviewing biological data. Table 18 presents the results of QHEI assessments at each of the 12 stream sites sampled in the Treaty Creek-Wabash River Watershed during the summer of 2018. Figure 43 details metric and total scores for all sites. Among all the sites except Daniel Creek (S04), which rated as very poor, pool/riffle development scores, stream substrate, instream cover, and gradient were relatively good for Indiana streams contributing to overall high quality QHEI scores. The lowest scores occurred in Daniel Creek (S04) where stream flows are intermittent. This site contained poor stream substrate, limited instream cover, narrow riparian zones, and pool and riffle development was absent, it is not surprising that this site scored poorly relative to other stream sites. The highest scores occurred on Mill Creek (S06), where comparatively high amounts of instream cover, intact riparian buffers, and larger, more diverse substrates contributed strongly to the higher score at this site.

**Table 18. Qualitative Habitat Evaluation Index (QHEI) scores measured in the Treaty Creek-Wabash River Watershed.**

| Site | Substrate | Cover | Channel | Riparian | Pool | Riffle/Run | Gradient | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 12 | 13 | 9 | 8 | 6 | 6 | 69 |
| 2 | 13 | 12 | 13 | 9 | 6 | 6 | 6 | 65 |
| 3 | 14 | 10 | 11 | 9 | 6 | 5 | 6 | 61 |
| 4 | 2 | 2 | 5 | 5 | 0 | 0 | 6 | 20 |
| 5 | 12 | 10 | 10 | 9 | 6 | 5 | 6 | 58 |
| 6 | 16 | 14 | 14 | 10 | 8 | 7 | 6 | 75 |
| 7 | 13 | 12 | 13 | 9 | 6 | 6 | 6 | 65 |
| 8 | 12 | 10 | 11 | 9 | 6 | 6 | 6 | 60 |
| 9 | 12 | 11 | 10 | 10 | 6 | 6 | 6 | 61 |
| 10 | 10 | 10 | 11 | 9 | 5 | 5 | 6 | 56 |
| 11 | 13 | 11 | 10 | 9 | 6 | 5 | 6 | 60 |
| 12 | 14 | 11 | 11 | 10 | 7 | 6 | 6 | 65 |

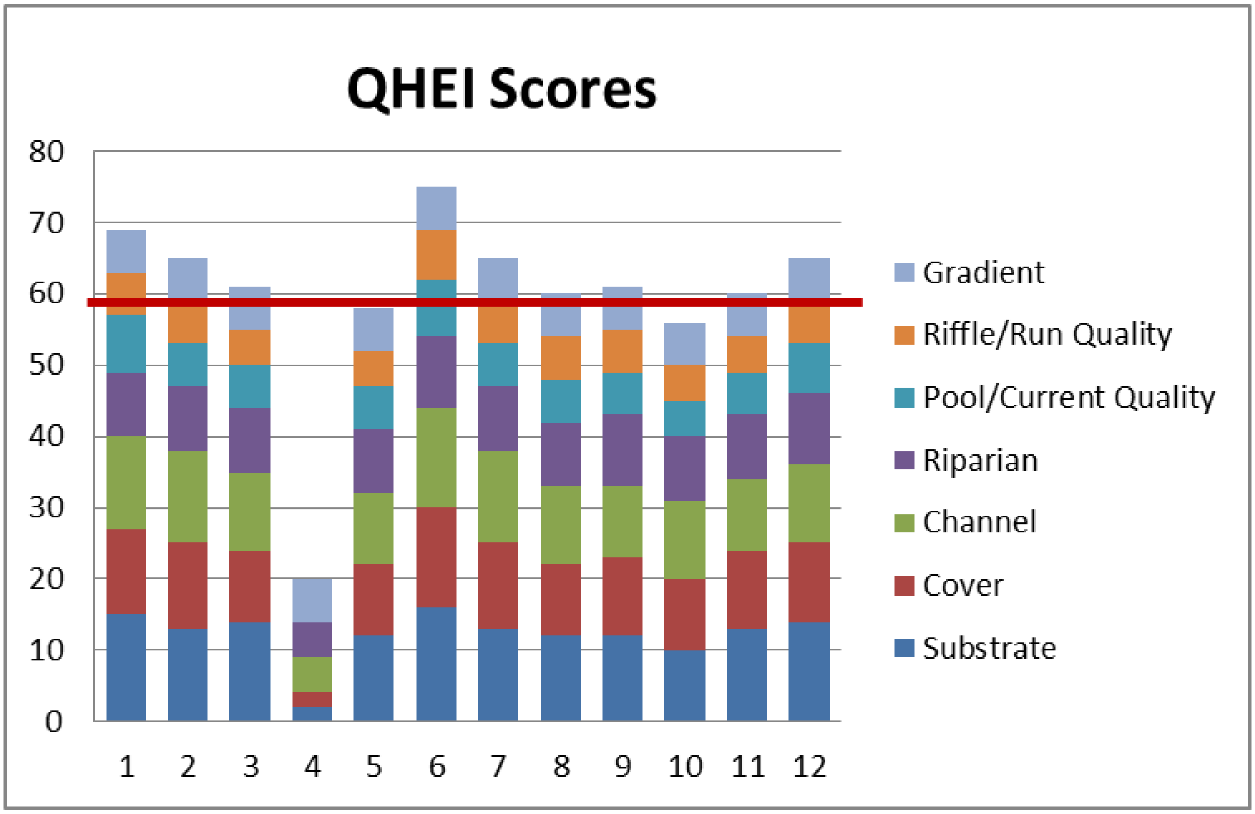


**Figure 43. Qualitative Habitat Evaluation Index (QHEI) total and component scores measured for stream sites in the Treaty Creek-Wabash River Watershed.**

## 3.4 Watershed Inventory Assessment

### 3.4.1 Watershed Inventory Methodologies

Volunteers completed windshield surveys throughout the Treaty Creek-Wabash River Watershed in spring of 2018. Volunteers conducted surveys by driving all accessible roads throughout the watershed. Large maps with aerial photographs, road and stream names, and public property labels were provided to each volunteer group. Volunteers recorded observations on the provided maps and data sheets, documented field conditions with photographs, and provided all notes to the steering committee for review. The windshield surveys were also used to confirm GIS map layer data throughout the watershed. Items targeted during the surveys included, but were not limited to the following:

- Aerial land use category
- Field or gully erosion
- Pasture locations and condition
- Small animal operations
- Livestock access and impact to streams
- Buffer condition and width
- Bed or bank erosion or stream head-cutting
- Environmental site confirmation (NPDES, CFO, open dump, Superfund, etc.)

### 3.4.2 Watershed Inventory Results

More than 450 individual road-stream crossings were inventoried by watershed volunteers. A majority of issues identified fall into two categories: stream buffers limited in width or lacking altogether and streambank erosion. Figure 44 details locations throughout the Treaty Creek-Wabash River Watershed where problems were identified. More than 47.6 miles of tributary streams possessed limited buffers, nearly 51.4 miles of streambank were eroded, and livestock had access to nearly 8.4 miles of streams.

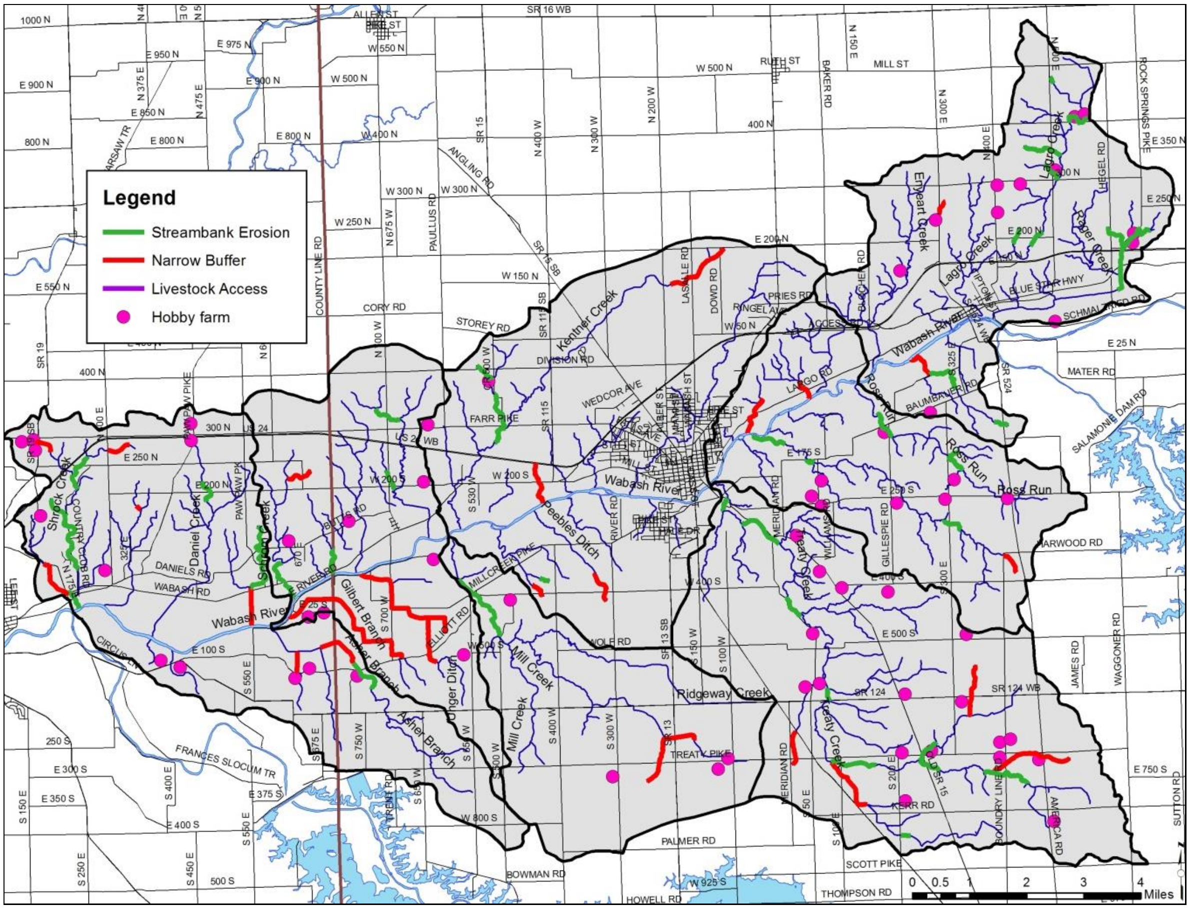

**Figure 44. Stream-related watershed concerns identified during watershed inventory efforts.**

## 4.0 WATERSHED INVENTORY II-B: SUBWATERSHED DISCUSSIONS

To gather more specific, localized data, the Treaty Creek-Wabash River Watershed was divided into seven subwatersheds with each subwatershed reflecting one 12-digit Hydrologic Unite Code (HUC; Figure 45). These subwatersheds reflect specific tributary drainages and similar land uses and hydrology. Land uses, point and non-point watershed concern areas, and historic water quality sampling locations and results are discussed in detail below for each subwatershed.

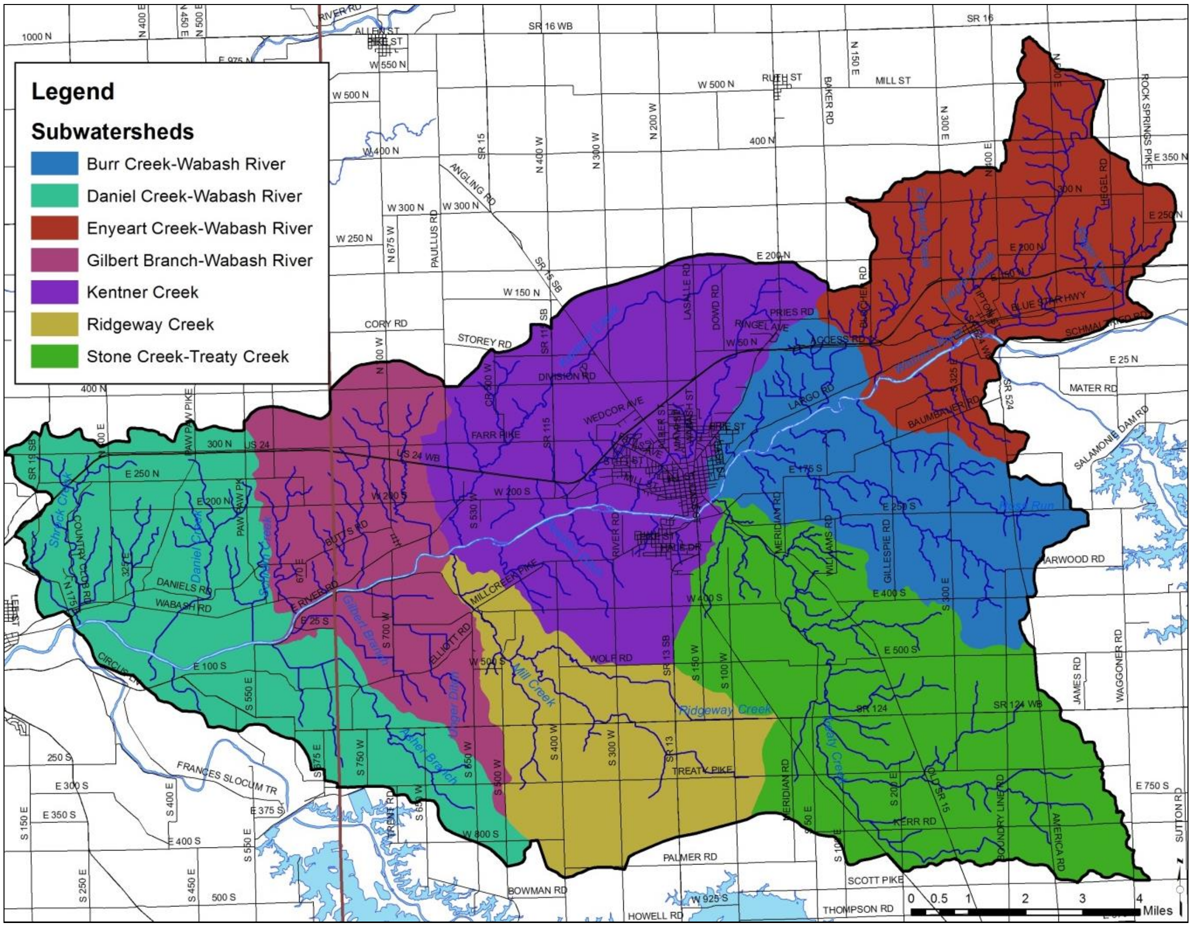


**Figure 45. 12-digit Hydrologic Unit Codes in the Treaty Creek-Wabash River Watershed.**

## 4.1 Enyeart Creek-Wabash River Subwatershed

The Enyeart Creek-Wabash River Subwatershed is located in Wabash County and forms the northeastern edge of the Treaty Creek-Wabash River Watershed (Figure 46). It includes one 12-digit HUC: 051201011401. The Enyeart Creek-Wabash River Subwatershed drains 13,849 acres or 21.6 square miles. There are 54.6 miles of stream, of which IDEM has classified 3 miles of stream as impaired for *E. coli*, nutrients, PCBs, and mercury.

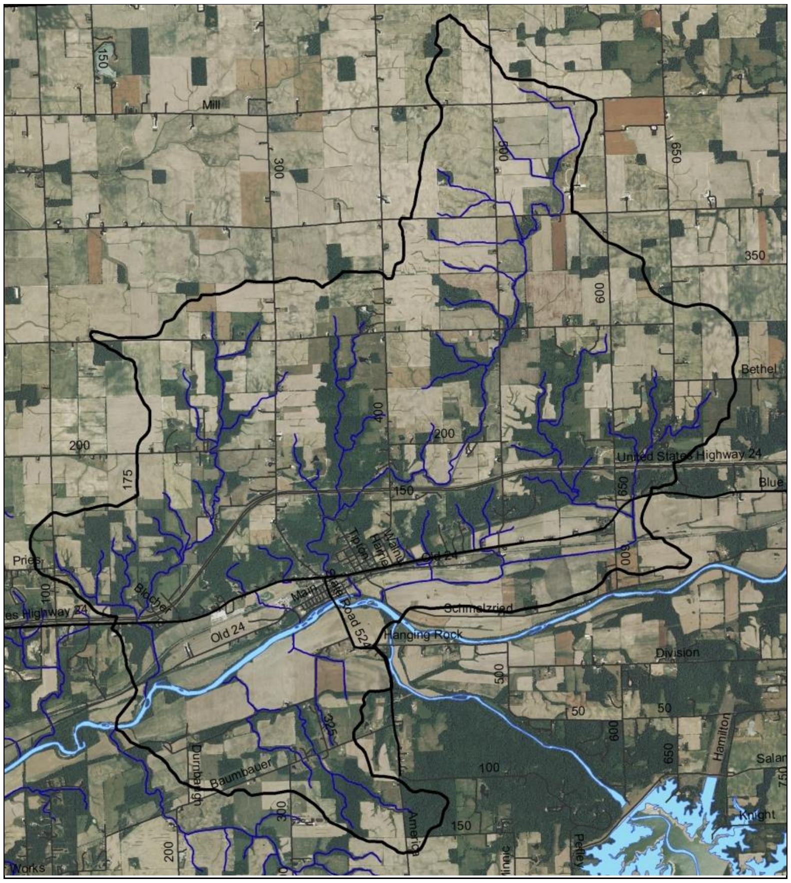

**Figure 46. Enyeart Creek-Wabash River Subwatershed.**

### 4.1.1 Soils

Soils in the Enyeart Creek-Wabash River Subwatershed are dominated by Blount-Glynwood-Morley soils, which lie on uplands north and south of the Wabash River floodplain. Millsdale-Newglarus-Randolph soils are found in riparian areas along the Wabash River channel. These soils are typically found in alluvium. The northern subwatershed boundary is covered by Blount-Pewamo-Glynwood soils. These soils are excessively drained and found on gentle to strong slopes. Hydric soils cover 1,181 acres (9%) of the subwatershed, indicating that only a small portion of the land was historically wetlands. Wetlands currently cover 2% (275 acres) of the subwatershed, representing a loss of 77% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 40% and 24% of the land, respectively. Nearly the entire subwatershed (98%) has soils which are severely limited for septic use.

### 4.1.2 Land Use

Agricultural land uses cover the largest percentage of the Enyeart Creek-Wabash River Subwatershed, with 71% (9,888 acres) in row crops or hay/pasture. Forest covers just over 2,569 acres, or 19%, of the subwatershed. Open water, wetlands, and grasslands account for 384 acre or 3% of the subwatershed. The Enyeart Creek-Wabash River Subwatershed contains the Town of Lagro, thus urban lands cover 7% or 1,014 acres of the subwatershed.

### 4.1.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are two leaking underground storage tanks (LUST) located west of Lagro (Figure 47). There is one NPDES-permitted facility, Celotex Corporation; however, no brownfields or open dumps are located in this subwatershed.

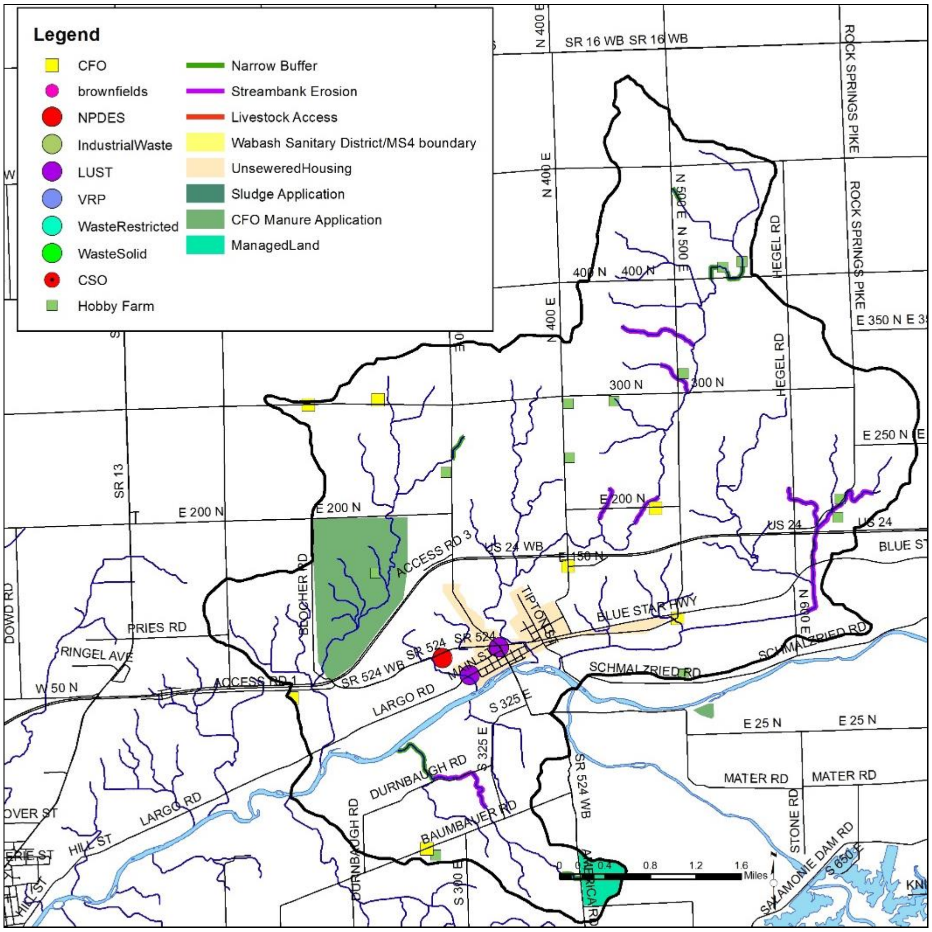


**Figure 47. Point and non-point sources of pollution and suggested solutions in the Enyeart Creek-Wabash River Subwatershed.**

### 4.1.4 Non-Point Source Water Quality Issues

Agricultural land uses dominate the Enyeart Creek-Wabash River Subwatershed. A number of small animal operations and pastures are also present (Figure 47). In total, 11 unregulated animal operations were identified during the windshield survey, which house more than 218 animals. NASS county-wide livestock estimates generate a higher density of 940 animals. Five active confined feeding operations are located within the subwatershed housing approximately 12,119 hogs, 500 beef cattle and 1,100 veal. In total, small animal and confined feeding operations generate 55,578 tons of manure. This manure contains almost 157,000 pounds of nitrogen and almost 116,950 pounds of phosphorus. Approximately 11.1 miles of streambank erosion and 3.4 miles of streams with narrow buffers were identified within the subwatershed.

### 4.1.5 Water Quality Assessment

Waterbodies within the Enyeart Creek-Wabash River Subwatershed have been sampled historically at 4 locations (Figure 48, Table 19). Assessments include collection of water chemistry data IDEM (2 sites) and 2015 water quality assessment by the Wabash River Defenders (3 sites). The fish community has been assessed by the Indiana Department of Environmental Management (1 site) and the Indiana Department of Natural Resources (1 site). Macroinvertebrates were sampled at one site by the IDEM; freshwater mussels were also assessed at one site by the DNR non-game program. No stream gages are located in the Enyeart Creek-Wabash River Subwatershed. pH levels measured below the lower state standards twice during the current assessment at each site. Turbidity exceeded target values during 4 to 6 sampling events with Lagro Creek (S11) exceeding targets more than Rager Creek or Enyeart Creek. Total suspended solids exceeded target concentrations during four sampling events in Rager and Lagro Creeks but during only one event in Enyeart Creek (S12). E. coli concentrations exceeded the state standard during 17-19 sampling events with concentrations measuring on average the highest in Lagro Creek. Nitrate-nitrogen and total phosphorus concentrations exceeded targets during nearly all sampling events. Macroinvertebrate communities at all sites rated as partially supporting with fish communities rating as poor to fair (S10), fair (S11) and good (S12). Habitat is rated as good at all sites.

**Table 19. Water quality data collected in the Enyeart Creek-Wabash River Subwatershed, March 2018 to March 2019.**

| Site | | DO (mg/L) | Temp (deg C) | pH | Cond (mg/L) | Turb (NTU) | Nitrate (mg/L) | TP (mg/L) | Ecoli (col/100 mL) | TSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 Rager Creek | Median | 9.52 | 10.84 | 7.31 | 543 | 7.05 | 2.86 | 0.0725 | 470 | 13.75 |
| | Max | 15.36 | 21.04 | 8.11 | 623 | 77.4 | 5.76 | 1.26 | 1950 | 69.25 |
| | Min | 2.85 | 0.91 | 5.72 | 330 | 2.57 | 1.22 | 0.011 | 10 | 1.25 |
| | #Samples | 15 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 20 |
| | #Exceed | 6 | 0 | 2 | 0 | 4 | 22 | 12 | 17 | 4 |
| | % Exceed | 40.0% | 0.0% | 8.7% | 0.0% | 17.4% | 91.7% | 50.0% | 73.9% | 20.0% |
| 11 Lagro Creek | Median | 11.365 | 12.185 | 7.635 | 517.5 | 4.805 | 1.655 | 0.082 | 610 | 9.875 |
| | Max | 16.94 | 21.29 | 8.41 | 604 | 186 | 7.77 | 2.99 | 2550 | 60 |
| | Min | 4.88 | -0.03 | 5.78 | 127 | 0.75 | 0.144 | 0.013 | 50 | 1.25 |
| | #Samples | 14 | 22 | 22 | 22 | 22 | 22 | 22 | 21 | 20 |
| | #Exceed | 7 | 0 | 2 | 0 | 6 | 13 | 11 | 19 | 4 |
| | % Exceed | 50.0% | 0.0% | 9.1% | 0.0% | 27.3% | 59.1% | 50.0% | 90.5% | 20.0% |
| 12 Enyeart Creek | Median | 11.14 | 9.75 | 7.64 | 569 | 2.62 | 1.68 | 0.0225 | 460 | 8 |
| | Max | 16.45 | 20.97 | 8.45 | 625 | 231 | 2.57 | 2 | 810 | 33.5 |
| | Min | 4.86 | 0.51 | 5.64 | 114 | 0.79 | 0.588 | 0.001 | 70 | 3 |
| | #Samples | 15 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 20 |
| | #Exceed | 4 | 0 | 2 | 0 | 5 | 13 | 10 | 17 | 1 |
| | % Exceed | 26.7% | 0.0% | 8.7% | 0.0% | 21.7% | 54.2% | 41.7% | 73.9% | 5.0% |

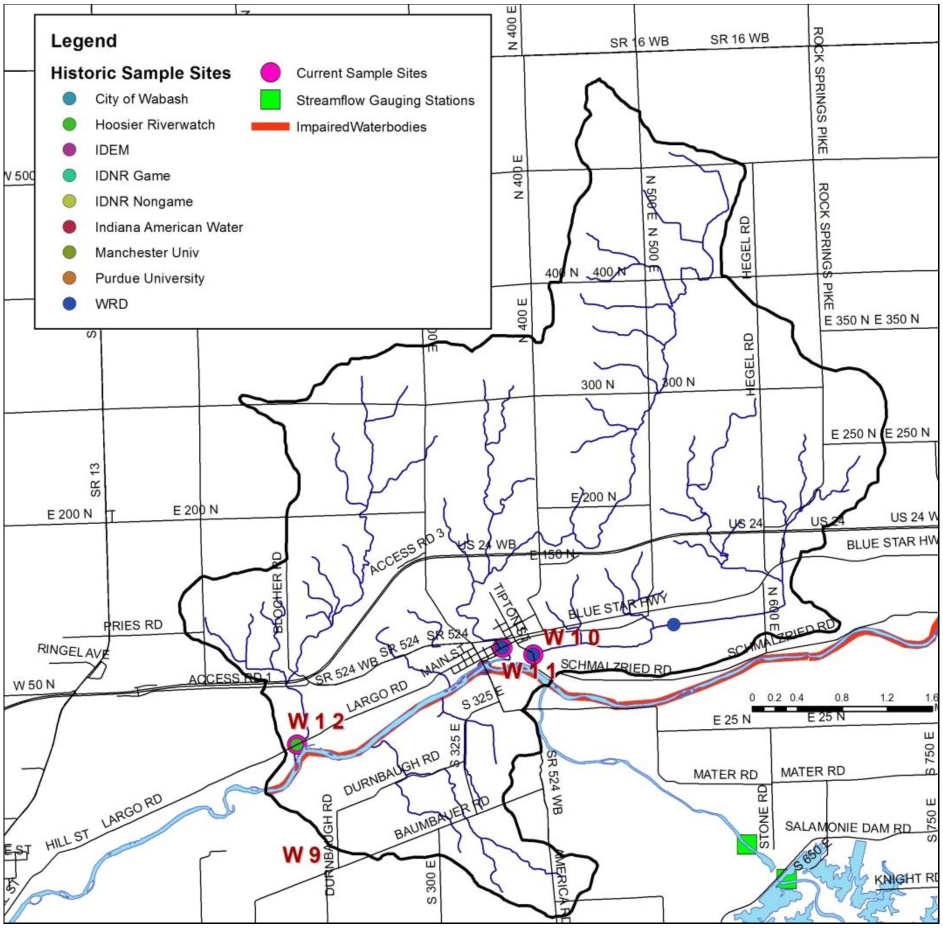


**Figure 48. Locations of historic water quality data collection and impairments in the Enyeart Creek-Wabash River Subwatershed.**

## 4.2 <u>Stone Creek-Wabash River Subwatershed</u>

The Stone Creek-Wabash River Subwatershed forms the southeast corner of the Treaty Creek-Wabash River Watershed within Wabash County and includes 12-digit HUC watershed: 051201011402 (Figure 49). The Stone Creek-Wabash River Subwatershed drains 19,267 acres or 30.1 square miles. There are 51.7 miles of streams.

