LITTLE BLUE RIVER WATERSHED MANAGEMENT PLAN
HENRY, RUSH AND SHELBY COUNTIES, INDIANA

A PROJECT OF THE

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LITTLE BLUE RIVER WATERSHED MANAGEMENT PLAN
HENRY, RUSH AND SHELBY 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 help 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 Little Blue River Watershed drains portions of Shelby, Rush and Henry Counties (67,040 ac) and includes one 10-digit Hydrologic Unit Code (HUC, 0512020402). The watershed includes the towns of Arlington, Manilla and Rays Crossing, and the City of Shelbyville. (Figure 1). The Little Blue River Watershed begins in southern Henry County and flows southwest through Rush and Shelby Counties. Tributaries include Gilson Creek, Linn Creek, Farmers Stream, Manilla Branch and Beaver Meadow Creek. The Little Blue River empties into the Big Blue River in Shelbyville. The Big Blue River flows southwest until it empties into the Driftwood River near Edinburgh (Figure 2).

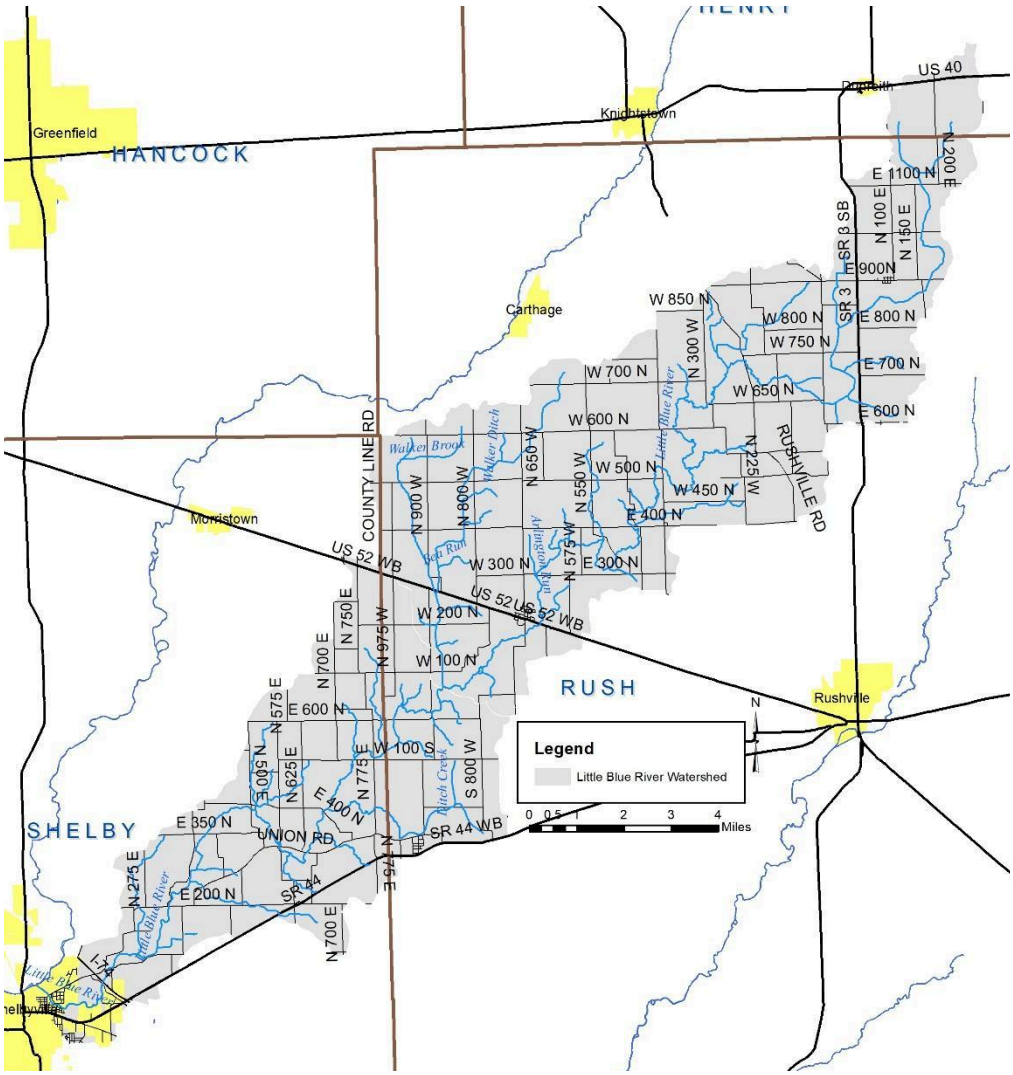

Figure 1. The Little Blue River Watershed.

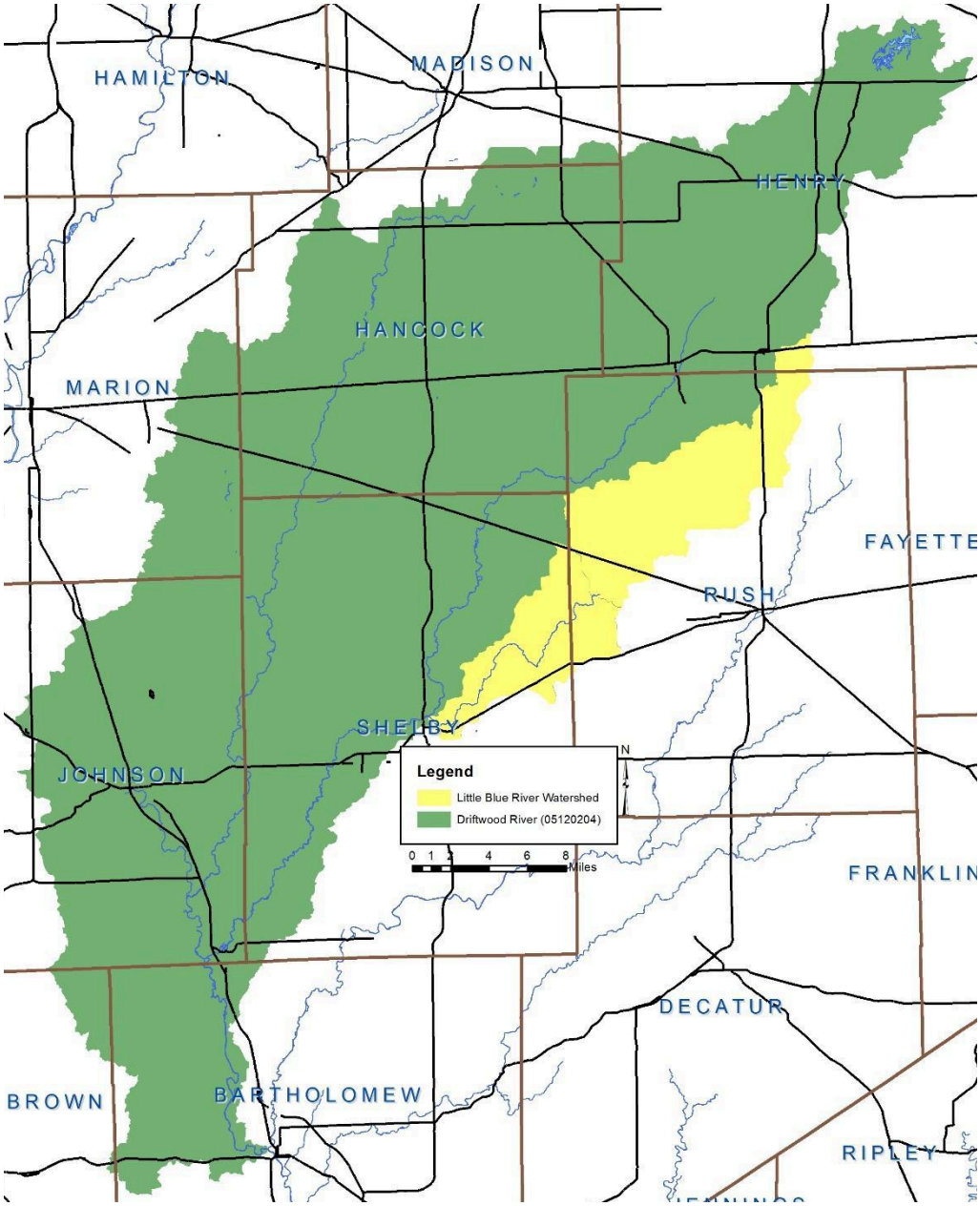

Figure 2. The Driftwood River Basin highlighting the Little Blue River Watershed.

1.2 Project History

The Little Blue River water quality monitoring project is being conducted as part of a rewrite of the Little Blue River Watershed Management Plan. A previous watershed management plan was completed in 2007 following 2003 guidelines. In 2010, the Shelby and Rush SWCDs completed the Little Blue River implementation project. The watershed management plan will be rewritten to follow the 2009 IDEM planning checklist and from which future efforts can be based. A revised plan is needed for the following reasons: 1) since the 2007 WMP, there have been observable changes in land use from development around Shelbyville and residential growth throughout the watershed; 2) since 2007, there has been a three-fold increase in the number of hogs in confined feeding operations, contributing to a total of nearly 145,000 animals housed within the watershed; and 3) the 2007 sediment goal was

exceeded, while the nitrogen goal has nearly been met. While the phosphorus goal has not been met, it was based on stormwater conditions. The current project will calculate watershed loading rates for each subwatershed. These data will be used to develop watershed critical areas and calculate watershed loading rates from which loading reductions to meet water quality targets will be developed.

There are more than 125.5 miles of streams in the Little Blue River watershed. Impairments include: 125.5 miles for *E. coli*, 52.3 miles for biotic communities and 52.3 miles for dissolved oxygen. During the development of the 2007 Little Blue River watershed plan, stakeholders identified *E. coli* as the primary water quality concern. Additional issues noted were illegal dumping, trash, eating fish from the Little Blue River, the need for more effective drainage, logjam removal, high sediment and nutrient levels and the need to educate the public and implement best management practices (BMPs) to protect and improve the river. The Little Blue River watershed plan (2007) identified improperly functioning/failing septic systems, erosion and sedimentation, pasture runoff, heavily grazed areas, livestock manure, manure fertilizer, livestock access to streams, wastewater treatment plants and wildlife as sources *of E. coli*.

Based on these concerns, the Shelby SWCD worked with partners throughout the watershed that might be interested in working with them to assess and improve water quality and quantity within the Little Blue River watershed. Identified potential stakeholders included: Shelby, Rush and Henry County SWCD and NRCS, Rush and Shelby County surveyors' offices, Shelby and Rush County Health Departments, Shelbyville Parks and MS4, Shelby County Recycling District, Shelby County Purdue Extension, Shelby County AIPC. This group formed a Steering Committee (Table 1), conducted windshield surveys of the watershed, and held several meetings open to the public in order to generate input in the development of a watershed management plan for the Little Blue River 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 and addressed water quantity concerns. The Little Blue River Project will involve stakeholders in the watershed management planning process through a series of public meetings and education and outreach events including workshops, field days and youth-focused education events.

1.3.1 Steering Committee

Individuals representing the towns and counties within the watershed, environmental groups, natural resource professionals and private citizens comprised the steering committee. The steering committee had its first meeting on March 22,2023. Table 1 identifies the steering committee members and their affiliations.

Table 1. Little Blue River Watershed steering committee members and their affiliation.

Individual	Organization(s) Represented
Derrick Byers	Shelbyville MS4
Lisa Carpenter	Shelby County Recycling District
Scott Gabbard	Shelby County Purdue Extension
Kaitlan Hudson	Shelby County SWCD
Robert Lewis	Shelby Health Department
Chris Lux	Shelbyville school corporation
Ethan McGivern	Shelby County SWCD
Ashley Pine	Shelby/Rush County NRCS
Marvin Rees	Rush County Surveyor
Heath Hartley	Local Resident
Joyce Miller	Rush SWCD, Heart of Rushville
Julia Apple	Rush Health Department
Kelly Riggs	Henry County SWCD
Desiree Calderella	Shelby County AIPC
Karen Martin	Shelbyville Parks
Cindy Scales	Shelby County SWCD

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 will be public meetings. 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 protect and improve water quality; and build support for future phases of the project.

The public meetings/listening sessions were advertised through press releases, partner email and a Facebook event. The first public meeting occurred on March 1, 2023 and was hosted as a drop in and chat meeting. In total, 35 individuals attended the meeting at which they learned about the project and its components and provided their concerns about the watershed, weighed in on project sample sites and reviewed upcoming events and activities.

The second meeting occurred November 19, 2024 and included an update on the status of the project 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 Little Blue River Watershed including the Little Blue River, its tributaries, and its watershed. Public and committee meetings were the primary mechanism of soliciting individual concerns. All comments were recorded and included as part of the concern documentation and prioritization process. Concerns voiced throughout the process are listed in Table 2. Similar stakeholder concerns were grouped roughly by topic and condensed by the committee. The order of concern listing does not reflect any prioritization by watershed stakeholders.

Table 2. Stakeholder concerns identified during public input sessions, steering committee meetings and via the watershed inventory process. Note: The order of concern listing does not reflect any prioritization by watershed stakeholders.

Stakeholder Concerns
Trash
Stormwater runoff
Streambank erosion
Flooding
Flooding impacts to agricultural cropland, property value impacts
E. coli levels are high (impaired streams)
Local recreation options should be improved
Can we eat the fish and/or swim/canoe on the stream?
Newly designated legal drain in Rush County - potential impacts for water quality, quantity, management and funding
Illegal dumping along the river, its tributaries and in rural areas
Make drainage more effective
Logjams, logjam impacts, logjam removal
Elevated nutrient levels
Water is cloudy, especially after it rains
Impaired biotic communities
Low dissolved oxygen levels
Wind and water erosion of soil impacts field productivity
Mussel species need protected - good water quality, regular instream flows, limit hydromodification
High quality habitats need protected

2.0 WATERSHED INVENTORY I: WATERSHED DESCRIPTION

2.1 Watershed Location

The Little Blue River Watershed is part of the Driftwood River Watershed and covers portions of Henry, Rush and Shelby counties (Figure 3) The Little Blue River Watershed begins in Henry County and flows southwest through Rush County then into Shelby County. The watershed drains 67,040 acres before emptying into the Big Blue River in Shelbyville, Indiana. The Big Blue River flows southwest and discharges into the Driftwood River in Johnson County, Indiana.

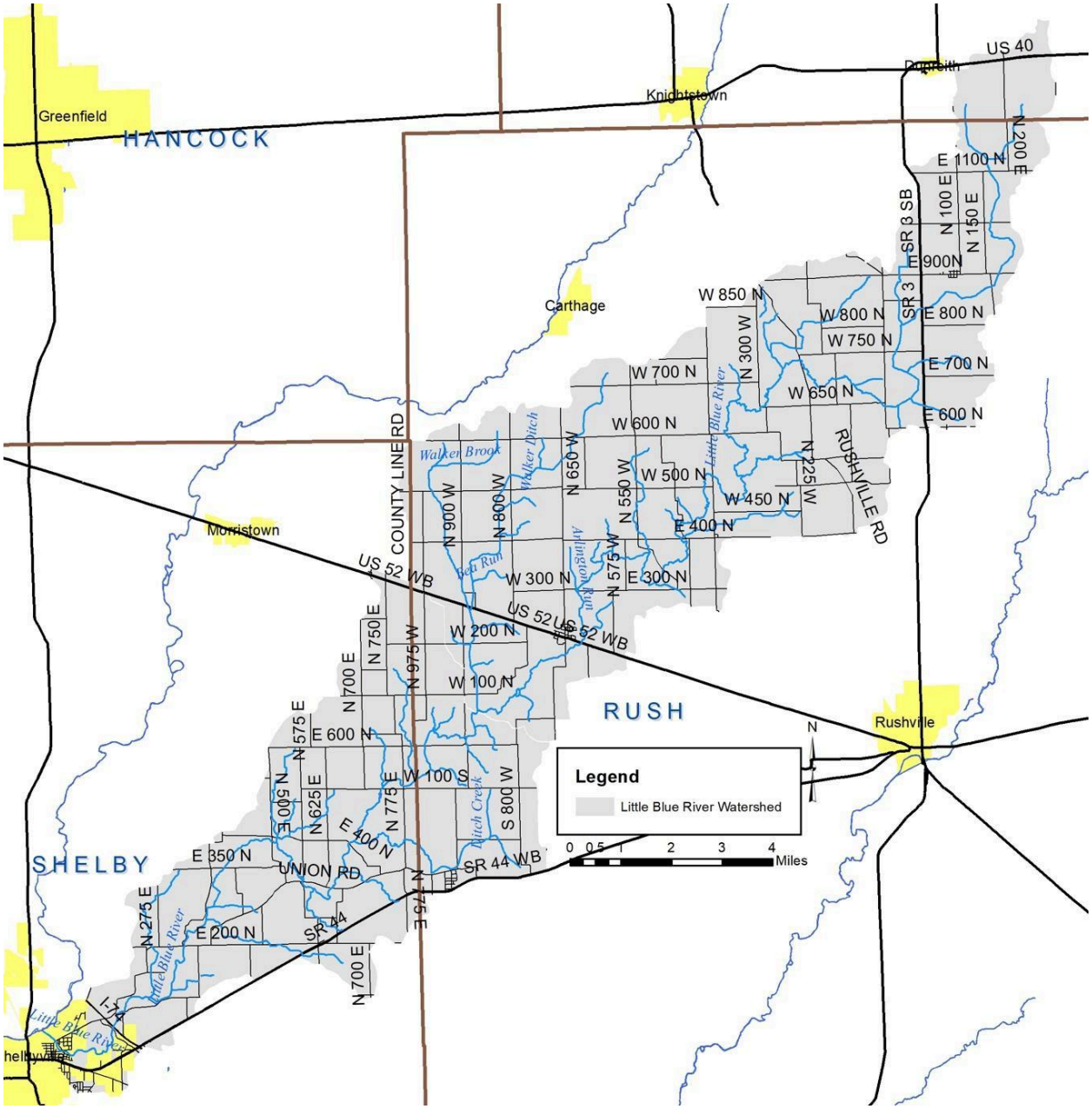

Figure 3. The Little Blue River Watershed covering portions of Henry, Rush, and Shelby counties.

