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LOWER PIGEON CREEK WATERSHED MANAGEMENT PLAN

VANDERBURGH, GIBSON AND WARRICK COUNTIES, INDIANA

6 MARCH 2023

A PROJECT OF THE
VANDERBURGH COUNTY SOIL AND WATER CONSERVATION DISTRICT
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EVANSVILLE, INDIANA 47710

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LOWER PIGEON CREEK WATERSHED MANAGEMENT PLAN
VANDERBURGH, GIBSON AND WARRICK COUNTIES, INDIANA

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VANDERBURGH, GIBSON AND WARRICK COUNTIES, INDIANA

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 drainageways 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 Pigeon Creek Watershed includes all the land that enters Pigeon Creek from its approximately 235,000 acre drainage. The watershed includes three 10-digit hydrologic unit codes (HUCs) including 0514020201, 0514020202 and 0514020203. The Lower Pigeon Creek Watershed is comprised of the most downstream 10-digit HUC: 0514020203. Pigeon Creek starts in Gibson County flows south and east through Pike and Warrick Counties into Vanderburgh County. Pigeon Creek carries water from Gibson, Pike, Warrick and Vanderburgh Counties and joins with the Ohio River in Evansville, Indiana (Figure 1).

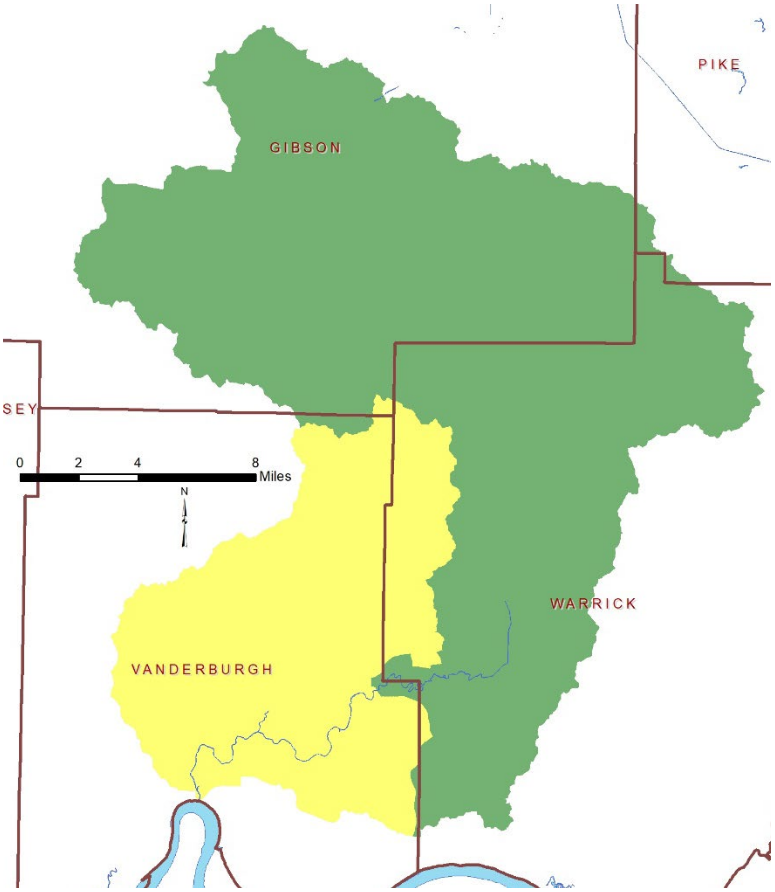

Figure 1. The Pigeon Creek Watershed (green) highlighting the Lower Pigeon Creek Drainage (yellow).

1.2 Project History

In 1988, the Highland-Pigeon Watershed steering committee began. Based on the committee's efforts a watershed management plan was developed (Harza, 2003). In 2001, with assitance from the Highland Pigeon Watershed steering committee, Harza Engineering Company completed the Pigeon Creek Watershed Diagnostic Study. The study noted that the Pigeon Creek Watershed upstream of Evansville was subjected to nonpoint source pollution from agricultural, mining and forested land uses. The study served the goals of the Gibson, Vanderburgh, Warrick and Pike SWCDs as well as the City of Evansville's required stream reach characterization and evaluation report as part of the Combined Sewer Overflow (CSO) assessment. Harza noted that permitted discharges, including eight CSOs, five industrial dischargers and six municipal wastewater treatment plants, row crop agriculture, mined lands, forested land and urban runoff all negatively impact the Pigeon Creek Basin. Harza recommended a variety of best management practices targeting agricultural land including conservation tillage, conservation buffers and nutrient management. Urban best management practices including source controls, treatment controls and constructed wetlands were also identified. Following plan completion, NRCS and SWCD funds totaling more than $2.2 million including DNR Lake and River Enhancement Program, Clean Water Indiana, Section 205j, Conservation Reserve Program, Floodplain Easement Program, Wetland Reserve Program, and Environmental Quality Incentives Program funds were utilized to focus conservation efforts in Pigeon Creek's Watershed.

Despite these efforts, elevated *E. coli* levels are still present in the Pigeon Creek Watershed. Based on these elevated levels, the Total Maximum Daily Load for Escherichia coli (*E. coli*) in the Highland-Pigeon Creek Watershed and Total Phosphorous for Hurricane Creek in Gibson, Pike, Vanderburgh, Posey, and Warrick Counties (IDEM, 2011) was drafted. The TMLD identified point sources, including wastewater treatment plants, combined sewer overflows, sanitary sewer overflows and municipal separate storm sewer systems (MS4), and nonpoint sources, inlcuding wildlife, stormwater runoff, small livestock operation, livestock with access to streams, urban runoff and failing septic systems, as sources of *E. coli*. The TMDL identifies septic system improvements; reducing livestock access to stream environments; adoption of manure collection and storage practices; improved riparian area management practices such as streambank stabilization and stream buffers; improved agricultural land management practices such as adoption of agronomic practices including cover crops, nutrient management, conservation tillage, pesticide management, and livestock fencing; and urban practices such as rain gardens, stormwater settling basins, buffer strips, pervious pavement, bioinfiltration basin and other low impact development techniques may reduce sediment and nutrient loading and *E. coli* concentrations entering the Lower Pigeon Creek Watershed.

The Vanderburgh, Gibson, Pike and Warrick County SWCDs began organizing efforts to update the Pigeon Creek Watershed Management Plan in 2018. Two watershed planning grants targeting the Upper Pigeon Creek Watershed and the Lower Pigeon Creek Watershed were submitted to the Indiana Department of Environmental Management in 2019. Both projects were funded and project planning commenced on the Lower Pigeon Creek Watershed Management Plan in the spring of 2021.

The Lower Pigeon Creek Watershed Project's overall goal of the project is to create a comprehensive, community-driven watershed management plan. The plan will focus on agricultural, post and current strip mining and urban sources of pollution. We will accomplish this goal by completing the following objectives: 1) identify and target the most critical sources of pollution through a comprehensive monitoring program; 2) increase public awareness about problems associated with water quality in the Lower Pigeon Creek watershed through a targeted education and outreach program; and 3) develop a watershed management plan that includes engaged stakeholders making decisions focused on improving water quality throughout the watershed. The Vanderburgh County SWCD will hire a watershed coordinator to guide all aspects of the watershed management plan including water quality data collection and analysis, public awareness and engagement efforts and completion of the watershed management plan. The Vanderburgh SWCD in partnership with the Evansville MS4, County Health Departments and other SWCDs will continue education and outreach efforts already in place. It is anticipated that the following entities will be represented: Vanderburgh, Warrick and Gibson County SWCD Staff/board of supervisors; Vanderburgh County Surveyor staff; Vanderburgh County Health Department; Evansville Water and Sewer Utility, which includes the MS4; Purdue Extension staff; County NRCS staff; other several key stakeholders in the Lower Pigeon Creek Watershed.

The Lower Pigeon Creek watershed drains approximately 68,700 acres and is in mixed use. Agricultural dominates with 36% of the watershed covered by row crop agriculture or pasture land, 34% in developed land uses including the City of Evansville and towns of Darmstadt and Elberfeld, and 30% in forest or wetland. A majority of the agricultural land within the watershed is privately-owned and in a soybean-corn rotation. With 6% conventional tilling and 27% of farm land using reduced tillage (2018 Fall tillage transect) in Vanderburgh County, high amounts of sediments and nutrients are draining into tributaries of the Pigeon Creek. Only an estimated 16% of farm land located in Lower Pigeon Creek Watershed benefits from the use of cover crops, leaving 84% of agricultural ground within the HUC with bare ground (2018 Fall Tillage transect). Based on limited riparian habitat and the sandy nature of soils, livestock access and streambank erosion are prevalent throughout the Lower Pigeon Creek Watershed.

The City of Evansville is actively working to reduce Combined Sewer Overflow and stormwater issues through their federal consent decree to address their CSO and SSO issues and via MS4 education and implementation efforts. Vanderburgh County is home to upwards of 20,000 septic systems. The health department consults on more than 600 septic issues and assist with more than 80 septic repairs and replacements annually. Portions of the Lower Pigeon Creek Watershed were strip mined from 1973-1993; however, areas including the Bluegrass Fish and Wildlife Area, which contains 28 strip pits with nearly 600 acres of open water, have been vegetated and provide hunting, fishing, and wildlife viewing activities. Active strip mining and agricultural production occurs in the upper portions of the Pigeon Creek drainage and their impacts are likely felt within the Lower Pigeon Creek Watershed.

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. The Lower Pigeon Creek Project 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 WMP, starting in December 2017. Table 1 identifies the steering committee members and their affiliation.

Table 1. Lower Pigeon Creek Watershed steering committee members and their affiliation.

Individual	Organization(s) Represented
Ron Adler	Vanderburgh SWCD
Karan Barnhill	Vanderburgh MS4
Rita Becker	Vanderburgh NRCS
Christian Borowiecki	Vanderburgh Health Dept
Dr. Paul Doss	USI Professor
Linda Freeman	Vanderburgh surveyor
Randy Gerth	Vanderburgh Storm Water Coordinator
Melissa Heichelbech	Gibson SWCD
Brandon Jackson	Farmer
Ryan Key	Evansville Water and Sewer
Kevin Kolb	Evansville Water and Sewer

Individual	Organization(s) Represented
Kent Lamey	Farmer
Julie Loehr	Watershed Coordinator, Upper Pigeon Creek
Eldon Maasberg	Vanderburgh SWCD
Holly McCutchan	Warrick SWCD
Stephanie Mitchell	Gibson NRCS
Amanda Moimian	Warrick Purdue Ext
Justin Mooney	Warrick NRCS
Peter Putzier	Resident
Megan Riiterskamp	Vanderburgh SWCD
Erin Shoup	Vanderburgh SWCD
Mike Thomas	Farmer
Linda Voglund	ISDA
Megan Winka	Vanderburgh SWCD
Megan Diss	Vanderburgh Purdue Extension

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 on 15 March 2021 and 16 September 2022. The public meetings were used to introduce the project and develop a concerns list and allow individuals to provide their thoughts on potential projects that will be targeted in future implementation efforts. 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 and via postcards and emails sent to local landowners and conservation partners. 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 distributed information via their website and social media pages as well as through their email distribution list.

The first public meeting was held on 15 March 2021 at the Vanderburgh County 4h Fairgrounds in Evansville, Indiana. Attendees represented citizens, farmers, conservation partners, and city officials. During this meeting, the Vanderburgh County SWCD 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 Lower Pigeon Creek Watershed.

The second meeting occurred on September 16, 2022 as a drop in meeting at the annual regional Soil Health Workshop. A table was set up to engage with Lower Pigeon Creek farmers during the soil health workshop and included an overall project update, review of project goals and future timelines and focused on gathering feedback on critical areas, practices selected for implementation and the likelihood of meeting project goals gathered.

1.4 Public Input

Throughout the planning process, project stakeholders, the steering committee, and the general public listed concerns for the Lower Pigeon Creek 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 via the watershed inventory process.

Stakeholder Concerns
Elevated stream nutrient concentrations
High *E. coli* levels
Livestock access to streams
Small farms, including sheep & horse farms
Manure management
Industrial legacy pollutants
Combined sewer overflows
Wastewater treatment impacts – including sanitary sewer overflows
Airport, industry, paving operation, junk yard
Quarry – Mulzer Stone
Strip mining (historic), remining (current)
Country club, golf courses
Access to Pigeon Creek – parks and recreation opportunities
Streambank erosion
Litter, trash, dumping especially in urban portion
Sandy, highly erodible soils
Development impacts
Forest management
Streams are turbid following even small rain events
Agricultural management – soil health needs
Narrow/limited buffers
Dog park adjacent to Pigeon Creek
Protection of high quality areas – Wesselman Woods, Bluegrass Creek FWA
Education and signage – public access to Pigeon Creek should take advantage of this
Low dissolved oxygen levels were observed in the stream
Sports park off Heckle and Green River (intensive use)

2.0 WATERSHED INVENTORY I: WATERSHED DESCRIPTION

2.1 Watershed Location

The Lower Pigeon Creek Watershed is part of the Ohio River Watershed and covers portions of Gibson, Warrick and Vanderburgh counties (Figure 1). The Lower Pigeon Creek Watershed includes all the land that enters Pigeon Creek from its drainage including portions of Gibson, Warrick, Vanderburgh Counties. The Lower Pigeon Creek drainage receives water from the Upper and Middle Pigeon Creek Watersheds. Pigeon Creek starts in Gibson County south and then west through Warrick and Vanderburgh Counties. Pigeon Creek continues to flow south to join the Ohio River in Evansville draining 337,253 acres.

2.2 Subwatersheds

In total, six 12-digit Hydrologic Unit Codes are contained within the Lower Pigeon Creek Watershed (Figure 2, Table 3). Each of these drainages will be discussed in further detail under *Watershed Inventory II*.

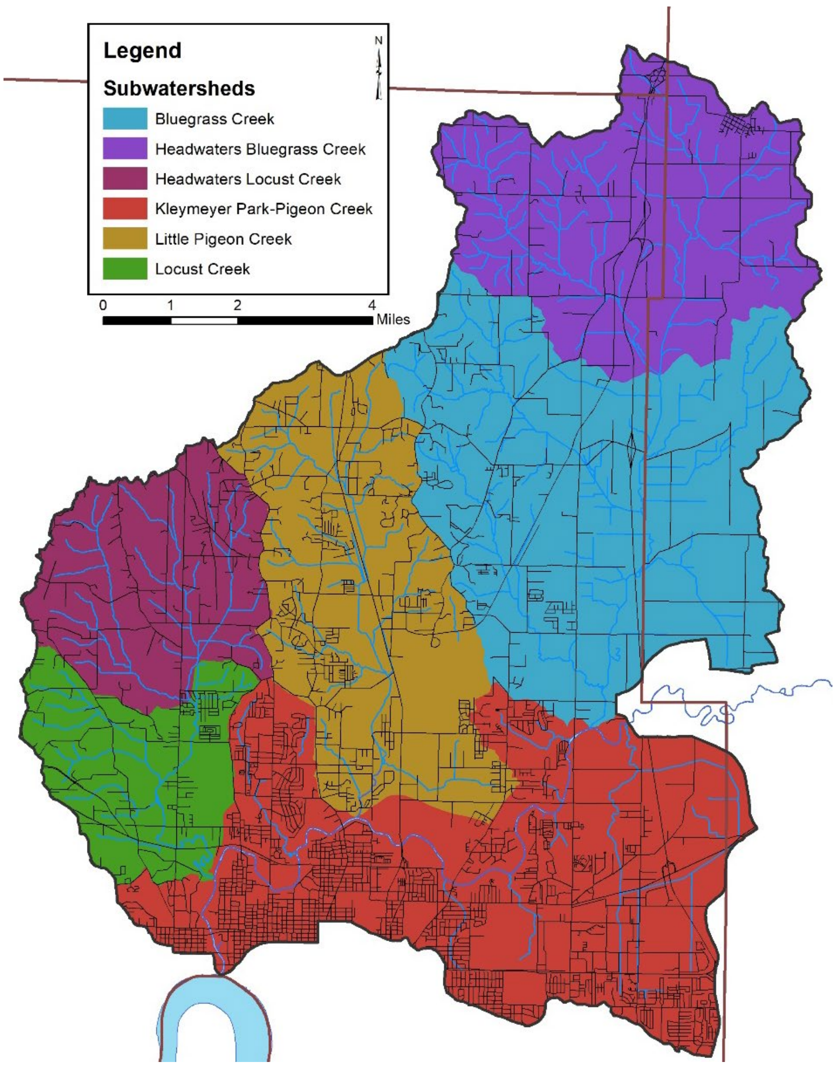

Figure 2. 12-digit Hydrologic Unit Codes in the Lower Pigeon Creek Watershed.

Table 3. 12-digit Hydrologic Unit Code (HUC) watersheds in the Lower Pigeon Creek Watershed.

Subwatershed Name	Hydrologic Unit Code	Area (acres)	Percent of Watershed
Headwaters Bluegrass Creek	051402020301	11,414.1	17%
Bluegrass Creek	051402020302	16,920.3	25%
Little Pigeon Creek	051402020303	11,169.6	16%
Headwaters Locust Creek	051402020304	6,531.5	10%
Locust Creek	051402020305	4,897.4	7%
Kleymeyer Park-Pigeon Creek	051402020306	17,775.3	26%
	Entire Watershed	**68,708.0**	

2.3 Climate

In general, Indiana has a temperate climate with warm summers and cool to cold winters. The Lower Pigeon Watershed is no different. Climate in this watershed is characterized by four distinct seasons throughout the year. High temperatures measure approximately 87°F in August, while low temperatures measure near freezing (23 °F) in January (US Climate, 2017). The growing season typically extends from early April through late October. On average, 46.6 inches of precipitation occur within the Highland-Pigeon Watershed with precipitation occurring as small, frequent rain events spread almost evenly throughout the year.

2.4 Geology and Topography

The underlying bedrock is comprised of Pennsylvanian age shale and sandstone (Gutschick, 1966). Patoka and Shelburn Formation covers much of the watershed, with small areas of Carbondale Group around Evansville and along the eastern edge of the watershed near the Warrick County line (Figure 3). Surficial geology indicates that the Lower Pigeon Creek Watershed lies within a mix of alluvium, lake and lowland silt, sandstone and undifferentiated outwash formed during the Holocene, Wisconsinan and Middle Pennsylvanian glacial periods (Figure 4). Small areas of alluvium cover the Lower Pigeon Creek tributaries with undifferentiated outwash lying along the southern border of the watershed near the Ohio River. Lake silt and clay, which is remnant from a glacial-age lake, covers much of the Lower Pigeon Creek Watershed. A mix of lowland silt; sandstone, shale and limestone; made land and loess covers the western portion of the watershed.

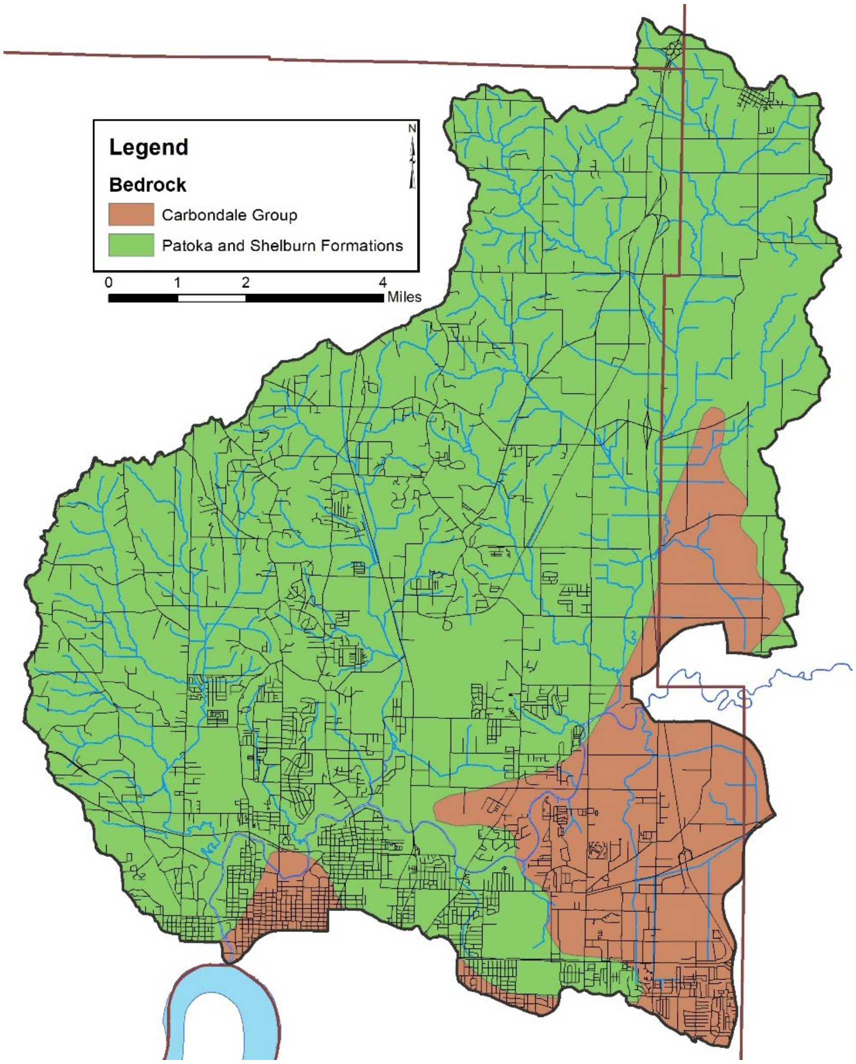

Figure 3. Bedrock in the Lower Pigeon Creek Watershed.

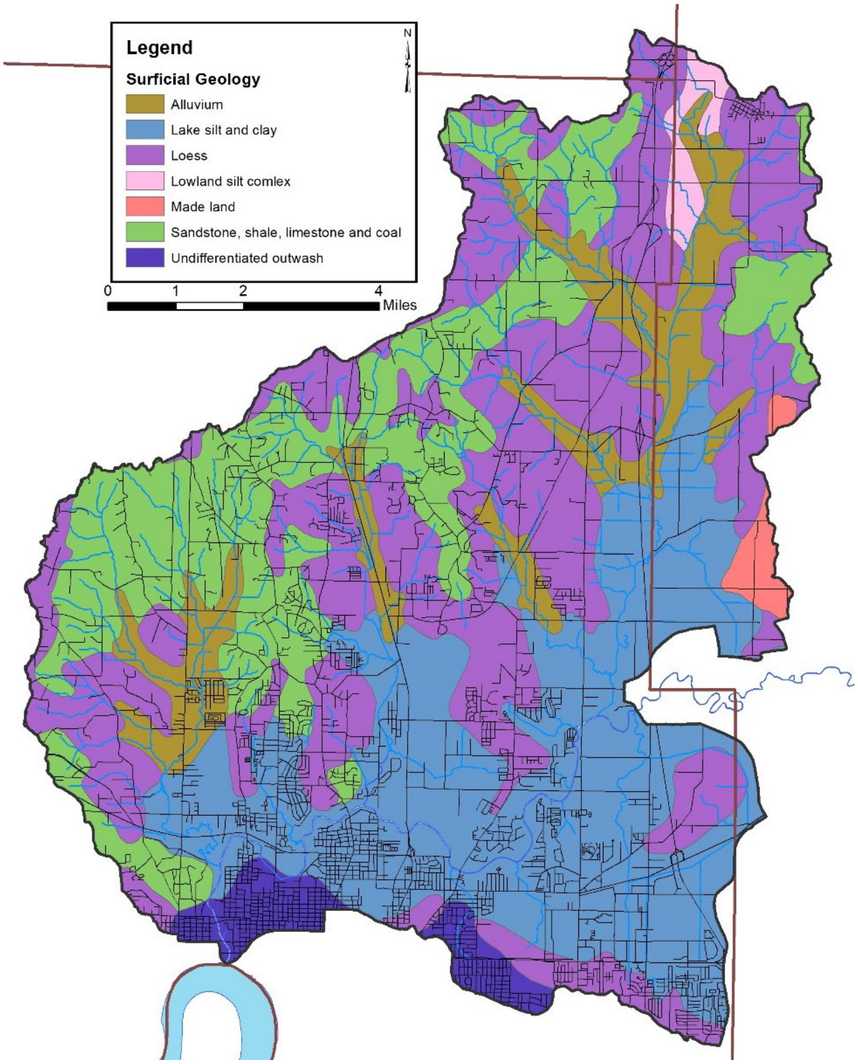

Figure 4. Surficial geology throughout the Lower Pigeon Creek Watershed.

The topography of the Lower Pigeon Creek Watershed ranges from flat rolling agricultural fields to undulating hills and valleys (Figure 5). The landscape changes from gently rolling terrain in the northeastern portion of the watershed to steep valleys north of Evansville before flattening again near the southern portion of the watershed near the Ohio River. The Lower Pigeon Creek Watershed elevation is highest measuring 601 feet msl along the far western portion of the watershed. Steep valleys surround many of the Lower Pigeon Creek streams. The relatively flat surface near the Ohio River shows limited topographic elevation changes. The lowest elevation (349 feet msl) occurs near the intersection Lower Pigeon Creek with the Ohio River.

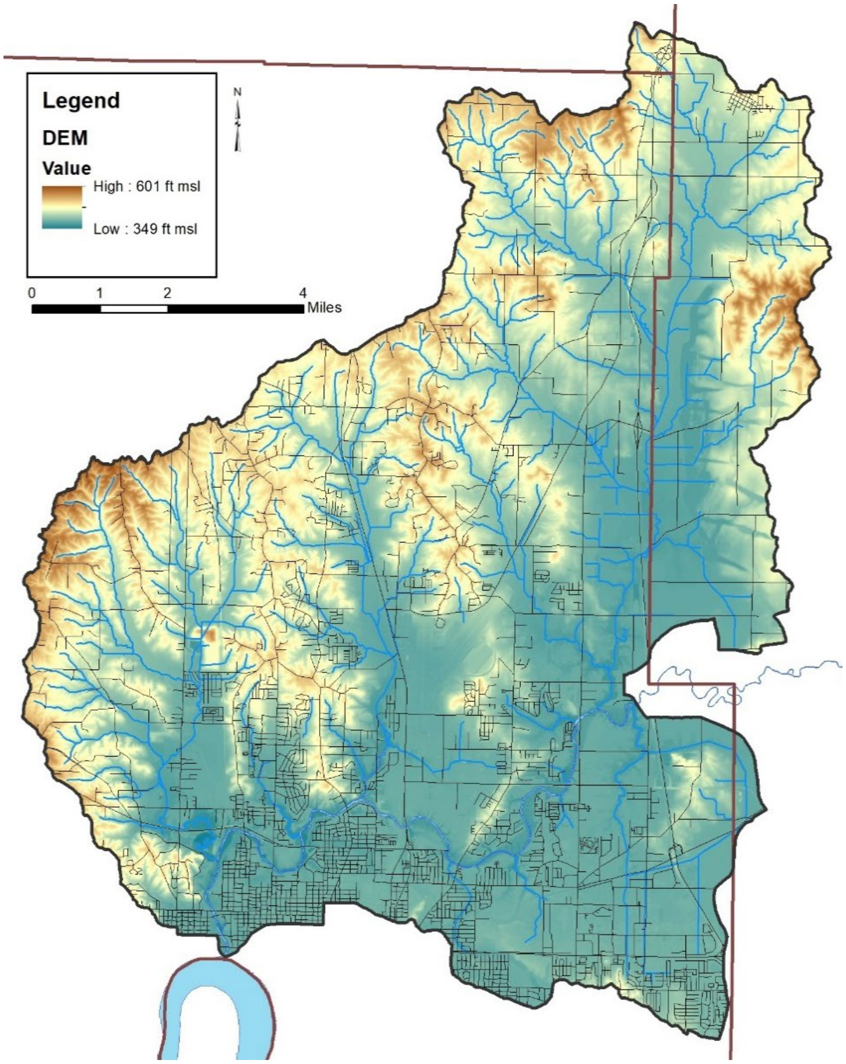

Figure 5. Surface elevation in the Lower Pigeon Creek Watershed.

2.5 Soil Characteristics

There are hundreds of different soil types located within the Lower Pigeon Creek 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 the overall characteristics across the 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 Hydrologic Soil Group

The hydrologic soil group classification is a means for categorizing soils by similar infiltration and runoff characteristics during periods of prolonged wetting. The vast majority of the Lower Pigeon Creek Watershed is covered by poorly drained soils which suggests that flooding may be common. Within floodplains, somewhat poorly drained to well-drained soils are located within river deposits on nearly level land. Soils are classified by the NRCS into four hydrologic soil groups based on the soil's runoff potential (Table 4). The majority of the watershed is covered by category D soils (59%) followed by category B soils (22%), and category C soils (14%). D soils are found throughout the northern portion of the watershed cover much of Warrick County and areas in Vanderburgh County north of Evansville. D soils are slow infiltration soils where flooding can regularly occur. Soils in the southern portion of the Lower Pigeon Creek Watershed are mostly category C soils, while soils along the headwaters of Lower Pigeon Creek tributaries are comprised of mostly B soils (Figure 6). Category B soils are moderately deep and well drained, while Category C soils are finer and allow for slower infiltration.

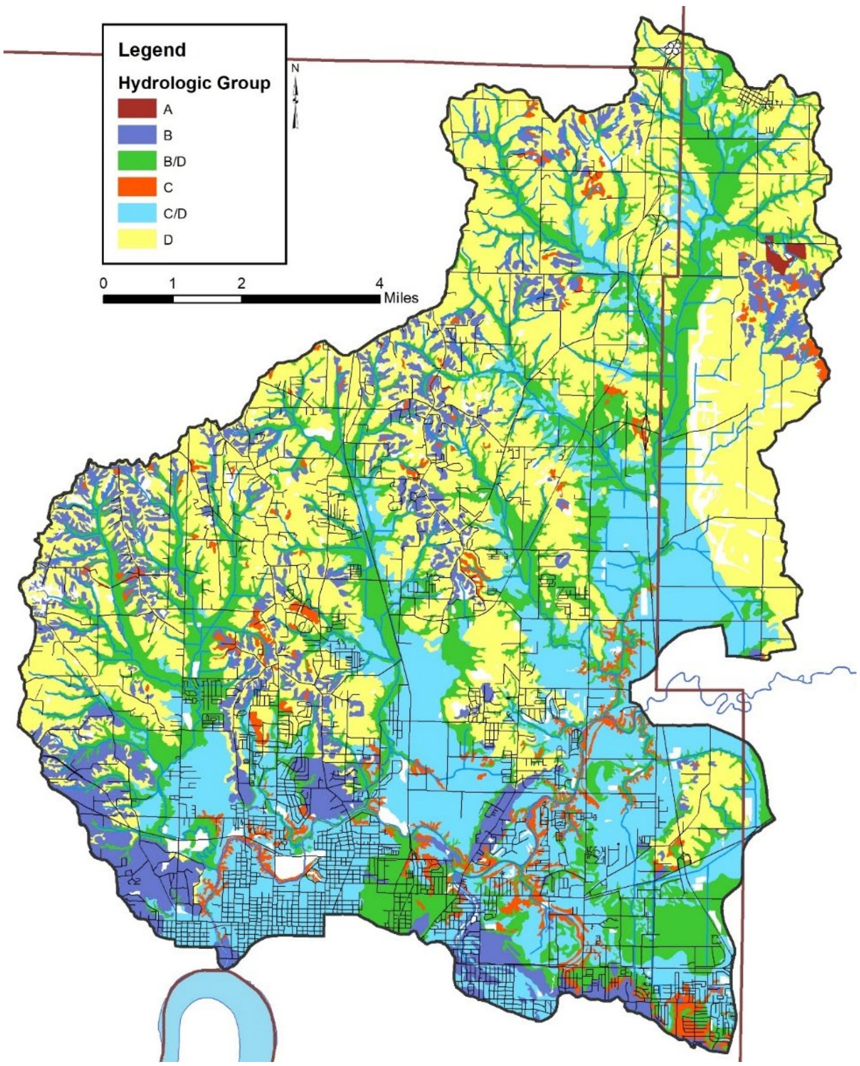

Figure 6. Hydrologic soil groups throughout the Lower Pigeon Creek Watershed.

Table 4. Hydrologic soil group summary.

Hydrologic Soil Group	Description
A	Soils with high infiltrations rates. Usually deep, well drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.

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 Lower Pigeon Creek watershed. Highly erodible soils cover 87% of the watershed or 59,901 acres. Highly erodible soils are found throughout the watershed with no discernable pattern of location. All other soils are not rated as highly erodible or potentially highly erodible.

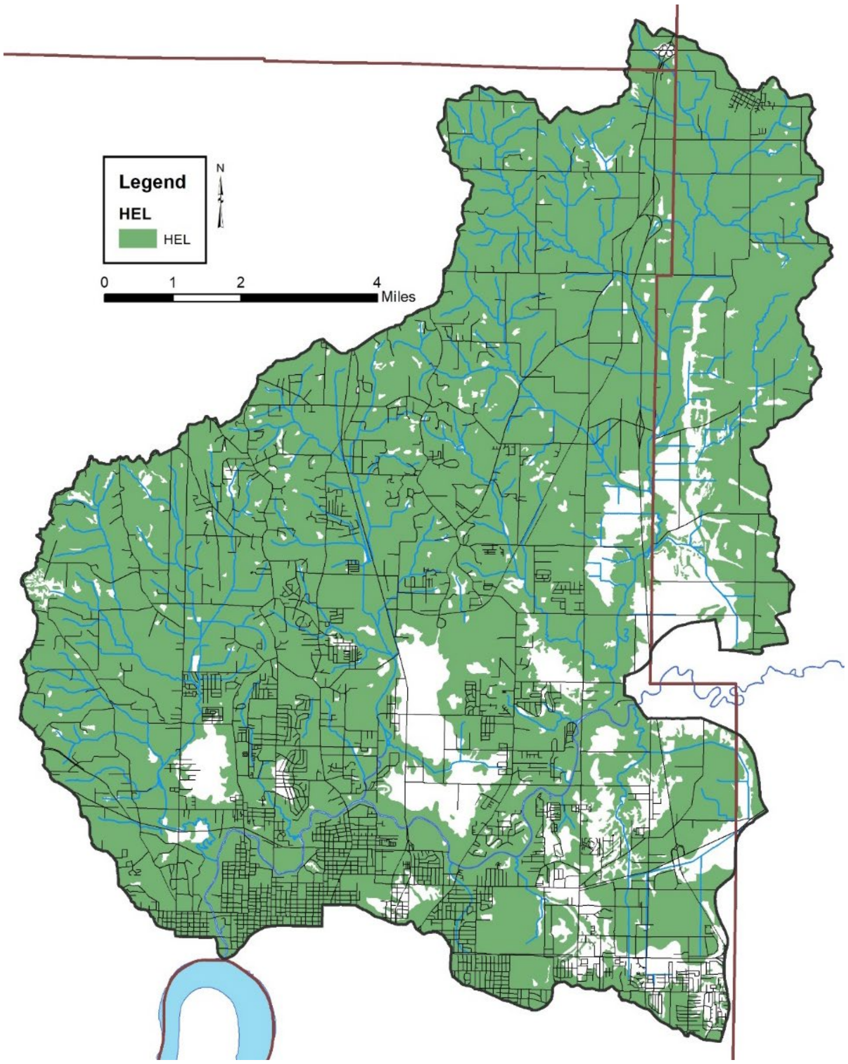

Figure 7. Highly erodible land in the Lower Pigeon Creek Watershed. Source: NRCS, 2018.

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 11,380 acres (17%) of the watershed was covered by hydric soils (Figure 8). Hydric soils are concentrated along the Vanderburgh-Warrick County Line along Bluegrass and Little Pigeon Creeks and in areas immediately north of Evansville. 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. Many of these soils have been drained for agricultural production or urban development.

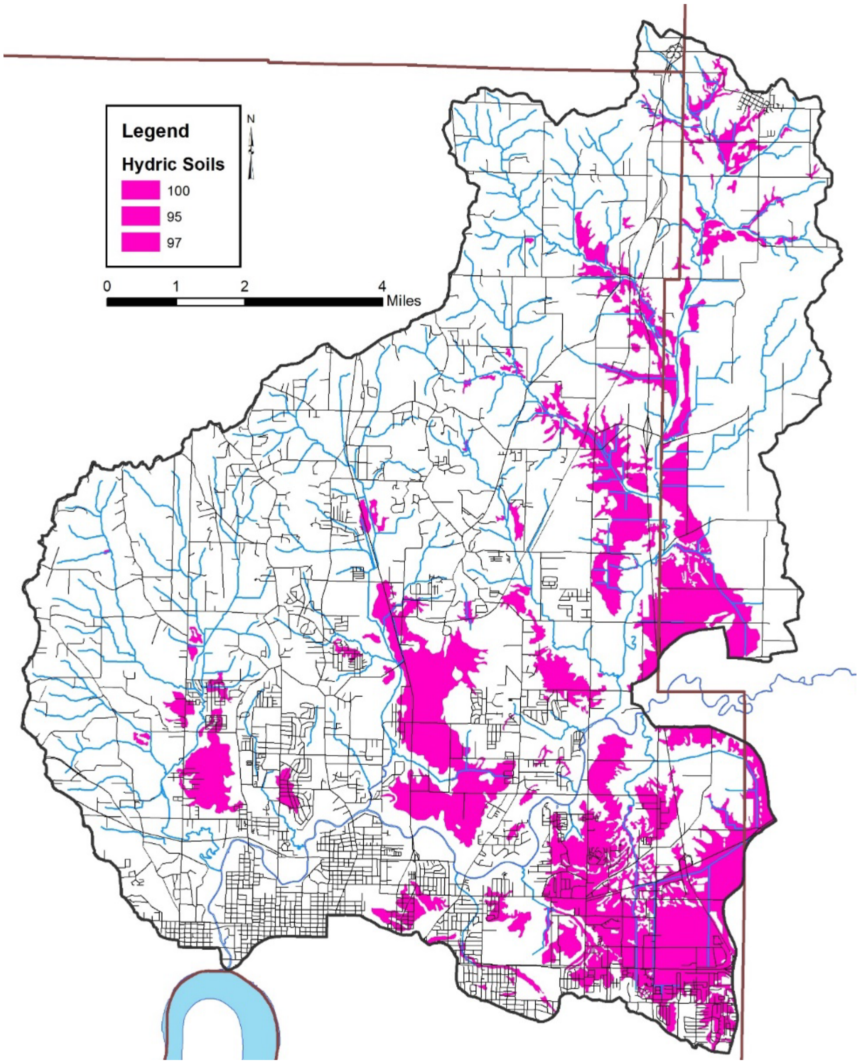

Figure 8. Hydric soils in the Lower Pigeon Creek Watershed. Source: NRCS, 2018.

2.5.4 Tile-Drained Soils

Soils drained by tile drains cover 16,953 acres or 25% of the Lower Pigeon Creek Watershed as estimated utilizing methods details in Sugg, 2007. This method of drainage is widely used in row crop agricultural settings within the watershed and 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. 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. A majority of tile-drained soils are located in Bluegrass Creek drainage including much of Warrick County (Figure 9). 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.

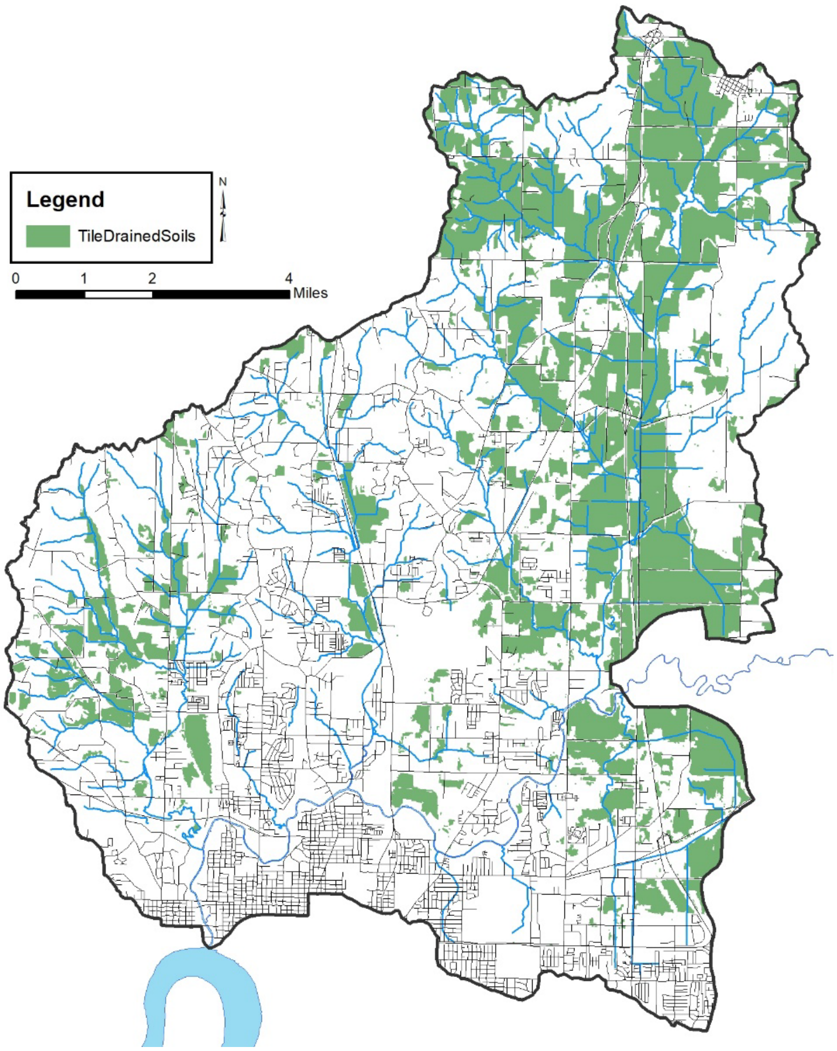

Figure 9. Tile-drained soils in the Lower Pigeon Creek Watershed. Source: NLCD, 2011 and NRCS, 2018.

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 and 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 system is expelled in the state of Indiana annually. The true impact of these systems on the water quality in the 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 64,379 acres or 94% of the watershed is covered by soils that are considered very limited for use in septic tank absorption fields. Nearly 2,013 (3%) acres are somewhat limited meaning that these soils are generally suitable for septic systems. The remaining 2,315 acres (3%) are not rated for septic usage as it is not generally industry standard to install a septic system in these geographic locations.

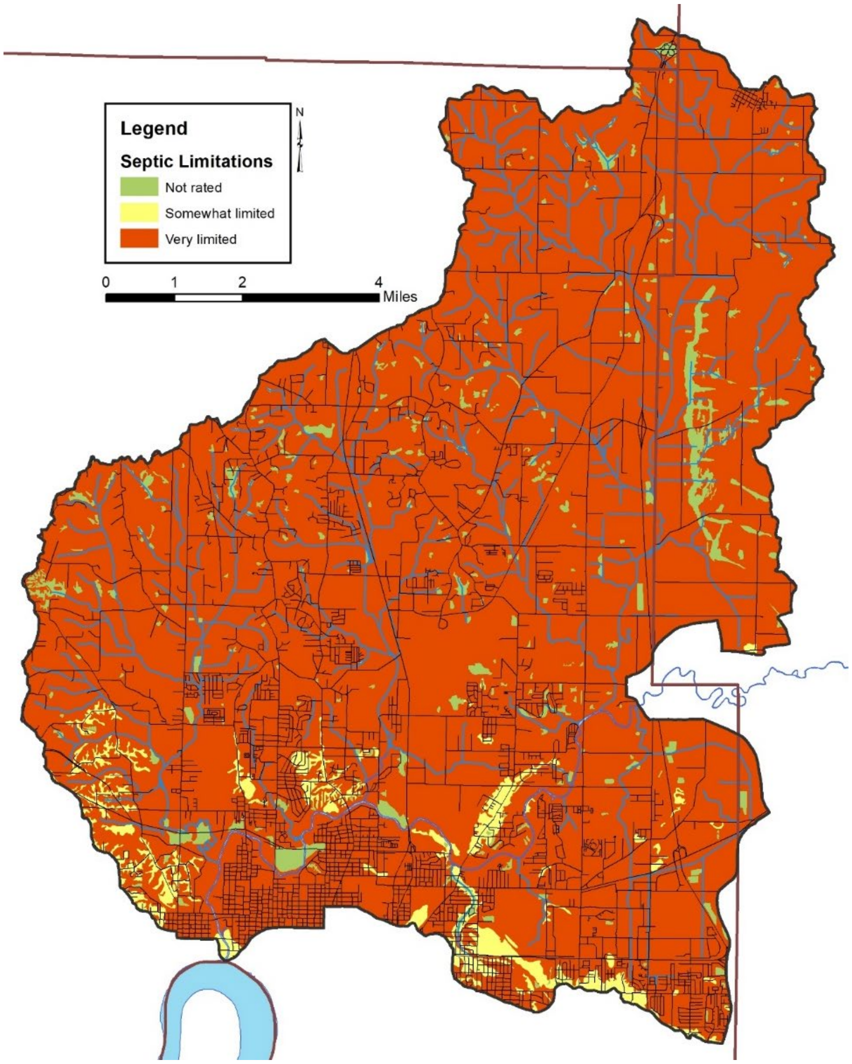

Figure 10. Suitability of soils for septic tank usage in the Lower Pigeon Creek Watershed. Source: NRCS, 2018.

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, 2 NPDES-regulated facilities are located within the watershed (Figure 11). The City of Evansville Water and Sewer Utility also treats wastewater within the Lower Pigeon Creek Watershed; however, neither plant are located within the watershed. Table 5 details the NPDES facility name, activity, and permit number. More detailed information for each facility will be discussed on a subwatershed basis in subsequent sections. Sludge from municipal wastewater treatment plants is applied on 960 acres throughout the watershed (Figure 11).

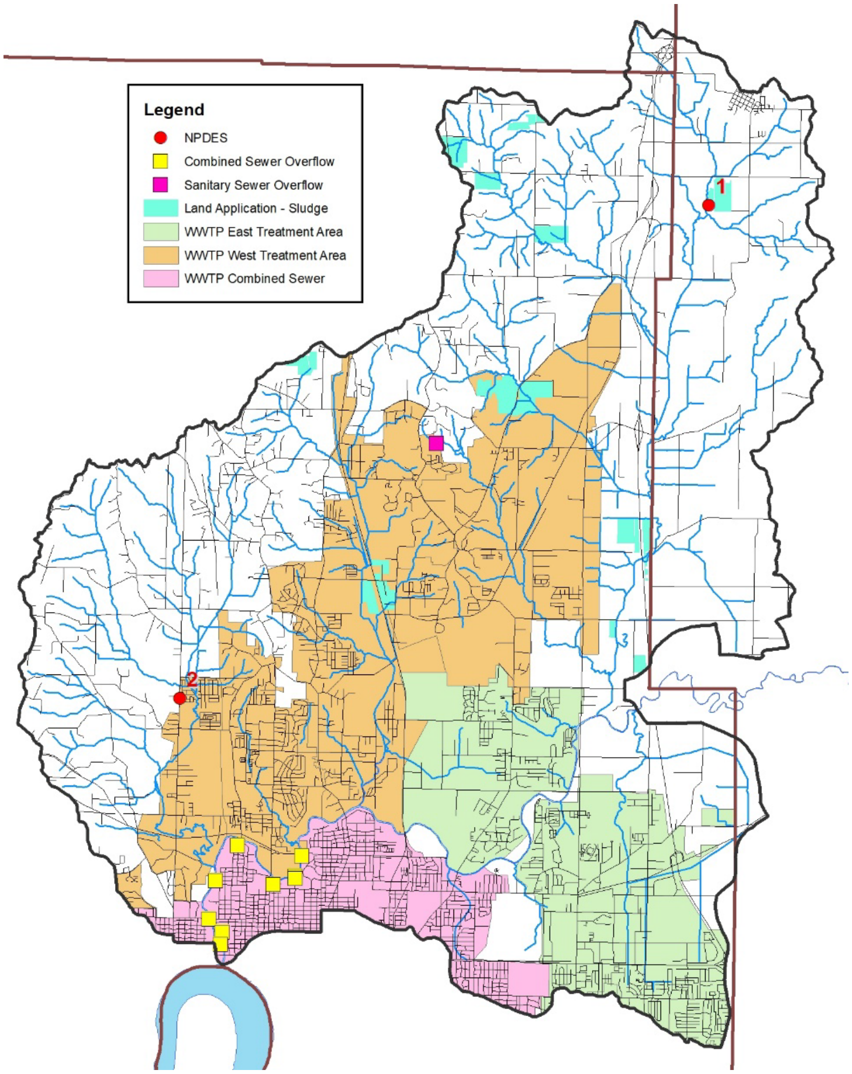

Figure 11. NPDES-regulated facilities, wastewater treatment areas and combined sewer areas in the Lower Pigeon Creek Watershed.

Table 5. NPDES-regulated facility information.

Map ID	NPDES ID	Facility Name
1	IN0020788	ELBERFELD MUNICIPAL STP
2	IN0039608	A. C. RANCH MOBILE HOME PARK/PLACES OF SANCTUARY LLC

2.6.3 Municipal Wastewater Treatment and Combined Sewer Overflows

There are two wastewater treatment facilities located within and discharging to Lower Pigeon Creek or a tributary including Elberfeld Municipal sewage treatment plant and the A.C. Ranch Mobile Home Park plant. Additionally, Evansville Sewer and Water Utility operates the eastside and westside plants which accept discharge to the Ohio River.

Bluegrass Creek is the receiving water for Elberfeld WWTP. The facility is permitted to discharge 0.3 million gallons per day of treated municipal wastewater to Bluegrass Creek. The permit requires the following effluent parameters to be limited and/or monitored: flow, carbonaceous BOD5, total suspended solids, ammonia nitrogen, dissolved oxygen, pH and total residual chlorine.

Locust Creek receives runoff from the A.C. Ranch Mobile Home Park. As of 2019, the mobile home park was removed and replaced by a small number of residences. 2019 inspection reports indicate that the wastewater plant was in a non-compliant state as the effluent piping was disconnected and the flow meter was not located during the inspection. Additional correspondence indicates efforts to improve conditions at the package plant.

While the EWSU wastewater treatment plants discharge to the Ohio River, the sewer system carries both stormwater and wastewater, and there are nine combined sewer outfalls that discharge to Pigeon Creek during wet weather. These discharges are permitted under NPDES Permits IN0032956 and IN0033073. In total, 4,398 acres of combined sewer drainage is located in the Lower Pigeon Creek Watershed (Figure 11).

Within the City of Evansville system, one sanitary sewer overflow point is located at the Oak Meadows lift station, seven combined sewer overflow discharge stations and three CSO facilities contribute combined sewage to Pigeon Creek during wet weather conditions (Figure 11). This includes 9 CSO points including: CSO 011 – Weinbach Lift Station (Oakhill Road), CSO 012 – Maryland Street – West Bank, CSO 013 – Delaware Street, CSO 014 – Dresden Street, CSO 016 – Franklin Street, CSO 017 – 6th Avenue, CSO 018 – Oakley Street, CSO 024 – Baker Street and CSO 025 – Diamond Avenue. More than 6% of the Lower Pigeon Creek Watershed is located in combined sewer overflow area. Evansville's combined sewer system is designed to carry sanitary sewage, which consists of domestic, commercial and industrial wastewater, and stormwater including surface drainage from rainfall or snowmelt in a single conduit. The combined sewer system has a capacity to carry normal sanitary sewage flows; however, stormwater entering the system during wet weather events exceeds the system's capacity. To prevent flooding of homes, businesses and commercial areas, combined sewer bypasses occur during wet weather events.

Montgomery, Watson, Harza (MWH, 2001) characterized the 420 miles of sanitary and combined sewers operated by EWSU within the Lower Pigeon Creek Watershed. Based on estimates in the 2018 CSO update, there are more than 770 miles of sanitary and combined sewers in the EWSU system (Renew Evansville, 2018). The sanitary and combined sewer are divided into 24 subsystems with nearly half operating within the eastside and half operating within the westside wastewater treatment plants. The sanitary and combined sewers are divided into 30 separate subbasins served by one interceptor sewer or main lift station. Three east subbasins, E-11, Lloyd and Covert, and six west subbasins, Highway 41, Millersburg, Skylane, Helfrich and W-8, service the Lower Pigeon Creek Watershed. Figure 11 details the eastside and westside drainages with 8,673 acres of the Lower Pigeon Creek Watershed's wastewater treated by the east plant and 17,054 acres of the Lower Pigeon Creek Watershed's wastewater treated by the west plant (Figure 11). In total, 44% of the Lower Pigeon Creek Watershed is connected to one of the EWSU treatment facilities. MWH (2001) details maintenance, operations and control measures for each CSO and SSO.

2.6.4 Unsewered Areas

Areas that have at least 25 houses within a square mile outside of the sanitary district boundaries are classified as dense, unsewered areas. No areas of unsewered dense housing are located in the Lower Pigeon Creek Watershed.