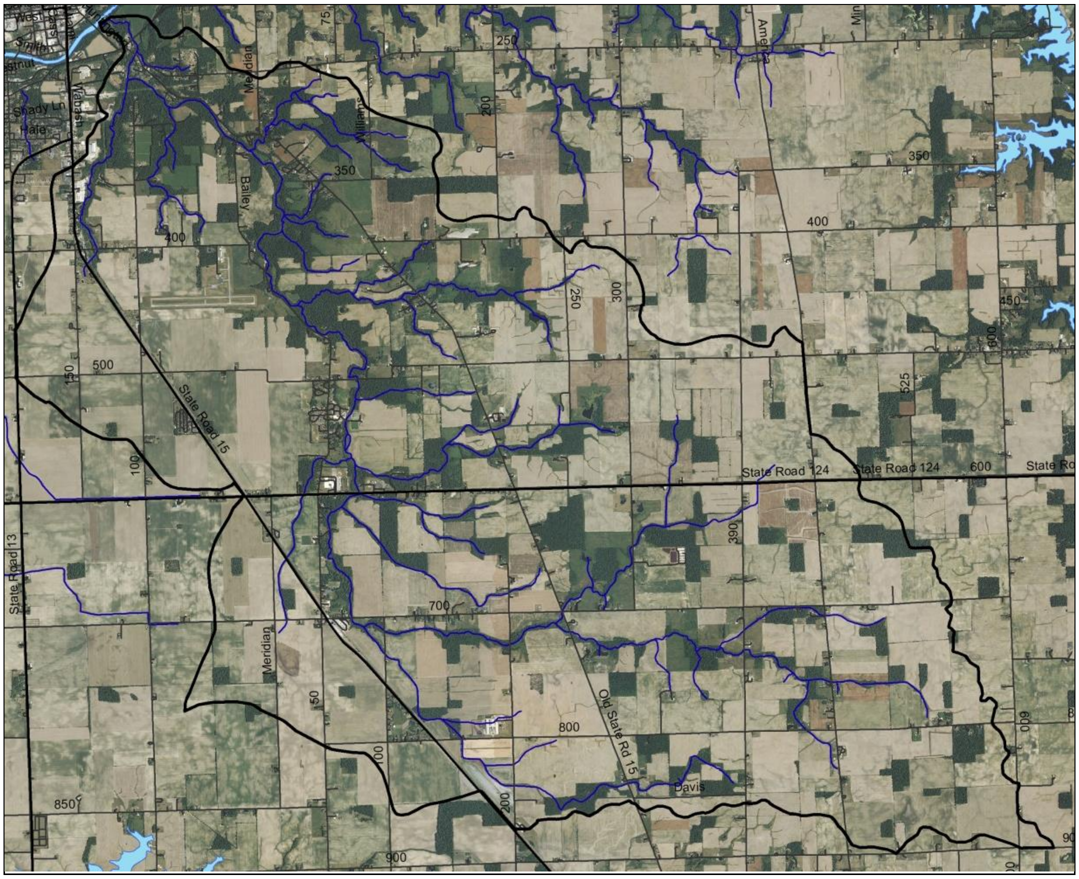


**Figure 49. Stone Creek-Wabash River Subwatershed.**

### 4.2.1 Soils

Soils in the Stone Creek-Wabash River Subwatershed transition from Blounty-Pewamo-Glynwood soils, which lie on uplands along the eastern border of the subwatershed to Blount-Glynwood-Morley soils, which are found in areas of loam till. Miami-Crosby-Treaty and Fincastle-Brookston-Miamian soils cover the lower and western portion of the subwatershed. Hydric soils cover 4,234 acres (22%) of the subwatershed, indicating that nearly one-quarter of the land was historically wetlands. Wetlands currently cover 1% (275.1) of the subwatershed, representing a loss of 73% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 15% and 19% of the land, respectively. Nearly the entire subwatershed (98%) has soils which are severely limited for septic use.

### 4.2.2 Land Use

The Stone Creek-Wabash River Subwatershed contains nearly 15,238 acres of agricultural row crop and pasture land (79%). Forested land use cover 2,207 acres or 11% of the Stone Creek-Wabash River Subwatershed. Urban land uses cover nearly 1,450 acres (7.5%) in the subwatershed. Wetlands, open water, and grasslands account for the remaining 2% (381.5 acres) of land within the subwatershed.

### 4.2.3 Point Source Water Quality Issues

There are few point sources of water pollution in the Stone Creek-Wabash River Subwatershed. There are two leaking underground storage tanks (LUST) located south and west of State Road 15 (Figure 50).

There is one NPDES-permitted facility, Southwood Elementary School; however, no brownfields or open dumps are located in this subwatershed.

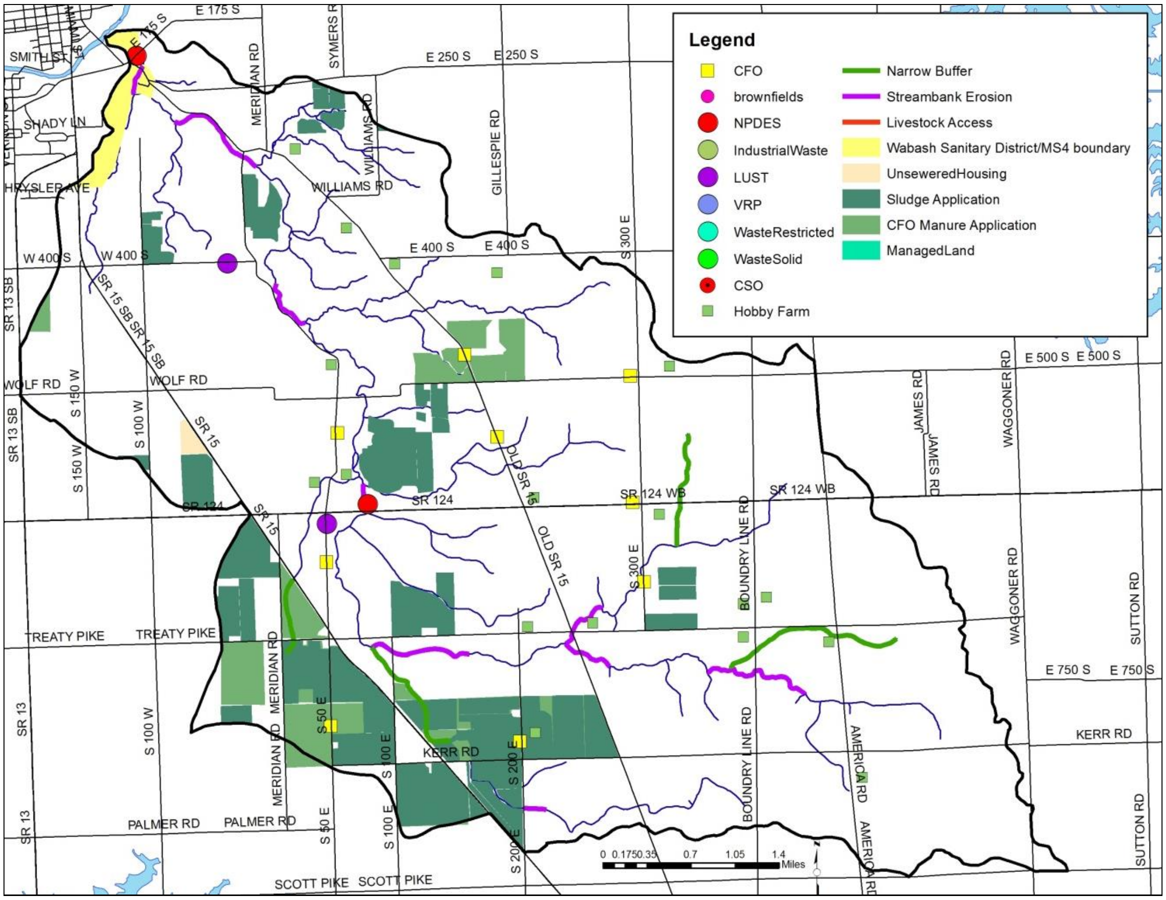

**Figure 50. Point and non-point sources of pollution and suggested solutions in the Stone Creek-Wabash River Subwatershed.**

### 4.2.4 Non-Point Source Water Quality Issues

Agricultural land uses dominate the Stone Creek-Wabash River Subwatershed, which is primarily in a corn-soybean rotation. Approximately 18 small animal operations housing nearly 80 animals are present (Figure 50). Areas where livestock have access to the stream were not identified in the subwatershed. Six active confined feeding operations housing more than 22,000 swine and more than 1800 dairy cattle per year are located in the Stone Creek-Wabash River Subwatershed. In total, manure is spread on 1,380 acres in the Stone Creek-Wabash River Subwatershed. Manure from the six CFO and 18 small animal operations produce more than 133,818 tons per year. This contains almost 292,927 pounds of nitrogen and almost 216,040 pounds of phosphorus. Municipal biosolids are applied to 1,989 acres within the subwatershed. Streambank erosion affects 9.4 miles of streams within the subwatershed, while 8.3 miles of streams possess narrow buffers.

### 4.2.5 Water Quality Assessment

Waterbodies within the Stone Creek-Wabash River Subwatershed have been sampled historically at one location (Figure 51, Table 20). Assessments include collection of water chemistry data by IDEM (1 site) and via the Wabash River Defenders (1 site). The fish and macroinvertebrate communities have been assessed by IDEM at the same sites. No stream gages are located in the Stone Creek-Wabash River

Subwatershed. pH levels measured below the lower state standards twice during the current assessment, turbidity and total suspended solids exceeded target concentrations during five and four sampling events, respectively. E. coli concentrations exceeded the state standard during 20 sampling events with concentrations measuring as high as 4500 colonies/100 ml. Nitrate-nitrogen and total phosphorus concentrations exceeded targets during 24 of 26 sampling events. Macroinvertebrate communities in Treaty Creek rated as partially supporting with fish communities rating as fair to good and habitat rating as good.

**Table 20. Water quality data collected in the Stone Creek-Wabash River Subwatershed, March 2018 to March 2019.**

| Site | | DO (mg/L) | Temp (deg C) | pH | Cond (mg/L) | Turb (NTU) | Nitrate (mg/L) | TP (mg/L) | Ecoli (col/100 mL) | TSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 7 Treaty Creek | Median | 9.71 | 10.25 | 7.6 | 533 | 6.65 | 2.16 | 0.087 | 520 | 14 |
| | Max | 14.21 | 21.17 | 8.23 | 637 | 101 | 9.52 | 0.826 | 4500 | 56 |
| | Min | 4.38 | 0.03 | 5.85 | 340 | 1.36 | 0.553 | 0.012 | 100 | 3.5 |
| | #Samples | 15 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 20 |
| | #Exceed | 5 | 0 | 2 | 0 | 5 | 15 | 14 | 20 | 4 |
| | % Exceed | 33.3% | 0.0% | 8.7% | 0.0% | 21.7% | 62.5% | 58.3% | 87.0% | 20.0% |

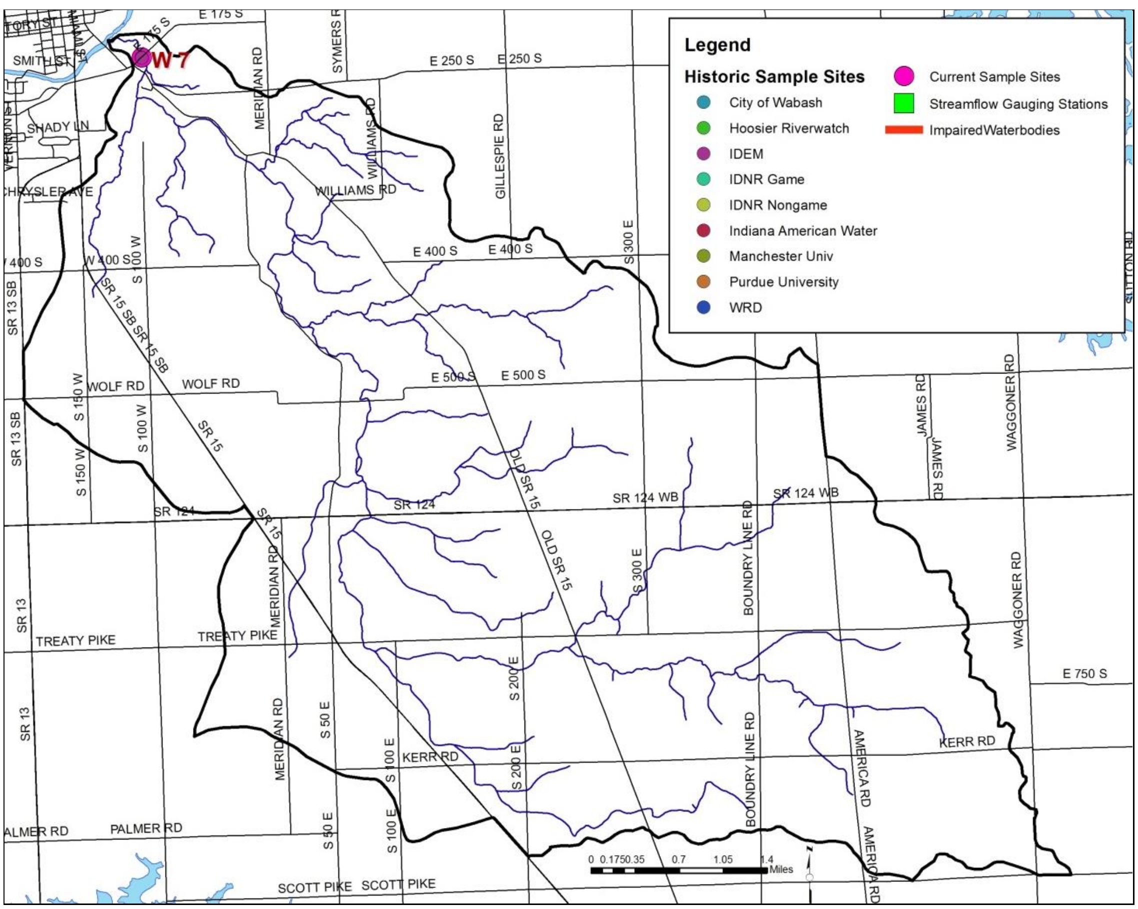


**Figure 51. Locations of historic water quality data collection and impairments in the Stone Creek-Wabash River Subwatershed.**

## 4.3 Burr Creek-Wabash River Subwatershed

The Burr Creek-Wabash River Subwatershed forms the eastern boundary of the Treaty Creek-Wabash River Watershed and lies completely within Wabash County (Figure 52). It encompasses one 12-digit HUC watershed: 051201011403. The Burr Creek-Wabash River Subwatershed drains 11,245.7 acres or 17.6 square miles. There are 41.6 miles of stream. IDEM has classified 3.6 miles of stream as impaired for *E. coli*, nutrients, PCBs, and mercury.

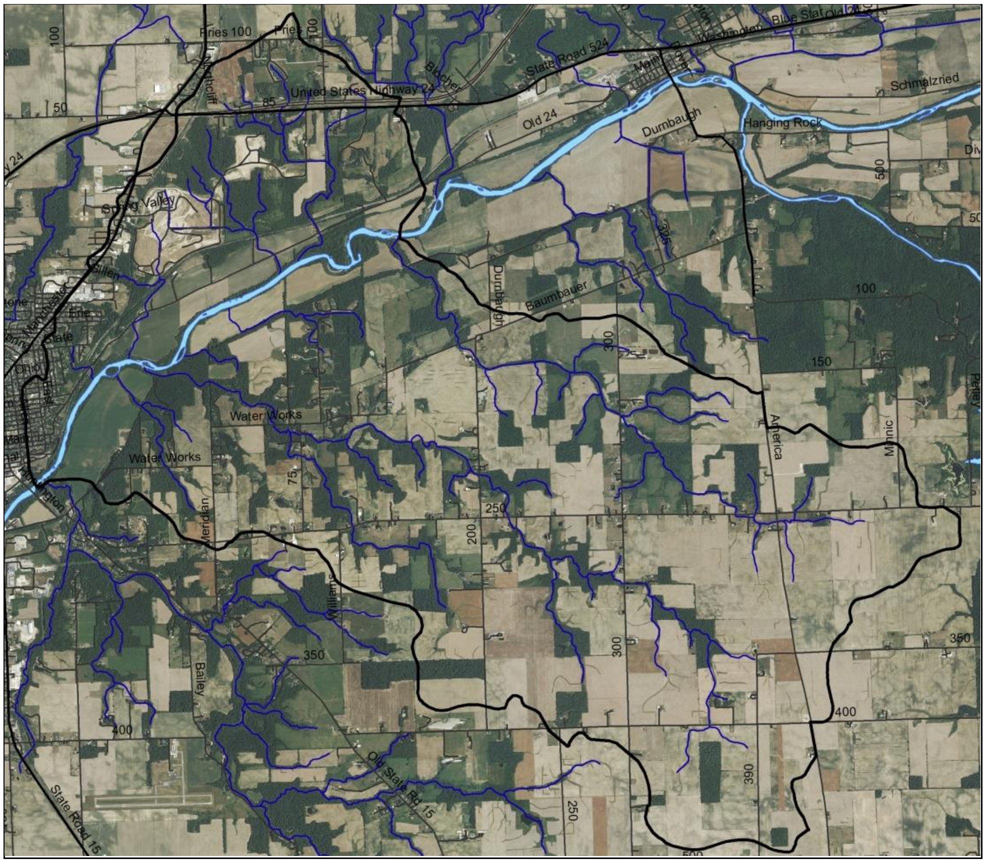


**Figure 52. Burr Creek-Wabash River Subwatershed.**

### 4.3.1 Soils

Soils in the Burr Creek-Wabash River Subwatershed are dominated by Blount-Pewamo-Glynwood soils which form the eastern subwatershed boundary. These soils transition to Blount-Glynwood-Morley soils which dominate the Burr Creek-Wabash River Subwatershed. Hydric soils cover 1,030 acres (9%) of the subwatershed, indicating that less than 10% of the subwatershed was historically wetlands. Wetlands currently cover 2% (276.1 acres) of the subwatershed, representing a loss of 73% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 41% and 13% of the subwatershed, respectively. Nearly half of subwatershed (52%) has soils which are severely limited for septic use.

### 4.3.2 Land Use

Agricultural land uses dominate the Burr Creek-Wabash River Subwatershed with 72% (8,116 acres) in agricultural land uses, including row crop and pasture. The 2012 NASS statistics suggest that a majority of row crop agriculture in the Burr Creek-Wabash River Subwatershed is in corn or soybeans with a small percentage in winter wheat. Forested land uses cover 1,863 acres (17%) of the subwatershed. Wetlands, open water, and grassland cover just over 385 acres, or 3%, of the subwatershed. Nearly 8% of the subwatershed (886 acres) are in urban land uses.

### 4.3.3 Point Source Water Quality Issues

Although the southern edge of the City of Wabash lies within the Burr Creek-Wabash River Subwatershed, there are few point sources of water pollution in the subwatershed (Figure 53). There are six leaking underground storage tanks (LUST) and two solid waste facilities within the subwatershed (Figure 53). No industrial waste facilities, open dumps, brownfields or NPDES-permitted facilities are located within the Burr Creek-Wabash River Subwatershed.

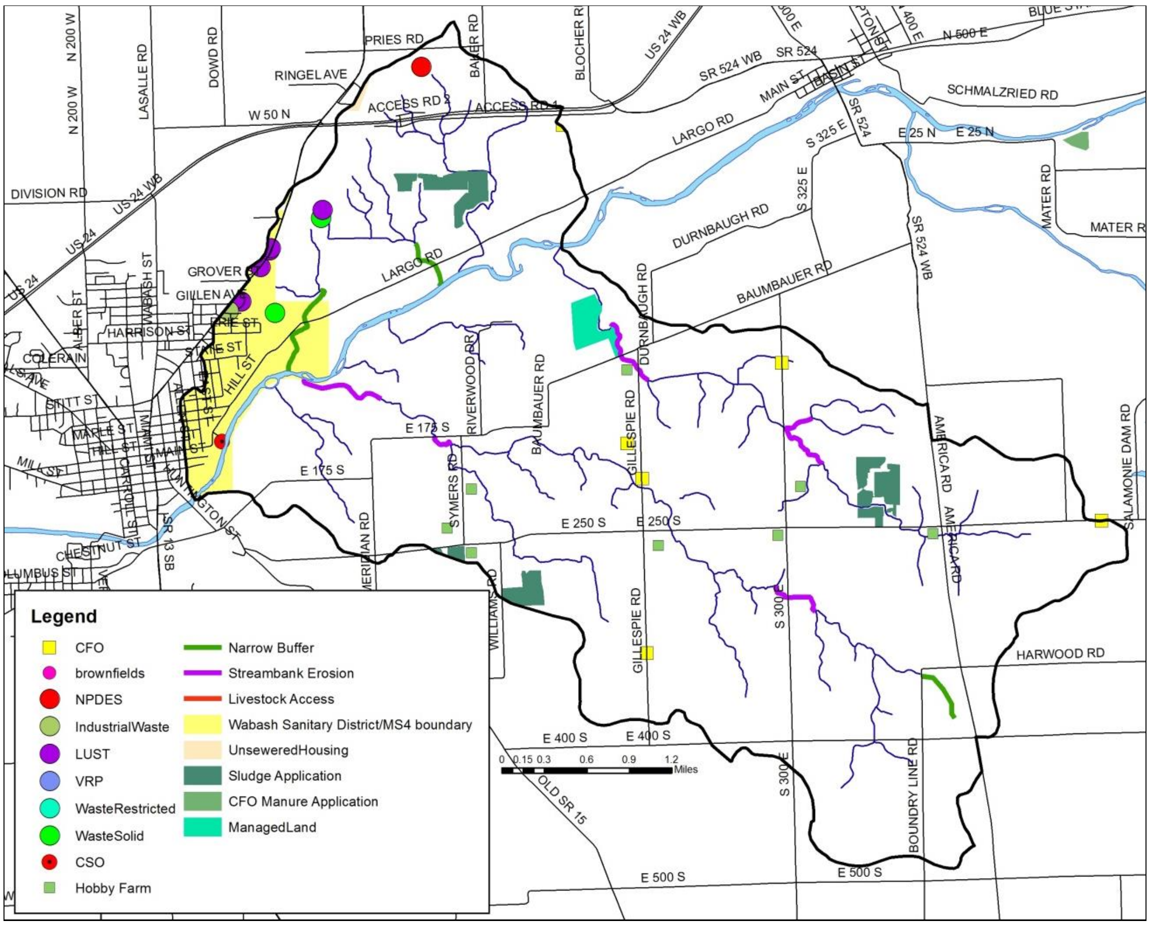

**Figure 53. Point and non-point sources of pollution and suggested solutions in the Burr Creek-Wabash River Subwatershed.**

### 4.3.4 Non-Point Source Water Quality Issues

Approximately 8 small animal operations housing more than 40 cows, horses, and poultry were identified during the windshield survey (Figure 53, Table 21). Observations are lower than estimates produced using county-wide NASS data, which suggest 764 animals are located in the Burr Creek-Wabash River Subwatershed. Three CFOs are located within the subwatershed housing nearly 4,200 swine, dairy cattle and veal. In total, manure from small animal operations and CFO total 46,202 tons per year, which contains almost 37,546 pounds of nitrogen and almost 23,315 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 3.2 miles of insufficient stream buffers and 4.8 miles of streambank erosion were identified within the subwatershed.

### 4.3.5 Water Quality Assessment

Waterbodies within the Burr Creek-Wabash River Subwatershed have been sampled historically at 3 locations (Figure 54, Table 21). Assessments include collection of water chemistry data by the Wabash River Defenders (2 sites) and by the City of Wabash as part of the stream reach characterization efforts. Fish and macroinvertebrate communities have not been sampled in this subwatershed. No stream gages are located in the Burr Creek-Wabash River Subwatershed. pH levels measured below the lower state standards twice during the current assessment. Turbidity exceeded target levels during seven sampling events in Burr Creek and six sampling events in Ross Run. Total suspended solids concentrations exceeded targets during two sampling events in Burr Creek and five sampling events in Ross Run. E. coli concentrations exceeded the state standard during 18 sampling events at both sites with concentrations measuring as high as 2700 colonies/100 ml. Nitrate-nitrogen and total phosphorus concentrations exceeded targets during more than half of the sampling events. Macroinvertebrate communities in Burr Creek rated as fully supporting, while communities in Ross Run rated as partially supporting. Fish communities rated as fair in both streams, while habitat rated as good.

**Table 21. Water quality data collected in the Burr Creek-Wabash River Subwatershed, March 2018 to March 2019.**

| Site | | DO (mg/L) | Temp (deg C) | pH | Cond (mg/L) | Turb (NTU) | Nitrate (mg/L) | TP (mg/L) | Ecoli (col/100 mL) | TSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 Burr Creek | Median | 9.17 | 9.9 | 7.34 | 492 | 5.45 | 1.47 | 0.121 | 700 | 17.75 |
| | Max | 16.05 | 21.06 | 8.15 | 616 | 295 | 11.4 | 2.04 | 2700 | 68.5 |
| | Min | 4.14 | 0.26 | 5.7 | 249 | 2.62 | 0.117 | 0.005 | 20 | 5.5 |
| | #Samples | 15 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 20 |
| | #Exceed | 4 | 0 | 2 | 0 | 7 | 12 | 14 | 18 | 2 |
| | % Exceed | 26.7% | 0.0% | 8.7% | 0.0% | 30.4% | 50.0% | 58.3% | 78.3% | 10.0% |
| 9 Ross Run | Median | 11.5 | 9.66 | 7.48 | 531 | 4.83 | 1.68 | 0.1165 | 540 | 13.5 |
| | Max | 16.16 | 23.83 | 8.28 | 688 | 267 | 4.31 | 1.99 | 1050 | 70.5 |
| | Min | 4.27 | 0.18 | 5.8 | 286 | 1.46 | 0.475 | 0.013 | 10 | 3.5 |
| | #Samples | 15 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 20 |
| | #Exceed | 7 | 0 | 2 | 0 | 6 | 12 | 13 | 18 | 5 |
| | % Exceed | 46.7% | 0.0% | 8.7% | 0.0% | 26.1% | 50.0% | 54.2% | 78.3% | 25.0% |

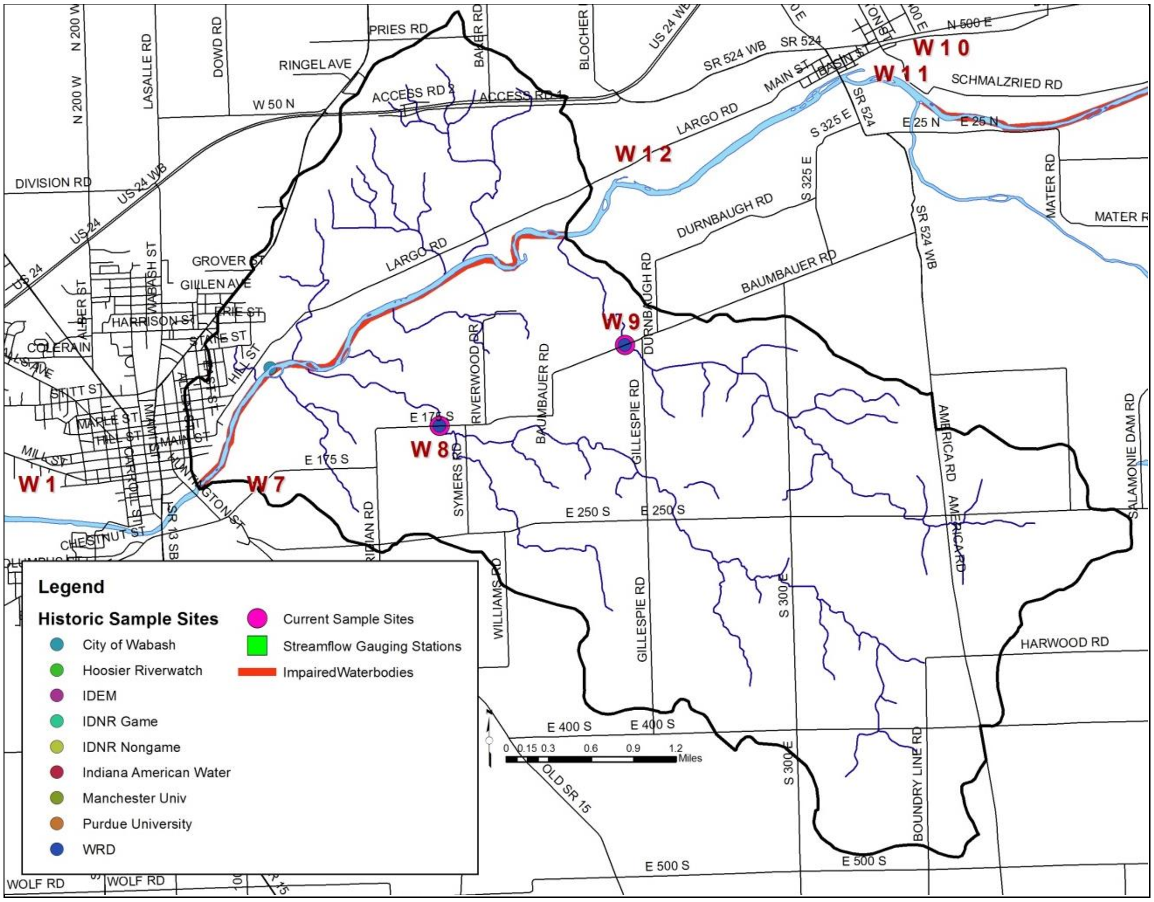


**Figure 54. Locations of current and historic water quality data collection and impairments in the Burr Creek-Wabash River Subwatershed.**

## 4.4 Ridgeway Creek Subwatershed

The Ridgeway Creek Subwatershed forms the southern portion of the Treaty Creek-Wabash Watershed south of the City of Wabash lying completely within Wabash County. It includes 12-digit HUC watershed: 051201011404 (Figure 55). The Ridgeway Creek Subwatershed drains 10,324.6 acres or 16.1 square miles. There are 20.3 miles of stream, of which 13 miles are impaired for impaired biotic communities.

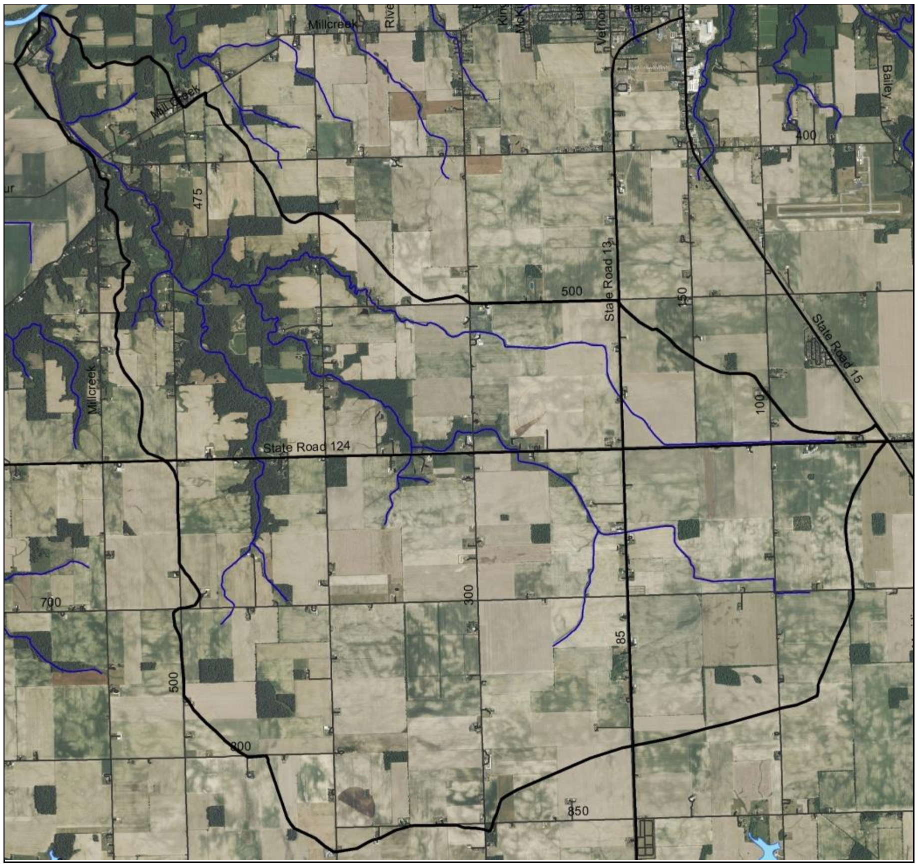


**Figure 55. Ridgeway Creek Subwatershed.**

### 4.4.1 Soils

Soils in the Ridgeway Creek Subwatershed transition from Fincastle-Brookston-Miamian soils, which lie on uplands along the southern border of the subwatershed into Miami-Crosby-Greaty soils along the lower portion of the subwatershed. These soils are excessively drained and found on gentle to strong slopes. Hydric soils cover 3,703 acres (36%) of the subwatershed, indicating that nearly one-third the land was historically wetlands. Wetlands currently cover 1% (53.9 acres) of the subwatershed, representing a loss of 99% of historic wetlands. This represents both the lowest wetland acreage and highest wetland loss of any of the Treaty Creek-Wabash River Subwatersheds. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 12% and 20% of the land, respectively. Nearly the entire subwatershed (95%) has soils which are severely limited for septic use.