2.2 Subwatersheds

In total, five 12-digit Hydrologic Unit Codes are contained within the Little Blue River Watershed (Figure 4, Table 3). Each of these drainages will be discussed in further detail under *Watershed Inventory II*.

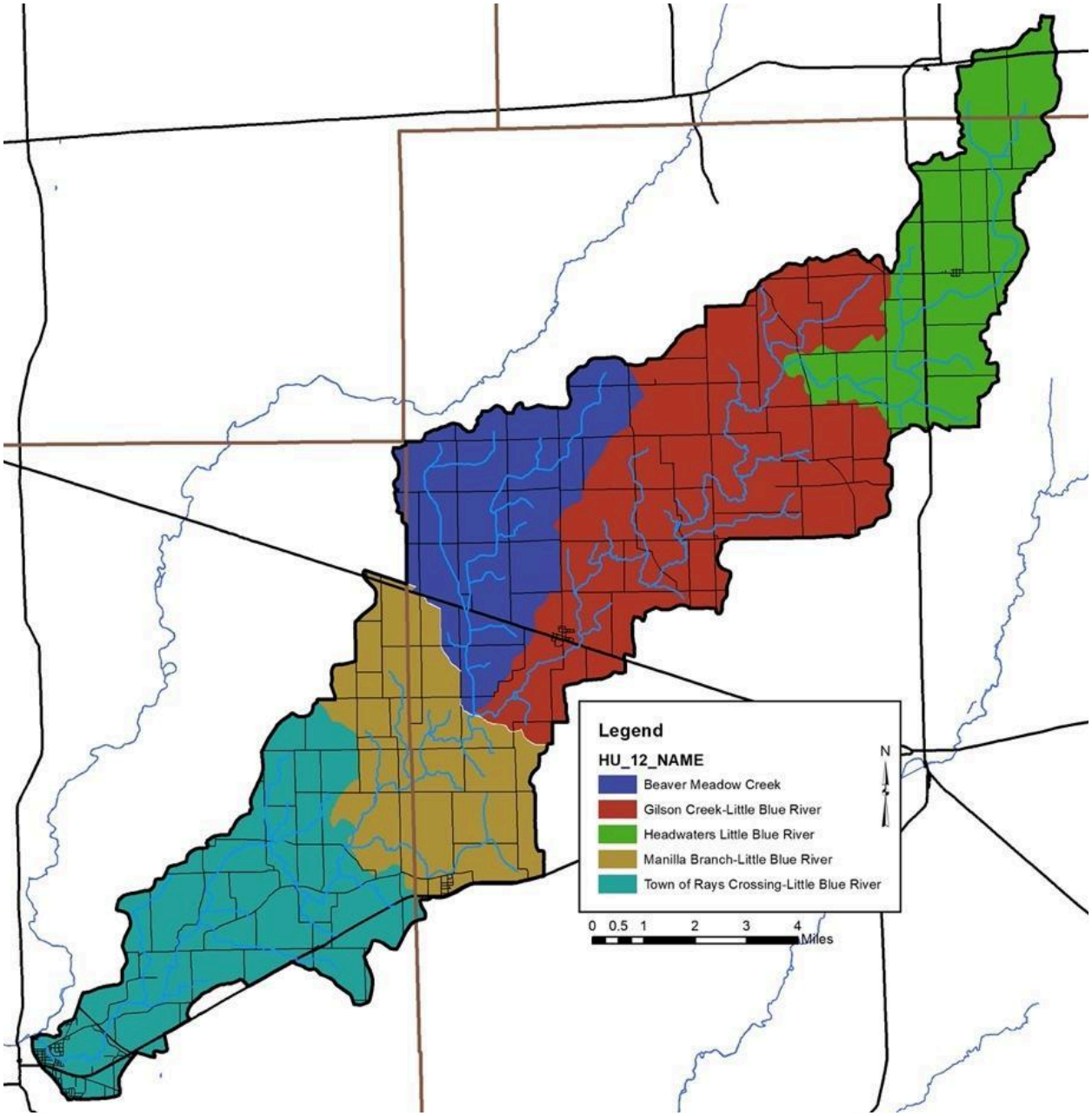

Figure 4. 12-digit Hydrologic Unit Codes in the Little Blue River Watershed.

Table 3. 12-digit Hydrologic Unit Code (HUC) Subwatersheds in the Little Blue River Watershed.

Subwatershed Name	Hydrologic Unit Code	Area (acres)	Percent of Watershed
Headwaters Little Blue River	051202040201	11,091	17%
Beaver Meadow Creek	051202040202	10,494	16%
Gilson Creek-Little Blue River	051202040203	20,706	31%
Manilla Branch-Little Blue River	051202040204	10,606	16%
Town of Rays Crossing-Little Blue River	051202040205	14,140	21%

	Entire Watershed	**67,037**	100%

2.3 Climate

Generally, Indiana distinctly follows the four seasons and has a temperate climate with warm summers and cold winters. The warm season lasts approximately four months between May and September. The cold season lasts approximately three months between December and March. Within the Little Blue River Watershed, high temperatures measure 85 °F in July while low temperatures measure below freezing in January at 19 °F in Shelbyville, Indiana (US Climate, 2019). Average annual precipitation is 41.93 inches (US Climate, 2019).

2.4 Geology and Topography

The Little Blue River Watershed exhibits six varying bedrock units formed during the Ordovician, Silurian, and Devonian ages approximately 40 million years ago (Figure 5). Limestone, shale and dolomite of Silurian Age (Louisville Limestone) form the headwaters of the watershed. Louisville Limestone covers portions of the upper, middle, and lower watershed, while Muscatatuck Group (dolomite and limestone) covers middle to lower portions. Most of the bedrock is covered by glacial surface deposits of sand, silt, gravel, and loam.

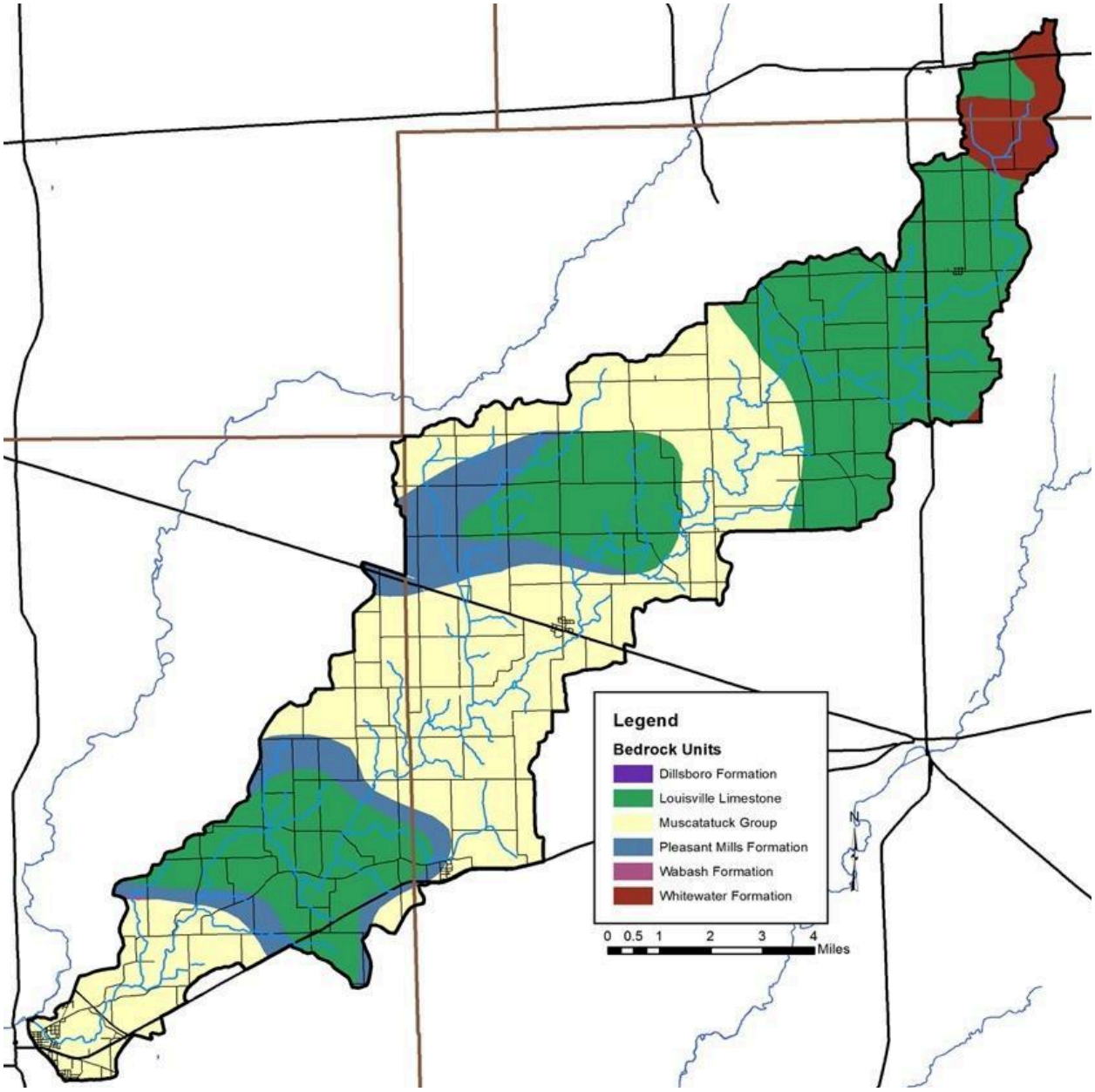

Figure 5. Bedrock in the Little Blue River Watershed.

The northern two-thirds of Indiana landscape was constructed by glaciers. The advancement of ice during the last glaciation, the Wisconsin, covered about two-thirds of Indiana (Wayne, 1966). The Wisconsin glaciation reached its maximum extent in Indiana 21,000 years ago at the Shelbyville Moraine. Moraines, or glacial till, develop from active glaciers. The Shelbyville Moraine marks the southern extent of the Little Blue River Watershed. The group of tills deposited by the glacial advancements during the Wisconsin Age in Indiana are known as the Trafalgar Formation. The ice that deposited the Trafalgar tills came from the northeast. The flow of the Little Blue River parallels the direction of those glacial deposits. The watershed is also bounded by the gently sloping plain, the Muscatatuck Regional Slope. Till covers much of the Little Blue River Watershed (Figure 6). Sand and gravel outwash are readily available resources along the mainstem of the Little Blue River floodplains as evidenced by the complex drift formations present.

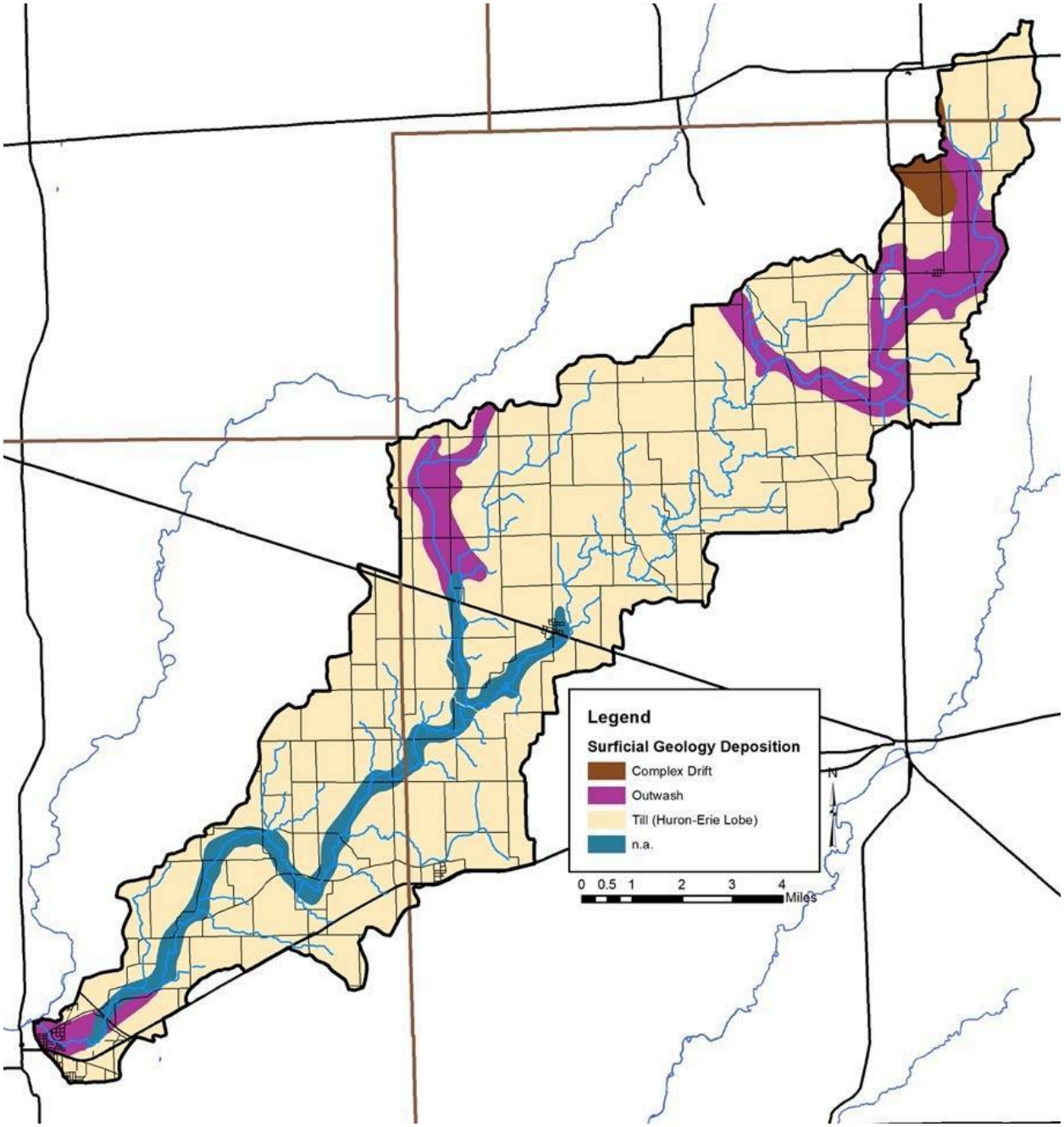

Figure 6. Surficial geology throughout the Little Blue River Watershed.

The Little Blue River Watershed is located within the 12,000 square mile central physiographic zone that is a depositional plain of low relief (Schneider, 1966). This zone, underlain mostly by thick glacial till, is known as the Tipton Till Plain. The Tipton Till Plain is a nearly flat to gently rolling glacial plain (Schneider, 1966). The Muscatatuck Regional Slope slopes from 1,100 feet above sea level at its eastern margin to 725 feet on the west (Schneider, 1966). Topographically, the terrain in the Little Blue River Watershed slopes southward from the start of the watershed. The terrain is highest (1067 feet msl) near the head of the watershed and lowest (743 feet msl) near the bottom of the watershed (Figure 7). The expanse of the Tipton Till Plain is broken up by moraines, eskers and esker troughs, and meltwater drainageways that trend in a northeast-southwest direction (Schneider, 1966).