2.7 Hydrology

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 Lower Pigeon Creek Watershed contains approximately 228.5 miles of perennial streams and regulated drains. Of these, approximately 16 miles are canals or ditches including Harper Ditch, Crawford-Brandeis Ditch, Weinsheimer Ditch, Barnes Ditch, Dennis Wagner Ditch, Stubbs Freidenberg Ditch and Schlensker Ditch. Approximately 20 miles of Lower Pigeon Creek has been modified and is mapped as an artificial path. The majority of streams in the Lower Pigeon Creek Watershed are not regulated. 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. Each time a ditch is cleaned out or maintained, this action increases the amount of sediment going downstream towards the mainstem of Lower Pigeon Creek.

Lower Pigeon Creek flows 20 miles draining 68,708 acres. The major tributaries to Lower Pigeon Creek include Locust Creek, Little Pigeon Creek, Licking Creek, Firlick Creek and Bluegrass Creek (Figure 12). Lower Pigeon Creek from its confluence with Bluegrass Creek to its drainage into the Ohio River is used for recreational kayaking and canoeing as well as fishing, swimming, and aesthetic enjoyment. Lower Pigeon Creek tributaries used for aesthetic enjoyment and fishing but are rarely accessed for canoeing or kayaking. Stakeholders are concerned with maintaining the recreational value of the creeks and have some concerns because portions of the watershed have been designated as impaired by IDEM for *E. coli*, nutrients, impaired biotic communities, mercury and PCBs.

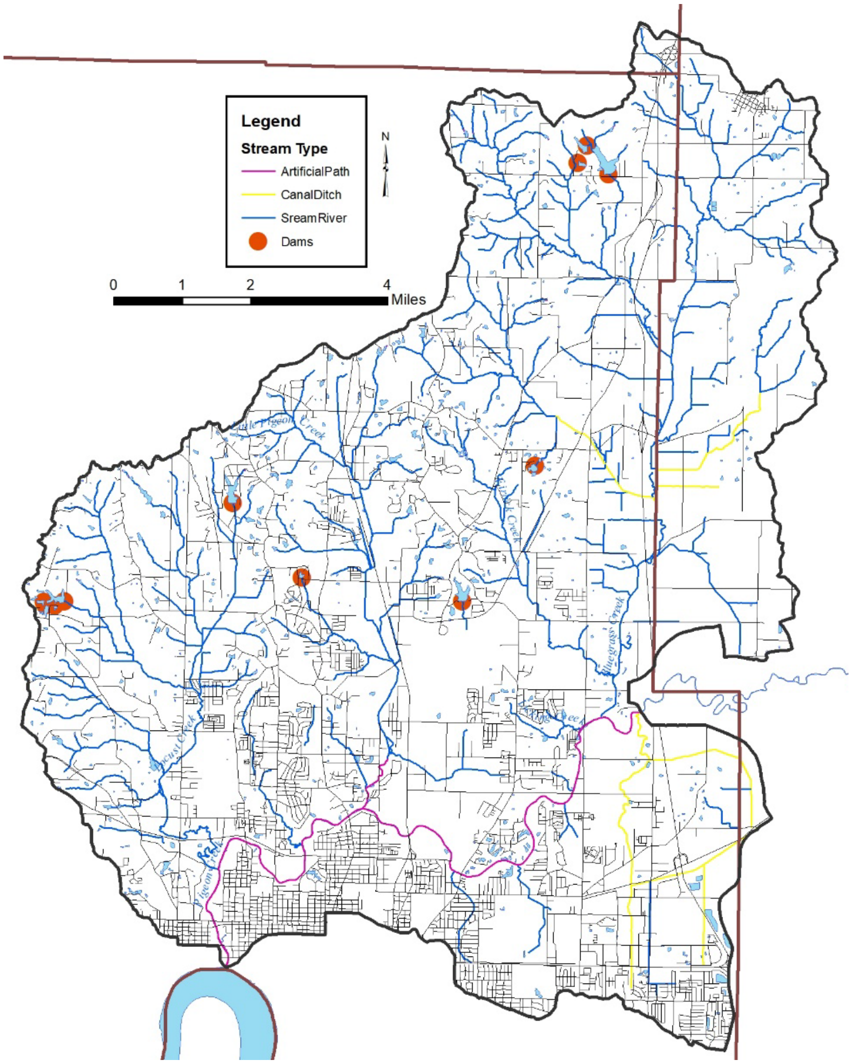

Figure 12. Streams in the Lower Pigeon Creek watershed. Source: USGS, 2018; IDNR, 1999.

2.7.2 Lakes, Ponds and Impoundments

Multiple small and large lakes and ponds dot the Lower Pigeon Creek Watershed landscape. In total, 726 lakes and ponds are present in the Lower Pigeon Creek Watershed ranging in size from 0.1 acre to 38 acres (Table 6). Lakes and ponds throughout the watershed 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. The most prominent, recreation lakes are the 28 reclaimed strip pit lakes which cover 600 acres of the 2,532 acre Blue Grass Fish and Wildlife Area (Figure 13). These lakes offer fishing access with seven boat ramps located on five strip pit lakes. Outboard motors are allowed on Blue Grass, Otter and Lon pits at idle speed only, while all other pits are limited to electric motors only. Muskie are stocked in Loon and Blue Grass pits and bag limits apply to these waters. Blue grass fish and wildlife area provides hunting, trapping, wildlife watching, mushroom hunting as well as nut and berry picking. A permit is required to remove
plants, animals, rocks, or fossils.

Table 6. Dam structures in the Lower Pigeon Creek Watershed.

Name	Surface Area (acres)	Drainage Area (sq mi)	Type
Autumn Winds Dam	0.0	0.00	Lake
Bell Conservation Lake	9.2	0.10	Lake
Kahre Lake Dam	25.1	0.31	Lake
Lake Shawnee Dam 1	44.6	0.67	Lake
Lake Shawnee Dam 2	3.0	0.03	Lake
Lake Talahi Dam	22.0	0.13	Lake
Ray Nell Lake Dam	6.3	0.04	Lake
Schnacke Lake Number 1 dam	16.8	0.37	Lake
Schnacke Lake Number 2 dam	5.0	0.04	Lake
Schnacke Lake Number 3 dam	2.0	0.05	Lake
Schnacke Lake Number 4 dam	2.0	0.17	Lake

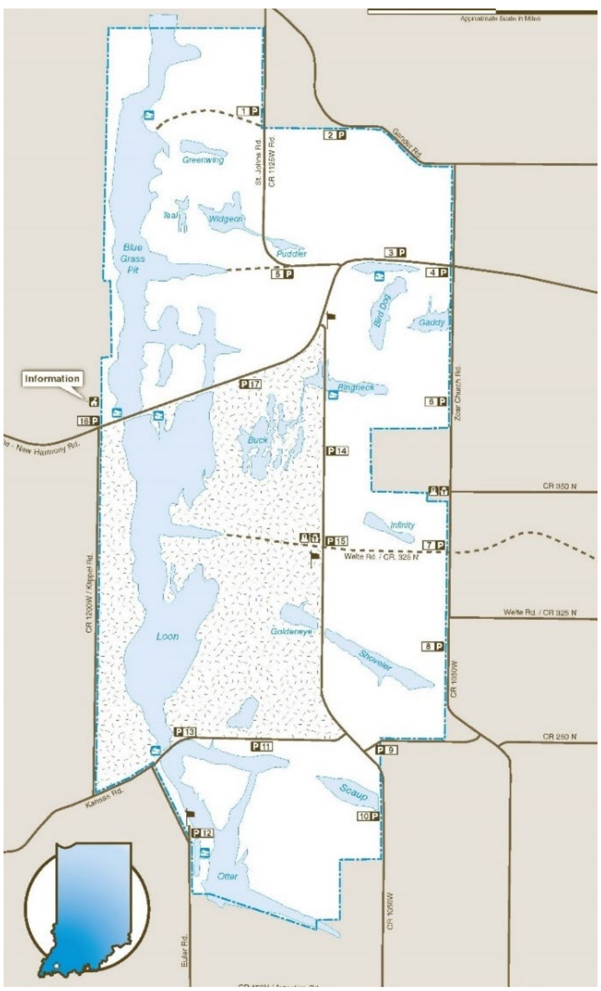

Figure 13. Pit lakes located at the Blue Grass Fish and Wildlife Area.

2.7.3 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 and 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 14 details the locations of floodplains within the Lower Pigeon Creek Watershed. The majority of floodplains in the Lower Pigeon Creek Watershed lie in Warrick County within or adjacent to the Bluegrass Fish and Wildlife Area. Approximately 5% (3,221.3 acres) of the Lower Pigeon Creek Watershed lies within the 100-year floodplain (Figure 14). 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. Nearly 2,200 acres of the Lower Pigeon Creek Watershed floodplain is in Zone A (4% 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. More than 21% (12,665 acres) of the Lower Pigeon Creek Watershed floodplain is in Zone AE.
- 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.

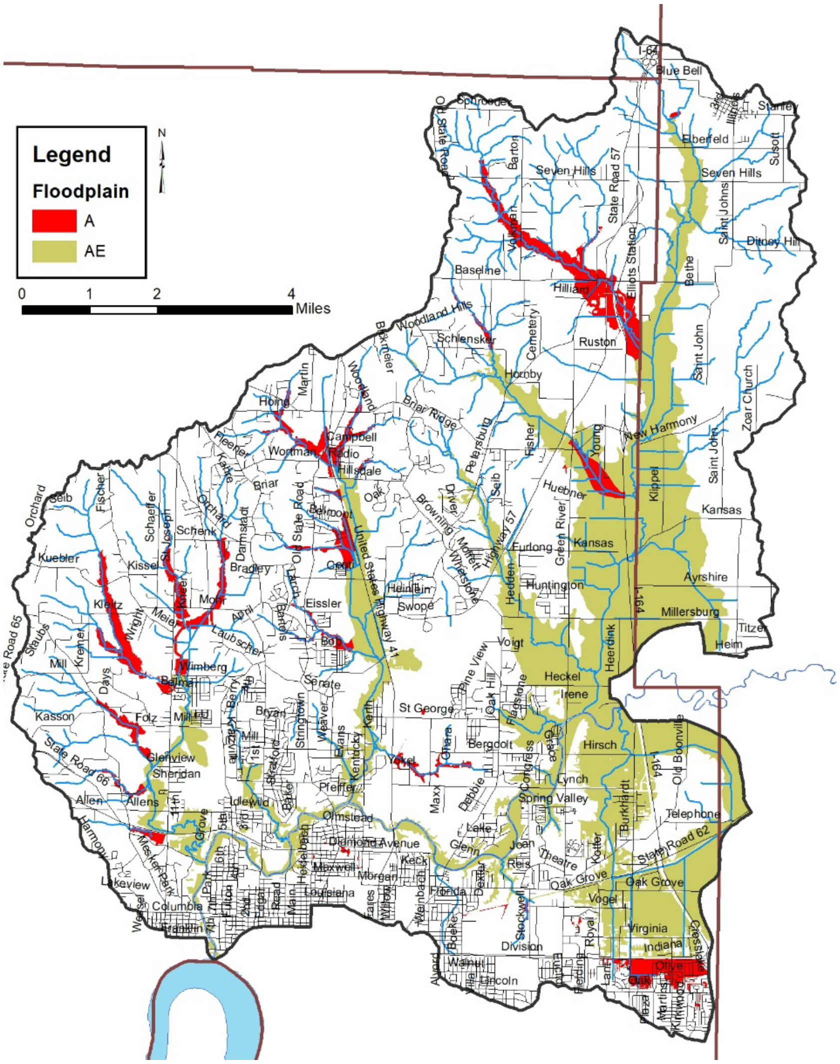

Figure 14. Floodplain locations within the Lower Pigeon Creek Watershed.

2.7.4 Wetlands

Approximately 25% of Indiana was covered by wetlands prior to European settlement (IDEM, 2007). 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 detention 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 2,758 acres, or 4%, of the watershed. When hydric soil coverage is used as an estimate of historic wetland coverage, it becomes apparent that more than 76% of wetlands have been modified or lost over time. This represents 8,622 acres of wetland loss within the Lower Pigeon Creek 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 15 shows the current extent of wetlands within the Lower Pigeon Creek Watershed. Wetlands displayed in Figure 15 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.

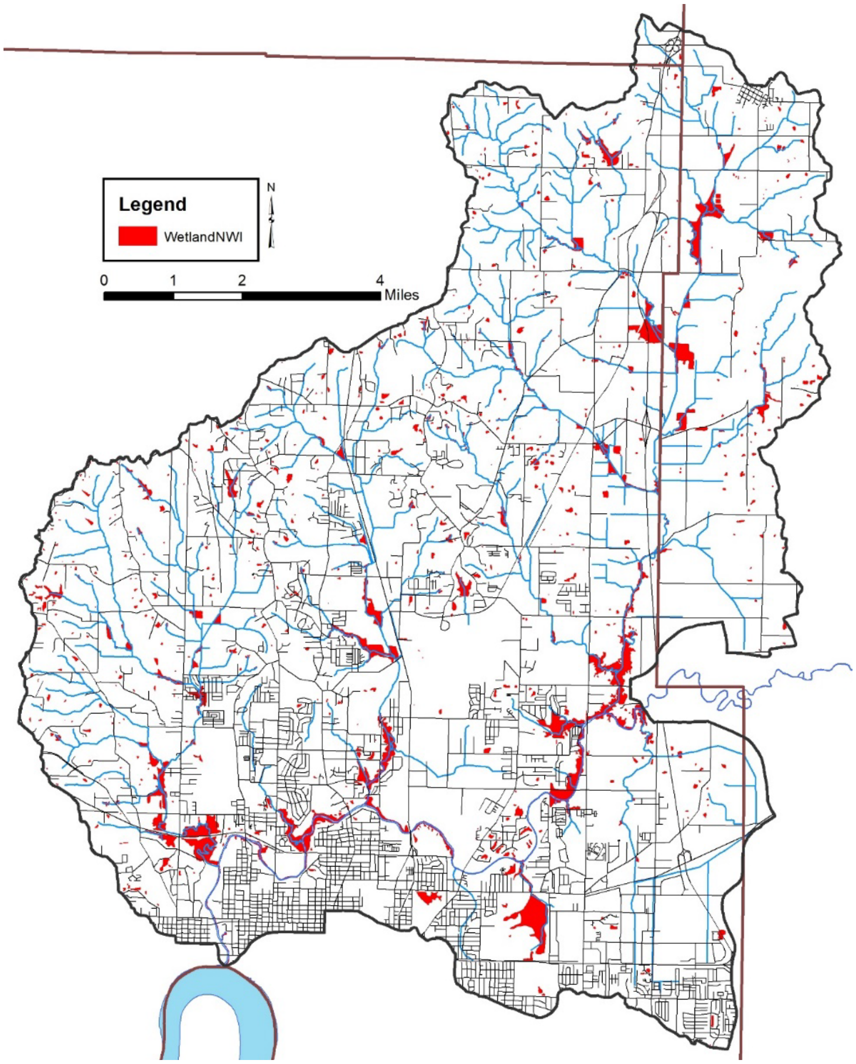

Figure 15. Wetland locations within the Lower Pigeon Creek Watershed. Source: USFWS, 2017.

2.7.5 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. The City of Evansville and Warrick and Vanderburgh Counties' municipal separate storm sewer systems (MS4s) work to mitigate stormwater impacts to Lower Pigeon Creek. While the entire Lower Pigeon Creek Watershed is covered by one of these three MS4s, the predominant developed area, or their area of work, is shown in Figure 16. In total, 38,661 acres (56%) of the Lower Pigeon Creek Watershed are located within the primary MS4 work area.

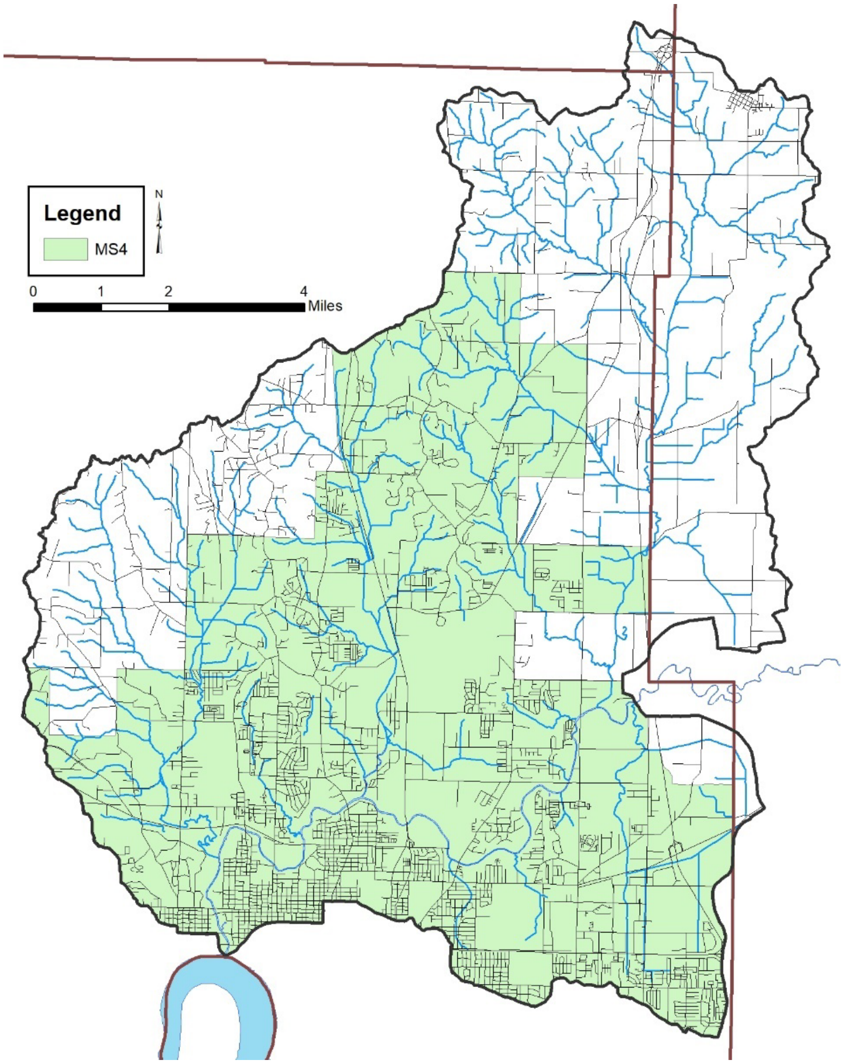

Figure 16. Primary MS4 work area within the Lower Pigeon Creek Watershed.

The Evansville and Vanderburgh County MS4 programs work to reduce the amount of pollution in stormwater runoff. Efforts to improve stormwater quality include:

- Educating the public, employees, commercial and industrial facilities, construction site personnel, and more about the ways they can minimize their impact on stormwater quality.
- Providing opportunities for citizens to participate in developing programs that improve water quality.
- Detecting illicit discharges and eliminating them before they reach waterways.
- Enforcing an erosion and sediment control ordinance for construction activities.
- Addressing discharges of post-construction storm water run-off from new development and redevelopment.
- Training municipal staff about pollution prevention and techniques to reduce the municipalities impact on storm water run-off.

2.7.6 Wellfields/Groundwater

Evansville supplies its residents with drinking water from collection and treatment of surface water and ground water. Water service is provided to Evansville by EWSI. Sources include the Ohio River and an auxiliary deep well. Filtration system capacity is 60.0 MGD to current peak demands of 35 MGD.

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.

2.8.1 Natural and Ecoregion Descriptions

According to Homoya et al.'s (1985) classification of natural regions in Indiana, the Lower Pigeon Creek Watershed lies within two natural regions: the Southwestern Lowlands natural region and the Southern Bottomlands natural region. The Southwestern Lowlands natural region is covered by the Driftless Section subregion. The Driftless Section covers all of Warrick and Gibson Counties and much of Vanderburgh County north of Evansville as well as the southeastern corner of the watershed (Figure 17). The driftless section is characterized by low hills and broad valleys and has the longest growing season of the state. Most of the natural communities are upland forest including well drained slopes which formed in loess and weathered bedrock and southern flatwoods occupying the lacustrine plain and river terraces adjacent to the Ohio River (Homoya et al., 1985). Barrens associated with the flatlands contain mosses, lichens and grasses unlike most flatlands in Indiana which contain prairie flora. The Southern Bottomlands Section covers the mainstem and floodplain of Pigeon Creek. This region includes alluvial bottomlands along rivers and larger streams in southern Indiana. It is distinguished from other bottomland regions in the state by the presence of several lower Mississippi and gulf coastal plains species. Bottomland forest, swamp, pond, slough and formerly marsh and prairie communities cover the Southern Bottomlands natural region.

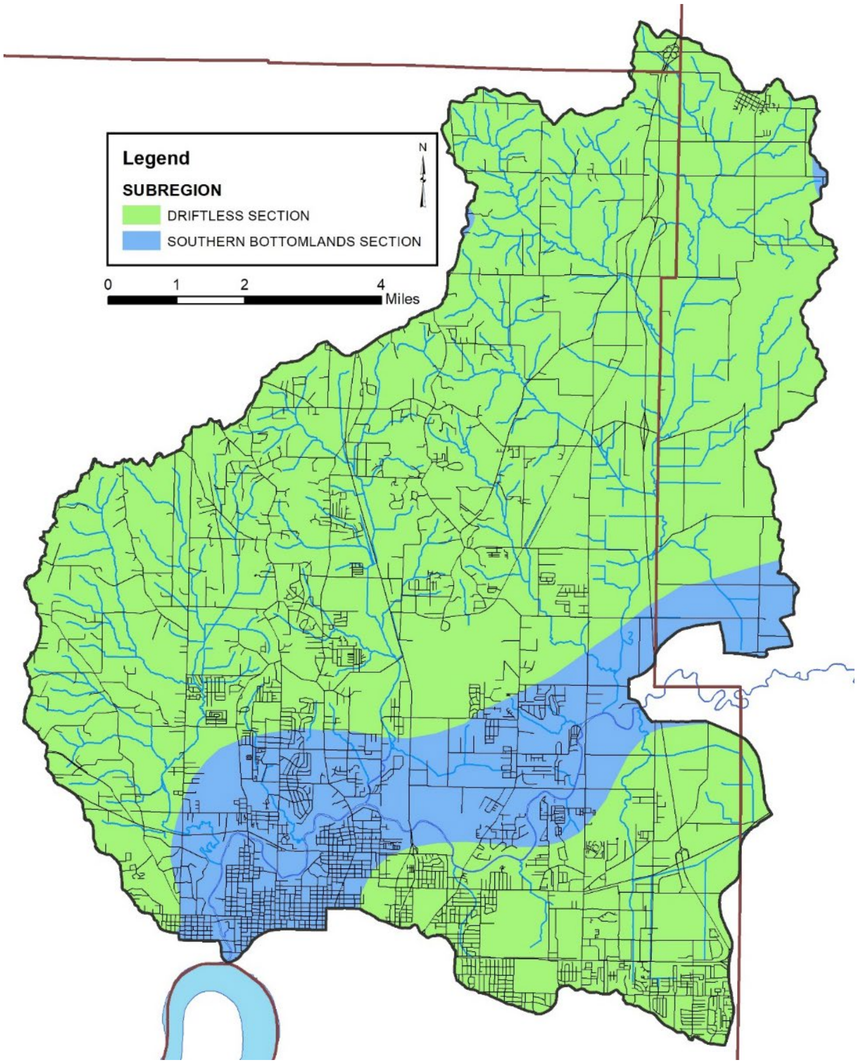

Figure 17. Natural regions in the Lower Pigeon Creek Watershed.

The Lower Pigeon Creek Watershed is covered by the Southern Wabash Lowland ecoregion (Figure 18). This ecoregion is divided into two sections: the Green River-Southern Wabash lowland and Wabash-Ohio Bottomlands. The Southern Wabash Lowland ecoregion is undulating to rolling and has many wide, shallow valleys. It is a pre-Wisconsinan age till plain; relict dunes and wind-blown silt deposits occur in the west, and shale and sandstone bedrock is exposed in the east. The ecoregion is further characterized by its long growing season and neutral to acid soils. Originally, oak-hickory forests grew on the well drained upland soils while western mesophyic forests occurred on more poorly-drained soils. Today, the woodland has been mostly cleared for corn, soybean, wheat, livestock, and vegetable farming as well as extensive surface coal mines.

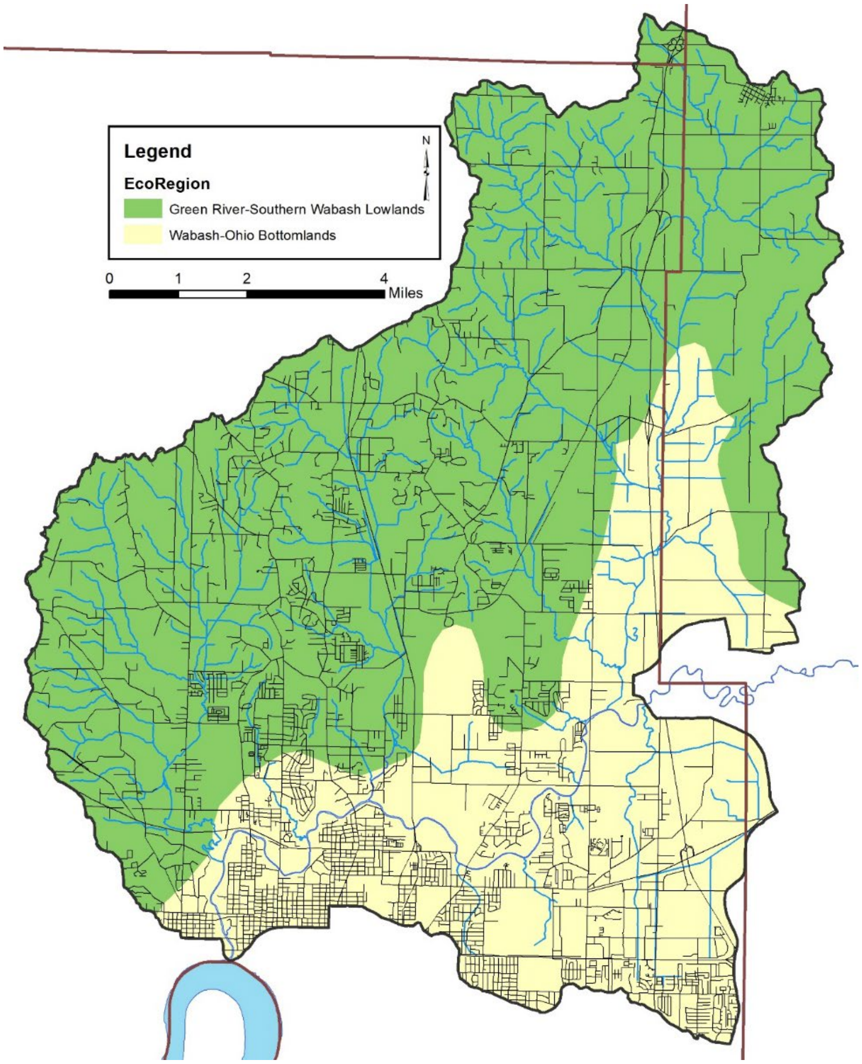

Figure 18. Level III eco-regions in the Lower Pigeon Creek Watershed.

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. Wildlife waste will be an issue in the more natural, forested or wetland portions of the watershed.

Table 7. Surrogate estimates of wildlife density in the IDNR southwest region, which includes the Lower Pigeon Creek Watershed.

Animal	2005 Population Observation (per 1000 hours of observation)
Beaver	0.4
Bobcat	1.2
Bobwhite	38.6
Coyote	43.4
Deer	806.3
Fox squirrel	572
Gray fox	1.2
Gray squirrel	156.3
Grouse	4
Domestic cat	12.3
Muskrat	0.8
Opossum	14.7
Rabbit	19.9
Raccoon	41.8
Red fox	3.6
Skunk	7.6
Turkey	255.8

Source: Plowman, 2006.

Pet populations can affect pathogen levels similar to the impacts provided by wildlife. While a count of pets for the Lower Pigeon Creek 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 the Lower Pigeon Creek Watershed is based on the average number of pets per household multiplied by the population of the watershed resulting in a suggested population of 48,939 cats and 42,989 dogs. Pet waste issues are more predominant in urban areas including Evansville but are also present at any residential parcel.

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, 24 observations of listed species and/or high quality natural communities occurred within the Lower Pigeon Creek Watershed (Figure 19; Davis, personal communication). These observations include one amphibian, 10 birds, one reptile, seven plants, two insects and two high quality natural communities. State endangered species include the hellbender, American bittern, Barn owl, Henslow's sparrow, Loggerhead shrike, Upland sandpiper, Virginia rail, blue scorpionweed, land of gold sedge, and small spikerush. While state threatened species include catbird grape, Maryland meadow beauty and social sedge and state rare species include the Indiana crayfish. The state extirpated species, American burying beetle, was also previously observed in the Lower Pigeon Creek Watershed. The southern bottomlands mesic upland forest and wet-mesic floodplain forest were observed in the Lower Pigeon Creek Watershed. Appendix A includes the database results for the Lower Pigeon Creek Watershed, as well as county-wide listings for Gibson, Vanderburgh and Warrick Counties.

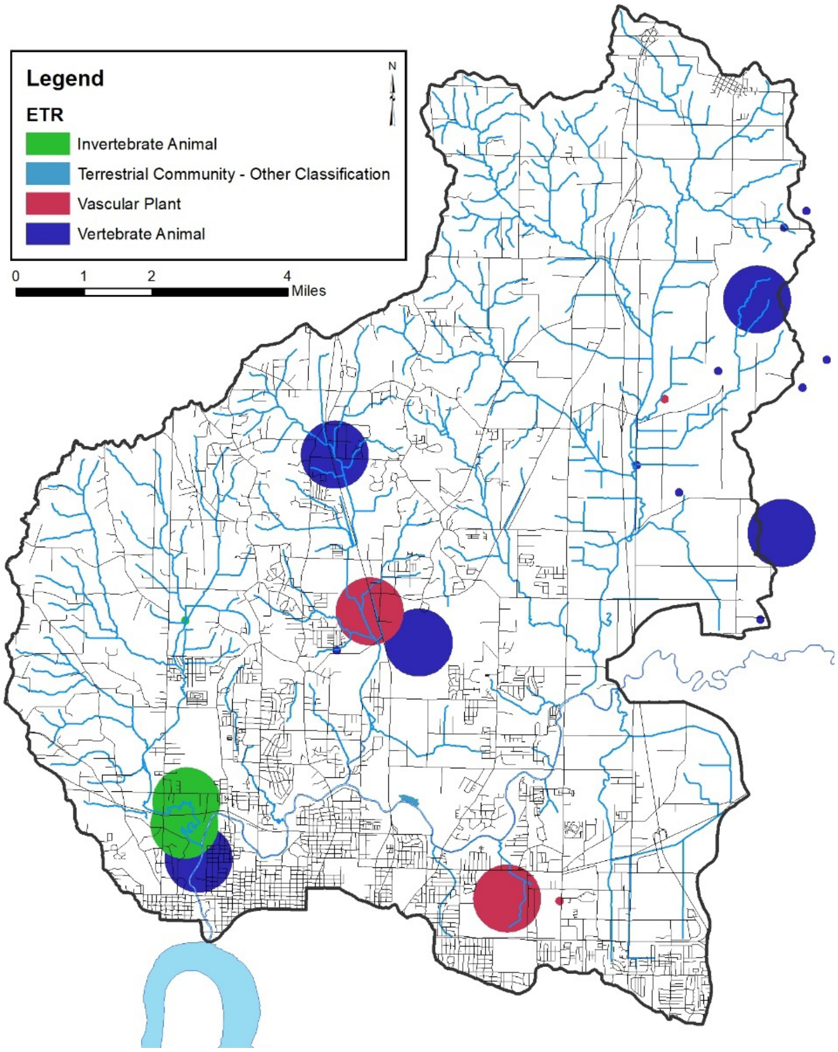

Figure 19. Locations of special species and high quality natural areas observed in the Lower Pigeon Creek Watershed. Source: Davis, 2021.

2.8.4 Recreational Resources and Significant Natural Areas

A variety of recreational opportunities and natural areas exist within the Lower Pigeon Creek Watershed. Recreational opportunities include parks, fish and wildlife areas, nature preserves, fairgrounds, golf courses and school grounds (Table 8, Figure 20). There are several significant natural areas located within the Lower Pigeon Creek Watershed. The Indiana DNR, Evansville and Vanderburgh County Park Boards and the National Park Service maintain, preserve and protect these properties. Riverfront Park and Garvin Park provide access to Lower Pigeon Creek. Additional recreational opportunities exist at various schools, golf complexes and sporting facilities.

Table 8. Natural areas in the Lower Pigeon Creek Watershed.

Natural Area	County	Organization
Bluegrass Fish and Wildlife Area	Warrick	Indiana DNR
Crane Tract	Vanderburgh	Indiana DNR
Garvin Park	Vanderburgh	Evansville Park Board
Golfmoor (Helfrih) Park	Vanderburgh	Evansville Park Board
Riverfront Park	Vanderburgh	Evansville Park Board
Stockwell Park	Vanderburgh	Evansville Park Board
Stream Valley Park	Vanderburgh	Vanderburgh County Park Board
Wesselman National Landmark	Vanderburgh	National Park Service
Wesselman Park Natural Area	Vanderburgh	Evansville Park Board
William J. Moutoux Park	Vanderburgh	Evansville Park Board

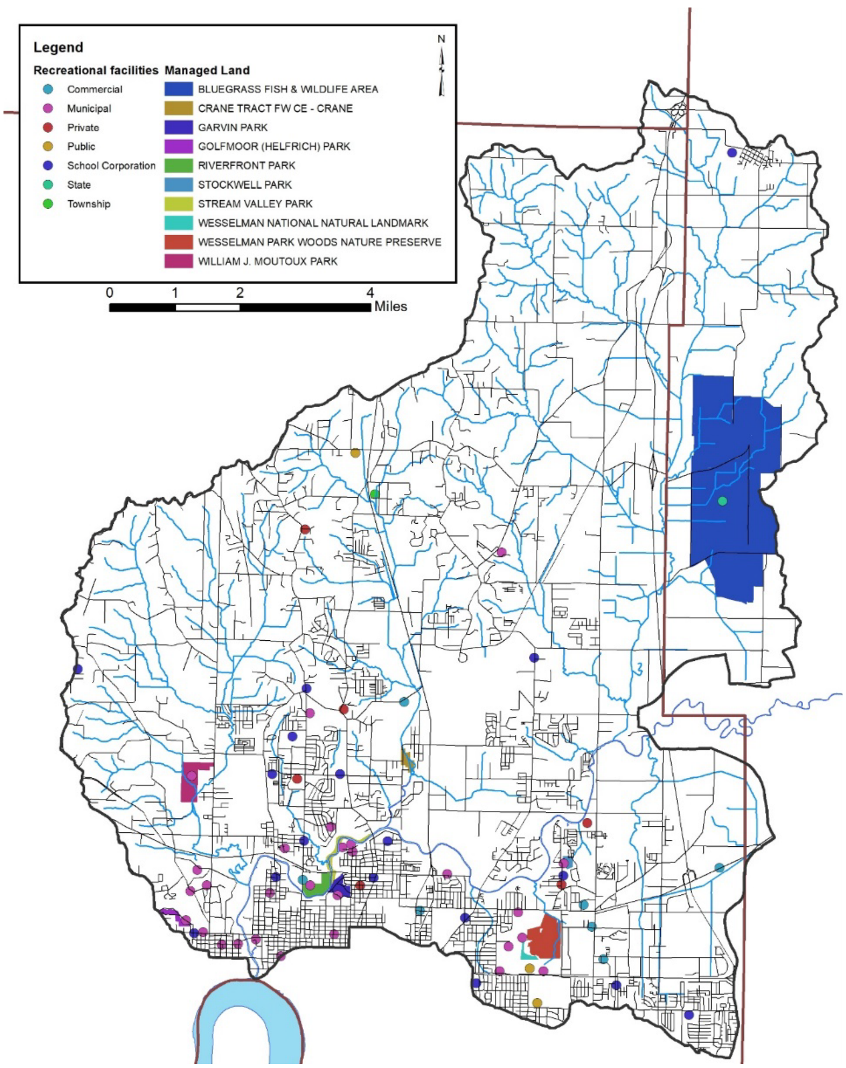

Figure 20. Recreational opportunities and natural areas in the Lower Pigeon Creek Watershed.

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 majority of the Lower Pigeon Creek Watershed is covered by row crop agriculture (25%) with an additional 11% of the watershed in pasture (Table 9, Figure 21). Nearly 26% of the watershed is mapped in forestland, while 34% of the watershed is covered by developed open space or is in low, medium, or high intensity developed areas. Grassland, open water, and wetlands cover the remaining 5% of the watershed.

Table 9. Detailed land use in the Lower Pigeon Creek Watershed.

Classification	Area (acres)	Percent of Watershed
Cultivated crop	17,164.0	25%
Deciduous forest	12,963.3	19%
Developed open space	9,083.7	13%
Low intensity developed	7,490.1	11%
Pasture/hay	7,233.2	11%
Medium intensity developed	4,675.8	7%
Mixed forest	4,465.7	6%
High intensity developed	2,327.4	3%
Open water	1,409.3	2%
Woody wetland	1,265.4	2%
Grassland	403.5	1%
Evergreen forest	105.7	0.2%
Emergent wetland	88.8	0.1%
Shrub/scrub	46.4	0.1%
Barren land	37.5	0.1%
Entire Watershed	**68,759.6**	**100.0%**

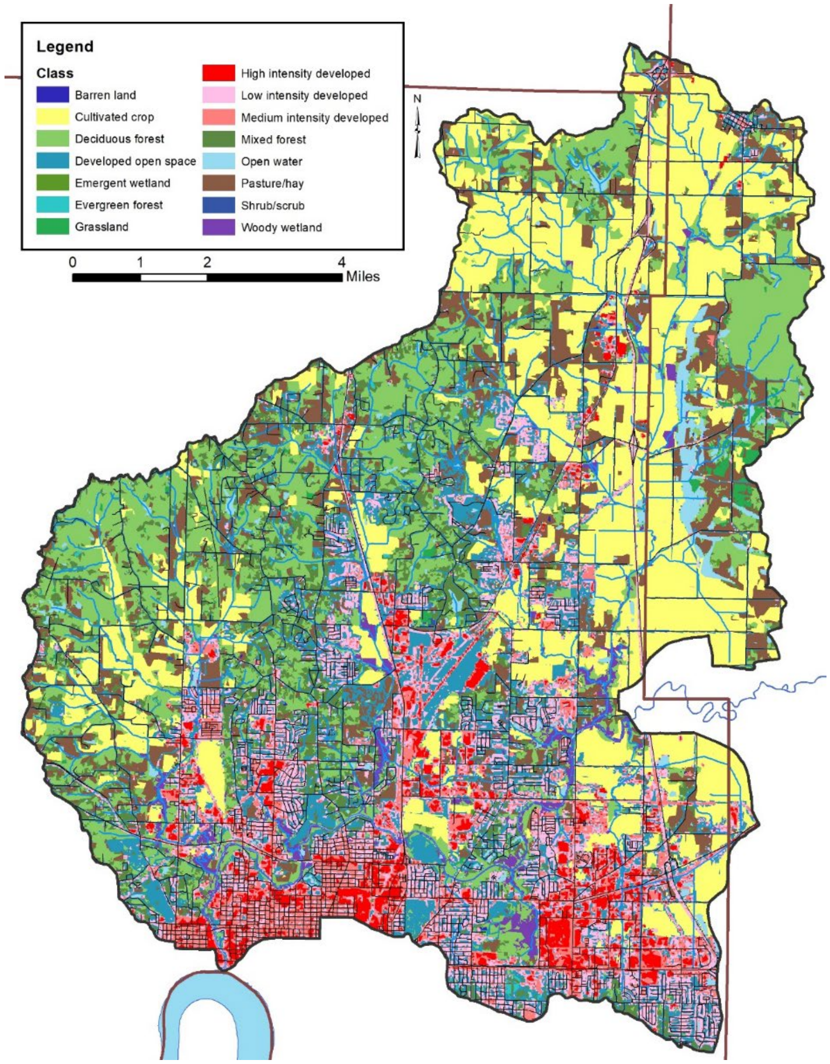

Figure 21. Land use in the Lower Pigeon Creek Watershed. Source: NLCD, 2011.

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 Gibson, Vanderburgh and Warrick counties was compiled for 2019 (Table 10; ISDA, 2019). 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 10 provides the number of acres and percent of acres on which conservation tillage was utilized for each county by corn and soybeans.

Table 10. Conservation tillage data as identified by county tillage transect data for corn and soybeans (ISDA, 2019).

County	Corn (acres)	Corn (%)	Soybeans (acres)	Soybeans (%)
Gibson	21,244	26%	12,660	15%
Vanderburgh	5,239	20%	12,632	42%
Warrick	3,757	11%	7,506	21%

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) by county (NASS, 2017). These data indicate that corn (142,057 acres in Gibson, Vanderburgh and Warrick counties) and soybeans (150,219 acres in in Gibson, Vanderburgh and Warrick counties) are the two primary crops grown in the watershed.

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 10,470 tons of nitrogen and 5,179 tons of phosphorus are applied annually within the Lower Pigeon Creek Watershed counties (Table 11).

Table 11. Agricultural nutrient usage for corn in the Lower Pigeon Creek Watershed counties.

Nutrient	Acres of Corn	% of Area Applied	Applications (#/year)	Rate/Application (lb/acre)	Total Applied/Year (tons)
Nitrogen	142,057	100	2.2	67	10,470
Phosphorus	142,057	93	1.4	56	5,179

Source: NASS, 2007; ISDA, 2019

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, 2007). Using these rates, we estimated that a little over 88 tons of atrazine and approximately 98 tons of glyphosate are applied to cropland in the Lower Pigeon Creek Watershed counties annually (Table 12).

Table 12. Agricultural herbicide usage in the Lower Pigeon Creek Watershed counties.

Crop	Acres	Application Rate (lb/acre)	Total Applied (lbs)	Total Applied/Year (tons)
Corn (Atrazine)	142,057	1.24	176,151	88
Corn (Glyphosate)	142,057	0.6	85,234	43
Soybeans (Glyphosate)	150,219	0.73	109,660	55

Source: NASS, 2007; ISDA, 2019

Confined Feeding Operations and Hobby Farms

An inventory to identify small, unregulated and larger, regulated livestock operations (confined feeding operations) was completed for the Lower Pigeon Creek Watershed. Small farms are those which house less than 300 animals, while 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 permit applications 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).

In total, 36 small, unregulated animal farms containing nearly 250 animals were observed during the windshield survey, which is most likely an underestimate of the actual number. These small "mini farms" contain small numbers of cattle (90), horses (115), sheep (45), poultry, or goats (10), which could be sources of nutrients and *E. coli* as these animals exist on small acreage lots with limited ground cover. Approximately 20 of these unregulated animal farms are horse boarding facilities. These facilities generate approximately 4,120 tons of manure per year spread over the watershed. This volume of manure contains approximately 3,220 pounds of nitrogen, 1,606 pounds of phosphorus and 4.71×10^{14} colonies of *E. coli*. No confined feeding operations are located in the Lower Pigeon Creek Watershed.

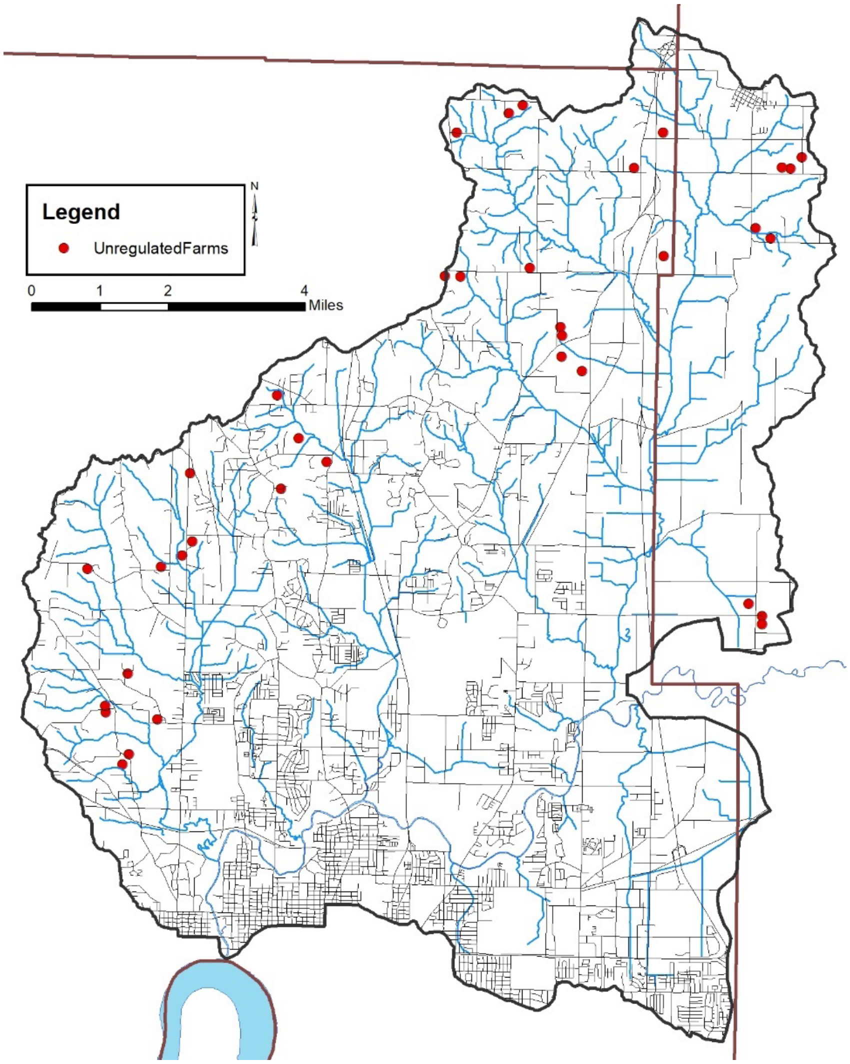

Figure 22. Unregulated animal farm locations within the Lower Pigeon Creek Watershed.

2.9.3 Natural Land Use

Natural land uses including forest, wetlands, and open water cover approximately 31% of the watershed. Approximately 26% of the watershed are covered by trees. Forest cover occurs adjacent to waterbodies throughout the watershed. The majority of forested lands lie in the western and eastern portions of the watershed (Figure 21). Many forested tracts are contiguous and large lengths of the watershed streams contain intact riparian buffers.

2.9.4 Urban Land Use

Urban land uses cover nearly 34% of the watershed (Table 9). Most of the urban areas lie within or adjacent to the City of Evansville and there are some significant issues related to the developed areas. Especially troublesome are issues related to failing septic systems, impervious surfaces, flooding, combined sewer overflows and stormwater runoff that allow untreated sewage and stormwater to flow into the watershed during heavy rain events.

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, 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.

Much of the northern portion of the Lower Pigeon Creek Watershed is covered by low levels of impervious surfaces. However, within the City of Evansville and in areas north and east of town where development is on-going, impervious surfaces are relatively dense. Estimates indicate that 19% of the watershed is 25% or more covered by hard surfaces (Figure 23). 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).

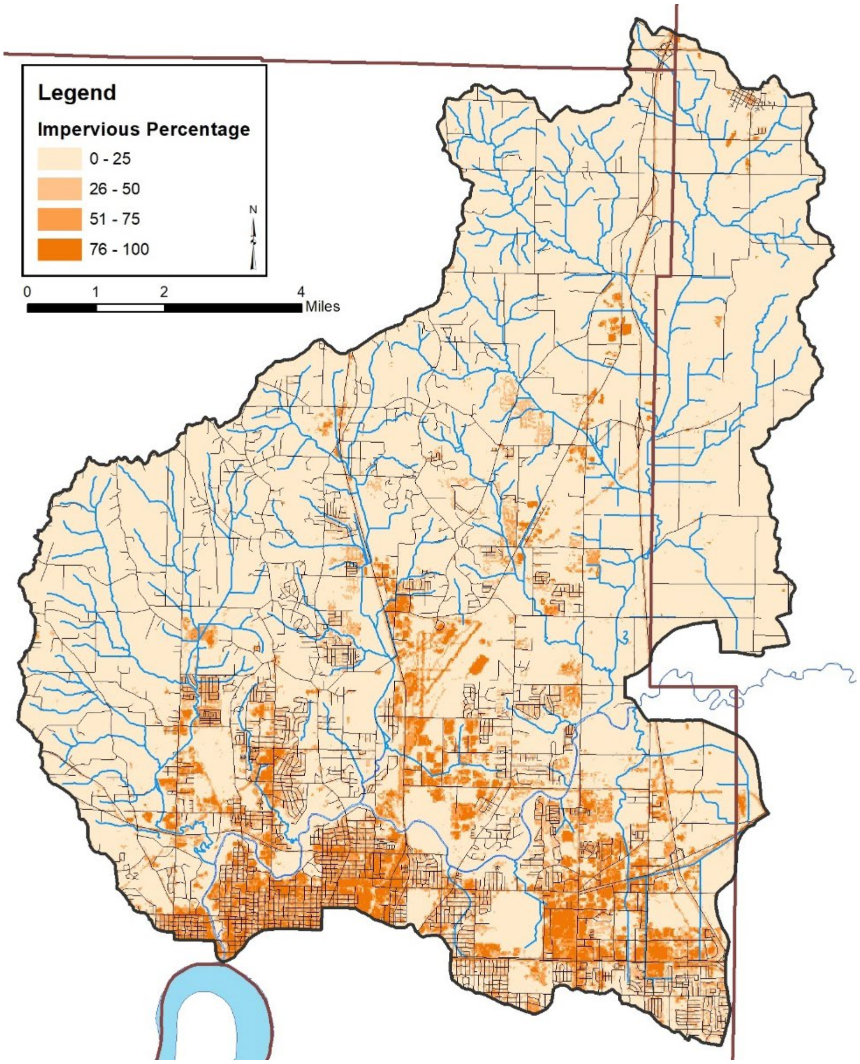

Figure 23. Impervious surface density in the Lower Pigeon Creek Watershed.

Remediation Sites

Remediation sites including industrial waste, leaking underground storage tanks (LUST), open dumps, and brownfields are present throughout the Lower Pigeon Creek Watershed (Figure 24). Most of these sites are located within the developed areas of the watershed including Evansville and the US 40 corridor. In total, 318 underground storage facilities (138 considered leaking underground storage tanks), four voluntary remediation projects (VRP), two open dumps, two solid waste facilities, 65 industrial waste facilities and 16 brownfields are present within the watershed. While there are no Superfund sites within the watershed, the Jacobsville Superfund site is located immediately south of the Lower Pigeon Creek Watershed. Specifically, operational unit 2, which includes 10,000 residences across 4.6 miles are impacted by contamination associated with this site (Figure 25). Four facilities, Blount Plow Works, Advance Stove Works, Newton-Kelsay and Sharps Shot Works, are associated with the Jacobsville Superfund site. Characterization of the site occurred between 1990 and 2006 and in 2007, a feasibility study was prepared which evaluated remediation alternatives. Assessments identified elevated lead, iron, copper and other heavy metals across the facilities. Since 2012, more than 900 residential properties in operational area 2 were remediated with soils removed and replaced with clean backfill in an effort to reduce lead and arsenic concentrations found in soils in the area (SulTRAC, 2017).