### 4.4.2 Land Use

The Ridgeway Creek subwatershed contains nearly 8,708 acres (84%) of row crop and pasture. Forested land uses cover 913 acres (9%) of the Ridgeway Creek Subwatershed. Wetlands, open water, and grasslands account for 2% (547.6 acres) of land within the subwatershed, while urban land uses cover the remaining 547 acres (5.3%).

### 4.4.3 Point Source Water Quality Issues

The Ridgeway Creek Subwatershed contains no point sources (Figure 56).

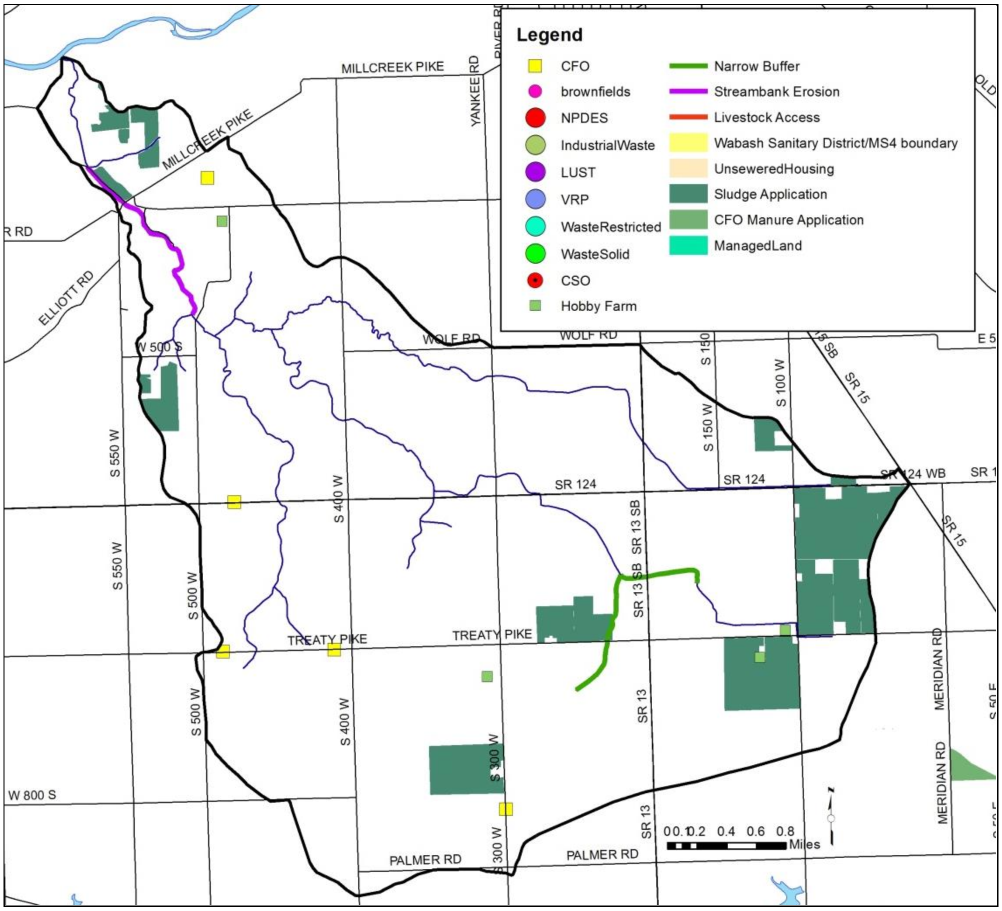


**Figure 56. Point and non-point sources of pollution and suggested solutions in the Ridgeway Creek Subwatershed.**

### 4.4.4 Non-Point Source Water Quality Issues

Agricultural land uses dominate the Ridgeway Creek Subwatershed, primarily in a corn-soybean rotation. Approximately 4 small animal operations housing nearly 30 animals are present (Figure 56). Areas where livestock have access to the stream were not identified in the subwatershed. Three active confined feeding operations housing a total of more than 3,900 swine per year are located in the Ridgeway Creek Subwatershed. Manure from the three CFOs and 4 small animal operations produce more than 16,848 tons per year. This contains almost 49,291 pounds of nitrogen and almost 37,202 pounds of phosphorus. Municipal biosolids are applied to 813 acres within the subwatershed. Narrow stream buffers were observed along 3.1 miles of streams within the subwatershed.

### 4.4.5 Water Quality Assessment

Waterbodies within the Ridgeway Creek Subwatershed have been sampled historically at 2 locations (Figure 57, Table 22). Assessments include collection of water chemistry data by IDEM (2 sites) and via the Wabash River Defenders (1 site). The fish and macroinvertebrate communities have been assessed by IDNR at 2 sites. No stream gages are located in the Ridgeway Creek Subwatershed. pH levels measured below the lower state standards twice during the current assessment. Turbidity and total suspended solids exceeded target concentrations during five sampling events. E. coli concentrations exceeded the state standard during 20 sampling events with concentrations measuring as high as 3750 colonies/100 ml. Nitrate-nitrogen concentrations exceeded targets during 75% of sampling events (18) while total phosphorus concentrations exceeded targets during only 20% of sampling events (5)

Macroinvertebrate communities rated as partially supporting with fish communities rating as good and habitat rating as excellent.

**Table 22. Water quality data collected in the Ridgeway Creek Subwatershed, March 2018 to March 2019.**

| Site | | DO (mg/L) | Temp (deg C) | pH | Cond (mg/L) | Turb (NTU) | Nitrate (mg/L) | TP (mg/L) | Ecoli (col/100 mL) | TSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 Mill Creek | Median | 10.07 | 10.52 | 7.49 | 519 | 4.02 | 3.06 | 0.029 | 490 | 10.125 |
| | Max | 15.38 | 22.5 | 8.35 | 574 | 60.9 | 6.74 | 0.528 | 3750 | 54.5 |
| | Min | 4.18 | 1.16 | 5.81 | 344 | 1.12 | 0.92 | 0.003 | 150 | 2.25 |
| | #Samples | 15 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 20 |
| | #Exceed | 5 | 0 | 2 | 0 | 5 | 18 | 5 | 20 | 5 |
| | % Exceed | 33.3% | 0.0% | 8.7% | 0.0% | 21.7% | 75.0% | 20.8% | 87.0% | 25.0% |

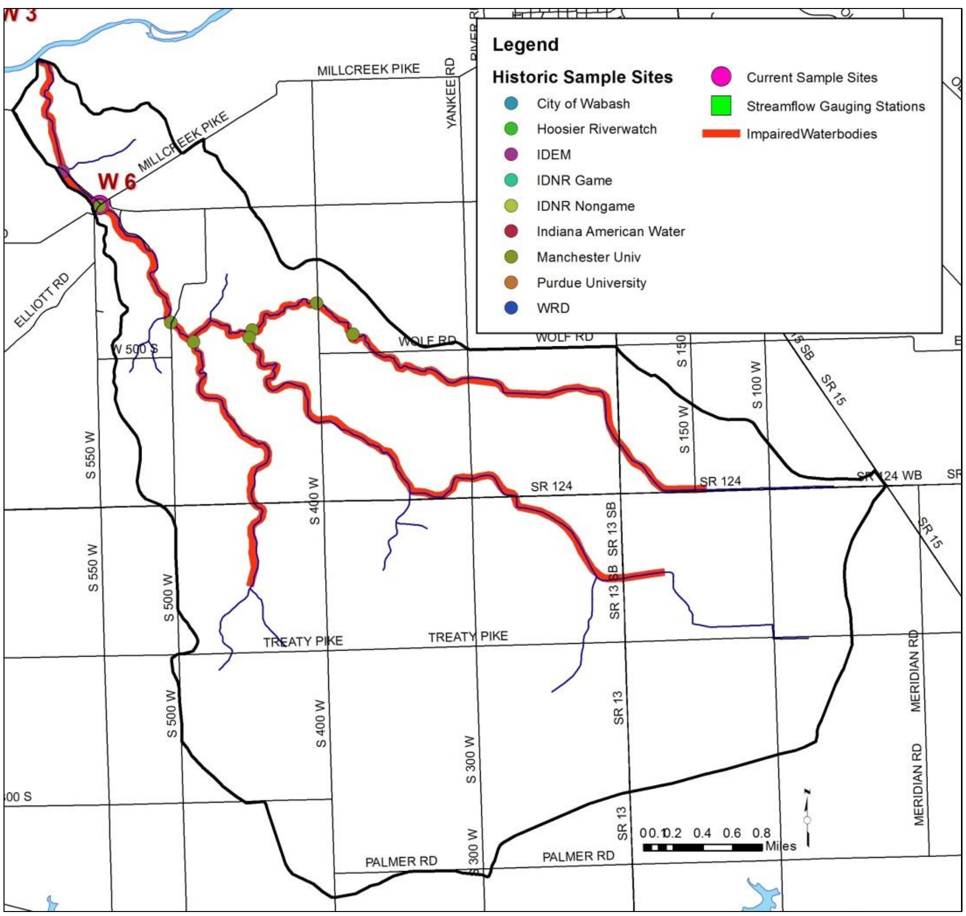


**Figure 57. Locations of historic water quality data collection and impairments in the Ridgeway Creek Subwatershed.**

## 4.5 Kentner Creek Subwatershed

The Kentner Creek Subwatershed forms the northcentral portion of the Treaty Creek-Wabash RIver Watershed including much of the City of Wabash (Figure 58). The Kentner Creek Subwatershed encompasses one 12-digit HUC watersheds: 051201011405. The subwatershed drains 18,635 acres or 29.1 square miles. There are 45.9 miles of stream, of which 5.0 mile are impaired for *E. coli*, nutrients, PCBs, and mercury.

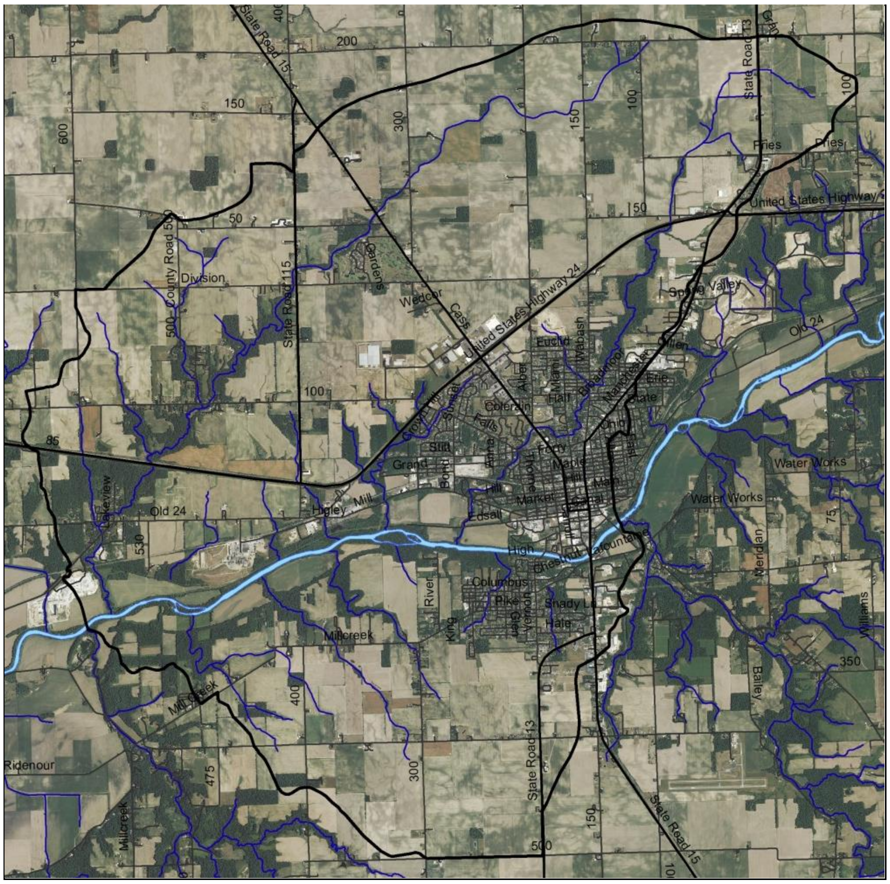


**Figure 58. Kentner Creek Subwatershed.**

### 4.5.1 Soils

Fincastle-Brookston-Miamian soils form the northern subwatershed. Miami-Crosby-Treaty soils, which dominate the uplands throughout the subwatershed transition to Millsdale-Newglarus-Randolph soils, which lie along the Wabash River floodplain. Hydric soils cover 4,048 acres (22%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. In total, 191.6 acres (1% of the watershed) of wetlands remain in the Kentner Creek Subwatershed representing a 96% wetland loss. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 12% and 20% of the land, respectively. Nearly the entire Kentner Creek Subwatershed (95%) has soils which are severely limited for septic use.

### 4.5.2 Land Use

Agricultural land uses dominate the Kentner Creek Subwatershed with 67% in row crops and hay/pasture. Nearly 4,043 acres of urban land is located within the Kentner Creek Subwatershed covering the largest percentage of any of the Treaty Creek-Wabash River drainages. Forest covers the smallest percentage of any Treaty Creek-Wabash River Subwatershed accounting for just 1,583 acres (8%) of the Kentner Creek Subwatershed. The smallest area (2% or 446.1 acres) of wetlands, open water, and grassland are also found within the Kentner Creek Subwatershed.

### 4.5.3 Point Source Water Quality Issues

As the Kentner Creek Subwatershed contains the City of Wabash, a number of point sources of pollution are present (Figure 59). There are three NPDES permitted facilities including Lakeview MHP, Wabash Alloys, and the City of Wabash municipal treatment plant. There are 14 industrial waste facilities, one restricted waste facility and two facilities participating in the voluntary remediation program. There are 42 leaking underground storage tank (LUST) located throughout the City of Wabash (Figure 59). There are eight combined sewer overflow points and the entire City of Wabash MS4 is located within the Kentner Creek Subwatershed.

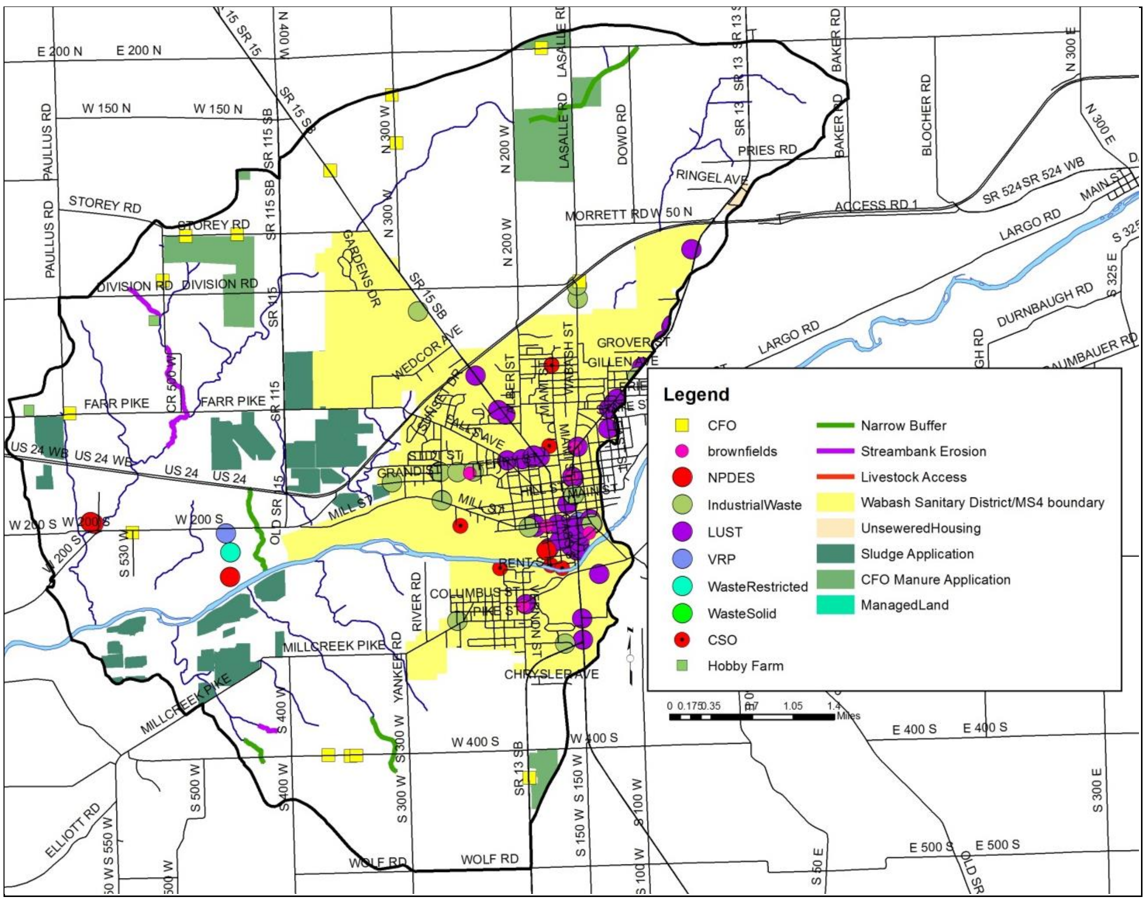


**Figure 59. Point and non-point sources of pollution and suggested solutions in the Kentner Creek Subwatershed.**

### 4.5.4 Non-Point Source Water Quality Issues

Only two unregulated animal operations were identified during the windshield survey housing approximately 25 animals (Figure 59). County-wide NASS statistics suggest a higher animal density of 1,266. Less than 0.8 miles of streambank exhibit livestock access impacts in the Kentner Creek Subwatershed. Seven active confined feeding operations are located within the Kentner Creek Subwatershed housing more than 11,280 swine and beef and dairy cattle. Overall, small animal operations and CFOs produce over 56,134 tons per year. This contains almost 139,039 pounds of nitrogen and almost 102,239 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 5.8 miles of insufficient stream buffers and 3.4 miles of streambank erosion were identified within the subwatershed (Figure 59).

#### 4.5.5 Water Quality Assessment

Waterbodies within the Kentner Creek Subwatershed have been sampled historically at 11 locations (Figure 60, Table 23). Assessments include collection of water chemistry data by IDEM (2 sites), via the City of Wabash as part of their stream reach characterization (4 sites), by Indiana American Water (1 site), and by the Wabash River Defenders (4 sites). The fish community was assessed by Ball State University, the Indiana DNR, and by IDEM. Macroinvertebrates were sampled by IDEM at the same sites. The watershed's only USGS stream gages is located in the Kentner Creek Subwatershed. pH levels measured below the lower state standards once during the current assessment. Turbidity levels exceeded targets during one sampling event. Total suspended solids exceeded target concentrations during one sampling event in Charley Creek but did not exceed targets in Kentner Creek. E. coli concentrations exceeded the state standard during 11 sampling events in Charley Creek with concentrations as high as 620 colonies/100 ml and in 21 events in Kentner Creek with concentrations as high as 2550 colonies/100 ml. Historic water quality data indicate that combined sewer overflows continue in Charley Creek with elevated E. coli concentrations observed immediately below overflow locations during storm events. However, these elevated concentrations appear to be mitigated by the time Charley Creek reaches the sample site. Nitrate-nitrogen concentrations exceeded targets during 14 and 19 events in Charley Creek and Kentner Creek, respectively and total phosphorus concentrations exceeded targets during 12 sampling events at both sites. Macroinvertebrate communities at Charley Creek rated as fully supporting with fish communities and habitat both rating good. In Kentner Creek, macroinvertebrate communities rated as partially supporting with fish communities rating good-excellent and habitat rating good.

**Table 23. Water quality data collected in the Kentner Creek Subwatershed, March 2018 to March 2019.**

| Site | | DO (mg/L) | Temp (deg C) | pH | Cond (mg/L) | Turb (NTU) | Nitrate (mg/L) | TP (mg/L) | Ecoli (col/100 mL) | TSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 Charley Creek | Median | 11.1 | 8.515 | 7.675 | 586.5 | 4.915 | 2.22 | 0.0695 | 230 | 7.5 |
| | Max | 14.26 | 21.24 | 8.41 | 662 | 51.3 | 4.69 | 0.358 | 620 | 45 |
| | Min | 5.92 | -0.06 | 5.98 | 353 | 1.76 | 0.546 | 0.007 | 60 | 3 |
| | #Samples | 13 | 22 | 22 | 22 | 22 | 24 | 24 | 23 | 20 |
| | #Exceed | 4 | 0 | 1 | 0 | 3 | 14 | 12 | 11 | 1 |
| | % Exceed | 30.8% | 0.0% | 4.5% | 0.0% | 13.6% | 58.3% | 50.0% | 47.8% | 5.0% |
| 2 Kentner Creek | Median | 9.84 | 10.98 | 7.43 | 572 | 1.78 | 3.655 | 0.0615 | 390 | 3.875 |
| | Max | 14.97 | 19.03 | 8.2 | 668 | 81.3 | 7.58 | 2.85 | 2550 | 16 |
| | Min | 4.05 | 1.23 | 5.93 | 200 | 0.39 | 1.14 | 0.006 | 150 | 0.5 |
| | #Samples | 15 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 20 |
| | #Exceed | 5 | 0 | 1 | 0 | 3 | 19 | 12 | 21 | 0 |
| | % Exceed | 33.3% | 0.0% | 4.3% | 0.0% | 13.0% | 79.2% | 50.0% | 91.3% | 0.0% |

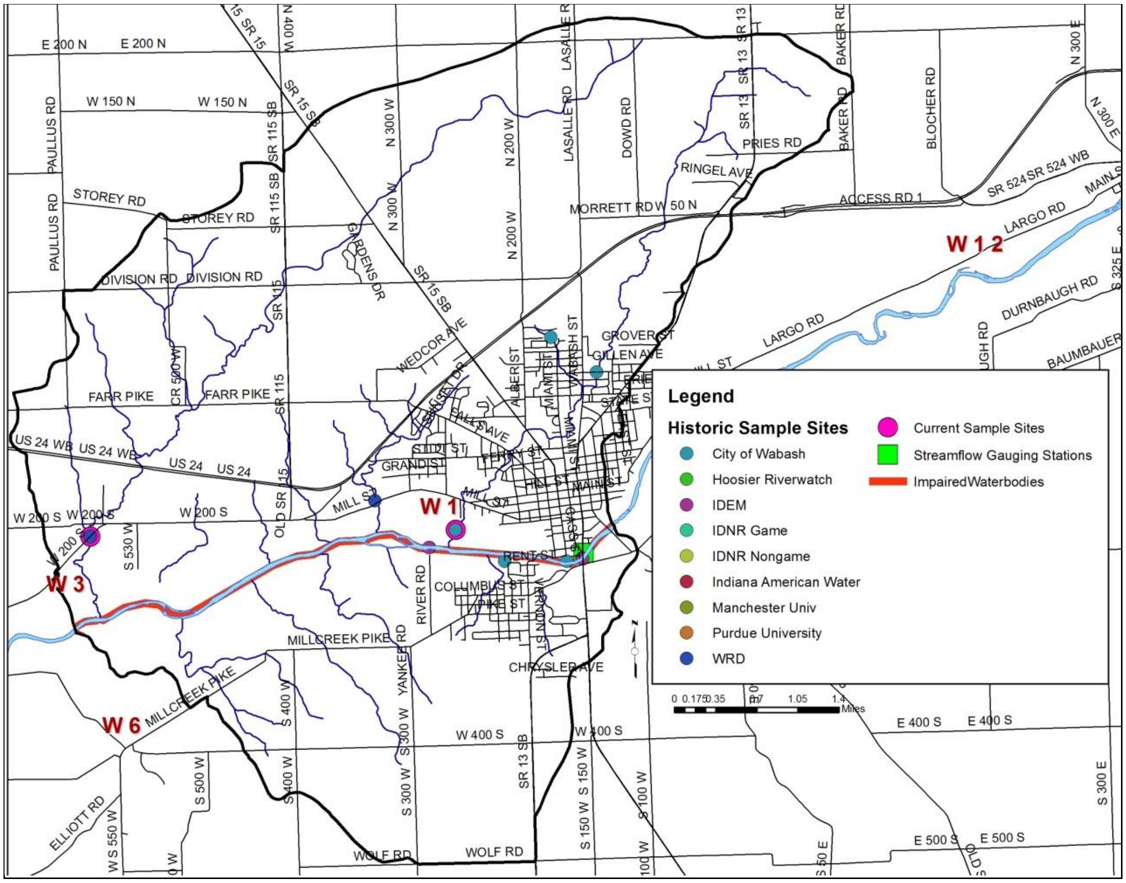

Figure 60. Locations of historic water quality data collection and impairments in the Kentner Creek Subwatershed.

## 4.6 Gilbert Branch-Wabash River Subwatershed

The Gilbert Branch-Wabash River Subwatershed lies within Miami and Wabash Counties forming the northern border of the Treaty Creek-Wabash River Watershed west of the City of Wabash (Figure 61). The Gilbert Branch-Wabash River Subwatershed drains 11,224 acres or 17.5 square miles. There are 36.8 miles of stream. IDEM has classified 3.8 miles of stream as impaired for nutrients and *E. coli*, nutrients, PCBs, and mercury.

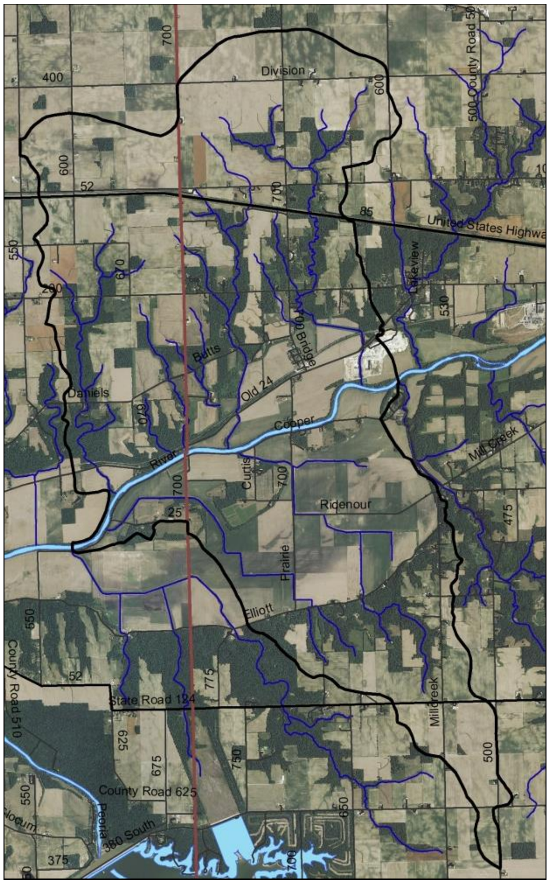


**Figure 61. Gilbert Branch-Wabash River Subwatershed.**

### 4.6.1 Soils

Soils in the Gilbert Branch-Wabash River Subwatershed are dominated by Sawmill-Laswon-Genesee soils which cover much of the Wabash River floodplain and corridor. These soils are found on shallowly sloped, relatively well-drained areas. Smaller areas of Blount-Glynwood-Morley, Fincastle-Brookston-Miamian and Miami-Crosby-Treaty soils cover the remainder of the subwatershed. These soils are moderately well-drained and found on shallowly sloped areas. Hydric soils cover 2,679 acres (24%) of the subwatershed, indicating that less than one quarter of the land was historically wetlands. Wetlands currently cover 1% (116.4 acres) of the subwatershed, representing a loss of 96% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 16% and 11% of the land, respectively. More than half of the subwatershed (69%) has soils which are severely limited for septic use.

### 4.6.2 Land Use

Agricultural land uses, including row crop and pasture, account for 8,505 acres (76%) of the subwatershed land use. Forested land uses are present on 1,590 acres (14%) of the Gilbert Branch-Wabash River Subwatershed. Urban land use with nearly 7% (774.8 acres) covered by developed lands. Wetland, open water, and grasslands account for just 3% (360.5 acres) of the Gilbert Branch-Wabash River Subwatershed.

### 4.6.3 Point Source Water Quality Issues

There are no point sources of water pollution in the Gilbert Branch-Wabash River Subwatershed (Figure 62).

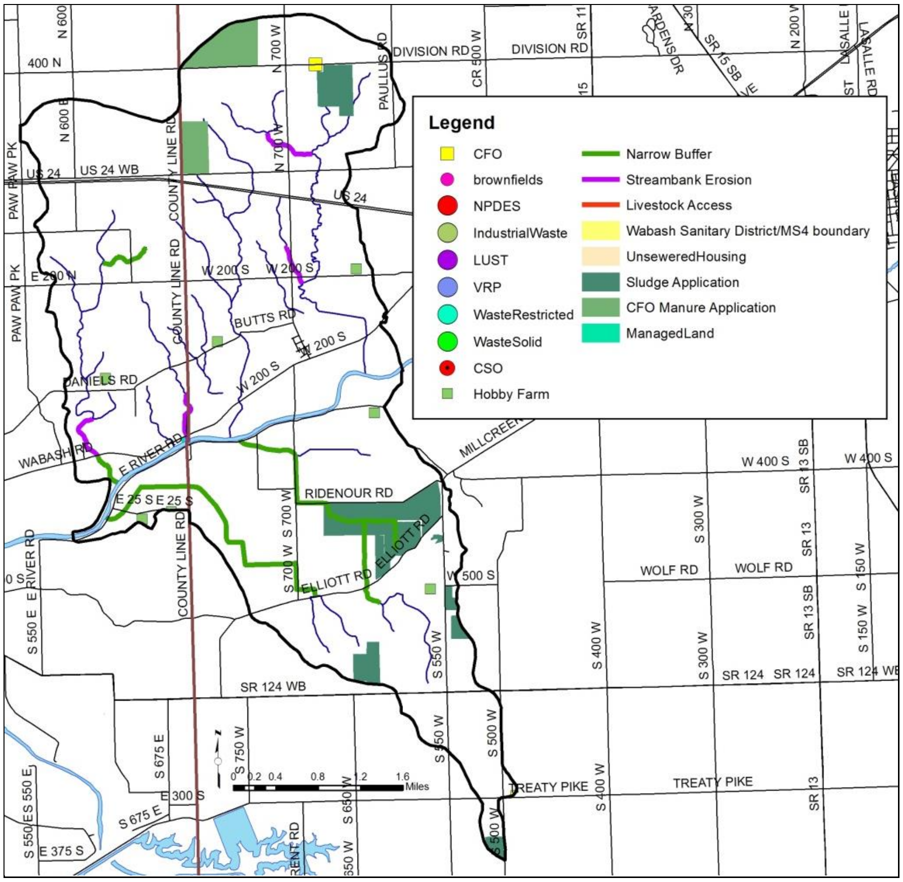


**Figure 62. Point and non-point sources of pollution and suggested solutions in the Gilbert Branch-Wabash River Subwatershed.**

### 4.6.4 Non-Point Source Water Quality Issues

Approximately seven small animal operations are present within the Gilbert Branch-Wabash River Subwatershed (Figure 62). These unregulated animal operations housing approximately 76 animals were identified during the windshield survey. NASS county-wide statistics provide a higher estimated density of 762 animals in the Gilbert Branch-Wabash River Subwatershed. One active confined feeding operation housing a total of 1,200 swine per year is located within the Gilbert Branch-Wabash River Subwatershed. Manure from this CFO is spread on 109 acres in the Gilbert Branch-Wabash River Subwatershed. In total, approximately 5,917 tons of manure is generated annually from CFOs and small animal operations. This contains almost 16,038 pounds of nitrogen and almost 12,041 pounds of phosphorus. Municipal biosolids are applied to 476 acres within the subwatershed. Streambank erosion impacts 4.5 miles of stream throughout the Gilbert Branch-Wabash River Subwatershed, while nearly 13.8 miles of streams possess narrow buffers.