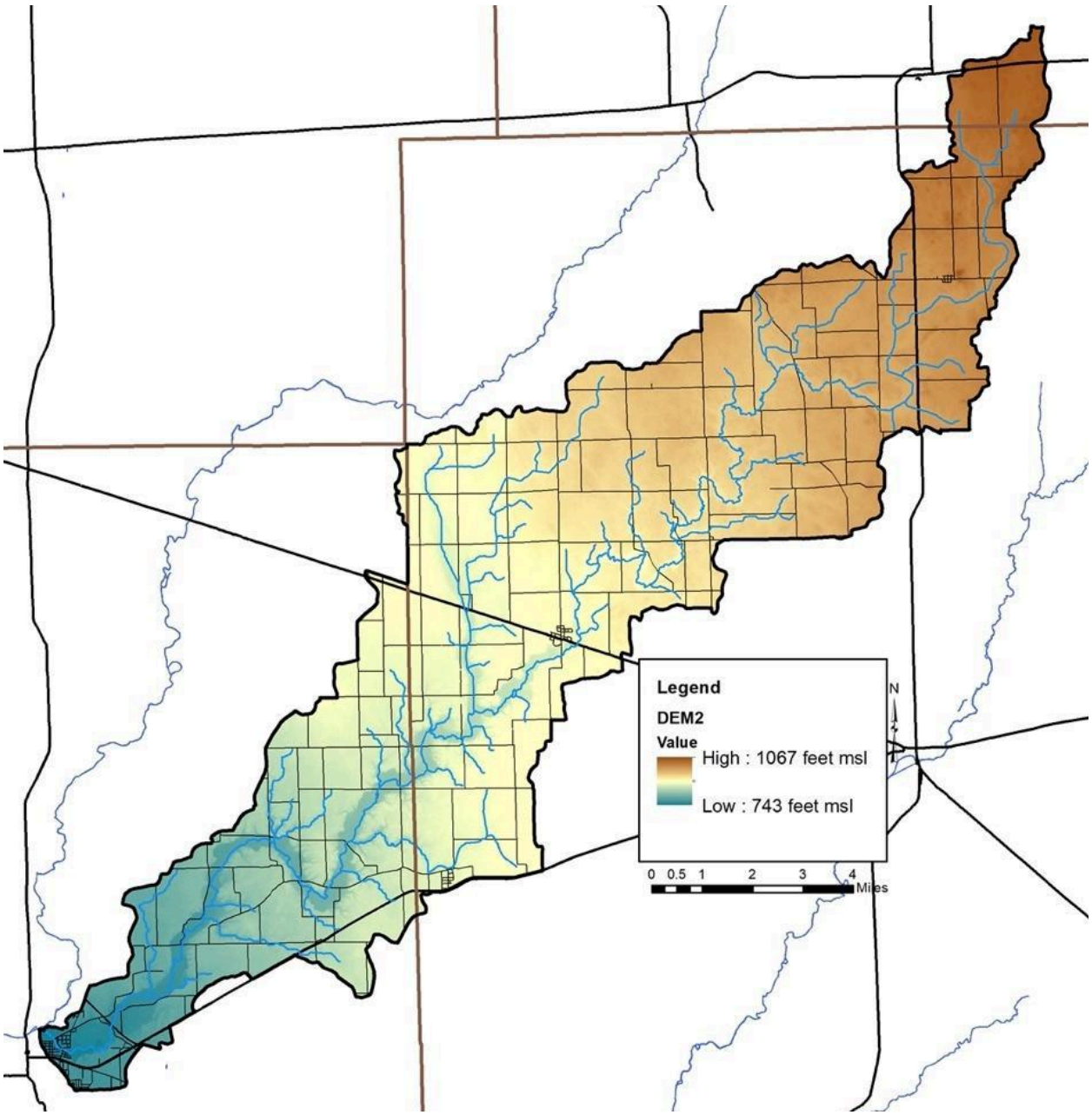

Figure 7. Surface elevation in the Little Blue River Watershed.

2.5 Soil Characteristics

The parent material of soils in Indiana are directly or indirectly mostly related to glaciation (Ulrich, 1966). The main parent materials found in the counties that are located in the watershed are glacial outwash and till, ice-contact sand and gravel deposits, alluvium, and organic materials left after glacier recession. 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.

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. Soils are classified by the Natural Resource Conservation Service into four hydrological soil groups based on the runoff potential of soils. The four groups are A, B, C and D, generally with the lowest runoff potential in category A and greatest runoff potential in category D.

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.

If D soils can be adequately drained, they are assigned to dual hydrologic soil groups. The first letter applies to the drained condition and the second letter to the undrained condition. The majority of the Little Blue River Watershed is covered by category C/D soils (39%) followed by category B/D soils (35%), and category C soils (18%). C/D and B/D soils are found throughout the entirety of the watershed, while category C soils are found along the Little Blue River mainstem (Figure 8). C/D and B/D soils risk frequent flooding and high amounts of runoff when undrained, while still having slow to moderate infiltration rates when drained. B soils are moderately deep and well drained, while C soils are finer and have slower water movement.

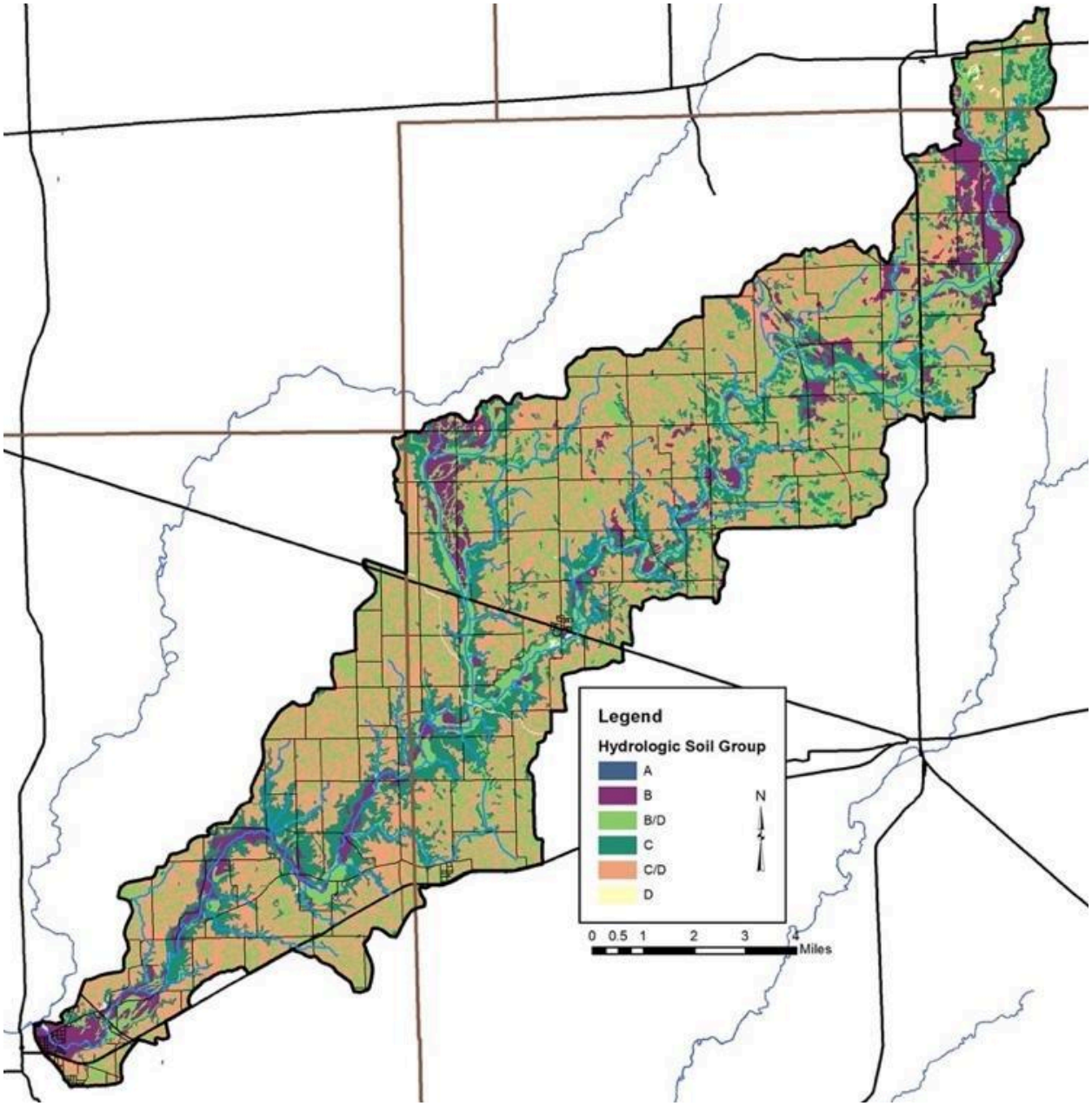

Figure 8. Hydrologic soil groups throughout the Little Blue River Watershed.

2.5.2 Soil Erodibility

Some soils erode more easily than others depending on their characteristics and percent of slope. Soil particles that are transported to water bodies can degrade water quality, interfere with recreational uses, and impair 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. Highly erodible soils cover 62% of the watershed, or 41,594 acres. Highly erodible soils are found throughout the watershed, with greater concentration surrounding the Little Blue River and its tributaries (Figure 9).

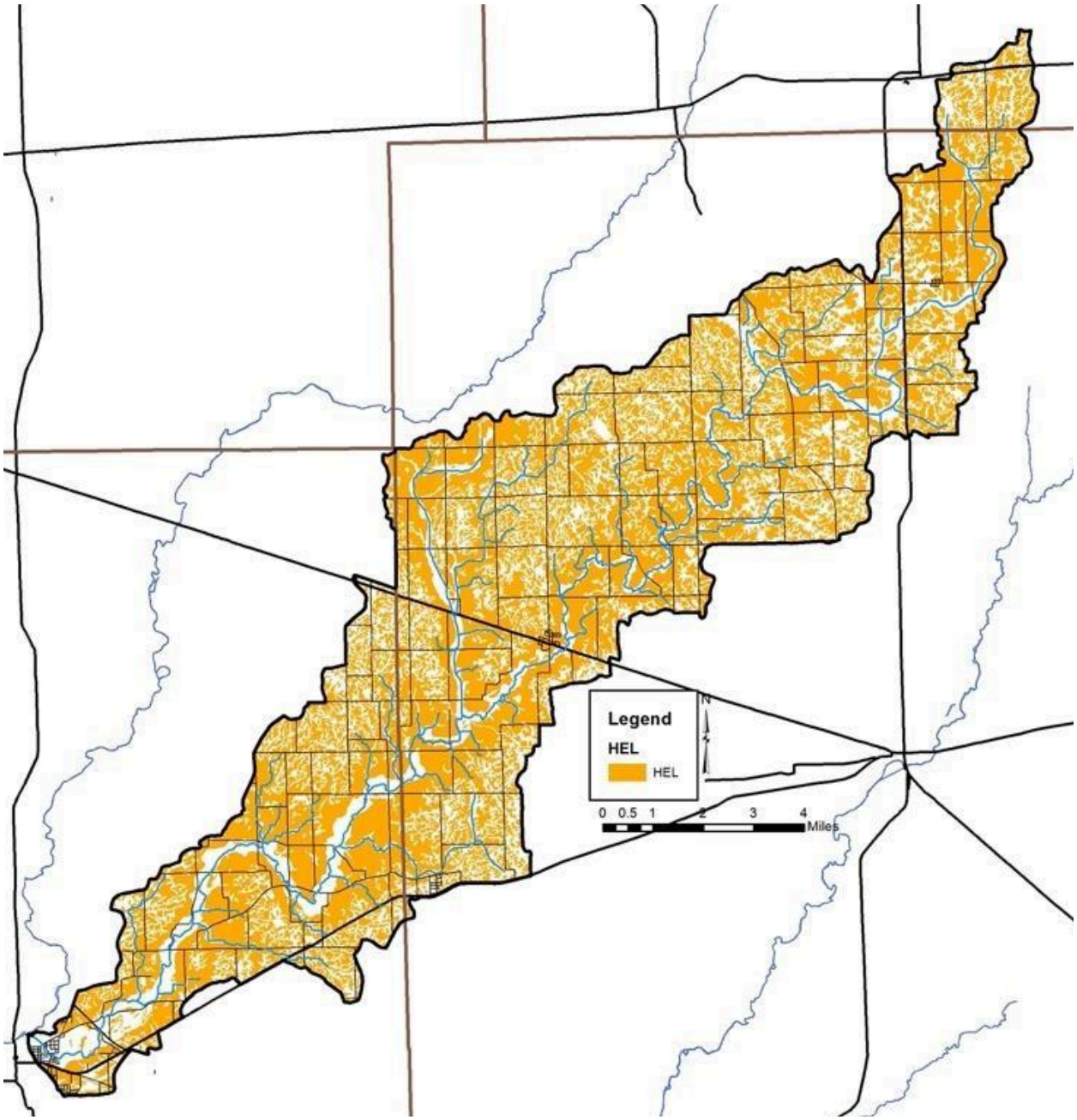

Figure 9. Highly erodible lands in the Little Blue River Watershed.

2.5.3 Hydric Soils

Hydric soils are those which remain saturated for a sufficient period to generate a series of chemical, biological, and physical processes. The oxidation and reduction of iron in the soil causes color changes that are 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. Approximately 21,960 acres (33%) of the watershed is covered by hydric soils (Figure 10). Hydric soils are found throughout the watershed, but with greater concentrations in Rush County and near the Henry-Rush County Line. Hydric soils are located more on the border of the watershed as it enters Shelby County. As these soils are considered to have developed under wetland conditions, they are a good indicator of historic wetland locations and therefore will be revisited in the land use section.

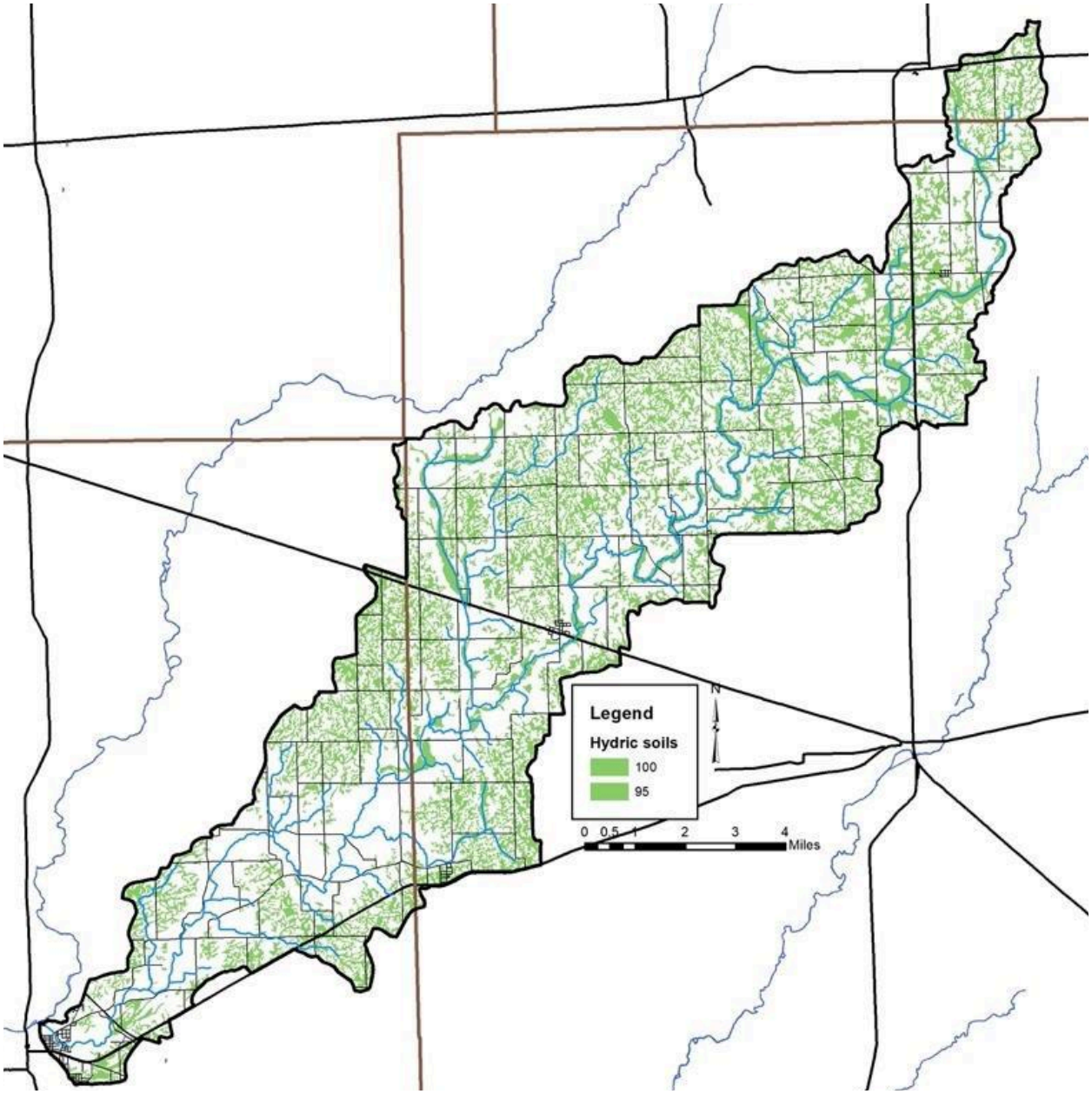

Figure 10. Hydric soils in the Little Blue River Watershed.