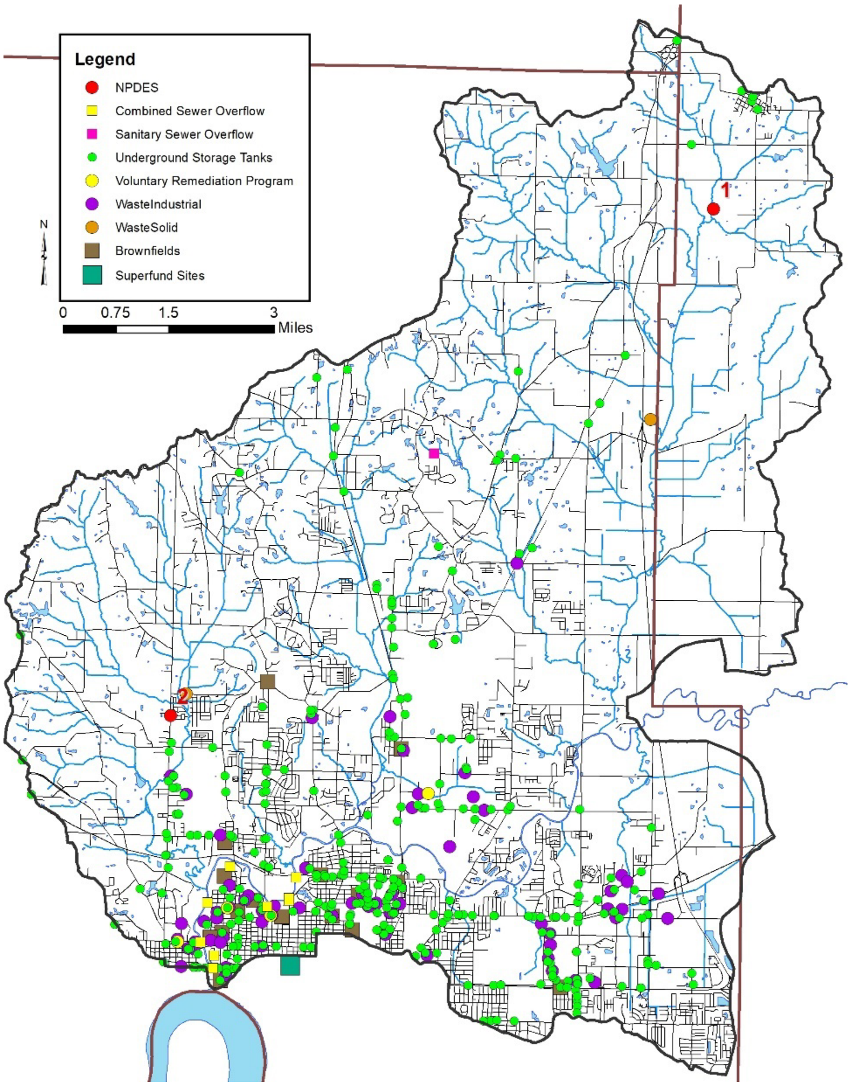

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Figure 24. Industrial remediation and waste sites within the Lower Pigeon Creek Watershed. Source: IDEM.

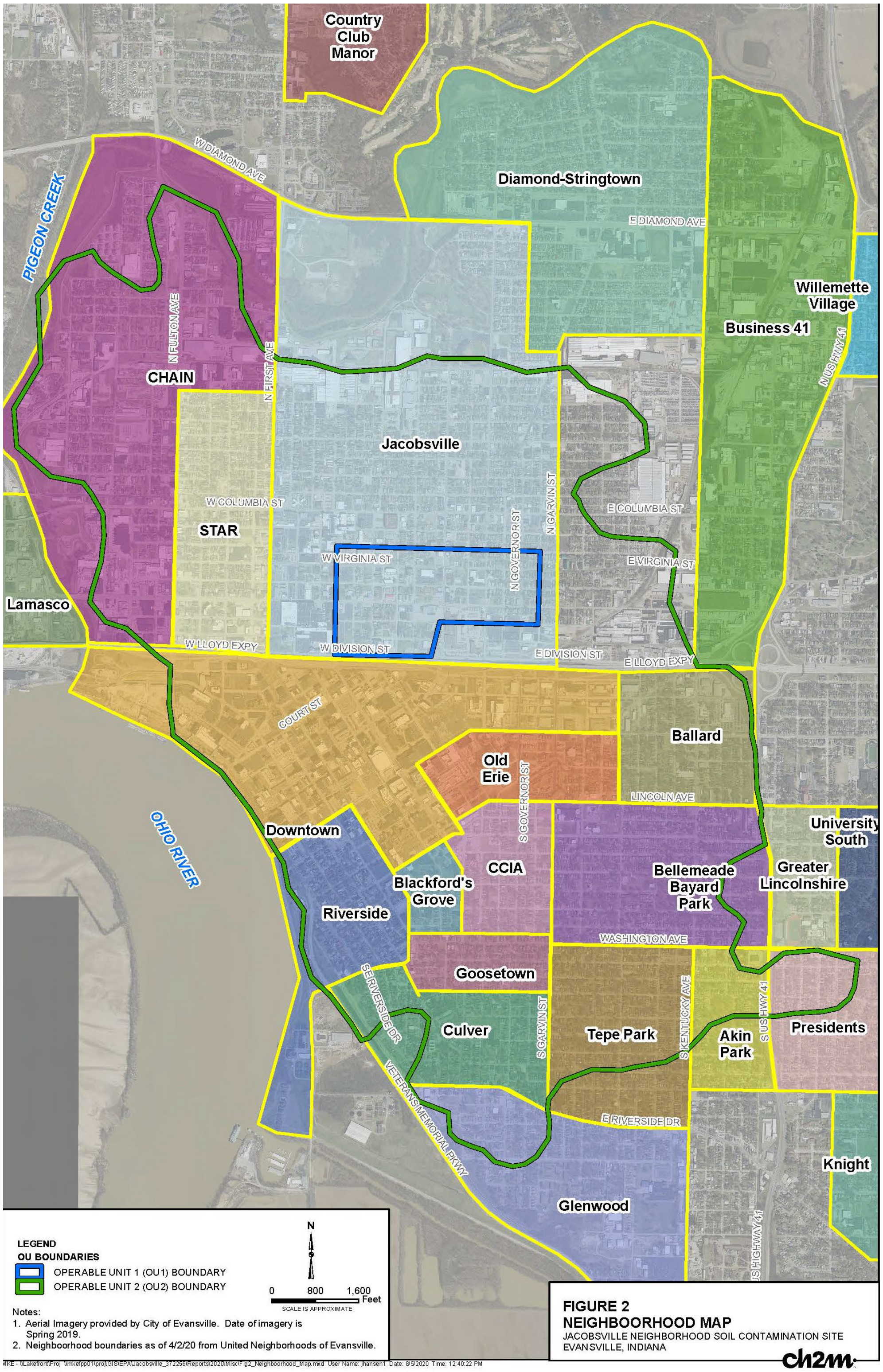

Figure 25. Jacobsville Superfund site operable unit boundaries.

2.9.5 Mining Impacts

Nearly 100,000 acres of southwest Indiana has been disturbed by strip mining since the early 1920s with Warrick County as the third highest county in active mining operations (Powerll, 1972). In total, 22,992 acres of Warrick County was disturbed by strip mining with an estimated 20 acres of coal was removed with an estimated 20 acres of spoil added (Powell, 1972). Major mines near or within the Lower Pigeon Creek Watershed included Amax's Ayrshire pits on the western edge of Warrick County in what is now Blue Grass Fish and Wildlife Area; the Peabody operations scattered south and east of Elberfeld and Squaw Creek mines northwest of Booneville. The Warrick County planning commission mapped 6,553 acres of underground and 56,002 acres of surface mined area which accounts for nearly 25% of Warrick County. Drillings in southern Gibson, eastern Vanderburgh, and western Warrick Counties show the presence of a coal bed, called Coal IE, having an average thickness of 5.5 to 6 feet. Most underground mining in the Evansville area ceased in the 1960s. Some of the oldest mines were never accurately mapped, but there are sections of Newburgh, Boonville, Elberfeld, Chandler and Yankeetown which are known to be undermined. Warrick County is considered one of the four most active subsidence areas in Indiana. In addition, a large section of Evansville's West Side sits atop abandoned underground mines (Spencer, 1953). The IDNR Coal Mine Information System details surface (rust) and underground (blue) mines present in the Lower Pigeon Creek basin (Figure 26).

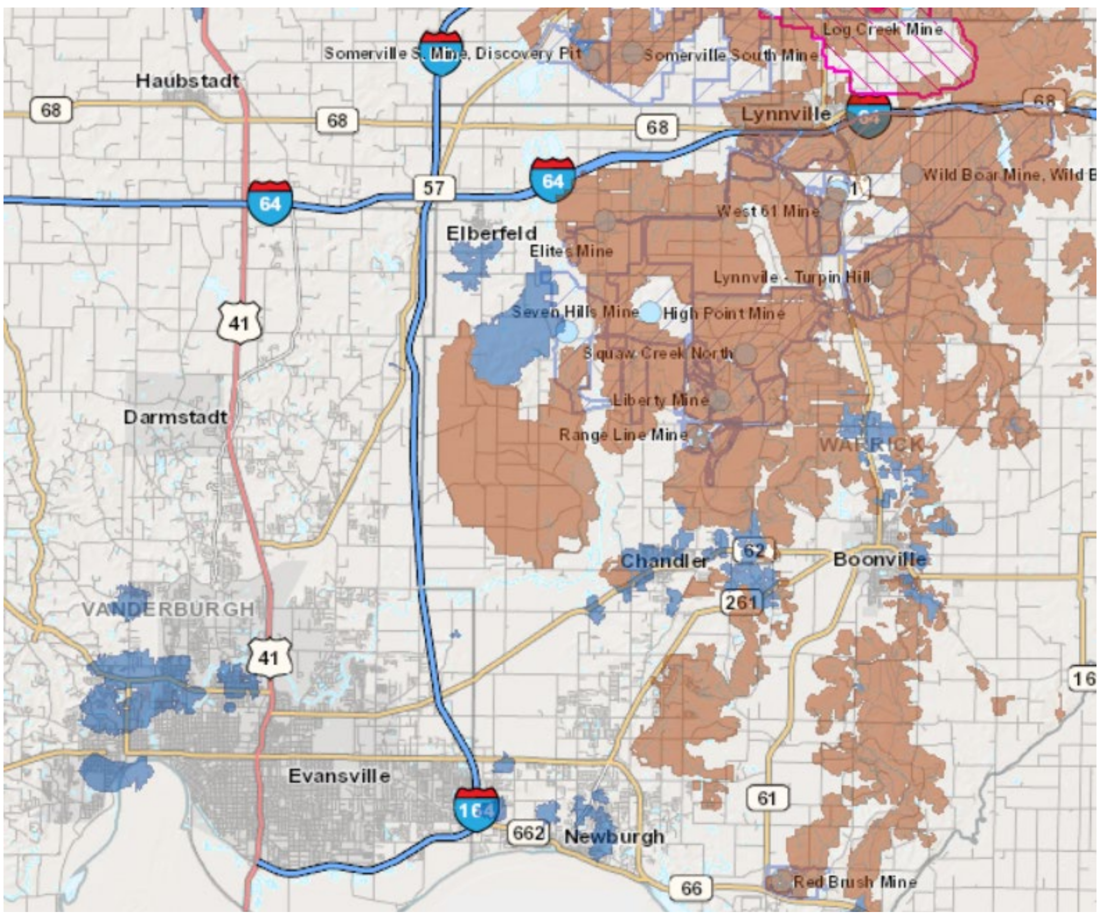

Figure 26. Surface and underground mining locations mapped as part of the IDNR coal mine information system.

2.10 Population Trends

The northern and eastern portion of the Lower Pigeon Creek Watershed is relatively sparsely populated while the City of Evansville has a relatively dense population. One city, Evansville, and several incorporated towns are located within the watershed. Tracking population changes within a watershed is challenging as data is published by counties and townships rather than watershed boundaries. Changes in watershed population and the associated land use changes and infrastructure impacts were noted by watershed stakeholders. 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 Lower Pigeon Creek Watershed lies within three counties. It drains only 0.4% of Gibson County, 84% of Vanderburgh County, and 16% of Warrick County. Population trends for these counties derived from the most recently completed census (2010) are shown in Table 13, while Table 14 displays estimated populations for the portion of each county located within the watershed (StatsIndiana, 2018). These data indicate modest growth in all three counties over the past decade.

Table 13. County demographics for counties within Lower Pigeon Creek Watershed.

County	Area (acres)	Population (2010)	Population Growth (2000-2010)	Pop. Density (#/sq. mi)
Gibson	319,360	33,656	+212.0	67.4
Vanderburgh	151,232	181,451	+2,286.2	767.9
Warrick	250,240	62,998	+4,422.4	161.1

Table 14. Estimated watershed demographics for the Lower Pigeon Creek Watershed.

County	Acres of County in Watershed	Percent of County in Watershed	Population
Gibson	319,360	0.4%	127.7
Vanderburgh	151,232	83.8%	152,010.7
Warrick	250,240	15.8%	9,982.3
		Total Estimated Population	**162,120.7**

2.11 Planning Efforts in the Watershed

Numerous larger plans have encompassed portions of the Lower Pigeon Creek Watershed or areas which it drains or outlets into. Planning efforts include the city, county, Evansville Water and Sewer Utility, and county-wide master plans.

Pigeon Creek Watershed Diagnostic Study (2001)

The Evansville Water and Sewer Utility and Four Rivers Resource Conservation and Development Area worked with Montgomery Watson Harza to complete the Pigeon Creek Watershed Diagnostic Study in 2001 (MWH, 2001). The Pigeon Creek Watershed Diagnostic Study is a comprehensive examination of Pigeon Creek and tributaries in Vanderburgh, Warrick and Gibson Counties and their surrounding watershed. The project had two objectives:

1. The Pigeon Creek watershed upstream of Evansville is subjected to nonpoint source pollution (NPS) from agricultural, mining and other land uses detrimental to stream health. The Soil and Water Conservation Districts (SWCDs) of Vanderburgh, Gibson and Warrick Counties have

commissioned a diagnostic study of NPS in the watershed under the sponsorship of the Department of Natural Resources' Lake and River Enhancement Program and the Department of Environmental Management's (IDEM) Nonpoint Source Program.

2. The Evansville Water and Sewer Utility (EWSU) is required under their National Pollutant Discharge Elimination System (NPDES) Permit to prepare a Stream Reach Characterization and Evaluation Report (SRCER) that addresses combined sewer overflows (CSOs) in its service area drained by Pigeon Creek.

The Pigeon Creek Watershed encompasses 240,000 acres of Vanderburgh, Warrick and Gibson counties, Indiana. At the time of the assessment, the watershed was 48% row crop agriculture and 20% pasture or grassland. Forested lands and wetlands accounted for 8% of the watershed land use, while urban land uses, including urban open space and low, medium, and high intensity developed areas, account for56% of the watershed.

MWH examined point and nonpoint sources of pollution identifying eight CSO discharges, five industrial dischargers and six municipal wastewater treatment plants. At the time of the assessment, MWH noted that the five industrial dischargers were minor contributors to Pigeon Creek pollution with generally good records of compliance. The wastewater treatment plans were noted as having generally unacceptable performance records and requiring expansion, upgrades or additional training. Only the Elberfld plant, which was noted as expansion planning underway, is located in the Lower Pigeon Creek Watershed.

MWH noted major nonpoint sources of pollutants to the watershed are row crop agriculture, mined lands, and urban runoff. Cropland area in the watershed has been reasonably constant since 1997. Watershed wide, conservation tillage systems were used on 25% of cropland in 1997, 16% of cropland in 1998, and 33% of cropland in 2000. Data on the conservation tillage in the watersheds are insufficient to statistically demonstrate trends. In the year 2000, the Warrick County portion of the study area had the highest rate of conservation tillage adoption, with 51% of its cropland in some type of conservation tillage. Based on modeled results, MWH identified subwatersheds 6, 18, 20, 22, 23, 24, 26 and 26 as the priority areas for investing in soil erosion controls. None of these subwatersheds are located in the Lower Pigeon Creek Watershed.

MWH recommended stream corridor restoration efforts in nearly all subwatersheds. Corridor restoration is a complex endeavor that begins with the recognition that human-induced changes that began nearly two centuries ago have damaged the structure and function of the ecosystem and prevent the recovery of the watershed to a sustainable condition. A restoration effort of this magnitude will require institutional and public support at all levels to succeed. To facilitate corridor restoration, MWH recommended the following initial steps:

1. Revitalization of a stakeholder steering committee to focus and direct the effort.
2. Preparation of a restoration feasibility study and master plan.
3. Consideration of local ordinances requiring stream conservation buffers.

Additionally, MWH monitored Evansville's combined sewer system tributary to Pigeon Creek and examined available operational records. MWH also monitored CSO events for eight months. Based on the water quality data, MWH noted that the waterway is most affected by the discharges of *E. coli* bacteria and that the state water quality standard was regularly exceeded during wet weather both within and upstream of the CSO discharge area. MWH noted little evidence that other water quality standards are routinely violated due to CSO discharges.

MWH recommended that as overflow continue to be significant and are perhaps causing deterioration of Pigeon Creek, Evansville should continue to investigate the feasibility of providing in-line storage in 11 subsystems and detention/retention basins at various sites. Recommendations included installation of a gate control system, which would control the non-automated CSOs to Pigeon Creek and the Ohio River and would allow the storage of combined sewerage in the interceptors tributary to the diversions. This gate control system could provide about 154,5000 cubic feet (11.6 MG) of storage. Further, MWH recommended that a study to investigate the feasibility of such a system and the condition of the sewers at the storage sites was warranted and should be implemented. Additionally, evaluation of a runoff control program to store and control runoff before it enters the combined system was also recommended. MWH noted that the feasibility and effectiveness of this alterative requires development of a system model, scheduled for completion as part of the long-term CSO control plan.

Warrick County Comprehensive Plan (2007)
Warrick County updated its Comprehensive Plan in 2007. Surveying of registered voters in Warrick County showed people want to see more jobs in the county, are in favor of increasing efforts to promote industrial development, a desire for greater recreational opportunities, safer commercial developments, and enhanced planning/zoning administration. The following goals are identified that are relevant to the Lower Pigeon Creek Watershed:

- Develop standards for drainage improvements and easements to insure an integrated stormwater runoff control system.
- Require that stormwater drainage plans can accommodate a 25-year storm.
- Require the continual private maintenance of stormwater infrastructure.
- Maintain a systematic program for the maintenance of the County's legal drains and roadway ditches.
- Replace aging infrastructure.
- Eliminate the inflow of stormwater into the sanitary sewer system.

Highland-Pigeon Watershed Management Plan (2003)
In 2003, the Highland-Pigeon steering committee and Four Rivers RC&D completed the Highland Pigeon Watershed Management Plan. The Highland-Pigeon Watershed Plan utilized water quality data collected as part of the Pigeon Creek Watershed Diagnostic Study. It should be noted that the Lower Pigeon Creek Watershed includes subwatersheds 1, 2, 3, 4, 8, 9 and 12. Goals identified as part of the Highland-Pigeon Watershed Management Plan are as follows:

- Reduce sediment loading in subwatersheds 23, 24, 25, 26, MF4, MF8, MF9, and MF10 by 50% in five to ten years.
- Restore riparian habitat to improve Aquatic Life Use Support/aesthetic value in subwatersheds 23, 24, 25, 26, MF8, MF9, and MF10 in five to ten years.
- Reduce levels of phosphorus by at least 50% in subwatersheds 16, 17, 18, 24 and 25 in five to ten years.
- Eliminate discharges of raw or inadequately treated sewage by supporting preparation of preliminary engineering reports of Gibson, Warrick and Posey Counties in five to ten years.

  - Support continued work on combined sewer overflow elimination in Evansville.
  - Encourage upgrade of the Fort Branch wastewater treatment plan in five to 25 years.
- Reduce runoff from livestock operations in subwatersheds MF4, MF8, MF8 and 20 in three to five years.
- Reduce illegal dumping of solid waste and cleanup existing sites in subwatersheds MF2, 7, 15, 16 and 25 in five to ten years.
- Restore impaired wetlands or create new wetlands by enrolling at least 100 acres in the wetland reserve program. Target wetlands in subwatersheds 16, 25 and 33 in five to ten years.
- Encourage adoptions of urban erosion control practices and enforce current rules and ordinances.
- Provide education opportunities including field days, public meetings, school visits regarding water, watersheds ad land use to all stakeholders.

Warrick County Comprehensive Plan for Elberfeld/Greer and Campbell Townships (2009)

This Comprehensive Plan is an amendment to the 1993 Warrick County Comprehensive Plan for the portion covering Campbell and Greer Townships with an emphasis on Elberfeld. This plan directs the future physical development of the community. The following goals are identified that are relevant to the Lower Pigeon Creek Watershed:

- Explore the management structures, capital costs and financing mechanisms associated with the improvement of natural and man-made drainage systems to adequately accommodate stormwater flows.
- Ensure adequate stormwater retention/detention facilities in conjunction with any new or expanded development to prevent increased water flows onto abutting property.
- Examine the adequacy of flood protection facilities and define appropriate actions to address deficiencies.
- Buffer streams and lakes to prevent water quality degradation.
- Prohibit development on steep slopes.
- Protect, the extent possible, areas of endangered species, wetlands, public parks, unique natural areas and other areas with significant natural features.

Evansville-Vanderburgh County I-69 Gateway Subarea Plan (2010)

The Evansville-Vanderburgh County I-69 Gateway Subarea Plan (Subarea Plan) represents a long-term vision for the I-164 (I-69) corridor through Vanderburgh County. This plan was also born of recommendations in the 2004-2025 Comprehensive Plan of Evansville and Vanderburgh County to further study the northeastern portion of Vanderburgh County. The plan highlights the following natural resources goals:

- Explore incentives to encourage stormwater best management practices (BMP's) for new development that preserves or enhances the quality of the local waterways (e.g. Bluegrass or Pigeon Creeks).
- Promote environmental/water quality awareness by providing roadway signage that identifies waterway crossings and watersheds, or by initiatives such as drainage inlet labels indicating that the stormwater run-off drains into local waterways (including the Ohio River).
- Consider providing shared stormwater detention facilities or regional detention for large parcel commercial and industrial development.

- Encourage low impact development adjacent to existing communities resulting in the preservation of open space, farmland, natural features, and critical habitats.

Evansville-Vanderburgh County Unified Development Ordinance (2021)
The Evansville-Vanderburg County Unified Development Ordinance was drafted and completed from 2019-2021. The plan process highlighted the need for organization changes, simplifying ordinance language, and streamlining processes. The following goals that are relevant to the Lower Pigeon Creek Watershed are included:

- Acknowledging that drainage and stormwater management are public concerns.
- Requiring green space in residential, commercial, and industrial zones.
- Properly following floodplain regulations.
- Promoting the use of green infrastructure.

Highland-Pigeon *E. coli* TMDL (2011)
In 2006, the portion of the Highland-Pigeon Creek watershed flowing from Warrick Ditch to an unnamed tributary downstream was listed on Indiana's 303(d) list as impaired for *E. coli*. IDEM conducted a survey of the Highland-Pigeon Creek watershed for *E. coli* in 2007 and for nutrients in September 2009, October 2009, and May 2010. Sites were sampled for *E. coli* September 4, 2007 through October 2, 2007. IDEM completed a reassessment of the reaches within the Highland-Pigeon Creek Watershed using data collected during the 2007, 2009/2010 sampling seasons during the development of the Highland-Pigeon Creek TMDLs. This reassessment indicated that additional assessment units of the Highland-Pigeon Creek Watershed were impaired for both *E. coli* and total phosphorous.

These data indicate that 19 of 27 sample sites exceeded the state geometric mean standard for *E. coli* (125 col/100 ml). Data indicate that the largest exceedances for *E. coli* occur during wet weather events. Dry weather contributions were noted as a source of *E. coli* throughout the watershed as well; however, dry weather contributions were less influential in the watershed than in other areas of the state. Waste load allocations were set for most of the Lower Pigeon Creek Watershed (Table 15) with all numbers shown in MPN/day. IDEM notes that TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a Margin of Safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody.

Table 15. *E. coli* daily loading set for Lower Pigeon Creek Subwatersheds by the Highland-Pigeon TMDL.

Watershed	TMDL Very High (MPN/col)	TMDL High (MPN/col)	TMDL Normal (MPN/col)	TMDL Lower (MPN/col)	TMDL Low (MPN/col)
Headwaters Bluegrass Creek	1716.4	219.4	57.9	8.8	1.8
Bluegrass Creek	None set	None set	None set	None set	None set
Little Pigeon Creek	None set	None set	None set	None set	None set
Headwaters Locust Creek	1715.6	218.6	57.1	8.0	1.0
Locust Creek	1715.6	218.6	57.2	8.0	1.0
Kleymeyer Park-Pigeon Creek	1715.6	218.6	57.1	8.0	1.0

Additionally, the TMDL details previous watershed projects completed in the Highland-Pigeon Watershed. While those details are not repeated here, it should be noted that Vanderburgh County invested more than $603,000 in local, state and federal funds, while Warrick County invested more than $945,000 in local, state and federal funds and Gibson County invested more than $676,000 in local, state and federal funds.

The TMDL notes the following potential future activities:

- Implement best management practices in agriculture, forestry, urban land development and industry to reduce the potential damage to natural resources from human activities.
- Manage riparian areas to protect streambanks and riverbanks with a buffer zone of vegetation.
- Collect, store and handle manure in such a way that nutrients or bacteria do not runoff into adjacent surface waters or leach into groundwater.
- Farm with row patters and field operations aligned at or nearly perpendicular to the slope of the land.
- Practice no-till farming.
- If manure application is desired, sampling and chemical analysis of manure should be performed to determine nutrient content for establishing the proper manure application rate to avoid over application and runoff.
- Install drift fences to direct livestock movement away from streams and prevent direct input of *E. coli* to streams.
- Educate pet owners to improve water quality runoff from urban areas.
- Manage septic systems to provide a systematic approach to reducing septic system pollution. Property maintenance and the removal of illicit discharges can alleviate some of the anthropogenic sources of *E. coli*.
- Plant cover crops to increase soil organic matter, capture and recycle nutrients in the soil profile and minimize and reduce compaction.
- Provide an alternate water source for livestock.
- Utilize low impact development to mimic a sites predevelopment hydrology and infiltrate, filter, store, evaporate or detail stormwater.
- Install bioretention systems as an alterative to a conventional urban best management practice.

Evansville Water and Sewer Utility (EWSU) 'Renew Evansville' (2013)

The first wastewater collectors to be installed in the City of Evansville were the combination storm water and sanitary sewers. These combined sewers were made of brick and many of them were built over 100 years ago. There are over 500 miles of combination sewer lines in the system. The majority of the older areas of the city are served by the combined collectors. During heavy rainfall, Evansville residents are all too familiar with the problems associated with the combined system. These problems include local street flooding, reduced capacity and efficiency of the treatment plant operations caused by treating storm water, sewers backing up into basements, and direct sewage overflow discharge. When the amount of storm water in the system exceeds plant capacity, the overflow gates open to allow the contents of the combined sewers to discharge directly into the Ohio River and Pigeon Creek. These gates and discharges are known as combination sewer overflows (CSOs). There is a total of 22 permitted CSO outfalls in the collection system; nine of these overflow points send combined stormwater and wastewater directly into Pigeon Creek.

The city entered into a Consent Decree with the Environmental Protection Agency (EPA), the Indiana Department of Environmental Management and the U.S Department of Justice. Based on this agreement, EWSU produced an Integrated Overflow Control Plan (IOCP, 2013). EWSU refers to the capital program described in the IOCP as 'Renew Evansville'. It is the City's largest investment in clean water infrastructure and will upgrade the sewer system over 25 years and cost approximately $730 million in 2015 dollars. The IOCP aims to:

- Significantly reduce CSOs into the Ohio River and Pigeon Creek during rain and snowmelt events and address backups and sewer overflows in the separate sanitary sewer system.
- Improve the flood protection infrastructure along Pigeon Creek.
- Reduce sewer overflows should improve water quality in Pigeon Creek specifically targeting reductions in *E. coli*.

The combined sewer system in the Pigeon Creek watershed flow to the west wastewater treatment plant. As described in the IOCP, there are multiple projects planned to reduce the number of CSOs in the Combined Sewer System. The projects basically consist of the following:

- Upgrading the West WWTP.
- Upgrading specific lift and pump stations.
- Inspecting, cleaning, and repairing existing pipes.
- Separating sanitary sewer and storm sewer pipes.
- Installing electronic systems that allow for real-time monitoring of sewer flows.
- Constructing new storage areas to hold sewer water during storm events.
- Use existing pipe network to temporarily store sewer water during storm events.

Specific projects for the combined sewer system are described below as listed in the IOCP (Ch2mHill, 2013).

- Control Measure 3 – West Wastewater Treatment Plant Improvement Projects: Upgrades to the wastewater plant will allow for additional combined sewer flows to be treated during storm events. These improvements include a new Headworks Facility designed and constructed to reliably treat up to the 47 MGD peak secondary treatment capacity. This higher flow rate would be achieved through construction of a pipe that would allow up to 7 MGD of wet-weather flow to be sent directly to the secondary process during events when flow is greater than the 40 MGD primary clarifier capacity. The plan also includes conversion of the disinfection process to hypochlorite.

- Control Measure 4 – Pigeon Creek Interceptor Optimization and Real-Time Control Projects: The Pigeon Creek interceptor is a large pipe that carries sewer water to the west wastewater treatment plant. This pipe will be inspected, cleaned, and repaired as necessary.

  Previously, the utility focused on flood prevention on the city side of the levee for Pigeon Creek. This will be accomplished through improved management of the sewer system. In May 2012, the Utility launched a project to collect and analyze flow and precipitation data in the Pigeon Creek Interceptor in conjunction with levee gate and pump station operational data to better understand the in-system conditions in the interceptor during rain events. This project includes the development of a real-time decision support system to facilitate and direct operational decisions with the goal of capturing more wet-weather flow in the system without causing surface flooding or backups into homes or businesses. It also includes a task to identify potential opportunities to store wet-weather flow in the trunk sewer tributary to the Pigeon Creek Interceptor, and with the same requirement that no surface flooding or backups occur as a result.

- Control Measure 5 – 7th Avenue, Franklin Street, Fulton Avenue, 9th Avenue, and St Joseph Avenue CSO Control Projects: The 7th Avenue Lift Station plays a vitally important role in transferring millions of gallons of wastewater to the West wastewater treatment plant. Currently, the station has no onsite backup power system and only a single screen with no redundancy. This lack of backup equipment poses a high risk for large sewer overflows in the event of a power interruption or problem with the screen.

  To reliably capture and pump wet-weather flows in the future, the Utility determined through its analyses of this facility that it needs to be replaced. The recommended plan would replace the 7th Avenue Lift Station. The station would be designed and constructed to ultimately have a firm pumping capacity of 135 MGD, with 45 MGD being pumped to the West WWTP and 90 MGD being pumped to an onsite storage and ballasted flocculation HRT (Actiflo) treatment facility. Screening, grit removal, and backup power would be included as well.

- Control Measure 6 – Diamond Avenue/Baker Street Sewer Separation and CSO Control Projects: One of the key features is reducing stormwater runoff at key locations to reduce the size and cost of CSO control facilities. The City's 2007 Stormwater Master Plan (Clark Dietz, Inc. 2007) identified several partial sewer separation projects in the Diamond Avenue subbasin that direct street drainage into the 90-inch storm sewer that runs east to west along Diamond Avenue. Each of the projects will include green infrastructure components to provide water quality treatment for the stormwater-borne pollutants. These projects will free up significant capacity in the CSS to convey, store, and treat additional combined flows from other subareas.

  In addition to the sewer separation projects, control of the CSOs from the Diamond Avenue and Baker Street CSOs will be accomplished by constructing an underground CSO storage facility beneath the Diamond Avenue levee pump station and pumping CSO flow from the Baker Street CSO to the storage facility. Stored CSO will be pumped into the Pigeon Creek Interceptor and routed to the West WWTP for treatment.

- Control Measure 7 – Oakley Street CSO Storage Facility: CSO flow from the Oakley Street CSO will be captured in an underground CSO storage facility near the Oakley Street CSO diversion structure. Stored CSO will be drained by gravity into the Pigeon Creek Interceptor and routed to the West WWTP for treatment.

- Control Measure 8 – Oak Hill Sewer Separation and CSO Storage Facility: This control measure includes the Akin Park, State Hospital, Boeke Road Outfall, Weinbach and Keck sewer separation projects from the 2007 Stormwater Master Plan (Clark Dietz, Inc., 2007) and an underground CSO storage facility that will be located near the Oak Hill CSO outfall. Stored CSO will be pumped into the adjacent sewer collection system and routed to the East WWTP for treatment. The areas to be separated are described and presented within the 2007 Stormwater Master Plan.

- Control Measure 10 – 6th Avenue, Dresden Street, Maryland Street, and Delaware Street CSO Control Projects: In this control measure, a CSO storage facility will be constructed near the Delaware Street CSO outfall. A relief sewer system will capture CSO from the Maryland Street, Dresden Street, and 6th Avenue CSOs and route it to the proposed Delaware Street CSO Storage Facility. Stored flow from the CSOs will be pumped into the Pigeon Creek Interceptor and routed to the West WWTP for treatment

Overflows and backups also occur in parts of the separate sanitary sewer system, referred to as sanitary sewer overflows (SSOs). In the Consent Decree, the EPA requires the Utility to eliminate anticipated SSOs. The plan to address SSOs is the Sanitary Sewer Remedial Measure Plan (SSRMP). The goal of the Utility's SSRMP is to prevent sanitary sewer overflows that may occur because of the sewer systems' inability to transport large amounts of sewer water during storm events. The SSRMP focuses on reducing inflow and infiltration (I/I) of stormwater into the separate sanitary sewer pipes and SSO remediation. This means inspecting and repairing broken manholes and pipes.

There are thirteen subbasins in the Pigeon Creek Watershed that are listed as priorities. Each subbasin has multiple manholes and pipes that require repairs. These subbasins are listed in the SSRMP as the following:

- W-8-1 (North Park) Basin
- W-8-3 (North Park) Basin
- W-8-4 (North Park) Basin
- W-8-5 (North Park) Basin
- W-8-6 (North Park) Basin
- W-8-7 (North Park) Basin
- W-9-4 (Allen's Lane North (Skylane) Basin
- E-9-2 (Lloyd) Basin
- E-9-3 (Lloyd) Basin
- E-9-9 (Lloyd) Basin
- E-10-3 (Lloyd) Basin
- E-11-4 (E11, Bergdolt Rd) Basin
- E-11-5 (E11, Bergdolt Rd) Basin

Evansville-Vanderburgh County Comprehensive Plan 2015-2035 (2014)

The 2015-2035 Comprehensive Plan for Evansville and Vanderburgh County is the guide for decisions that relate to land use and the framework for the ongoing land use planning process. The intent is to guide growth in a manner that supports and reinforces the community qualities important to City and County residents. These qualities include employment and housing opportunities, safety and security, quality schools, neighborhoods with a strong sense of community, and a clean environment. The following goals that are relevant to the Lower Pigeon Creek Watershed are included:

- Acknowledge that watershed and environmental efforts in the county, which include Pigeon Creek, must be examined to prevent pollution.
- Investigate techniques, such as overlay zoning, stream buffer zones, or conservation easements, to protect Pigeon Creek and other major creeks as beneficial community resources.
- Support the watershed management and planning efforts for the Ohio River and Pigeon Creek to include working with our state legislators and the Indiana Department of Natural Resources

to gain final determination of Navigability status for Pigeon Creek and funding for maintenance of the creek.
- Get Pigeon Creek designated as a blueway and improve accessibility.
- Update Pigeon Creek Master Plan of 1994.
- Investigate legislative options to ensure consistent maintenance of Pigeon Creek, and for a better method to establish legal drains.

Evansville Bicycle and Pedestrian Connectivity Master Plan (2015)
Bicycling and walking are on the rise in Evansville. From the hustle and bustle of foot traffic in the city's commercial and historic districts to the crowds of cyclists, joggers and hikers on the Pigeon Creek Greenway, residents and visitors alike are choosing walking and bicycling for transportation and recreation. This master plan notes that the Pigeon Creek Greenway is the longest, most popular corridor for bicycling in Evansville. The following goals are identified that are relevant to the Lower Pigeon Creek Watershed:
- Environmental benefits include reduced automobile use.
- Access to and awareness of the region's natural resources.

Evansville Downtown Master Plan (2017)
The Downtown Evansville Master Plan Update identifies priorities for downtown improvements, policies and actions for the next five-to-seven-year investment cycle. It was initiated in mid-2015 by the Evansville Redevelopment Commission (ERC). The following goals are identified that are relevant to the Lower Pigeon Creek Watershed:
- Street elements may include green infrastructure to reduce stormwater runoff.
- The need to collect and store stormwater in the urban core will provide opportunities to create urban parks and complete streets.

Watershed Management Plan for Pigeon Creek in Gibson County, Indiana (2022 draft)
The Pigeon Creek in Gibson County watershed plan identifies the top threats to water quality in the headwaters of Pigeon Creek and provides an action plan to address those threats over the next 25 years. These include soil erosion and sedimentation; water quality and drinking water supplies; litter, trash and other materials in streams; soil health, productivity and fertility; flooding and excess water during heavy rains; streambank protection and stabilization; non-native, invasive species; logjams and beavers; heavy metals, petroleum, toxics and inorganic pollution; wildlife habitat; wastewater treatment; air pollution; drainage and tiling, livestock manure, CFOs; excess nutrients in surface and ground water; forest management; insufficient water and drought; failing septic systems and lack of maintenance; wetland restoration needs; outdoor recreation and solar and wind turbines. Protecting water quality in the headwater of Pigeon Creek will require reducing phosphorus, nitrogen, sediment, and *E. coli* loads entering Pigeon Creek and its tributaries from the watershed over the next 25 years. The action plan includes:
- Increasing the adoption of best management practices.
- Promoting buffer enhancement and practice which emphasize livestock management.
- Working with contractors and the health department to promote septic system education.
- Conducting spring and fall tillage transects.
- Public education about soil erosion and conservation practices; livestock and pasture management and best management practices.

- Pooling resources with partners to promote BMPs, monitoring and education efforts.
- Implementing Section 319, CWI and other cost-share programs to implement BMPs that enhance wetland riparian habitat.
- Promoting CRP, WRP, CREP and other cost-share programs.
- Improving water quality through better habitat and land management targeting nonpoint sources.
- Encouraging new producers to enroll in cost-share programs.
- Pursuing mutually beneficial partnerships with local organizations.

2.12 Watershed Summary: Parameter Relationships

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 Lower Pigeon Creek Watershed have a direct correlation to water quality. Approximately 90% of the Lower Pigeon Creek Watershed is mapped in highly erodible land. Highly erodible land is very susceptible to erosion. Nutrients, such as phosphorus, and sediment erode easily when these soils are not covered. Sediments and nutrients that reach Lower Pigeon Creek 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.

Topography within the watershed is generally flat in the headwaters of the Lower Pigeon Creek Watershed with topography increasing as water moves south through 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 85% of the watershed headwaters are in a corn-soybean rotation with nearly 35% of the entire Lower Pigeon Creek Watershed in agricultural row crop production. Because of the low slope and poor drainage, tile drains are extensively used throughout the headwaters portion of 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 riparian areas in the watershed where forested land uses predominate. 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 are found. Protecting and restoring the forested riparian buffer in this area will be important to reducing streambank erosion and in-stream sediment levels.

2.12.2 Development and Population Centers

Much of the watershed's population is located within incorporated areas including the City of Evansville and Towns of Elberfeld, McCutchanville and Darmstadt. While much of the watershed drains to one of the city's wastewater treatment plants, septic systems are used throughout nearly one-third of the watershed. 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 Lower Pigeon Creek Watershed stakeholders. The highest impervious surface densities and highest number of NPDES-regulated facilities occur within these urban population centers and are home to the most urban development issues including high densities of impervious surfaces and legacy pollutants from brownfields, leaking underground storage tanks (LUST), a Superfund site and industrial waste sites. The concentration of urban pollution issues suggests that within these areas, urban solutions are required to control water quality pollution and improve conditions within the Lower Pigeon Creek Watershed.

2.12.3 High Quality Habitat and Wetlands and Floodplains

Hydric soils denoting historic wetland locations and floodplains occur along the mainstem of Lower Pigeon Creek as well as lower portions of Bluegrass Creek, Little Pigeon Creek and other tributaries. While some of the high-quality areas are preserved by the Indiana DNR and city and county parks, large areas with heavy forest cover and steep topography associated with riparian areas which provide unique habitats remain unprotected. The topography, bedrock and soils in these areas support ravines and mature forest habitats that 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. Former wetland locations and riparian floodplains are especially important to protect and preserve as these areas provide a direct connection to groundwater and can concentrate negative impact making these important areas 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 Lower Pigeon Creek 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 16 details the selected parameters and the benchmark utilized to evaluate collected water quality data.

Table 16. Water quality benchmarks used to assess water quality from historic and current water quality assessments.

Parameter	Water Quality Benchmark	Source
Dissolved oxygen	>4 mg/L or <12 mg/L	Indiana Administrative Code
pH	>6 or <9	Indiana Administrative Code
Temperature	Monthly standard	Indiana Administrative Code
Conductivity	<1050 μmhos/cm	Indiana Administrative Code
E. coli	<235 colonies/100 mL	Indiana Administrative Code
Nitrate-nitrogen	<1.5 mg/L	Dodds et al. (1998)
Ammonia-nitrogen	0.0 – 0.21 mg/L	Indiana Administrative Code
Total Kjeldahl nitrogen	0.57 mg/L	USEPA (2000)
Total phosphorus	<0.08 mg/L	Dodds et al. (1998)
Orthophosphorus	<0.05 mg/L	Dunne and Leopold (1978)
Total suspended solids	<15 mg/L	Waters (1995)
Turbidity	<5.7 NTU	USEPA (2000)
Qualitative Habitat Evaluation Index	>51 points	IDEM (2008)
Index of Biotic Integrity	>36 points	IDEM (2008)
Macroinvertebrate Index of Biotic Integrity	>2.2 points (old) >36 points (new)	IDEM (2008)

3.2 Historic Water Quality Sampling Efforts

A variety of water quality assessment projects have been completed within the Lower Pigeon Creek Watershed (Figure 27). Statewide assessments and listings include the impaired waterbodies assessment and fish consumption advisories. Additionally, the Indiana Department of Environmental Management (IDEM), Indiana Department of Natural Resources (IDNR), U.S. Geological Survey (USGS), GLEON, Harza and Arion Consultants have all completed assessments within the watershed. A summary of each assessment methodology and general results are discussed below. Specific data results are detailed within subwatershed discussions in subsequent section.

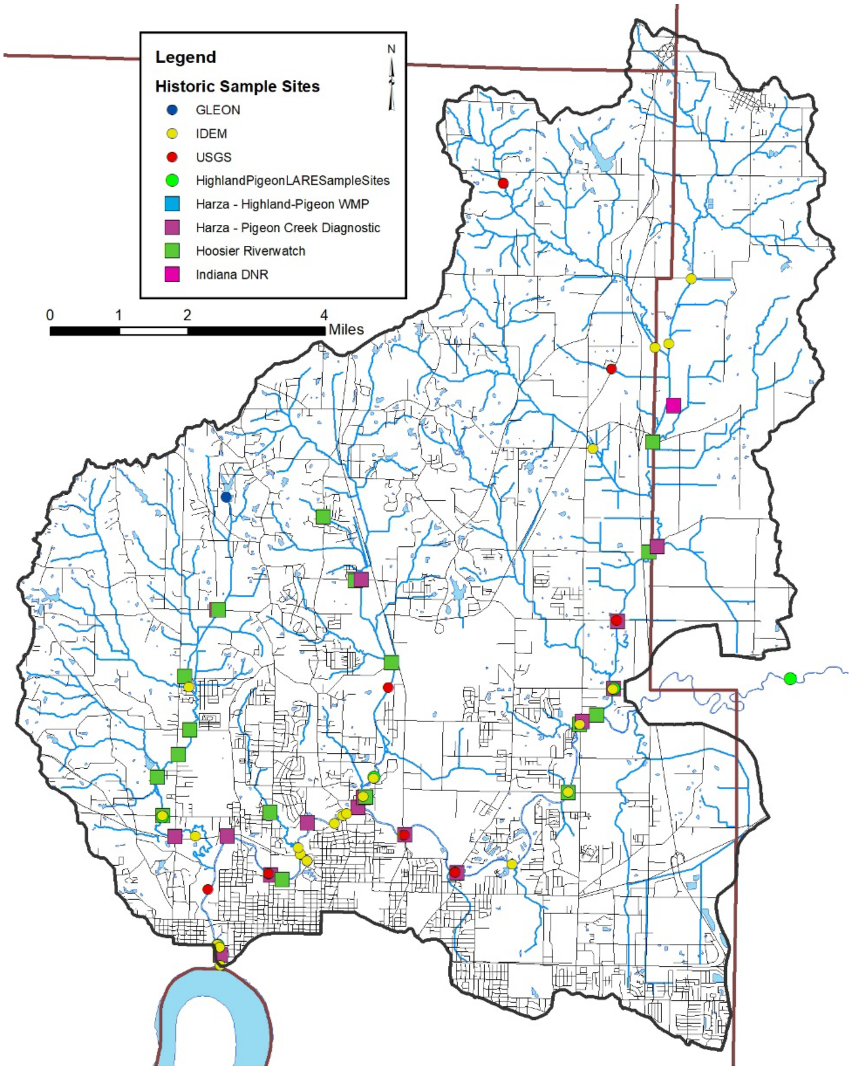

Figure 27. Historic water quality assessment locations.

3.2.1 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. Nearly 25 stream segments within the Lower Pigeon Creek Watershed are included on the list of impaired waterbodies (IDEM, 2018). Table 17 and Figure 28 details the listings in the watershed, while Figure 28 maps the segments and their locations within the watershed. Waterbodies are listed as impaired for *E. coli* (32.2 miles), nutrients (6.8 miles), impaired biotic communities (<0.1 miles), dissolved oxygen (24.8 miles), and PCBs in fish tissues (1.6 miles).

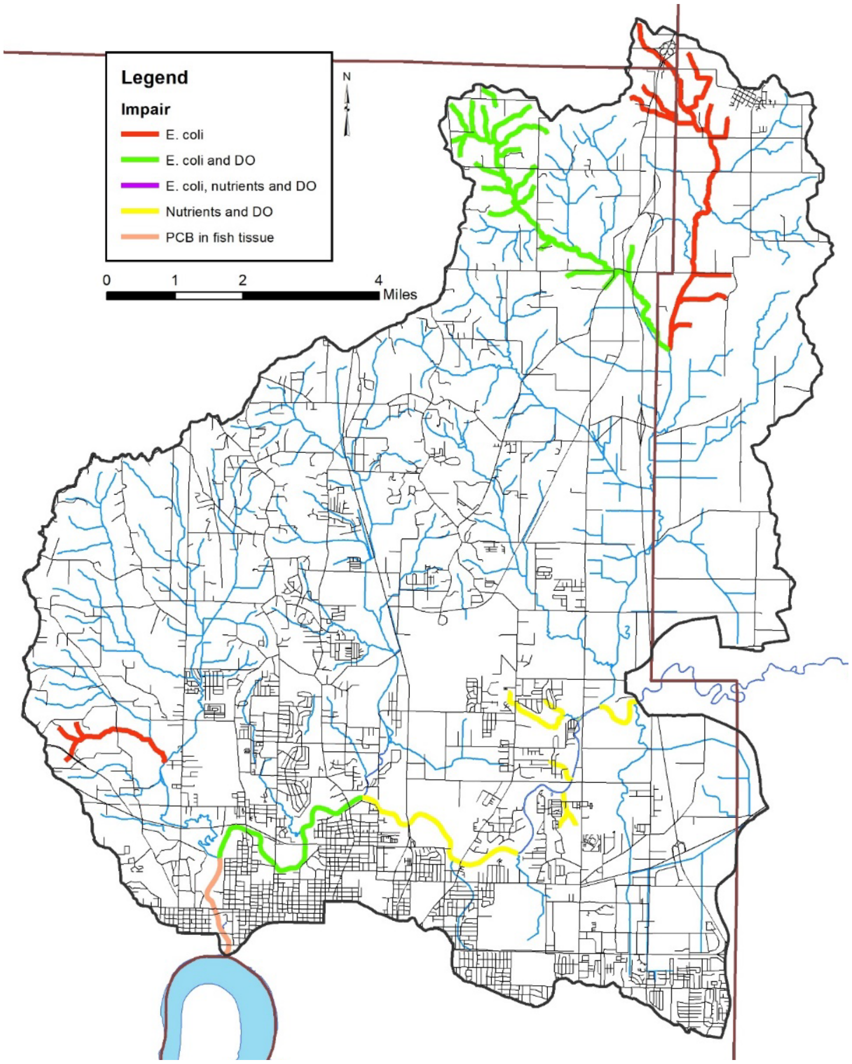

Figure 28. Impaired waterbody locations in the Lower Pigeon Creek Watershed. Source: IDEM, 2020.

Table 17. Impaired waterbodies in the Lower Pigeon Creek Watershed 2020 IDEM 303(d) list.

Stream Segment	Segment ID	Impairment	Length (miles)
Pigeon Creek	INE0224_01	*E. coli*	0.0008
Bluegrass Creek – Unnamed Tributary	INE0231_02	*E. coli*	13.6
Bluegrass Creek – Unnamed Tributary	INE0231_T1001	*E. coli*	2.8
Locust Creek	INE0234_01	*E. coli*	5.2
Locust Creek – Unnamed Tributary	INE0234_T1001	*E. coli*	1.4
Locust Creek – Unnamed Tributary	INE0234_T1002	*E. coli*	1.3
Locust Creek – Unnamed Tributary	INE0234_T1003	*E. coli*	6.6
Locust Creek – Unnamed Tributary	INE0234_T1004	*E. coli*	0.7
Locust Creek – Unnamed Tributary	INE0234_T1005	*E. coli*	6.5
Locust Creek – Unnamed Tributary	INE0234_T1006	*E. coli*	2.9

Stream Segment	Segment ID	Impairment	Length (miles)
Locust Creek – Unnamed Tributary	INE0234_T1007	*E. coli*	0.9
Locust Creek	INE0235_01	*E. coli*	5.1
Pigeon Creek	INE0224_01	IBC	0.0008
Bluegrass Creek	INE0231_01	*E. coli*	11.6
Bluegrass Creek – Unnamed Tributary	INE0231_02	Dissolved oxygen	13.6
Locust Creek – Unnamed Tributary	INE0235_T1002	*E. coli*	2.6
Pigeon Creek	INE0236_01	Nutrients	8.3
Pigeon Creek	INE0236_02	PCBS in fish tissue	3.6

3.2.2 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. Advisories listings from the 2017 report (ISDH, 2017) 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:

- In Vanderburgh County, sensitive and general populations should not consume channel catfish up to 20 inches in size more than one time per month, crappie species of all sizes more than one meal per week, flathead catfish up to 16 inches more than one meal per month and not consume those over 16 inches in size, freshwater drum one meal per month, largemouth bass more than one meal per week, spotted bass more than one meal per month and sunfish more than one meal per week.
- In Warrick and Gibson Counties, sensitive and general populations should follow statewide consumption guidance which include not consuming buffalo species up to 23 inches more than one meal per week or larger than 23 inches more than one meal per month, bullhead species more than one meal per week, carpsucker species up to 16 inches more than one meal per week and larger than 16 inches more than one meal per month, channel catfish up to 21 inches more than one meal per week and larger than 21 inches more than one meal per month, common carp up to 20 inches more than one meal per week, 20-30 inches mor than one meal per month and not eating those over 30 inches in size, crappie species of all sizes more than one meal per week, flathead catfish up to 19 inches more than one meal per week and larger than 19 inches more than one meal per month, freshwater drum up to 15 inches more than one meal per week and over 15 inches more than one meal per month, largemouth bass up to 16 inches more than one meal per week and over 16 inches more than one meal per month, northern pike up to 30 inches more than one meal per week and over 30 inches more than one meal per month, redhorse

species up to 23 inches more than one meal per week and over 23 inches more than one meal per month, rock bass all sizes one meal per month, sauger up to 14 inches on meal per week and over 14 inches one meal per month, silver carp over 14 inches one meal per week, smallmouth bass up to 14 inches one meal per week and over 14 inches one meal per month, spotted bass up to 10 inches on meal per week and over 10 inches one meal per month, sunfish species of all sizes one meal per week, walleye up to 19 inches one meal per week and over 19 inches one meal per month and white/striped/hybrid bass up to 12 inches one meal per week and over 12 inches on meal per month.

3.2.3 U.S. Geological Survey Assessments (1989-2014)

The USGS assessed streams within the Lower Pigeon Creek Watershed at 8 locations. Based on the USGS assessments, the following conclusions can be drawn:
Limited data were collected at each of the 22 sampling locations with most sites possessing less than 8 water quality samples.

- Field measurements, including dissolved oxygen, temperature, and hardness measure within standard ranges at all sites.
- Chlorophyll a concentrations and periphyton biomass are within standard levels at all sites.
- *E. coli* data collected at six sites indicate that concentrations routinely exceeded targets.

3.2.4 IDEM Rotational Basin Assessments (1992-2019)

From 1992 to 2019, IDEM sampled water chemistry, macroinvertebrates, fish and habitat at several locations in the Lower Pigeon Creek Watershed via their rotational basin, watershed assessment, and source ID assessment programs. Additionally, one site on Pigeon Creek at 1st Avenue is sampled monthly as part of IDEM's fixed station monitoring program. A few of the assessments which occurred via various IDEM assessment program included a single sample event with most assessments including five sample events and a few assessments including up to 12 events. Based on the water chemistry assessments, the following conclusions can be drawn:

- *E. coli* concentrations exceeded the state standard in 46% of fixed station samples and in 46% of all other samples collected in the Lower Pigeon Creek Watershed.
- Nitrate-nitrogen concentrations exceeded target concentrations in 55% of fixed station samples and in 21% of all other samples collected in the Lower Pigeon Creek Watershed.
- Total phosphorus concentrations exceeded the recommended criteria in 94% of fixed station samples and in 77% of all other samples collected in the Lower Pigeon Creek Watershed.
- Total suspended solids concentrations exceeded the recommended criteria in 79% of fixed station samples collected in the Lower Pigeon Creek Watershed.
- Turbidity levels routinely exceed the recommended standard in more than 69% of fixed station and 52% of all other samples collected in the Lower Pigeon Creek Watershed.
- Conductivity levels exceeded the state standard in 52% of fixed station samples and in 25% of all other samples collected in the Lower Pigeon Creek Watershed.
- Macroinvertebrate community assessments occurred at two Pigeon Creek sites, two Bluegrass Creek sites and in a tributary to Bluegrass Creek. mIBI scores indicate that Lower Pigeon Creek and its tributaries rate as severely impaired using the kick net sampling procedure and rate as non-supporting using multimetric habitat approach.
- Fish community assessments occurred in Bluegrass Creek, a tributary to Bluegrass Creek and Pigeon Creek. IBI scores indicate that Lower Pigeon Creek and its tributaries rate as poor. IDEM

notes that at sites that rate as poor "top carnivores and many expected species absent or rare, omnivores and tolerant species dominant".