### 4.6.5 Water Quality Assessment

Waterbodies within the Gilbert Branch-Wabash River Subwatershed have been sampled historically at 4 locations (Figure 63; Table 24). Assessments include collection of water chemistry data by Wabash River

Defenders (1 site). The fish community has been assessed by Indiana DNR and Purdue University (1 site), while the mussel community has been assessed at the same site by the Indiana DNR non-game program. Macroinvertebrates have not been sampled historically in this subwatershed. No stream gages are located in the Gilbert Branch-Wabash River Subwatershed. pH levels measured below the lower state standards twice during the current assessment. Turbidity levels exceeded targets during three sampling events, while total suspended solids concentrations did not exceed targets. E. coli concentrations exceeded the state standard during 19 sampling events with concentrations measuring as high as 1670 colonies/100 ml. Nitrate-nitrogen concentrations exceeded targets during 18 events while total phosphorus concentrations exceeded targets during only nine sampling events. Macroinvertebrate communities rated as partially supporting, while fish communities rated as good-excellent and habitat rated as good.

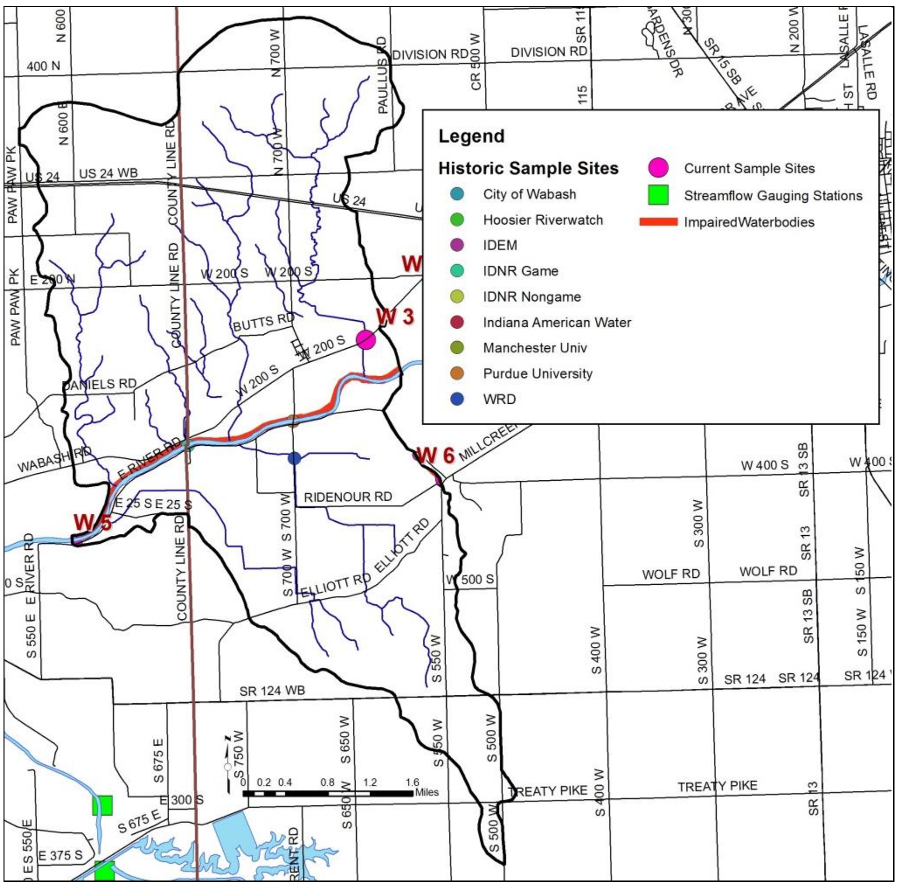


**Figure 63. Locations of historic water quality data collection and impairments in the Gilbert Branch-Wabash River Subwatershed.**

**Table 24. Water quality data collected in the Gilbert Creek-Wabash River Subwatershed, March 2018 to March 2019.**

| Site | | DO (mg/L) | Temp (deg C) | pH | Cond (mg/L) | Turb (NTU) | Nitrate (mg/L) | TP (mg/L) | Ecoli (col/100 mL) | TSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 Carlin Branch | Median | 9.04 | 10.51 | 7.51 | 560 | 2.48 | 3.245 | 0.055 | 700 | 11.625 |
| | Max | 14.76 | 21.3 | 8.24 | 596 | 63.6 | 6.18 | 0.518 | 1670 | 25.5 |
| | Min | 3.6 | 0.1 | 5.97 | 200 | 1.21 | 0.752 | 0.013 | 150 | 2.75 |
| | #Samples | 15 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 20 |
| | #Exceed | 6 | 0 | 2 | 0 | 3 | 18 | 9 | 19 | 0 |
| | % Exceed | 40.0% | 0.0% | 8.7% | 0.0% | 13.0% | 75.0% | 37.5% | 82.6% | 0.0% |

## 4.7 Daniel Creek-Wabash River Subwatershed

The Daniel Creek-Wabash River Subwatershed is the western-most subwatershed which lies completely within Miami County (Figure 64). It encompasses one 12-digit HUC watershed: 051201011407. The Daniel Creek-Wabash River Subwatershed drains 16,314 acres or 25.5 square miles. There are 46.1 miles of streams of which 3.85 miles are impaired for *E. coli*, nutrients, PCBs, and mercury.

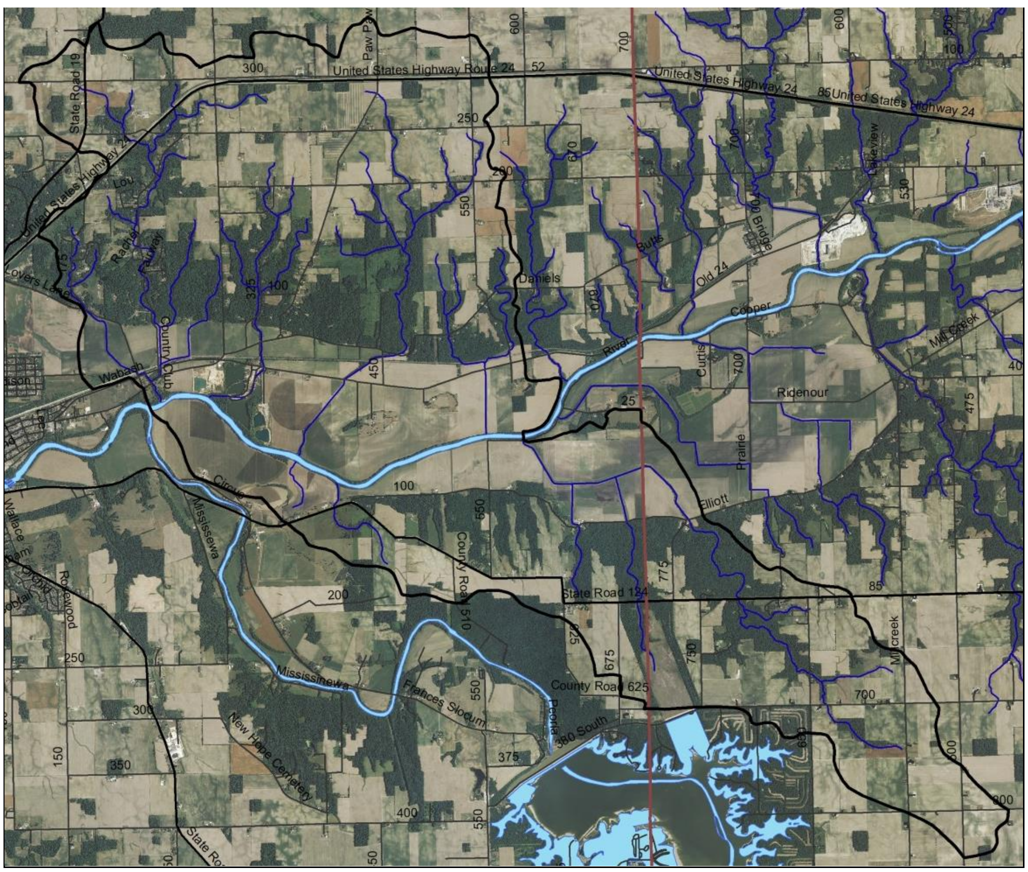


**Figure 64. Daniel Creek-Wabash River Subwatershed.**

### 4.7.1 Soils

Soils in the Daniel Creek-Wabash River Subwatershed are dominated by Sawmill-Laswon-Genesee soils which cover much of the Wabash River floodplain and corridor. These soils are found on shallowly sloped, relatively well-drained areas. Smaller areas of Blount-Glynwood-Morley, Fincastle-Brookston-Miamian and Miami-Crosby-Treaty soils cover the remainder of the subwatershed. These soils are moderately well-drained and found on shallowly sloped areas. Blount-Pewamo-Glynwood soils cover the northern border of the subwatershed. Hydric soils cover 2,201 acres (13%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. Wetlands currently cover 2% (314.4 acres) of the subwatershed, representing a loss of 86% of historic wetlands. Highly erodible and potentially highly erodible soils are present throughout the subwatershed, covering 21% and 3% of the land, respectively. Nearly the entire subwatershed (97%) has soils which are severely limited for septic use.

### 4.7.2 Land Use

Agricultural land uses are dominant within the Daniel Creek-Wabash River Subwatershed. In total 11,183.2 acres (69%) of the subwatershed is in row crop agriculture or pasture. Nearly 2,924 acres (18% ) of the watershed is in forest land use. Wetlands, open water, and grassland cover 936.3 acres or 6% of the subwatershed. Nearly 1,280 acres (7.8%) of the Daniel Creek-Wabash River Subwatershed is in urban land uses including suburban development east of the City of Peru.

### 4.7.3 Point Source Water Quality Issues

There are no point sources of water pollution in the subwatershed (Figure 65).

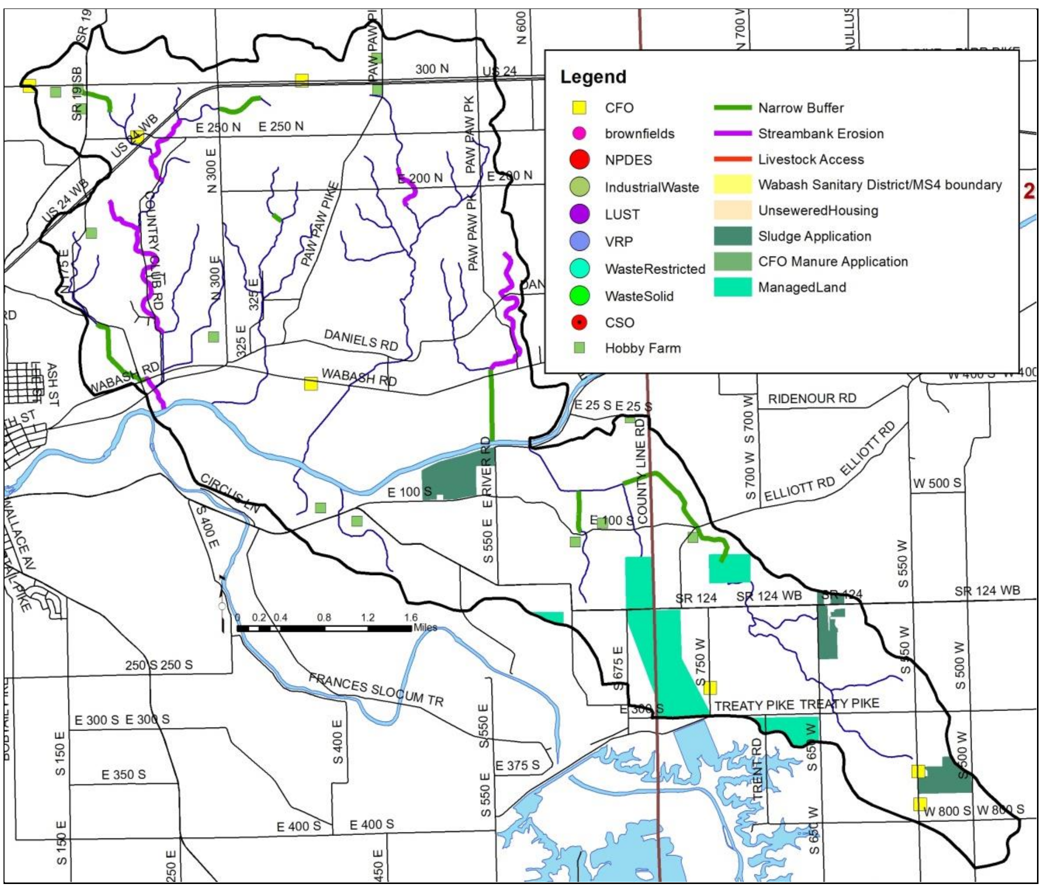


**Figure 65. Point and non-point sources of pollution and suggested solutions in the Daniel Creek-Wabash River Subwatershed.**

### 4.7.4 Non-Point Source Water Quality Issues

Non-point sources of pollution are found throughout the Daniel Creek-Wabash River Subwatershed (Figure 65). More than 12 small animal operations housing more than 105 animals were identified during the windshield survey, which house approximately 100 animals. NASS county-wide statistics suggest a higher animal density of 578 animals within the Daniel Creek-Wabash River Subwatershed. Livestock had access to the stream impacting 1.4 miles of streambank. Four active confined feeding operations housing more than 23,000 swine are located within the Daniel Creek-Wabash River Subwatershed. Manure from confined feeding operations and small animal operations totals over 94,850 tons per year. This contains almost 276,762 pounds of nitrogen and almost 211,277 pounds of phosphorus. Approximately 11.2 miles of streambank erosion and nearly 6.6 miles of streams with narrow buffers were identified within the subwatershed.

### 4.7.5 Water Quality Assessment

Waterbodies within the Daniel Creek-Wabash River Subwatershed have been sampled historically at 1 location (Figure 66, Table 25). Assessments include collection of water chemistry data via the current project and fish community assessments via Purdue University (1 site). Macroinvertebrates have not been sampled by any other groups in this subwatershed. No stream gages are located in the Daniel Creek-Wabash River Subwatershed. Additionally, it should be noted that Daniel Creek is an intermittent stream with interstitial flow conditions present during a majority of the sampling period. With this in mind, only 12 sample sets were collected of the possible 26 sampling events. pH levels measured below the lower state standards twice during the current assessment in Asher Branch. Turbidity levels were elevated during 36% of sampling events in Daniel Creek (4) and in 26% of events in Asher Branch (6). Total suspended solids exceeded target concentrations during 22% and 15% of sampling events, respectively. E. coli concentrations exceeded the state standard during all sampling events in Daniel Creek and in 70% of samples collected from Asher Branch (16). Nitrate-nitrogen exceeded target concentrations in all samples collected from Daniel Creek and in 54% of samples collected from Asher Branch (13). Total phosphorus concentrations exceeded targets during 33% of sampling events in Daniel Creek and in 54% of sampling events in Asher Branch. Macroinvertebrate communities at both sites rated as partially supporting. Fish in Asher Branch rated as fair to good with habitat rating as good. In Daniel Creek, no fish were observed during the sampling event, thus the community rated as very poor. Habitat also rated as very poor.

**Table 25. Water quality data collected in the Daniel Creek-Wabash River Subwatershed, March 2018 to March 2019.**

| Site | | DO (mg/L) | Temp (deg C) | pH | Cond (mg/L) | Turb (NTU) | Nitrate (mg/L) | TP (mg/L) | Ecoli (col/100 mL) | TSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 Daniel Creek | Median | 11.94 | 1.16 | 7.77 | 514 | 7.78 | 3.165 | 0.0415 | 590 | 16.25 |
| | Max | 16.43 | 15.81 | 8.41 | 569 | 112 | 3.62 | 0.432 | 1950 | 47 |
| | Min | 3.8 | -0.1 | 7.5 | 272 | 2.58 | 1.81 | 0.02 | 240 | 10.25 |
| | #Samples | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 11 | 9 |
| | #Exceed | 6 | 0 | 0 | 0 | 4 | 12 | 4 | 11 | 2 |
| | % Exceed | 54.5% | 0.0% | 0.0% | 0.0% | 36.4% | 100.0% | 33.3% | 100.0% | 22.2% |
| 5 Asher Branch | Median | 10.4 | 10.04 | 7.61 | 505 | 3.6 | 2.21 | 0.0725 | 510 | 13.5 |
| | Max | 15.44 | 21.78 | 8.35 | 550 | 70.7 | 5.76 | 0.284 | 3150 | 57 |
| | Min | 4.04 | -0.1 | 5.93 | 310 | 1.03 | 0.399 | 0.006 | 20 | 1 |
| | #Samples | 15 | 23 | 23 | 23 | 23 | 24 | 24 | 23 | 20 |
| | #Exceed | 4 | 0 | 2 | 0 | 6 | 15 | 13 | 16 | 3 |
| | % Exceed | 26.7% | 0.0% | 8.7% | 0.0% | 26.1% | 62.5% | 54.2% | 69.6% | 15.0% |

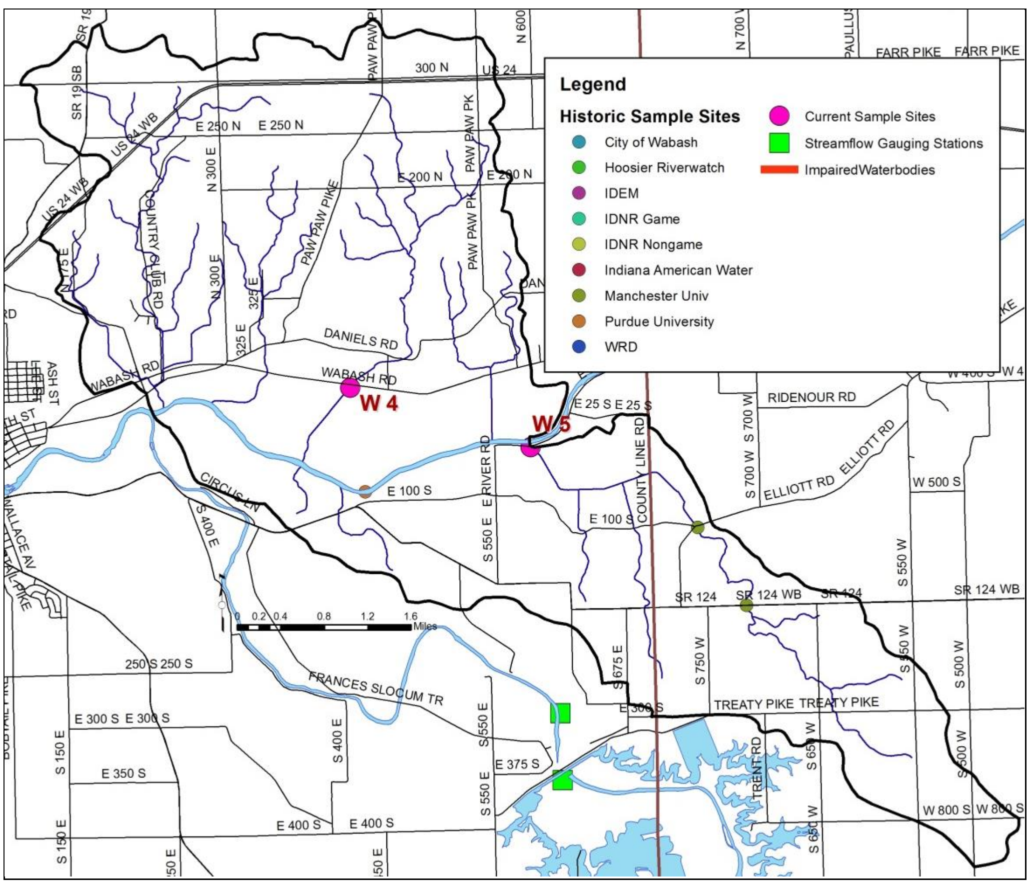


**Figure 66. Locations of current and historic water quality data collection and impairments in the Daniel Creek-Wabash River Subwatershed.**

# 5.0 WATERSHED INVENTORY III: WATERSHED INVENTORY SUMMARY

Several important factors and relationships become apparent when the Treaty Creek-Wabash River Watershed is observed both as a whole and in part. Many of these were discussed in the individual subwatershed discussions above. An overall summary of water quality impairments and a review of stakeholder concerns and any data which support these concerns are included below.

## 5.1 Water Quality Summary

Several water quality impairments were identified during the watershed inventory process, based on current and historic data collected from IDEM, IDNR, Manchester University, Indiana American Water, the City of Wabash, and Hoosier Riverwatch. These include elevated nitrate-nitrogen, total phosphorus, total suspended solids or turbidity, and *E. coli* concentrations; pH concentrations outside of target ranges; and limited habitat and/or fish and macroinvertebrate communities at some sites.

Table 26 summarizes current samples which measured outside the target values (Table 14) during the current assessment. Elevated nitrate-nitrogen concentrations were observed at all sample sites with concentrations exceeding targets during 50% or more of sampling events throughout the Treaty Creek-Wabash River Watershed. Elevated total phosphorus concentrations were observed at many sample sites with concentrations exceeding total phosphorus targets during 50% or more of collected samples at Charley Creek, Kentner Creek, Asher Branch, Treaty Creek, Ross Run, Rager Creek, Lagro Creek and Enyeart Creek (Sites 01, 02, 05, 07, 07, 09, 10, 11 and 12). Elevated total suspended solids concentrations were observed at multiple sites with 12% of all samples exceeding targets; however, no site contained elevated TSS concentrations in more than 25% of samples. Turbidity concentrations exceeded targets in 21% of collected sample; however, no site exceeded turbidity targets in more than 36% of samples. *E. coli* concentrations that exceeded the state grab sample standard were measured at all sites with 75% of samples exceeding state standards. All sites except Charley Creek (S01) exceeded E. coli concentrations in more than 50% of collected samples. pH concentrations measured outside of targets in 7% of all samples or between 4 and 9% of collected samples at each site.

**Table 26. Percent of samples collected in the Treaty Creek-Wabash River Watershed from March 2018 through March 2019 which measured outside of target values.**

| Site | DO (mg/L) | Temp (deg C) | pH | Conductivity (mg/L) | Turbidity (NTU) | Nitrate (mg/L) | TP (mg/L) | Ecoli (col/100 mL) | TSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 31% | 0% | 5% | 0% | 14% | 58% | 50% | 48% | 5% |
| 2 | 33% | 0% | 4% | 0% | 13% | 79% | 50% | 91% | 0% |
| 3 | 40% | 0% | 9% | 0% | 13% | 75% | 38% | 83% | 0% |
| 4 | 55% | 0% | 0% | 0% | 36% | 100% | 33% | 100% | 22% |
| 5 | 27% | 0% | 9% | 0% | 26% | 63% | 54% | 70% | 15% |
| 6 | 33% | 0% | 9% | 0% | 22% | 75% | 21% | 87% | 25% |
| 7 | 33% | 0% | 9% | 0% | 22% | 63% | 58% | 87% | 20% |
| 8 | 27% | 0% | 9% | 0% | 30% | 50% | 58% | 78% | 10% |
| 9 | 47% | 0% | 9% | 0% | 26% | 50% | 54% | 78% | 25% |
| 10 | 40% | 0% | 9% | 0% | 17% | 92% | 50% | 74% | 20% |
| 11 | 50% | 0% | 9% | 0% | 27% | 59% | 50% | 90% | 20% |
| 12 | 27% | 0% | 9% | 0% | 22% | 54% | 42% | 74% | 5% |

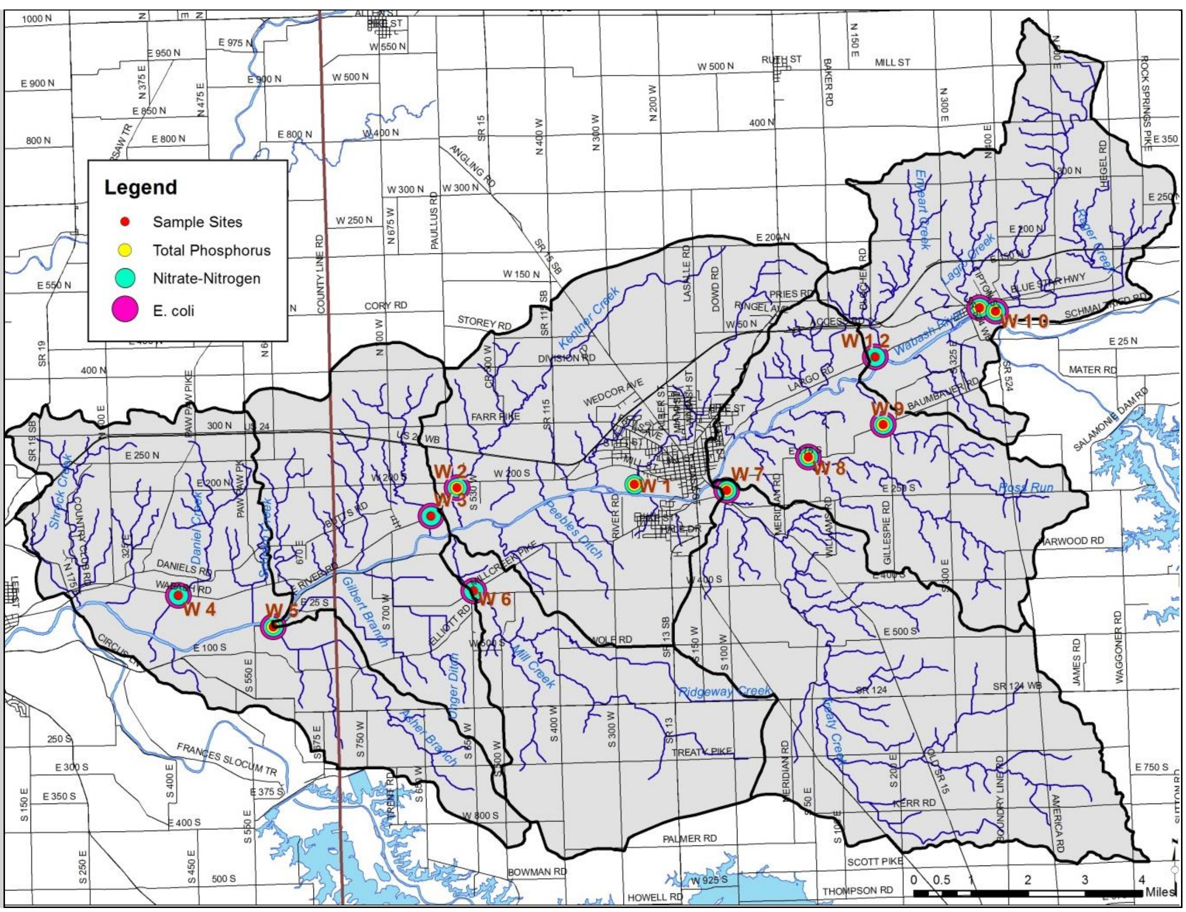


**Figure 67. Sample sites with poor water quality(50% or more of samples collected during current water quality monitoring were outside the target values).**

In general, Treaty Creek-Wabash River streams contain good quality habitat, with macroinvertebrate communities rating as partially to fully supporting and fish communities rate as good to excellent. Charley Creek (S01) and Burr Creek (S08) macroinvertebrate communities rated as fully supporting, while all other sites' communities rated as partially supporting. Fish communities in Kentner Creek (S02) and Carlin Branch (S03) rated as good to excellent, while Mill Creek (S06), Charley Creek (S01) and Enyeart Creek (S12) rated as good. The fish community in Daniel Creek (S04) rated as very poor due to the intermittent nature of the stream – water typically flows interstitially through a series of pools within the stream channel which limits the ability for fish to thrive. Habitat in Mill Creek (S06) rated as excellent, while Daniel Creek (S04) rated as very poor. All other sites' habitat rated as good.

## 5.2 Stakeholder Concern Analysis

All of the identified concerns generated both from stakeholder input and through water quality and watershed inventory efforts are detailed in Table 27. The steering committee rated each concern as to whether it is supported by watershed-based data, what evidence does or does not support the concern, whether the concern is quantifiable, whether it is in the scope of the watershed management plan, and if it is something on which the committee wants to focus. Nearly all concerns were quantifiable, and many were rated as being within the scope and items on which the committee wants to focus.