2.5.4 Tile-Drained Soils

The purpose of agricultural drainage is to remove excess water from the soil to enhance crop production. As most of the land within the Little Blue River Watershed is covered by cultivated crop agriculture, agricultural drainage is a widely used method to remove excess water from soil in agricultural fields. Soils drained by tile drains cover approximately 51,099 acres or 76% of the watershed as estimated utilizing methods detailed 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 on stream water quality can be reduced by the use of tile control structures and drainage water management. About half of Indiana's cropland is artificially drained (Frankenberger and Kladivko), allowing for greater potential crop yield, but also increasing the risk of wetland loss, downstream flooding, nutrient runoff, and stream incision. Controlled drainage and subirrigation are possible methods to maintain crop yield while protecting water quality.

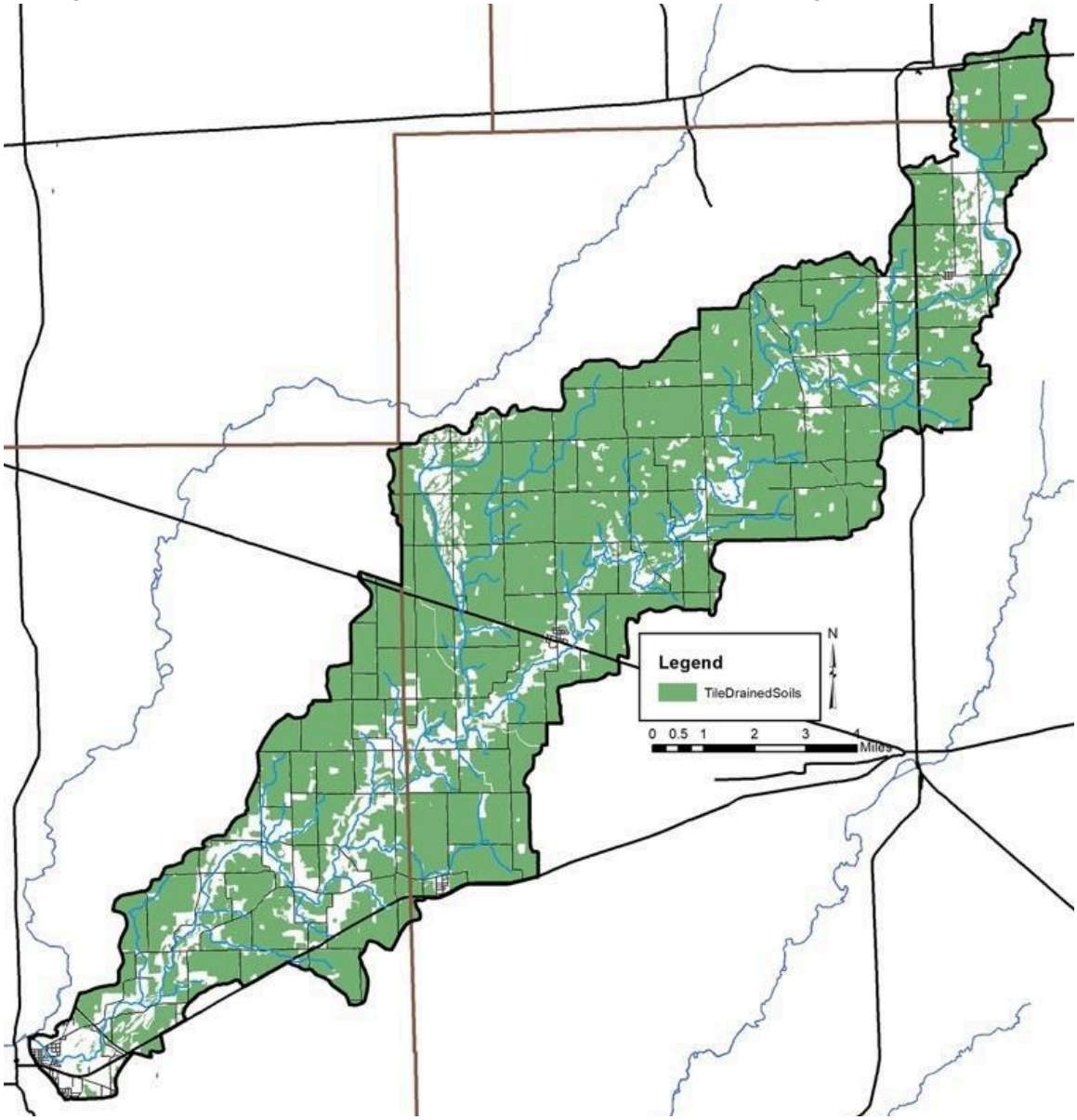

Figure 11. Tile-drained soils in the Little Blue River Watershed.

2.6 Wastewater Treatment

2.6.1 Soil Septic Tank Suitability

Onsite sewage disposal systems do not result in an off-lot discharge of treated effluent, requiring the use of a septic tank to settle and digest sewage solids before the wastewater is treated and distributed for absorption into the soil. The Indiana Department of Health estimates more than 800,000 onsite

sewage disposal systems are currently used in Indiana, with more than 15,000 permits issued per year for new systems. Households depend upon septic tank absorption fields 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 12). Approximately 66,854 acres or 99.8% of the Little Blue River Watershed is covered by soils that are considered very limited for use in septic tank absorption fields. The small, remaining acres are not rated for septic usage.

Septic systems that are properly designed and maintained should not serve as a source of contamination to surface waters. However, septic systems do fail for a variety of reasons. Common soil-type limitations which contribute to failure are seasonal high water tables, compact glacial till, bedrock, coarse sand and gravel outwash and fragipan. When these septic systems fail via surface

breakouts or due to inadequate soil filtration there can be adverse effects to surface waters due to E. coli, nitrate and total phosphorus (Horsely and Witten, 1996). Septic systems contain all the water discharged from homes and businesses and can be significant sources of pathogens and nutrients.

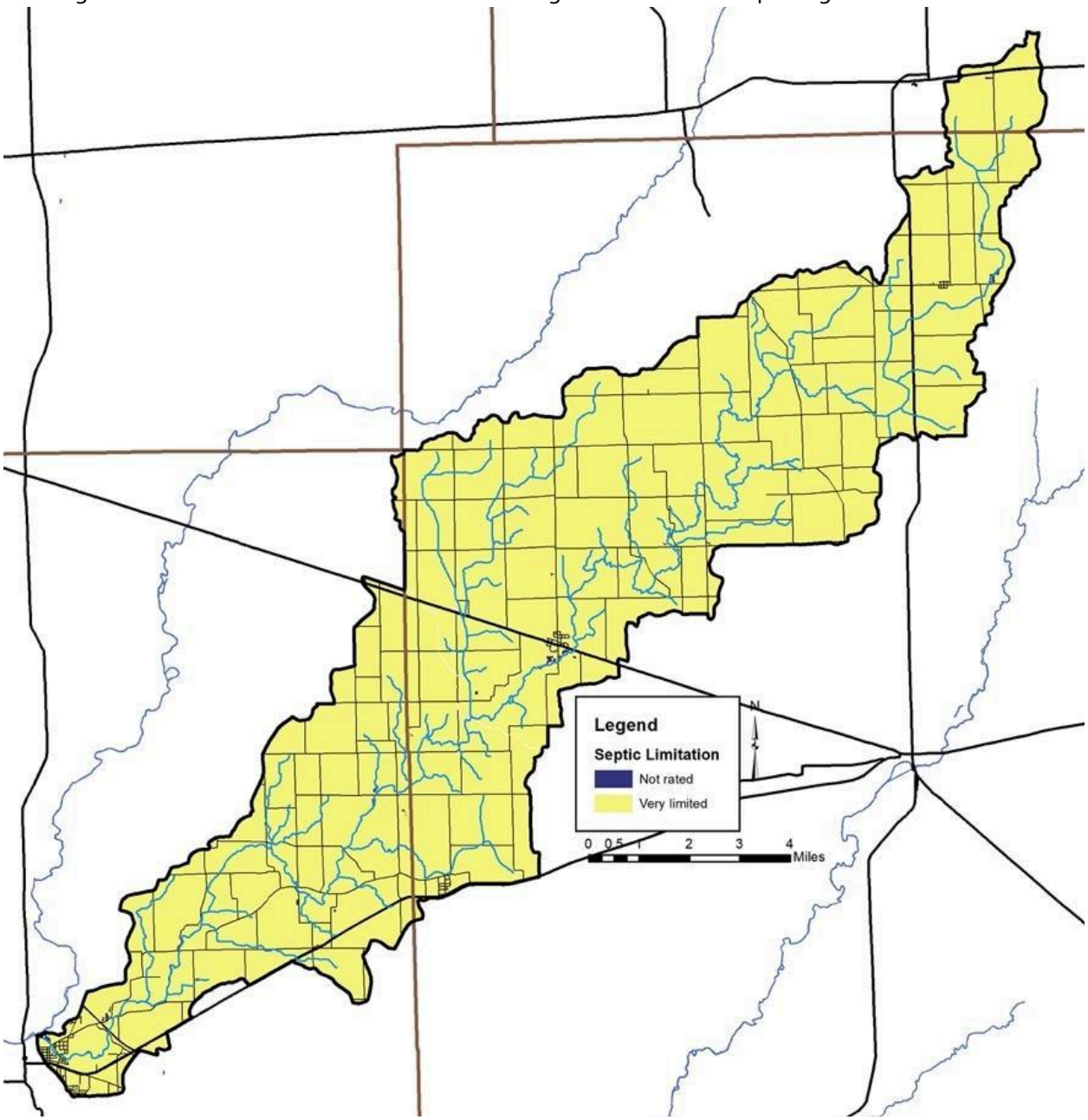

Figure 12. Suitability of soils for septic tank usage in the Little Blue River Watershed.

2.6.2 Wastewater Treatment

The National Pollution Discharge Elimination System (NPDES) grants permits and limits facilities to discharge an amount of a pollutant into a receiving water under certain conditions. These permits place these limits and are set at levels aimed at protecting both aquatic life and human health. According to the Environmental Protection Agency, these permits may authorize facilities to process, incinerate, landfill, or use sewage sludge. In Indiana the purpose of these permits is to control the point source discharge of pollutants into the water of the state so that the quality of the water is maintained in

accordance with certain standards. Based on permit databases, there are not any NPDES facilities in the Little Blue River Watershed. There are however about 760 acres of land where NPDES facility sludge is permitted to be land applied in the watershed (Figure 13).

2.6.3 Unsewered Areas

Three dense unsewered areas approximating 400 acres are within the watershed (Figure 13). These areas include the towns of Arlington, Mays, and Manilla. Areas that have at least 25 houses within a square mile outside of the sanitary district boundaries were classified as dense, unsewered areas.

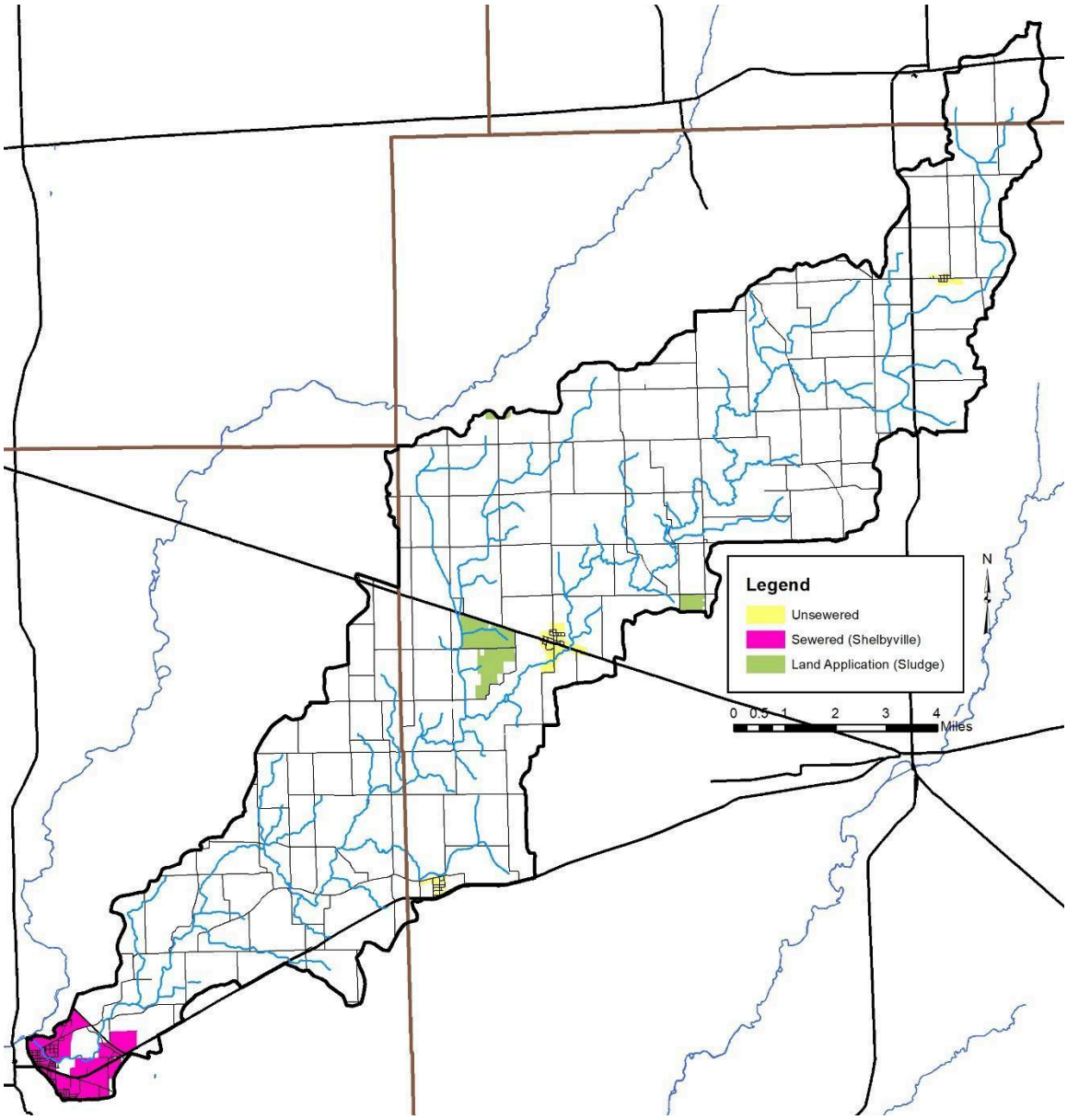

Figure 13. Unsewered and the sewered (City of Shelbyville) areas in the Little Blue River Watershed.

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 entire Little Blue River Watershed contains approximately 125 miles of perennial streams and regulated drains (Figure 14). Major tributaries in the Little Blue River Watershed include Little Gilson Creek, Farmer Stream, Beaver Meadow Creek, Linn Creek, Manila Branch, and Ray's Crossing Tributary. Combined, these tributaries have a total length of 27.6 miles. The mainstem of the Little Blue River is approximately 43.0 miles. Together, the mainstem of the river and major tributaries represent approximately 70.6 miles of stream length in the watershed. In total, there are 124 miles of streams, rivers and legal drains in the watershed. The majority of streams in the Little Blue River Watershed are not regulated with only about 21 miles of legal drain present. 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 the Little Blue River. The unnamed streams consist of drains, and private pipes and tiles.