- Habitat assessments completed along Lower Pigeon Creek and its tributaries indicate that habitat is non supporting for aquatic life uses with scores from assessments occurring in concert with macroinvertebrate community assessments ranging from 29 to 46.

3.2.5 Indiana DNR (1986, 1992, 2004)

The Indiana Department of Natural Resources (IDNR) assessed the fish community in the Pigeon Creek Watershed in 1986 and again in 1992 and assessed Blue Grass and Loon Pits in 2004 (Doll, 2005). Based on these reports, the following conclusions can be drawn:

- Assessments completed in 1986 indicate that the tributaries to Pigeon Creek provide better habitat and are home to higher fish community density and diversity than the mainstem sites. DNR fisheries biologists attributed this difference to the high siltation levels and elevated turbidity found in the Pigeon Creek mainstem (Schultheis, 1986).
- As part of the 1986 assessment, DNR biologists noted that fish kills were common in the Pigeon Creek Watershed, that the mainstem was turbid due high levels of erosion, open banks and higher siltation levels. Further, it was noted that below Elberfeld, Pigeon Creek was more palustrine than riverine and was choked with emergent and floating vegetation and algal blooms were common.
- DNR fisheries biologists compared the 1986 assessment to one completed in 1942 noting that 34% of fish species collected in 1942 were not collected during the 1986 assessment. DNR details that most of the species that were not collected are adversely affected by siltation and noted that several species lost are specifically riffle species suggesting that this represents a decline in riffle habitat and silting of the stream.
- The 1992 fish community assessment focused on the City of Evansville and Pigeon Creek's urban fisheries potential (Stefanavage, 1994). DNR assessed three Pigeon Creek sites within the City of Evansville collecting 21 species. Gizzard shad dominated the community by number and common carp dominated by weight representing more than 53% of the community. All field parameters were within state standards with the exception of the conductivity measurement at the most upstream site which measured nearly double the state standard.
- Largemouth bass collected from Blue Grass Pit ranged in size from 3.5 to 20.7 inches and weighed 154 pounds (Doll, 2005). The proportional stock density (PSD) rated as 13 which is an improvement from the PSD measured in 2001 (5). However, as a healthy, balanced fishery PSD ranges from 40-70 the PSD in Blue Grass Pit is considered low.
- Largemouth bass collected in Loon Pig scored a PSD of 6 which is down from 17 in 2000 and 13 in 2001.
- The best fishing at Blue Grass and Loon pits is for crappie, channel catfish and catch and release for largemouth bass. Fishing pressure is considered moderated in Blue Grass Pit and low in Loon Pit.

3.2.6 Pigeon Creek Watershed Diagnostic Study and Highland-Pigeon Watershed Management Plan

Harza developed the Pigeon Creek Diagnostic Study in three volumes from 2000 to 2001 and these data were used to develop the Highland-Pigeon Watershed Management Plan in 2003 (Harza, 2000; Montgomery Watson Harza, 2001A, 2001B and 2003). None of the sample sites included in the three diagnostic studies or the watershed management plan overlap. In total, Harza monitored chemistry, habitat, and macroinvertebrate communities at 43 sites throughout the Highland-Pigeon Watershed of which 15 sites are located in the Lower Pigeon Creek Watershed. Diagnostic study sites monitoring occurred twice annually and watershed management plan sites monitored once in total. As monitoring occurred nearly continuously from 1999 through 2002 as part of these two projects, their data are summarized together. Based on the Harza assessments completed to develop the diagnostic study, the following conclusions can be drawn:

- Temperature and pH are generally within standard ranges (6-9). Only 2 of 30 samples or 7% exceeded pH concentrations. Those measurements were above the upper pH water quality standard.
- Conductivity concentrations exceeded state water quality standard (1050 cm/μmhos) in 63% of collected samples. These concentrations suggest that point sources may be a concern in the Lower Pigeon Creek Watershed.
- Dissolved oxygen concentrations routinely measured above the upper dissolved oxygen state standard (12 mg/L) suggesting streams were supersaturated with dissolved oxygen at the time of the assessments.
- Total Kjeldahl nitrogen concentrations (0.59 mg/L) exceeded water quality targets in 23% of collected samples; however, overall concentrations were relatively low.
- Total phosphorus concentrations exceed target concentrations (0.08 mg/L) during 28 of 32 samples or in nearly 93% of collected samples, while nitrate-nitrogen concentrations exceed target concentrations (1.5 mg/L) during 2 of 32 samples (7%).
- Total suspended solids concentrations exceeded water quality targets (15 mg/L) In 21 of 32 samples or 70% of those collected. Concentrations measured as high as 200 mg/L.
- *E. coli* concentrations exceeded state standards (235 col/100 mL) in 14 of 32 collected samples (47% of samples). Concentrations in excess of state standards as high as 24,000 colonies/100 mL.

3.2.7 Highland-Pigeon Monitoring Study (Arion Consultants, 2018)

In 2018, Arion Consultants sampled eight stream sites in the Highland-Pigeon Watershed to assess the impact of Lake and River Enhancement Program-funded conservation practices. Four of those sites are located in the Lower Pigeon Creek Watershed. Based on these data, the following conclusions can be drawn:

- Dissolved and particulate phosphorus concentrations were elevated throughout the watershed under all sampling conditions. Orthophosphorus, or dissolved phosphorus, comprised a majority of the phosphorus present within the system. This indicates that phosphorus is readily available by for use by plants and algae.
- Total Kjeldahl nitrogen concentrations measured above EPA target concentrations; however, concentrations were generally low throughout the Highland-Pigeon Watershed.
- Nitrate-nitrogen concentrations were elevated throughout the watershed, with all sites exceeding the concentration at which eutrophication occurs.
- Total suspended solids and *E. coli* concentrations measured low under base flow conditions but exceeded TSS targets and *E. coli* state standards at all sites under storm flow conditions. Conductivity was elevated in Smith Fork, Big Creek, Bluegrass Creek, and Pigeon Creek at Barnes Ditch.

- Under base and storm flow conditions, Pigeon Creek at the Pigeon Creek outlet possessed the greatest loads for all parameters except ortho and total phosphorus under storm flow conditions. These results are to be expected, since these sites possess the largest drainage areas.
- Macroinvertebrate communities rated as moderately to slightly impaired at all sites assessed in the Lower Pigeon Creek Watershed.
- Three of four sites scored habitat assessments lower than the target score (51). Habitat was generally limited by poor instream cover, limited channel developed and the absence of quality pool-riffle complexes.

3.2.8 Hoosier Riverwatch Sampling (2002-2020)

From 1999 to present, volunteers trained through the Hoosier Riverwatch program assessed 16 sites within the Lower Pigeon Creek Watershed. As part of monitoring efforts, volunteers monitored stream stage, flow rate, and discharge; collected water chemistry samples for analysis using HACH test kits and test strips; assessed instream habitat using the Citizen's QHEI; and surveyed the streams' macroinvertebrate communities. 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:

- Dissolved oxygen concentrations exceed water quality standards in 12% of collected samples.
- Turbidity exceeded water quality targets in 38% of collected samples.
- Orthophosphorus concentrations exceeded target concentrations during more than 91% of collected samples.
- Nitrate-nitrogen concentrations exceed target concentrations in 38% of samples.
- *E. coli* samples exceed state standards in 52% of collected samples.
- Hoosier Riverwatch data collected indicate fair to good quality conditions and a moderate to severe Pollution Tolerance Index during all assessments.

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

3.3.1 Water Quality Sampling Methodologies

As part of the current project, the Lower Pigeon Creek Watershed Project implemented a one-year water quality monitoring program. The program included monthly water chemistry sample collection and one macroinvertebrate community and habitat assessment. The program is detailed below and in the Quality Assurance Project Plan for the Lower Pigeon Creek Watershed Management Plan approved on March 17, 2021. Sites sampled through this program are displayed in Figure 29. Sample sites were selected based watershed drainage and correspond with sites sampled by IDEM in the past. The monthly sampling regimen was enacted to create a baseline of water quality data.

Stream Flow

Stream flow was calculated by scaling stream flow measured at the U.S. Geological Survey (USGS) stream gages to subwatershed drainage area during high flow events. The Pigeon Creek USGS gage near Fort Branch (USGS 03322011) was used for tributary stream sites, while the Big Creek near Wadesville (USGS 03378550) was used to scale flow for the outlet of Pigeon Creek.

Field and Laboratory Chemistry Parameters

The Lower Pigeon Creek Watershed Project established eight chemistry monitoring stations as part of the monitoring program. Dissolved oxygen, temperature, pH, turbidity, conductivity, nitrate-nitrogen, total phosphorus, *E. coli* and total suspended solids were measured monthly at the sampling stations. Sampling occurred from April 2021 through March 2022. Appendix B details the parameters measured.

Biological Community and Habitat

The physical habitat at each of the 8 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. Macroinvertebrate communities were assessed using the macroinvertebrate Index of Biotic Integrity (mIBI) with all 8 sites assessed in the fall of 2021.

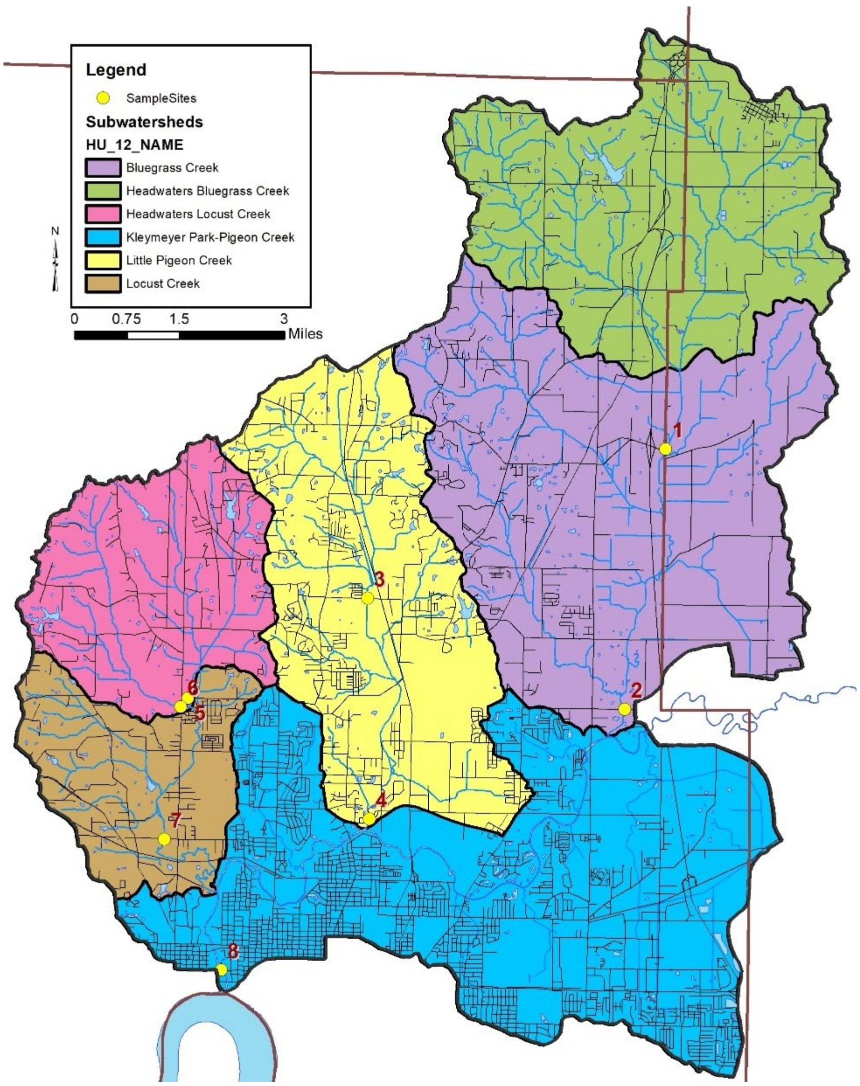

Figure 29. Sites sampled as part of the Lower Pigeon Creek Watershed Management Plan.

3.3.2 Field Chemistry Results

Figure 30 through Figure 35 display results for non-nutrient field chemistry data collected monthly at the eight sample sites. At each of the stream sites, a multi parameter probe was deployed during each sampling event. The probe collects data for temperature, dissolved oxygen, specific conductivity, and pH. All field chemistry results are contained in Appendix B.

Temperature

Figure 30 illustrates the monthly temperature measurements in the watershed streams. 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 between 36.3 to 80.6 °F in all streams. The highest temperatures occurred during the July, August and September assessments depending on riparian cover and stream depth present at each location.

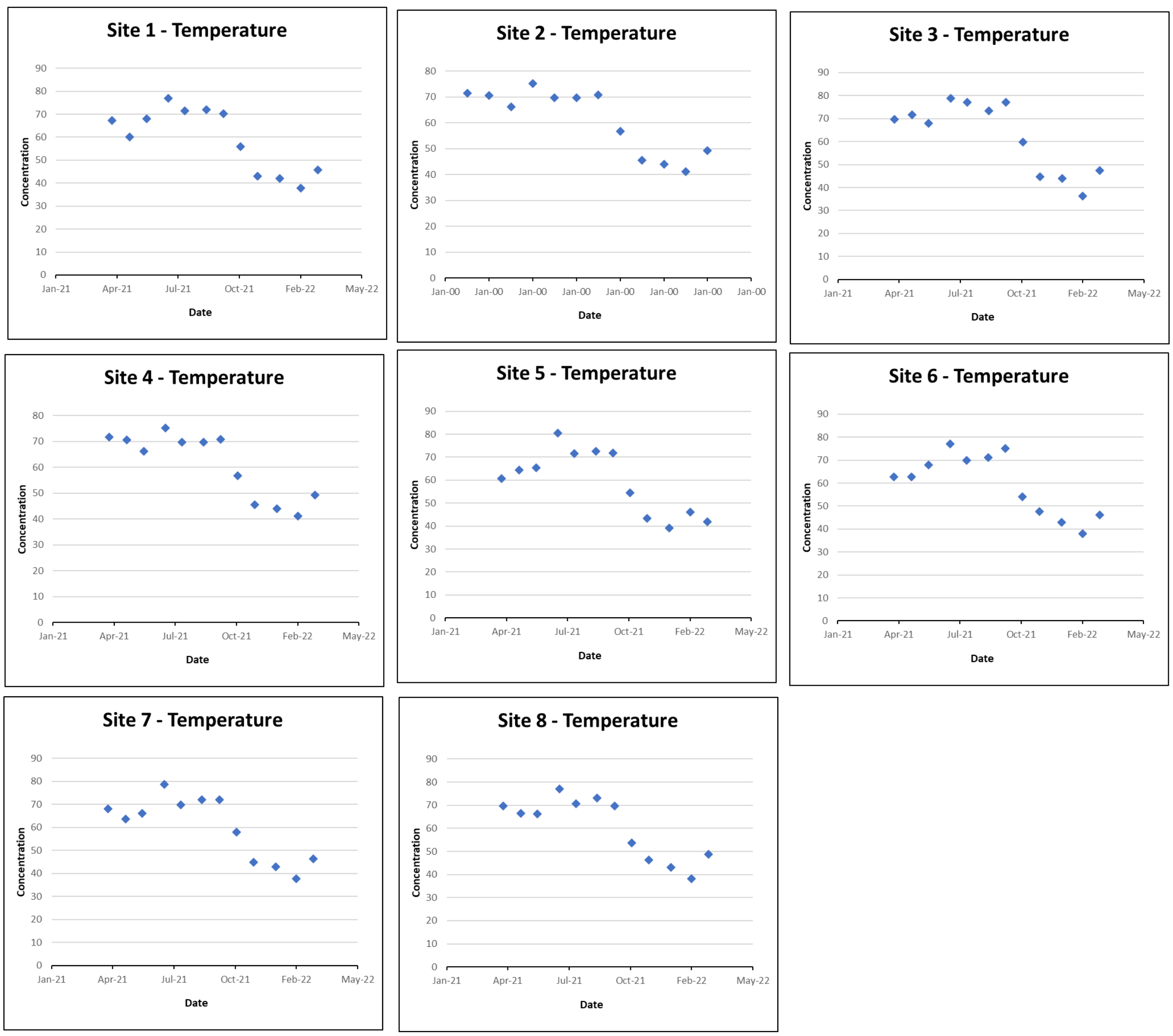

Figure 30. Temperature measurements in Lower Pigeon Creek Watershed samples sites from April 2021-March 2022. Note differences in scale along the concentration (y) axis.

Dissolved Oxygen

Dissolved oxygen concentrations also display seasonal changes like those observed for temperature. However, as shown in Figure 31, 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 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 Site 5 during November 2021. The highest DO concentrations occurred during the January and February sampling events with all but one site (Site 8) exceeding the upper DO water quality standard. In total, 35% of samples (34 of 96 samples) measured above the upper or below the lower dissolved oxygen state standard (4 m/g/L).

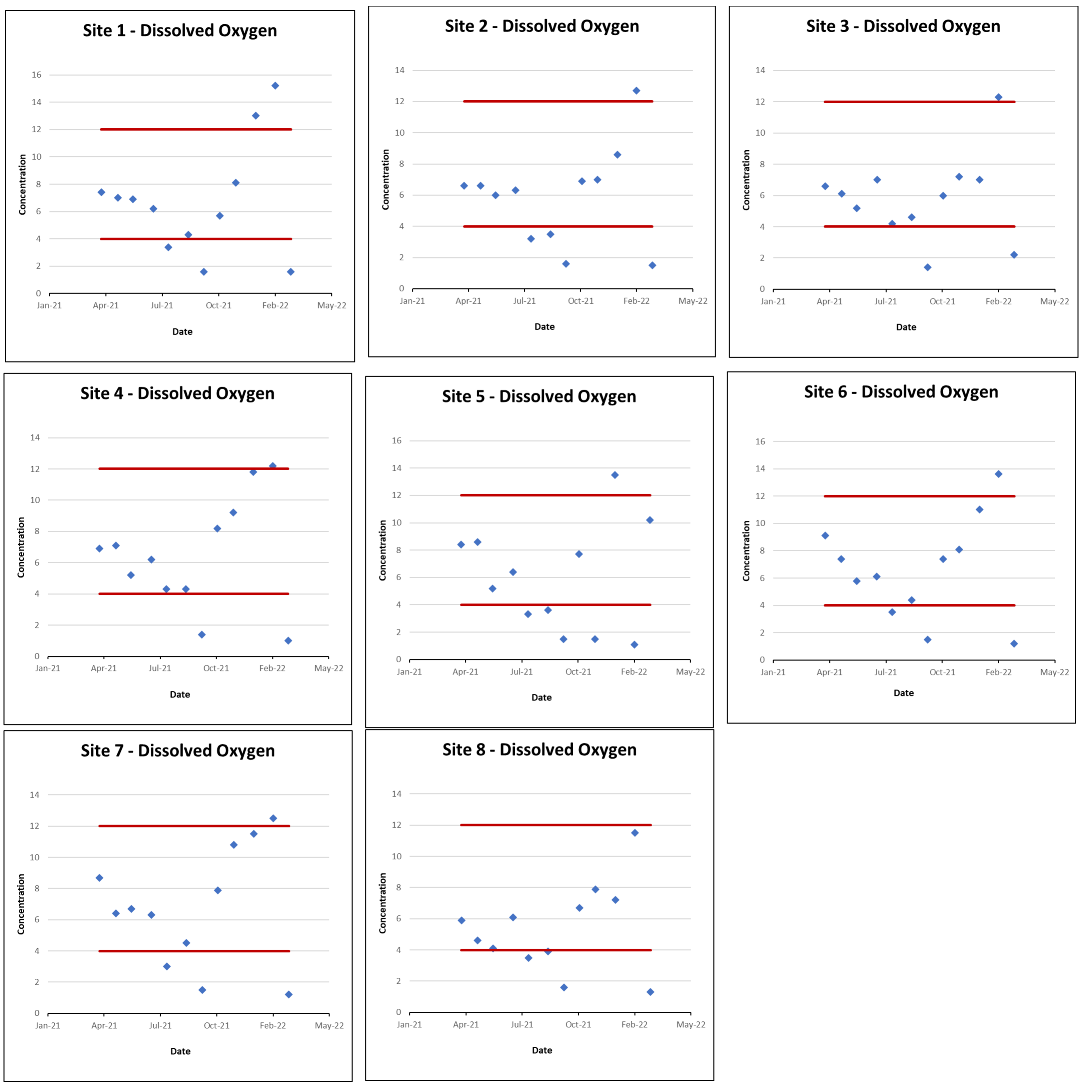

Figure 31. Dissolved oxygen measurements in Lower Pigeon Creek Watershed samples sites from April 2021-March 2022. Note differences in scale along the concentration (y) axis.

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 32). One sample (Site 1 during February 2022) measured above the upper pH state standard (9.0). Elevated pH levels may be due to algal activities.

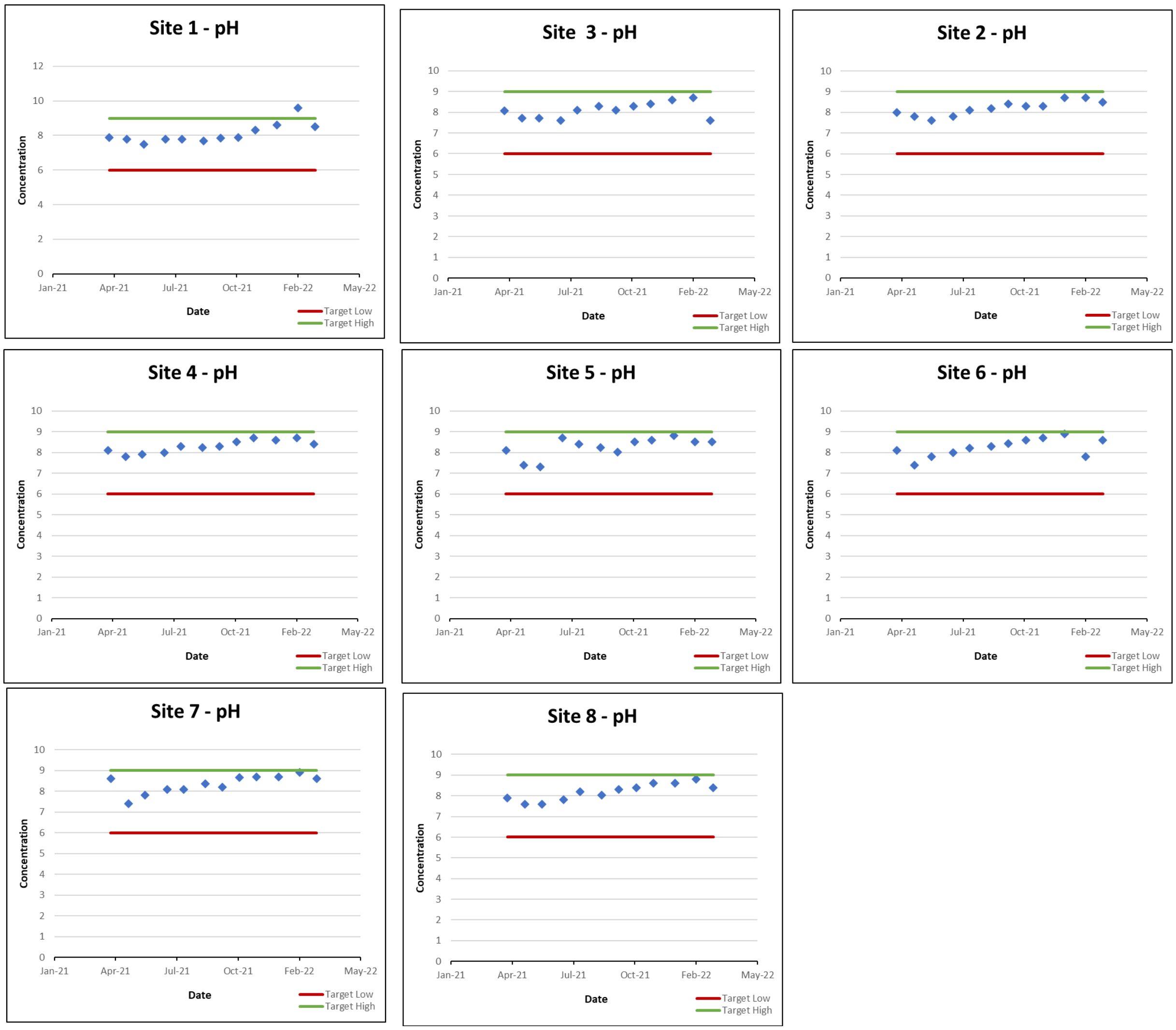

Figure 32. pH measurements in Lower Pigeon Creek Watershed samples sites from April 2021-March 2022.

Specific Conductivity

Figure 33 displays conductivity measurements in the watershed streams. Conductivity measurements varied greatly over the sampling period. Conductivity exceeded state standard (1060 S/cm) three times: Site 8 during the June 2021 sampling event and Site 2 during the August and October 2021 sampling events. Conductivity did not exceed state standards at any other sites.

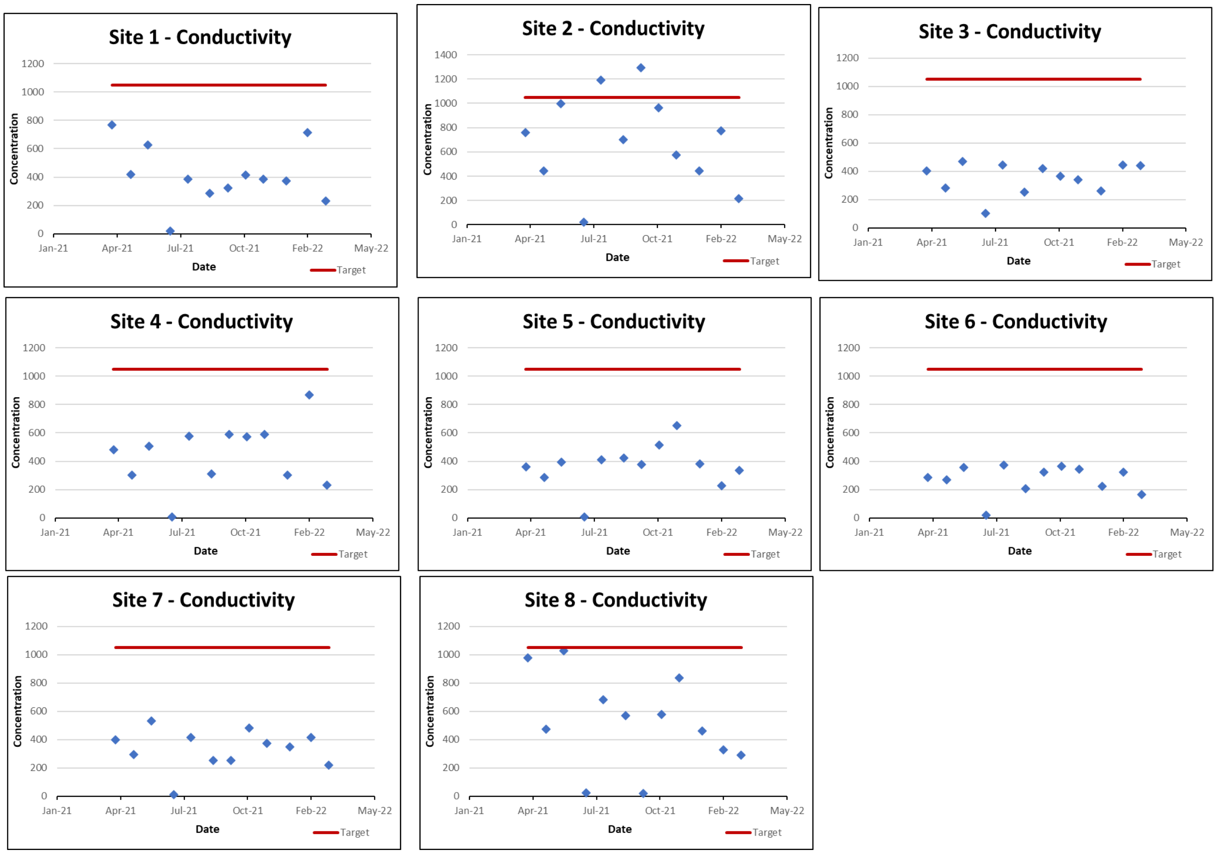

Figure 33. Conductivity measurements in Lower Pigeon Creek samples sites from April 2021-March 2022.

Turbidity

Figure 34 displays conductivity measurements in the watershed streams. Turbidity measurements varied greatly over the sampling period. Turbidity exceeded target levels at all sites during the July 2021 sampling event, which occurred following 1.2 inches of rain. In total, 33 of 96 samples exceeded turbidity targets (5.7 NTU) with 34% of samples exceeding targets during the sampling period.

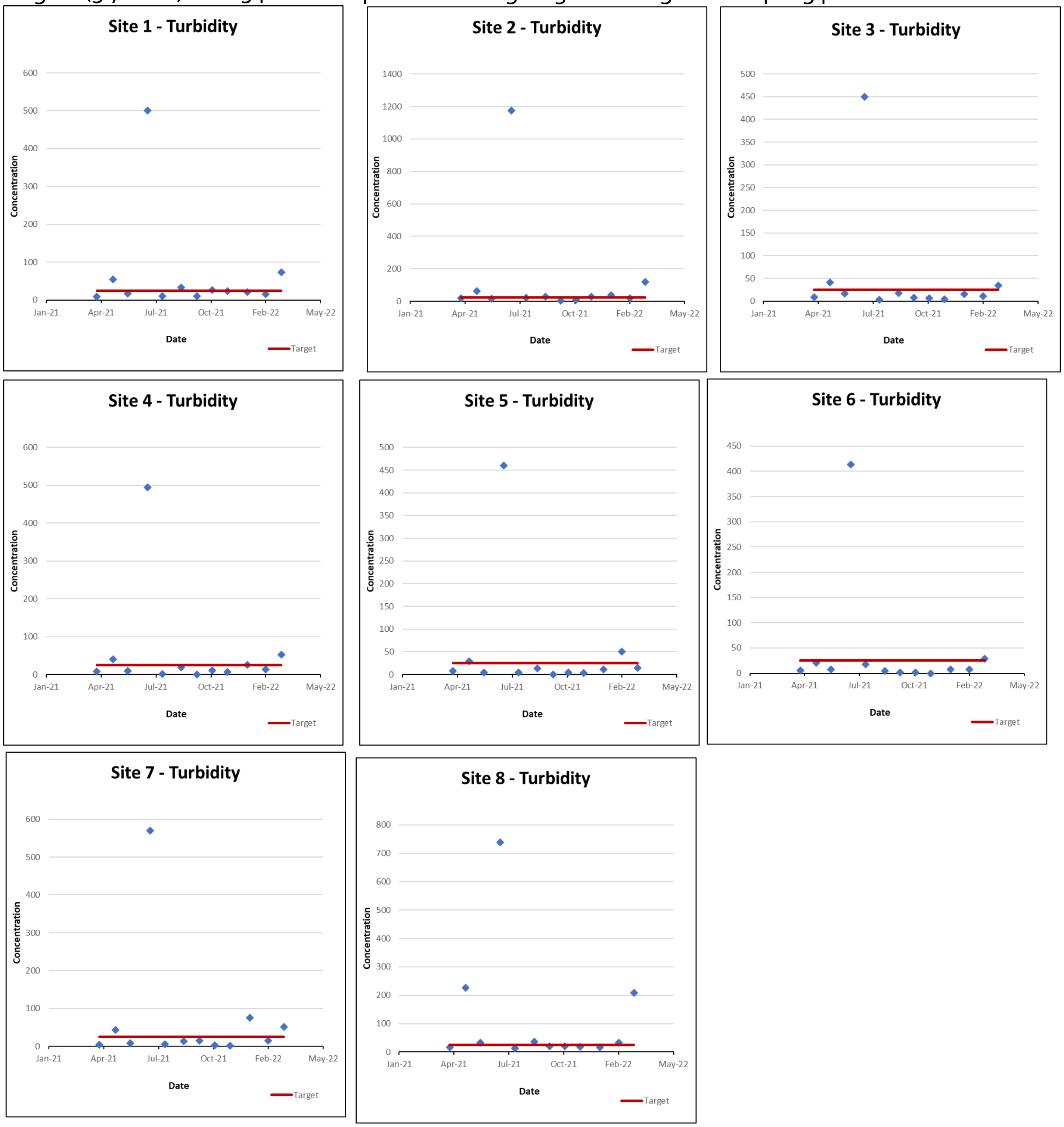

Figure 34. Turbidity measurements in Lower Pigeon Creek samples sites from April 2021-March 2022.

3.3.3 Water Chemistry Results

Figure 35 to Figure 38 display results for nitrate-nitrogen, total phosphorus, total suspended solids, and *E. coli* collected biweekly from twelve locations in the Lower Pigeon Creek Watershed. Data are displayed in comparison to target concentration and on load duration curves during the sample period. Appendix C details individual measurements collected throughout the sampling period.

Nitrate-nitrogen

Figure 35 displays nitrate-nitrogen concentrations compared to target levels (1 mg/L). As shown below, nitrate-nitrogen concentrations exceeded target levels in more than 47% of collected samples (45 of 96). However, Sites 3 and 4 always measured under the nitrate-nitrogen target level. Nitrate-nitrogen concentrations measured the highest during the spring, falling throughout the summer and increasing again in the fall. Sites 1, 6, 7 and 8 possessed the highest average concentrations. These sites averaged nitrate-nitrogen concentrations higher than the median concentration at which biological communities are impaired (1.0 mg/L).

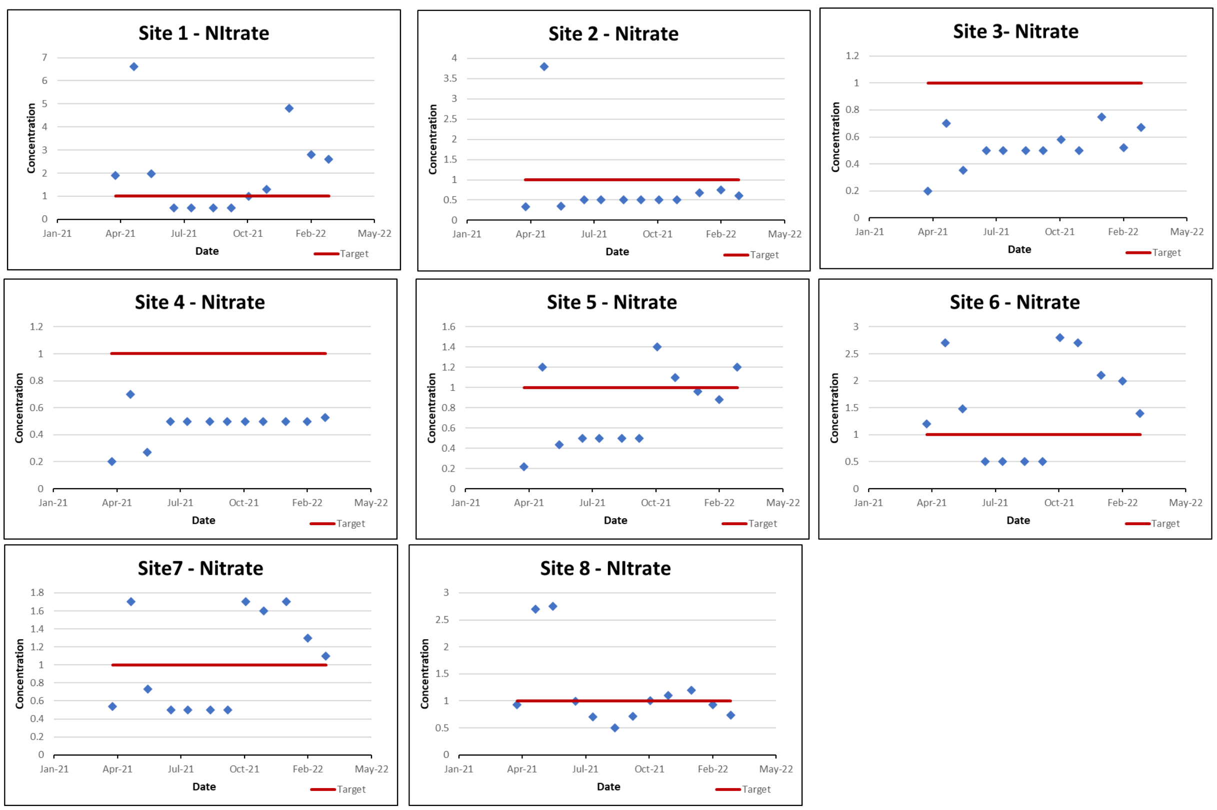

Figure 35. Nitrate-nitrogen concentrations measured in Lower Pigeon Creek samples sites from April 2021-March 2022. Note differences in scale along the concentration (y) axis.

Total Phosphorus

Total phosphorus concentrations exceed target concentrations in 85% of samples (82 of 96 samples; Figure 36). The highest average concentrations occurred at Sites 1, 3 and 8 with concentrations exceeding 0.2 mg/L Concentrations measured throughout the watershed measured in excess of the level at which total phosphorus concentrations impair biological communities (0.08 mg/L) with exceedances under all flow conditions. All sites possess average total phosphorus concentrations in excess of the level at which biological impairments occur (0.08 mg/L).

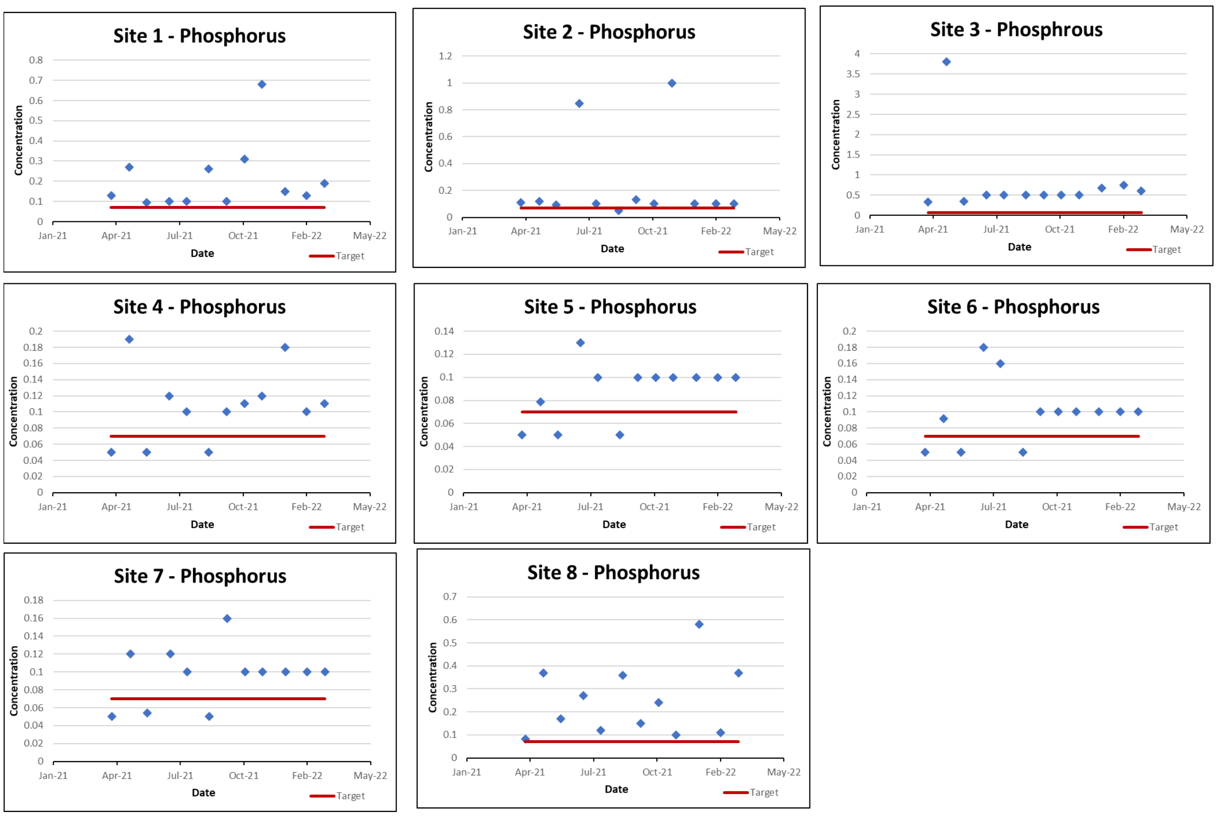

Figure 36. Total phosphorus concentrations measured in Lower Pigeon Creek samples sites from April 2021-March 2022. Note differences in scale along the concentration (y) axis.

Total Suspended Solids

Total suspended solids (TSS) levels measured above target levels (15 mg/L) during high flow events (Figure 37) with 21% of samples exceeding target concentrations (20 of 96 samples). Site 3 contained the highest average concentrations measuring 64.4 mg/L. TSS concentrations exceeded 600 mg/L at Site 3 during the July 2021 sampling event and exceeded 100 mg/L at Site 8 during May 2021 and March 2022.

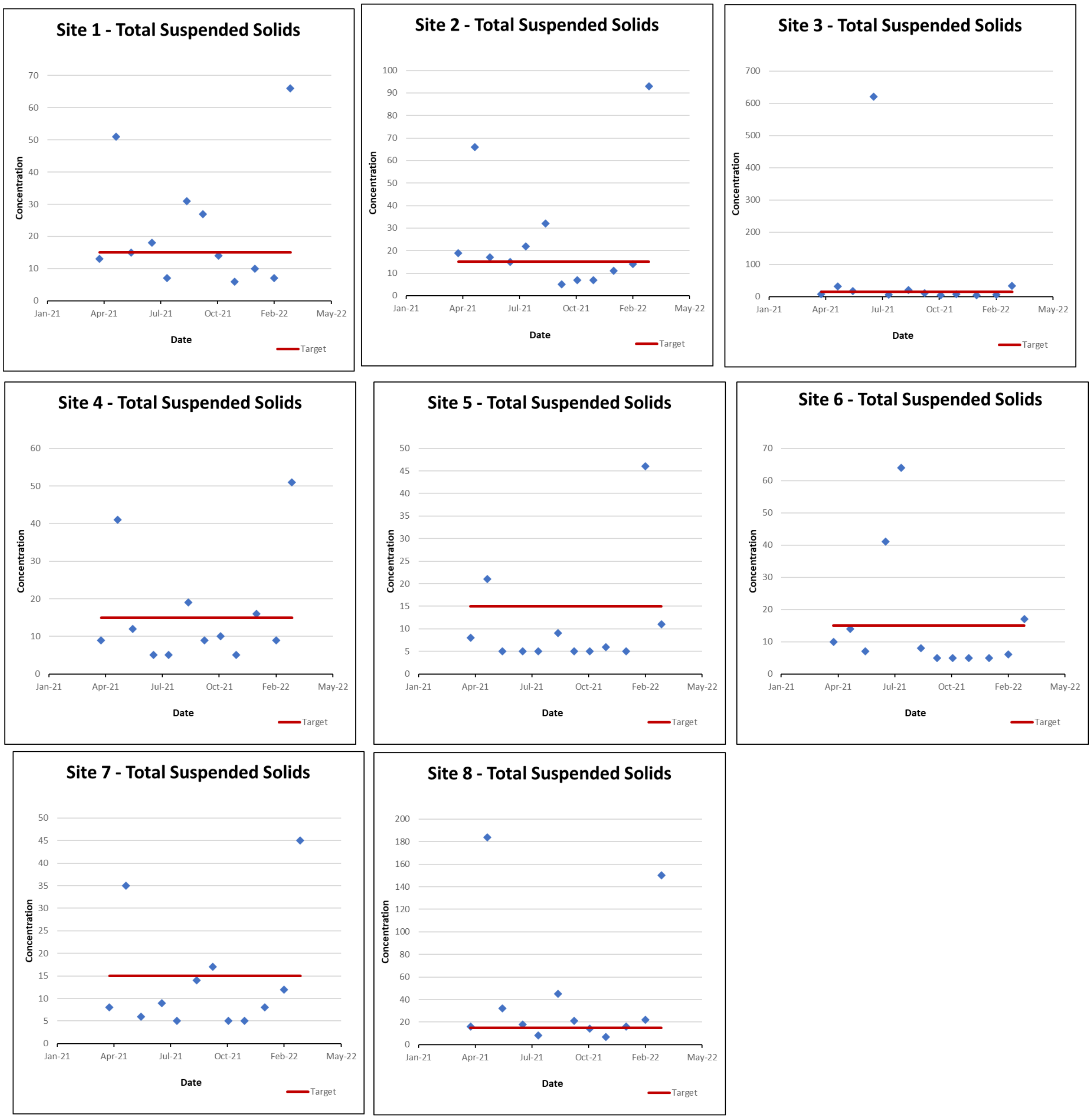

Figure 37. Total suspended solids concentrations measured in Lower Pigeon Creek samples sites from April 2021-March 2022. Note differences in scale along the concentration (y) axis.

E. coli

E. coli concentrations observed at Lower Pigeon Creek Watershed sites are shown in Figure 38. *E. coli* concentrations exceed state standards in 43% of collected samples (41 of 96 samples). Sites 5 and 6 contained the highest average *E. coli* concentrations with both averaging more than 5400 col/100 mL). All Lower Pigeon Creek Watershed sites except Site 7 possessed average *E. coli* concentrations in excess of state standards (235 col/100 mL). *E. coli* exceedances at several sites appear to coincide with elevated flow conditions.

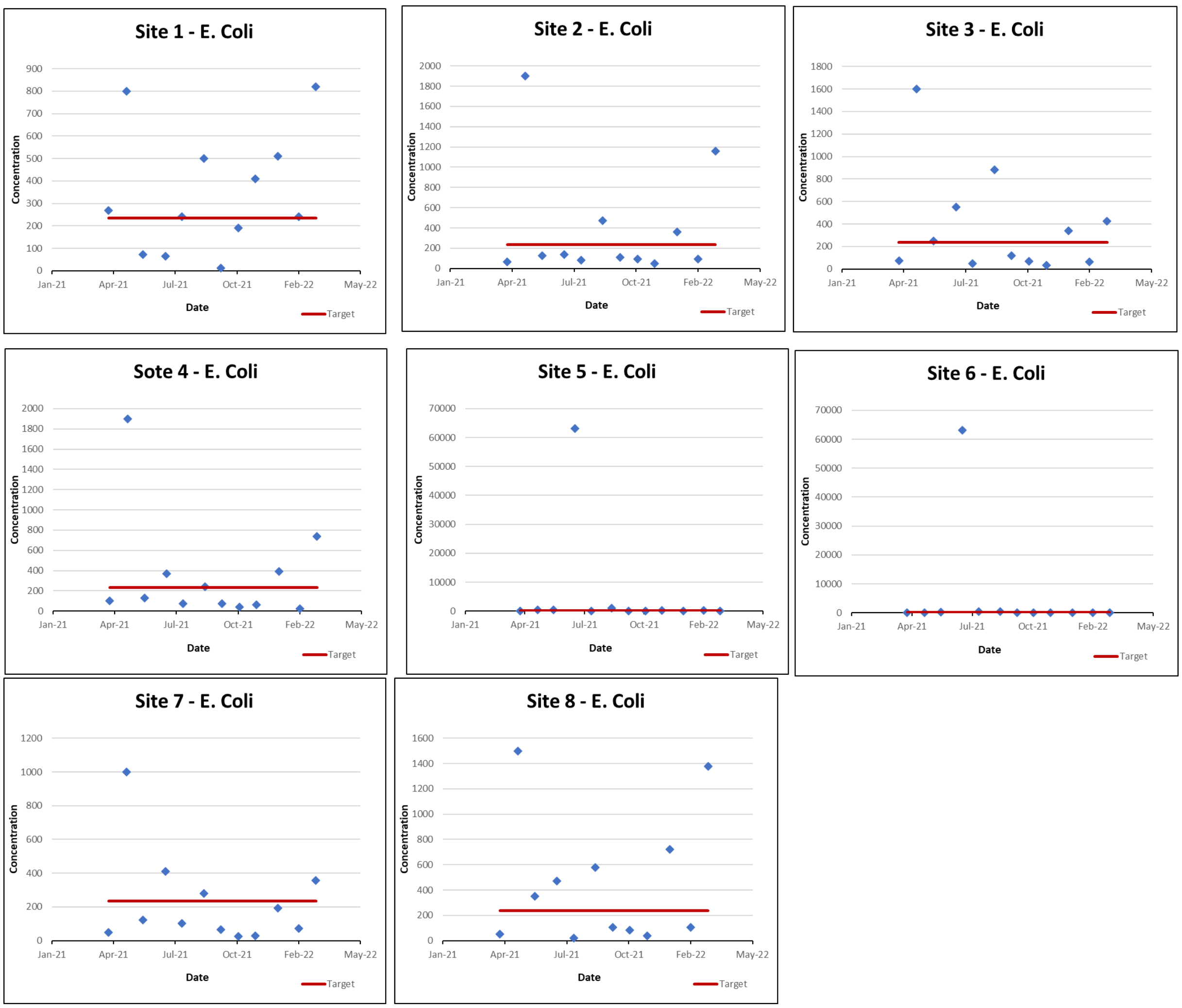

Figure 38. *E. coli* concentrations measured in Lower Pigeon Creek samples sites from April 2021-March 2022. Note differences in scale along the concentration (y) axis.

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 eight sample sites during the time of study from April 2021 to March 2022. Data used for the curves were calculated by scaling flow measured at Big Creek and Pigeon Creek at Fort Branch. 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 39 to Figure 42). In the graphs, the total daily load of each contaminant sample result (points) is plotted against the “percent time exceeded” for the day of sampling (curve). The time exceeded refers to instream flow conditions. 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), Dry (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-nitrogen Load Duration Curves

Nitrate-nitrogen loads measure higher than target loads at most sites during all conditions (Figure 39). Sites 1, 5, 6, 7 and 8 nitrate-nitrogen loading rates measured above target levels more than 90% of the time. This suggests that a steady stream of nitrate-nitrogen is available within these subwatersheds. Further, nitrate-nitrogen concentrations at all sites are highest during high flow conditions (0% of the time or left edge of the graphic) and lower during low flow conditions (100% of the time or right edge of the graphic). Sites 1, 5, 6, 7 and 8 indicate sources of nitrate-nitrogen to these streams under all flow conditions suggesting that nitrate-nitrogen loads to the streams during both high flow, high runoff conditions and during low flow, low runoff conditions. This could mean that there are continuous sources of nitrate-nitrogen at these sites including septic system inputs or nitrogen from manure or other dissolved sources.