**Table 27. Analysis of stakeholder concerns identified in the Treaty Creek-Wabash River Watershed.**

| Concern | Supported by our data? | Evidence | Able to Quantify? | Outside Scope? | Group wants to focus on? |
|---|---|---|---|---|---|
| River is muddy – where does sediment originate? | Yes | 51.4 miles of tributary streambank were identified as eroding during the windshield survey. 73% of the watershed is covered by agricultural land use while urban lands uses cover 9% of the watershed. More than 75% of Wabash River fixed station samples exceed TSS targets. 8% of turbidity and 6% of TSS samples exceed targets. | Yes | No | Yes |
| Flooding impacts from non-natural stream flows – Salamonie dam releases | Maybe | Floodplain covers 7.6%of the watershed. 99% of historic wetlands have been modified or lost. There is anecdotal evidence of historic flooding following Salamonie Dam releases but no analysis of these impacts has occurred. | Releases are quantifiable; however, releases do not always correspond with downstream flooding | Yes | No |
| Engaging local individuals with the river | Yes | Anecdotal evidence based on communication with stakeholders. | Yes | No | Yes |

| Concern | Supported by our data? | Evidence | Able to Quantify? | Outside Scope? | Group wants to focus on? |
|---|---|---|---|---|---|
| Flooding impacts/topsoil loss/impacts from agricultural land | Yes | 73% of the watershed is covered by agricultural land use. 7.6% of the watershed is mapped in floodplain with more than 97% of floodplain in agricultural land uses. | Yes | No | Yes |
| Impacts of impaired waterbodies on the watershed | Yes | Waterbodies are listed as impaired for *E. coli* (19.2 miles), impaired biotic communities (13.1 miles), nutrients (19.2 miles), mercury and PCBs (19.2 miles). Based on the development of the Wabash River Nutrient and Pathogen TMDL Development the *E. coli* and nutrient impaired segments are considered category 4 impaired waterbodies, while impaired biotic community, and mercury and PCB impaired segments are considered category 5 impairments. | Yes | No | Yes |
| Nutrient concentrations are elevated | Yes | 58% of nitrate and 38% of TP samples exceed targets during the current sampling period. IDEM documented elevated N and P concentrations in the Wabash River, Mill Creek, and Treaty Creek. 2015 WRD monitoring indicate elevated N and P concentrations at all stream sites. The City CSO assessment indicates elevated P and BOD in Charley Creek and the Wabash River downstream of outfalls. | Yes | No | Yes |
| Livestock access to Wabash River tributaries | Yes | Livestock access was documented along 8.4 miles of tributaries during the watershed inventory. | Yes | No | Yes |

| Concern | Supported by our data? | Evidence | Able to Quantify? | Outside Scope? | Group wants to focus on? |
|---|---|---|---|---|---|
| Fertilizers and pesticides flowing into the river | Yes | An estimated 9953 tons of nitrogen and 4923 tons of phosphorus are applied in Miami and Wabash Counties. An estimated 84tons of atrazine and 112 tons of glyphosate are applied in Miami and Wabash counties. | Yes | No | Yes |
| Ecoli concentrations are elevated | Yes | 75% of E.coli samples exceed current targets. .IDEM documented elevated E coli concentrations in the Wabash River, Mill Creek, and Treaty Creek. 2015 WRD monitoring indicate high E. coli concentrations at all stream sites. The City CSO assessment indicates elevated E coli in Charley Creek and the Wabash River downstream of outfalls. | Yes | No | Yes |
| Livestock manure impacts to the River and its tributaries | Yes | Approximately 44,900 animals per year are housed in CFOs and small unregulated animal operations in the watershed, generating approximately 510,183,400 pounds of manure per year spread over more than 3,200 acres in the watershed. Manure produced on permitted CFOs contains nearly 538,340 pounds of nitrogen and 392,490 pounds of phosphorus. | Yes | No | Yes |
| Agricultural producer & landowner participation in existing conservation programs | Yes | Anecdotal evidence based on communication with stakeholders. | Yes | No | Yes |

| Concern | Supported by our data? | Evidence | Able to Quantify? | Outside Scope? | Group wants to focus on? |
|---|---|---|---|---|---|
| Redside dace (ETR) occurs in Mill Creek- impacts of water quality/habitat on this species? | Anecdotal | The redside dace was documented in Mill Creek during 2009 through 2012 assessments and in Asher Branch in 2012. | Possibly but are water chemistry or habitat more important? | No | Yes |
| Landfill – is this impacting the Wabash River | Anecdotal | Anecdotal evidence suggests that the landfill may negatively impact the Wabash River. The landfill assesses the fish population annually – those reports are not currently available. No documented water chemistry impacts could be identified. | No | No: monitoring and education only | Yes, education focused |
| Indiana American Water drinking water supply – Wabash River in wellhead protection area | No | The Indiana American Water wellhead protection area is 100% located within the watershed. IAC collects samples from the Wabash River to assess surface water impacts with no adverse impacts identified during recent sample collection. | No | Yes | No |
| Septic impacts | Yes but not to specific locations | More than 97% of the watershed is mapped in soils which are severely limited for septic tank usage. Unsewered, dense housing (more than 25 houses/sq. mi) were mapped on 370 acres within the watershed. | Yes but not to specific locations | No | Yes, education focused |
| Habitat loss along the river and its tributaries | Anecdotal | Anecdotal evidence based on communication with stakeholders as data have not been compiled. | No | No: Education | Yes, education focused |
| Invasive species impacts to water quality | Anecdotal | There are more than 20 documented invasive plant species in the 2 counties covered by the watershed. Several invasive species were observed in riparian areas during the windshield survey. | Anecdotal | No: education | Yes, education focused |

| Concern | Supported by our data? | Evidence | Able to Quantify? | Outside Scope? | Group wants to focus on? |
|---|---|---|---|---|---|
| Streambank erosion – mouth of Treaty Creek, areas along Mill Creek, island erosion, near Lagro, along River and tributary sharp bends | Yes | More than 26% of the watershed is mapped in highly erodible or potentially highly erodible soils. Nearly 14 miles of streambank erosion were documented during the windshield survey. | Yes | No | Yes |
| Hardscape impacts/water quantity impacts during stormwater runoff events | Yes | 9% of the watershed is mapped as developed land. 7% of the watershed is mapped as more than 25% covered by hard surfaces. 8 combined sewer overflow points are located within the City of Wabash. The City's LTCP identifies nearly $13 million in projects to reduce CSO impacts to the river. | Yes | No | Yes |
| Industrial impacts to the Wabash River including materials from manufacturing process and/or inputs from runoff | Anecdotal | 8 documented NPDES permitted located occur in the watershed. Two of these are industrial in nature; neither possess documented releases that affected their permit. | Yes | Yes | No |
| Long-term efforts to remove trash – are there still sources and if so, where? | Yes | Individual observations during the watershed inventory indicate trash accumulation is a problem. More than 96 tons of materials have been removed from the Wabash River over the past 7 years. | Yes | No | Yes, education focused |
| Biodiversity is limited in the watershed | Anecdotal | ETR data suggests high quality communities are present and that many ETR species are still observed | Yes | No | Yes, education focused |
| General public needs educated about agricultural practice use | Anecdotal | Educational opportunities are available however, attendance suggests there are opportunities to educate watershed stakeholders | Yes | No | Yes, education focused |

| Concern | Supported by our data? | Evidence | Able to Quantify? | Outside Scope? | Group wants to focus on? |
|---|---|---|---|---|---|
| Urban residents are unaware of their impacts to the Wabash River | Anecdotal | Educational opportunities are available however, attendance suggests there are opportunities to educate watershed stakeholders | Yes | No | Yes, education focused |
| Education is needed on watershed concepts, elevated nutrients, etc | Anecdotal | Educational opportunities are available however, attendance suggests there are opportunities to educate watershed stakeholders | Yes | No | Yes, education focused |
| Preserving local high-quality areas | Anecdotal | Salamonie State Forest, Ross Run and Hanging Rock, Asherwood Nature Preserve, Paradise Springs Historic Park and Riverwalk, Hanna Park, Charley Creek Park, Broadmore Park and Lagro Park offer current protection for high quality areas. | Anecdotal | No: education | Yes, education focused |
| Impact of potential Riverwalk on wildlife | Anecdotal | A portion of the current projected Riverwalk lies within the Wabash River floodplain. Impacts to the floodplain could adversely impact wildlife that use that portion of the watershed. | Anecdotal | Yes | No |
| Gravel pits/gravel pit overflow as source of sediment | Anecdotal | Several gravel pits occur within the watershed; no documentation of these as a source of sediment is available. | Yes | Yes | No |
| Potential for spills from the railroad | No | The railroad crosses the Wabash River; no documented spills occurred in the last 25 years. | Yes | Yes | No |

Following a review of the stakeholder concerns, the steering committee determined the following concerns identified by the public to be outside of this project's approach: potential for spills from or at railroad crossings, gravel pits and their impact on sediment concentrations, the potential impact of the discussed City of Wabash Riverwalk on wildlife, industrial impacts to the Wabash River, Indiana American Waters' wellhead protection area, and flooding impacts from the Salamonie Dam and its flow regime/stormwater releases. Therefore, these concerns will not be addressed in this watershed management plan.

## 6.0 PROBLEM AND CAUSE IDENTIFICATION

After evaluation of stakeholder concerns and completion of the watershed inventory, watershed problems can be summarized as shown in Table 28. Problems represent the condition that exists due to a particular concern or group of concerns. Table 29 details potential causes of problems identified in Table 28.

**Table 28. Problems identified for the Treaty Creek-Wabash River Watershed based on stakeholder and inventory concerns.**

| Concern(s) | Problem |
|---|---|
| • Streambank erosion<br>• Livestock access to the Wabash River and tributaries<br>• River is muddy<br>• Flooding impacts, top soil loss, impacts from agricultural land<br>• Hardscape impacts, water quality impacts during stormwater runoff events | Area streams are very cloudy and turbid |
| • Impacts of impaired waterbodies on the watershed<br>• Septic impacts<br>• Livestock manure impacts to the Wabash River and tributaries<br>• Fertilizers and pesticides flowing into the river<br>• Nutrient concentrations are elevated<br>• Livestock access to the Wabash River and tributaries<br>• Hardscape impacts, water quality impacts during stormwater runoff events<br>• Streambank erosion<br>• Flooding impacts, top soil loss, impacts from agricultural land | Area streams have nutrient levels exceeding the target set by this project |
| • E coli concentrations are elevated<br>• Impacts of impaired waterbodies on the watershed<br>• Septic system impacts including too many residences sited on unsuitable soils and inputs to streams from straight pipes and abandoned facilities, poor maintenance<br>• Livestock access to the Wabash River and tributaries<br>• Livestock manure impacts to the Wabash River and tributaries | Area streams are impaired for recreational contact by IDEM's 303(d) list (high E. coli) |

| Concern(s) | Problem |
|---|---|
| | |
| • Engaging local individuals with the river<br>• Biodiversity is limited in the watershed<br>• General public needs educated about agricultural practice use<br>• Education is needed on watershed concepts, elevated nutrients, etc<br>• Urban residents are unaware of their impacts to the Wabash River | A unified education program for entire watershed does not currently exist |
| • Invasive species, especially Asian bush honeysuckle, impacts to water and soil quality<br>• Habitat loss along the Wabash River and its tributaries<br>• Redside dace occurs in three Wabash River tributaries –impacts of water quality and habitat on this endangered species | Habitat is insufficient to protect soil and water quality. |

**Table 29. Potential causes of identified problems in the Treaty Creek-Wabash River Watershed.**

| Problem | Potential Cause(s) |
|---|---|
| Area streams are very cloudy and turbid | Total Suspended Sediment concentrations and turbidity levels exceed the targets set by this project |
| Area streams have nutrient levels exceeding the targets set by this project | Nutrient levels exceed the target set by this project |
| Area streams are impaired for recreational contact by IDEM's 303(d) list (high E. coli) | E.coli levels exceed the water quality standard |
| A unified education program for entire watershed does not currently exist | Educational efforts targeting funders, local agencies, and the public are lacking. |
| Habitat is insufficient to protect soil and water quality. | Invasive species are negatively impacting soil and water quality; habitat and water quality is insufficient to protect endangered species. |

## 7.0 SOURCE IDENTIFICATION AND LOAD CALCULATION

### 7.1 Source Identification: Key Pollutants of Concern

Nonpoint pollution sources are varied, yet common throughout almost any watershed. Several earlier sections of this document identify potential sources of the pollutants of concern in the Treaty Creek-Wabash River Watershed. These and other potential sources of these causes are discussed in further detail in subsequent sections. A summary of potential sources identified in the Treaty Creek-Wabash River Watershed for each of our concerns is listed below:

Nutrients (Nitrogen and Phosphorus):

- Conventional tillage cropping practice
- Wastewater treatment discharges

- Gully or ephemeral erosion
- Agricultural fertilizer
- Poor riparian buffers
- Poor forest management
- Streambank and bed erosion
- Animal waste (livestock in streams, poor manure management, domestic and wildlife runoff)
- Confined feeding operations
- Human waste (failing septic systems, package plants, inadequately treated wastewater)

Sediment:

- Conventional tillage cropping practice
- Streambank and bed erosion
- Poor riparian buffers
- Gully or ephemeral erosion
- Cropped floodplains
- Livestock access to streams
- Altered hydrology (ditching and draining, altered stream courses)

*E. coli*:

- Human waste (failing septic systems, package plants, inadequately treated wastewater)
- Animal waste (livestock in streams, poor manure management, domestic and wildlife runoff)
- Combined Sewer Overflows

Habitat and wildlife concerns:

- Lack of fence rows, windbreaks and field borders
- Lack of forest connectivity/limited riparian buffers
- Invasive species impacts
- Habitat and water quality impacts to endangered species

## 7.2 Potential Sources of Pollution

The steering committee used GIS data, water quality data, watershed inventory observations and anecdotal information as available to evaluate the potential sources of nonpoint pollution in Treaty Creek-Wabash River Watershed. There are little to not data available on a subwatershed basis for several potential sources noted above, including conventional tillage, gully or ephemeral erosion, fertilizer usage, cropped floodplains, altered hydrology and more. These concerns are therefore not listed in the tables below. Appendix E contains tables detailing each potential source within each subwatershed. Table 30 through Table 34 summarizes the magnitude of potential sources of pollution for each problem identified in the Treaty Creek-Wabash River Watershed.

**Table 30. Potential sources causing nutrient problems.**

| | |
|---|---|
| Problems: | Area streams have nutrient levels exceeding the targets set by this project |
| Potential Causes: | Nutrient concentrations exceed target values set by this project. |
| Potential Sources: | • 4 livestock access areas (11,616 linear feet of streams) were observed throughout the watershed. The highest percent of stream miles accessed by livestock were found in the Kentner Creek (1.7%) and Daniel Creek-Wabash River (3.1%) subwatersheds.<br>• 63 unregulated animal operations were observed housing nearly 568 animals throughout the watershed. The highest number of unregulated animals houses on operations were observed in the Enyeart Creek-Wabash River (218), Daniel Creek-Wabash River (105), and Stone Creek-Treaty Creek subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading.<br>• 44.2 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in Gilbert Branch-Wabash River (38%), Stone Creek-Treaty Creek (16%), and Ridgeway Creek (15%) subwatersheds.<br>• 44.4 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization found in Daniel Creek-Wabash River (24%), Enyeart Creek-Wabash River (20%), and Stone Creek-Treaty Creek (18%) subwatersheds.<br>• Manure from confined feeding operations is applied in the Enyeart Creek-Wabash River, Stone Creek-Treaty Creek, Kentner Creek, and Gilbert Branch-Wabash River subwatersheds.<br>• Manure from small animal operations is applied across the Treaty Creek-Wabash River Watershed with more than 412,013 tons produced annually. More than 969,827 lb of N and 719,677 lb of P are delivered annually with this manure.<br>• Failing septic systems add nutrients to the system within the rural portion of the watershed and in areas of dense unsewered housing.<br>• The entire City of Wabash MS4 is located within the Kentner Creek subwatershed.<br>• Wastewater treatment plant sludge is applied on more than 4,500 acres of the Treaty Creek-Wabash River Watershed with the Stone Creek-Treaty Creek (10%) and Ridgeway Creek (8%) subwatersheds receiving the largest volume of land applied sludge. |

**Table 31. Potential sources causing sediment problems.**

| | |
|---|---|
| Problems: | Area streams are cloudy and turbid. |
| Potential Causes: | Total Suspended Sediment concentrations and turbidity levels exceed the targets set by this project |
| Potential Sources: | • 4 livestock access areas (11,616 linear feet of streams) were observed throughout the watershed. The highest percent of stream miles accessed by livestock were found in the Kentner Creek (1.7%) and Daniel Creek-Wabash River (3.1%) subwatersheds.<br>• 44.2 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in Gilbert Branch-Wabash River (38%), Stone Creek-Treaty Creek (16%), and Ridgeway Creek (15%) subwatersheds.<br>• 44.4 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization found in Daniel Creek-Wabash River (24%), Enyeart Creek-Wabash River (20%), and Stone Creek-Treaty Creek (18%) subwatersheds.<br>• 63 unregulated animal operations were observed housing nearly 568 animals throughout the watershed. The highest number of animals housed on unregulated operations was observed in the Enyeart Creek-Wabash River (218), Daniel Creek-Wabash River (105), and Stone Creek-Treaty Creek subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading.<br>• The highest density of highly erodible and potentially highly erodible soils occurs in Enyeart Creek-Wabash River (40% HES, 24% PHES), Burr Cree-Wabash River (41% HES, 13% PHES) Stone Creek-Treaty Creek (15% HES, 19% PHES) subwatersheds. |

**Table 32. Potential sources causing *E. coli* problems.**

| | |
|---|---|
| Problems: | Area streams are impaired for recreational contact by IDEM's 303(d) list (high E. coli) |
| Potential Causes: | *E. coli* concentrations exceed target values and the state standard. |
| Potential Sources: | • 4 livestock access areas (11,616 linear feet of streams) were observed throughout the watershed. The highest percent of stream miles accessed by livestock were found in the Kentner Creek (1.7%) and Daniel Creek-Wabash River (3.1%) subwatersheds.<br>• 63 unregulated animal operations were observed housing nearly 568 animals throughout the watershed. The highest number of animals housed on unregulated operations was observed in the Enyeart Creek-Wabash River (218), Daniel Creek-Wabash River (105), and Stone Creek-Treaty Creek subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading.<br>• Manure from confined feeding operations is applied in the Enyeart Creek-Wabash River, Stone Creek-Treaty Creek, Kentner Creek, and Gilbert Branch-Wabash River subwatersheds.<br>• Manure from small animal operations is applied across the Treaty Creek-Wabash River Watershed with more than 412,013 tons produced annually. More than 969,827 lb of N and 719,677 lb of P are delivered annually with this manure.<br>• Failing septic systems add nutrients to the system within the rural portion of the watershed and in areas of dense unsewered housing.<br>• The entire City of Wabash MS4 is located within the Kentner Creek subwatershed.<br>• Wastewater treatment plant sludge is applied on more than 4,500 acres of the Treaty Creek-Wabash River Watershed with the Stone Creek-Treaty Creek (10%) and Ridgeway Creek (8%) subwatersheds receiving the largest volume of land applied sludge. |

**Table 33. Potential sources causing habitat problems.**

| | |
|---|---|
| Problems: | Habitat is insufficient to protect soil and water quality. |
| Potential Causes: | Invasive species are negatively impacting soil and water quality; habitat and water quality is insufficient to protect endangered species. |
| Potential Sources: | • Invasive species are present throughout the watershed.<br>• Forest land is not contiguous/riparian buffers are not intact.<br>• Habitat or water quality are insufficient to protect the redside dace (endangered species). |

**Table 34. Potential sources causing education problems.**

| | |
|---|---|
| Problems: | A unified education program for entire watershed does not currently exist |
| Potential Causes: | Educational efforts targeting funders, local agencies, and the public are lacking. |
| Potential Sources: | N/A |

## 7.3 Load Estimates

Nonpoint source pollution is generated from diffuse sources found on public and private lands. The USEPA notes that sources of nonpoint source pollution include: stormwater runoff, construction activities, solid waste disposal, atmospheric deposition, streambank erosion, and more. Inventory data in Table 30 through Table 34 identify potential sources of nonpoint pollution within the watershed. These tables – generated using GIS, water quality data, windshield surveys, local knowledge, and other sources of data – are useful for generally identifying water quality problems. Two methods could be used to understand the loading of nutrients, sediment, and pathogens in waterbodies in the Treaty Creek-Wabash River Watershed: 1) measured results from the monitoring regime and 2) modeled results. Each method can estimate both the current load and the reduction in load needed to reach target concentrations. These methods each present advantages and disadvantages for understanding the loading in this watershed in particular. The steering committee considered the monitoring data to draft long term goals and critical areas. These data were used to calculate final goals and set long term goals, short term goals, and critical areas.

Results from monitoring data can be used to estimate loads of nonpoint source pollution. Concentrations of nutrients, sediments, and pathogens taken at sampling sites can be combined with flow data to estimate the current loads in those waterbodies. Target loads for those waterbodies can also be calculated using available flow data.

As discussed above, twelve monitoring sites were sampled biweekly from March 2018 through March 2019. There is clear value in using these measurements from the Treaty Creek-Wabash River Watershed to estimate loads and load reductions. However, there are some limitations in the measured dataset. Sampling methods did not allow for continuous flow measurements at each site, so data from the closest USGS gage (Wabash River near Wabash, Indiana USGS 03325000) was used to approximate flow. While the Wabash River gage over approximates the size of the entire Treaty Creek-Wabash River drainage, it is the most closely associated with the Treaty Creek-Wabash River drainage. Additionally, this site receives similar precipitation as that observed in the Treaty Creek-Wabash River drainages, it receives the same climatic impacts and can be scaled to approximate instream flows at each sample site. These continuous flow numbers combined with grab sample data were used to create load duration curves. These curves represent the current loading rate for each parameter calculated at each sample site.

As discussed in above, the steering committee selected water quality benchmarks for nitrate-nitrogen, total phosphorus, and total suspended solids that will significantly improve water quality in Treaty Creek-Wabash River (Table 14). Target loads needed to meet these benchmarks were calculated for each subwatershed for each parameter. Sample site data from each tributary stream within each of the 12-digit HUC subwatershed's sampling sites were used to calculate annual loading rates and load reductions. The current loading rate was calculated using continuous flow data scaled from the Wabash River at Wabash USGS gage (USGS 03325000). Concentration data collected biweekly was multiplied by the representative days between sampling events (typically 8-15 days) and then by the average flow during that period of time. Load reduction targets were calculated using the water quality targets selected by the steering committee for each parameter. These targets were multiplied by the same scaled average continuous flow data used to calculate current loading rates and the number of days between sampling events. Current loading rates for nitrate-nitrogen, total phosphorus, total suspended solids and E. coli are shown in Table 35, while the target loading rate (Table 36) and load reduction needed to meet target loading rates (

Table **37**) for each parameter are detailed for each sample site. Appendix F details loading calculation data.

**Table 35. Estimated current loading rate by sample site in the Treaty Creek-Wabash River Watershed.**

| Site | Subwatershed | NO3 Annual Load (lb/year) | TP Annual Load (lb/year) | TSS Annual Load (lb/year) | Ecoli Annual Load (col/year) |
|---|---|---|---|---|---|
| 1 | Kentner | 25,097.10 | 1,107.25 | 326,724.20 | 3.56E+13 |
| 2 | Kentner | 69,013.65 | 2,569.56 | 1,627,913.38 | 1.85E+14 |
| 3 | Gilbert | 18,186.32 | 764.29 | 553,365.30 | 4.11E+13 |
| 4 | Daniel | 6,611.96 | 253.35 | 612,144.39 | 2.69E+13 |
| 5 | Daniel | 28,866.10 | 1,004.65 | 221,687.30 | 1.13E+13 |
| 6 | Ridgeway | 63,185.77 | 1,941.65 | 511,212.79 | 4.03E+14 |
| 7 | Stone-Treaty | 182,067.03 | 12,807.70 | 8,252,789.51 | 8.16E+14 |
| 8 | Burr | 26,239.40 | 2,985.55 | 704,674.21 | 1.54E+14 |
| 9 | Burr | 4,840.60 | 597.49 | 90,883.94 | 3.00E+13 |
| 10 | Enyeart | 43,130.91 | 2,150.53 | 637,334.09 | 1.31E+14 |
| 11 | Enyeart | 24,726.14 | 3,174.16 | 671,703.35 | 1.12E+14 |
| 12 | Enyeart | 12,280.61 | 1,515.02 | 570,484.37 | 4.74E+13 |

**Table 36. Estimated target loading rate by sample needed to meet water quality target concentrations in the Treaty Creek-Wabash River Watershed.**

| Site | Subwatershed | NO3 Annual Load (lb/year) | TP Annual Load (lb/year) | TSS Annual Load (lb/year) | Ecoli Annual Load (col/year) |
|---|---|---|---|---|---|
| 1 | Kentner | 7,574.8 | 454.5 | 454,488.6 | 1.62E+13 |
| 2 | Kentner | 15,565.4 | 933.9 | 933,925.7 | 3.32E+13 |
| 3 | Gilbert | 5,583.5 | 335.0 | 335,009.2 | 1.19E+13 |
| 4 | Daniel | 2,905.2 | 174.3 | 174,310.3 | 6.20E+12 |
| 5 | Daniel | 12,108.3 | 726.5 | 726,498.9 | 2.58E+13 |
| 6 | Ridgeway | 24,124.3 | 1,447.5 | 723,729.6 | 5.15E+13 |
| 7 | Stone-Treaty | 23,467.4 | 1,408.0 | 1,408,044.2 | 5.01E+13 |
| 8 | Burr | 10,150.2 | 609.0 | 609,014.0 | 2.17E+13 |
| 9 | Burr | 1,138.6 | 68.3 | 68,317.5 | 2.43E+12 |
| 10 | Enyeart | 10,908.5 | 654.5 | 654,507.3 | 2.33E+13 |
| 11 | Enyeart | 6,929.0 | 415.7 | 415,738.5 | 1.48E+13 |
| 12 | Enyeart | 6,927.4 | 415.6 | 415,643.5 | 1.48E+13 |

**Table 37. Estimated load reduction by sample site needed to meet water quality target concentrations in the Treaty Creek-Wabash River Watershed.**

| Site | Subwatershed | NO3 Annual Load (lb/year) | TP Annual Load (lb/year) | TSS Annual Load (lb/year) | Ecoli Annual Load (col/year) |
|---|---|---|---|---|---|
| 1 | Kentner | 17,522.3 | 652.8 | No reduction | 1.94E+13 |
| 2 | Kentner | 53,448.2 | 1,635.6 | 693,987.7 | 1.52E+14 |
| 3 | Gilbert | 12,602.8 | 429.3 | 218,356.1 | 2.92E+13 |
| 4 | Daniel | 3,706.8 | 79.0 | 437,834.1 | 2.07E+13 |
| 5 | Daniel | 16,757.8 | 278.1 | No reduction | No reduction |
| 6 | Ridgeway | 39,061.4 | 494.2 | No reduction | 3.51E+14 |
| 7 | Stone-Treaty | 158,599.6 | 9,915.7 | 6,844,745.3 | 7.66E+14 |
| 8 | Burr | 16,089.2 | 2,376.5 | 95,660.2 | 1.32E+14 |
| 9 | Burr | 3,702.0 | 529.2 | 22,566.4 | 2.76E+13 |
| 10 | Enyeart | 32,222.5 | 1,496.0 | No reduction | 1.07E+14 |
| 11 | Enyeart | 17,797.2 | 2,758.4 | 255,964.8 | 9.68E+13 |
| 12 | Enyeart | 5,353.2 | 1,099.4 | 154,840.9 | 3.26E+13 |

## 8.0 CRITICAL AND PRIORITY AREA DETERMINATION

Critical areas are defined as the areas where sources of water quality problems occur in the highest densities and where restoration measures can improve water quality. These areas indicate locations where best management practices should be targeted to address nonpoint sources of pollution. Priority areas are those areas of the watershed where high quality habitat is found, and the aquatic biological community is classified as good or excellent. Best management practices to protect the higher quality conditions should be targeted to these areas.

Using the list of potential sources developed for each parameter of concern as a base, the steering committee developed a mechanism for determining critical areas for each parameter. GIS-based mapping data from desktop and windshield survey efforts, loading calculations, and current and historic water quality data were used as a basis for decision-making. Data for each subwatershed are detailed in Appendix E. The steering committee reviewed subwatershed data and developed a criteria list for each parameter. For each parameter, each subwatershed was evaluated to determine whether it met each criteria developed by the steering committee. Each parameter's criteria are detailed in subsequent sections. Each subwatershed was scored based on the total number of criteria that were met (1=yes, 0=no) and the subwatersheds with the highest scores were prioritized as critical areas for each parameter. For nutrients, those subwatersheds that scored three or more of the five parameters, for sediment, those subwatersheds that scored three or more of four parameters and for pathogens, those subwatersheds that scored three or more parameters were prioritized.

### 8.1 Critical Areas for Nitrate-Nitrogen and Total Phosphorus

Nitrate-nitrogen was the nitrogen form used to determine our nitrogen critical areas. Total phosphorus was the form of phosphorus used to determine phosphorus critical areas (Figure 68). Nitrate-nitrogen and total phosphorus are readily available in the Treaty Creek-Wabash River Watershed, entering surface water via human and animal waste, fertilizer use, and via tile drains on agricultural lands. Phosphorus enters the Treaty Creek-Wabash River Watershed through streambank and bed erosion, unfiltered runoff, agricultural land use in floodplains, stormwater runoff, and livestock access. Based on the data reviewed by the steering committee, the following criteria were priorities for nutrient critical areas:

- Percent of highly erodible soils
- Percent of manure produced per subwatershed
- Streambank erosion – percent of miles
- Percent of nitrate-nitrogen samples exceeding targets
- Percent of total phosphorus samples exceeding targets

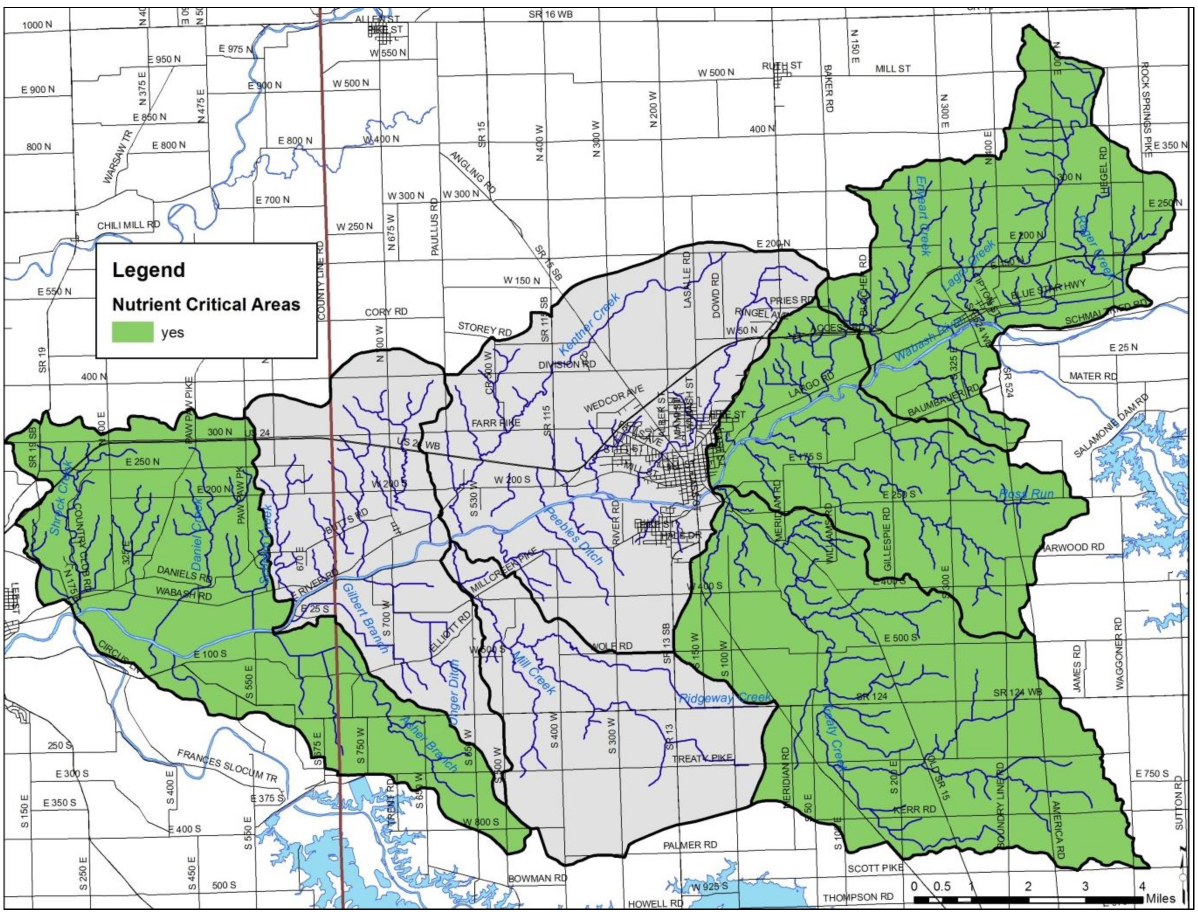


**Figure 68. Critical areas for nutrients in the Treaty Creek-Wabash River Watershed: Enyeart Creek-Wabash River, Stone Creek-Treaty Creek, Burr Creek-Wabash River, Daniel Creek-Wabash River.**

## 8.2 Critical Areas for Sediment

Total suspended solids concentrations were used to determine sediment-based critical areas (Figure 69). Total suspended solids enter Treaty Creek-Wabash River Watershed streams through streambank and bed erosion, unfiltered runoff, agricultural land use in floodplains, stormwater runoff, and livestock access. Based on the data reviewed by the steering committee, the following criteria were priorities for sediment critical areas:

- Percent of highly erodible soils
- Percent observed streambank erosion miles
- Percent observed narrow buffers
- Percent total suspended solids samples exceeding targets