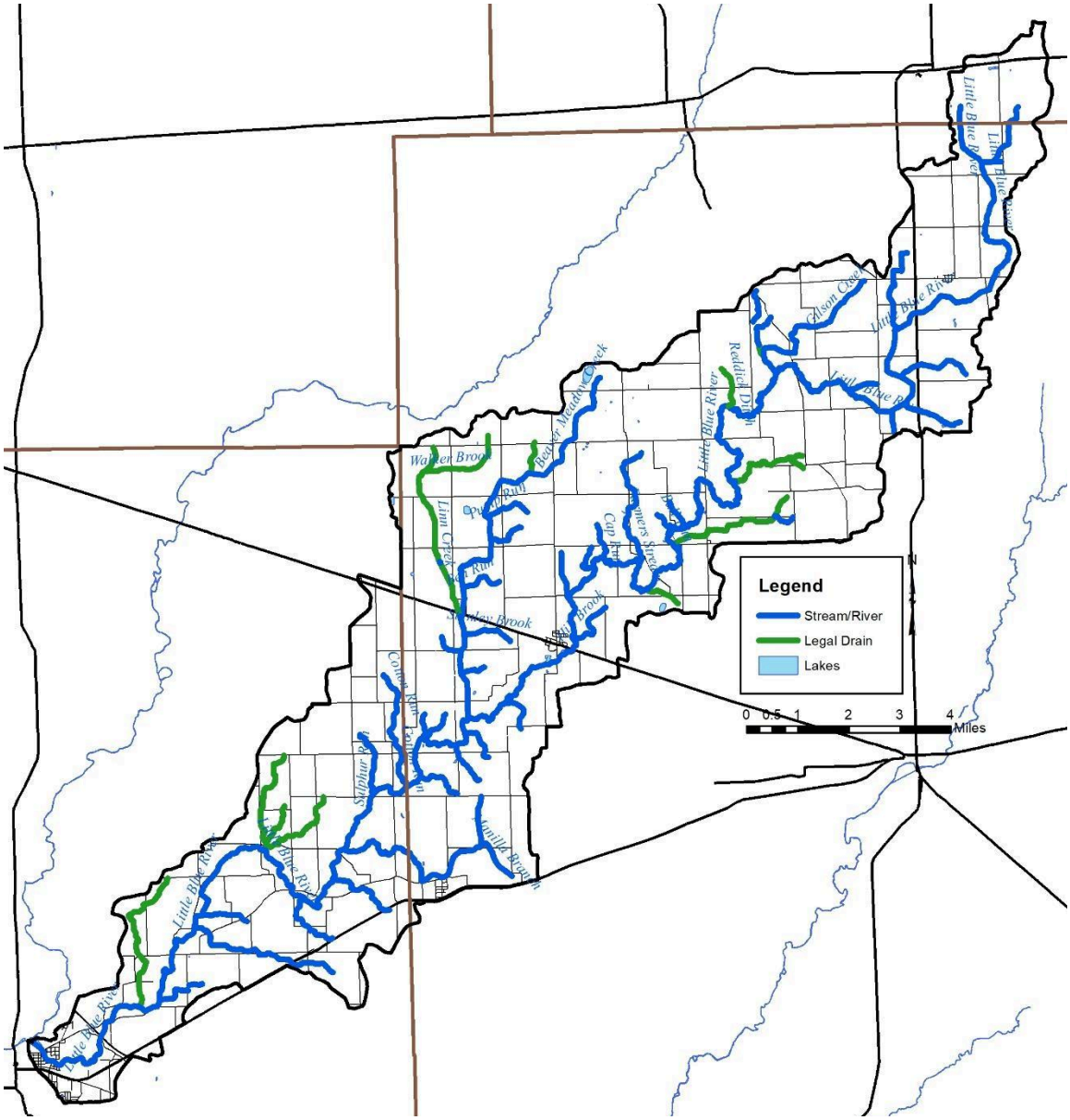

Figure 14. Streams in the Little Blue River Watershed.

The Little Blue River from the Rush- Shelby County Line to the mouth is used for recreational kayaking and canoeing as well as fishing, swimming, and aesthetic enjoyment. Several tributaries to the Little Blue River are used for fishing and aesthetic enjoyment. 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* and mercury and PCBs in fish tissue.

2.7.2 Lakes, Ponds and Impoundments

There are 73 lakes in the Little Blue River Watershed ranging in size from 0.03 acres to 24.3 acres. There are 165 total acreages of lakes in the watershed. Most of these are likely farm ponds used for aesthetics, flood control, fishing and limited recreation. These provide local swimming holes, recreational boating

options and localized fishing as well as providing water storage and retention to assist with flooding. There are currently no dams (lowhead or otherwise) in the Little Blue River Watershed.

2.7.3 Floodplains

Historically, 25% of the total area in Indiana was covered by wetlands (IDNR). Considering this, and the major rivers and tributaries in the state, much of Indiana is susceptible to flooding given certain circumstances. Increased imperviousness, encroachment on the floodplain, deforestation, stream obstruction, tiling, or faulty flood control structures increase the risk of flooding. Flooding can impose environmental risks such as stream bank erosion, riparian vegetation loss, water quality degradation, and channel or riparian area modification. In addition, floods can impose risks of casualty and property and utility damage as well as cutting off vital transportation routes via bridges and roads.

Floodplains are lands that are adjacent to water bodies and act as temporary storage for flood water. Floodplains can serve as an ecological function and provide nurseries for wildlife, improve water quality, and buffer water from nearby land usage. Local stakeholders are concerned about impacts to floodplains from development, lack of landowner maintenance, and soil erosion and deposition within the floodplain.

Figure 15 details the locations of floodplains within the Little Blue River Watershed. The majority of the floodplains lie within Shelby County. Approximately 4% (2,638 acres) of the Little Blue River Watershed lies within the 100-year floodplain. This 100-year floodplain is composed of three regions:

- Zone A is an area inundated during a 100-year flood event for which no base flood elevations (BFE) have been established. Approximately 2,322 acres (88%) of the Little Blue River Watershed floodplain is in zone A. This zone accounts for roughly 4% of the total 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 hydraulic models which allows zone AE floodplains to be more accurate. Approximately 262 acres (10%) of the Little Blue River Watershed floodplain is in zone AE. This zone accounts for less than 1% of the total watershed.
- Zone X includes area outside the 100-year and 500-year floodplains which have a 1% chance of flooding to a depth of 1 foot of water. No BFEs are available for such areas and no flood insurance is required. In total, 53 acres (2%) of the Little Blue River Watershed floodplain are within zone X. This zone accounts for less than 1% of the total watershed.

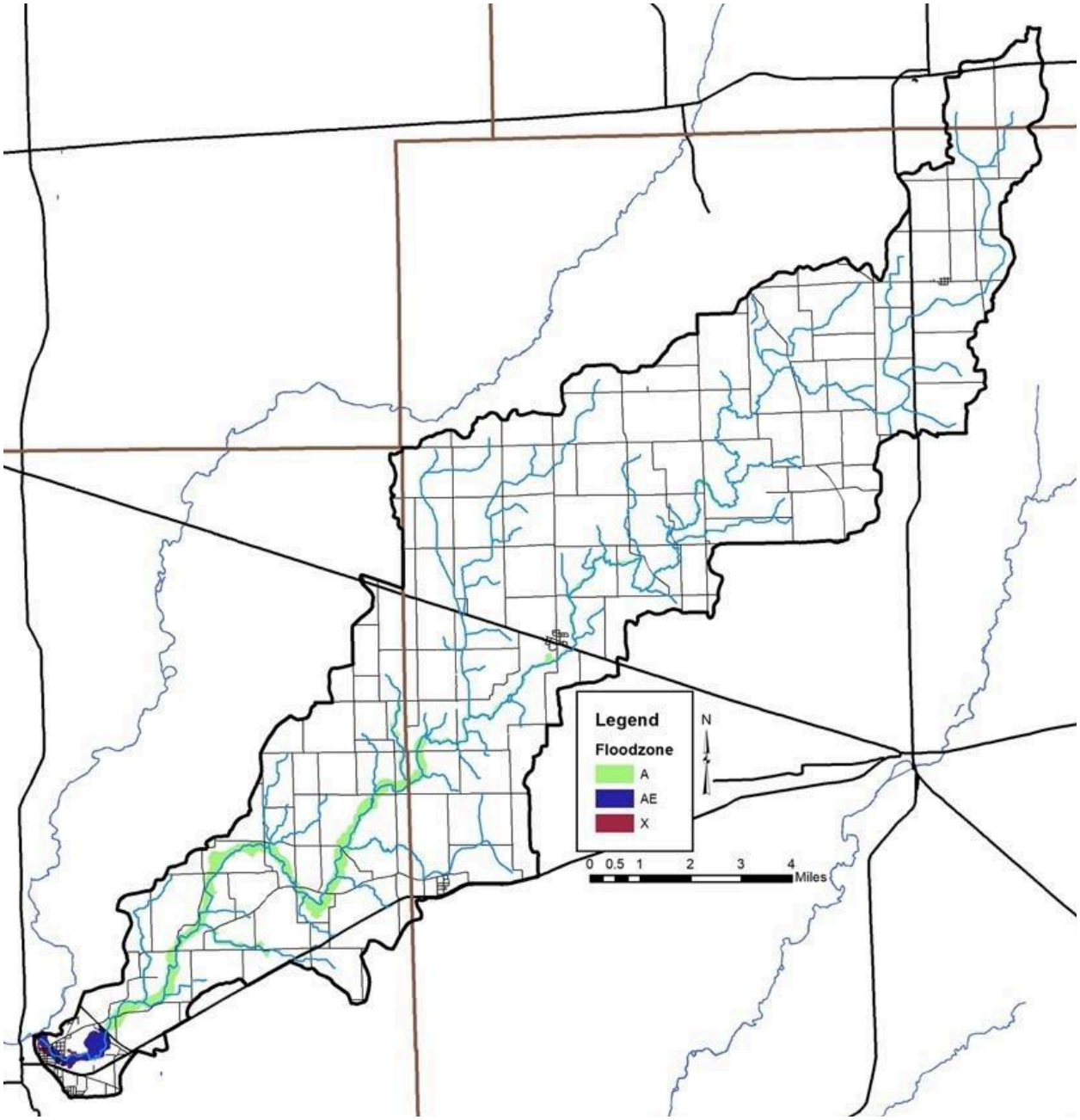

Figure 15. Floodplain locations within the Little Blue River Watershed.

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 1165.7 acres or 2% of the Little Blue River Watershed. When hydric soil cover (23,126 acres) is used as an estimate, it becomes apparent that most of the watershed's wetlands have been lost or modified over time (Figure 16). It can be estimated that approximately 95% of wetlands have been modified or lost over time in the area. 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. Among the 50 states, Indiana ranks 4th in regard to wetland acreage and percentage lost (IDNR). A majority of the 85% of wetlands lost in the state is due to drainage for agricultural production. The wetlands in Indiana are still impacted today via agricultural activities, commercial and residential development, road building, water development projects, groundwater withdrawal, loss of instream flows, water pollution, and vegetation removal.

Figure 16 shows the current extent of wetlands within the Little Blue River Watershed. Wetlands displayed in Figure 16 results from efforts by The U.S. Fish and Wildlife service as part of the National Wetland Inventory (NWI). The NWI Is a digitized map that provides information on the potential location, size, and type of wetlands across the country. 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 as estimates of wetland coverage.

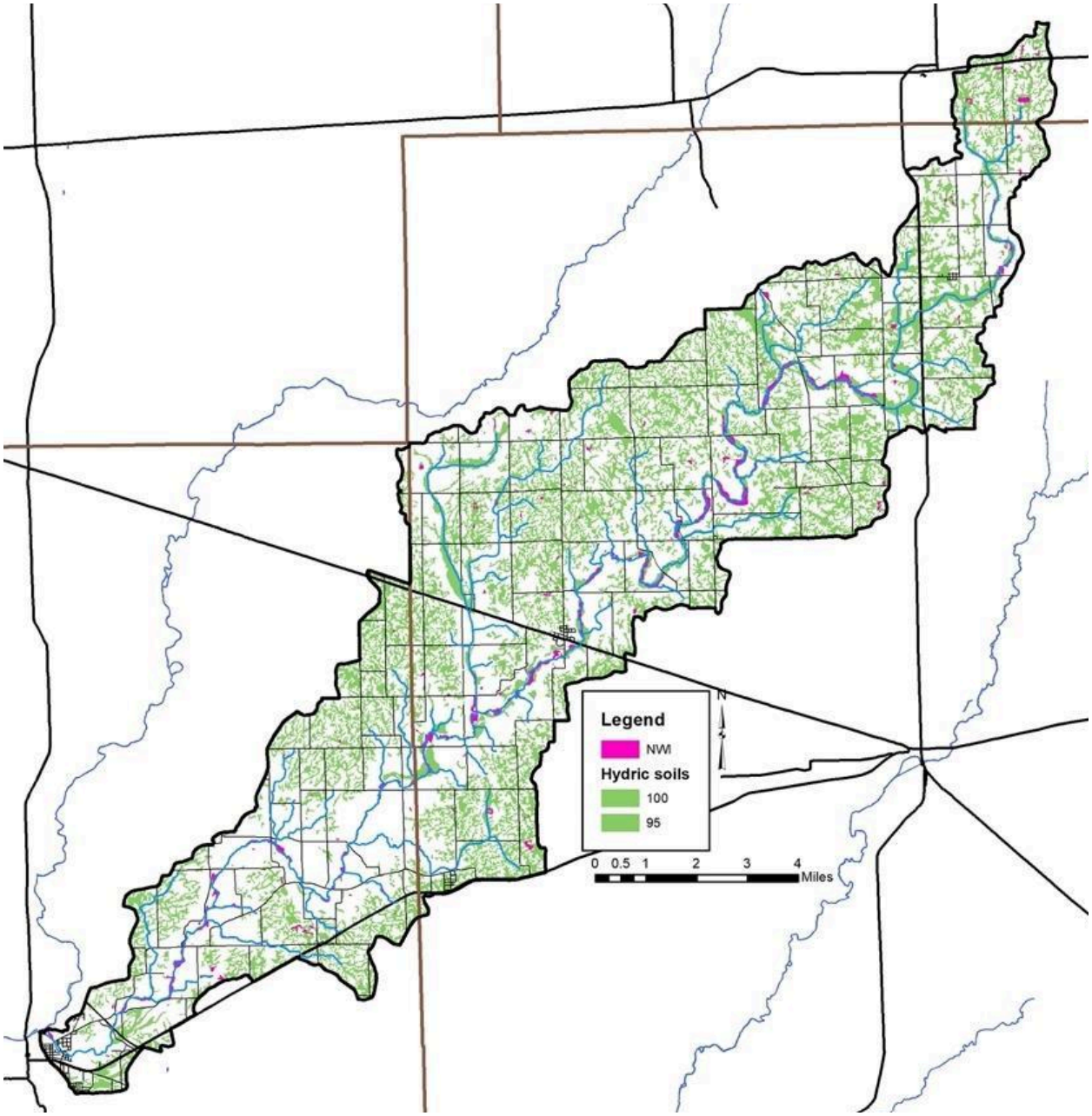

Figure 16. Wetland locations and hydric soils within the Little Blue River Watershed.

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. There is one municipal separate storm sewer system (MS4) in the Little Blue River Watershed. Under the 1987 Clean Water Act amendments, the U.S. EPA developed new stormwater regulations to address stormwater that might impact water quality. The regulations were set up in two phases depending upon population and are enforced by the U.S. EPA through IDEM. Phase II requires certain urbanized areas with a Municipal Separate Storm Sewer System (MS4) to establish a plan for

storm water quality improvement within their jurisdictions. The City of Shelbyville in Shelby County is an active MS4 community. To meet the new requirements, each designated MS4 entity was required to submit a permit application to IDEM. The permit application requires development of a Storm Water Quality Management Plan to institute and fulfill six measures:

1. Public education and outreach
2. Public involvement and participation
3. Illicit discharge detection and elimination
4. Construction site stormwater runoff control
5. Post construction stormwater management in new development and redevelopment
6. Pollution prevention/Good housekeeping for municipal operations maintenance

According to the City of Shelbyville website, stormwater from the city is discharged into the Big and Little Blue Rivers, Brandywine River, Lewis Creek or the Thompson and Glessner Ditches. The Shelbyville MS4 boundary, totaling 1,161 acres, is shown in Figure 17 and Figure 18.

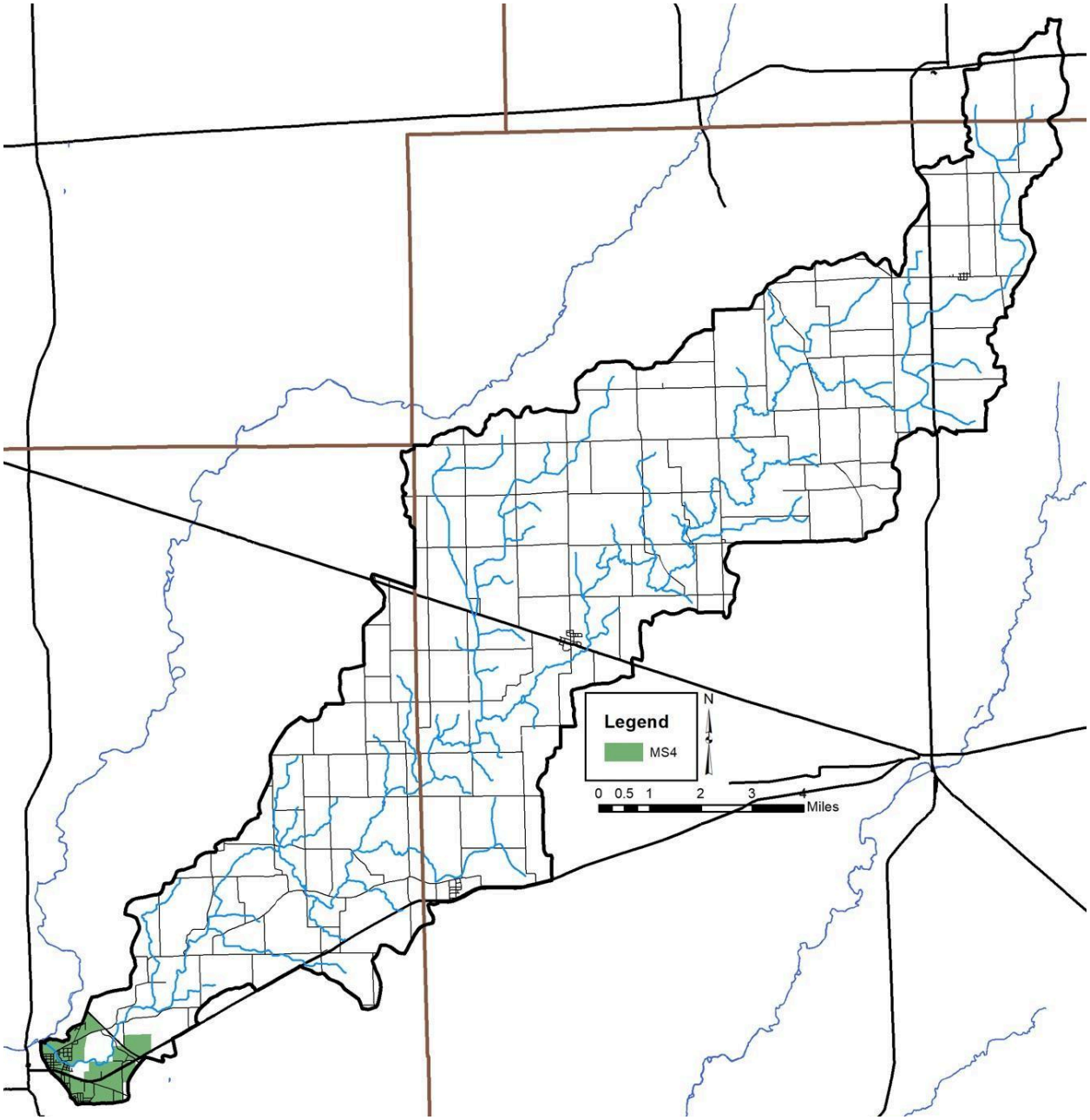

Figure 17. Shelbyville MS4 boundaries within the Little Blue River Watershed.