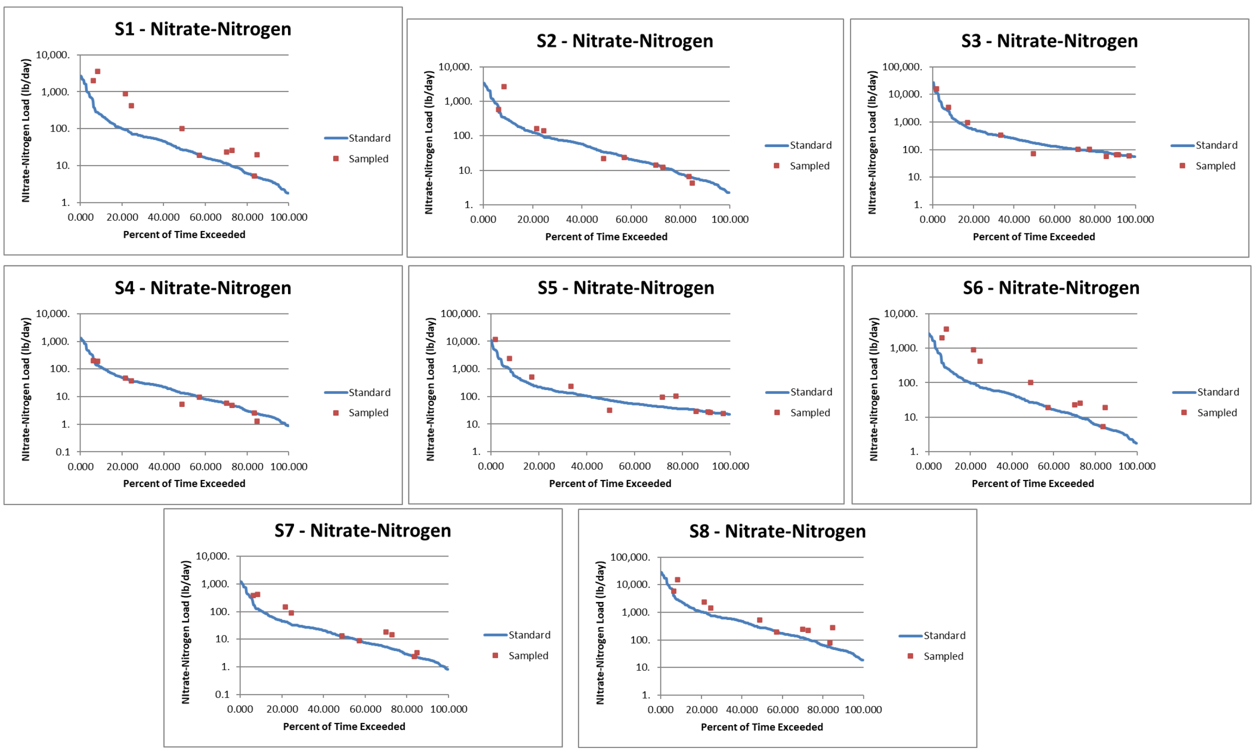

Figure 39. Nitrate-nitrogen load duration curves for Lower Pigeon Creek samples sites from April 2021-March 2022.

Total Phosphorus Load Duration Curves

Total phosphorus (TP) levels generally measured above target levels under all flow conditions (Figure 40). 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 suggesting erosion or runoff is the cause of these values. All sites 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 Lower Pigeon Creek Watershed under all conditions.

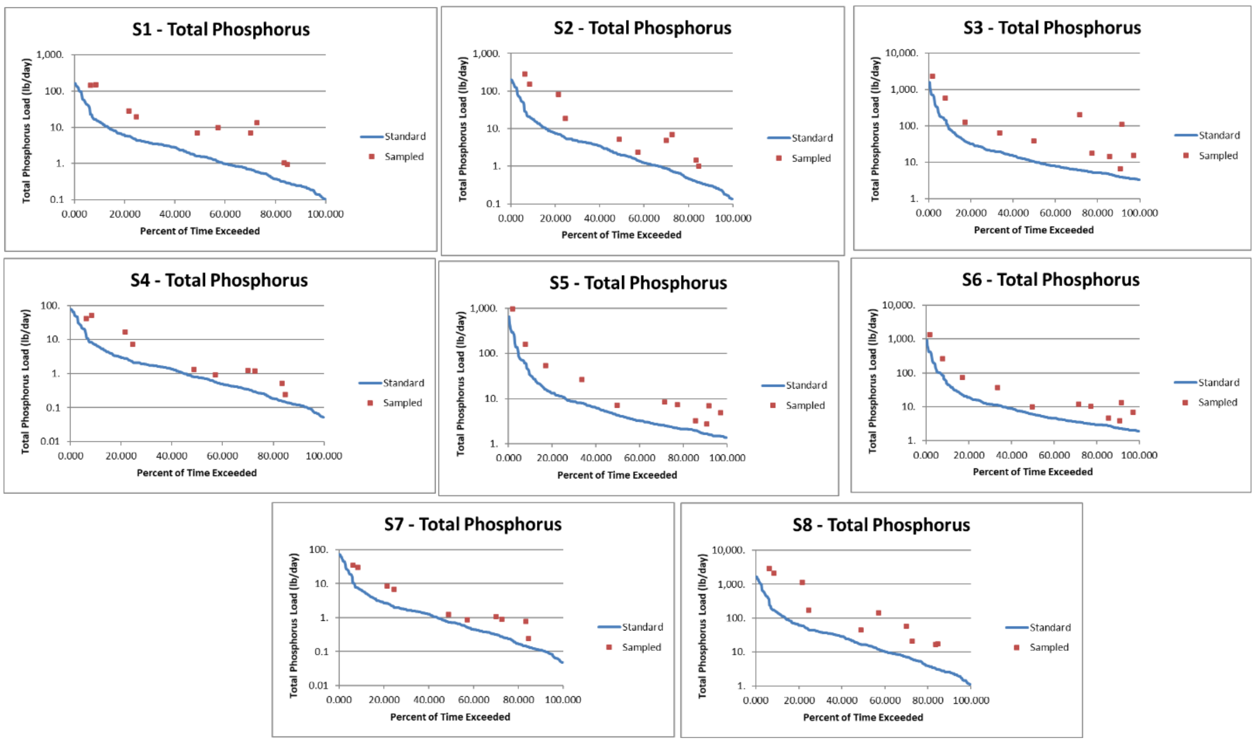

Figure 40. Total phosphorus load duration curves for Lower Pigeon Creek samples sites from April 2021-March 2022.

Total Suspended Solids Load Duration Curves

Total suspended solids (TSS) levels generally measured at or below target levels during most flow events at most stream sites (Figure 41). Most exceedances occurred in the Lower Pigeon Creek Watershed during storm flow events suggesting erosion or runoff is the cause of these values. Site 3, 6 and 7 exhibited several exceedances during lower flow conditions as well. Possible sources of total suspended solids include the livestock access or streambank and bed erosion, both of which can provide a continuous source of total suspended solids.

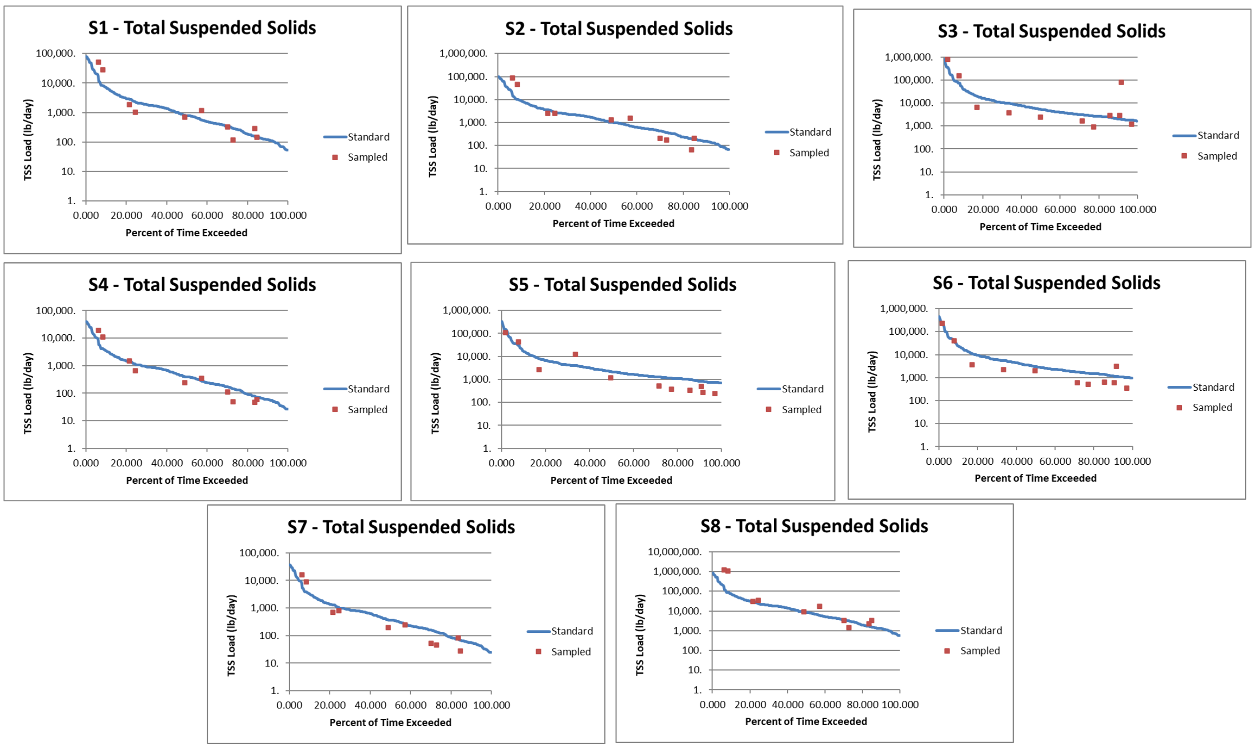

Figure 41. Total suspended solids load curves for Lower Pigeon Creek samples sites from April 2021-March 2022.

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 42). *E. coli* curves indicate that *E. coli* levels exceed targets during all flow conditions. These data suggest a nearly continuous source of *E. coli* within these streams. When flows are at their lowest, Site 3, 5, 6 and 8 contain *E. coli* concentrations measure above target levels suggesting that during dry or low exceedance conditions (60-100), there are sources of *E. coli* within these streams. Site 1-4 load duration curves suggest that *E. coli* loads typically exceed targets only during high flow conditions.

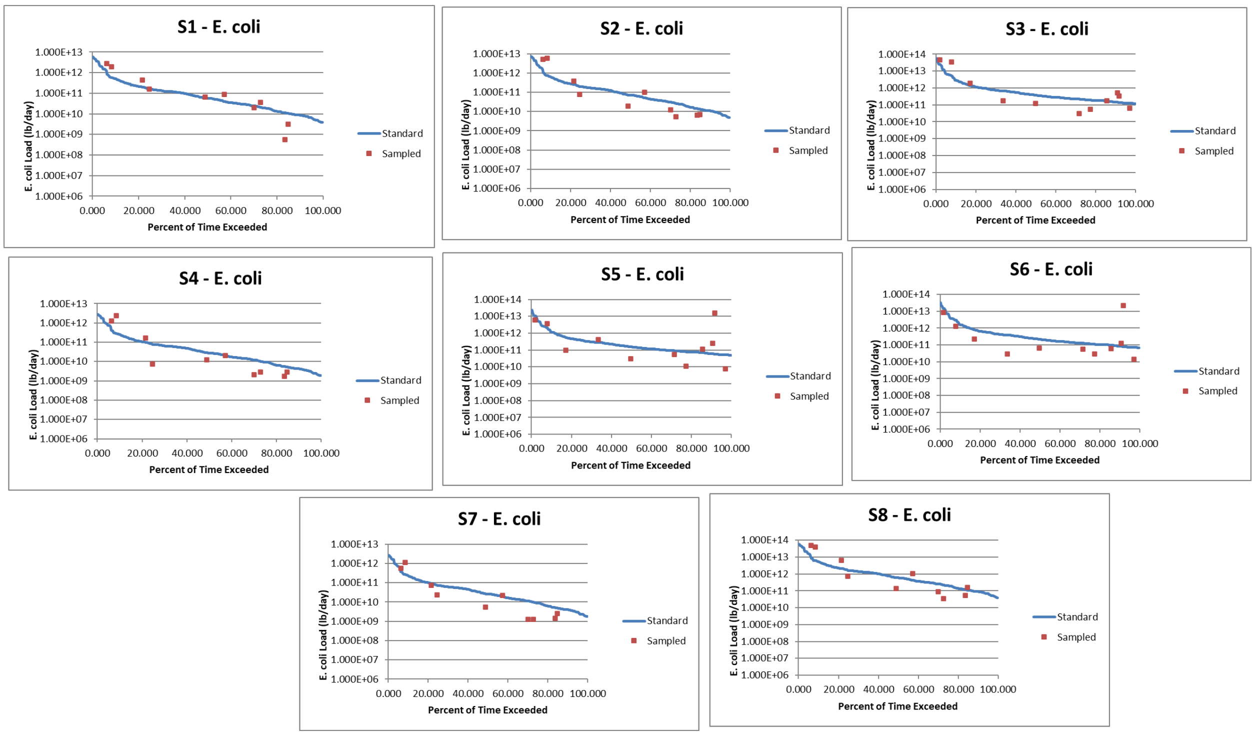

Figure 42. *E. coli* concentrations load duration curves for Lower Pigeon Creek samples sites from April 2021-March 2022.

3.3.5 Macroinvertebrate Community Assessment Results

Overall, macroinvertebrate community quality was limited in the Lower Pigeon Creek Watershed. No macroinvertebrates could be found after sampling all available habitat and spending an additional 30 minute searching in Pigeon Creek (Site 8). Additionally, while the reference site was sampled, its overall quality was relatively poor. Therefore, it was not used as a comparison for the mIBI scores. In general, the Headwaters Bluegrass Creek (Site 1) supports a more diverse community than other sites in the Lower Pigeon Creek Watershed (Figure 43, Table 18). Little Pigeon Creek outlet (Site 4) and Locust Creek outlet (Site 7) contained the most pollution intolerant communities, while Bluegrass Creek (Site 2) and Headwaters Little Pigeon Creek (Site 3) contained the most pollution tolerant communities. All sites contained low numbers of the more sensitive EPT families – however, Bluegrass Creek (Site 2) contained the lowest diversity. Pigeon Creek (Site 8), Bluegrass Creek (Site 2) and Locust Creek outlet (Site 7) contained the lowest number of taxa (0, 6 and 8, respectively). Only the Headwaters Bluegrass Creek (Site 1) and Locust Creek headwaters (Site 6) rated as fully supporting for aquatic life use designation based on IDEM guidance. Appendix B details the macroinvertebrate species collected at each sample site.

Table 18. Metric classification scores and mIBI score for the Lower Pigeon Creek Watershed sample sites as sampled in 2021.

Metric	1	2	3	4	5	6	7	8	Reference
Taxa Richness	6	6	6	6	6	6	6	0	6
HBI	6	6	6	6	6	6	6	0	6
Scrapers/Filterer-Collectors	0	0	6	6	6	4	6	0	6
EPT/Chironomids	6	6	6	6	6	6	6	0	6
% Dominant Taxa	6	6	6	6	6	6	6	0	6
EPT Index	6	2	4	4	4	4	4	0	6
CLI	6	0	0	0	0	6	0	0	6
Shredders/Total	6	6	6	6	6	6	6	0	6
Total Score	36	26	34	34	34	38	34	0	42

Figure 43. Cumulative metrics used to calculate mIBI scores for Lower Pigeon Creek Watershed streams in 2021.

3.3.6 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 19 presents the results of QHEI assessments at each of the 8 stream sites sampled in the Lower Pigeon Creek Watershed during the summer of 2021. Figure 44 details metric and total scores for all sites. Site 3 (Little Pigeon Creek headwaters), 4 (Little Pigeon Creek outlet) and 7 (Locust Creek outlet) rated as good. For these sites, pool/riffle development scores, stream substrate, instream cover, and gradient were relatively good for Indiana streams contributing to overall high quality QHEI scores. Site 5 (Locust Creek tributary) rated as fair, while all other sites including the Headwaters Bluegrass Creek (Site 1), Bluegrass Creek (Site 2), Locust Creek headwaters (Site 6) and Pigeon Creek (Site 8) rated as very poor or poor. The lowest scores occurred in Headwaters Bluegrass Creek (Site 1) which possessed poor substrate, poor instream cover, limited riparian quality and lacked pool/riffle complexes.

Table 19. Qualitative Habitat Evaluation Index (QHEI) scores measured in the Lower Pigeon Creek Watershed.

Site	Substrate	Cover	Channel	Riparian	Pool	Riffle/Run	Gradient	Total
1	5	3	7	4	6	0	4	29
2	5	6	7	8	6	0	4	36
3	11	14	10	9	7	4	6	61
4	15	15	16	6	6	5	6	69
5	13	5	8	4	8	4	6	48
6	11	5	7	8	5	0	6	42
7	9	13	14	6	8	4	5	59
8	1	9	7	4	9	0	6	36
Reference	8	12	11	10	8	0	6	55

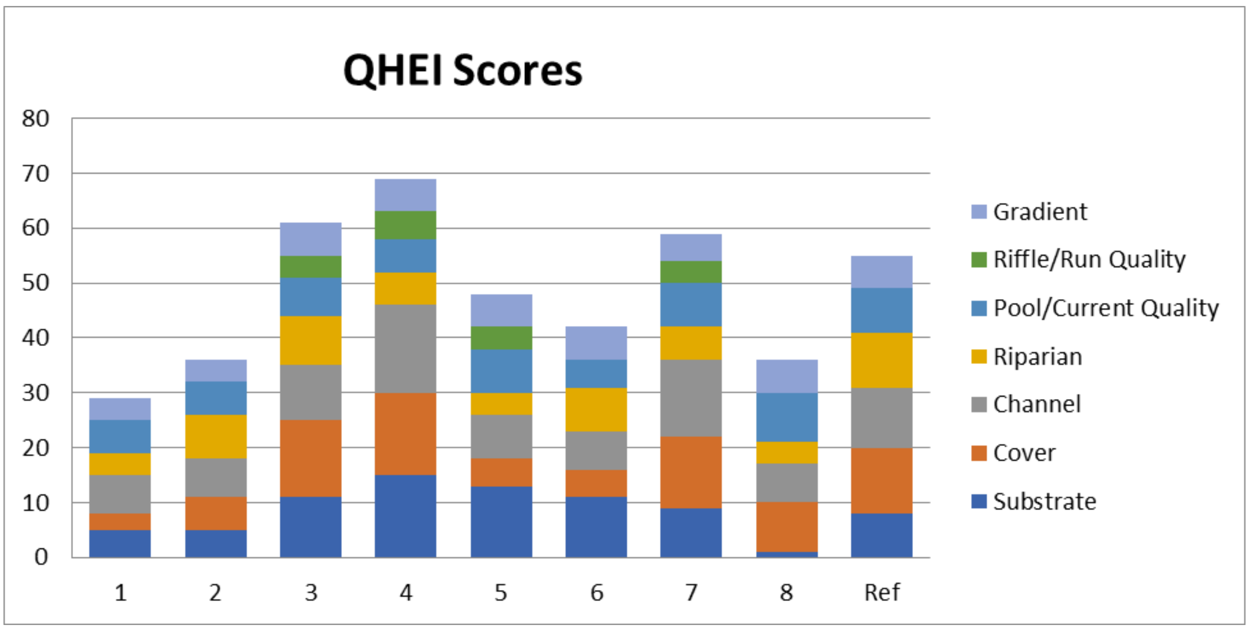

Figure 44. Qualitative Habitat Evaluation Index (QHEI) total and component scores measured for stream sites in the Lower Pigeon Creek Watershed.

3.4 Watershed Inventory Assessment

3.4.1 Watershed Inventory Methodologies

Volunteers and the project coordinator completed windshield surveys throughout the Lower Pigeon Creek Watershed in in the spring of 2021. Windshield surveys were conducted 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 Project Coordinator 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
- Livestock access and impact to streams
- Buffer condition and width
- Bank erosion or head-cutting
- Logjams located within the stream
- Dumping areas or areas where trash or debris accumulate
- Abandoned mines or mine shafts
- Small, unregulated farms
- Environmental site confirmation (NPDES, CFO, open dump, Superfund, etc.)

3.4.2 Watershed Inventory Results

All accessible road-stream crossings were inventoried based on observations of the watershed coordinator, project partners and volunteers. A majority of issues identified fall into five categories: stream buffers limited in width or lacking altogether, areas of livestock access, streambank erosion, dumping areas, and unregulated farms. Figure 45 details locations throughout the Lower Pigeon Creek Watershed where problems were identified. Much of the watershed is not visible from the road; therefore, those identified in Figure 45 should not be considered exhaustive. More than 10.7 miles of streams possessed limited buffers on both banks (21.4 miles total) and nearly 67.9 miles of streambank were eroded on both banks (135.8 miles). Livestock access points were not observed during the windshield survey.

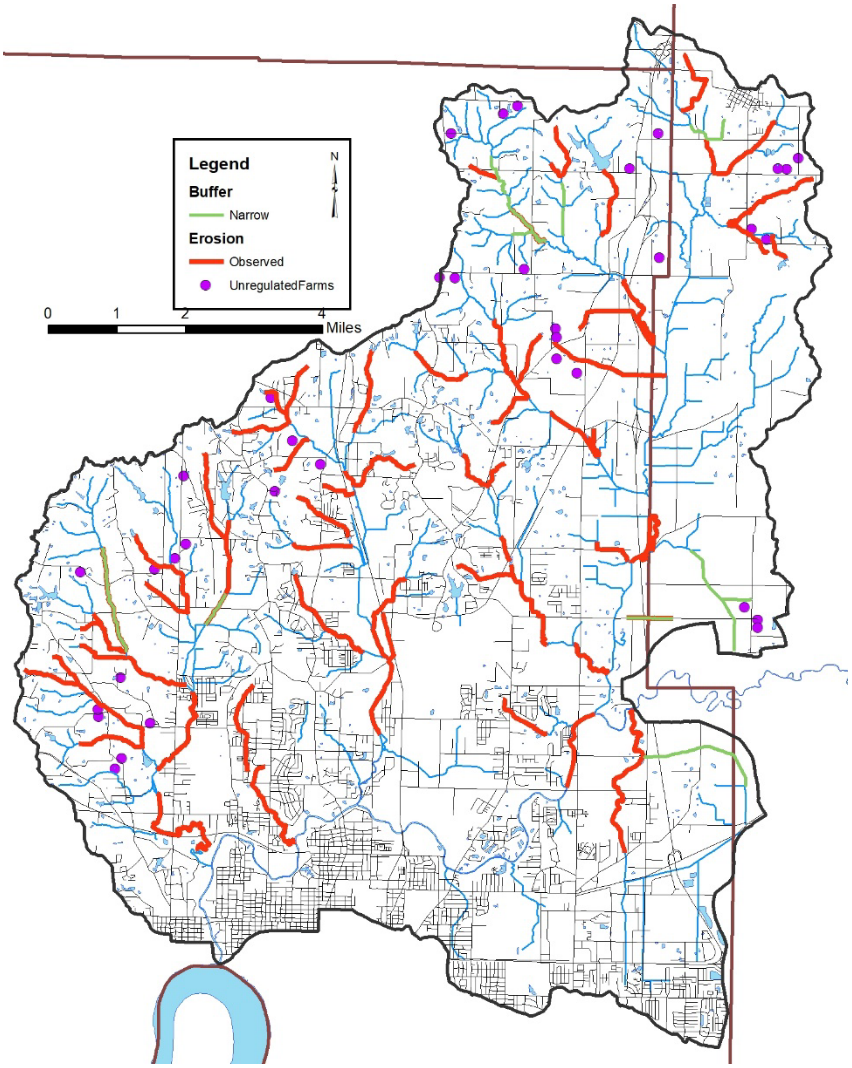

Figure 45. Stream-related watershed concerns identified during watershed inventory efforts.

4.0 <u>WATERSHED INVENTORY II-B: SUBWATERSHED DISCUSSIONS</u>

To gather more specific, localized data, the Lower Pigeon Creek Watershed was divided into six (6) subwatersheds with each subwatershed reflecting one 12-digit Hydrologic Unit Code (HUC; Figure 46). 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.

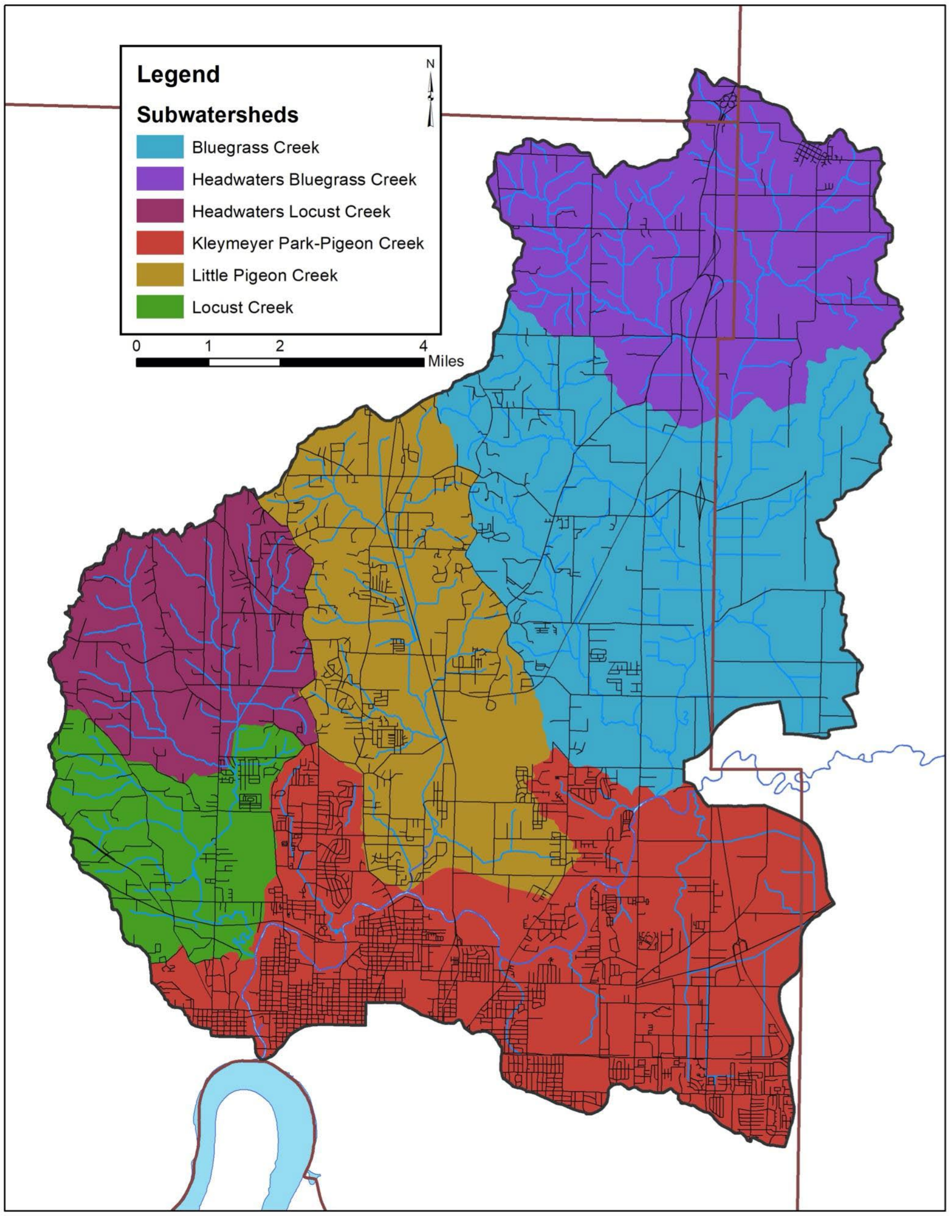

Figure 46. 12-digit Hydrologic Unit Codes Subwatersheds in the Lower Pigeon Creek Watershed.

4.1 Headwaters Bluegrass Creek Subwatershed

The Headwaters Bluegrass Creek Subwatershed is the northernmost subwatershed of the Lower Pigeon Creek Watershed and is primarily rural pasture and row crop agriculture (Figure 47). The Headwaters Bluegrass Creek Subwatershed is also the only subwatershed in the Lower Pigeon Creek Watershed to fall in three counties - Warrick, Gibson and Vanderburgh Counties (Figure 46). This subwatershed encompasses one 12-digit HUC watershed: 051402020301 and drains 11,422.7 acres or 17.8 square miles accounting for 16.6% of the total watershed area. There are 49.7 miles of stream. IDEM has classified 26.1 miles of stream as impaired for *E. coli* and 14.42 miles of stream as impaired for dissolved oxygen (DO).

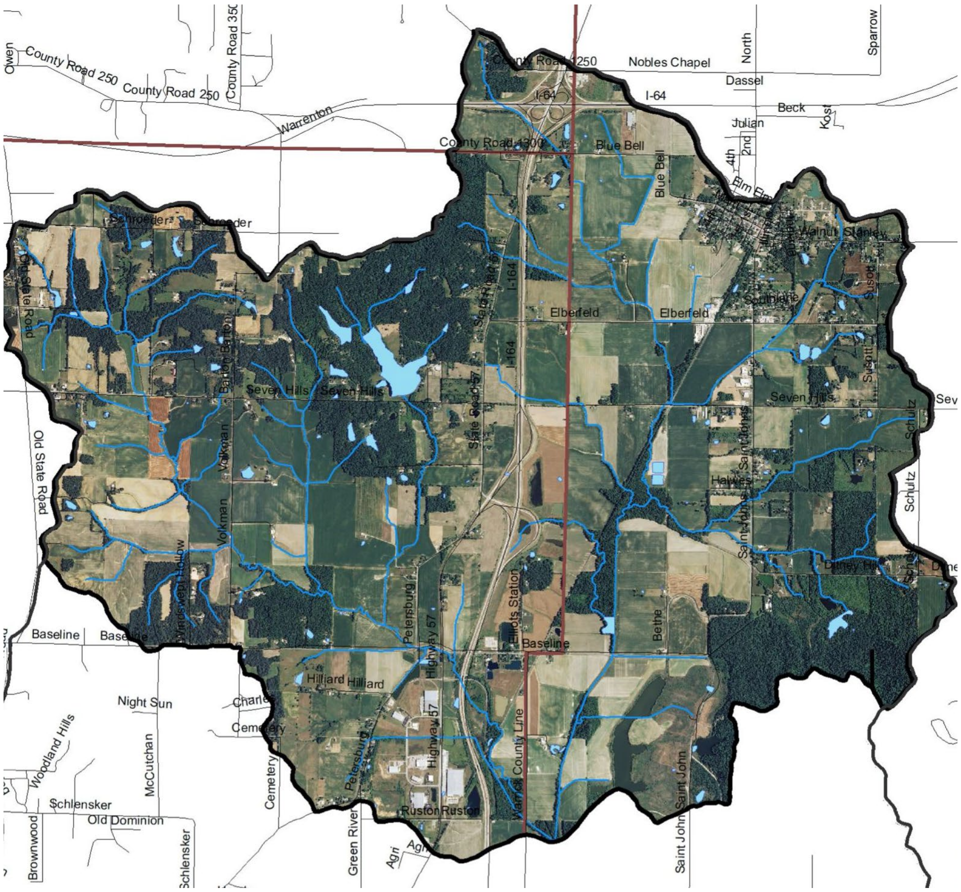

Figure 47. Headwaters Bluegrass Creek Subwatershed.

4.1.1 Soils

Hydric soils currently cover 9.2% (1,049.5 acres or 424.7 ha) of the subwatershed; wetlands currently cover 3% (341 acres or 137.9 ha) of the subwatershed. Highly erodible soils are prevalent throughout the subwatershed covering 11,133.8 acres (4,505 ha) or 97.5% of the subwatershed. Nearly two thirds of the subwatershed, 63.7% (7,280.7 acres or 2,946.4 ha), has soils which are very limited for septic use. The majority of the Headwaters Bluegrass Creek Subwatershed is rural, indicating many homes utilize on-site septic systems. Based on the soil septic suitability, maintenance and inspection of septic systems is important to ensure proper function and capacity.

4.1.2 Land Use

Agricultural land use dominates the Headwaters Bluegrass Creek Subwatershed covering 65% (7,426.6 acres or 3,005.4 ha) of the watershed. This consists of row crops and pasture land. Forested land use accounts for nearly a quarter of land in the subwatershed (22.9% or 2,621.2 acres or 1,060.8 ha). Urban land use makes up less than a tenth of the watershed with 9.1% (1,033.9 acres or 418.4 ha) covered. Interstate 69 runs through the easternmost edge of Vanderburgh County, and the center of the subwatershed. Some urbanization can be attributed to the highway as well as the Town of Elberfeld located on the subwatershed's northeastern edge. Wetlands, open water, and grassland cover just 341 acres (137.9 ha) or 3%, of the subwatershed.

4.1.3 Point Source Water Quality Issues

There are two sources of point source-based water pollution in the subwatershed. There are seven leaking underground storage tanks, six of which are located in the northeast corner of the subwatershed within the Town of Elberfeld (Figure 48). There is one NPDES-permitted facility, the Elberfeld wastewater treatment plant.

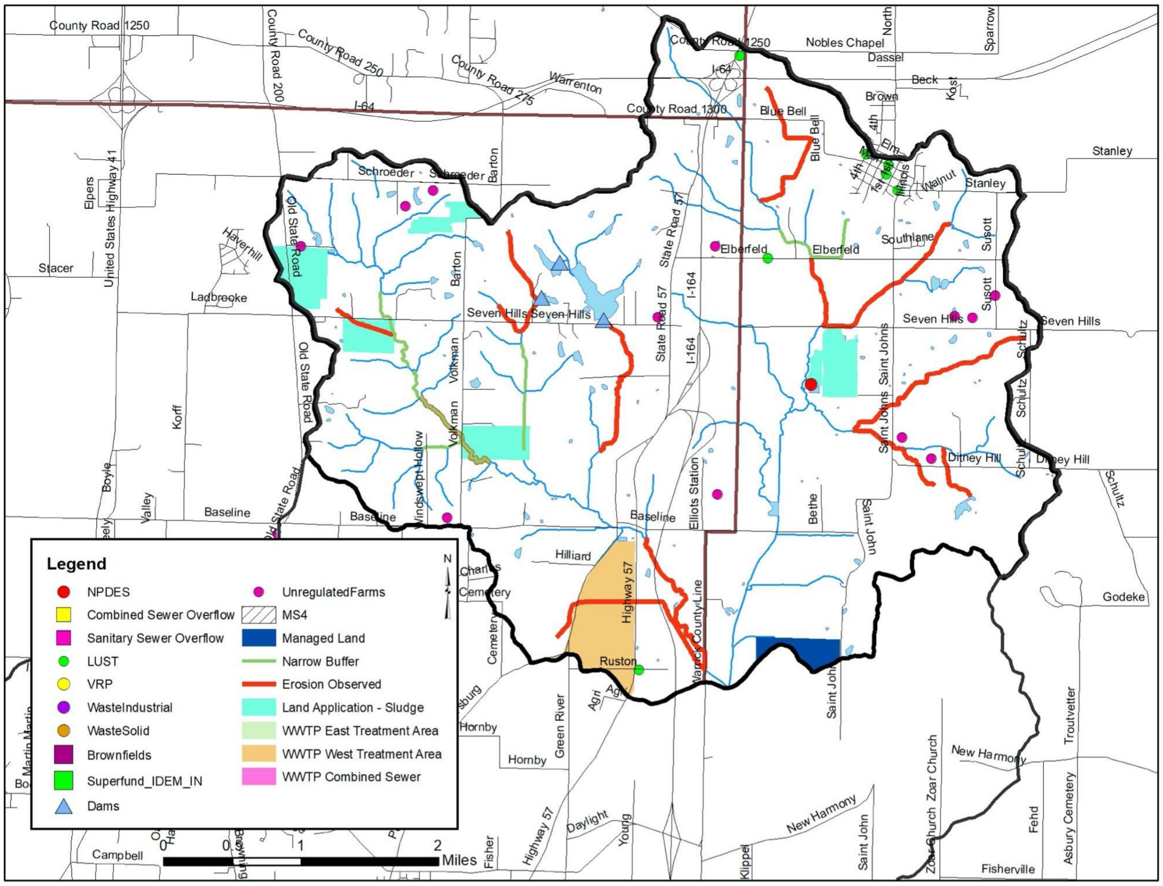

Figure 48. Point and non-point sources of pollution and suggested solutions in the Headwaters Bluegrass Creek Subwatershed.

4.1.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Headwaters Bluegrass Creek Subwatershed with a decent number of small animal operations and pastures present (Figure 48). Twelve unregulated animal operations housing more than 61 cows, horses, and goats were identified during the windshield survey. In total, manure from small animal operations total over 1,088 tons per year, which contains almost 782 pounds of nitrogen, almost 400 pounds of phosphorus and more than 6.13E+13 col of *E. coli*. Livestock do not have access to the Headwaters Bluegrass Creek Subwatershed streams based on observations during the windshield survey. No active confined feeding operations are located within the Headwaters Bluegrass Creek Subwatershed. Using National Agricultural Statistics Survey Data (2007), approximately 551 animals are present in the Headwaters Bluegrass Creek Subwatershed. Streambank erosion is a concern in the subwatershed. Approximately 12.4 miles of streambank erosion were identified within the subwatershed. Additionally, nearly 3.8 miles of narrowly buffered stream were observed in the Headwaters Bluegrass Creek Subwatershed during the windshield survey.

4.1.5 IDEM TMDL Assessment Water Quality Assessment

IDEM created and evaluated load duration curves and precipitation graph to determine what flow regimes contribute to elevated *E. coli* concentrations (Table 20). Based on the water quality duration curves, IDEM concluded that the majority of sources of *E. coli* in the Headwaters Bluegrass Creek Subwatershed occur under very high flow and high flow regimes. To reduce *E. coli* in the Headwaters Bluegrass Creek Subwatershed, reduction of *E. coli* during high flow conditions is necessary.

Table 20. Flow regime TMDL analysis for *E. coli* in the Headwaters Bluegrass Creek Subwatershed.

Upstream Characteristics					
Drainage Area	17.83 square miles				
TMDL Sample Site	27				
Listed Segments	INE0231_01, INE0231_T1001				
Land Use	Agriculture: 73.0% Forest: 17.4% Urban: 5.7% Water: 1.1% Wetland: 2.7%				
NPDES Facilities	Elberfeld Municipal WWTP (IN0020788)				
MS4 Communities	NA				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	Very High Flows	Higher Flow Conditions	"Normal" Flows	Lower Flow Conditions	Low Flows
LA	1544.06	196.76	51.41	7.22	1.0
WLA	0.7	0.7	0.7	0.7	0.7
MOS (10%)	171.64	21.94	5.79	0.88	0.18
TMDL = LA+WLA+MOS	1716.4	219.4	57.9	8.8	1.8

4.1.6 Water Quality Assessment

Waterbodies within the Headwaters Bluegrass Creek Subwatershed have been sampled at 5 locations (Figure 49). Assessments include collection of water chemistry and biology data by IDEM (4 sites) and by USGS (1 site). Biological assessments occurred at two locations. No stream gages are in the Jackson Creek-Clear Creek Subwatershed.

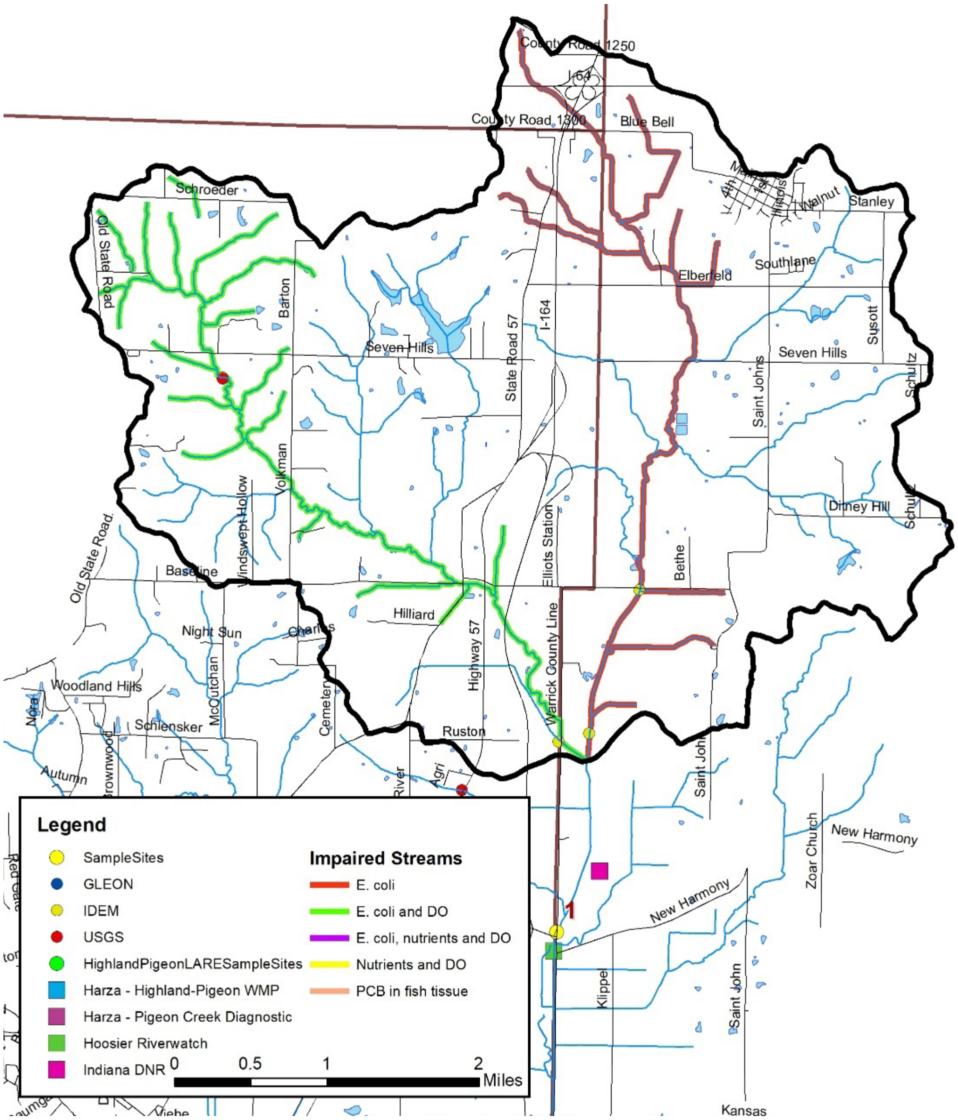

Figure 49. Locations of historic and current water quality data collection and impairments in the Headwaters Bluegrass Creek Subwatershed.

Table 21 details historic water quality data collected in the Headwaters Bluegrass Creek Subwatershed. As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 52% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1.5 mg/L) in 27% of samples, while total Kjeldahl nitrogen concentrations exceed water quality targets (0.57 mg/L) in 75% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 75% of samples. Total suspended solids concentrations did not exceed water quality targets (15 mg/L), while turbidity levels exceed water quality targets (5.7 NTU) in 75% of samples.

Table 21. Headwaters Bluegrass Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	279	878	0	31	0%
DO	2.8	18.5	2	2	100%
E. coli	1	21,492	11	21	52%
Nitrate-Nitrogen	0.2	0.1	2	4	50%
pH	7.17	9.02	1	31	3%
TKN	0.7	0.7	3	4	75%
Total Phosphorus	0.07	0.66	3	4	75%
Total Suspended Solids	6	140	0	4	0%
Turbidity	9.1	153.8	12	16	75%

Biological monitoring was conducted by IDEM at 2 sites with both sites assessed for macroinvertebrate and fish. Macroinvertebrate scores rated as non-supporting for the streams aquatic life use designation scoring 28 and 30. Fish communities rated as poor scoring 28 and 32. Habitat assessments completed as part of both the macroinvertebrate and fish community assessments scored between 39 and 46 indicating habitat was limited at the two sites assessed.

The sample site for the Headwaters Bluegrass Creek is located in the Bluegrass Creek Subwatershed and is shown in Figure 49 as the label 1. As shown in Table 22, *E. coli* samples from Site 1 exceed state grab sample standards (235 col/100 ml) in 67% of samples collected at Site 1 sampled during the current project. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 67% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 100% of samples. Total suspended solids concentrations exceed water quality targets (15 mg/L) in 42% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 100% of samples. pH concentrations exceed targets in 8% of samples (1 of 12 collected), while dissolved oxygen concentrations exceed upper and lower water quality standards in 33% of collected samples.

Table 22. Headwaters Bluegrass Creek Subwatershed water quality data summary, 2021-2022.

Site		Temp (deg C)	DO (mg/L)	pH	Cond (mg/L)	Turb (NTU)	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100 ml)
1	Median	63.68	6.9	7.875	23	385.5	1.6	0.14	14.5	255
	Max	77	10.8	9.6	500	770	6.6	0.68	66	820
	Min	37.94	1.5	7.5	8.71	21	0.5	0.096	6	12
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		4	1	0	12	8	12	5	8
	% Exceed		33%	8%	0.0%	100%	67%	100%	42%	67%

4.2 Bluegrass Creek Subwatershed

The Bluegrass Creek Subwatershed is the largest of the six subwatersheds and straddles Warrick and Vanderburgh counties (Figure 50). It encompasses one 12-digit HUC watershed: 051402020302. This subwatershed drains 19,185.7 acres. The Bluegrass Creek Subwatershed accounts for nearly a quarter of the watershed (24.6%) of the total watershed area. There are 60.4 miles of stream. IDEM has not classified any of the stream in the Bluegrass Creek Subwatershed as impaired for *E. coli*, polychlorinated biphenyls (PCBs), impaired nutrients, or impaired for biotic communities.

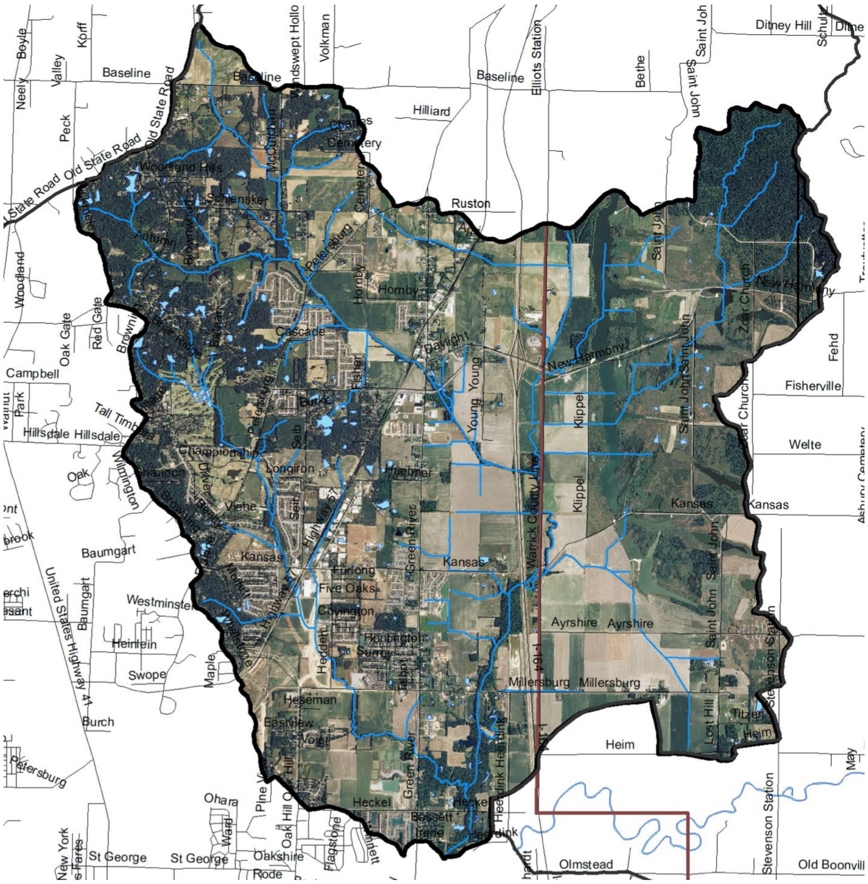

Figure 50. Bluegrass Creek Subwatershed.

4.2.1 Soils

Hydric soils cover 3,001 acres (1,214.5 ha) or 17.7% of the subwatershed. Wetlands currently cover 7.3% (1,243.7 acres or 503.3 ha) of the subwatershed. Highly erodible soils nearly cover the entire subwatershed (83%) or 14,060.6 acres (5,690.1 ha). In total, 11,213.1 acres (4,537.8 ha) or 66.2% of the subwatershed is identified as very limited for septic use. However, nearly half of the subwatershed drains to the Evansville West wastewater treatment plant with a small portion also draining to the Evansville East wastewater treatment plant

4.2.2 Land Use

Agricultural land use dominates the Bluegrass Creek Subwatershed covering 51.4% (8,697.2 acres or 3,519.6 ha). Forested land use covers 21% (3,558.1 acres or 1,440 ha). Wetlands, open water, and grassland cover 1,243.7 acres (503.3 ha), or 7.3%, of the subwatershed. Small communities, residential subdivisions and urbanized areas of the county along Interstate 69 account for much of the urban land use within the subwatershed. In total, 3,434.1 acres (1,389.7 ha) or 20.3% of the subwatershed are in urban land uses.

4.2.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed (Figure 51). There is one sanitary sewer overflow, two MS4 communities including, the City of Evansville and Vanderburgh County, and one solid waste facility. There are nine leaking underground storage tanks and one industrial waste facility. There are no open dumps, brownfields, superfund sites, voluntary remediation program sites, or corrective action sites located within the Bluegrass Creek Subwatershed.

4.2.4 Non-point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Bluegrass Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. In total, 8 unregulated animal operations housing more than 93 cows, horses, and goats were identified during the windshield survey (Figure 39). Animals produce more than 1,914 tons of manure annual which contains more than 1,051 pounds nitrogen, 533 pounds of phosphorus and more than 4.15E+13 colonies of *E. coli*. Based on windshield survey observations, livestock do not appear to have access to the Bluegrass Creek Subwatershed streams. No active confined feeding operations are located within the subwatershed. Using National Agricultural Statistics Survey Data (2007), approximately 794 animals are present in the Bluegrass Creek Subwatershed. However, streambank erosion is a concern in the subwatershed. Approximately 15.5 miles of streambank erosion were identified within the subwatershed. Additionally, nearly 2.8 miles of narrowly buffered stream were observed in the Bluegrass Creek Subwatershed during the windshield survey.

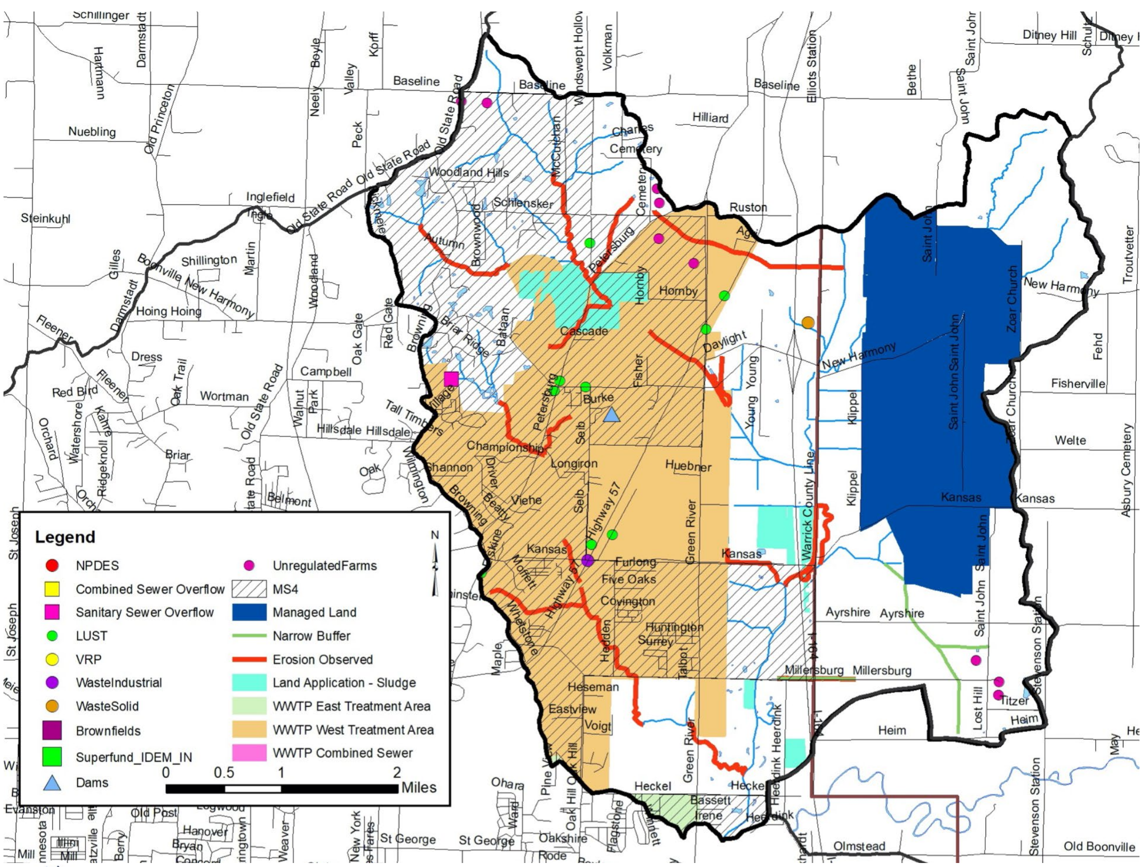

Figure 51. Point and non-point sources of pollution in the Bluegrass Creek Subwatershed.

4.2.5 IDEM TMDL Assessment

IDEM did not create or evaluate load duration curves or precipitation graph for the Bluegrass Creek Subwatershed as part of the TMDL. Based on their assessment, a reduction in *E. coli* loading was not warranted in the Bluegrass Creek Watershed.

4.2.6 Water Quality Assessment

Waterbodies within the Bluegrass Creek Subwatershed have been sampled at 12 locations (Figure 49). Assessments include collection of water chemistry data by IDEM (2 sites), by USGS (2 sites), DNR (1 site), Harza (3 sites), Arion Consultants (1 site) and Hoosier Riverwatch Volunteers (3 sites). No biological assessments have been conducted in the Bluegrass Creek Subwatershed. No stream gages are in the Jackson Creek-Clear Creek Subwatershed.