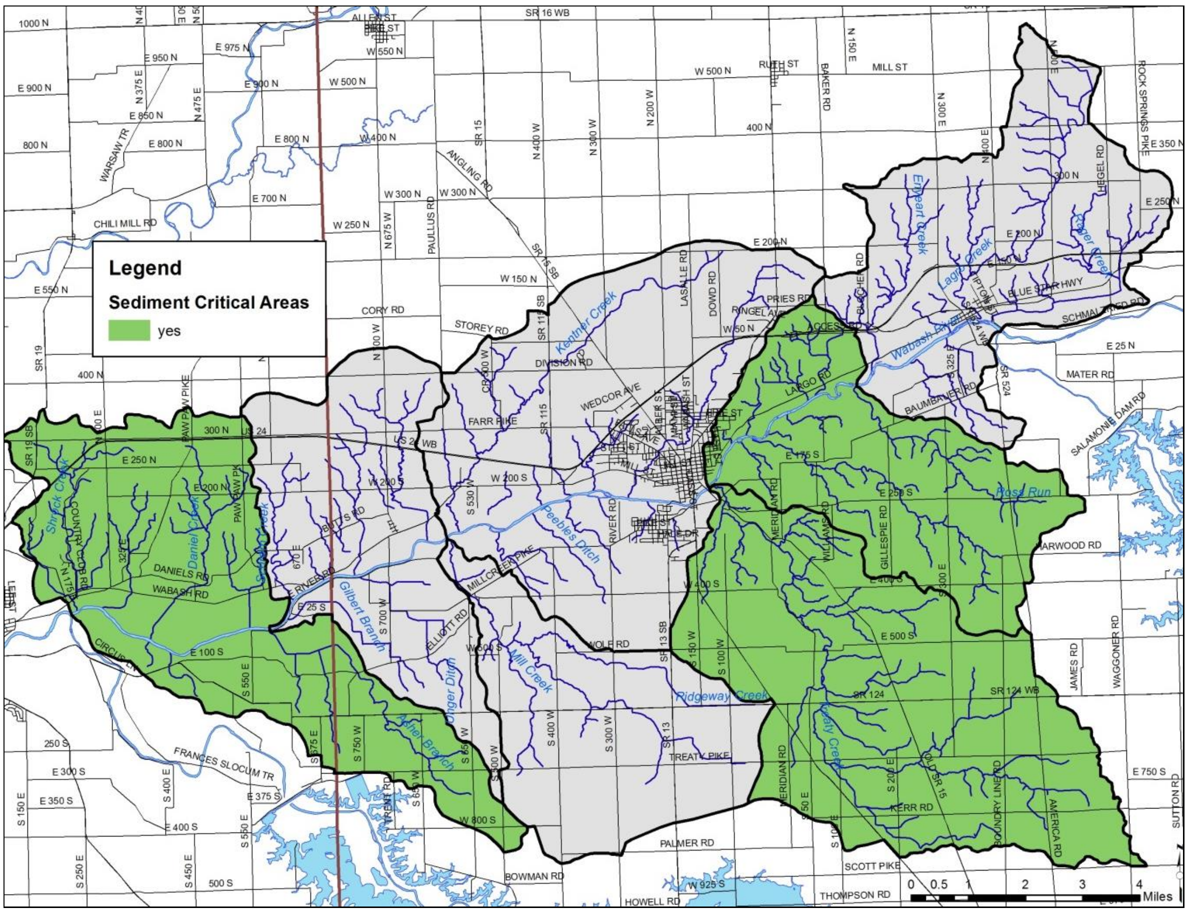


**Figure 69. Critical areas for sediment in the Treaty Creek-Wabash River Watershed: Stone Creek-Treaty Creek, Burr Creek-Wabash River, Daniel Creek-Wabash River.**

## 8.3 Critical Areas for *E. coli*

*E. coli* concentrations were used to determine our critical areas (Figure 70). *E. coli* enters streams in the Treaty Creek-Wabash River Watershed through human and animal waste, livestock access, and infrastructure issues. Additional areas of concern, such as areas with manure management issues or failing septic systems, may also be included. While those areas have not been quantified, dense unsewered areas were included as a method for identifying these areas. Based on the data reviewed by the steering committee, the following criteria were priorities for *E. coli* critical areas:

- Percent of E coli samples exceeding target concentrations current data
- Manure volumes estimated from small farm counts and CFO permit numbers
- Septic soil limitations
- Sludge application – percent cover

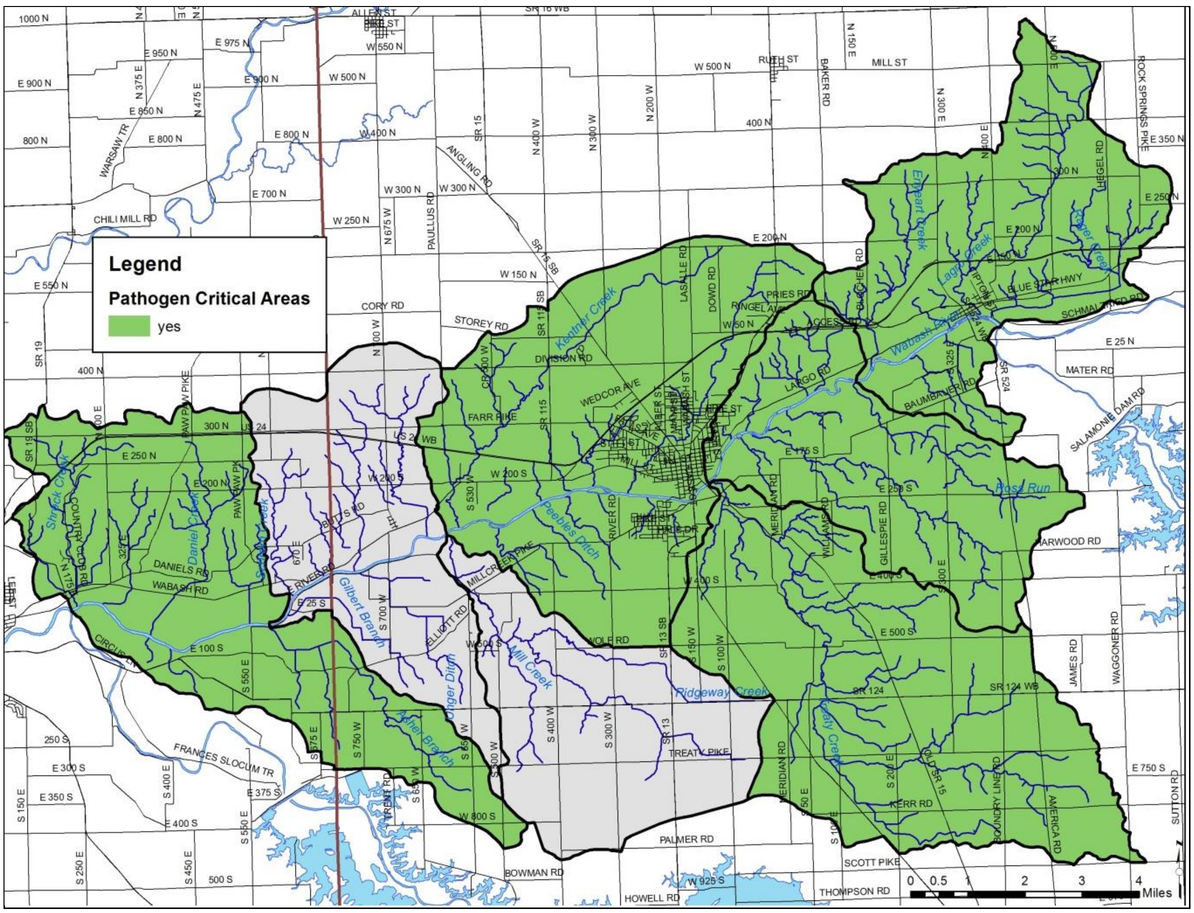


**Figure 70. Critical areas for *E. coli* in the Treaty Creek-Wabash River Watershed: Enyeart Creek-Wabash River, Stone Creek-Treaty Creek, Kentner Creek, Burr Creek-Wabash River, Daniel Creek-Wabash River.**

## 8.4 Critical Areas Summary

The subwatersheds identified as critical areas for each parameter are summarized in Figure 68 to Figure 70. To identify the highest priority subwatersheds, the steering committee decided to divide them into three tiers (high, medium and low priority), based on the number of parameters that were determined to be critical. The highest priority subwatersheds are those that were determined to be critical for two of the three potential parameters. The medium priority subwatersheds are those that were determined to be critical for two of the four potential parameters. The lowest priority subwatersheds were critical for one of the four potential parameters. Daniel Creek-Wabash River, Stone Creek-Treaty Creek, and Burr Creek-Wabash River subwatershed rated as high priority, while Enyeart Creek-Wabash River rated as medium priority and Kentner Creek rated as low priority (Figure 71). After setting initial goals, selecting target practices for the implementation phase, and calculating potential load reductions, the steering committee reviewed the likelihood of meeting water quality targets. Based on these calculations, no modifications were made to critical areas within the Treaty Creek-Wabash River Watershed.

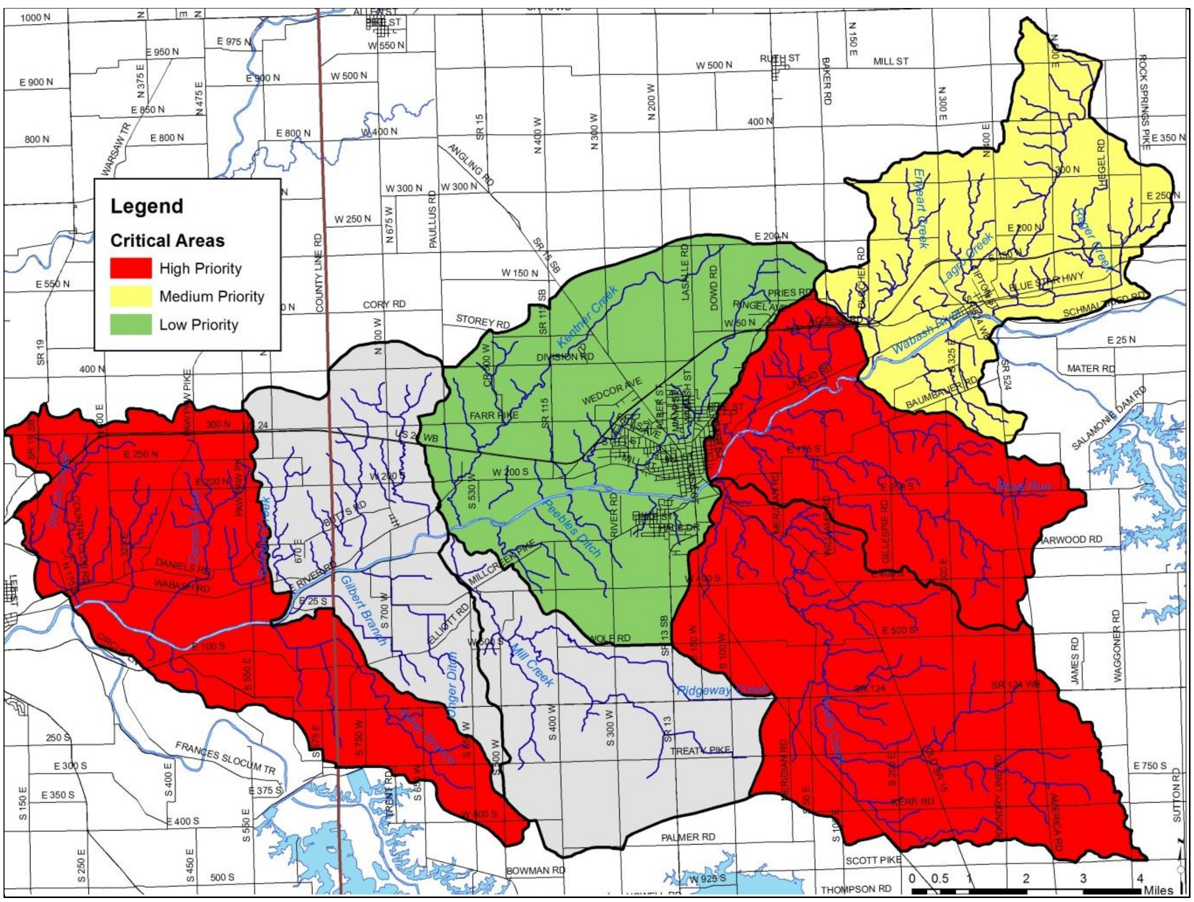


**Figure 71. Prioritized critical areas in the Treaty Creek-Wabash River Watershed.**

Two subwatersheds, Gilbert Branch-Wabash River and Ridgeway Creek, were not prioritized as critical areas meaning they were not identified as the areas of highest concern for any of the four parameters (nitrogen, phosphorus, sediment or pathogens). It is anticipated that implementation efforts will be targeted at these watersheds as part of EPA-funded implementation efforts only after implementation efforts are exhausted in higher priority areas. Implementation via other funding sources, via landowner interest in NRCS-based federal funding programs will occur as landowners are interested. The Treaty

Creek-Wabash River stakeholder group will continue volunteer monitoring efforts to continue to assess the quality of these subwatersheds and identify any changes in water quality as they occur.

## 8.5 Critical Acre Determination

To be eligible for Mississippi River Basin Initiative (MRBI) Funding, the Treaty Creek-Wabash River Watershed steering committee considered options for targeting all agricultural acreage within the Watershed rather than limiting implementation efforts to specific 12-digit HUC subwatersheds. Table 38 details critical acres by subwatershed based on the criteria selected for nutrient, sediment and E. coli critical areas. These acres within each of the prioritized critical areas identified in Figure 71 will be targeted for implementation in advance of moving on to lower priority critical acres within the priority subwatersheds. The technical committee will target hot spots or problem areas identified within each subwatershed including but not limit to 1) ensuring that all highly erodible lands and potentially highly erodible lands are covered; 2) targeting livestock restriction, streambank erosion and buffer strip installation in areas where erosion, livestock access and/or narrow buffers were identified; and 3) working with producers to reduce the impacts of the high volume of manure production and municipal sludge application within the Treaty Creek-Wabash River Watershed (Figure 72). Treaty Creek-Wabash River Watershed stakeholders identified the need for soils with septic limitation to be targeted for septic treatment; however, this is not an MRBI targeted practice and is therefore not included in Table 38. Note that manure application acres have not been mapped as these application areas are only identified as potential areas for manure application for each permitted confined feeding operation.

**Table 38. Critical acres by subwatershed in the Treaty Creek-Wabash River Watershed.**

| Subwatershed | HUC | Agricultural Land Use (acres) | HES/PES (acres) | Sludge Application (acres) |
|---|---|---|---|---|
| Enyeart Creek-Wabash River | 051201011401 | 9,888.1 | 8,910.4 | -- |
| Stone Creek-Treaty Creek | 051201011402 | 15,238.0 | 6,479.4 | 1,898.9 |
| Burr Creek-Wabash River | 051201011403 | 8,116.4 | 6,087.1 | 171.7 |
| Ridgeway Creek | 051201011404 | 8,707.8 | 1,819.1 | 813.1 |
| Kentner Creek | 051201011405 | 12,572.5 | 6,001.7 | 873.1 |
| Gilbert Branch-Wabash River | 051201011406 | 8,504.8 | 3,029.3 | 475.9 |
| Daniel Creek-Wabash River | 051201011407 | 11,183.2 | 3,844.1 | 271.6 |
| Totals | | 74,210.9 | 36,171.1 | 4,504.3 |
| **Subwatershed** | **Manure Volume (tons)** | **Livestock Access (miles)** | **Streambank Erosion (miles)** | **Narrow Buffer (miles)** |
| Enyeart Creek-Wabash River | 58,245.1 | -- | 11.1 | 3.4 |
| Stone Creek-Treaty Creek | 133,818.0 | -- | 9.4 | 8.3 |
| Burr Creek-Wabash River | 46,202.0 | -- | 4.8 | 3.2 |
| Ridgeway Creek | 16,848.0 | -- | -- | 3.1 |
| Kentner Creek | 56,134.0 | 0.8 | 3.4 | 5.8 |
| Gilbert Branch-Wabash River | 5,917.0 | -- | 4.5 | 13.8 |
| Daniel Creek-Wabash River | 94,849.0 | 1.4 | 11.2 | 6.6 |
| Totals | 412,013.1 | 2.2 | 44.4 | 44.2 |

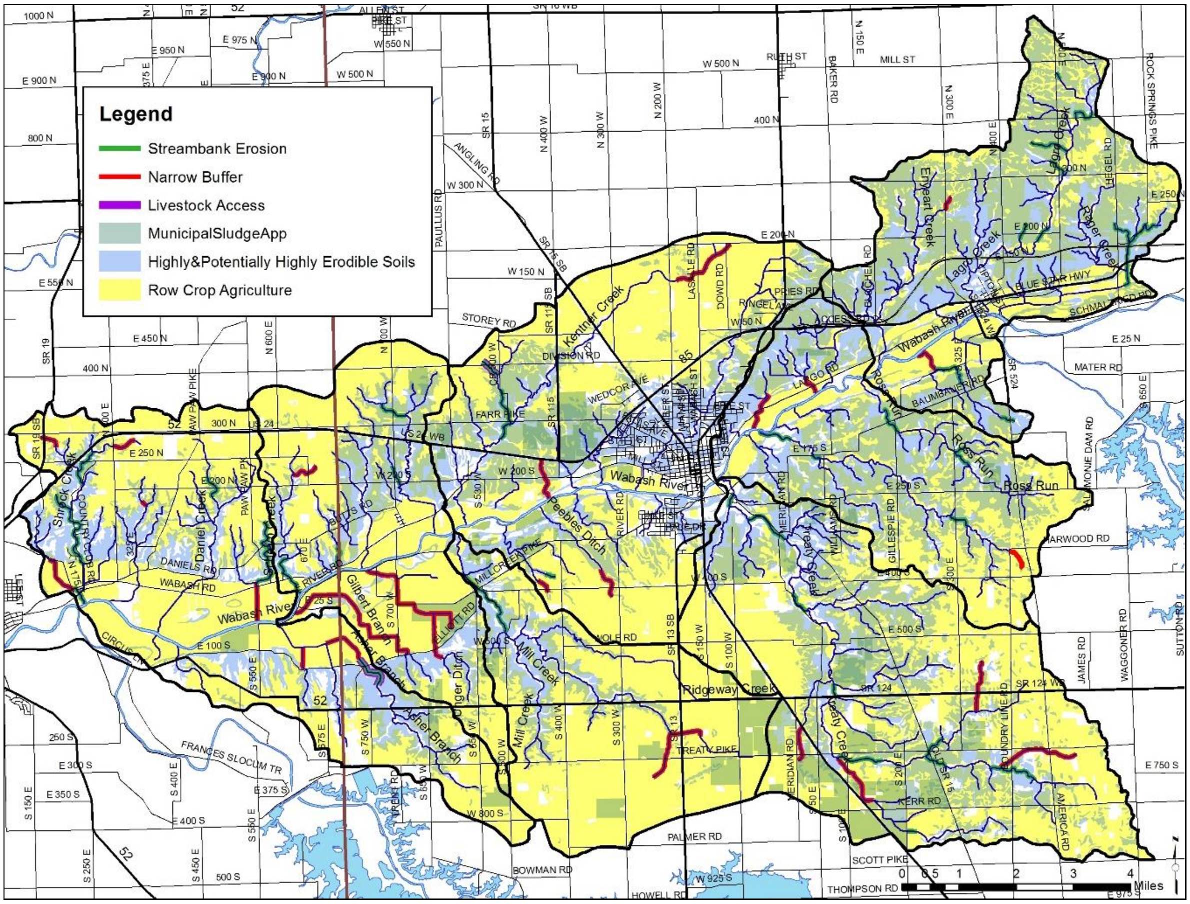


**Figure 72. Critical acres in the Treaty Creek-Wabash River Watershed.**

**8.6 Current Level of Treatment**

In an effort to inform producer interest in various practices, the existing level of implementation within each subwatershed and identify potential solutions for nutrient, sediment and pathogen concern areas, the Treaty Creek-Wabash River steering committee cataloged practices implemented utilizing NRCS funding from 2014 to 2018. These data allowed the steering committee to determine the current baseline of implementation efforts and will allow for more targeted implementation in the future. Based on data from NRCS, more than 17,060 acres of best management plans including but not limited to cover crops, nutrient and pest management, forage and biomass planting, forest and shrub restoration; 23,000 feet of fencing, access control, streambank stabilization and open channel construction; and more than 65 grade stabilization structures, waste storage facilities, watering facilities, WASCOBs and more have been implemented over the last 5 years in the Treaty Creek-Wabash River Watershed. Table 39 details practices by acre, linear foot or count.

**Table 39. Practices installed from 2014-2018 in the Treaty Creek-Wabash River Watershed based on NRCS data.**

| FOTG ID | Practice | Unit | Enyeart Creek-Wabash River | Stone Creek-Treaty Creek | Burr Creek-Wabash River | Ridgeway Creek | Kentner Creek | Gilbert Branch-Wabash River | Daniel Creek-Wabash River |
|---|---|---|---|---|---|---|---|---|---|
| 106 | Forest Management Plan - Written | count | 1 | | 1 | 2 | 1 | 1 | 1 |
| 314 | Brush Management | acres | 86 | 21.8 | | | | 17.4 | |
| 315 | Herbaceous Weed Control | acres | 8.9 | | | | | 8.9 | |
| 325 | High Tunnel System | sq feet | 3,138 | | 960 | | | | 2,178 |
| 329 | Residue and Tillage Management, No Till/Strip Till | acres | 1,324.2 | 529.2 | 96.1 | 45.4 | 48 | | |
| 340 | Cover Crop | acres | 1,213.6 | 362.4 | | | 48 | 85.3 | 49.6 |
| 342 | Critical Area Planting | acres | 1.6 | | | | | | 1.6 |
| 360 | Closure of Waste Impoundments | count | 4 | | | 4 | | | |
| 380 | Windbreak/Shelterbelt Establishment | acres | 417 | | | | 417 | | |
| 382 | Fence | acres | 1,172 | | | | 1172 | | |
| 410 | Grade Stabilization Structure | count | 1 | | | | | | 1 |
| 412 | Grassed Waterway | acres | 0.4 | | | | | | 0.4 |
| 484 | Mulching | acres | 2 | | | | | | 2 |

| FOTG ID | Practice | Unit | Enyeart Creek-Wabash River | Stone Creek-Treaty Creek | Burr Creek-Wabash River | Ridgeway Creek | Kentner Creek | Gilbert Branch-Wabash River | Daniel Creek-Wabash River |
|---|---|---|---|---|---|---|---|---|---|
| 512 | Forage and Biomass Planting | acres | 19.5 | 19.5 | | | | | |
| 516 | Livestock Pipeline | acres | 1,056 | | | | 1056 | | |
| 561 | Heavy Use Area Protection | sq feet | 1,700 | | | | 1700 | | |
| 580 | Streambank and Shoreline Protection | feet | 180 | | | | | | 180 |
| 582 | Open Channel | feet | 1,800 | | | | | | 1,800 |
| 590 | Nutrient Management | acres | 2,036.2 | 947.1 | 96.1 | 45.4 | 48 | | 539.6 |
| 595 | Integrated Pest Management | acres | 1,907.6 | 818.5 | 96.1 | | | | 539.6 |
| 606 | Subsurface Drain | feet | 1,240 | | 783 | | | | 457 |
| 614 | Watering Facility | count | 2 | | | | 2 | | |
| 620 | Underground Outlet | feet | 11,190 | 6,985 | 1,360 | | | | |
| 638 | Water & Sediment Control Basin | count | 26 | 15 | 3 | | | | |
| 647 | Early Successional Habitat Development/Management | acres | 9.5 | | | | | 9.5 | |
| 666 | Forest Stand Improvement | acres | 184.5 | 21.8 | | | | | 115.9 |

# 9.0 GOAL SETTING

Based on watershed inventory efforts; stakeholder input for concerns, problems, and sources; and watershed loading information, the following goals and strategies were developed.

## 9.1 Goal Statements

The steering committee wrote goals for each parameter or area of concern based on a goal of meeting the target concentrations identified by the committee. In an effort to scale goals to manageable levels, a twenty-year timeframe was initially used for goal setting. High priority (short term, 5-year goals), medium priority (medium term, 10-year goals), and low priority (long term, 20-year goals) were generated. The following process is described below:

1. High, medium, and low priority subwatersheds were ranked based on critical areas;
2. Current and target loading rates were determined to calculate the short (high), medium and long (low) term goals;
3. The steering committee selected a 25% reduction for all high priority subwatersheds in the first five years. The remaining reduction will be accomplished in the next five years (10 years total time).
4. Medium and low priority watershed targets will meet their goals every 10 years following this initial 10-year period (medium priority in 20 years and low priority in 30 years).
5. This resulted in a shift in timing to a 30-year total timeframe for meeting load reduction targets.

The subwatersheds are ranked as follows:

- High Priority Subwatersheds: Daniel Creek-Wabash River, Stone Creek-Treaty Creek, and Burr Creek-Wabash River
- Medium Priority Subwatersheds: Enyeart Creek-Wabash River
- Low Priority Subwatersheds: Kentner Creek

**Reduce Nutrient Loading**

Based on collected water quality data, the committee set the following goals for nitrate-nitrogen and total phosphorus (Table 40 and Table 41).

Short term: Reduce nitrate-nitrogen inputs from 248,625.1 pounds per year to 186,468.8 pounds per year (25% reduction) and total phosphorus inputs from 17,648.7 pounds per year to 13,236.6 pounds per year (25% reduction) in high priority subwatersheds in the Treaty Creek-Wabash River Watershed by 2024 (5 years).

Medium term: Reduce nitrate-nitrogen inputs from 186,468.8 pounds per year to 111,956.8 pounds per year (60% reduction) and total phosphorus inputs from 13,236.6 pounds per year to 4,470.2 pounds per year (60% reduction) in high priority subwatersheds by 2029 (10 years) and reduce nitrate-nitrogen inputs from 80,137.7 pounds per year to 24,764.8 pounds per year (69% reduction) and total phosphorus inputs from 6,839.7 pounds per year to 1,495.9 pounds per year (78% reduction) in medium priority subwatersheds in the Treaty Creek-Wabash River Watershed by 2039 (20 years).

Long term: Reduce nitrate-nitrogen inputs from 94,110.7 pounds per year to 23,140.2 pounds per year (75% reduction) and total phosphorus inputs from 3,676.8 pounds per year to 1,388.4 pounds per year (62% reduction) in low priority subwatersheds in the Treaty Creek-Wabash River Watershed by 2049 (30 years).

**Table 40. Nitrate-nitrogen goal calculations for prioritized critical areas.**

| | Current Load (lb/yr) | Target Load (lb/yr) | Reduction Needed (lb/yr) | Period Percent Reduction | Total Percent Reduction |
|---|---|---|---|---|---|
| High Priority Subwatersheds (Short term, 5-year goal) | 248,625.1 | 186,468.8 | 62,156.3 | 25% | N/A |
| High Priority Subwatersheds (Medium term, 10-year goal) | 186,468.8 | 74,503.0 | 111,965.8 | 60% | 70% |
| Medium Priority Subwatersheds (Medium term, 20-year goal) | 80,137.7 | 24,764.8 | 55,372.8 | N/A | 69% |
| Low Priority Subwatersheds (Long term, 30-year goal) | 94,110.7 | 23,140.2 | 70,970.5 | N/A | 75% |

**Table 41. Total phosphorus goal calculations for prioritized critical areas.**

| | Current Load (lb/yr) | Target Load (lb/yr) | Reduction Needed (lb/yr) | Period Percent Reduction | Total Percent Reduction |
|---|---|---|---|---|---|
| High Priority Subwatersheds (Short term, 5-year goal) | 17,648.7 | 13,236.6 | 4,412.2 | 25% | N/A |
| High Priority Subwatersheds (Medium term, 10-year goal) | 13,236.6 | 4,470.2 | 8,766.4 | 66% | 75% |
| Medium Priority Subwatersheds (Medium term, 20-year goal) | 6,839.7 | 1,485.9 | 5,353.8 | N/A | 78% |
| Low Priority Subwatersheds (Long term, 30-year goal) | 3,676.8 | 1,388.4 | 2,288.4 | N/A | 62% |

**Reduce Sediment Loading**

Based on collected water quality data, the committee set the following goals for total suspended solids (Table 42).

Short term: Reduce total suspended sediment inputs from 9,882,179 pounds per year to 7,411,635 pounds per year (25% reduction) in high priority subwatersheds in the Treaty Creek-Wabash River Watershed by 2024 (5 years).

Medium term: Reduce total suspended sediment inputs from 7,411,635 pounds per year to 2,235,090 pounds per year (77% reduction) in high priority subwatersheds by 2029 (10 years) and reduce total suspended sediment inputs from 1,879,522 to 1,485,889.3 pounds per year (21% reduction) to 24,764.8 pounds per year in medium priority subwatersheds in the Treaty Creek-Wabash River Watershed by 2039 (20 years).

Long term: Reduce total suspended sediment inputs from 1,954,638 pounds per year to 1,388,414 pounds per year (29% reduction) in low priority subwatersheds in the Treaty Creek-Wabash River Watershed by 2049 (30 years).

**Table 42. Total suspended solids goal calculations for prioritized critical areas.**

| | Current Load (lb/yr) | Target Load (lb/yr) | Reduction Needed (lb/yr) | Period Percent Reduction | Total Percent Reduction |
|---|---|---|---|---|---|
| High Priority Subwatersheds (Short term, 5-year goal) | 9,882,179.4 | 7,411,634.5 | 2,470,544.8 | 25% | N/A |
| High Priority Subwatersheds (Medium term, 10-year goal) | 7,411,634.5 | 2,986,184.9 | 4,425,449.6 | 60% | 70% |
| Medium Priority Subwatersheds (Medium term, 20-year goal) | 1,879,521.8 | 1,485,889.3 | 3693,632.5 | N/A | 21% |
| Low Priority Subwatersheds (Long term, 30-year goal) | 1,954,637.6 | 1,388,414.3 | 566,223.3 | N/A | 29% |

**Reduce *E. coli* Loading**

Based on collected water quality data, the committee set the goals for *E. coli* (Table 43).

Short term: Reduce E. coli inputs from 1.04E+15 colonies per year to 7.78E+14 colonies per year (25% reduction) in high priority subwatersheds in the Treaty Creek-Wabash River Watershed by 2024 (5 years).

Medium term: Reduce E. coli inputs from 7.78E+14 colonies per year to 1.59E+14 colonies per year (80% reduction) in high priority subwatersheds by 2029 (10 years) and reduce E. coli inputs from 2.9E+14 colonies to per year 5.3E+13 colonies per year (82% reduction) in medium priority subwatersheds in the Treaty Creek-Wabash River Watershed by 2039 (20 years).

Long term: Reduce E. coli inputs from 2.2E+14 colonies per year to 4.9E+13 colonies per year (64% reduction) in low priority subwatersheds in the Treaty Creek-Wabash River Watershed by 2049 (30 years).

**Table 43. E. coli short goal calculations for prioritized critical areas.**

| | Current Load (lb/yr) | Target Load (lb/yr) | Reduction Needed (lb/yr) | Period Percent Reduction | Total Percent Reduction |
|---|---|---|---|---|---|
| High Priority Subwatersheds (Short term, 5-year goal) | 1.04E+15 | 7.78E+14 | 2.59E+14 | 25% | N/A |
| High Priority Subwatersheds (Medium term, 10-year goal) | 7.78E+14 | 1.59E+14 | 6.19E+14 | 80% | 85% |
| Medium Priority Subwatersheds (Medium term, 20-year goal) | 2.9E+14 | 5.3E+13 | 2.4E+14 | N/A | 82% |
| Low Priority Subwatersheds (Long term, 30-year goal) | 2.2E+14 | 4.9E+13 | 1.7E+14 | N/A | 78% |

**Increase Public Awareness and Participation**

A unified education program for entire watershed does not currently exist and educational efforts targeting funders, local agencies, and the public are lacking.