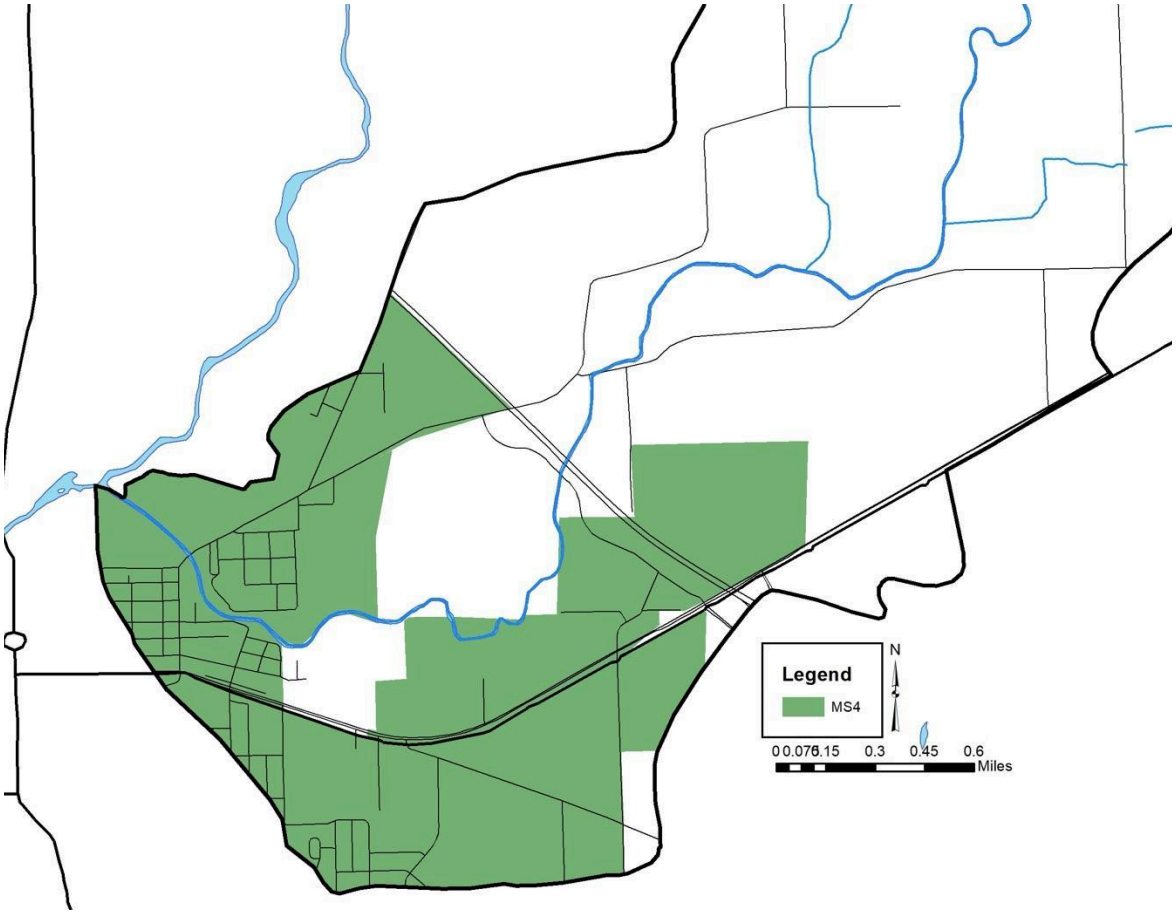

Figure 18. MS4 boundary for the City of Shelbyville.

2.7.6 Groundwater

The city of Shelbyville provides its residents with drinking water from groundwater treated through the Indiana American Water company.

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

The Little Blue River Watershed lies within the Central Till Plain natural region (Homoya et al., 1985). This is the largest natural region in Indiana and is a formerly forested plain of Wisconsinan till in the central area of the state. It is a relatively topographically homogeneous region, although there are several glacial features, including moraines, that are common. The Little Blue River Watershed falls within the Tipton Till Plain Section of the Central Till Plain. The Tipton Till Plain is characterized by loamy and limy Wisconsinan till from glacial deposits. The soil in this section is predominantly neutral silt and silty clay loams of the Crosby-Brookston Association. The Little Blue River Watershed exists within the Eastern Corn Belt Plains Ecoregion (Omernik and Gallant). Originally, natural tree cover

within this ecoregion was extensive. Beech forests were common on Wisconsinan soils while both beech forests and elm-ash swamp forests were associated with wetter pre-Wisconsinan soils. Today, extensive agricultural and livestock production occurs on the land. The Little Blue River Watershed lies mostly within the Loamy, High Lime Till Plains and Whitewater Interlobate Area ecoregions of the Eastern Corn Belt Plains. The Loamy, High Lime Till Plains ecoregion covers the very eastern edge of the watershed and contains soils that developed from glacial deposits of Wisconsinan age. Beech forests, oak-sugar maple forests, and elm-ash swamp forests once grew on the nearly level terrain. Today, corn, soybean, and livestock production is common. The Whitewater Interlobate Area ecoregion has distinctive cool water with coarse-bottomed streams that support fauna absent or uncommon in other ecoregions of the Eastern Corn Belt Plains. Dolomitic drift and meltwater deposits are common and overlie limestone, calcareous shale, and dolomitic mudstone in this ecoregion.

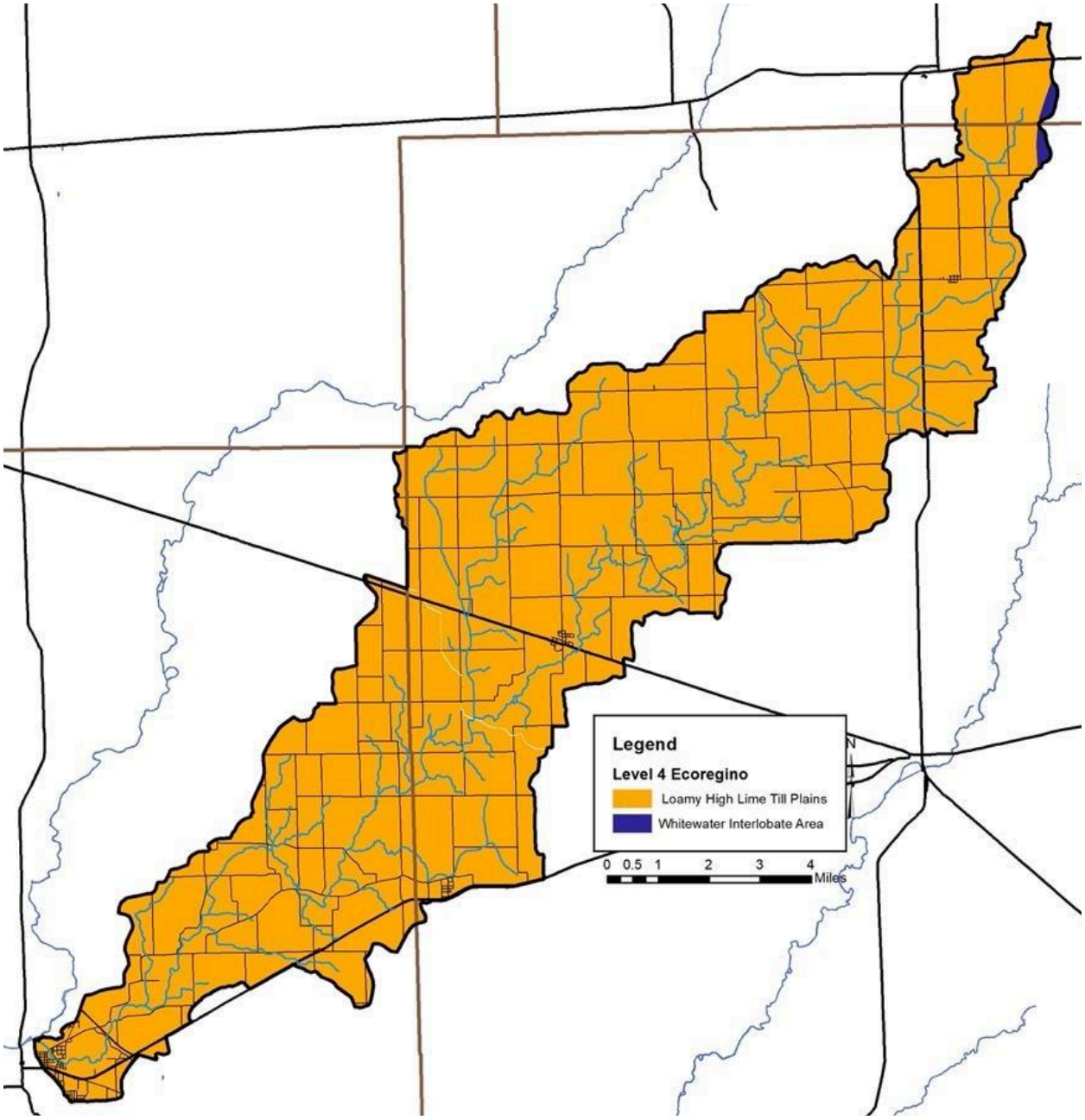

Figure 19. Level III eco-regions in the Little Blue River Watershed.

2.8.2 Wildlife Populations and Pets

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 5 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 5. Surrogate estimates of wildlife density in the IDNR southeast region, which includes the Little Blue River 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.

The Little Blue River Watershed, once covered in forest, now consists primarily of agricultural fields, rural residences, and small towns. The wildlife population within the watershed is consistent with the available, modern landscape. The largest predators in the area are foxes and coyotes. As noted above, deer, raccoon, opossum, rabbit, muskrat, beaver and other mammals, reptiles, amphibians, and birds inhabit the Little Blue River Watershed. During the 2022 season, IDNR estimated 42 square miles of deer habitat in Rush County with approximately 480 deer mortalities (IDNR, 2022). Wildlife and pet populations may impact pathogen and nutrient levels within the watershed.

Pet populations can affect pathogen levels similarly to the impacts provided by wildlife. While count of pets for the Little Blue River Watershed was not completed, dog and cat populations were estimated for the watershed using statistics reported in the 2012 U.S. Pet Ownership & Demographics Sourcebook. Specifically, the Sourcebook reports that on average 37.4 percent of households own dogs and 32.9 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of *E. coli* in population centers. The estimated number of domestic pets in the Little Blue River Watershed is based on the average number of pets per household multiplied by the population of the watershed resulting in a suggested population of 1,870 cats and 1,642 dogs. Pet waste issues are more predominant in urban areas such as Shelbyville but are also present in any residential lot.

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, 13 observations of listed species and/or high-quality natural communities occurred within the Little Blue River Watershed (Figure 20). The Indiana Heritage Data provides observations of listed species in the Little Blue River that classify as a state species of special concern including the slippershell mussel (*Alasmidonta viridis*), wavyrayed lampmussel (*Lampsilis fasciola*), Kidneyshell mollusk (*Pytchobranchus fasciolaris*), Purple Lilliput (*Toxolasma lividus*), Rainbow mollusk (*Villosa iris*) and Little Spectaclecase (*Villosa lienosa*). The Clubshell mollusk (*Pleurobema clava*) is listed as state and federally endangered. The bald eagle (*Haliaeetus leucocephalus*) was observed and is listed. The Central Till Plain Flatwoods is listed as a high quality natural community. The Indiana Heritage Data provides observations made within 0.5 miles of the Little Blue River Watershed.

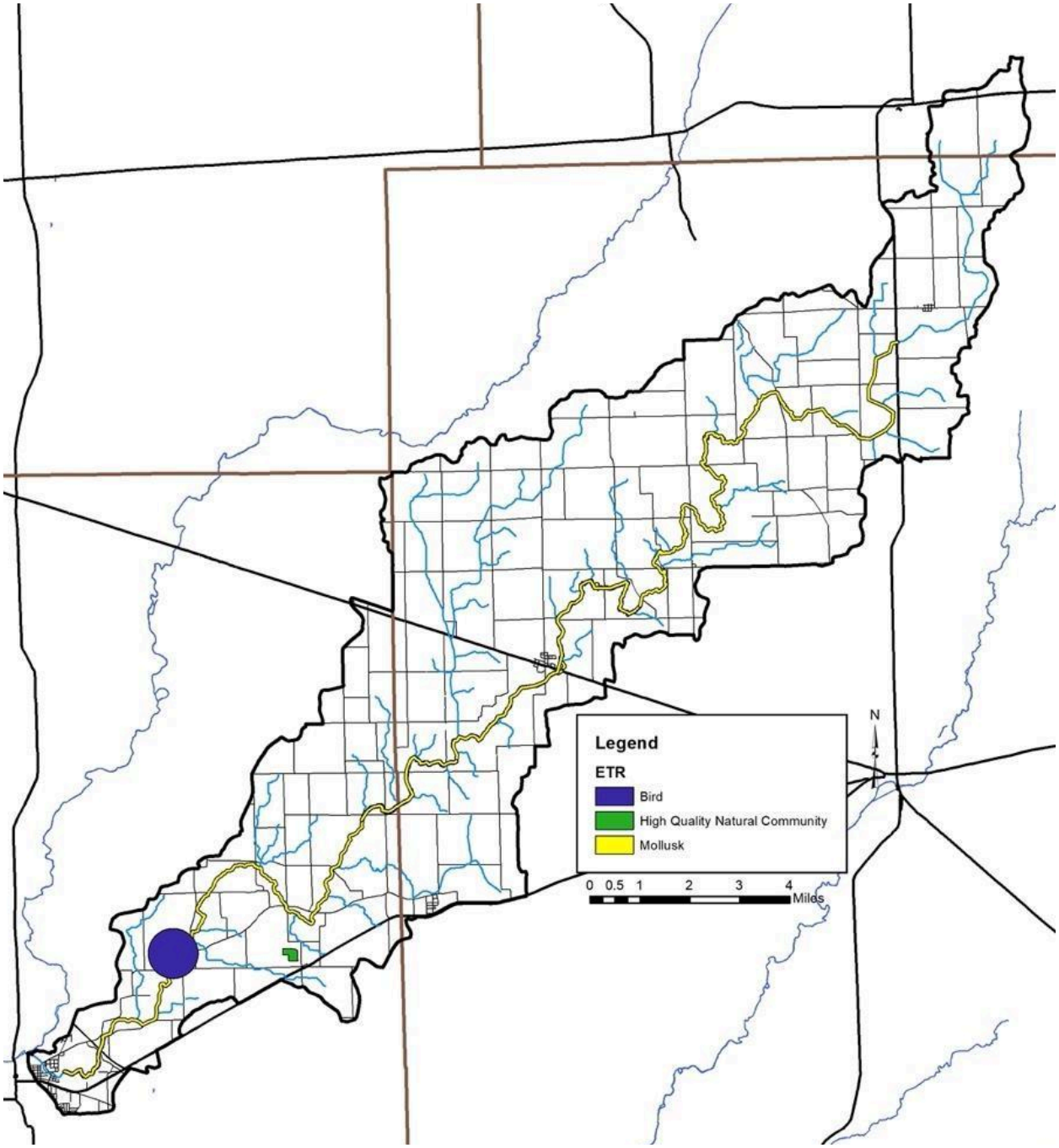

Figure 20. Locations of special species and high quality natural areas observed in the Little Blue River Watershed.

2.8.4 Recreational Resources and Significant Natural Areas

There are 10 recreational resources and natural areas within the Little Blue River Watershed. Recreational opportunities in the watershed include parks, fairgrounds, campgrounds and school grounds. These include four schools, Pitts Ford, Redbud Campground, Blue River Park, Shelby County Fairgrounds, Kennedy Park/Riverside Park, and Manilla Park provide recreational and natural areas within the watershed (Figure 21).