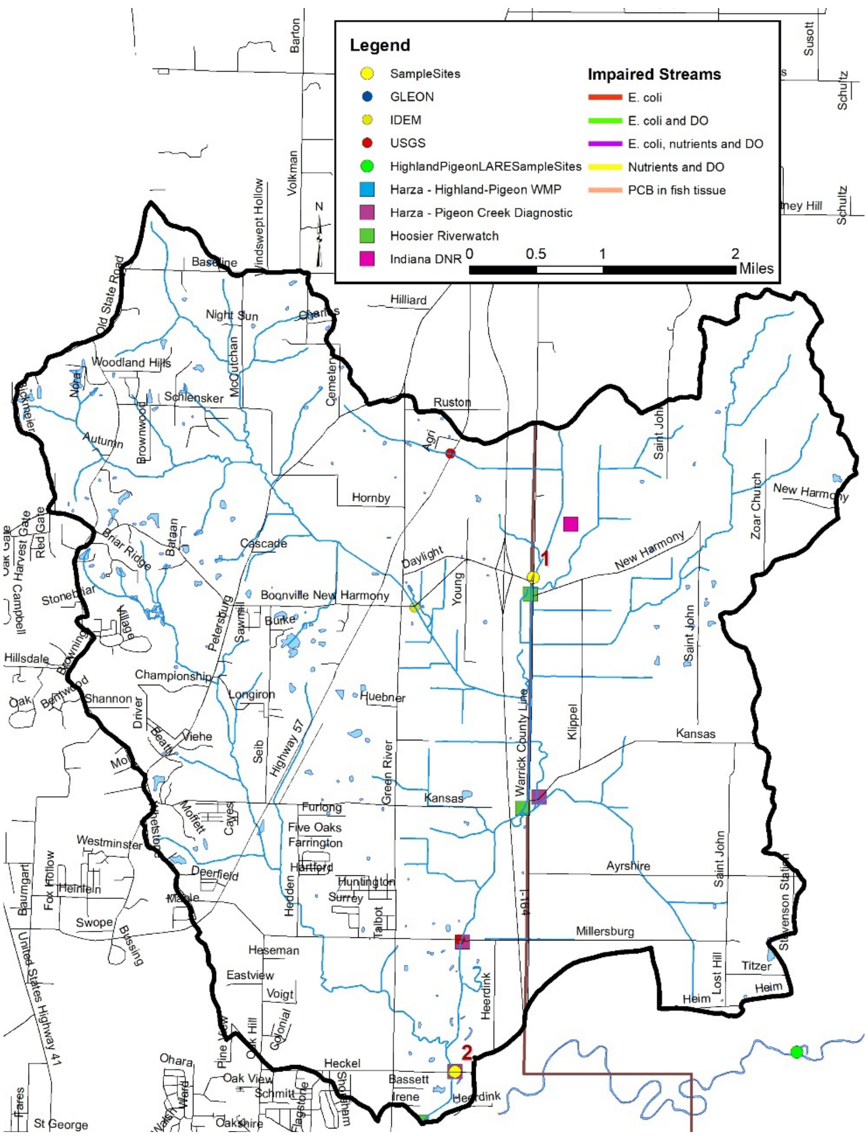

Figure 52. Locations of historic and current water quality data collection and impairments in the Bluegrass Creek Subwatershed.

Table 23 details historic water quality data collected in the Bluegrass Creek Subwatershed. As shown in the table, conductivity exceeded water quality standards (1050 cm/mS) in 56% of samples. *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 31% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1.5 mg/L) in 13% of samples, while total Kjeldahl nitrogen concentrations exceed water quality targets (0.57 mg/L) in 33% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 100% of samples. Total suspended solids concentrations did exceeded water quality targets (15 mg/L) in 100% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 90% of samples.

Table 23. Bluegrass Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	302	2191	9	16	56%
DO	4.9	16	5	15	33%
E. coli	17.5	3,500	5	16	31%
Nitrate-Nitrogen	0.1	3.7	1	8	13%
pH	7.3	9.35	1	15	7%
TKN	1.4	4.2	2	6	33%
Total Phosphorus	0.29	0.65	8	8	100%
Total Suspended Solids	8	76	6	8	75%
Turbidity	6.1	155	9	10	90%

Table 24 details water quality data collected in the Bluegrass Creek Subwatershed (Site 2) sampled during the current project). As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 33% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 17% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 92% of samples. Total suspended solids concentrations exceed water quality targets (15 mg/L) in 50% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 92% of samples. Dissolved oxygen concentrations measured both above and below water quality standards in 33% of samples collected.

Table 24. Bluegrass Creek Subwatershed water quality data summary, 2020-2021.

Site		Temp (deg C)	DO (mg/L)	pH	Cond (mg/L)	Turb (NTU)	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100 ml)
2	Median	66.38	6.7	8.25	24.475	731	0.5	0.175	16	117
	Max	77	13.5	8.7	1174	1295	3.8	0.34	93	1900
	Min	38.12	3.5	7.6	4.3	19	0.33	0.05	5	46
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		4	0	2	11	2	11	6	4
	% Exceed		33%	0%	17%	92%	17%	92%	50%	33%

4.3 Little Pigeon Creek Subwatershed

The Little Pigeon Creek Subwatershed is located immediately west of the Bluegrass Creek Subwatershed forming the middle of the Lower Pigeon Watershed. It lies fully within Vanderburgh County (Figure 53) and encompasses one 12-digit HUC watershed: 051402020303. This subwatershed drains 11,169.6 acres and accounts for 16.3% of the total watershed area. In total, the Little Pigeon Creek Subwatershed drains 17.5 square miles. There are 36.7 miles of stream none of which are included on IDEM's impaired waterbodies list.

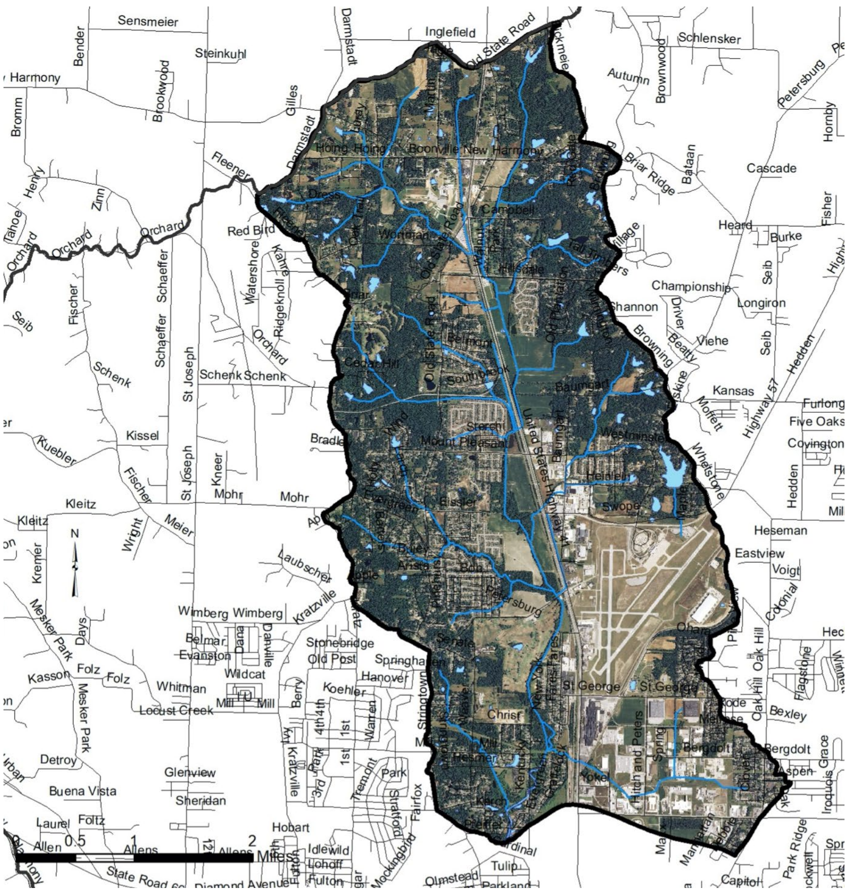

Figure 53. Little Pigeon Creek Subwatershed.

4.3.1 Soils

Hydric soils cover 1,648.7 acres (667.2 ha) or 14.7% of the subwatershed. Wetlands currently cover 3.8% (428.5 acres or 173.4 ha) of the subwatershed. Highly erodible soils nearly cover 87.4% of the subwatershed with 9,767.5 acres (3952.8 ha). In total, 8,615.4 acres (3486.5 ha) or 77.1% of the subwatershed is identified as very limited for septic use. Nearly 75% of the subwatershed drains to the east or west Evansville wastewater treatment plant. Outside of these areas, maintenance and inspections of septic systems in the Little Pigeon Creek Subwatershed is important to ensure proper function and capacity.

4.3.2 Land Use

Forested and urban land uses co-dominate the Little Pigeon Creek Subwatershed with 36.1% (4,038.9 acres or 1,634.4 ha) in forested land use and 42.5% (4,750.1 acres or 1,922.3 ha) in urban land uses. Wetlands, open water, and grassland cover 428.5 acres (173.4 ha), or 3.8%, of the subwatershed. The communities of Darmstadt, Mechanicsville, Stringtown and Erskine Station and Hillsdale and Interstate 69 accounts for much of the urban land use within the subwatershed. In total, 1,960.4 acres (793.3 ha) or 17.5% of the subwatershed account for agricultural land uses, including row crop and pasture.

4.3.3 Point Source Water Quality Issues

There are many point sources of water pollution in the subwatershed (Figure 42). There are 50 leaking underground storage tanks (LUST; Figure 54). The City of Evansville and Vanderburgh County MS4 cover much of the Little Pigeon Creek Subwatershed. There are seven industrial waste facilities, two brownfields and one voluntary remediation site. There are no open dumps or corrective action sites located within the Little Pigeon Creek Subwatershed.

4.3.4 Non-Point Source Water Quality Issues

While urban and forested land uses are the predominant land uses in the Little Pigeon Creek Subwatershed, many agricultural non-point sources of pollution impact the Little Pigeon Creek Subwatershed. A number of small animal operations and pastures are present. Surveyors observed four unregulated animal operations housing more than 17 cows and horses during the windshield survey (Figure 54). Animals produce more than 330 tons of manure annual which contains more than 206 pounds nitrogen, 107 pounds of phosphorus and more than 4.90E+12 colonies of *E. coli*. Based on windshield survey observations, livestock do not have access to Little Pigeon Creek Subwatershed streams. No active confined feeding operations are located within the Little Pigeon Creek Subwatershed. Using National Agricultural Statistics Survey Data (2007), approximately 558 animals are present in the Little Pigeon Creek Subwatershed. Streambank erosion is a concern in the subwatershed. Approximately 13.7 miles (0.4%) of streambank erosion were identified within the subwatershed.

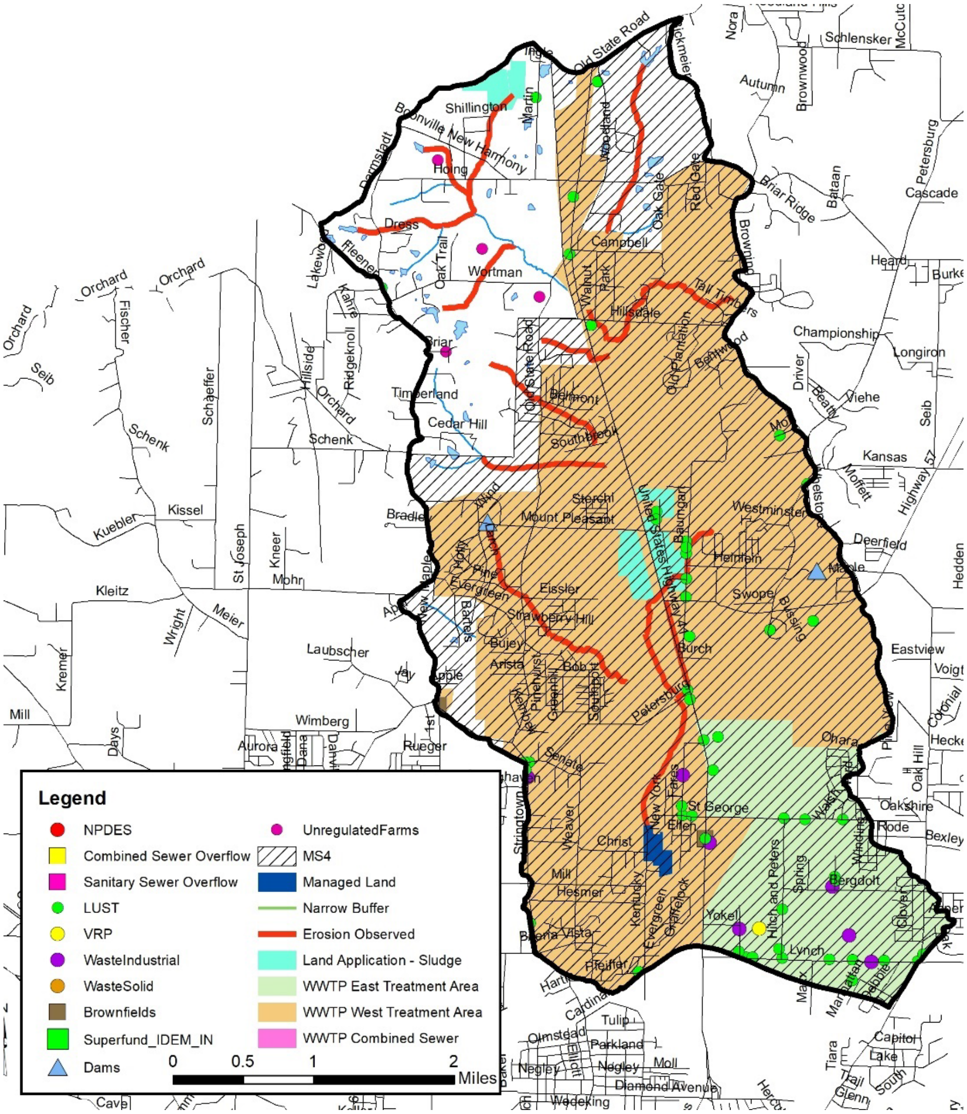

Figure 54. Point and non-point sources of pollution and suggested solutions in the Little Pigeon Creek Subwatershed.

4.3.5 IDEM TMDL Assessment

IDEM did not create or evaluate load duration curves or precipitation graph for the Little Pigeon Creek Subwatershed as part of the TMDL. Based on their assessment, a reduction in *E. coli* loading was not warranted in the Little Pigeon Creek Watershed.

4.3.6 Water Quality Assessment

Waterbodies within the Little Pigeon Creek Subwatershed have been sampled at 10 locations (Figure 55). Assessments include collection of water chemistry by IDEM (2 sites), by USGS (1 site), by Harza (2 sites), by Arion Consultants (1 site) and by Hoosier Riverwatch volunteers (4 sites). No stream gages are in the Little Pigeon Creek Subwatershed.

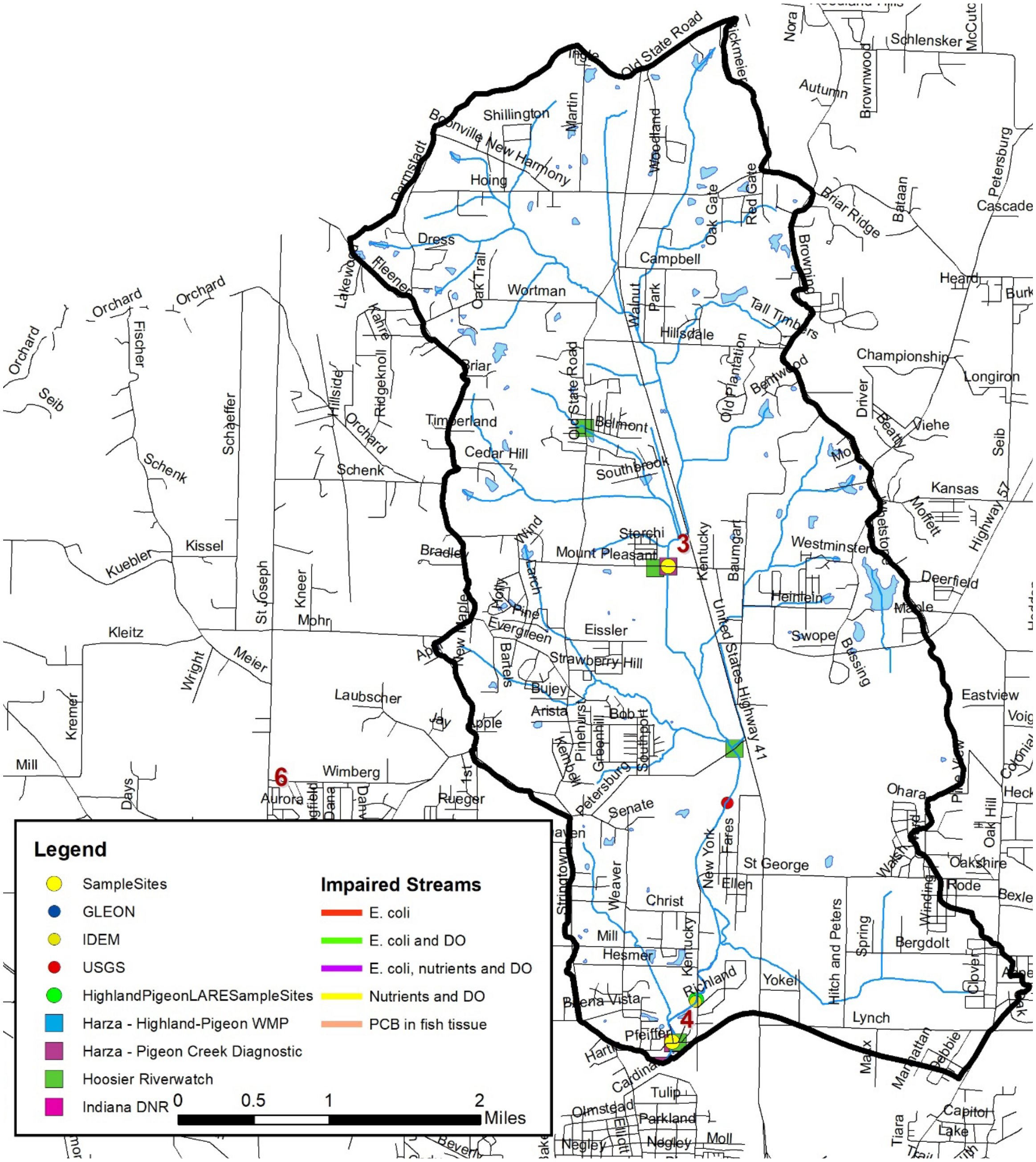

Figure 55. Locations of historic and current water quality data collection and impairments in the Little Pigeon Creek Subwatershed.

Table 25 details historic water quality data collected in the Little Pigeon Creek Subwatershed. As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 60% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1.5 mg/L) in 14% of samples, while total Kjeldahl nitrogen concentrations exceed water quality targets (0.57 mg/L) in 29% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 86% of samples. Total suspended solids concentrations exceeded water quality targets (15 mg/L) in 86% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 90% of samples.

Table 25. Little Pigeon Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	178	760	0	14	0%
DO	3	15	3	14	21%
E. coli	1	2,420	6	10	60%
Nitrate-Nitrogen	0.05	3.1	1	7	14%
pH	5.92	8.59	0	12	0%
TKN	0.05	4.2	2	7	29%
Total Phosphorus	0.01	0.65	6	7	86%
Total Suspended Solids	7	76	3	7	43%
Turbidity	3.4	78.1	9	10	90%

Table 26 details water quality data collected in the Little Pigeon Creek Subwatershed. Two sample sites, Site 3 (headwaters) and Site 4 (outlet) were sampled during the current project. As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 50% of headwaters and 42% of outlet samples. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 17% of headwaters and 8% of outlet samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 92% of headwaters and 75% of outlet samples. Total suspended solids concentrations exceed water quality targets (15 mg/L) in 42% of headwaters and 33% of outlet samples, while turbidity levels exceed water quality targets (5.7 NTU) in 83% of all samples. Dissolved oxygen concentrations measured both above and below water quality targets with 67% of headwaters and 25% of outlet samples exceeding water quality standards. These data suggest that many of the sources of nutrients and sediment occur in the headwaters of Little Pigeon Creek and that these concentrations are diluted as water moves downstream.

Table 26. Little Pigeon Creek Subwatershed water quality data summary, 2021-2022.

Site		Temp (deg C)	DO (mg/L)	pH	Cond (mg/L)	Turb (NTU)	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100 ml)
3	Median	68	5.2	8.1	13.05	384	0.5	0.1	9	185
	Max	75.2	15.2	8.7	450	470	0.75	1	621	1600
	Min	41.18	1.1	7.6	3.38	102	0.2	0.05	5	32
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		8	0	0	10	2	11	5	6
	% Exceed		67%	0%	0%	83%	17%	92%	42%	50%
4	Median	65.66	6.55	8.29	12.55	495	0.5	0.105	9.5	117
	Max	75.2	10.2	8.7	494	870	0.7	0.19	51	1900
	Min	37.76	1.2	7.8	0.16	6.8	0.2	0.05	5	23
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		3	0	0	10	1	9	4	5
	% Exceed		25%	0%	0%	83%	8%	75%	33%	42%

4.4 <u>Headwaters Locust Creek Subwatershed</u>

The Headwaters Locust Creek Subwatershed forms the northwestern boundary of the Lower Pigeon Creek Watershed and lies fully within Vanderburgh County (Figure 56). It encompasses one 12-digit HUC watershed: 051202020304. This subwatershed drains 6,513.5 acres or 10.2 square miles and accounts for 9.5% of the total watershed area. There are 25.8 miles of stream. None of its streams are listed as impaired by IDEM.

Figure 56. Headwaters Locust Creek Subwatershed.

4.4.1 Soils

Hydric soils make up 38.2 acres or 0.6% within the subwatershed. Wetlands currently cover 2.8% (181.8 acres or 73.6 ha) of the subwatershed. Highly erodible soils nearly cover the entire subwatershed with 6,273.5 acres (2,538.8 ha) or 96% mapped as HEL. More than 4,822.3 acres (73.8%) of the subwatershed are identified as very limited for septic use. Homes in the Headwaters Locust Creek Subwatershed are mostly rural using on-site septic systems. Maintenance and inspection of septic systems in this area are important to ensure proper function and capacity.

4.4.2 Land Use

Forested land use dominates the Headwaters Locust Creek Subwatershed with 55.5% (3,625.4 acres or 1,467.1 ha) in forested land use. Agricultural land uses, including row crop and pasture, account for 30.9% (2,020.9 acres or 817.8 ha). There is very little wetland area in this subwatershed. Wetlands, open water, and grassland cover 181.8 acres (73.6 ha), or 2.8%, of the subwatershed. Urban land uses cover 708.1 acres (286.6 ha) or 10.8% of the subwatershed.

4.4.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed (Figure 57). There are 2 leaking underground storage tanks sites. No brownfields, industrial waste facilities, solid waste facilities, or waste restricted locations, open dumps, NPDES-permitted locations, superfunds, corrective action sites, or voluntary remediation sites are located within the Headwaters Locust Creek Subwatershed.

4.4.4 Non-Point Source Water Quality Issues

Forested and agricultural land uses are the predominant land use in the Headwaters Locust Creek Subwatershed. A number of small animal operations and pastures are present. In total, six unregulated animal operations housing more than 48 cows, horses, and goats were identified during the windshield survey. In total, manure from small animal operations total over 1,002 tons per year, which contains almost 513 pounds of nitrogen, almost 261 pounds of phosphorus and 2.96E+13 colonies of *E. coli*. Based on windshield survey observations, livestock do not appear to have access to the subwatershed streams. No active confined feeding operations are located within the Headwaters Locust Creek Subwatershed. Streambank erosion is a concern in the subwatershed. Using National Agricultural Statistics Survey Data (2007), approximately 326 animals are present in the Headwaters Locust Creek Subwatershed Approximately 10.2 miles (0.4%) of streambank erosion were identified within the subwatershed. Additionally, nearly 2.2 miles of narrowly buffered stream were observed during the windshield survey. Further, due to the forested cover, a significant presence of wildlife is expected to use the stream corridor.

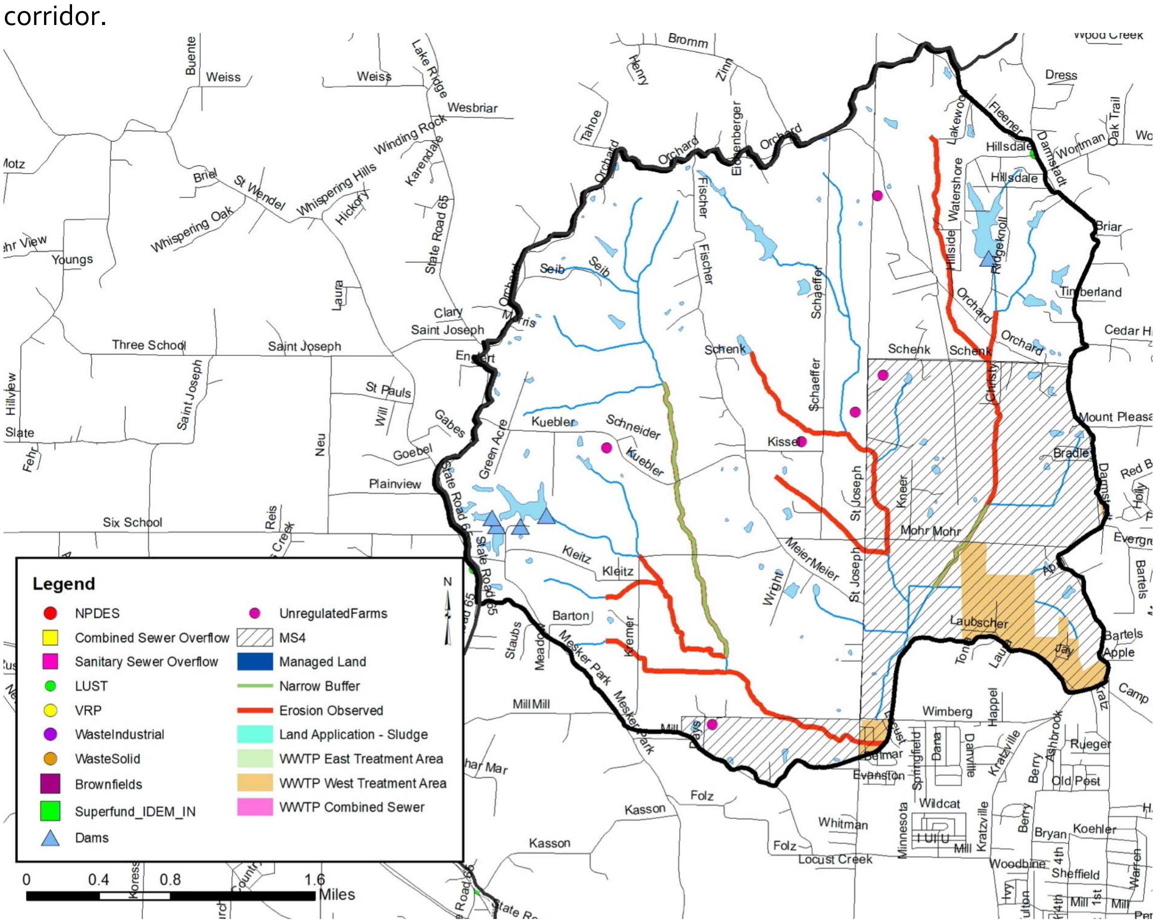

Figure 57. Point and non-point sources in the Headwaters Locust Creek Subwatershed.

4.4.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph to determine what flow regimes contribute to elevated *E. coli* concentrations (Table 27). Based on the water quality duration curves, IDEM concluded that the majority of sources of *E. coli* in the Headwaters Locust Creek Subwatershed occur under very high flow and high flow regimes. To reduce *E. coli* in the Headwaters Locust Creek Subwatershed, reduction of *E. coli* during high flow conditions is necessary.

Table 27. Flow regime TMDL analysis for *E. coli* in the Headwaters Locust Creek Subwatershed.

Upstream Characteristics					
Drainage Area	10.25 square miles				
TMDL Sample Site	25				
Listed Segments	INE0234_01, INE0234_T1001, INE0234_T1002, INE0234_T1003, INE0234_T1004, INE0234_T1005, INE0234_T1006, INE0234_T1007				
Land Use	Agriculture: 45.8% Forest: 48.7% Urban: 2.7% Water: 1.3% Wetland: 1.6%				
NPDES Facilities	NA				
MS4 Communities	NA				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	Very High Flows	Higher Flow Conditions	"Normal" Flows	Lower Flow Conditions	Low Flows
LA	1544.04	196.74	51.39	7.2	0.9
WLA	NA	NA	NA	NA	NA
MOS (10%)	171.56	21.86	5.71	.80	.10
TMDL = LA+WLA+MOS	1715.6	218.6	57.1	8.0	1.0

4.4.6 Water Quality Assessment

Waterbodies within the Headwaters Locust Creek Subwatershed have been sampled at 4 locations (Figure 58) Assessments include collection of water chemistry by Harza (1 Site), by GLEON volunteers (1 site) and at 2 sites by Hoosier Riverwatch volunteers. No stream gages are in the Jackson Creek-Clear Creek Subwatershed.

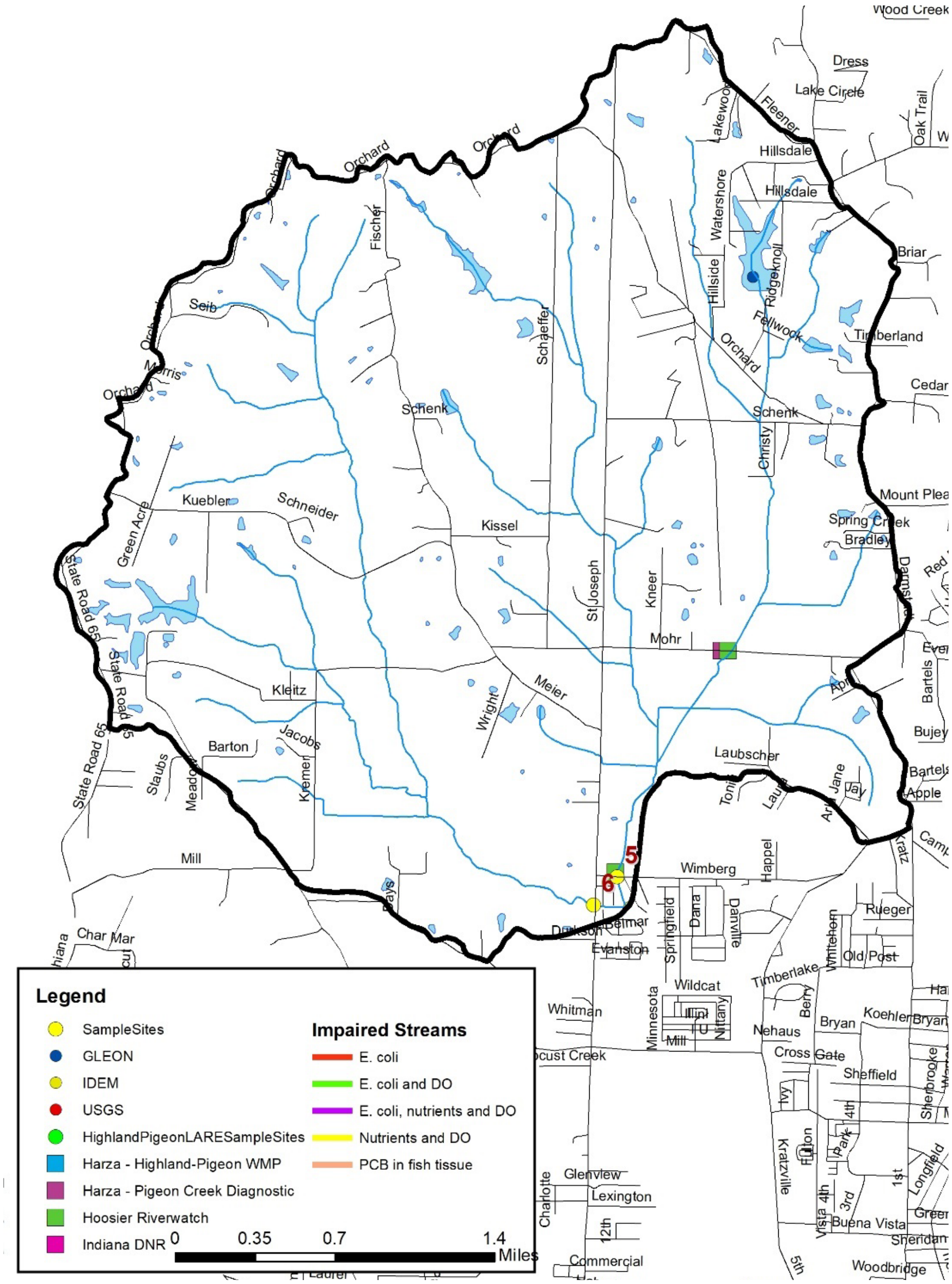

Figure 58. Locations of historic and current water quality data collection and impairments in the Headwaters Locust Creek Subwatershed.

Table 28 details historic water quality data collected in the Headwaters Locust Creek Subwatershed. As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 100% of samples collected. Total Kjeldahl nitrogen concentrations exceed water quality targets (0.57 mg/L) in 50% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 100% of samples. Total suspended solids concentrations exceed water quality targets (15 mg/L) in 100% of samples.

Table 28. Little Pigeon Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	316	394	0	2	0%
DO	2.77	18.5	2	2	100%
E. coli	580	640	2	2	100%
Nitrate-Nitrogen	0.05	0.05	0	2	0%
pH	7.92	8.51	0	2	0%
TKN	0.5	3.2	1	2	50%
Total Phosphorus	0.08	0.66	2	2	100%
Total Suspended Solids	22	140	2	2	100%
Turbidity	--	--	0	0	N/A

Table 29 details water quality data collected in the Headwaters Locust Creek Subwatershed (Sites 5 and 6). As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 42% of Locust Creek tributary samples (Site 5) and in 25% of Locust Creek samples (Site 6) collected. Nitrate-nitrogen concentrations exceed water quality targets (1.mg/L) in 50% of Locust Creek tributary samples and in 67% of Locust Creek samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 75% of all samples. Total suspended solids concentrations exceeded water quality targets (15 mg/L) in 17% of Locust Creek tributary samples and in 25% of Locust Creek samples. Turbidity levels exceed water quality targets (5.7 NTU) in 58% of all samples. Dissolved oxygen concentrations measured above and below water quality standards in 25% of Locust Creek tributary and 8% of Locust Creek samples.

Table 29. Headwaters Locust Creek Subwatershed water quality data summary, 2021-2022.

Site		Temp (deg C)	DO (mg/L)	pH	Cond (mg/L)	Turb (NTU)	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100 ml)
5	Median	62.6	6.75	8.45	9.505	379.5	0.69	0.1	5.5	145
	Max	80.6	9.2	8.8	460	654	1.4	0.13	46	63200
	Min	39.2	3	7.3	0	7.4	0.22	0.05	5	32
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		3	0	0	7	6	9	2	5
	% Exceed		25%	0%	0%	58%	50%	75%	17%	42%
6	Median	62.6	6.85	8.25	7.65	303	1.44	0.1	7.5	104
	Max	77	11.8	8.9	414	373	2.8	0.18	64	63200
	Min	37.94	3.6	7.4	0	19	0.5	0.05	5	18
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		1	0	0	7	8	9	3	3
	% Exceed		8%	0%	0%	58%	67%	75%	25%	25%

4.5 <u>Locust Creek</u>

The Locust Creek Subwatershed forms the western boundary of the Lower Pigeon Creek Watershed and is fully located within Vanderburgh County (Figure 59). It encompasses one 12-digit HUC watershed:

051402020305. This subwatershed drains 4,897.4 acres and accounts for 7.1% of the total watershed area. The Locust Creek Subwatershed drains 7.7 square miles. There are 18.7 miles of stream. None of its stream is listed as impaired by IDEM.

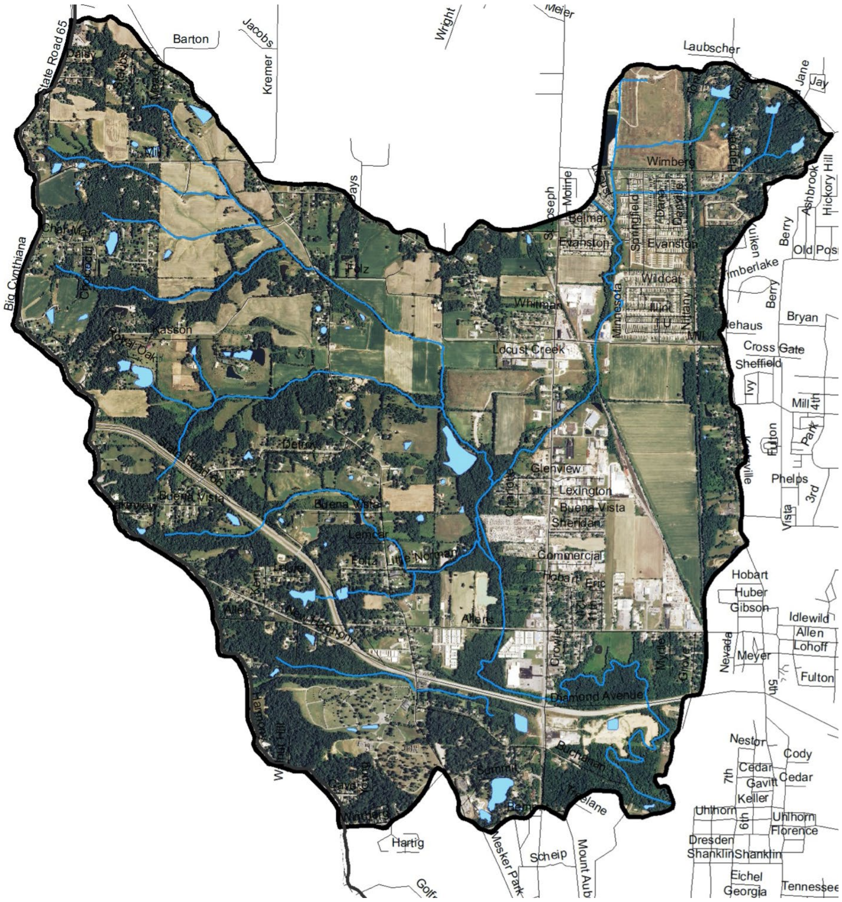

Figure 59. Locust Creek Subwatershed.

4.5.1 Soils

Hydric soils cover 521.6 acres (10.6%) of the Locust Creek Subwatershed. Wetlands currently cover 4.9% (237.9 acres) of the subwatershed. Highly erodible soils nearly 89.7% the subwatershed or 4,395.5 acres (1,778.8 ha). In total, 3,927.8 miles (80.1%) of the subwatershed are identified as very limited for septic use. While nearly half of the Locust Creek Subwatershed drains to the City of Evansville West wastewater treatment plant, in areas where septic systems are utilized, maintenance and inspections of septic systems in the area is important to ensure proper function and capacity.

4.5.2 Land Use

Forested, urban, and agricultural land split the Locust Creek subwatershed in nearly equal thirds. Nearly 30.2% (4,901.0 acres) are in agricultural land uses, including row crop and pasture with 33.6% of the watershed (1,646.0 acres) is in forested land uses. Urban land use makes up the final third with 1,536.1 acres, or 31.3%, of the subwatershed. In total, 237.9 acres or 4.9% of the subwatershed are in wetland land uses. Urban land use is comprised mainly of the City of Evansville's western edge.

4.5.3 Point Source Water Quality Issues

Despite the large portion of the subwatershed in urban land uses, there are few point sources of water pollution in the subwatershed (Figure 60). There are 26 leaking underground storage tanks sites. There is one NPDES-permitted facility, the AC Mobile home park. There are two industrial waste sites, and one solid waste site. No brownfields or waste restricted locations, open dumps, superfund sites, corrective action sites, or voluntary remediation sites are located within the Locust Creek Subwatershed.

4.5.4 Non-Point Source Water Quality Issues

Forested land use, agricultural land use, and urban land use make up the three primary forms of land use in the Locust Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present (Figure 60). In total, five unregulated animal operations housing more than 48 cows, horses, sheep and goats were identified during the windshield survey. In total, manure from small animal operations total over 199 tons per year, which contains almost 693 pounds of nitrogen, almost 498 pounds of phosphorus and 4.14E+13 colonies of *E. coli*. Livestock do not appear to have access to the subwatershed streams based on windshield survey observations. No active confined feeding operations are located within the Locust Creek Subwatershed. Using National Agricultural Statistics Survey Data (2007), approximately 244 animals are present in the Bluegrass Creek Subwatershed Streambank erosion is a concern in the subwatershed. Approximately 7.8 miles of streambank erosion were identified within the subwatershed.

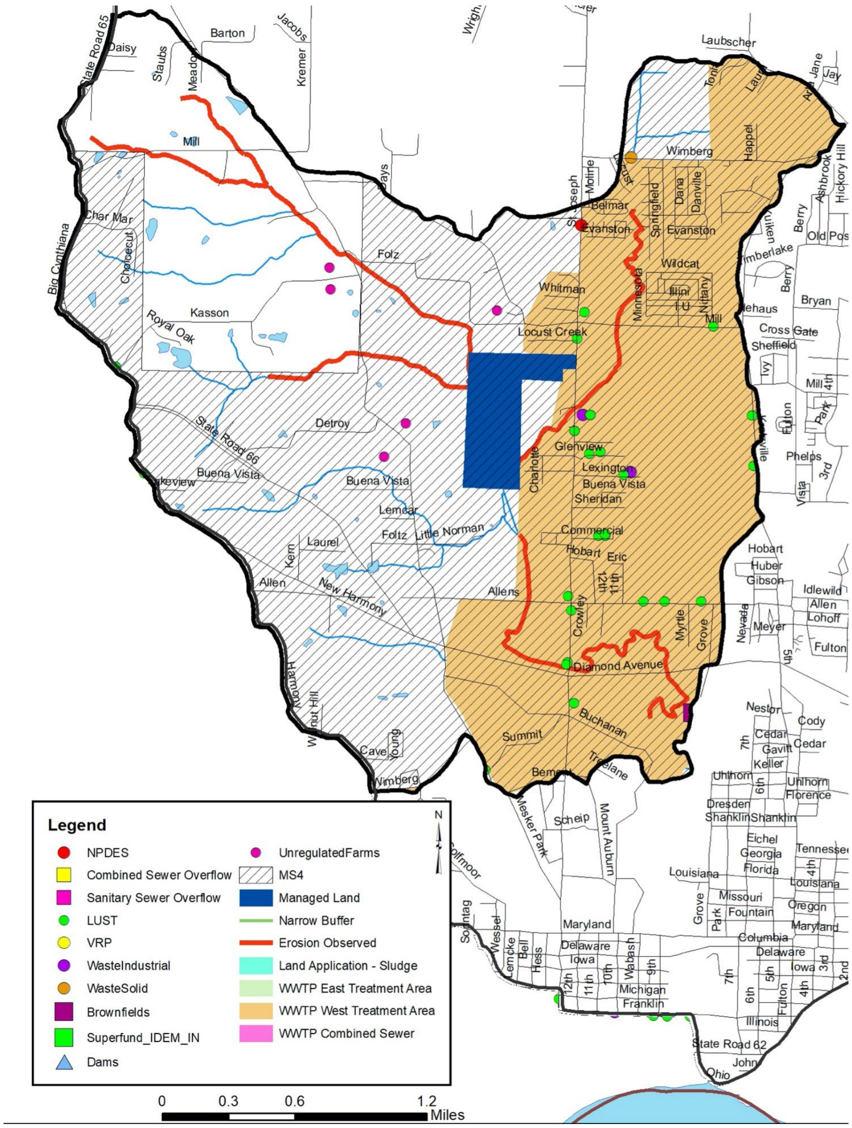

Figure 60. Point and non-point sources of pollution in the Locust Creek Subwatershed.

4.5.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph to determine what flow regimes contribute to elevated *E. coli* concentrations (Table 30). Based on the water quality duration curves, IDEM concluded that the majority of sources of *E. coli* in the Locust Creek Subwatershed occur under very high flow and high flow regimes. To reduce *E. coli* in the Locust Creek Subwatershed, reduction of *E. coli* during high flow conditions is necessary.

Table 30. Flow regime TMDL analysis for *E. coli* in the Locust Creek Subwatershed.

Upstream Characteristics					
Drainage Area	7.65 square miles				
TMDL Sample Site	24				
Listed Segments	INE0235_01				
Total Land Use	Ag: 48.2% Forest: 30.1% Urban: 14.4% Water: 0.8% Wetland: 6.5%				
Non-MS4 Land use	Ag: 91.44% Forest: 85.10% Urban: 90.18% Water: 90.33% Wetland: 81.60%				
NPDES Facilities	AC Ranch Mobile Home Park (IN0039608)				
MS4 Communities	City of Evansville MS4(INR040057) (0.655 square miles w/in MS4 8.56%)				
MS4 Land use	Ag: 2.85% Forest: 14.90% Urban: 9.82% Water: 9.67% Wetland: 18.40%				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	Very High Flows	Higher Flow Conditions	"Normal" Flows	Lower Flow Conditions	Low Flows
LA	1411.853	179.882	47.056	6.567	0.806
WLA	132.187	16.858	4.424	0.633	0.094
MOS (10%)	171.56	21.86	5.72	0.8	0.1
TMDL = LA+WLA+MOS	1715.6	218.6	57.2	8	1

4.5.6 Water Quality Assessment

Waterbodies within the Locust Creek Subwatershed have been sampled at 9 locations (Figure 61). Assessments include collection of water chemistry data by IDEM (2 sites), by Harza (1 site), by Arion Consultants (1 site) and Hoosier Riverwatch Volunteers (5 sites). No stream gages are in the Locust Creek Subwatershed.

Table 31 details historic water quality data collected in the Locust Creek Subwatershed (Site 7). As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 43% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1.5 mg/L) in 20% of samples, while total Kjeldahl nitrogen concentrations exceed water quality targets (0.57 mg/L) in 20% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) 60% of samples. Total suspended solids concentrations exceeded water quality targets (15 mg/L) in 40% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 93% of samples.

Table 31. Locust Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	162	3,510	0	17	0%
DO	1.4	18.9	3	17	18%
E. coli	1	24,000	6	14	43%
Nitrate-Nitrogen	0.05	4.3	1	5	20%
pH	6.88	8.87	1	17	6%
TKN	0.05	5	1	5	20%
Total Phosphorus	0.05	1.817	3	5	60%
Total Suspended Solids	8	824	2	5	40%
Turbidity	19	444	14	15	93%

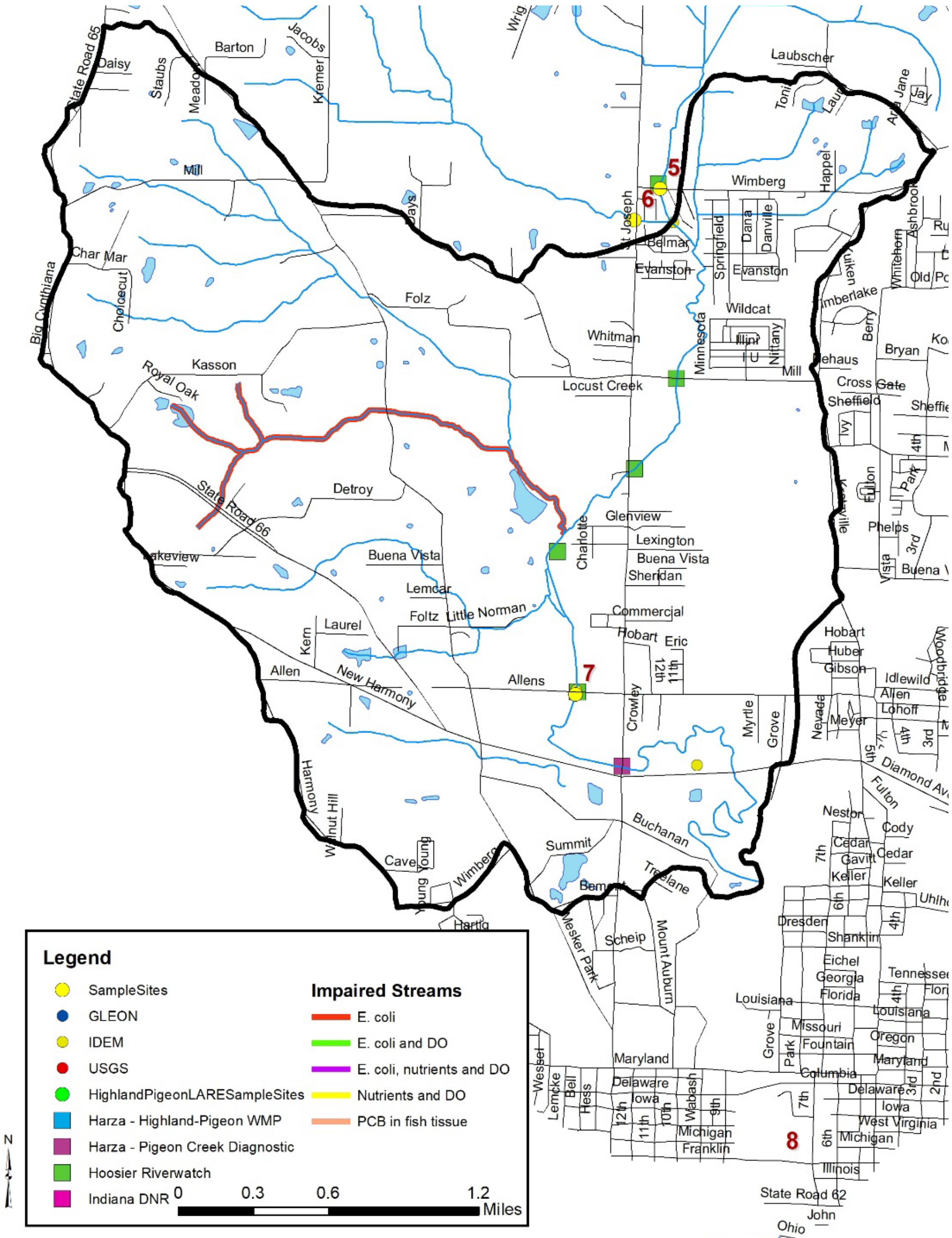

Figure 61. Locations of historic and current water quality data collection and impairments in the Locust Creek Subwatershed.

Table 32 details water quality data collected in the Locust Creek Subwatershed (Site 7). As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 33% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 58% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 75% of samples. Total suspended solids concentrations exceeded water quality targets (15 mg/L) in 25% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 75% of samples. Dissolved oxygen concentrations measured both above and below state standards exceeding these in 58% of samples.

Table 32. Locust Creek Subwatershed water quality data summary, 2021-2022.

Site		Temp (deg C)	DO (mg/L)	pH	Cond (mg/L)	Turb (NTU)	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100 ml)
7	Median	64.94	5.5	8.48	14.45	361.5	0.917	0.1	8.5	113
	Max	78.8	13.6	8.9	570	534	1.7	0.16	45	1000
	Min	37.76	1.4	7.4	1.51	13	0.5	0.05	5	27
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		7	0	0	9	7	9	3	4
	% Exceed		58%	0%	0%	75%	58%	75%	25%	33%

4.6 Kleymeyer Park-Pigeon Creek Subwatershed

The Kleymeyer Park-Pigeon Creek Subwatershed forms the southern boundary of the Lower Pigeon Creek Watershed (Figure 62). It encompasses one 12-digit HUC watershed: 051402020306. This subwatershed drains 17,775.3 acres and accounts for 25.9% of the total watershed area The Kleymeyer Park-Pigeon Creek Subwatershed drains 27.8 square miles. There are 37.2 miles of stream. IDEM has classified 3.62 miles of stream as impaired for *E. coli*, *1.59* miles of stream as impaired for polychlorinated biphenyl (PCB), 6.80 miles of stream as impaired for nutrients, and 10.42 miles of stream impaired for dissolved oxygen. It should be noted that the Kleymeyer Park-Pigeon Creek Subwatershed receives drainage from the entire Lower Pigeon Creek Watershed in addition to the Upper and Middle Pigeon Creek Watersheds.