Long term: Increase public awareness and knowledge about the Treaty Creek-Wabash River Watershed and what individuals and communities can do to improve the quality of these waterways by 2049 (30 years). Measurement will occur by an increase in the total number of event attendees annually.

**In-stream Habitat**
The existing habitat is insufficient to protect soil health and water quality; invasive species are negatively impacting soil and water quality. Additionally, habitat and water quality are insufficient to protect endangered species

Long term: Increase instream habitat by 15 QHEI points in target streams (Mill Creek and Asher Branch) reaches and reduce terrestrial invasive species spread by 10% by 2039 (20 years). QHEI assessments will occur prior to any riparian or instream restoration efforts and will be used to gage habitat changes by comparing scores post establishment. Invasive species removal efforts will be monitored via bird call counts collected prior to and following any invasive species removal. Each habitat assessment will be compared with previous assessments to determine whether habitat quality is increasing.

## 10.0 IMPROVEMENT MEASURE SELECTION

A wide variety of practices are available for on-the-ground implementation to reduce sediment, nutrient, and *E. coli* loading within the Treaty Creek-Wabash River Watershed. A list of potential best management practices was reviewed by the project steering committee. From this list, the practices which were deemed most appropriate to remediate the sources of pollution in the watershed and most likely to successfully meet loading reduction targets were identified. It should be noted that no practice list is exhaustive and that additional techniques may be both possible and necessary to reach water quality goals.

### 10.1 Best Management Practices Descriptions

A list of potential BMPs were reviewed by the Treaty Creek-Wabash River steering committee. Committee members reviewed potential practices taking into account the identified resource concerns, watershed land uses, and Treaty Creek-Wabash River Watershed Project goals. From the potential practice list, the most appropriate BMPs to remediate sources of pollution and address resource concerns in the Treaty Creek-Wabash River Watershed was developed. This practice list is not exhaustive and new and emerging technologies and techniques should be considered as possible and necessary options to meet water quality targets within the Treaty Creek-Wabash River Watershed. A combination of practices detailed below aimed at avoiding, controlling and trapping nutrients and sediment and the implementation of a conservation system could be necessary to make lasting, measurable changes in Treaty Creek water quality. Selected practices are appropriate for all critical areas since they all contain agriculture land use and pasture, and crop resource concerns were identified in all subwatersheds. Selected practices with descriptions are listed below.

Potential best management practices include the following:

Bioreactor
Bioretention
Composting Facility
Conservation Tillage
Cover Crop/Critical Area Planting/Conservation Cover
Drainage Water Management
Fencing
Field Border/Buffer Strip
Forage/Biomass Planting
Grade Stabilization Structure
Grassed Waterway/Mulching/Subsurface Drain
Gypsum
Livestock Restriction/Prescribed Grazing
Manure Management Planning
Nutrient/Pest Management
Rain Barrel
Saturated Buffer
Septic System Care/Maintenance
Streambank Stabilization

T&E Species Protection (Habitat Improvement)
Tree/Shrub Establishment
Two Stage Ditch
Waste Storage Facility
Water and Sediment Control Basin
Wetland Creation/Enhancement/Restoration

**Bioreactors**

Bioreactors use bacteria to digest organic materials including manure, remnant plant material, and woody debris. Bioreactors typically generate energy, water, and fertilizer. Bioreactors use a series of tanks and treatment processes to separate cellulose-based materials from oils and gases. Materials are then broken down into carbon dioxide or methane gas and ethanol.

**Bioretention**

Bioretention practices use biofiltration or bioinfiltration to filter runoff by storing it in shallow depressions. Bioretention uses plant uptake and soil permeability mechanisms in a variety of manners typically in combination. Potential practices include sand beds, pea gravel overflow structures, organic mulch layers, plant materials, gravel underdrains, and an overflow system to promote infiltration. Bioinfiltration can also be used to treat runoff from parking lots, roads, driveways and other areas in the urban environment. Bioretention should not be used in highly urbanized areas rather, it should be used in areas where on-site storage space is available.

**Composting Facility**

A composting facility is a structure to facilitate the controlled anaerobic decomposition of manure or other organic material by microorganisms into a biologically stable organic material that is suitable for use as a soil amendment. It can reduce the pollution potential and improve the handling characteristics of organic waste solids and produce a soil amendment that adds organic matter and beneficial organisms, provides slow-release plant-available nutrients, and improves soil conditions (FOTG Code 317, NRCS, 2011).

**Conservation Tillage (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 (Holdren et al., 2001). Tillage methods encompassed by conservation tillage include no-till, mulch-till, ridge-till, and strip till. The purpose of conservation tillage is to reduce sheet and rill erosion, maintain or improve soil organic matter content, conserve soil moisture, increase available moisture, reduce plant damage, and provide habitat and cover for wildlife. The remaining crop residue helps reduce soil erosion and runoff volume.

Several researchers have demonstrated the benefits of conservation tillage in reducing pollutant loading to streams and lakes. A comprehensive comparison of tillage systems showed that no-till results in 70% less herbicide runoff, 93% less erosion, and 69% less water runoff volume when compared to conventional tillage (Conservation Technology Information Center, 2000). Reductions in pesticide loading have also been reported (Olem and Flock, 1990).

**Cover Crops/Critical Area Planting/Conservation Cover**

Cover crops include legumes, such as clover, hairy vetch, field peas, alfalfa, and soybean, and non-legumes, such as rye, oats, wheat, radishes, turnips, and buckwheat 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, suppressing weed cover, and encouraging beneficial insect growth. Cover crops reduce phosphorus transport by reducing soil erosion and runoff. Both wind and water erosion move soil particles that have phosphorus attached. Sediment that reaches water bodies may release phosphorus into the water. Runoff water can wash soluble phosphorus from the surface soil and crop residue and carry it off the field. The cover crop vegetation recovers plant-available nutrients in the soil and recycles them through the plant biomass for succeeding crops.

**Drainage Water Management/Subirrigation**

Subsurface tile drainage is an essential water management practice on highly productive fields. As a result of tile drainage, nitrate carried in drainage water enters adjacent surface waterbodies. Drainage water management is necessary to reduce nitrate loads entering adjacent surface waterbodies from tile drainage networks. Drainage water management uses water control structures within lateral drains to vary the depth of tile outlets. Typically, the outlet is raised after harvest to limit outflow from the tile and reduce nitrate transport to adjacent waterbodies; lowered in the spring and fall to allow tile water to flow freely from the field to adjacent waterbodies; and raised in the summer to help store water making it available for crops (Frankenberger et al., 2006). Drainage water management can be used in concert with a suite of other conservation practices including subirrigation, cover crops and conservation tillage to promote a systems approach and be better stewards of water quantity.

**Fencing/Alternate Watering Systems**

Fencing livestock out of stream systems allows for the restoration of the stream channel. 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. This results in less *E. coli*, phosphorus, nitrogen, and sediment entering a surface waterbody. Alternative watering systems may include pump systems or gravity systems connected to a well, or running pipe from a pond or spring.

**Field Border/Buffer Strip/Filter Strip**

Installing natural buffers or filters along major and minor drainages in the watershed helps reduce the nutrient and sediment loads reaching surface waterbodies. Buffers provide many benefits including restoring hydrologic connectivity, reducing nutrient and sediment transport, improving recreational opportunities and aesthetics, and providing wildlife habitat. Sediment, phosphorus, nitrogen, and *E. coli* are at least partly removed from water passing through a naturally vegetated buffer. The percentage of pollutants removed depends on the pollutant load, the type of vegetation, the amount of runoff, and the character of the buffer area. The most effective buffer width can vary along the length of a channel. Adjacent land uses, topography, runoff velocity, and soil and vegetation types are all factors used to determine the optimum buffer width.

Many researchers have verified the effectiveness of filter strips in removing sediment from runoff with reductions ranging from 56-97% (Arora et al., 1996; Mickelson and Baker, 1993; Schmitt et al., 1999; Lee et al, 2000; Lee et al., 2003). Most of the reduction in sediment load occurs within the first 15 feet of installed buffer. Smaller additional amounts of sediment are retained and infiltration is increased by increasing the width of the strip (Dillaha et al., 1989). Filter strips have been found to reduce sediment-bound nutrients like total phosphorus but to a lesser extent than they reduce sediment load itself. Phosphorus predominately associates with finer particles like silt and clay that remain suspended longer and are more likely to reach the strip's outfall (Hayes et al., 1984). Filter strips are least effective at reducing dissolved nutrients like those of nitrate and phosphorus, and atrazine and alachlor, although reductions of dissolved phosphorus, atrazine, and alachlor of up to 50% have been documented

(Conservation Technology Information Center, 2000). Simpkins et al. (2003) demonstrated 20-93% nitrate-nitrogen removal in multispecies riparian buffers. Short groundwater flow paths, long residence times, and contact with fine-textured sediments favorably increased nitrate-nitrogen removal rates. Additionally, up to 60% of pathogens contained in runoff may be effectively removed. Computer modeling also indicates that over the long run (30 years), filter strips significantly reduce amounts of pollutants entering waterways.

Filter strips should be designed as permanent plantings to treat runoff and should not be considered part of the annual rotation of adjacent cropland. Filter strips should receive only sheet flow and should be installed on stable banks. A mixture of grasses, forbs, and herbaceous plants should be used. In more permanent plantings, shrubs and trees should be intermingled to form a stable riparian community.

**Forage and Biomass Planting**
Forage and biomass plantings establish adapted and/or compatible species, varieties, or cultivars of herbaceous species suitable for pasture, hay or biomass production. Purposes include: Improve or maintain livestock nutrition and/or health; provide or increase forage supply during periods of low forage production; reduce soil erosion; improve soil and water quality; produce feedstock for biofuel or energy production.

**Grade Stabilization**
A grade stabilization structure is used to stabilize and control soil erosion in natural and artificial channels. It can prevent the formation or advance of gullies, enhance environmental quality, and reduce pollution hazards. Special attention is given to maintaining or improving habitat for fish and wildlife.

**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. When properly constructed, grassed waterways can safely transport large water flows downslope. These waterways can also be used as outlets for water released from contoured and terraced systems and from diverted channels. The amount of precipitation that runs off the soil surface rather than infiltrating down into the soil profile is increased by tillage and other farming activities that increase soil compaction and decrease soil organic matter and macro-pore content. For these reasons, the establishment or refurbishing of a grassed waterway should, when possible, be coupled with other practices that aim to increase the rate of water infiltration into the soil. This BMP can reduce sediment concentrations of nearby waterbodies and pollutants in runoff. The vegetation improves the soil aeration and water quality due to its nutrient removal through plant uptake and absorption by soil. The waterways can also provide wildlife corridors and allows more land to be natural areas.

**Gypsum**
Amending soil with gypsum, or calcium sulfate dehydrate-derived products, changes the physical and chemical properties of the soil. This practice is used to improve soil health by improving physical/chemical properties and increasing infiltration of the soil; improve surface water quality by reducing dissolved phosphorus concentrations in surface runoff and subsurface drainage; improve soil health by ameliorating subsoil aluminum toxicity; and improve water quality by reducing the potential for pathogens and other contaminants transported from areas of manure and bio solids application.

**Livestock Restriction/Rotational Grazing**

Livestock that have unrestricted access to a stream or wetland have the potential to degrade the waterbody's water quality and biotic integrity. Livestock can deliver nutrients and pathogens directly to a waterbody through defecation. Livestock also degrade stream ecosystems indirectly. Trampling and removal of vegetation through grazing of riparian zones can weaken banks and increase the potential for bank erosion. Trampling can also compact soils in a wetland or riparian zone decreasing the area's ability to infiltrate water runoff. Removal of vegetation in a wetland or riparian zone also limits the area's ability to filter pollutants in runoff. The degradation of a waterbody's water quality and habitat typically results in the impairment of the biota living in the waterbody.

Restoring areas impacted by livestock grazing often involves several steps. First, the livestock in these areas should be restricted from the wetland or stream to which they currently have access. If necessary, an alternate source of water should be created for the livestock. Second, the wetland or riparian zone where the livestock have grazed should be restored. This may include stabilizing or reconstructing the banks using bioengineering techniques. Minimally, it involves installing filter strips along banks or wetland edge and replanting any denuded areas. Finally, if possible, drainage from the land where the livestock are pastured should be directed to flow through a constructed wetland to reduce pollutant loading, particularly nitrate-nitrogen loading, to the adjacent waterbody. Complete restoration of aquatic areas impacted by livestock will help reduce pollutant loading, particularly nitrate-nitrogen, sediment, and pathogens.

A livestock exclusion system is a system of permanent fencing (board, barbed, etc) installed to exclude livestock from streams and areas not intended for grazing. This will reduce erosion, sediment, and nutrient loading, and improve the quality of surface water. Landowners can additionally section off the pasture land and move the animals from one paddock to the next, ensuring adequate vegetation growth for nutrient removal. Using this system of rotational grazing no one piece of land gets overgrazed and ensures a high quality food for the livestock and adequate ground cover for nutrient and sediment retention. Education and outreach programs focusing on rotational grazing and exclusionary fencing are important in the success of this BMP.

**Manure Management Planning**

Large volumes of manure are generated by both small, unregulated animal operations and by confined feeding operations located throughout the Big Pine watershed. Many entities have manure management plans in place and are currently using these plans to manage the volume of manure produced on their facility. 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.

Animal waste is a major source of pollution to waterbodies. To protect the health of aquatic ecosystems and meet water quality standards, manure must be safely managed. Good management of manure keeps livestock healthy, returns nutrients to the soil, improves pastures and gardens, and protects the environment, specifically water quality. Poor manure management may lead to sick livestock, unsanitary and unhealthy conditions for humans and other organisms, and increased insect and parasite populations. Proper management of animal waste can be done by implementing BMPs, through safe storage, by application as a fertilizer, and through composting. Proper manure management can effectively reduce *E.coli* concentrations, nutrient levels and sedimentation. Manure management can also be addressed in education and outreach to encourage farmers to participate in this BMP.

**Nutrient/Pest Management Planning including Variable Rate Application and Waste Storage Facility**
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 and can be in commercial/non-manure fertilizer or manure-based fertilizers. 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. Realistic yields are based on soil productivity information, potential yield, or historical yield data based on a 5-year average. Nutrient management plans specify the form, source, amount, timing, and method of application of nutrients on each field in order to achieve realistic production levels while minimizing transport of nutrients to surface and/or groundwater.

**Rain Barrel**
A rain barrel is a container that collects and stores rainwater from your rooftop (via your home's disconnected downspouts) for later use on your lawn, garden, or other outdoor uses. Rainwater stored in rain barrels can be useful for watering landscapes, gardens, lawns, and trees. Rain is a naturally soft water and devoid of minerals, chlorine, fluoride, and other chemicals. In addition, rain barrels help to reduce peak volume and velocity of stormwater runoff to streams and storm sewer systems. Although rain barrels don't specifically reduce nutrient or sediment loading to waterbodies, their presence can reduce the first flush of water reaching storm drains. This impact is great especially in portions of the watershed where combined sewers are still in operation. Although a high percentage of urban residents indicated a general knowledge of rain barrels, only 3% of survey respondents indicate that they have installed a rain barrel. Furthermore, 75% of respondents indicate a willingness to consider installing a rain barrel.

**Rain Garden**
Rain gardens are small-scale bioretention systems that be can be used as landscape features and small-scale stormwater management systems for single-family homes, townhouse units, some small commercial development, and to treat parking lot or building runoff. Rain gardens provide a landscape feature for the site and reduce the need for irrigation, and can be used to provide stormwater depression storage and treatment near the point of generation. These systems can be integrated into the stormwater management system since the components can be optimized to maximize depression storage, pretreatment of the stormwater runoff, promote evapotranspiration, and facilitate groundwater recharge. The combination of these benefits can result in decreased flooding due to a decrease in the peak flow and total volume of runoff generated by a storm event. Additionally, rain gardens can be designed to provide a significant improvement in the quality of the stormwater runoff.

**Saturated Buffer**
Saturated buffers are an option in situations where a field is bordered by a riparian buffer. The conventional practice is to extend the tile main line from the field, through the buffer and discharge the water directly into the receiving stream. Subsurface drainage water, therefore, bypasses the buffer and has no opportunity for interaction with the biota in the buffer. Saturated buffers provide a means for distributing some or all of the drainage water through the buffer. For the purpose of utilizing the buffer, a diverter box, or control structure, is installed on the tile main line at the edge between the field and the buffer. The diverter box is used to direct the water into a subsurface distribution pipe running parallel to

the stream along the edge of the field. The distribution pipe is regular perforated drainage pipe. The drainage water can then seep out of the distribution pipe and into the soil and make its way down gradient to the stream. The nitrate in the water is removed by the buffer through denitrification, immobilization in bacterial biomass and plant uptake. An overflow discharge pipe to the stream is connected to the diverter box to allow bypass flow during times of high drainage flow rates, thereby ensuring that no water is being backed up in the main tile line.

**Septic System Care, Maintenance, and Upgrades**

Septic, or on-site waste disposal systems, are the primary means of sanitary flow treatment outside of incorporated areas including most of the small towns and unincorporated areas in the Treaty Creek-Wabash River Watershed. Because of the prohibitive cost of providing centralized sewer systems to many areas, septic tank systems will remain the primary means of treatment into the future. Annual maintenance of septic systems is crucial for their operation, particularly the annual removal of accumulated sludge. The cost of replacing failed septic tanks is about $5,000-$15,000 per unit based on industry standards.

Property owners are responsible for their septic systems under the regulation of the County Health Department. When septic systems fail, untreated sanitary flows are discharged into open watercourses that pollute the water and pose a potential public health risk. Septic systems discharging to the ground surface are a risk to public health directly through body contact or contamination of drinking water sources. Additionally, septic systems can contribute significant amounts of nitrogen and phosphorus to the watershed. Therefore, it is imperative for homeowners not to ignore septic failures. If plumbing fixtures back up or will not drain, the system is failing. Funding for this practice is limited. Our efforts will include developing an education plan for homeowners in the watershed, and hosting a series of septic system care and maintenance workshops.

**Streambank Stabilization**

Streambank stabilization or stream restoration techniques are used to improve stream conditions so they more closely mimic natural conditions. The most feasible restoration options return many of the stream's natural functions (flood storage, nutrient removal, etc.) without restoring the stream completely to its original condition. However, even a partial restoration of this type is extremely expensive, takes quite a bit of land to accomplish, and is likely unrealistic as a large scale strategy in this watershed. Our efforts will focus primarily on two-stage ditch construction, which is a cheaper way to incorporate a small floodplain into the ditch itself in the form of benches on either side of the main channel that allow for increased capacity in the ditch resulting in slower moving water along the banks resulting in reduced bank slumping and failure. Restoration and stabilization options are limited by available floodplain, modifications to natural flows, and development structure locations. Reestablishment of riparian buffers, restoration of stream channels, stabilization of eroding stream banks, installation of riffle-pool complexes, and general maintenance can all improve stream function while reducing sediment and nutrient transport into and within the system.

**T&E Species Protection (Habitat Improvement)**

Threatened and endangered species are those plant and animal species whose survival is in peril. Federally and state listed species identified within the Treaty Creek-Wabash River Watershed are highlighted in the Watershed Inventory. Threatened species are those that are likely to become endangered in the foreseeable future. Federally endangered species are those that are in danger of extinction throughout all or a significant portion of their range. A state-endangered species is any species that is in danger of extinction as a breeding species in Indiana.

Protecting threatened and endangered species requires consideration of their habitat including food, water, and nesting and roosting living space for animals and preferred substrate for plants and mussels. Corridors for species movement are also necessary for long-term protection of these species. Protection of habitat can include providing clean water and available food but likely requires protection of the physical living space and associated corridor. Conservation management plans should be developed for each species, if they are not already in place. Such plans should consider habitat needs including purchase or protection of adjacent properties to current habitat locations, hydrologic needs, pollution reduction, outside impacts, and other techniques necessary to protect threatened and endangered species.

**Tree/Shrub Establishment/Reforestation including Invasive Control/Timber Stand Improvement**
Reforestation is the establishment of forests, usually accomplished through the planting of tree seedlings. It is important to match the species being planted to the site chosen for reforestation. Control of competing vegetation and invasive plants is often necessary to ensure establishment and survival of planted trees. This is usually done through mowing and/or herbicide application. Reforestation can provide many benefits to the landscape. Increasing the amount of forest through tree planting provides more habitat for forest dependent species, improves water quality by reducing erosion, decreases nutrient loading and lowers floodwater velocity.

**Two-Stage Ditch**
When water is confined to stream or ditch channel it has the potential to cause bank erosion and channel down-cutting. Current ditch design generates narrow channels with steep sides. Water flowing through these systems often result in bank erosion, channel scour and flooding. A relatively new technique focuses on mitigating these issues through an in-stream restoration called a two-stage ditch. The design of a two-stage ditch incorporates a floodplain zone, called benches, into the ditch by removing the ditch banks roughly 2-3 feet above the bottom for a width of about 10 feet on each side depending on the size of the channel. This allows the water to have more area to spread out on and decreases the velocity of the water. This not only improves the water quality, but also improves the biological conditions of the ditches where this is located.

The benefits of a two-stage ditch over the typical agricultural ditch include both improved drainage function and ecological function. The two-stage design improves ditch stability by reducing water flow and the need for maintenance, saving both labor and money. It also has the potential to create and maintain better habitat conditions. Better habitats for both terrestrial and aquatic species are a great plus when it comes to the two-stage ditch design. The transportation of sediment and nutrients is decreased considerably because the design allows the sorting of sediment, with finer silt depositing on the benches and coarser material forming the bed. A recent study by the University of Notre Dame found that the average two-stage ditch reduces the amount of sediment transported annually by over 100,000 pounds per half mile of two-stage (Tank, unpublished data).

**Water and Sediment Control Basin**
A water and sediment control basin is an earthen embankment constructed across the slope of a minor watercourse to form a sediment trap and water detention basin with a stable outlet. This practice can reduce watercourse and gully erosion, trap sediment, and reduce downstream runoff. It is particularly applicable where watercourse or gully erosion is a problem and where sheet and rill erosion is controlled by other conservation practices. It can help in areas where sediment in runoff is severe, though it needs to be placed where adequate outlets can be provided (FOTG Code 638, NRCS, 2011).

**Wetland Construction or Restoration**

Visual observation and historical records indicate at least a portion of the Treaty Creek-Wabash River Watershed has been altered to increase its drainage capacity. Riser tiles in low spots on the landscape and tile outlets along the waterways in the watershed confirm the fact that the landscape has been hydrologically altered. This hydrological alteration and subsequent loss of wetlands has implications for the watershed's water quality. Wetlands serve a vital role in storing water and recharging the groundwater. When wetlands are drained with tiles, the stormwater reaching these wetlands is directed immediately to nearby ditches and streams. This increases the peak flow velocities and volumes in the ditch. The increase in flow velocities and volumes can in turn lead to increased stream bed and bank erosion, ultimately increasing sediment delivery to downstream water bodies. Wetlands also serve as nutrient sinks at times. The loss of wetlands can increase pollutant loads reaching nearby streams and downstream waterbodies.

Restoring wetlands in the watershed could return many of the functions that were lost when these wetlands were drained. Through this process, a historic wetland site is restored to its historic status. These restored systems store nutrients, sediment, and *E. coli* while also increasing water storage and reducing flooding. Wetlands also provide additional habitat, stormwater mitigation, and recreational opportunities.

## 10.2 Best Management Practice Selection and Load Reduction Calculations

Table 44 details selected agricultural and urban best management practices and reflect those parameters which NRCS eFOTG, if appropriate, indicate can be utilized to impact each parameter. The critical area and the selected best management practices are based on subwatershed characteristics and available water quality data. Table 45 outlines suggested BMPs, estimated load reduction for nutrients and sediment (if available), and the target volume (area, length) of each practice, while Table 46 details estimated costs for implementing each practice based on the target volume. The steering committee identified BMPs that would be of interest to local producers, while the project coordinator calculated volume of BMPs necessary to meet project goals. The Region V model was used to estimate the approximate load reductions for BMPs unless otherwise noted. BMPs with dashes (-) do not have load reductions available using the Region V Model or other identifiable source. The target volumes of BMPs proposed to be installed are not required to be implemented as the quantities suggest. These targets are simply guidelines for achieving goals. Load reductions solely using this model meet the project targets for nitrogen, phosphorus and sediment goals for short, medium and long term goals. If the volume of practices specific in Table 45 is met, then the target loading rates detailed in Table 35 through Table 37 will be achieved for Daniel Creek-Wabash River, Stone Creek-Treaty Creek and Burr Creek-Wabash River (short term); for Enyeart Creek-Wabash River (medium term); and for Kentner Creek (long term). However, if the steering committee chooses to target only nitrogen and phosphorus load reductions and forego meeting sediment target loading rates, then the volume of each BMP targeted in
Table 45 can be reduced. The steering committee realizes that the model's calculations are only an estimate, and actual reductions could be beyond the model's estimation. The Region V model does not provide estimated reductions for all suggested BMPs; these load reductions cannot be included in the calculations. The steering committee acknowledges that they have set the bar high by establishing ambitious water quality targets that may be difficult to obtain. The group is committed to improve water quality the best that they can, even in the event that the original load reduction goals are not met.

**Table 44. Suggested Best Management Practices to address Treaty Creek-Wabash River critical areas. Note BMPs were selected by the steering committee.**

| Practice | Nutrients | Sediment | Pathogens |
|---|---|---|---|
| Bioreactor | X | | |
| Bioretention | X | X | X |
| Composting Facility | X | | X |
| Conservation Tillage | X | X | X |
| Cover Crop/Critical Area Planting/Conservation Cover | X | X | X |
| Drainage Water Management | X | X | |
| Fencing | X | X | X |
| Field Border/Buffer Strip | X | X | X |
| Forage/Biomass Planting | X | X | X |
| Grade Stabilization Structure | X | X | |
| Grassed Waterway/Mulching/Subsurface Drain | X | X | X |
| Gypsum | X | | |
| Livestock Restriction/Prescribed Grazing | X | X | X |
| Manure Management Planning | X | | X |
| Nutrient/Pest Management | X | | |
| Rain Barrel | X | X | |
| Saturated Buffer | X | X | |
| Septic System Care/Maintenance | X | | X |
| Streambank Stabilization | X | X | |
| T&E Species Protection (Habitat Improvement) | X | X | |
| Tree/Shrub Establishment | X | X | |
| Two Stage Ditch | X | X | X |
| Waste Storage Facility | X | | X |
| Water and Sediment Control Basin | X | X | |
| Wetland Creation/Enhancement/Restoration | X | X | X |

**Table 45. Suggested Best Management Practices, target volumes, and their estimated load reduction per practice to meet short term-high priority (S-H), medium term-high priority (M-H), medium term-medium priority (M-M) and long term-low priority (L-L) goals.**

| Suggested BMPs: | S-H BMP Targets | M-H BMP Targets | M-M BMP Targets | L-L BMP Targets | Unit | Nitrogen (lb/year) | Phosphorus (lb/year) | Sediment (t/year) |
|---|---|---|---|---|---|---|---|---|
| Conservation Cover (327) | 2,500 | 32,038 | 9,888 | 19,300 | acre | 23 | 11 | 10 |
| Cover Crop (340) | 2,500 | 32,038 | 9,888 | 19,300 | acre | 15 | 7 | 7 |
| Fence (382) | 1,500 | 5,892 | -- | 14,784 | feet | 0.4 | 0.4 | 0.4 |
| Filter Strip (393) | 50 | 16 | 1,000 | 103,488 | acre | 24 | 12 | 10 |
| Forage and Biomass Planting (512) | 100 | 10,261 | 9,888 | 19,300 | acre | 23 | 11 | 10 |
| Grassed Waterway (412) | 1,000 | 5,908 | 150 | 0 | acre | 232.9 | 116.4 | 101.3 |
| Livestock Restriction (Alt Watering System, Access Control) | 5,000 | 2,392 | 1,000 | 14,784 | feet | 2.8 | 0.83 | 7.52 |
| Nutrient/Pest Management (590)^ | 1,000 | 33,538 | 9,888 | 19,300 | Acre | 4.16 | 6.24 | - |
| Prescribed Grazing (528) | 5,000 | 5,361 | 9,888 | 19,300 | acre | 17 | 9 | 8 |
| Residue and Tillage Management (329) | 2,500 | 32,038 | 9,888 | 19,300 | acres | 21 | 10 | 11 |
| Streambank Stabilization* | 22,500 | 25,000 | 75,000 | 47,500 | feet | 0 | 0.83 | 14 |
| Tree/shrub Establishment (612) | 1,000 | 5,000 | 2,000 | 5,000 | acre | 10 | 5 | 5 |
| Water and Sediment Control Basin (638) | 100 | 300 | 100 | 300 | unit | 129.8 | 64.9 | 56.4 |

^Assumes all nutrient management is non-manure based. Increase to 6.24 lb/ac/yr for N and 8.77 lb/ac/yr P for manure-based nutrient management.
*Assumes average width of 5 feet.

**Table 46. Estimated cost for selected Best Management Practices to short term-high priority (S-H), medium term-high priority (M-H), medium term-medium priority (M-M) and long term-low priority (L-L) goals.**

| Suggested BMPs: | Estimated Cost per Unit | S-H Estimated Cost | M-H Estimated Cost | M-M Estimated Cost | L-L Estimated Cost |
|---|---|---|---|---|---|
| Conservation Cover (327) | $75 | $187,500 | $2,402,828 | $741,600 | $1,447,470 |
| Cover Crop (340) | $25 | $62,500 | $800,943 | $247,200 | $482,490 |
| Fence (382) | $1 | $1,500 | $5,892 | $0 | $14,784 |
| Filter Strip (393) | $75 | $3,750 | $1,185 | $75,000 | $7,761,600 |
| Forage and Biomass Planting (512) | $75 | $7,500 | $769,598 | $741,600 | $1,447,470 |
| Grassed Waterway (412) | $5,000 | $5,000,000 | $29,537,700 | $750,000 | $0 |
| Livestock Restriction (Alt Watering System, Access Control) | $1,000 | $5,000,000 | $2,392,000 | $1,000,000 | $14,784,000 |
| Nutrient/Pest Management (590)^ | $4.00 | $4,000 | $134,151 | $39,552 | $77,198 |
| Prescribed Grazing (528) | $15.00 | $75,000 | $80,420 | $148,320 | $289,494 |
| Residue and Tillage Management (329) | $15 | $37,500 | $480,566 | $148,320 | $289,494 |
| Streambank Stabilization** | $1,000 | $22,500,000 | $25,000,000 | $75,000,000 | $47,500,000 |
| Tree/shrub Establishment (612) | $450 | $450,000 | $2,250,000 | $900,000 | $2,250,000 |
| Water and Sediment Control Basin (638) | $2,500 | $250,000 | $750,000 | $250,000 | $750,000 |
| | | | | | |
| **Total Cost** | | **$33,579,250** | **$64,605,281** | **$80,041,592** | **$77,094,000** |

## 10.3 Action Register

All activities to be completed as part of the Treaty Creek-Wabash River Watershed management plan are identified in Table 47. The goals set by the steering committee are listed below. Each objective in the action register corresponds to one or more goals, and reflects the estimated amount of each BMP that will be needed in order to achieve the target load reductions. Nutrient and sediment removal efficiencies were not available for all BMPs, so the estimated number of BMPs needed was calculated based only on those BMPs that had load reduction estimates. For those BMPs that did not have associated load reduction estimates, the objective was developed with an amount of each BMP that the steering committee determined to be reasonably achievable. Therefore, if all the BMPs listed in all objectives are implemented, the total load reductions achieved will far exceed the load reductions needed to meet the water quality benchmarks.