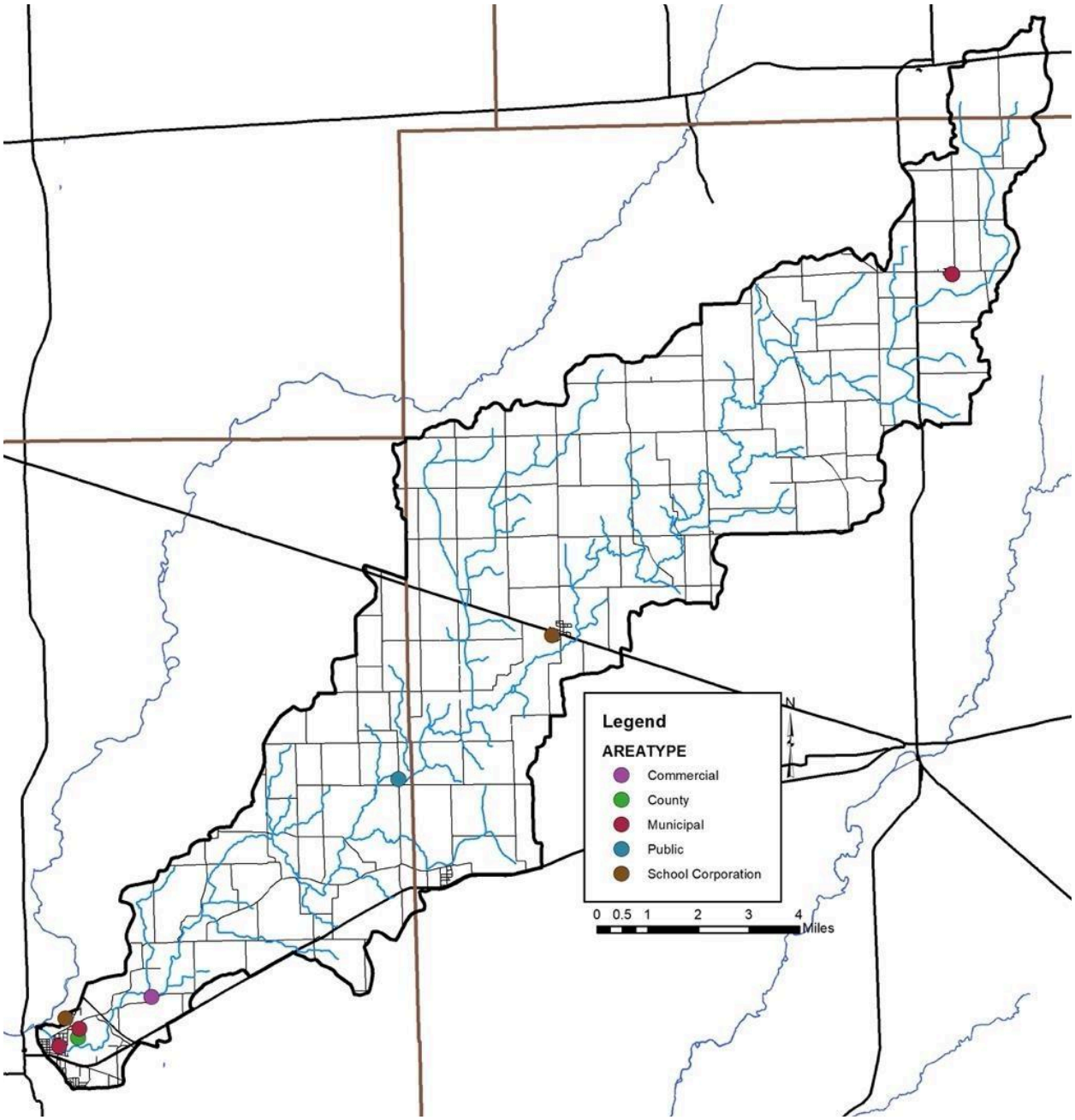

Figure 21. Recreational opportunities and natural areas in the Little Blue River Watershed.

2.9 Land Use

Water quality is greatly influenced by current and past land use. Varying land uses contribute different contaminants to surface waters. As water flows across agricultural lands, pesticides, fertilizers, excessive nutrients, sediment, pathogens, and manure is gathered and transported. However, when water flows across urban settings, it not only gathers and transports 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 Little Blue River Watershed is covered by cultivated crop agriculture (82.5%) with an additional 4.3% covered by pasture (Table 6, Figure 22). Nearly 6% of the watershed is covered by forestland, while nearly 7% is open space or occupied by low, medium, or high intensity developed areas. The remaining small percentage of watershed land use is covered by grassland and open water.

Table 6. Detailed land use in the Little Blue River Watershed.

Classification	Area (acres)	Percent of Watershed
Cultivated crop	55,273.2	82.5%
Deciduous forest	3,541.7	5.3%
Developed open space	3,212.5	4.8%
Pasture/hay	2,872.4	4.3%
Low intensity developed	696.7	1.0%
Woody wetland	545.7	0.8%
Medium intensity developed	324.6	0.5%
High intensity developed	191.4	0.3%
Grassland	159.3	0.2%
Mixed forest	112.4	0.2%
Open water	80.6	0.1%
Emergent wetland	19.0	<0.1%
Shrub/scrub	6.6	<0.1%
Evergreen forest	1.3	<0.1%
Barren land	0.4	<0.1%
Entire Watershed	**67,037.8**	**100.0%**

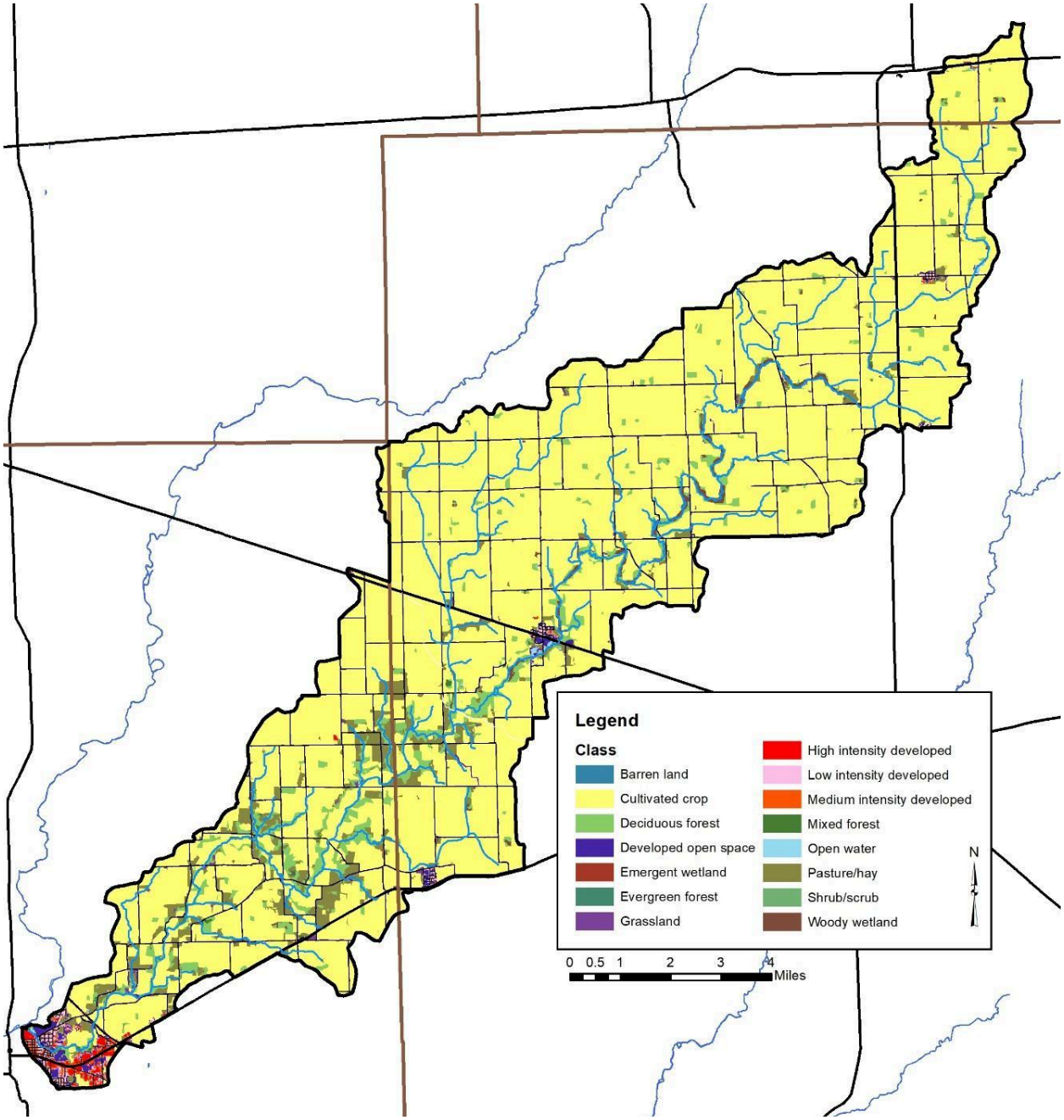

Figure 22. Land use in the Little Blue River Watershed.

2.9.2 Agricultural Land Use

The volume of exposed soil entering adjacent waterbodies, the prevalence of tiled fields and 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 agricultural practices that cause concern to water quality in the watershed.

Tillage Transect

Tillage transect information data for Henry, Rush and Shelby counties was compiled for 2023. 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 7 provides the number of acres and percent of acres on which conservation tillage was utilized for each county by corn and soybeans.

Table 7. Conservation tillage data as identified by county tillage transect data for corn and soybeans (ISDA, 2023, NASS, 2022).

County	Corn (acres)	Corn (%)	Soybeans (acres)	Soybeans (%)
Henry	65,585	65%	78,307	83%
Rush	48,660	78%	78,739	58%
Shelby	92,250	78%	95,653	72%

Agricultural Input 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, 2021). These data indicate that corn (262,529 acres planted in Henry, Rush and Shelby counties) and soybeans (299,706.15 acres planted in Henry, Rush and Shelby 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 93% 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 19,348 tons of nitrogen and 9,571 tons of phosphorus are applied annually within the counties in which the Little Blue River Watershed is located (Table 8).

Table 8. Agricultural nutrient usage for corn in the Little Blue River Watershed counties.

Nutrient	Acres of Corn	% of Area Applied	Applications (#/year)	Rate/Application (lb/acre)	Total Applied/Year (tons)
Nitrogen	262,529	100	2.2	67	19,348
Phosphorus	262,529	93	1.4	56	9,571

Source: NASS, 2007; NASS, 2021

Pesticides are also used on crops grown in Indiana. The Office of the Indiana State Chemist indicates that the two predominant herbicide active ingredients applied are atrazine and glyphosate. Atrazine is most commonly applied as a corn herbicide, while glyphosate is used on both corn and soybean fields as an herbicide. NASS indicates that in 2005, an average of 1.24 pounds of atrazine and 0.6 pounds of glyphosate were applied per acre of corn, and 0.73 pounds of glyphosate were applied per acre of soybeans (NASS, 2006). Using these rates, we estimated that approximately 163 tons of atrazine and 79 tons of glyphosate are applied to corn and approximately 153 tons of glyphosate are applied to soybeans in the Little Blue River Watershed counties annually (Table 9).

Table 9. Agricultural herbicide usage in the Little Blue River Watershed counties.

Crop	Acres	Application Rate (lb/acre)	Total Applied (lbs)	Total Applied/Year (tons)
Corn (Atrazine)	206,495	1.24	530,381	265
Corn (Glyphosate)	206,495	0.6	256,636	128
Soybeans (Glyphosate)	252,699	0.73	306,681	153

Source: NASS, 2006; NASS, 2022

Confined Feeding Operations and Hobby Farms

A mixture of small, unregulated and larger, regulated livestock operations are found within the Little Blue River Watershed. Small farms are those that house less than 300 animals, while large farms that house large numbers of animals longer than 45 days per year are regulated by IDEM as confined feeding operations (CFO) or concentrated animal feeding operations (CAFO). Regulations are based on the number and type of animal(s) present. IDEM requires permit applications that document animal housing, manure storage and disposal, and nutrient management plans for farms that maintain 300 or more cattle, 600 or more swine, or 30,000 or more poultry. These facilities are considered confined feeding operations (CFO). IDEM identifies a concentrated animal feeding operation (CAFO) as a farm that meets or exceeds an animal threshold number in the U.S. Environmental Protection Agency's (EPA) definition, which is 700 mature dairy cows, 1,000 veal calves, 1,000 cattle other than mature dairy cows, 2,500 swine above 55 pounds, 10,000 swine less than 55 pounds, 500 horses, 10,000 sheep or lambs, 55,000 turkeys, 30,000 laying hens or broilers with a liquid manure handling system, 125,000 broilers with a solid manure handling system, 82,000 laying hens with a solid manure handling system, 30,000 ducks with a solid manure handling system or 5,000 ducks with a liquid manure handling system.

In total, 70 small, unregulated animal farms containing nearly 800 animals were observed during the windshield survey, likely an underestimated amount to the true number. These hobby farms contain numbers of cattle (597), horses (51), goats (48), swine (6), and sheep (79) that could provide sources of nutrients and *E. coli* within the watershed, as some animals have access to water within the watershed. Additionally, two CFOs and three CAFOs are located in the Little Blue River Watershed. These facilities are permitted to house up to 18,560 swine. These facilities generate approximately 879,497 of manure per year spread over the watershed. This volume of manure contains approximately 1,792,716 pounds of nitrogen, 1,299,378 pounds of phosphorus and $3.17X10^{17}$ colonies of *E. coli*.

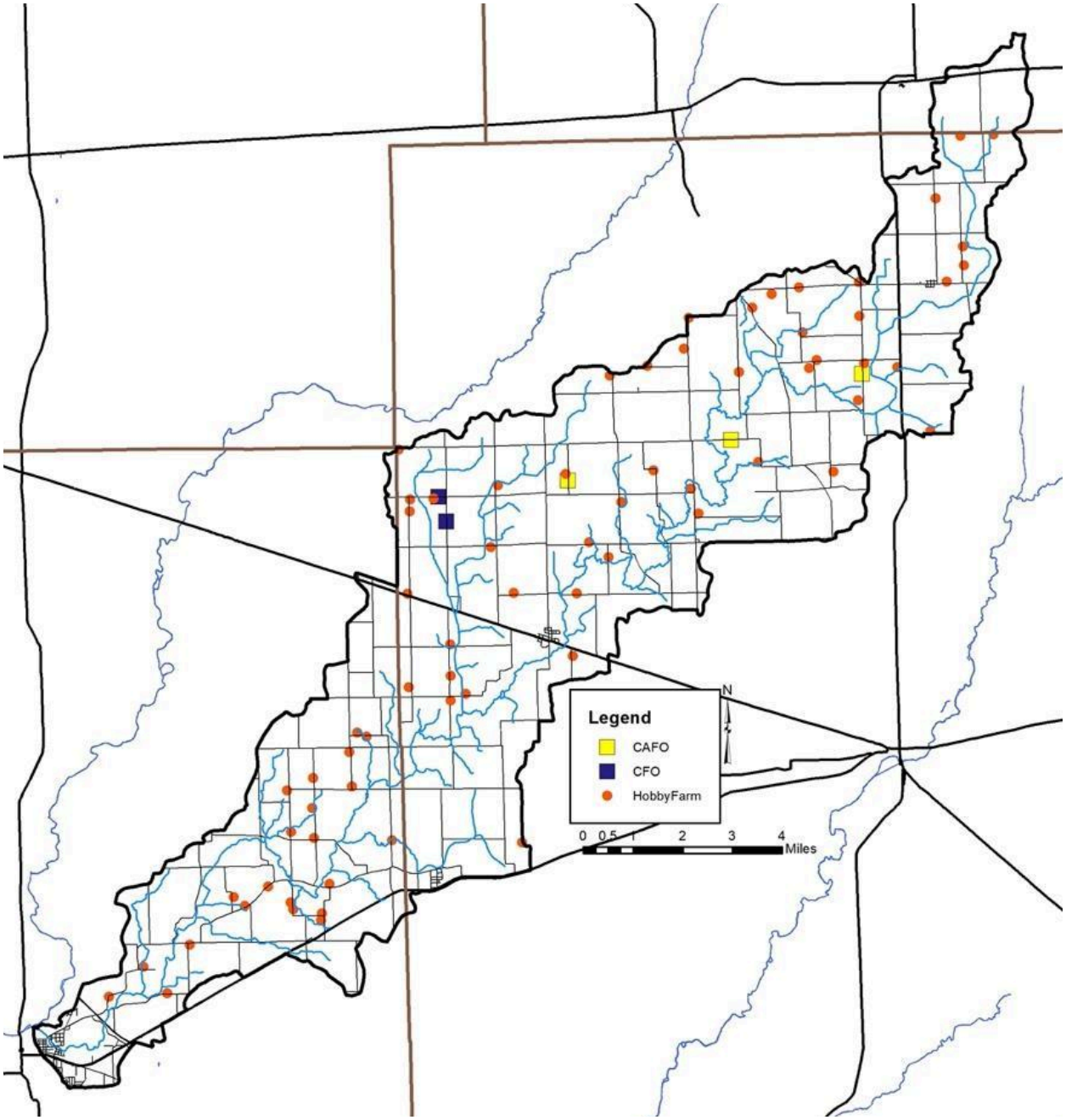

Figure 23. Confined feeding operations and hobby farm locations within the Little Blue River Watershed.