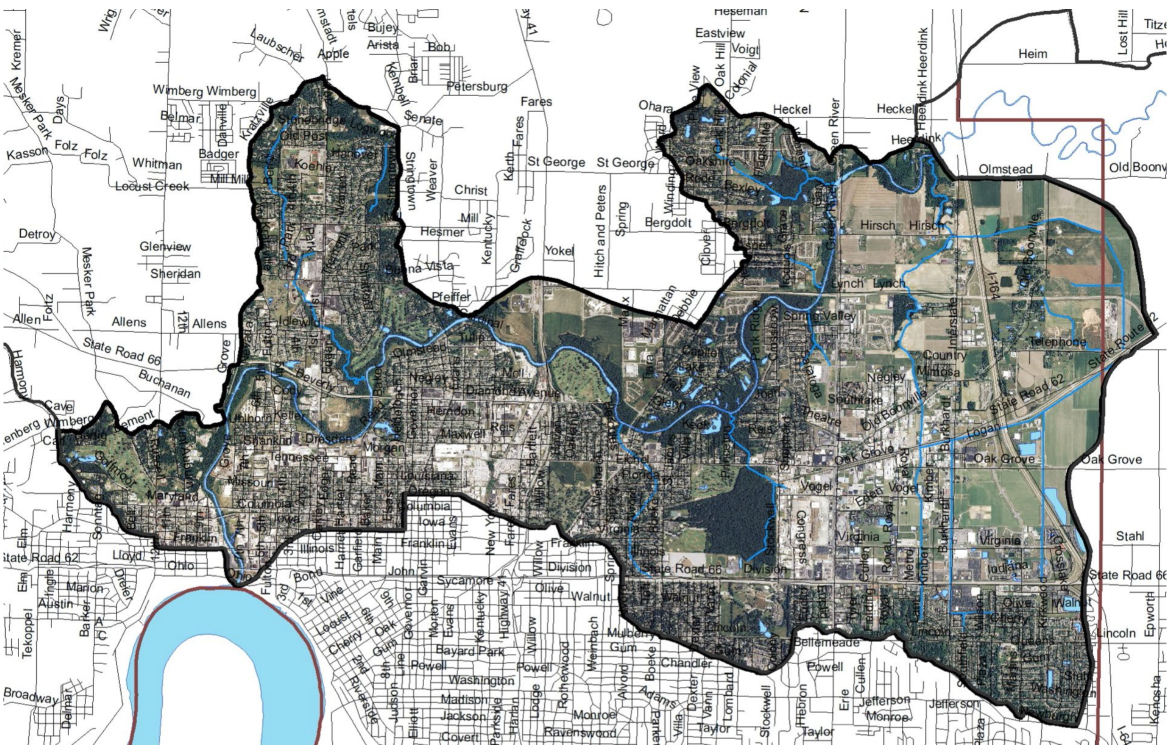

Figure 62. Kleymeyer Park-Pigeon Creek Subwatershed.

4.6.1 Soils

Hydric soils cover 5,121.9 acres (28.8%) of the subwatershed, indicating that nearly one-third of the subwatershed was historically covered by wetlands. Wetlands currently cover 4.4% (780.4 acres) of the subwatershed. Highly erodible soils nearly cover a majority of the subwatershed (80.2%). In total, 14,287.4 acres (80.3%) of the subwatershed are identified as very limited for septic use. However, nearly 100% of the watershed drains to the Evansville East or West wastewater treatment plants. In areas where septic systems are utilized, maintenance and inspection of these septic systems are important to ensure proper function and capacity.

4.6.2 Land Use

Urban land use dominates the Kleymeyer Park-Pigeon Creek Subwatershed with 68.1% (12,114.6 acres) covered by residential, commercial or industrial land uses. Just 15.8% (2,811.0 acres) of the subwatershed is in agricultural land use, including row crop and pasture. Nearly 11.7% (2,082.8 acres) is in forested land use. Wetlands, open water, and grassland cover 780.4 acres, or 4.4%, of the subwatershed.

4.6.3 Point Source Water Quality Issues

There are a number of point sources of water pollution in the subwatershed. There are 224 LUST sites located in the subwatershed (Figure 63), one NPDES permitted location, eight Combined sewer overflow points, 14 brownfield, three Voluntary Remediation Sites, and 55 industrial waste facilities. Additionally, while the Superfund site is not located within the Pigeon Creek drainage, the Kleymeyer Park-Pigeon Creek Subwatershed is impacted by the Jacobsville Superfund site and likely includes areas being remediated for contaminated soils. No open dumps, or corrective action sites are located within the Kleymeyer Park-Pigeon Creek Subwatershed.

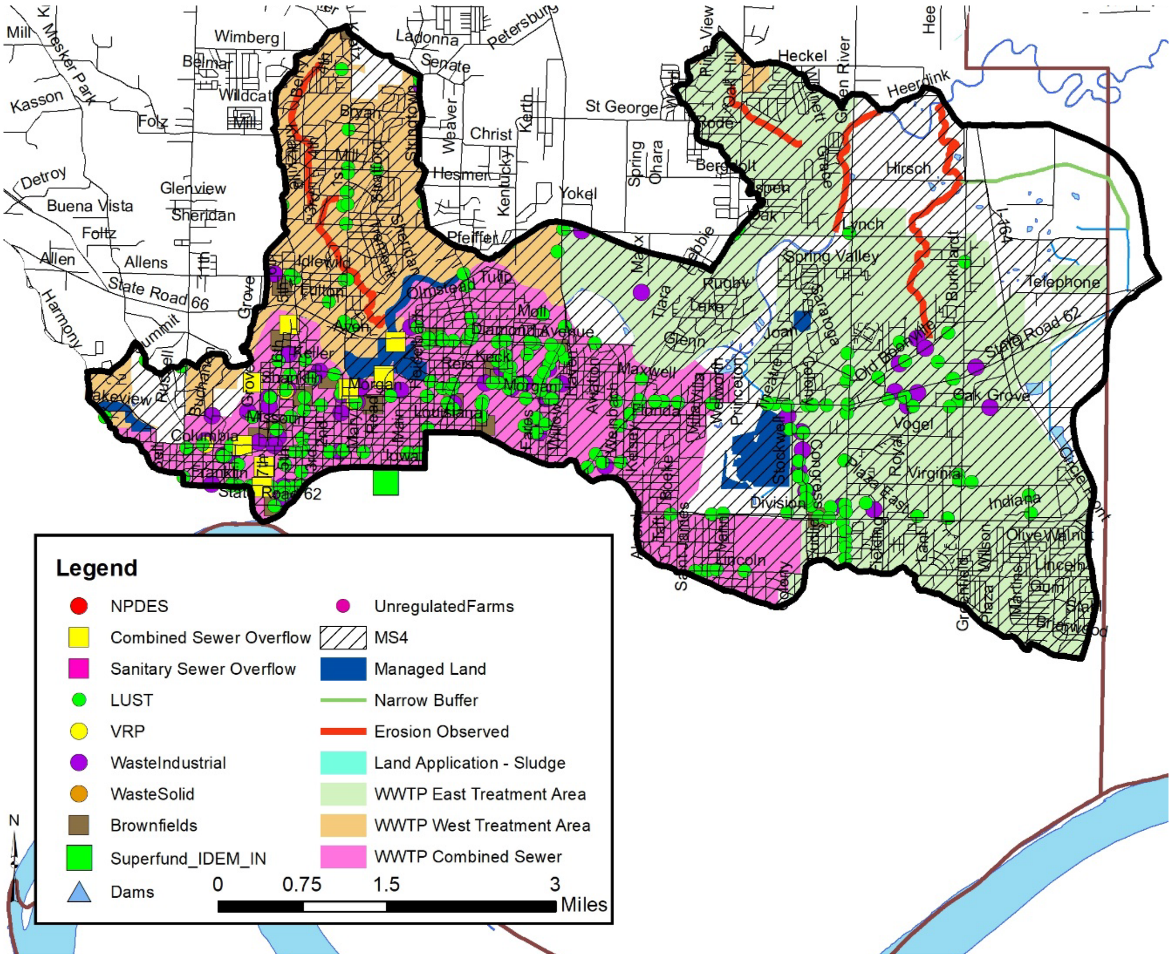

Figure 63. Point and non-point sources of pollution and suggested solutions in the Kleymeyer Park-Pigeon Creek Subwatershed.

4.6.4 Non-Point Source Water Quality Issues

Considering that urban land dominates the Kleymeyer Park-Pigeon Creek Subwatershed, there were no unregulated animal operations identified during the windshield survey. Additionally, based on observations during the windshield survey, livestock do not have access to Kleymeyer Park-Pigeon Creek Subwatershed streams. However, approximately 8.3 miles (0.02%) of streambank erosion were identified within the subwatershed. An additional 1.9 miles of narrow buffer were observed during the windshield survey.

4.6.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph to determine what flow regimes contribute to elevated *E. coli* concentrations (Table 33). Based on the water quality duration curves, IDEM concluded that the majority of sources of *E. coli* in the Kleymeyer Park-Pigeon Creek Subwatershed occur under very high flow and high flow regimes. To reduce *E. coli* in the Kleymeyer Park-Pigeon Creek Subwatershed, reduction of *E. coli* during high flow conditions is necessary.

Table 33. Flow regime TMDL analysis for *E. coli* in the Kleymeyer Park-Pigeon Creek Subwatershed.

Upstream Characteristics					
Drainage Area	27.77 square miles				
TMDL Sample Site	21				
Listed Segments	INE0236_01, INE0236_02				
Total Land Use	Ag: 41.0% Forest: 14.1% Urban 39.0% Water: 0.9% Wetland: 4.9%				
Non-MS4 Land Use	Ag: 64.97% Forest: 15.74% Urban 8.13% Water: 97.23% Wetland: 36.13%				
NPDES Facilities	NA				
MS4 Communities	City of Evansville MS4(INR040057) (18.28 square miles w/in MS4 65.24%)				
MS4 Land Use	Ag: 35.03% Forest: 84.26% Urban 91.87% Water: 2.77% Wetland: 63.879%				
CSO Communities	Evansville-Nine (9) CSOs				
CAFOs	NA				
CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	Very High Flows	Higher Flow Conditions	"Normal" Flows	Lower Flow Conditions	Low Flows
LA	536.708	68.387	17.863	2.503	0.313
WLA*	1007.332	128.353	33.527	4.697	0.587
MOS (10%)	171.56	21.86	5.71	0.8	0.1
TMDL = LA+WLA+MOS	1715.60	218.60	57.10	8.00	1.00
*65.24% WLA estimated on percent of MS4 in watershed					

4.6.6 Water Quality Assessment

Waterbodies within the Kleymeyer Park-Pigeon Creek Subwatershed have been sampled at 36 locations (Figure 63). Assessments include collection of water chemistry and biology data by IDEM (19 sites), by USGS (4 sites), by Harza (9 sites), by Arion Consultants (1 site) and Hoosier Riverwatch Volunteers (5 sites) with some overlap in sample sites between sampling programs. No stream gages are in the Kleymeyer Park-Pigeon Creek Subwatershed.

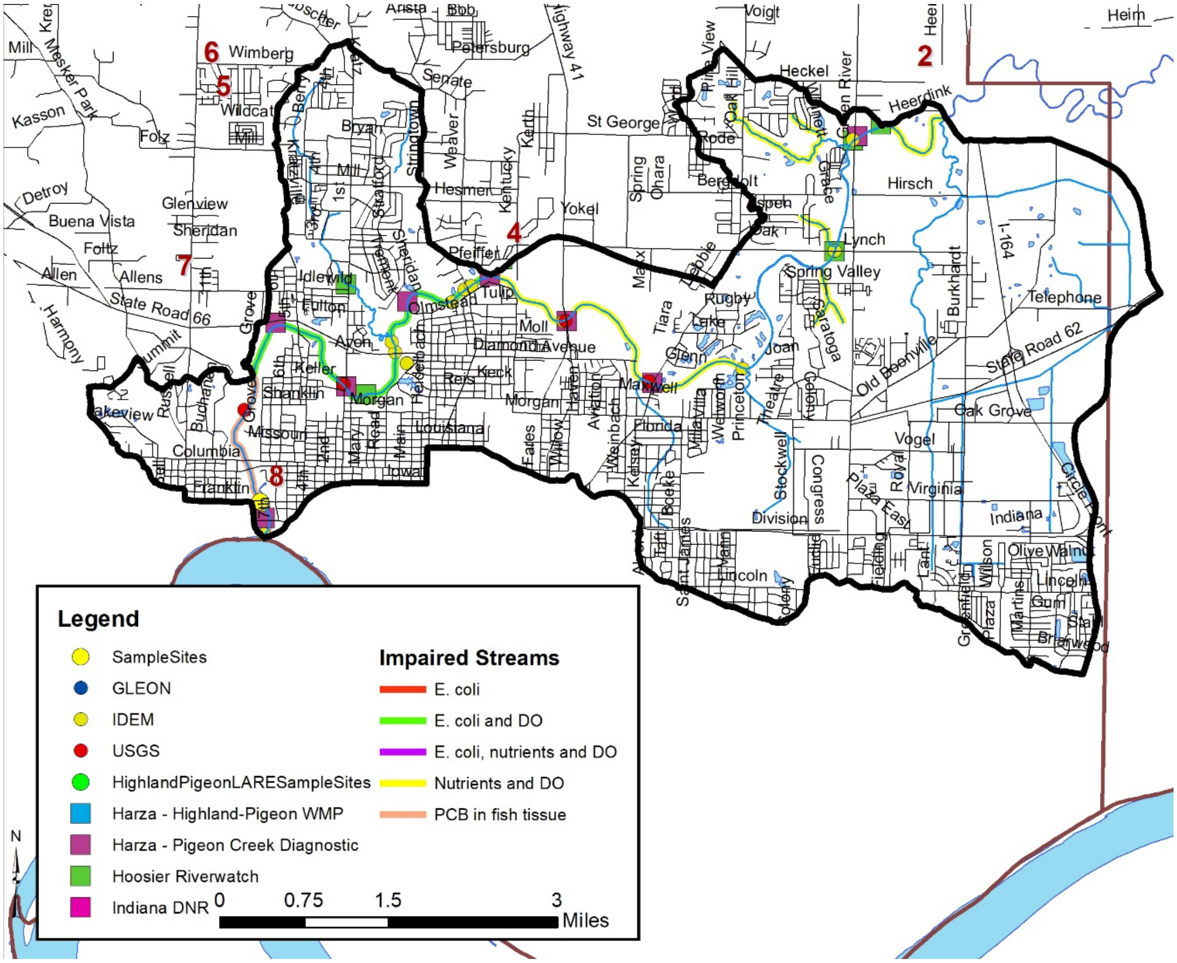

Figure 64. Locations of historic and current water quality data collection and impairments in the Kleymeyer Park-Pigeon Creek Subwatershed.

Table 34 details historic water quality data collected in the Kleymeyer Park-Pigeon Creek Subwatershed. As shown in the table, conductivity concentrations exceed water quality targets (1050 mS/cm) in 53% of samples. *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 81% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1.5 mg/L) in 36% of samples, while total Kjeldahl nitrogen concentrations exceed water quality targets (0.57 mg/L) in 81% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 95% of samples. Total suspended solids concentrations exceed water quality targets (15 mg/L) in 51% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 97% of samples.

Table 34. Kleymeyer Park-Pigeon Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	186	654	170	322	53%
DO	1.6	15.5	70	324	22%
E. coli	1	4,884	29	36	81%
Nitrate-Nitrogen	0.1	0.4	101	284	36%
pH	7.09	8.82	0	324	0%
TKN	0.6	1.4	229	282	81%
Total Phosphorus	0.08	0.6	270	283	95%
Total Suspended Solids	5	51	142	283	51%
Turbidity	7.8	198.5	32	33	97%

Biological monitoring was conducted by IDEM at two sites with one assessed for both macroinvertebrates and fish and one assessed for only macroinvertebrate community health. Macroinvertebrate assessments indicate the community is severely impaired scoring 1.6 and 1.8 using the kick survey method and rating as non-supporting for its aquatic life use destination using the multihabitat assessment. The fish community rated as poor. Habitat assessments completed as part of the biological assessments indicate habitat is poor at these reaches of Pigeon Creek scoring between 44 and 46.

Table 35 details water quality data collected in the Kleymeyer Park-Pigeon Creek Subwatershed (Site 8). As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 50% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 92% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 100% of samples. Total suspended solids concentrations exceeded water quality targets (15 mg/L) in 75% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 100% of samples. Dissolved oxygen concentrations measured both above and below water quality standards in 33% of samples.

Table 35. Kleymeyer Park-Pigeon Creek Subwatershed water quality data summary, 2021-2022.

Site		Temp (deg C)	DO (mg/L)	pH	Cond (mg/L)	Turb (NTU)	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)	*E. coli* (col/100 ml)
8	Median	68.9	6.05	8.25	27	522	0.96	0.205	19.5	228
	Max	78.8	7.9	8.8	738	1030	2.75	0.58	184	1500
	Min	36.32	1	7.6	12.92	19.7	0.5	0.081	7	22
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		4	0	0	12	11	12	9	6
	% Exceed		33%	0%	0%	100%	92%	100%	75%	50%

5.0 WATERSHED INVENTORY III: WATERSHED INVENTORY SUMMARY

Several important factors and relationships become apparent when the Lower Pigeon Creek 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 historic data collected from IDEM, USGS, Harza, IDNR and Hoosier Riverwatch as well as current water quality assessments completed as through the professional and Hoosier Riverwatch monitoring programs conducted during the current project. These impairments include elevated nitrate-nitrogen, total phosphorus, total suspended solids, conductivity and *E. coli* concentrations, as well as pH and dissolved oxygen concentrations outside of target ranges.

Based on historic data, Table 36 highlights those locations within the Lower Pigeon Creek Watershed where concentrations of these parameters measured higher than the target concentrations or those locations where impaired waterbodies were identified by IDEM. Sample sites are mapped only if 50% or more of samples collected at those sites were outside the target values. Table 36 summarizes where historic samples were outside the target values and are grouped by subwatershed. Figure 65 shows the locations of historical sites that that exceeded target values.

Table 36. Percent of samples historically collected in Lower Pigeon Creek Subwatersheds which measured outside target values.

Subwatershed	*E. coli*	Turb	DO	N	P	TSS	Cond
Headwaters Bluegrass Creek	53%	75%	27%	50%	83%	33%	0%
Bluegrass Creek	33%	100%	23%	0%	100%	75%	62%
Little Pigeon Creek	56%	100%	25%	0%	80%	40%	0%
Headwaters Locust Creek	53%	75%	27%	50%	83%	33%	0%
Locust Creek	43%	100%	29%	0%	80%	60%	0%
Kleymeyer Park-Pigeon Creek	81%	100%	29%	0%	80%	60%	0%

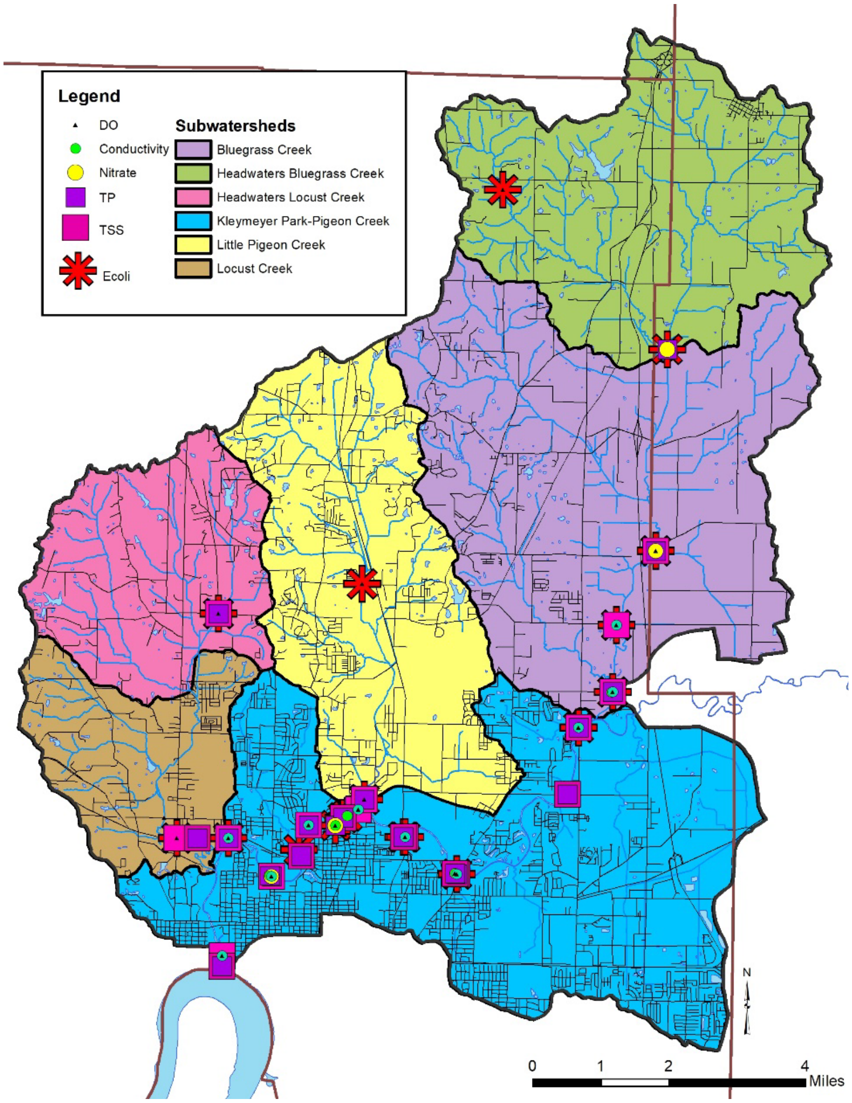

Figure 65. Lower Pigeon Creek Watershed historical sampling sites that exceed target values.

Table 37 summarizes current samples which measured outside the target values during the current assessment. Figure 66 provides a map of current sampling sites that exceed target values. Elevated nitrate-nitrogen concentrations were observed in Site 1, 6, 7 and 8 representing the Headwaters Bluegrass Creek, Headwaters Locust, Locust Creek and Kleymeyer Park-Pigeon Creek subwatersheds. In total, 47% of collected samples throughout the watershed. Elevated total phosphorus concentrations were observed at all sample sites with concentrations exceeding total phosphorus targets in 85% of collected samples at all sample sites. Elevated total suspended solids concentrations were observed at Sites 2 and 8 representing Bluegrass Creek and Kleymeyer Park-Pigeon Creek subwatersheds with 21% of all samples exceeding targets. *E. coli* concentrations that exceeded the state grab sample standard were measured at all sites. Exceedances were most common at Site 1, 3 and 8 representing the Headwaters Bluegrass Creek, Little Pigeon Creek and Kleymeyer Park-Pigeon Creek subwatersheds. In total, 43% of samples exceeding state standards.

Both high and low dissolved oxygen concentrations were observed at all sites during the sampling period. Site 3 (Little Pigeon Creek) and Site 7 (Locust Creek) possessed the most exceedances. Specific conductivity exceeded targets at a single site (Site 2, Bluegrass Creek) during two sampling events. pH concentrations exceeded targets at a single site (Site 1, Headwaters Bluegrass Creek) during one sampling event. Habitat assessments occurred once during the project. The Headwaters Bluegrass Creek (Site 1), Bluegrass Creek (Site 2), Locust Creek tributary (Site 5), Locust Creek (Site 6) and Pigeon Creek all scored below the QHEI target (51). Biological communities rated poorer than targets for macroinvertebrate communities at Bluegrass Creek (Site 2), Little Pigeon Creek headwaters (Site 3), Little Pigeon Creek outlet (Site 4), Locust Creek tributary (Site 5), Locust Creek outlet (Site 7) and Pigeon Creek (Site 8). However, as only one macroinvertebrate assessment occurred during the current project and historic assessments include sporadic sites, biological data where sites do not meet water quality targets are not included in Table 37.

Table 37. Percent of samples collected in the Lower Pigeon Creek Watershed during the 2021-2022 sample collection which measured outside target values.

Subwatershed	DO	pH	Cond	Turb	N	P	TSS	E coli
Headwaters Bluegrass Creek	33%	8%	0%	100%	67%	100%	42%	67%
Bluegrass Creek	33%	0%	17%	92%	17%	92%	50%	33%
Little Pigeon Creek	46%	0%	0%	83%	13%	83%	38%	46%
Headwaters Locust Creek	17%	0%	0%	58%	58%	75%	21%	33%
Locust Creek	58%	0%	0%	75%	58%	75%	25%	33%
Kleymeyer Park-Pigeon Creek	33%	0%	0%	100%	92%	100%	75%	50%

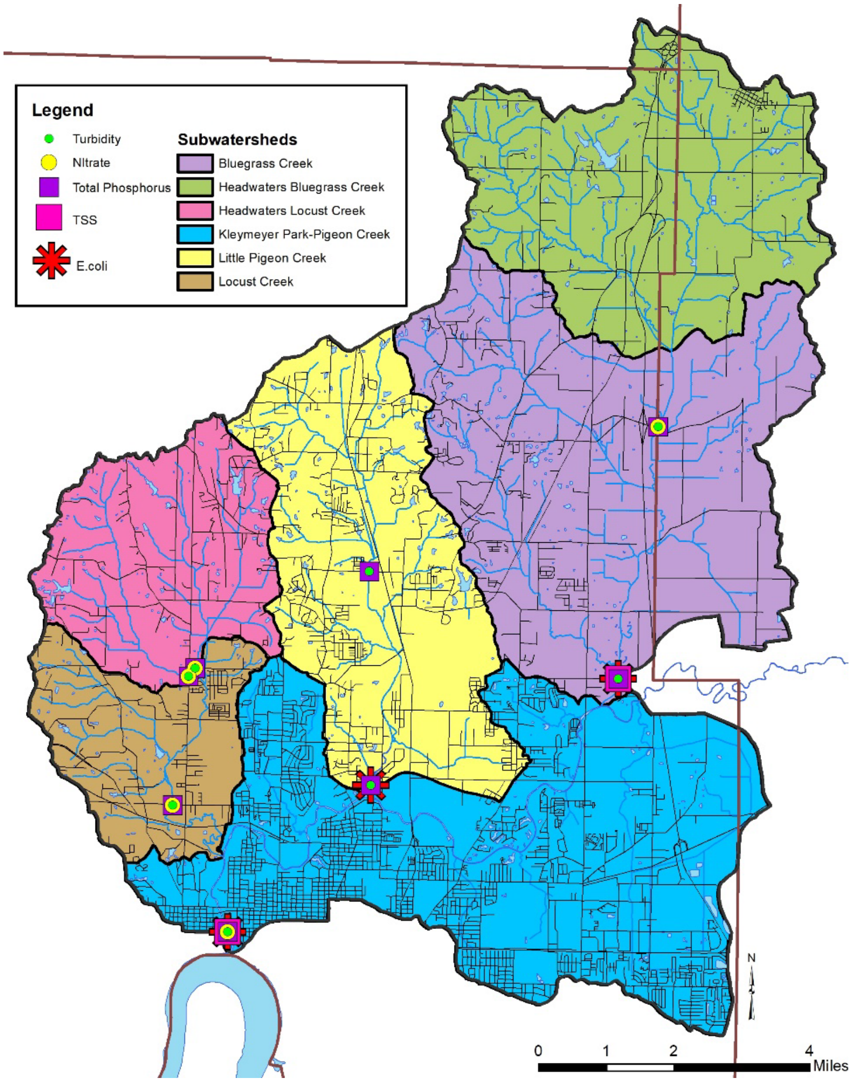

Figure 66. Lower Pigeon Creek Watershed sampling sites that exceed target values during the current sampling period.

5.2 Stakeholder Concern Analysis

All identified concerns generated both from stakeholder input and through water quality and watershed inventory efforts are detailed in Table 38. This list represents a work in progress and additional concerns may be added as the steering and monitoring committees work through data analysis. 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 38. Analysis of stakeholder concerns identified in the Lower Pigeon Creek Watershed.

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Elevated stream nutrient concentrations	Yes	In historic samples, 35% of nitrate-nitrogen, 78% of total Kjeldahl nitrogen, 94% of total phosphorus, 50% of total suspended solids and 90% of turbidity samples collected exceed water quality targets. Waterbodies are listed as impaired for nutrients (6.8 miles). During the current project, 32% of nitrate-nitrogen and 83% of total phosphorus samples exceed water quality targets.	Yes	No	Yes
High *E. coli* levels	Yes	Waterbodies are listed as impaired for *E. coli* (32.2 miles). 58% of historic *E. coli* samples and 42% of samples collected during the current project exceed state standards. The Pigeon Creek TMDL sets daily loading rates of 1.0 to 1715.6 MPN/colony. The Pigeon Creek TMDL identified a number of potential sources of E. including wastewater treatment plants, Municipal Separate Storm Sewer Systems (MS4s), Sanitary Sewer Overflows, pet waste, unregulated stormwater runoff, agriculture runoff, direct deposition or field runoff from livestock, wildlife direct deposits, leaking or failing septic systems and illegal straight pipe systems.	Yes	No	Yes
Low dissolved oxygen levels were observed in the stream	Yes	Historic data indicate 20% of samples measure above or below state water quality standards.	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
		During the current project, 27% of dissolved oxygen samples measure above or below the state water quality standard. 24.8 miles of Lower Pigeon Creek Watershed streams are impaired for dissolved oxygen.			
Livestock access to streams	No	While livestock with access to watershed streams were not observed during the windshield survey, anecdotal information indicates livestock have access to Lower Pigeon Creek streams.	Yes	Yes	Yes
Small farms, including sheep, horse farms	Yes	The watershed is home to 36 small farms and horse boarding facilities housing more than 260 animals. These small farms produce 4,120 tons of manure annually which accounts for 3,220 pounds of nitrogen, 1,606 pounds of phosphorus and $4.7x10^{14}$ col of *E. coli*.	Yes	No	Yes
Manure management					
Combined sewer overflows	Yes	More than 4,400 acres (6%) of the Lower Pigeon Creek is located within a combined sewer overflow area. In total, 9 CSO or SSO points occur within the Lower Pigeon Creek Watershed.	Yes	No	No
Wastewater treatment impacts – including sanitary sewer overflows	Yes	More than 770 miles of sanitary and combined sewer pipes are present in the EWSU system with 420 miles occurring in the Lower Pigeon Creek Watershed. More than 44% of the watershed is covered by EWSU wastewater treatment which discharges to the Ohio River.	Yes	No	No
Narrow/limited buffers	Yes	During the windshield survey, 21.4 miles of watershed streams were noted with narrow buffers. This is likely an underestimate.	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Agricultural management – soil health needs	Yes	Pastureland covers 19% of the watershed, row crop agriculture covers 11% of the watershed. Between 15 and 42% of soybeans and 11 to 26% of corn planted in Gibson, Vanderburgh and Warrick Counties use conservation tillage.	Yes	No	Yes
Streams are turbid following even small rain events	Yes	Nearly 68 miles of streambanks were identified as eroding during the windshield survey. This is likely an underestimate. In historic samples, 50% of total suspended solids and 90% of turbidity samples collected exceed water quality targets. During the current project, 20% of TSS and 88% of turbidity samples exceed water quality targets (incomplete data).	Yes	No	Yes
Streambank erosion	Yes	Nearly 68 miles of streambanks were identified as eroding during the windshield survey. This is likely an underestimate.	Yes	No	Yes
highly erodible soils	Yes	Nearly 87% of the watershed is mapped in highly erodible soils.	Yes	No	Yes
Forest management	Yes	Forested land covers 26% of the watershed.	Yes	No	Yes
Quarry – Mulzer Stone	No	Mulzer Stone is located in the Lower Pigeon Creek Watershed. Mulzer delivers thousands of tons of state-approved crushed stone annually.	No	Yes	No
Development impacts	Yes	Nearly 34% of the watershed is considered in urban land use based on land cover estimates. More than 56% of the watershed (38,661 acres) are located in an MS4.	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
		Nearly 20% of the watershed is 25% or more covered by impervious surfaces – the level at which stream degradation occurs. More than 11,000 acres of wetland have been converted to urban or agricultural land uses. Based on estimates, more than 48,000 cats and nearly 43,000 dogs are present in the Lower Pigeon Creek Watershed.			
Industrial legacy pollutants	Yes	Nearly 320 LUST, 4 voluntary remediation projects, 2 open dumps, 2 solid waste facilities, 65 industrial waste facilities and 5 brownfields are present in the watershed. The Jacobsville Superfund site is located immediately south of the watershed and contaminated soil associated with this site is located within the watershed. Since 2012, more than 900 residential properties have been remediated.	Yes	No	Yes – Education
Airport, industry, paving operation, junk yard	No	High intensity developed areas cover 3% of the Lower Pigeon Creek Watershed. As part of the Pigeon Creek Diagnostic Study, MWH noted the presence of 5 industrial wastewater dischargers all of which had good records of compliance (2001).	Yes	Yes	No
Strip mining (historic), remining (current)	No	Surface mining occurred on the western edge of Evansville with underground mining occurring across nearly 25% of Warrick County. Historically strip pit mined areas have been converted to the Blue Grass Fish and Wildlife Area.	Yes	Yes	No

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
		Remining of previously coal mined areas is under consideration in Warrick County; however, current areas are located outside of the Lower Pigeon Creek Watershed.			
Country club, golf courses	Yes	Hamilton Golf Course, Clearcrest Pines Country Club, Nevada Bob's Golf, Fendrich Golf Course, Tee Time Golf Complex, Adventureland Golf, Putt Putt Golf and Games, The Midget Links, Helfriech Hills Golf Course and Evansville Country Club are all located within the Lower Pigeon Creek Watershed.	Yes	No	Yes - education
Litter, trash, dumping especially in urban portion	Yes	Litter and trash have not been quantified but were observed during the windshield survey. Highlight previous pick up programs.	Yes	No	Yes - education
Dog park adjacent to Pigeon Creek	Yes	The central Bark Dog Parks is located at Kleymeyer Park. Woodmere Dog Park is located at the state hospital grounds (within the watershed but not adjacent to Pigeon Creek).	Yes	Yes	No
Access to Pigeon Creek – parks and recreation opportunities	Yes	Pigeon Creek can be accessed via Kleymeyer Park, Stream Valley Park and the Pigeon Creek Greenway. Canoe access is present at Heidelbach Canoe Launch at the Evansville Country Club and at the Green River Road canoe launch (Rotary Club launch).	Yes	Yes	No – access should not be encourag ed
Protection of high quality areas – Wesselman Woods, Bluegrass Creek FWA	Yes	Wesselman Woods also is a unique part of the county as one of the largest old-growth forests within a city throughout the country, boasting 200 acres of trees that have never been touched or cut down.	Yes	No	Yes
Education and signage – public	Yes	Some signage is present at Kleymeyer and Lamasco Parks.	Yes	No	Yes - education

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
access to Pigeon Creek should take advantage of this		Signage details Pigeon Creek, the greenway, combined sewer overflows and stormwater impacts.			
Sports park off Heckle and Green River (intensive use)	Yes	Limited shade (lack of trees), soil limitations, additional habitat needed, opportunity to create demonstration area.	Yes	No	Education, demonstration site

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: combined sewer overflows and wastewater treatment impacts including sanitary sewer overflows, as the CSO are is already under consent decree with plans in place to mitigate; airport, industry, paving operations, junk yard and other heavy industrial or commercial operations, quarry operations, strip mining or remining, as these are regulated entities which the steering committee did not feel they could influence; and dog parks adjacent to Pigeon Creek and access to Pigeon Cree; as access to Pigeon Creek should be discouraged rather than encouraged until CSO issues are resolved. While these are valid issues, these concerns do not fall within the scope of the project. 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 39. Problems represent the condition that exists due to a particular concern or group of concerns. Table 40 details potential causes of problems identified in Table 39.

Table 39. Problems identified for the Lower Pigeon Creek watershed based on stakeholder and inventory concerns.

Concern(s)	Problem
• Livestock access to streams • Small farms, including sheep, horse farms • Agricultural management – soil health needs • Narrow/limited buffers • Streams are turbid following even small rain events • Streambank erosion • Highly erodible soils • Development impacts • Forest management • Low dissolved oxygen levels observed in streams	Sediment: area streams are cloudy/turbid

Concern(s)	Problem
• Elevated stream nutrient concentrations • Livestock access to streams • Small farms, including sheep, horse farms • Manure management • Combined sewer overflows • Wastewater treatment impacts – including sanitary sewer overflows • Agricultural management – soil health needs • Narrow/limited buffers • Streams are turbid following even small rain events • Streambank erosion • Highly erodible soils • Development impacts • Forest management • Country club, golf courses • Dog park adjacent to Pigeon Creek • Straight pipe/lack of septic maintenance • Goose population • Low dissolved oxygen levels observed in streams	Nutrients: Area streams have nutrient levels exceeding the target set by this project
• High *E. coli* levels • Livestock access to streams • Small farms, including sheep, horse farms • Agricultural/Manure management • Combined sewer overflows • Wastewater treatment impacts – including sanitary sewer overflows • Narrow/limited buffers • Development impacts • Forest management • Dog park adjacent to Pigeon Creek • Straight pipe/lack of septic maintenance • Goose population	*E. coli*: Area streams are impaired for recreational contact and listed on IDEM's 303(d) list
• Industrial legacy pollutants • Litter, trash, dumping especially in urban portion • Access to Pigeon Creek – parks and recreation opportunities • Protection of high quality areas – Wesselman Woods, Bluegrass Creek FWA	Education of the public, both adults and children, is needed to increase awareness of water quality protection needs and solutions. Increase in local support and awareness is needed.

Concern(s)	Problem
• Sports park off Heckle and Green River (intensive use) • Education and signage – public access to Pigeon Creek should take advantage of this	

Table 40. Potential causes of identified problems in the Lower Pigeon Creek watershed.

Problem	Potential Cause(s)
Sediment: area streams are cloudy/turbid	Suspended Sediment concentration levels exceed the target set by this project
Nutrients: Area streams have nutrient levels exceeding the target set by this project	Nutrient levels exceed the target set by this project Targeted nutrient reduction education does not exist
E. coli: Area streams are impaired for recreational contact by IDEM's 303(d) list	*E. coli* levels exceed the water quality standard
Education of the public, both adults and children, is needed to increase awareness of water quality protection needs and solutions. Increase in local support and awareness is needed.	Lack of perceived benefits/impacts; Lack of interest; Efforts to education local officials, foundations and other funding sources on the importance of watershed protection is lacking

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 Lower Pigeon Creek 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 Lower Pigeon Creek Watershed for each of our concerns is listed below:

Nutrients (Nitrogen and Phosphorus):

- Conventional tillage cropping practice
- Wastewater treatment discharges
- 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, inadequately treated wastewater)
- Development impacts (diffuse, disorganized, lack of proper stabilization technique use)
- Stormwater from municipal sources (MS4s)

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)
- Development impacts (diffuse, disorganized, lack of proper stabilization technique use)
- Invasive species impacts to land cover/soil stability
- Stormwater from municipal sources (MS4s)

E. coli:

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

7.1.1 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 the Lower Pigeon Creek Watershed. Appendix D contains tables detailing each potential source within each subwatershed. Table 42 through Table 44 summarizes the magnitude of potential sources of pollution for each problem identified in the Lower Pigeon Creek Watershed. Several sources listed above are not included below as specific data for each concern is not available: conventional tillage by subwatershed; wastewater treatment discharges (compliance issues or violations were not identified as an issue); gully or ephemeral erosion (none identified during the watershed inventory but likely present); poor forest management (not assessed); animal waste (domestic and wildlife runoff numbers not identified on the subwatershed level); cropped floodplains (they occur but density and distribution was not mapped); development impacts; and invasive species (a list was developed but the volume was not assessed.

Table 41. Potential sources causing sediment problems.

Problems:	Area streams are cloudy and turbid.
Potential Causes:	Suspended sediments and/or turbidity exceed target values set by this project.
Potential Sources:	• 67.9 miles of stream lack adequate Bluegrass Creek, Headwaters Bluegrass Creek, Little Pigeon Creek and Headwaters Locust Creek subwatersheds. • 11-26% of corn fields and 15-42% of soybean fields are under conventional tillage. • 148.9 miles of stream lack adequate stabilization. • A number of unregulated animal operations were observed housing nearly 270 animals throughout the watershed. The highest number of animals were observed in the Bluegrass Creek, Headwaters Bluegrass Creek, Headwaters Locust Creek and Locust 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. • 59,902 acres of land are located on highly erodible soils. The highest density of HES occur in the Headwaters Bluegrass Creek, Headwaters Locust Creek, and Locust Creek subwatersheds. All subwatersheds are covered by 80% or more HES. • The City of Evansville and Vanderburgh County MS4s lies in the Lower Pigeon Creek Watershed (Section 2.7.6).

Table 42. Potential sources causing nutrient problems.

Problems:	Area streams have nutrient levels exceeding the target set by this project
Potential Causes:	• Nutrient levels exceed the target set by this project • Targeted nutrient reduction education does not exist
Potential Sources:	• 67.9 miles of stream lack adequate Bluegrass Creek, Headwaters Bluegrass Creek, Little Pigeon Creek and Headwaters Locust Creek subwatersheds. • 11-26% of corn fields and 15-42% of soybean fields are under conventional tillage. • 10.7 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in Headwaters Bluegrass Creek, Bluegrass Creek, Headwaters Locust Creek and Kleymeyer Park-Pigeon Creek subwatersheds. • A number of unregulated animal operations, including horse boarding facilities, were observed housing nearly 270 animals throughout the watershed. The highest number of animals were observed in the Bluegrass Creek, Headwaters Bluegrass Creek, Headwaters Locust Creek and Locust 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. • Manure from small animal operations is applied across the Lower Pigeon Creek Watershed with more than 4533 tons produced annually. More than 3245 lb of N and 1799 lb of P are delivered annually with this manure.

	• 59,902 acres of land are located on highly erodible soils. The highest density of HES occur in the Headwaters Bluegrass Creek, Headwaters Locust Creek, and Locust Creek subwatersheds. All subwatersheds are covered by 80% or more HES. • The City of Evansville and Vanderburgh County MS4s lies the Lower Pigeon Creek Watershed (Section 2.7.6). • Failing septic systems add nutrients to the system within the rural portion of the watershed and in areas of dense unsewered housing. • Municipal wastewater sludge is applied to 965 acres of the Lower Pigeon Creek Watershed.

Table 43. Potential sources causing *E. coli* problems.

Problems:	Area streams are impaired for recreational contact and listed on IDEM's 303(d) list.
Potential Causes:	*E. coli* concentrations exceed target values and the state standard.
Potential Sources:	• A number of unregulated animal operations, including horse boarding facilities, were observed housing nearly 270 animals throughout the watershed. The highest number of animals were observed in the Bluegrass Creek, Headwaters Bluegrass Creek, Headwaters Locust Creek and Locust 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. • Manure from small animal operations is applied across the Lower Pigeon Creek Watershed with more than 4533 tons produced annually. More than 3245 lb of N and 1799 lb of P are delivered annually with this manure. • The City of Evansville and Vanderburgh County MS4s lies the Lower Pigeon Creek Watershed (Section 2.7.6). • Failing septic systems add nutrients to the system within the rural portion of the watershed and in areas of dense unsewered housing. • Municipal wastewater sludge is applied to 965 acres of the Lower Pigeon Creek Watershed.

Table 44. Potential sources causing education problems.

Problems:	• Education of the public, both adults and children, is needed to increase awareness of water quality protection needs and solutions. Increase in local support and awareness is needed.
Potential Causes:	• Lack of perceived benefits/impacts; Lack of interest; Efforts to education local officials, foundations and other funding sources on the importance of watershed protection is lacking.
Potential Sources:	N/A

7.2 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 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 Lower Pigeon Creek 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 in Section 3.1, eight monitoring sites were sampled from April 2021 to March 2022. There is clear value in using these measurements from the Lower Pigeon Creek 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 gages (Big Creek (USGS 03378550) and Pigeon Creek at Fort Branch (USGS 03322011)) were used to approximate flow. 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 above, the steering committee selected water quality benchmarks for nitrate-nitrogen, total phosphorus, total suspended solids, and *E. coli* that will significantly improve water quality in Lower Pigeon Creek (Table 16). Target loads needed to meet these benchmarks were calculated for each subwatershed for each parameter. The current loading rate was calculated using water chemistry data collected monthly at each of the eight sample sites and flow data from the USGS stream gages at Big Creek (USGS 03378550) and Pigeon Creek at Fort Branch (USGS 03322011). Flow data from both gages were scaled to the drainage area for Lower Pigeon Creek sample sites with the Big Creek gage used to calculate loading rates for the Lower Pigeon Creek site (Site 8) and Pigeon Creek at Fort Branch used to calculate loading rates at all other sites (Sites 1-7). Concentration data collected monthly (Lower Pigeon Creek) was multiplied by the representative days between sampling events (typically 30 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. All calculations are in lb/year and are shown as percent of the current load (Table 45 to Table 48).

Table 45. Current and target nitrogen load reduction needed to meet water quality target concentrations in the Lower Pigeon Creek Watershed.

Site	Subwatershed	Current Load (lb/year)	Target Load (lb/yr)	Load Reduction (lb/year)	Percent Reduction
S1	Headwaters Bluegrass Creek	193,486	43,005	150,481	78%
S2	Bluegrass Creek	96,465	54,040	42,425	44%
S3	Little Pigeon Creek	530,994	283,063	247,932	47%
S4	Little Pigeon Creek	13,471	21,323	-7,851	-58%
S5	Headwaters Locust Creek	380,257	116,814	263,444	69%
S6	Headwaters Locust Creek	773,540	163,734	609,805	79%
S7	Locust Creek	30,207	19,799	10,408	34%
S8	Kleymeyer Park-Pigeon Creek	729,413	449,694	279,719	38%

Table 46. Current and target phosphorus load reduction needed to meet water quality target concentrations in the Lower Pigeon Creek Watershed.

Site	Subwatershed	Current Load (lb/year)	Target Load (lb/yr)	Load Reduction (lb/year)	Percent Reduction
S1	Headwaters Bluegrass Creek	10,211	2,580	7,630	75%
S2	Bluegrass Creek	14,737	3,242	11,495	78%
S3	Little Pigeon Creek	92,000	16,984	75,016	82%
S4	Little Pigeon Creek	3,342	1,279	2,063	62%
S5	Headwaters Locust Creek	31,566	7,009	24,557	78%
S6	Headwaters Locust Creek	45,465	9,824	35,641	78%
S7	Locust Creek	2,306	1,188	1,119	48%
S8	Kleymeyer Park-Pigeon Creek	180,644	26,982	153,663	85%

Table 47. Current and target total suspended solids load reduction needed to meet water quality target concentrations in the Lower Pigeon Creek Watershed.

Site	Subwatershed	Current Load (lb/year)	Target Load (lb/yr)	Load Reduction (lb/year)	Percent Reduction
S1	Headwaters Bluegrass Creek	2,138,049	1,290,137	847,912	40%
S2	Bluegrass Creek	3,634,175	1,621,210	2,012,965	55%
S3	Little Pigeon Creek	26,337,677	8,491,884	17,845,793	68%
S4	Little Pigeon Creek	858,770	639,675	219,095	26%
S5	Headwaters Locust Creek	4,251,035	3,504,417	746,618	18%
S6	Headwaters Locust Creek	7,178,293	4,912,034	2,266,259	32%
S7	Locust Creek	683,758	593,969	89,788	13%
S8	Kleymeyer Park-Pigeon Creek	60,341,416	13,490,816	46,850,601	78%

Table 48. Current and target *E. coli* loads in pounds/year and load reduction needed to meet water quality target concentrations in the Lower Pigeon Creek Watershed.

Site	Subwatershed	Current Load (col/year)	Target Load (col/yr)	Load Reduction (col/year)	Percent Reduction
S1	Headwaters Bluegrass Creek	1.48E+14	9.17E+13	5.59E+13	38%
S2	Bluegrass Creek	3.01E+14	1.15E+14	1.86E+14	62%
S3	Little Pigeon Creek	2.16E+15	6.04E+14	1.55E+15	72%
S4	Little Pigeon Creek	1.01E+14	4.55E+13	5.55E+13	55%
S5	Headwaters Locust Creek	6.96E+14	2.49E+14	4.47E+14	64%
S6	Headwaters Locust Creek	8.48E+14	3.49E+14	4.99E+14	59%
S7	Locust Creek	4.88E+13	4.22E+13	6.60E+12	14%
S8	Kleymeyer Park-Pigeon Creek	2.54E+15	9.59E+14	1.58E+15	62%

Based on loading rate calculations, only one site, Little Pigeon Creek for total phosphorus, meets water quality targets. All other sites require a reduction in nutrient, sediment and pathogen loading rates to meet water quality targets. In total, 34 to 79% reductions in nitrate-nitrogen are needed, while 48-85% reductions in total phosphorus are needed. Total suspended solids reductions ranges from 13 to 78% and *E. coli* loading rates indicate reductions of 14 to 72% are required to meet state standards.

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.

There are several options for defining critical areas. These include 1) using a list of potential sources developed for each parameter of concern on a subwatershed or watershed-wide basis; 2) ranking subwatersheds based on these parameters or a portion of these parameters, such as miles of impaired streams or acreage of highly erodible soils; or 3) utilizing source identification to prioritize across the watershed based on the most significant sources or data available. The steering committee discussed all of these options and working in small groups reviewed data for each subwatershed with the goal of listing potential sources for each concern noted above (nutrients, sediment, *E. coli*). However, once review was complete, the committee noted that the overall impact area might be too limited to reach individuals within the Lower Pigeon Creek Watershed. The steering committee reviewed options for ranking each subwatershed based on one set of parameters regardless of concern noted above (nutrients, sediment, *E. coli*). While this resulted in better cohesion throughout the watershed, the committee determined that the coverage 1) would not sufficiently cover the watershed as a whole, 2) would be too limiting to meet load reduction targets and 3) would not allow for sufficient reach to individuals and entities throughout the watershed where the greatest need and highest benefit could occur. With this in mind, the steering committee decided a source-based approach would be used to define Lower Pigeon Creek Watershed critical areas.

Several potential sources of pollution were reviewed as options for defining critical areas in the Lower Pigeon Creek Watershed. These included:

1. Using individual data such as combined sewer overflow areas, highly erodible land coverage, agricultural land use across the watershed or within the floodplain, areas of streambank erosion or narrow buffers, manure volume produced, septic soil limitations and more. Table 49 details the parameters reviewed by the committee and the associated rank based on each subwatersheds percent cover. Lower numbers are used for subwatersheds with higher cover and higher numbers are used for subwatersheds with lower cover. Any subwatersheds with zero (0) as the value was given a score of six (6). The lowest average identifies the subwatershed of greatest concern. Based on source analysis, Headwaters Locust Creek, Headwaters Bluegrass Creek and Bluegrass Creek subwatersheds would be prioritized the highest. Appendix D contains all subwatershed data.

Table 49. Critical areas ranking based on source evaluation.

	Ag Land	HEL	Manure estimate	CSO	Septic Soils	Streambank Erosion	Narrow Buffer	Average
Headwaters Locust Creek	3	2	3	6	5	2	1	3.1
Headwaters Bluegrass Creek	1	1	2	6	6	5	2	3.3
Bluegrass Creek	2	5	1	6	3	4	3	3.4
Locust Creek	4	3	5	6	4	1	3	3.7
Little Pigeon Creek	5	4	4	6	1	3	6	4.1
Kleymeyer Park-Pigeon Creek	6	6	6	1	1	6	6	4.6

2. Using *E. coli* impairment by miles impaired as the main critical area and reviewing historic and/or current water quality data. *E. coli* represents the major impairment for the watershed and the committee noted that efforts to reduce *E. coli* sources would likely result in a reduction in sediment and nutrient concentrations as well. However, through further discussion, the steering committee determined that addressing the main sources of *E. coli* may not sufficiently address sources of nutrients and sediment. Thus, the committee determined that using *E. coli* impairment by stream mile may not provide adequate watershed coverage or address all concerns noted by stakeholders.

Review of historic and current water quality data occurred in an effort to identify instream issues (Table 36 and Table 37). Table 50 and Table 51 detail rankings. Lower numbers are used for subwatersheds with higher cover and higher numbers are used for subwatersheds with lower cover. Any subwatersheds with zero (0) as the value was given a score of six (6). The lowest average identifies the subwatershed of greatest concern. Based on historic water quality data analysis, Bluegrass Greek and Kleymeyer Park-Pigeon Creek subwatersheds would be prioritized the highest. Based on current data, Headwaters Bluegrass Creek and Kleymeyer Park-Pigeon Creek subwatersheds would be prioritized.

Table 50. Critical area ranking based on historic water quality data.

	E. coli	Turbidity	DO	N	P	TSS	Conductivity	Average
Bluegrass Creek	6	1	6	6	1	1	1	3.1
Kleymeyer Park-Pigeon Creek	1	1	1	6	6	2	6	3.3
Headwaters Bluegrass Creek	3	5	3	1	2	5	6	3.6
Headwaters Locust Creek	3	5	3	1	2	5	6	3.6
Locust Creek	5	1	1	6	6	2	6	3.9
Little Pigeon Creek	2	1	5	6	6	4	6	4.3

Table 51. Critical area ranking based on current water quality data.