**Table 47. Action Register.**

| Education and Outreach Goals | Objective | Target Audience | Milestone | Cost | Possible Partners (PP) & Technical Assistance (TA) |
|---|---|---|---|---|---|
| Nutrients, Sediment, E. coli | Coordinate on-the-ground cost-share program by 2021. | Urban and agricultural landowners, producers | Develop a cost-share program. | $25,000 annually | PP=Indiana American Water, City and County schools, Izaak Walton League, Wabash River Defenders, Technical assistance providers<br><br>TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, County surveyor |
| | | | Implement cost-share program. | | |
| | | | Identify potential funding sources to augment cost-share program including MRBI, RCPP, LARE, CWA and others. | | |
| Education | Develop an education plan targeting each practice identified above by 2021. | | Create mechanism to promote each practice using methods including but not limited to press releases; stream clean up; float trip; stream, field or pasture walk; website creation; local events; county fair booth; educational booth; workshop; field days and public meetings. | $10,000 | |
| | | | Develop funding mechanism for education efforts. | | |
| | | | The education program should include educational efforts which includes but is not limited to the following: all practices identified by the steering committee and noted in tables above; septic system use, maintenance and care; high quality natural areas; wetland protection and preservation and general stream processes. | $25,000 annually | |
| Education | Continue to cultivate quarterly Hoosier Riverwatch-based volunteer monitoring program. | Local residents, river enthusiasts, government agency staff | Create annual training and consider retraining volunteers as needed. | $5,000 | PP=volunteers, Izaak Walton League, Wabash River Defenders<br><br>TA=City of Peru, The Nature Conservancy, Izaak Walton League |
| | | | Identify watershed-wide monitoring locations. | | |
| | | | Recruit volunteer monitors. | | |
| | | | Profile volunteers and their monitoring efforts on partner websites and through marketing effort. | | |
| | | | Complete quarterly sampling at the 12 sites monitored as part of the planning project. | | |
| Education | Promote hands-on opportunities to improve natural areas and habitat within the Treaty Creek-Wabash River Watershed. | Local residents, river enthusiasts, government agency staff | Identify partner organizations which host field days, work days, and clean-up events. | $15,000 | PP/TA=Local schools, river enthusiasts, The Nature Conservancy, ACRES land trust, NRCS, SWCD, FSA |
| | | | Annually, identify partner work days for river clean-up, float trip, exotic species control, or habitat restoration opportunities and promote throughout the watershed. | | |

| Nutrient Goal | Objective | Target Audience | Milestones | Cost (includes BMPs, staff and supplies) | Potential Partners/ Technical Assistance |
|---|---|---|---|---|---|
| Short term: Reduce nitrate-nitrogen by 25% total phosphorus by 25% in high priority subwatersheds by 2024.<br><br>Medium term: Reduce nitrate-nitrogen by 60% and total phosphorus by 60% in high priority subwatersheds and reduce nitrate-nitrogen inputs by 69% and TP by 78% in medium priority subwatersheds 2039.<br><br>Long term: Reduce nitrate-nitrogen inputs by 75% and total phosphorus by 62% low priority subwatersheds by 2049. | Educate and promote installation of BMPs through field days/workshops | Urban and agricultural landowners, producers | Host at least one local event (field day, public meeting, workshop) annually targeting agricultural BMPs and one local event every two years targeting urban or habitat-based BMPs. | $2,836,890 annually | PP=Indiana American Water, City and County schools, Izaak Walton League, Wabash River Defenders, CCAs, REMC, Technical assistance providers, Huntington and Manchester universities<br><br>TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, County surveyor, CCAs |
| | Education through publications, web posts, and press releases | | Develop quarterly (4) print materials publications, press releases, web updates, social media posts or other publications annually. | | |
| | | | Implement one fifth of the short term practices annually from 2020-2024, one fifth of the medium term-high priority practices annually from 2025-2029, one tenth of the medium term-medium priority practices annually from 2030-2039 and one tenth of the long-term practices annually from 2010-2049. | | |
| | | | Achieve 5 year interim BMP target and load reduction goals: 25% nitrate-nitrogen and 25% total phosphorus reduction. | | |
| | Implement 319, MRBI CWI, LARE and other cost-share programs to put nutrient-reducing BMPs in place | | Achieve 10 year interim BMP target and load reduction goal: 60% nitrate-nitrogen and 78% total phosphorus reduction. | | |
| | | | Achieve 20 year interim BMP target and load reduction goal: 69% nitrate-nitrogen and 78% total phosphorus. | | |
| | | | Achieve 30 year BMP target and load reduction goal: 75% nitrate-nitrogen and 62% total phosphorus reduction. | | |

| Sediment Goal | Objective | Target Audience | Milestones | Cost (includes BMPs, staff and supplies) | Potential Partners/ Technical Assistance |
|---|---|---|---|---|---|
| Short term: Reduce total suspended sediment by 25% in high priority by 2024.<br><br>Medium term: Reduce total suspended sediment by 77% reduction) in high priority subwatersheds by 2029 and by 60% in medium priority subwatersheds by 2039.<br><br>Long term: Reduce total suspended sediment by 64% in low priority by 2049. | Educate and promote installation of BMPs through field days/workshops | Urban and agricultural landowners, producers | Host at least one local event (field day, public meeting, workshop) annually targeting agricultural BMPs and one local event every two years targeting urban or habitat-based BMPs. | $2,836,890 annually | PP=Indiana American Water, City and County schools, Izaak Walton League, Wabash River Defenders, CCAs, REMC, Technical assistance providers, Huntington and Manchester universities<br><br>TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, County surveyor, CCAs |
| | Education through publications/press releases | | Develop quarterly (4) print materials publications, press releases, web updates, social media posts or other publications annually. | | |
| | Implement 319, CWI, LARE and other cost-share programs to put erosion-reducing BMPs in place | | Implement one fifth of the short term practices annually from 2020-2024, one fifth of the medium term-high priority practices annually from 2025-2029, one tenth of the medium term-medium priority practices annually from 2030-2039 and one tenth of the long-term practices annually from 2010-2049. | | |
| | | | Achieve 5 year interim BMP target and load reduction goals: 25% reduction | | |
| | | | Achieve 10 year interim BMP target and load reduction goal: 77% reduction. | | |
| | | | Achieve 20 year interim BMP target and load reduction goal: 60% reduction. | | |
| | | | Achieve 30 year BMP target and load reduction goal: 64% reduction. | | |

| E. coli Goal | Objective | Target Audience | Milestones | Cost (includes BMPs, staff and supplies) | Potential Partners/ Technical Assistance |
|---|---|---|---|---|---|
| Short term: Reduce E. coli inputs by 25% in high priority subwatersheds by 2024. Medium term: Reduce E. coli by 80% high priority subwatersheds by 2029 and by 82% in medium priority subwatersheds by 2039. Long term: Reduce E. coli by 64% in low priority subwatersheds by 2049. | Educate and promote installation of BMPs through field days/workshops | Urban and agricultural landowners, producers | Host at least one local event (field day, public meeting, workshop) annually targeting agricultural BMPs and one local event every two years targeting urban or habitat-based BMPs. | $2,836,890 annually | PP=Indiana American Water, City and County schools, Izaak Walton League, Wabash River Defenders, CCAs, REMC, Technical assistance providers, Huntington and Manchester universities<br><br>TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, County surveyor, CCAs |
| | Education through publications/press releases | | Develop quarterly (4) print materials publications, press releases, web updates, social media posts or other publications annually. | | |
| | Implement 319, CWI, LARE and other cost-share programs to put *E.coli*-reducing BMPs in place | | Implement one fifth of the short term practices annually from 2020-2024, one fifth of the medium term-high priority practices annually from 2025-2029, one tenth of the medium term-medium priority practices annually from 2030-2039 and one tenth of the long-term practices annually from 2010-2049. | | |
| | | | Achieve 5 year interim BMP target and load reduction goals: 25% reduction | | |
| | Educate and promote proper septic maintenance | | Achieve 10 year interim BMP target and load reduction goal: 80% reduction. | | |
| | | | Achieve 20 year interim BMP target and load reduction goal: 82% reduction. | | |
| | | | Achieve 30 year BMP target and load reduction goal: 64% reduction. | | |

## 11.0 FUTURE ACTIVITIES

The next steps for the project include starting implementation of the Treaty Creek-Wabash River Watershed Management Plan. The Wabash River Defenders in partnership with the project steering committee and other regional partners are working to identify options for funding implementation via IDEM Section 319 and NRCS Mississippi River Basin Initiative grant applications. Additional funding may be available via the Indiana DNR Lake and River Enhancement Program or Clean Water Indiana funds. If funded, these grants would provide funds for a cost-share program to install BMPs, promotion of the cost-share program, and an education and outreach program. If the grant is awarded, the steering committee will develop a cost-share program that will include steps to meeting the goals and management strategies of this plan. The anticipated cost-share program will use a ranking system to fund applications that will have the most impact in improving water quality. Factors such as location within watershed (priority areas), distance from streams, number of resource concerns addressed, and number of practices planned will be considered as part of the ranking process to further prioritize BMPs. It is anticipated that implementation efforts will target high priority critical areas and focus on the implementation of short-term goals.

### 11.1 Tracking Effectiveness

Implementation of policies, programs, and practices will improve water quality and watershed conditions within the Treaty Creek-Wabash River Watershed, helping reach goal statements for high, medium and low priority critical areas by 2049. For each practice identified, an annual target for the acres or number of each BMP implemented is included in the action register (Table 47). Measurement of the success of implementation is a necessary part of any watershed project (Table 48). Both social indicator and water quality data will be used to measure observable changes following implementation. In order to track the project's progress of reaching goals and improving water quality, information and data will need to be continually collected during implementation.

**Table 48. Strategies for and indicators of tracking goals and effectiveness of implementation.**

| Tracking Strategy | Frequency | Total Estimated Cost (Staff Time Included) | Partners/Technical Assistance |
|---|---|---|---|
| BMP Count | Continuous | $5,000 | SWCDs, NRCS, ISDA |
| BMP Load Reductions | Continuous | $5,000 | SWCDs, NRCS, ISDA |
| Attendance at Workshops/Field Days | Yearly | $500/workshop | N/A |
| Post Workshop Surveys for Effectiveness | Yearly | $250/workshop | SWCD, NRCS, Purdue Extension |
| Number of Educational Programs/students reached | Yearly | $250/program | N/A |
| Windshield Surveys | Every 4-5 years | $2,500 annually | SWCDs, Committee, ISDA |
| Tillage/Cover Crop Transects | Yearly | $20,000 in SWCD and ISDA staff time | SWCDs, NRCS, ISDA, Staff, Committee, Volunteers |
| Volunteer Water Monitoring | Yearly | $5,000 | Volunteers, SWCD, TNC |
| Number of educational publications/press releases | Yearly | $500/release | SWCD |
| IDEM Probabilistic Monitoring | Every 9 years | N/A (IDEM provides staff and funding) | IDEM |

The tracking strategies illustrated in Table 48 will be used to document changes and aid in the plan re-evaluation. Activities to be completed as part of this watershed management plan are identified in the action register in Table 47. Table 49 identifies the annual target for the number or acres of BMPs to be installed during each implementation phase. Work completed towards each goal/objective documented will include scheduled and completed activities, numbers of individuals attending or efforts completed toward each objective, and load calculations for each goal, objective, and strategy. Overall, project progress will be tracked by measurable items such as workshops held, BMPs installed, meetings held, number of attendees, etc. Load reductions will be calculated for each BMP installed. These values and associated project details including BMP type, location, dimensions, load reductions, and more will be tracked over time and documented on the Indiana State Department of Agriculture Conservation Tracking sheet. Individual landowner contacts and information will be tracked for both identified and installed BMPs. Volunteer water monitoring results will be documented on the Hoosier Riverwatch website. The Treaty Creek-Wabash River Project Coordinator will be responsible for keeping the mentioned records. The Wabash Land Conservancy will be responsible for the long-term housing of records.

**Table 49. Annual targets for short term-high priority (S-H), medium term-high priority (M-H), medium term-medium priority (M-M) and long term-low priority (L-L) goals for each best management practice.**

| Suggested BMPs: | S-H BMP Targets | M-H BMP Targets | M-M BMP Targets | L-L BMP Targets |
|---|---|---|---|---|
| Conservation Cover (327) | 500 | 6,408 | 989 | 1,930 |
| Cover Crop (340) | 500 | 6,408 | 989 | 1,930 |
| Fence (382) | 300 | 1,178 | 0 | 1,478 |
| Filter Strip (393) | 10 | 3 | 100 | 1,000 |
| Forage and Biomass Planting (512) | 20 | 2,052 | 989 | 1,930 |
| Grassed Waterway (412) | 200 | 1,182 | 15 | 0 |
| Livestock Restriction (Alt Watering System, Access Control) | 1,000 | 478 | 100 | 1,478 |
| Nutrient/Pest Management (590) | 200 | 6,708 | 989 | 1,930 |
| Prescribed Grazing (528) | 1,000 | 1,072 | 989 | 1,930 |
| Residue and Tillage Management (329) | 500 | 6,408 | 989 | 1,930 |
| Streambank Stabilization | 4,500 | 7,000 | 7,500 | 4,750 |
| Tree/shrub Establishment (612) | 200 | 1,000 | 200 | 500 |
| Water and Sediment Control Basin (638) | 2 | 6 | 3 | 3 |

## 11.2 Indicators of Success

Water quality, social, and administrative indicators will be used to monitor progress towards successful achievement of the goals for the high and medium priority critical areas. Water quality indicators will include monitoring total phosphorus, nitrate-nitrogen, total suspended solids and E. coli. If local laboratory partners will continue to analyze collected samples as an in-kind service, laboratory data will be utilized as an indicator for each parameter. If laboratory partners are not able to assist with running samples or funding for water quality analysis cannot be identified, then monitoring will occur as part of the Hoosier Riverwatch volunteer program, at a minimum. Region 5 load reduction calculations and annual tillage and cover crop transect data will also be used to compare against current loading rates and levels of implementation. Administrative indicators will be listed with each strategy included in the action register.

**Reduce Nutrient Loading**

- Water Quality Indicator: Nitrate-nitrogen and total phosphorus will be measured monthly during the growing season at the sample sites monitored during the current project. After five years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the target level for nitrate-nitrogen of 1.5 mg/L and for total phosphorus of 0.7 mg/L.
- Administrative Indicator: The number of BMPs that can reduce nitrate-nitrogen and total phosphorus will be tracked annually. Individual load reductions calculated for each BMP will be reviewed to determine if cumulative loading rates for nitrate-nitrogen and phosphorus are sufficient to meet the target reductions.

**Reduce Sediment Loading**

- Water Quality Indicator: Total suspended solids will be measured monthly during the growing season at the sample sites monitored during the current project. After five years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the target level for total suspended solids of 15 mg/L.
- Administrative Indicator: The number of BMPs that can reduce total suspended solids will be tracked annually. Individual load reductions calculated for each BMP will be reviewed to determine if the cumulative loading rate for total suspended solids is sufficient to meet the target reduction.

**Reduce *E. coli* Loading**

- Water Quality Indicator: *E. coli* will be measured monthly during the growing season at the sample sites monitored during the current project. After five years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the state standard.
- Administrative Indicator: The number of BMPs that can reduce *E. coli* will be tracked annually.

**Increase Public Awareness and Participation**

- Administrative Indicator: The number of people who attend education and outreach events will be tracked. The percent of targeted households reached will increase annually.
- Social Indicator: Pre and post surveys of attendees will be conducted at workshops to determine changes in individuals' knowledge of the topic as a result of attending the workshop. It would be expected that 75% of workshop attendees would have a better understanding of the topic after the workshop.

**In-stream Habitat**

- Water Quality Indicator: QHEI will be measured annually at the sample sites monitored during the current project. After five years of implementation in target streams, instream habitat will show an increasing trend.
- Administrative Indicator: Increase instream habitat by 15 QHEI points in target streams (Mill Creek and Asher Branch) reaches and reduce terrestrial invasive species spread by 10% by 2039 (20 years). QHEI assessments will occur prior to any riparian or instream restoration efforts and will be used to gage habitat changes by comparing scores post establishment. Invasive species

removal efforts will be monitored via bird call counts collected prior to and following invasive species removal.

## 11.3 NEPA Concerns and Compliance

The National Environmental Policy Act (NEPA) was signed into law in 1970. The law requires federal agencies to assess the environmental impacts of their proposed actions prior to making decisions. This law also applies to watershed planning activities. As part of the planning process the NRCS is required to evaluate the individual and cumulative effects of proposed actions. Any project that has significant environmental impacts must be evaluated with an Environmental Assessment (EA) or Environmental Impact Statement (EIS) unless the activities are eligible under a categorical exclusion or already covered by an existing EA or EIS. The NRCS utilizes a planning process that incorporates an evaluation of potential environmental impacts using an Environmental Evaluation Worksheet. There are several NRCS conservation practices and activities that fall under a categorical exclusion. A categorical exclusion is a category of actions that do not normally create a significant individual or cumulative effects on the human environment. There are 21 NRCS approved conservation or restoration categorical exclusions identified in GM190 §410.6. These categorical exemptions include practices that reduce soil erosion, involve planting vegetation and restoring areas to natural ecological systems.

This watershed plan calls for conservation practices that control soil erosion and runoff from agricultural fields and structural practices to address runoff and waste management issues. Many of these practices are covered by either a categorical exclusion or may be included in an existing environmental assessment. A list of practices likely to be used to implement the plan is listed in Table 44 and Table 45.

Prior to practice implementation with USDA NRCS assistance, an NRCS CPA 52 Environmental Evaluation form will be completed for each practice. Using this form, each planned practice and practices system will be evaluated to determine if it meets the criteria of categorical exclusions and any existing Environmental assessments. Any adverse impacts from practices will first try to be avoided then minimized or mitigated as necessary. If resource concerns are found, NRCS will contact the agency with responsibility for the resource. Agencies will include, but are not limited to US Fish and Wildlife Service and the State Historic Preservation Office. It is not anticipated that the practices planned for the Treaty Creek-Wabash River Watershed will require an Environmental Assessment or an Environmental Impact Statement.

## 12.0 Outreach plan

Based on steering committee knowledge, a multi-tiered strategy will be required to fully implement the Treaty Creek-Wabash River Watershed Management Plan. The plan will use targeted outreach to agricultural producers which will encourage the adoption of conservation practices to avoid, control and trap nutrients and sediment. Additional associated landowners will receive information about the project with the goal of raising awareness and informing the local community. For the targeted producers, outreach methods will include but not be limited to the following:

- Targeted landowner and producer mailings to announce the program and encourage the adoption of conservation practices. Mailings will occur no less than once but may occur annually, as needed.
- Practice specific field days and workshops. No less than 2 workshops or field days will occur annually.
- Newsletters. The Treaty Creek-Wabash River steering committee will work with partners to distribute information on a quarterly basis within partner newsletters including SWCD, county extension, FSA, and others.

- Post information at public locations such as farm and garden centers.
- Work with regional CCAs to provide information about the program.
- Maintain a project website which will be used to promote project events, announce fund availability and detail funding deadlines.
- Social media posts will occur on project social media no less than monthly and will be shared across partner social media as well.
- Radio announcements (PSAs) and news releases will occur no less than quarterly to local media.
- Additional options such as bill boards, videos, tabling at community events, and others will be considered by the technical committee.

The following partners will be engaged as part of the outreach efforts:

- Natural resources conservation service (NRCS) conservationists provide technical assistance and expertise, coordinate conservation planning and distribute financial assistance for local producers. The Miami and Wabash County service centers provide assistance for the Treaty Creek-Wabash River Watershed.
- Miami and Wabash County SWCD offices assist producers with conservation choices via farm planning assistance as well as targeted education and outreach.
- Indiana State Department of Agricultural staff provides technical assistance and expertise with conservation practice design and assessment.
- The Treaty Creek-Wabash River Watershed Project will provide education and outreach assistance and assist with program promotion.

## 12.1 Adapting Strategies in the Future

Due to the uncertainty of the watershed management planning, an adaptive management strategy will be implemented to improve the project's success. While much thought and expertise has been put into the planning process, not all scenarios can be foreseen. Often times there are changes such as a shift in community attitude/behavior, changes in resource concerns, development of new information or accomplishing a goal sooner or later than expected. By implementing an adaptive management strategy, the Treaty Creek-Wabash River Project Steering Committee can adjust the watershed management plan to ensure project success. A four-step adaptive management strategy has been outlined for the Treaty Creek-Wabash River Watershed Project and can be found below.

**Step 1: Planning** The planning process used to develop the Treaty Creek-Wabash River WMP follows the IDEM 2009 Watershed Management Checklist. The project coordinator worked in concert with and was guided by the Treaty Creek-Wabash River Project Steering Committee to develop the WMP using knowledge of the watershed, inputs from stakeholders, new data from water monitoring and windshield surveys, and historical data. This plan includes goals, action register, and schedule outlining how and when to achieve the defined goals.

**Step 2: Implementation** The action register and schedule will be implemented to achieve the goals of the Treaty Creek-Wabash River Watershed Project objectives and goals. Partnering agencies such as NRCS, SWCD, ISDA, and IDEM will carry out the implementation. Implementation will include a cost-share program and education events targeting both for youth and adults. Practices implemented through the cost-share program will follow the NRCS Field Office Technical Guide (FOTG) Practice Standards or other technical standards as detailed in the cost-share program, once developed. The cost-share program will include but will not be limited to practices such as cover crops, watering facilities, fencing, conservation buffers, grassed waterways, and nutrient and pest management plans. Cost-share funding will be implemented in priority areas, addressing high priority areas before the medium priority area. A ranking system will be used to prioritize applications that will have the greatest impact on water quality improvement.

**Step 3: Evaluate & Learn** Evaluations of indicators identified above and in Table 48 will occur often to check the progress being made toward the project goals. The steering committee will annually review progress and determine if the project is on track to meet interim and project end goals outlined in the Action Plan (Table 47) and goals. Factors evaluated will include but will not be limited to numbers of BMPs installed, calculated/estimated load reductions of installed BMPs, number of individuals reach through outreach, etc. The evaluations will be conducted by the Treaty Creek-Wabash River Project Steering Committee. The group will then provide recommendations that will improve project success. Progress against the watershed management plan will be reviewed no less than every two years (i.e. 2021, 2023, etc).

**Step 4: Alter Strategy** The project's implementation and management strategy will be adjusted to improve the project's success. If progress is not made proportionate to the time into the project (i.e. at the end of year 3, approximately 30% (3/10) of 10 year goals should be met), the steering committee will have the opportunity to alter their strategy in order to meet the goals of the project. Adjustments will be based off of recommendations from the Evaluate and Learn step. Once the adjustments are agreed upon by the steering committee, the project will revert back to Implementation (Step 2) to continue with the Adaptive Management strategy (steps 2-4) until all goals have been met or all conservation opportunities have been exhausted.

The Wabash River Defenders are responsible for maintaining records for the project including tracking plan successes and failures and any necessary revisions.

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## 13.0 LITERATURE CITED

Armitage, B.J. and E.T. Rankin. 2009. An assessment of threats to the biological condition of the Wabash River aquatic ecosystem of Indiana. Prepared for The Nature Conservancy, Indiana Chapter, Indianapolis, Indiana.

Center for Watershed Protection. 2003. Effects of impervious cover on aquatic resources. Ellicott City, Maryland.

Clark, F. 1994. Indian GAP analysis: Implications for biodiversity conservation and restoration. Proceedings of the Indiana Academy of Science, Vol 103(3-4): 215-224.

Clark, T. 2018. ETR and high quality natural communities database search, personal communications, 5 February 2018.

Coulter, J. 1886. Indiana Geological Report for 1886.

Elvidge, C. D., C. Milesi, J. B. Dietz, B. T. Tuttle, P. C., Sutton, R. Nemani, and J. Vogelmann. 2004. U.S. constructed areas approaches the size of Ohio, Eos Trans. AGU, 85(24), 233.

Grove, G. 2007. Bedrock aquifer systems of Wabash County, Indiana. Indiana Department of Natural Resources, Division of Water, Indianapolis, Indiana.

Gutschick, R.C. 1966. Bedrock Geology. In Lindsey, 1966. Natural features of Indiana, Indiana Academy of Science, Indianapolis, Indiana

Homoya, M.A., B.D. Abrell, J.R. Alrich, and T.W. Post. 1985. The natural regions of Indiana. Indiana Academy of Science, 91.

IDEM. 2007. [web site] Wetlands. http://www.in.gov/idem/4138.htm [Accessed 22 February 2018

IDEM. 2016. Indiana integrated water monitoring and assessment report 2016. Section 305(b) water quality report and consolidated list including Section 303(d) list of impaired waterbodies. IDEM, Office of Water Quality, Watershed Branch, Indianapolis, Indiana.

Indiana Department of Environmental Management. 2015. Confined Feeding Operations GIS layer.

Indiana Department of Environmental Management. 2018. Municipal biosolid land application sites, GIS metadata. Indianapolis, Indiana.

Indiana Department of Natural Resources. 2001. [web page] https://www.in.gov/history/markers/20.htm Visited 13 February 2018.

Indiana Geological Survey. 2015. Aquifer sensitivity near surface. Source: IndianaMap

Indiana State Department of Agriculture. 2017. [web page] Tillage transect data. http://www.in.gov/isda/2383.htm [Accessed 4 February 2018]

Indiana State Department of Agriculture. 2017A. [web page] Tillage transect data, Miami County. http://www.in.gov/isda/2383.htm [Accessed 4 February 2018]

Indiana State Department of Agriculture. 2017B. [web page] Tillage transect data, Wabash County. http://www.in.gov/isda/2383.htm [Accessed 4 February 2018]

ISDH. 2017. 2017 Indiana fish advisory. [web page] https://www.in.gov/isdh/23650.htm [Accessed 2 February 2018]

Kennedy, A.J., D.J. Daugherty, T.M. Sutton, and B.E. Fisher. 2007. Population characteristics of shovelnose sturgeon in the Upper Wabash River, Indiana. North American Journal of Fisheries Management, 27: 52-62.

Krenz, J.L. and B.D. Lee. 2004. Mineralogy and hydraulic conductivity of selected moraines and associated till plains in northeast Indiana.

Kroeker Consulting, LLC. 2016. Lower Salamonie River Watershed Management Plan. Indiana Department of Environmental Management EDS A305-3-9.

Lee, B., D. Jones, and H. Peterson. 2005 Septic system failure. Home and Environment 1: 1-3.

Malott, C.A. 1922. The physiography of Indiana, in Handbook of Indiana Geology. Indiana Department of Conservation.

National Agricultural Statistics Service. 2006. [web page] Agricultural chemical use database. http://www.pestmanagement.info/nass/ [Accessed 25 August 2009]

National Agricultural Statistics Service. 2007. [web page] 2007 Census publications State and County profiles. http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Indiana/index.asp [Accessed 22 July 2009]

National Land Cover Database. 2011. [web page] https://www.mrlc.gov/nlcd2011.php [Visited 2 January 2018]

Natural Resources Conservation Service. 2018 [ web page] https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm [Visited 2 January 2018]

Ohio EPA. 1999. Ohio EPA recommended criteria for Warm Water Habitat (WWH) headwater streams in Ohio EPA Technical Bulletin MAS//1999-1-1, Columbus, Ohio.

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest. U.S. Environmental Protection Agency, Corvallis, Oregon. EPA/600/3-88/037.

Petty, R.O. and M.T. Jackson. 1966. Plant communities. In: Lindsey, A.A. (ed) Natural features of Indiana. Indiana Academy of Science, Indiana State Library, Indianapolis, Indiana. page 264-296.

Plowman, B.W. 2006. 2005 Statewide archers index of furbearer populations. Indiana Department of Natural Resources, Wildlife Management and Research Note Number 915, Indianapolis, Indiana. http://www.in.gov/dnr/fishwild/files/MR_915_Archers_Index_2005.pdf

Pyron, M. and T.E. Lauer. 2004. Hydrological variation and fish assemblage structure in the Middle Wabash River. Hydrobiologia 525: 203-213.

Pyron, M. and T.E. Lauer. 2009. Middle Wabash River fish community assessment: Final report for 2008 data. Submitted to Eli Lilly and Company and Duke Energy.

Pyron, M., T. E. Lauer, and J. R. Gammon. 2006. Stability of the Wabash River fish assemblages from 1974-1998. Freshwater Biology 51:1789-1797.

StatsIndiana. 2018. [web page] http://www.stats.indiana.edu/topic/census.asp Visited 27 February 2018

Stefanavage, T.C. 2008. Wabash River fish community, aquatic habitat, and public access survey. Indiana Department of Natural Resources, Indianapolis, Indiana.

Sugg, Z. 2007. Assessing U.S. Farm Drainage: Can GIS lead to better estimates of subsurface drainage extent? World Resources Institute, Washington, D.C.

Sweeten, J. 2009. Redside dace (Clinostomus elongates) in Mill Creek, Wabash County: A strategy for population research. Indiana Department of Natural Resources, State Wildlife Grant annual report, 2009. https://www.in.gov/dnr/fishwild/files/fw-09WildlifeDiversityReportResearchRedSideDace.pdf

Sweeten, J. 2010. Redside dace (Clinostomus elongates) in Mill Creek, Wabash County: A strategy for population research. Indiana Department of Natural Resources, State Wildlife Grant annual report, 2009. https://www.in.gov/dnr/fishwild/files/fw-10WildlifeDiversityReportResearchRedSideDace.pdf

Sweeten, J. 2011. Redside dace (Clinostomus elongates) in Mill Creek, Wabash County: A strategy for population research. Indiana Department of Natural Resources, State Wildlife Grant annual report, 2009. https://www.in.gov/dnr/fishwild/files/fw-11WildlifeDiversityReportResearchRedSideDace.pdf

Sweeten, J. 2012. Redside dace (Clinostomus elongates) in Mill Creek, Wabash County: A strategy for population research. Indiana Department of Natural Resources, State Wildlife Grant annual report, 2009. https://www.in.gov/dnr/fishwild/files/fw-12WildlifeDiversityReportResearchRedSideDace.pdf

Sweeten, J., K. Airgood, M. Bowman, B. Cloud, E. Hammond, D. Losey, H. Manifold, A. Melick, and J. Wenger. 2013. Redside dace in Mill Creek, Wabash County, Indiana: A strategiy research and augmentation. Manchester University funded via an Indiana State Wildlife Grant (T07R07) through the Indiana Department of Natural Resources.

TetraTech, Inc. 2008. Wabash River nutrient and pathogen TMDL development. Illinois EPA and Indiana Department of Environmental Management, Indianapolis, Indiana.

U.S. Climate Date. 2018. [web page] https://www.usclimatedata.com/climate/wabash/indiana/united-states/usin0688. Visited 6 February 2018.

U.S. Environmental Protection Agency. 2018 EPA FRS Facilities State Single Download. Exported 21 February 2018. [web page] https://www.epa.gov/enviro/epa-frs-facilities-state-single-file-csv-download [visted 1 March 2018]

U.S. Fish and Wildlife Service. 2017. National Wetland Inventory. https://www.fws.gov/wetlands/

U.S. Geological Survey. 2018. [web page] National Hydrography Dataset. https://nhd.usgs.gov/ [Visited 2 January 2018]

United Consulting. 2003. Combined Sewer Overflow Stream Reach Characterization and Evaluation Report prepared for the City of Wabash, Wabash, Indiana.

United Consulting. 2016. Combined Sewer Overflow Operational Plan Update prepared for the City of Wabash, Wabash, Indiana.

Wabash County. 2012. Wabash County Comprehensive Plan, Wabash, Indiana.