	E. coli	Turbidity	DO	pH	N	P	TSS	Conductivity	Average
Headwaters Bluegrass Creek	1	1	4	0	2	1	3	6	1.7
Kleymeyer Park-Pigeon Creek	2	1	4	6	1	1	1	6	2.3
Bluegrass Creek	4	3	4	6	5	3	2	1	3.9
Little Pigeon Creek	3	4	2	6	6	4	4	6	4.1
Locust Creek	4	5	1	6	3	5	5	6	4.1
Headwaters Bluegrass Creek	1	1	4	0	2	1	3	6	1.7

3. Using only land use as the determinant for source identification. The steering committee noted that implementation on pasture and row crop would likely yield the biggest impact for dollars spent and selected all agricultural land as their highest priority critical area. Additionally, the steering committee identified several options for prioritizing urban land use including using areas mapped in urban land cover including residential, commercial and industrial; considering MS4 boundaries and using these areas to target urban practice implementation; or considering the combined sewer overflow areas as these areas likely represent the greatest need to increase stormwater infiltration and storage among urban areas throughout the Lower Pigeon Creek Watershed. The steering committee noted that agricultural row crop and pastureland are likely of highest priority followed by areas of the watershed which drain to a combined sewer overflow area. The steering committee noted that the City of Evansville is currently implementing a long-term control plan and that the best use of steering committee time in the short term is supporting this effort and focusing their efforts on education and outreach to residents in the CSO area.

4. Using a combination of all of these factors. High priority Lower Pigeon Creek Watershed critical areas are defined based on pollutant sources (option 1) combined with a review of historic water quality data as well as data collected during the current project (option 2). Averaging all of these data, the steering committee identified three subwatersheds: Headwaters Bluegrass Creek, Bluegrass Creek and Kleymeyer Park-Pigeon Creek as high priority areas. Using land use (option 3) finalizes the remaining critical areas with agricultural land use defined as medium priority and urban land use defined as low priority.

Critical areas are shown in Figure 67. These high priority subwatersheds will be targeted first, followed by medium and low priority areas of the Lower Pigeon Creek Watershed. Additionally, concerns identified by the steering committee will be used to target implementation within the project's critical areas when landowner interest outpaces available funds. The steering committee identified a few high priority concerns which will be used for targeting purposes. The rating of each concern will be determined during cost share program development and additional items may be added to further refine how each concern area be used to target hot spots or problem areas identified within the Lower Pigeon Creek Watershed. A rating system will be developed prior to cost share program implementation – the rating system will assign a weighted score to each potential project based on its location in a priority subwatershed as well as the following concerns:

- Ensuring that highly erodible soils areas are protected or covered.
- Targeting livestock restriction, streambank erosion and buffer strip installation in areas where erosion, livestock access and/or narrow buffers were identified during plan development.
- Working with producers to reduce the impacts from manure production within the Lower Pigeon Creek Watershed.
- Improving septic system installation and maintenance practices and highlighting on-going efforts to mitigate combined sewer overflows with a focus on education and outreach opportunities and identification of options for future funding for priority areas.

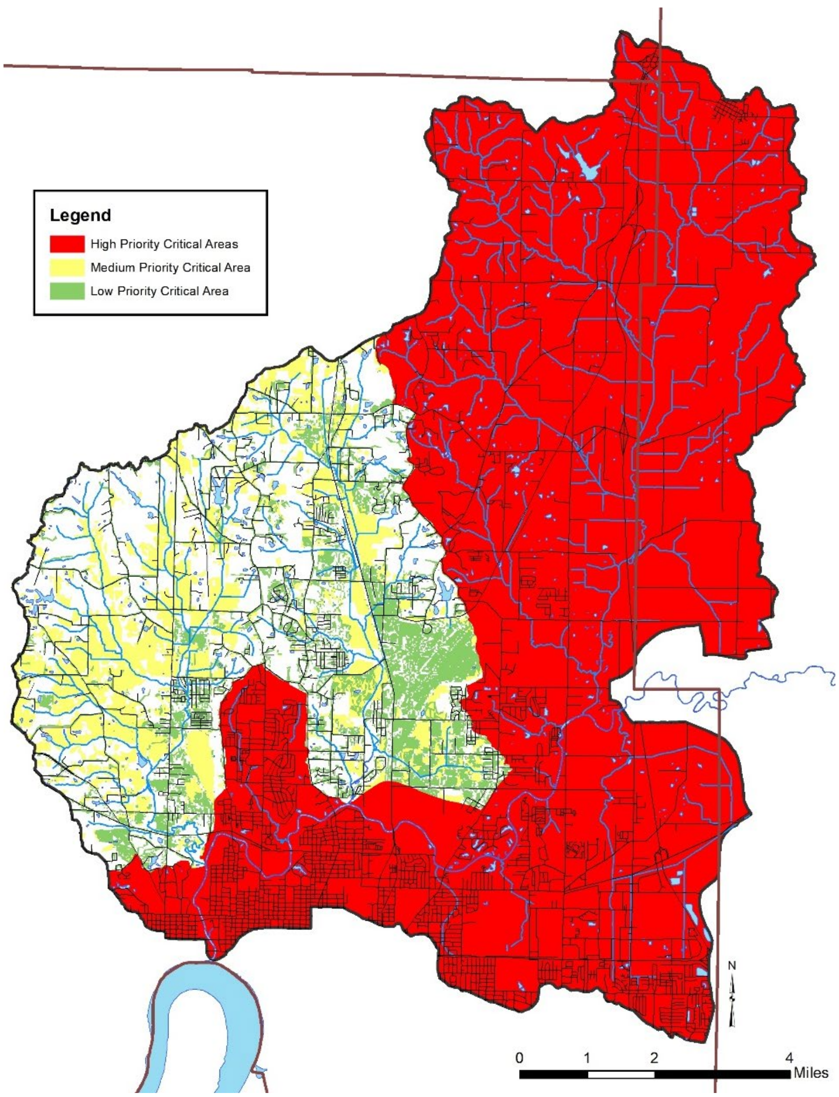

Figure 67. Lower Pigeon Creek critical areas.

Figure 67 shows the approximate locations of critical areas in the Lower Pigeon Creek Watershed. This map should be considered a starting point rather than the definitive map for agricultural land uses, while the combined sewer overflow areas are set by the City of Evansville based on drainage areas to locations within the city that are still serviced by combined stormwater and wastewater pipes. Further investigation will be needed to identify specific locations where problems are occurring and where solutions can be implemented. While some specific sources of streambank erosion, narrow buffers and livestock access to streams were identified, highly erodible soils and septic limitations are mapped, the field condition may be different than areas identified through desktop and windshield survey efforts. It should be noted that Section 319 funds will not be used to mitigate the combined sewer overflow itself but rather address nonpoint source concerns within these areas.

After setting initial goals, the steering committee reviewed the likelihood of meeting water quality targets based on these critical areas. Based on the projected likelihood of successful implementation within these areas, the Lower Pigeon Creek steering committee did not see any reason to adjust their critical areas. Additionally, the committee did not elect to select additional areas in which to work as the project continues through its lifetime. Much of the remaining land is in forested land use where local, state and federal funds are currently sufficient to address concerns on privately-owned forested land. The committee noted the need to continue education and outreach to forest landowners.

8.1 Critical Acre Determination

To be eligible for Mississippi River Basin Initiative (MRBI) Funding, the Lower Pigeon Creek 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 52 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 68 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 soils are protected or 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 from manure production within the Lower Pigeon Creek Watershed (Figure 68). Lower Pigeon Creek Watershed stakeholders identified the need for soils with septic limitation to be targeted for septic treatment; however, this is not an NWQI targeted practice and is therefore not included in Table 52. 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.

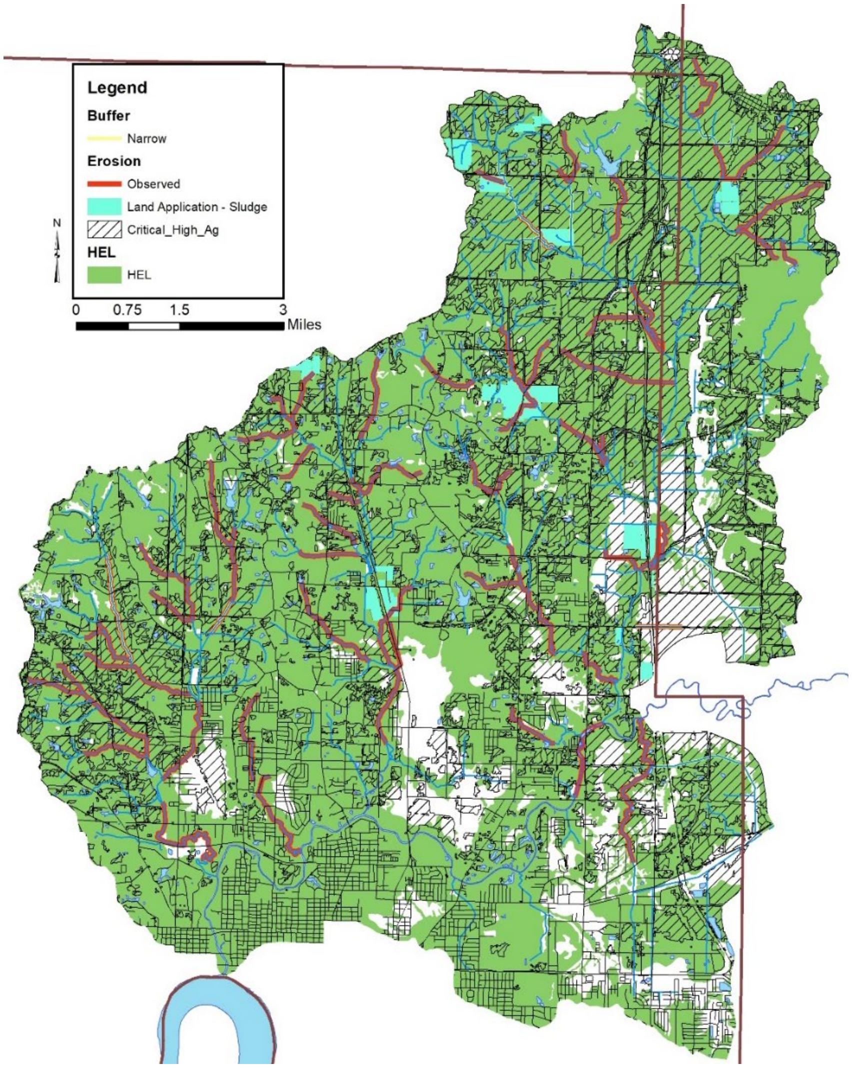

Figure 68. Critical acres in the Lower Pigeon Creek Watershed.

Table 52. Critical acres by subwatershed in the Lower Pigeon Creek Watershed.

Subwatershed Name	HUC	HEL (acres)	Manure estimate (tons)	Agricultural Land Use (acres)
Headwaters Bluegrass Creek	051402020301	11,133.8	1,088	7,426.6
Bluegrass Creek	051402020302	14,060.6	1,914	8,697.2
Little Pigeon Creek	051402020303	9,767.5	330	1,960.4
Headwaters Locust Creek	051202020304	6,273.5	1,002	2,020.9
Locust Creek	051402020305	4,395.5	199	1,481.0
Kleymeyer Park-Pigeon Creek	051402020306	14,271.2	0	2,811.0
		59,901.9	4,533.0	24,397.2
Subwatershed Name	**CSO Drainage (acres)**	**Streambank Erosion (miles)**	**Narrow Buffer (miles)**	**Municipal Sludge App (acres)**
Headwaters Bluegrass Creek	0.0	12.4	3.8	352.1
Bluegrass Creek	0.0	15.5	2.8	415.2
Little Pigeon Creek	0.0	13.7	0.0	188.8
Headwaters Locust Creek	0.0	10.2	2.2	0
Locust Creek	0.0	7.8	0.0	0
Kleymeyer Park-Pigeon Creek	4,397.7	8.3	1.9	0
TOTALS	4,397.7	67.9	10.7	956.2

8.2 Current Level of Treatment

Based on data from the Indiana Conservation Partnership, more than 1,575 acres of best management practices including but not limited to cover crops, conservation cover, fencing, firebreak installation, forage and biomass planting, residue tillage, water facility and heavy use protection area construction and more have been implemented over the last 5 years in the Lower Pigeon Creek Watershed. Table 53 details practices by acre.

Table 53. Practices installed from 2017-2021 in the Lower Pigeon Creek Watershed based on Indiana Conservation Partner data in acres.

	Headwaters Bluegrass Creek	Bluegrass Creek	Little Pigeon Creek	Headwaters Locust Creek	Locust Creek	Kleymeyer Park-Pigeon Creek
Cover Crop	521.9	247.5	484.65	--	--	37.8
Residue and Tillage	53.5	--	--	--	--	89.2
Early Successional Hab Dev/Mgmt	0.9	--	--	--	--	--
Tree/Shrub Establishment	0.015	--	--	--	--	--
Conservation Cover	--	--	--	--	0.4	--
Pollinator Habitat	0.3	--	--	--	--	0.3

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 The current loading rate was calculated using water chemistry data collected monthly at each of the eight sample sites and flow data from the USGS stream gages at Big Creek (USGS 03378550) and Pigeon Creek at Fort Branch (USGS 03322011). Flow data from both gages were scaled to the drainage area for Lower Pigeon Creek sample sites with the Big Creek gage used to calculate loading rates for the Lower Pigeon Creek site (Site 8) and Pigeon Creek at Fort Branch used to calculate loading rates at all other sites (Sites 1-7). The loading rates calculated for each sample site are detailed in Table 45 to Table 48. These loading rates were used by the steering committee when determining the best option for goal setting. In an effort to scale goals to manageable levels, short term (10 year), medium term (20 year), and long term (30 year) goals were generated. The calculation process is described below.

Option 1: Current and target loading rates were determined for the Lower Pigeon Creek sample sites (Table 54). Loading rates and target reductions for the entire watershed were calculated using data generated for the Lower Pigeon Creek outlet (Site 8). This option allow for the calculation of loading rates for the entire Pigeon Creek Watershed, including the Upper Pigeon Creek Watershed for which a watershed plan is currently being written and the Middle Pigeon Creek Watershed, which is not currently included in any planning project. The committee decided against this option as the Lower Pigeon Creek outlet (Site 8) includes inputs from areas of the drainage basin which they cannot impact with funds allocated for the Lower Pigeon Creek Watershed specifically.

Table 54. Loading rates calculated using the Lower Pigeon Creek outlet (Site 8) which represents the entire Pigeon Creek drainage.

Rate or Reduction	Nitrate-Nitrogen (lb/year)	Total Phosphorus (lb/year)	Total Suspended Solids (lb/year)	*E. coli* (col/year)
Current Loading Rate	729,413	180,644	60,341,416	2.54E+15
Target Loading Rate	449,694	26,982	13,490,816	9.59E+14
Reduction	279,719	153,663	46,850,601	1.58E+15
Percent Reduction	38%	85%	78%	62%

Option 2: Drainage basin outlet loading rates were calculated for Bluegrass Creek (Site 2), Little Pigeon Creek (Site 4) and Locust Creek (Site 7;Table 55). Details for loading rates for Sites 2, 4 and 7 can be found in Table 45 to Table 48. This option allows for the calculation of loading rates which the Lower Pigeon Creek Watershed Project can impact – those main drainages in the Lower Pigeon Creek Watershed upstream of the mainstem Pigeon Creek. The steering committee decided against this option as it underrepresents the area over which the project has influence leaving out the more urban portions of the watershed. While the steering committee recognizes that this option likely represents their most likely area of influence, leaving out the urban portion in which the City of Evansville is actively working leaves a key partnership and constituency out of Lower Pigeon Creek Watershed Project efforts.

Table 55. Loading rates calculated using the basin outlets (Site 2,4 and 7) which represents the tributaries to the Lower Pigeon Creek Watershed.

Rate or Reduction	Nitrate-Nitrogen (lb/year)	Total Phosphorus (lb/year)	Total Suspended Solids (lb/year)	*E. coli* (col/year)
Current Loading Rate	140,143	20,386	5,176,703	4.51E+14
Target Loading Rate	95,162	5,710	2,854,854	2.03E+14
Reduction	44,982	14,676	2,321,849	2.48E+14
Percent Reduction	32%	72%	45%	55%

Option 3: Loading rates for the Upper and Middle Pigeon Creek Watersheds were calculated using STEPL and subtracted from the measured Lower Pigeon Creek outlet (Site 8) loading rate (Table 56). This represents the loading rate for only the land located within the Lower Pigeon Creek Watershed, which Lower Pigeon Creek Watershed partners can impact through direct implementation efforts. The committee selected option 3 as this represents the best option for calculating current and future potential loading rates for land which they can make direct impact, that area located within the Lower Pigeon Creek Watershed. Based on the loading rates detailed in Table 56, the steering committee determine the following steps necessary to successfully implement their watershed management plan:

1. Select low and medium reduction targets target for nutrients, sediment and *E. coli* levels and set timeframes for achieving these goals.
2. Long term goals will result in water quality nutrient, sediment and *E. coli* targets being met throughout the watershed in 30 years.

Table 56. Loading rates calculated for the Lower Pigeon Creek Watershed using modeled data for the Upper and Middle Pigeon Creek Watersheds and the measured loading rates for the Pigeon Creek Watershed (Site 8) which represents only the land located in the Lower Pigeon Creek Watershed.

Rate or Reduction	Nitrate-Nitrogen (lb/year)	Total Phosphorus (lb/year)	Total Suspended Solids (lb/year)	*E. coli* (col/year)
Current Loading Rate	480,832.9	119,854.8	20,396,976.4	2.48E+15
Target Loading Rate	179,877.5	26,981.6	13,490,815.8	9.59E+14
Reduction	300,955.4	92,873.2	6,906,160.6	1.5E+15
Percent Reduction	63%	77%	34%	61%

Reduce Nutrient Loading

Based on collected water quality data for the Lower Pigeon Creek Watershed, the committee set the following long-term goals: Reduce nitrate-nitrogen loading from 480,833 lb/year to 179,878 lb/year (63%) by 2052 and reduce total phosphorus loading from 119,855 lb/year to 29,982 lb/year (77%) by 2052.

Short term goal: Reduce total phosphorus inputs from 119,855 pounds per year to 88,897 pounds per year (26% reduction) and nitrate-nitrogen from 480,833 pounds per year to 380,515 pounds per year (21% reduction) in Lower Pigeon Creek in 10 years (2032).

Medium term goal: Reduce total phosphorus inputs from 88,897 pounds per year to 57,940 pounds per year (35% reduction) and nitrate-nitrogen from 380,515 pounds per year to 280,196 pounds per year (26% reduction) in Lower Pigeon Creek in 10 years (2042).

Long term goal: Reduce total phosphorus inputs from 119,854 pounds per year to 26,981.6 pounds per year (53% reduction) and nitrate-nitrogen from 280,196 pounds per year to 179,878 pounds per year (36% reduction) in Lower Pigeon Creek in 10 years (2052).

Table 57. Nitrate-nitrogen short, medium, and long-term goal calculations for prioritized critical areas in Lower Pigeon Creek.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	480,832.9	100,318.5	380,514.5	21%
Medium Term (20 years)	380,514.5	100,318.5	280,196.0	26%
Long Term (30 years)	280,196.0	100,318.5	179,877.5	36%

Table 58. Total phosphorus short, medium, and long-term goal calculations for prioritized critical areas in Lower Pigeon Creek.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	119,854.8	30,957.7	88,897.1	26%
Medium Term (20 years)	88,897.1	30,957.7	57,939.4	35%
Long Term (30 years)	57,939.4	30,957.7	26,981.6	53%

Reduce Sediment Loading
Based on collected water quality data for the Lower Pigeon Creek Watershed, the committee set the following long-term goal: reduce total phosphorus loading from 20,396,977 lb/year to 13,490,816 lb/year (34%) by 2052.

Short term goal: Reduce total suspended solids inputs from 20,396,976 pounds per year to 18,094,923 pounds per year (11% reduction) in Lower Pigeon Creek in 10 years (2032).

Medium term goal: Reduce total suspended solids inputs from 18,094,923 pounds per year to 15,792,870 pounds per year (13% reduction) in Lower Pigeon Creek in 10 years (2042).

Long term goal: Reduce total suspended solids inputs from 15,792,870 pounds per year to 13,490,816 pounds per year (15% reduction) in Lower Pigeon Creek in 10 years (2052).

Table 59. Total suspended solids short, medium, and long-term goal calculations for prioritized critical areas in Lower Pigeon Creek.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	20,396,976.43	2,302,053.5	18,094,922.9	11%
Medium Term (20 years)	18,094,922.9	2,302,053.5	15,792,869.4	13%
Long Term (30 years)	15,792,869.4	2,302,053.5	13,490,815.8	15%

Reduce *E. coli* Loading

Based on collected water quality data for the Lower Pigeon Creek Watershed, the committee set the following long-term goal: reduce *E. coli* loading from 2.48E+15 to 9.59E+14 (61%) by 2052.

Short term goal: Reduce *E. coli* inputs from 2.48E+15 colonies per year to 1.97E+15 colonies per year (20% reduction) in Lower Pigeon Creek in 10 years (2032).

Medium term goal: Reduce *E. coli* inputs from 1.97E+15 colonies per year to 1.47E+15 colonies per year (26% reduction) in Lower Pigeon Creek in 10 years (2042).

Long term goal: Reduce total suspended solids inputs from 1.47E+15 colonies per year to 9.59E+14 colonies per year (35% reduction) in Lower Pigeon Creek in 10 years (2052).

Table 60. *E. coli* short, medium, and long-term goal calculations for prioritized critical areas in Lower Pigeon Creek.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	2.48E+15	5.06E+14	1.97E+15	20%
Medium Term (20 years)	1.97E+15	5.06E+14	1.47E+15	26%
Long Term (30 years)	1.47E+15	5.06E+14	9.59E+14	35%

Increase Public Awareness and Education

Long term: Increase the current level of outreach to engage a 50% increase of individuals in the watershed within 30 years. Baseline data will be gathered in year one of project implementation and will include the current reach of the Vanderburgh and Warrick SWCDs and City of Evansville and Vanderburgh County MS4s reach. Engagement should include an effort to educate local officials, foundations and other potential funders; engage with the local community to increase public awareness for watershed issues and work to overcome the issues created by the Lower Pigeon Creek Watershed covering multiple governmental boundaries (county, city, MS4, etc). This focused, cohesive education and outreach effort will result in an increase in public awareness with the goal of building a sense of place.

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 Lower Pigeon Creek 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 Lower Pigeon Creek steering committee. Committee members reviewed potential practices taking into account the identified resource concerns, watershed land uses, and Lower Pigeon Creek Watershed Project goals. From the potential practice list, the most appropriate BMPs to remediate sources of pollution and address resource concerns in the Lower Pigeon Creek 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 Lower Pigeon Creek 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 Lower Pigeon Creek water quality. Selected practices are appropriate for all critical areas since they predominantly contain agriculture land use and pasture, and crop resource concerns were identified in all subwatersheds. Several urban practices were also identified. These should be targeted at residential and commercial areas throughout the watershed including Evansville and small towns and reservoirs present throughout the watershed. It should be noted that specific forestry-based practices are not included in this list. Selected practices with descriptions are listed below.

Potential best management practices which will target high priority (agricultural) critical areas include the following:

Access Control
Alternate Watering System
Animal Mortality Facility
Bioreactor
Composting Facility
Conservation Tillage: Residue and Tillage Management, No till/Strip till/Direct Seed
Consider soil characteristics to minimize runoff
Cover Crop
Drainage Water Management
Fencing
Field Border or Filter Strip
Field ditch
Forage and Biomass Planting
Grade Stabilization Structure
Grassed Waterway
Heavy Use Area Protection
Lined Waterway or Outlet
Prescribed Grazing
Livestock Pipeline
Manure Management Planning
Mulching
Nutrient and/or Pest Management
Regular soil tests
Septic System Care and Maintenance
Streambank Stabilization
Tree/Shrub Establishment
Two Stage Ditch
University fertilization recommendations
Variable rate application
Waste Storage Facility
Waste Utilization
Water and Sediment Control Basin
Wetland Creation, Enhancement, Restoration

Potential best management practices which will target high priority education/medium priority (urban) critical areas include the following:

Bioretention – Rain Garden, Bioswale
Curb Openings/Curbless Design
Diversion structures
Drivable Grass
Flow Splitter
Green Roof
Infrastructure Retrofits
Pervious Pavement
Phosphorus Free Fertilizer Usage
Point Source Discharge Reduction
Rain Barrel
Tree Box Filter
Vegetated Swale

Access Control
Access control involves the temporary or permanent exclusion of animals, people, vehicles, and/or equipment from an area. Access control is used to achieve and maintain desired resource conditions by monitoring and managing the intensity of use by animals, people, vehicles, and/or equipment in coordination with the application schedule of practices, measures and activities specified in the conservation plan.

Animal Morality Facility
An animal mortality facility is an on-farm facility for the treatment or disposal of animal carcasses due to routine mortality. This standard applies to livestock and poultry operations where routine animal carcass storage, treatment, or disposal is needed. This standard does not apply to catastrophic animal mortality.

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.

Conservation cover focused on establishing and maintaining permanent vegetative cover with the focus of reducing sheet, rill or wind erosion and sediment loss or runoff; reduce ground and surface water quality degradation; enhance wildlife benefits and improve soil health. Critical area plantings establish permanent vegetation on sites that have or are expected to have high erosion rates. Critical area plantings can be used on sites which have conditions that prevent the establishment of vegetation utilizing normal practices.

Curb Openings/Curbless Design
An essential element of green infrastructure project design is ensuring the stormwater enters the system and is captured. In urban environments where curbs are prevalent, stormwater flow accumulates as it moves along the curbed edges of roadways. Adding curb cuts allows this concentrated flow to spill into green infrastructure practices. To capture stormwater runoff from curbed roads, curb cuts are added at intervals along a raised curb, resulting in areas of concentrated flow. This practice is commonly used in urban bioretention cells, stormwater curb extensions, stormwater planters and urban tree trenches. Three key criteria should be considered when designing curb cuts: placement, grading and size/angle of opening.

In contrast, stormwater drains off curbless roadways under sheet flow conditions to the lowest area. In areas without curbs and gutters, practices are designed to capture runoff via sheet flow across pavement and other surfaces. Establishing sheet f low conditions allows for an even distribution of runoff into the feature (Figures 4-10 and 4-11). Moreover, in conditions of low-velocity sheet flow, pretreatment such as a pea gravel apron installed between the impervious area and the practice can help capture suspended sediment. Green infrastructure practices that capture sheet flow from curbless streets and parking lots often include a band of concrete edging that lies flush with the stormwater feature and the street/parking lot surface. Because of concrete’s fine-grain composition, it is easier to use concrete than asphalt to achieve the necessary flat slope that will direct sheet flow into the stormwater feature. Sidewalks can be designed with slight in slopes or out slopes to direct sheet flow into green infrastructure practices, but the sidewalks must also comply with local codes and ordinances and meet the slope requirements outlined in the Americans with Disabilities Act.

Diversion Structures

A diversion structure is a channel generally constructed across the slope with a supporting ridge on the lower side. This practice may be applied to support various purposes including breaking up concentrations of water on long slopes, on undulating land surfaces, and on land that is generally considered too flat or irregular for terracing. Diverting water away from farmsteads, agricultural waste systems, and other improvements. Collecting or directing water for storage, water- spreading or water-harvesting systems. Protecting terrace systems by diverting water from the top terrace where topography, land use, or land ownership prevents terracing the land above. Intercept surface and shallow subsurface flow. Reducing runoff damages from upland runoff. Reducing erosion and runoff on urban or developing areas and at construction or mining sites. Diverting water away from active gullies or critically eroding areas. Supplementing water management on conservation cropping or strip cropping systems. Diversion structures can be applied to all land uses where surface runoff water control and/or management are needed and where soils and topography are such that the diversion can be constructed, and a suitable outlet is available or can be provided.

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.

Drivable Grass

Drivable grass is a permeable, flexible and plantable concrete pavement system that is environmentally friendly, aesthetically pleasing, and an alternative to poured concrete, asphalt and interlocking concrete pavers. Drivable grass is designed with an engineered polymer grid, which allows the product to be flexible and conform to irregular ground surface contours along pre-defined linear grooves, while providing the intended structural support.

Drivable grass facilitates the growth of a continuous root system below the product in the bedding course, promoting healthy turf while minimizing moisture evaporation. The distinctive thin profile and bearing properties of drivable grass enable superior root penetration into the underlying bedding course, establishing a cohesive root zone below the mats.

This unique product, whether planted or non-planted, is a solution for multiple applications of low impact development strategies ranging from commercial parking lots to drainage swales and practical DIY applications. Drivable grass is a great solution for many existing and emerging government regulations, codes and requirements. Contractors, specifiers, local and state municipalities can incorporate drivable grass on their projects to enhance water quality, mitigate stormwater runoff, increase greenspace, and reduce heat island effects.

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.

Field Ditch
A graded channel on the field surface for collecting and conveying excess water. Can be used to accomplish Intercept excess surface and shallow subsurface water from a field, conveying it to a surface main or lateral. Can also collect excess irrigation water for a tailwater reuse system.

Flow Splitter
A flow splitter is an engineered structure used to divide flow into two or more parts and divert these parts to different places. The design of a flow splitter uses specifically designed structures, pipes, orifices, and weirs set at specific elevations to control the direction of flow. An illustration of a simple type of flow splitter is provided in the accompanying figure. Typically, when managing storm water flows, a flow splitter is used to direct initial storm water flows to an off-line BMP. The splitter is placed at an elevation coordinated with the elevation of the treatment BMP, so that the elevation of water in the BMP governs the elevation in the flow splitter. As shown in the example illustration, storm water flows to the BMP until it reaches a pre-determined elevation. Once storm water reaches that elevation, a weir (or other hydraulic feature) directs additional flow to an alternative outlet. This simple type of flow splitter works on hydraulic principles and requires no mechanical components or instrumentation.

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.

Green Roof

A green roof system is an extension of the existing roof which involves, at a minimum, high quality waterproofing, root repellent system, drainage system, filter cloth, a lightweight growing medium, and plants.

Green roof systems may be modular, with drainage layers, filter cloth, growing media, and plants already prepared in movable, often interlocking grids, or loose laid/built-up whereby each component of the system may be installed separately. Green roof development involves the creation of "contained" green space on top of a human-made structure. This green space could be below, at, or above grade, but in all cases, it exists separate from the ground.

Green roofs can provide a wide range of public and private benefits and have been successfully installed in countries around the world. Green roofs provide a variety of environmental benefits to aesthetic improvements, waste diversion, moderation of the heat island effect, improved air quality, and stormwater benefits. Some of the water benefits include; water is stored by the substrate and then taken up by the plants from where it is returned to the atmosphere through transpiration and evaporation, in summer, green roofs can retain 70-90% of the precipitation that falls on them, in winter, green roofs can retain between 25-40% of the precipitation that falls on them, green roofs not only retain rainwater, but also moderate the temperature of the water and act as natural filters for any of the water that happens to run off, and green roofs reduce the amount of stormwater runoff and also delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods.

Heavy Use Area Protection

HUAP is used to stabilize a ground surface that is frequently used by people, animals, or vehicles and to protect water quality.

Infrastructure Retrofits

Typical stormwater infrastructure includes pipe and storm drains, or hard infrastructure, to convey water away from hard surfaces and into the stormwater system. Retrofitting these structures to implement low impact development techniques, use green practices, and introduce plants and filters to reduce sediment and nutrient concentrations contained in stormwater.

Livestock Restriction/Prescribed (Rotational) Grazing/Lined Waterway or Outlet

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 pastureland 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.

Mulching

Mulching is the application of plant residues to the land surface. This can help conserve soil moisture, moderate soil temperature, provide erosion control, facilitate the establishment of vegetative cover, improve soil quality, and reduce airborne particulates. This practice can be used alone or in combination with other practices (FOTG Code 484, NRCS, 2011).

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.

Pervious Pavement
Pervious pavement comes in many forms including porous pavement and modular block pavement. Both types of pervious pavement can be installed on most any travel surface with a slope of 5% or less. Pervious pavement has the approximate strength characteristics of traditional pavement with the ability to percolate water into the groundwater system. The pavement reduces sediment and nutrient transmission into the groundwater as water moves through the pores in the pavement. When installed, porous pavement includes a stone layer, filter fabric, and a filter layer covered by porous pavement. Correctly mixed porous pavement eliminates fine aggregates found in typical pavements. Porous asphalt is a type of porous pavement which includes a mix of Portland cement, coarse aggregates, and water that results in the formation of interconnected voids.

Modular pavement consists of individual blocks made of pervious material such as sand, gravel, or sod interspersed with strong structural material such as concrete. The blocks are typically placed on a sand or gravel base and designed to provide a load-bearing surface that is adequate to support personal vehicles, while allowing infiltration of surface water into the underlying soils. They usually are used in low-volume traffic areas such as overflow parking lots and lightly used access roads. An alternative to pervious and modular pavement for parking areas is a geotextile material installed as a framework to provide structural strength. Filled with sand and sodded, it provides a completely grassed parking area.

Phosphorus Free Fertilizer Usage
Phosphorus-free fertilizers are those fertilizers that supply nitrogen and minor nutrients without the addition of phosphorus. Phosphorus increases algae and plant growth which can cause negative impacts on water quality within aquatic systems. The Clear Choices, Clean Water program estimates that a one acre lawn fertilized with traditional fertilizer supplies 7.8 pounds of phosphorus to local waterbodies annually. Given that 75% of urban residents within the Region of the Great Bend of the Wabash River Watershed indicate either limited knowledge or that they don't use phosphorus free fertilizers, there is great potential for reducing urban sources of phosphorus by targeting this practice. Established lawns take their nutrients from the soil in which they grow and need little additional nutrients to continue plant growth. Fertilizers are manufactured in a variety of forms including that without phosphorus. Phosphorus-free fertilizer should be considered for use in areas where grass is already established.

Prescribed Grazing

This practice where grazing and/or browsing animals are managed on a prescribed schedule. Removal of herbage by the grazing animals is in accordance with production limitations, plant sensitivities and management goals. Frequency of defoliations and season of grazing is based on the rate of growth and physiological condition of the plants. Duration and intensity of grazing is based on desired plant health and expected productivity of the forage species to meet management objectives. In all cases enough vegetation is left to prevent accelerated soil erosion. Application of this practice will manipulate the intensity, frequency, duration, and season of grazing to: Improve water infiltration, maintain or improve riparian and upland area vegetation, protect stream banks from erosion, manage for deposition of fecal material way from water bodies and promote ecological and economically stable plant communities which meet landowner objectives. (FOTG Code 528, NRCS, 2010)

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.

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 Lower Pigeon Creek 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.

Soil testing - Consider soil characteristics to minimize runoff

Soil testing can be used to determine nutrient levels in the soil, determine pH levels and thus, lime needs; provides a decision-making tool to determine what nutrients to apply, how much, and when. Regular soil testing and the application of fertilizers at or below university fertilizer recommendations provides the potential for higher yielding, high quality crops with more targeted fertilizer use.

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.

Tree Box Filters

Tree box filters are a proprietary biotreatment device that is designed to mimic natural systems such as bioretention areas by incorporating plants, soil, and microbes. Tree box filters are installed at curb level and consist of an open bottom concrete barrel filled with a porous soil media, an underdrain in crushed gravel, and a tree. Tree box filters are highly adaptable solutions that can be used in all types of development and in all types of soils but are especially applicable to ultra-urban areas.

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).

University fertilization recommendations/Soil testing

Soil Testing can be used to determine Determines nutrient levels in the soil, determine pH levels and thus, lime needs; provides a decision-making tool to determine what nutrients to apply, how much, and when. Regular soil testing and the application of fertilizers at or below university fertilizer recommendations provides the potential for higher yielding, high quality crops with more targeted fertilizer use.

Variable Rate Application/Technologies

Precision agriculture is defined as a management system that uses information, technology, and site-specific data to manage variability within fields for optimum profitability, sustainability, and environmental protection. This method also includes guidance systems for agricultural equipment. The purposes of using precision agriculture are: To improve water quality by targeting pesticide or soil amendment applications to meet field-specific cropland yield capabilities; reduce the potential off-site impacts of fertilizer and pesticide applications; improve water quality by reducing pesticide and fertilizer inputs through avoidance of overlapping and end row/turn row applications; reduce surface runoff and through precisely controlled cropping equipment, resulting in less fuel being used; reduce compaction by limiting traffic to specified travel lane; and increase opportunity to operate equipment after dark.

Vegetated Swale

Vegetated swales are used in agricultural areas and are often considered landscape features. Swales are graded to be linear with a shallow, open channel of a trapezoidal or parabolic shape. Vegetation which is water tolerant is planted within the channel which promotes the slowing of water flow through the system. Swales reduce sediment and nutrients as water moves through the swale and water infiltrates into the groundwater.

Waste Utilization

Large volumes of manure are generated by small, unregulated animal operations located throughout the Lower Pigeon Creek 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. Specific technical practices that can be included in manure management planning can include waste storage facilities and waste utilization.

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.

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 Creation, Enhancement or Restoration

Visual observation and historical records indicate at least a portion of the Lower Pigeon Creek 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 61 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 62 outlines suggested BMPs, estimated load reduction for nutrients and sediment (if available), and the target volume (area, length) of each practice, while Table 63 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.

Table 61. Suggested Best Management Practices to address Lower Pigeon Creek critical areas. Note BMPs were selected by the steering committee.

Practice	Nutrients	Sediment	Pathogens
Access Control/Fencing	X	X	X
Alternative Watering System	X		X
Animal Mortality Facility			X
Bioreactor	X		
Bioretention: Rain garden, bioswale, native planting	X	X	X
Clearing Ditches			
Composting Facility	X	X	X
Conservation Tillage	X	X	X
Cover Crop/Critical Area Planting/Conservation Cover	X	X	X
Curb Openings/Curbless Design	X	X	
Diversion Structures	X	X	
Drainage Water Management	X	X	
Drivable Grass	X	X	X
Fencing	X	X	X
Field Border/Buffer Strip	X	X	X
Field Ditch			
Flow Splitter	X	X	X
Forage/Biomass Planting	X	X	X
Grade Stabilization Structure	X	X	
Grassed Waterway/Mulching/Subsurface Drain	X	X	X
Green Roof	X		
Habitat Corridor Identification and Improvement	X	X	
Heavy Use Area Protection	X	X	X
Lined Waterway or Outlet	X	X	X
Livestock Restriction/Pipeline; Prescribed Grazing	X	X	X
Manure Management Planning	X		X
Mulching	X	X	X
Nutrient/Pest Management	X		
Pervious Pavement	X	X	
Phosphorus Free Fertilizer	X		
Point Source Discharge Reduction			
Rain Barrel	X	X	
Septic System Care/Maintenance	X		X
Soil Testing	X	X	X
Streambank Stabilization	X	X	
Subsurface Infiltration			
Tree Box Filter	X	X	
Tree/Shrub Establishment	X	X	

Practice	Nutrients	Sediment	Pathogens
Two Stage Ditch	X	X	X
University Fertilization Recommendations/Soil Testing	X		
Variable Rate Application	X		
Vegetated Swale	X	X	
Waste Storage Facility	X		X
Waste Utilization	X		X
Water and Sediment Control Basin	X	X	
Wetland Creation/Enhancement/Restoration	X	X	X

The Region V model was used to estimate the approximate load reductions for BMPs unless otherwise noted (Appendix E). BMPs with dashes (-) do not have load reductions available using the Region V Model or other identifiable source. Using a set of BMPs regularly used in the Lower Pigeon Creek Watershed, the loading rates for estimated target volumes of BMPs proposed to be installed were calculated. Agricultural BMPs were utilized for this calculation as these provide the largest opportunity for achieving target load reductions. It should be noted that these volumes of BMPs are not required to be implemented as suggested, rather 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 62is met, then the target loading rates detailed in Table 57 to Table 60 will be achieved. The Region V model does not provide estimated reductions for all suggested BMPs; therefore, therefore, load reductions for these practices cannot be included in the calculations. The Lower Pigeon Creek steering committee set goals for each parameter, then selected best management practices which they can utilize to meet those goals. Best management practices were then phased to three 10-year terms (short, medium and long) with each phase of the goal being met by the same annual volume of best management practices. This results in the same number of best management practices targeted in each phase and the same cost for each best management practice within each phase. Table 63 details cost estimates by phase.

Table 62. Selected, routinely utilized, agricultural Best Management Practices, target volumes, and their estimated load reduction per practice to meet short-term, medium-term and long-term goals. These practices represent that meeting project goals are possible. Additional practices listed in sections above maybe utilized during implementation of the Lower Pigeon Creek Watershed Management Plan.

Suggested BMPs:	Lifetime Target (30 years)	Short Term (10 Year) Targets	Medium Term (20 Year) Targets	Long Term (30 Year) Targets	Unit	Nitrogen (lb/year)	Phosphorus (lb/year)	Sediment (t/year)
Conservation Cover (327)	3,000	1,000	1,000	1,000	acre	23	11	36.01
Cover Crop (340)	24,938	8,313	8,313	8,313	acre	15	7	7
Critical Area Planting (342)	2,000	667	667	667	acre	15	7	7
Filter Strip (393)	5,200	1,733	1,733	1,733	acre	24	12	10
Forage and Biomass Planting (512)	7,233	2,411	2,411	2,411	acre	23	11	10
Grade Stabilization	90	30	30	30	unit	69.9	34.9	30.4
Grassed Waterway (412), Underground outlet (620), Mulching (484)	2,221	740	740	740	acre	232.9	116.4	101.3
Nutrient/Pest Management (590)^	24,938	8,313	8,313	8,313	Acre	4.16	6.24	-
Prescribed Grazing (528)	7,233	2,411	2,411	2,411	acre	17	9	8
Residue and Tillage Management (329)	24,938	8,313	8,313	8,313	acres	21	10	11
Streambank Stabilization**	5300	1,767	1,767	1,767	feet	0	0.83	14
Tree/shrub Establishment (612)	2,400	800	800	800	acres	10	5	45.01
Water and Sediment Control Basin (638)	60	20	20	20	Unit	129.8	64.9	56.4
Urban BMPs (bioretention, rain barrel, rain garden, pervious pavement, treatments vaults, green roof)*	500	Education focus for urban BMPs	250	250	unit	0.5	0.2	0.2

^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 63. Estimated cost for selected Best Management Practices used to calculate the possibility to meet short-term, medium-term and long-term goals.

Suggested BMPs:	Estimated Cost per Unit	Short-term Estimated Cost	Medium-term Estimated Cost	Long-term Estimated Cost
Conservation Cover (327)	$25-75	$25,000	$25,000	$25,000
Cover Crop (340)	$75	$623,450	$623,450	$623,450
Critical Area Planting (342)	$650	$433,333	$433,333	$433,333
Filter Strip (393)	$75	$130,000	$130,000	$130,000
Forage and Biomass Planting (512)	$75	$180,825	$180,825	$180,825
Grade Stabilization	$2,500	$25,000	$25,000	$25,000
Grassed Waterway (412), Underground outlet (620), Mulching (484)	$5,000	$4,166,667	$4,166,667	$4,166,667
Nutrient/Pest Management (590)	$4	$33,251	$33,251	$33,251
Prescribed Grazing (528)	$15	$36,165	$36,165	$36,165
Residue and Tillage Management (329)	$15	$124,690	$124,690	$124,690
Streambank Stabilization	$5,000	$8,833,333	$8,833,333	$8,833,333
Tree/shrub Establishment (612)	$450	$375,000	$375,000	$375,000
Water and Sediment Control Basin (638)	$2,500	$50,000	$50,000	$50,000
Urban BMPs (bioretention, rain barrel, rain garden, pervious pavement, treatments vaults, green roof)	Varies	Education focus for urban BMPs	$100,000	$100,000
Total Cost		**$15,036,714**	**$15,136,714**	**$15,136,714**

10.3 Action Register

All activities to be completed as part of the Lower Pigeon Watershed management plan are identified in Table 64. 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. The steering committee noted that their possible partners are also technical assistance providers and are listed as both unless otherwise noted in Table 64.

Table 64. Action Register.

Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Nutrients, Sediment, *E. coli*	Coordinate on-the-ground cost-share program starting in 2023.	Producers, homeowners, landowners	Develop a cost-share program (2023).	$25,000 annually staffing	PP/TA: ICP partners, TNC, City of Evansville, Vanderburgh MS4
			Implement cost-share program (2023-2053).		
			Identify and apply for potential funding sources to augment cost-share program including MRBI, RCPP, LARE, CWA and others. Once received, implement cost-share program per program guidance.		
Nutrients, Sediment, *E. coli*	Promote and fund conservation practices which emphasize livestock management, soil health, forest management and target urban BMP implementation (2023-2053).	Producers, homeowners, landowners	Meet BMP annual targets detailed above.	$1.5 million annually BMP implementation	PP/TA: ICP partners, TNC, City of Evansville, Vanderburgh MS4
			Increase adoption of conservation plans and nutrient (including manure management) plans.		
			Developed targeted outreach and BMP programs for horse boarders.		
			Work with MS4 communities to ensure that urban BMPs are implemented on new construction and retrofits are included as possible on lands already developed.		
			Achieve short-term load reductions: 21% reduction in nitrate loading, 26% reduction in total phosphorus loading and 36% reduction in total suspended solids loading.		
			Achieve medium-term load reductions: 26% reduction in nitrate loading, 35% reduction in total phosphorus loading and 53% reduction in total suspended solids loading.		
			Achieve long-term load reductions: 11% reduction in nitrate loading, 13% reduction in total phosphorus loading and 15% reduction in total suspended solids loading.		

Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Nutrients, Sediment, *E. coli*; Education	Reduce negative impacts of stormwater on Lower Pigeon Creek (2023-2053).	Home owners, City of Evansville, Health Dept, Commercial, Industrial users	Work with Evansville Renew to implement the CSO plan.	$5,000 annually as part of education and outreach; project funding details per Renew on project-by-project basis	PP/TA: Utilities, engineers, City of Evansville
			Identify opportunities to encourage urban BMP adoption and stormwater infiltration to reduce negative impacts to CSO areas.		
			Use previously adopted urban BMPs including those installed at the Evansville WWTP to highlight opportunities for local residents to implement residential BMPs.		
Education; *E. coli*	Work with contractors and Health Depts to increase septic system maintenance and installation awareness (2023-2053)	Septic users, real estate agents	Produce and distribute septic maintenance brochure at local events, field days, city festivals and county fairs.	$5,000 annually	PP/TA: health department, real estate agents (PP), septic contractors
			Offer cost-share incentives to producers proving voluntary septic maintenance.		
			Explore options for future septic system maintenance or upgrade assistance funding.		
Education	Educate Lower Pigeon Creek Project stakeholders about soil erosion, increase awareness about applicable BMPs, inorganic pollution and cost-share opportunities (2023-2053).	Landowners, producers, homeowners, business owners	Develop an outreach plan targeting each practice identified above by 2023.	$5,000 annually	PP/TA: ICP partners, City of Evansville
			Create mechanism to promote each practice using methods including but not limited to press releases; workshops; field days; stream clean up; float trip; stream, field or pasture walk; website creation; local events; county fair booth; educational booth; and public meetings.		
			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.		
			Continue to maintain a project-based website and social media to promote events, cost-share fund availability and build project awareness.		

Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Education	Work with partners to identify and promote hands-on opportunities to improve natural areas and habitat within the Lower Pigeon Creek Watershed (2023-2053).	Landowners, producers, homeowners, 4H clubs, scout and church groups, golf courses	Identify partner organizations which host field days, work days, and clean-up events.	$5,000 annually	Wesselman Woods (PP), City of Evansville, Sierra Club (PP), Parks Dept, Vanderburgh CISMA and WISP, MS4s, ICP partners
			Annually, identify partner work days for river clean-up, float trip, invasive species control, low-head dam safety education, septic system maintenance and education, trash removal, illegal dumping or habitat restoration opportunities and promote throughout the watershed.		

11.0 FUTURE ACTIVITIES

The next steps for the project include starting implementation of the Lower Pigeon Creek Watershed Management Plan. The Vanderburgh County SWCD in partnership with the project steering committee and other regional partners are in the process of submitting an implementation-focused grant application. If funded, this grant 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 Lower Pigeon Creek Watershed, helping reach goal statements by 2053. For each practice identified which the committee deemed familiar and routinely utilized in the Lower Pigeon Creek Watershed and for which a load reduction calculation is readily available, an annual target for the acres or number of each BMP implemented is included in Table 62. Measurement of the success of implementation is a necessary part of any watershed project (Table 65). 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.

The tracking strategies illustrated in Table 65 will be used to document changes and aid in the plan re-evaluation. The steering committee listed potential partners and technical assistance provides as both unless otherwise noted. Activities to be completed as part of this watershed management plan are identified in the action register (Table 64). Table 66 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. The Vanderburgh County SWCD will be responsible for keeping the mentioned records.

Table 65. 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, MS4
BMP Load Reductions	Continuous	$5,000	SWCDs, NRCS, ISDA, MS4
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
Number of educational publications/press releases	Yearly	$500/release	SWCD
IDEM Probabilistic Monitoring	Every 9 years	N/A (IDEM provides staff and funding)	IDEM

Table 66. Annual targets for agricultural best management practices (short, medium, long term) and urban best management practices (medium, long term).

Suggested BMPs:	Annual BMP Targets	Units
Conservation Cover (327)	100	acre
Cover Crop (340)	831	acre
Critical Area Planting (342)	67	acre
Filter Strip (393)	173	acre
Forage and Biomass Planting (512)	241	acre
Grade Stabilization	3	unit
Grassed Waterway (412), Underground outlet (620), Mulching (484)	74	acre
Nutrient/Pest Management (590)	831	Acre
Prescribed Grazing (528)	241	acre
Residue and Tillage Management (329)	831	acres
Streambank Stabilization	177	feet
Tree/shrub Establishment (612)	80	acres
Water and Sediment Control Basin (638)	2	unit
Urban BMPs (bioretention, rain barrel, rain garden, pervious pavement, treatments vaults, green roof)	25	unit

11.2 Indicators of Success

Water quality, social, and administrative indicators will be used to monitor progress towards successful achievement of the short term, medium term and long-term goals and will serve as a feedback mechanism to adapt and tailor future education and outreach efforts. Pre and post event surveys will occur at each educational event. The information collected from each survey and/or event will be used to inform future education and outreach strategies creating an adaptive education strategy as implementation of the watershed management plan moves forward. Water quality indicators will include monitoring total phosphorus, nitrate-nitrogen, total suspended solids and *E. coli*. Monitoring will occur as part of the Hoosier Riverwatch volunteer program, at a minimum. 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. 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 using Hoosier Riverwatch or other methods at the Lower Pigeon Creek outlet. 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 1.0 mg/L and for total phosphorus of 0.08 mg/L. Additionally, a loading rate reduction will be measured with the loading rate calculated for 2021 fixed station data.
- Administrative Indicator: The number of BMPs that can reduce nitrate-nitrogen and total phosphorus will be tracked annually. The total number of acreage will be compared against annual targets identified in Table 66. Individual load reductions calculated for each BMP will be reviewed to determine if cumulative loading rates for nitrate-nitrogen and total phosphorus are sufficient to meet the target reductions.

Reduce Sediment Loading

- Water Quality Indicator: Total suspended solids will be measured monthly using Hoosier Riverwatch other methods at the Lower Pigeon Creek outlet. 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.
- Administrative Indicator: The number of BMPs that can reduce total suspended solids will be tracked annually. The total number of acreage will be compared against annual targets identified in Table 66. 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 five times during 30 days during the growing season in year 5 of implementation at the Lower Pigeon Creek outlet. 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. The total number of acreage will be compared against annual targets identified in Table 66.

Increase Public Awareness and Participation

- Administrative Indicator: The number of events and 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.

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 61 and Table 62.

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 Lower Pigeon Creek 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 Lower Pigeon Creek 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 Lower Pigeon Creek 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. Updates will be made to the project website no less than monthly or when education and engagement events occur, cost share funds are available or project-based meetings or other activities can be highlighted.
- 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 billboards, 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 Vanderburgh and Warrick County service centers provide assistance for Lower Pigeon Creek Watershed.
- Vanderburgh and Warrick 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 Lower Pigeon Creek 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. Oftentimes 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 Lower Pigeon Creek Project Steering Committee can adjust the watershed management plan to ensure project success. A four-step adaptive management strategy has been outlined for the Lower Pigeon Creek Watershed Project and can be found below.

Step 1: Planning The planning process used to develop the Lower Pigeon Creek WMP follows the IDEM 2009 Watershed Management Checklist. The project coordinator worked in concert with and was guided by the Lower Pigeon Creek 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 Lower Pigeon Creek 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. 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 65 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 64) 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 Lower Pigeon Creek 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. 2024, 2026, 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 Lower Pigeon Creek Project coordinated by the Vanderburgh County SWCD, are responsible for maintaining records for the project including tracking plan successes and failures and any necessary watershed management plan revisions. The plan will be re-evaluated at the end of Year 5 and every 5 years after that.

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