2.9.3 Natural Land Use

Natural land uses including forests, wetlands, and open water cover approximately 7% of the watershed. Nearly 6% of the watershed is covered by forests. Forested lands are dispersed throughout the watershed (Figure 22).

2.9.4 Urban Land Use

Urban land uses cover nearly 7% of the watershed. Most of the urban areas lie within or near the city of Shelbyville, but some forms of development occur in small rural towns of the watershed. Although this

is only a small portion of the watershed, there are some significant issues related to the developed areas. Especially troublesome are issues related to failing septic systems, impervious surfaces, flooding, and stormwater runoff that allow untreated sewage and stormwater to flow into the watershed during heavy rain events.

2.9.5 Remediation Sites

Remediation sites including industrial waste, leaking underground storage tanks, open dumps and brownfields are present throughout the Little Blue River Watershed (Figure 24). Most of these sites are located within the developed areas of the watershed including Shelbyville, but some sites are dispersed throughout the watershed. In total, 12 leaking underground storage tanks, one voluntary remediation program, one open dump, four industrial wastes, one corrective action and one brownfield are present within the Little Blue River Watershed.

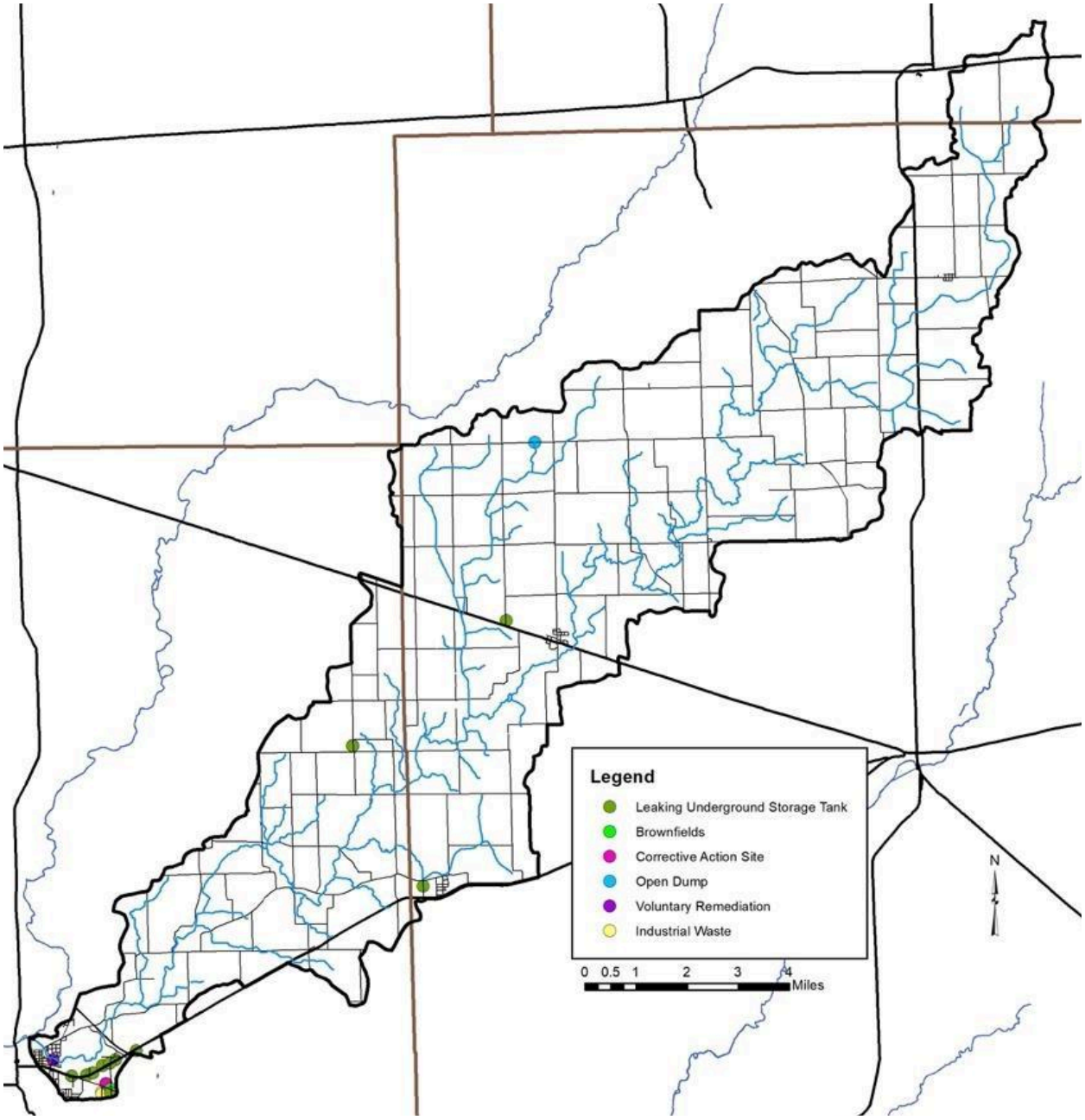

Figure 24. Industrial remediation and waste sites within the Little Blue River Watershed.

2.10 Population Trends

The northern portion of the Little Blue River Watershed is relatively sparsely populated while the southern portion and areas surrounding Shelbyville have the greater population density. One city, Shelbyville, and several towns, including Mays, Arlington and Manilla in Rush County and Rays Crossing in Shelby County, 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. Estimates of the population of the watershed are derived by calculating the percentage of the watershed within a county and extrapolating from county-wide data. The Little Blue River Watershed lies within three counties: Henry, Rush and Shelby. It drains 0.7% of Henry County, 17.9% of Rush

County, and 7.1% of Shelby County. Population trends for these counties derived from the most recently completed census (2020) are shown in Table 10, while Table 11 displays estimated populations for the portion of each county located within the watershed (StatsIndiana, 2020). These data indicate a decrease in two of the three counties (Henry and Rush Counties) located within the watershed over the past decade.

Table 10. County demographics for counties within the Little Blue River Watershed.

County	Area (acres)	Population (2020)	Population Growth (2010-2020)	Pop. Density (#/sq. mi)
Henry	250,803	48,914	-548	124.8
Rush	261,197	16,752	-640	41.0
Shelby	263,136	45,055	+619	109.6

Table 11. Estimated watershed demographics for the Little Blue River Watershed.

County	Acres of County in Watershed	Percent of County in Watershed	Population
Henry	1,762	0.7%	343.6
Rush	46,694	17.9%	2,994.7
Shelby	18,602	7.1%	3,185.1
Total Estimated Population			6,523.5

2.11 Planning Efforts in the Watershed

Little Blue River Watershed Diagnostic Study (2004)

The Little Blue River Diagnostic Study is a comprehensive examination of the Little Blue River and its surrounding watershed. In 2003, with funding from the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) Program, the Shelby County Soil and Water Conservation district hired the team of Indiana University and JFNew to conduct the study. The purpose of the study was to describe the historical and existing condition of the Little Blue River Watershed, identify potential problems, and make prioritized recommendations addressing the issues documented throughout the study. The study included a review of historical studies, several mapping exercises, an aerial and windshield tour of the watershed, and assessment of chemical, biological, and physical stream health, and interviews with watershed residents and representatives from local and state agencies.

Over 200 land treatment or restoration projects were recommended to reduce soil erosion and improve the biological, chemical, and physical condition of streams throughout the study area. Recommendations created by Indiana University and JFNew included:

- Livestock fencing
- Filter strip installation
- Wetland restoration
- Buffer zone establishment
- Bank stabilization
- Revegetation of exposed areas and
- Grassed waterway construction and maintenance.
- Additionally, nitrate-nitrogen and *E. coli* concentration reduction, nutrient and pesticide management, Conservation Reserve Program enrollment, coordination with the County

Drainage Board, Management at the watershed level, and public education and outreach were recommended.

Little Blue River Watershed Management Plan (2007)

The Little Blue River Watershed Steering Committee met during 2006 to study and identify primary water quality issues in the watershed. Based on the information gathered through the Little Blue River LARE-funded diagnostic study conducted in 2004, the following issues emerged:

- *E. coli* levels exceed the Indiana standard at most testing sites.
- Nitrate-nitrogen concentrations regularly exceed recommended target values.
- Sedimentation is a likely contributor to poor substrate quality and embeddedness throughout streams in the watershed.
- In addition to water quality issues, the public is interested in addressing other problems such as logjams, illegal dumping, habitat/wetland degradation, and reduced recreational opportunities.

The steering committee believes that water quality can be improved in portions of the Little Blue River as follows:

1. Promoting public awareness and understanding of local water resources.
2. Reducing nonpoint source runoff from urban sites involving construction, unprotected stream banks, fertilizer application, and impervious surfaces.
3. Increasing implementation of beneficial agricultural management practices such as conservation tillage, nutrient/pest management planning, filter strip installation, stream bank stabilization, and livestock exclusion.
4. Eliminating concentrated sources of E coli contamination from failing or poorly maintained septic systems, manure runoff, livestock access to streams, and nuisance wildlife.
5. Encouraging the establishment of riparian buffers along the river's mainstem segments and contributing tributaries.

The committee outlined the following goals for water quality improvement in the watershed:

- By the end of 2020, reduce E coli bacteria levels to the state standard of 235 colonies/100 mL in the Little Blue River Watershed while using volunteer monitoring and lab testing to verify the improvement and identify possible sources of contamination.
- By the end of 2020, reduce nitrate-nitrogen concentrations in the Little Blue River Watershed to the target value of 0.63 mg/L while using volunteer monitoring to determine concentrations.
- By the end of 2020, reduce turbidity levels in the Little Blue River Watershed to the target value of 9.89 NTU while using volunteer monitoring and visual observation to determine NTU levels, substrate quality, and erosion issues and targeted sub watersheds.
- Cultivate citizen interest and leadership in conservation and natural resources by educating children and adults through increased hands-on learning opportunities, information brochures, workshops, and service opportunities.

To ensure long term results, the watershed project developed strategies to ensure that efforts will provide long term water quality improvement as well as increased public awareness of water quality issues. Those strategies include:

1. Distribute copies of the watershed management plan to city and county plan commissions, county commissioners, county surveyors, drainage boards, mayors, health departments and other interested officials. The county commissioners and mayors and Rush and Shelby counties were to be personally briefed on the goals of the management plan and how activities to implement the goals benefit the community.

2. Post sections of the management plan on the Shelby County SWCD website and link them to other appropriate sites.
3. Purchase a nonpoint source pollution Enviroscape model as money becomes available, then offer it to educators throughout Rush and Shelby counties including SWCDs, Purdue Extension, schools, clubs, scouts, 4-H and other interested parties.
4. The Watershed project will seek additional funding to implement the Little Blue River Watershed Management Plan until water quality goals are met.
5. Permanent educational signs will be placed at demonstration sites to explain the benefits of BMPs that are installed.
6. Volunteer water quality monitoring will continue utilizing current volunteers and recruiting new ones annually.

During the process of management planning, the steering committee recognized the financial necessity for implementation. The committee applied for a grant through the LARE program to the IDNR, and an award of $35,000 was made for three priority tributaries subwatersheds: Little Gilson Creek, Cotton Run and Rays Crossing. In May of 2007, the project received a grant from the American Water Company to partner with the USGS, Knauf Fiberglass, and Shelbyville MS4 to install a permanent water quality monitoring probe and flow-gage at Kennedy Park in Shelbyville. And in 2008, the project received implementation grant funds via the IDEM Section 319 program.

Rush County Comprehensive Plan (2014)
The 2014 City of Rushville Comprehensive Plan states the key points of Natural Resources and Recreation in the watershed are:

- Limit drainage impacts associated with new development and help preserve and protect natural features.
- Protection of existing natural resources
- Protect remaining woodlands and wetlands along the Flat Rock River
- Preserve farmland by restricting development

Rush County is heavily dominated by farmland that could be converted to urban area over time, but care is being taken to make sure that that resource is not lost to industrialization.

Shelby County Comprehensive Plan (2018)
Shelby County's most recently available comprehensive plan is dated 2006—the county has plans to revise the plan in the 2018 year to revisit areas of concern and work to continue progress; however, a final plan has not been issued as of this draft of the plan. The six goals outlined in this plan are:

- Protect Area Floodways and Floodplains:
- Promote the Protection of Wetlands
- Eliminate Potentially Hazardous Septic Systems
- Support Wellhead Protection Practices
- Promote Countywide Storm Water Management
- Seek opportunities to establish regional detention facilities

The action steps to serve as back up to these goals are:

- Adopt a Wellhead Protection Ordinance
- Improve Understanding of the Local Environment
- Buffer Development
- Establish Best Management Practices

- Promote Appropriate Erosion Control Practices.
- Improve Performance of Septic Systems
- Participate in Regional Environmental Efforts

Shelby County has recognized the need for management of riparian areas and overall improved care for the Big Blue River, one of the county's largest assets. The comprehensive planning committee has highlighted the need to provide the river a buffer from development and to monitor farming practices (fertilizer and chemical runoff) in the surrounding areas.

The City of Shelbyville has put a great amount of effort into revitalizing the downtown area and attracting additional visitors with events including "First Fridays", farmers markets and lengthening/beautifying the Blue River Memorial Trail which borders the Blue River for a large portion of its length. The Big Blue River is only a few steps from the downtown Shelbyville area and the city is working to make the Riverfront District a well-known and maintained area; this has brought a great amount of attention to the cleanliness and overall appeal of the Big Blue River.

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

Soils have the greatest effect on the hydrology and septic suitability in the Little Blue River Watershed. While areas of gentle rolling hills do exist in the Little Blue River—the topography's effect on the other factors is minimal in comparison to the soils. In total, 62% of the land area in the Little Blue River is considered highly erosive, or is especially susceptible to erosion, which can lead to increased sedimentation and contamination (not necessarily in the same areas). Tillage, livestock, septic systems, and drainage all have direct impacts on water quality with deposition of sediment, nutrients and bacteria and can all be directly tied to the relationship amongst soils, topography, and hydrology.

Most of the soils in the watershed are rated somewhat limited or very limited for septic system suitability. Most homes in the watershed are not in a sewer system—they are operating on septic systems for waste water. Failing or improperly functioning septic systems can be large contributors to degrading water quality as leaching may occur and feed into adjacent waterways or directly contaminate through groundwater. Septic system maintenance, education, and remediation are stakeholder concerns.

2.12.2 Land Use and Planning Efforts

The vast majority of land use in the Little Blue River Watershed is agricultural; conservation tillage or no-till practices are being more widely implemented and have a positive impact on the Little Blue River watershed by reducing nutrient and sediment loads. The Indiana Conservation Partnership is active in each of counties of the Little Blue watershed and is working to educate landowners/producers on the implementation of best management practices to protect natural resources. Adoption of soil health management systems is rapidly becoming more predominant than conventional farming practices—this is a direct positive effect on water quality, soil degradation, and reductions in soil loss.

Planning efforts, according to most recently available comprehensive plans, do not indicate any major changes to land use in the foreseeable future—agriculture is highlighted as the major industry in each

plan. Counties and cities are recognizing the rising need to preserve natural resources and are making appropriate plans to address existing resource concerns as well as help to prevent future degradation.

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 Little Blue River Watershed.

3.1 Water Quality Targets

Many of the historic water quality assessments occurred using different techniques or goals. Several sites were sampled only one time and for a limited number of parameters. Monitoring committee members were reluctant to draw too many conclusions based on a single sampling event. Nonetheless, the available data are detailed below and compared in general with water quality targets. In order to compare the results of these assessments, the steering committee identified a standard suite of parameters and parameter benchmarks. Table 12 details the selected parameters and the benchmark utilized to evaluate collected water quality data.

Table 12. 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	Indiana Administrative Code
pH	>6 or <9	Indiana Administrative Code
Temperature	Monthly standard	Indiana Administrative Code
Conductivity	<1050 mmhos/cm	Indiana Administrative Code
E. coli	<235 colonies/100 mL	Indiana Administrative Code
Nitrate-nitrogen	<1.0 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 Little Blue River Watershed (Figure 25). Statewide assessments and listings include the impaired waterbodies assessment and fish consumption advisories. Additionally, the Indiana Department of Environmental Management (IDEM), JFNew via the Indiana DNR Lake and River Enhancement Program (LARE) and U.S. Geological Survey (USGS) have completed assessments within the watershed. Volunteer based sampling of water quality through the Hoosier Riverwatch program also provides water quality data that can characterize the watershed. A summary of each assessment methodology and general results are discussed below.

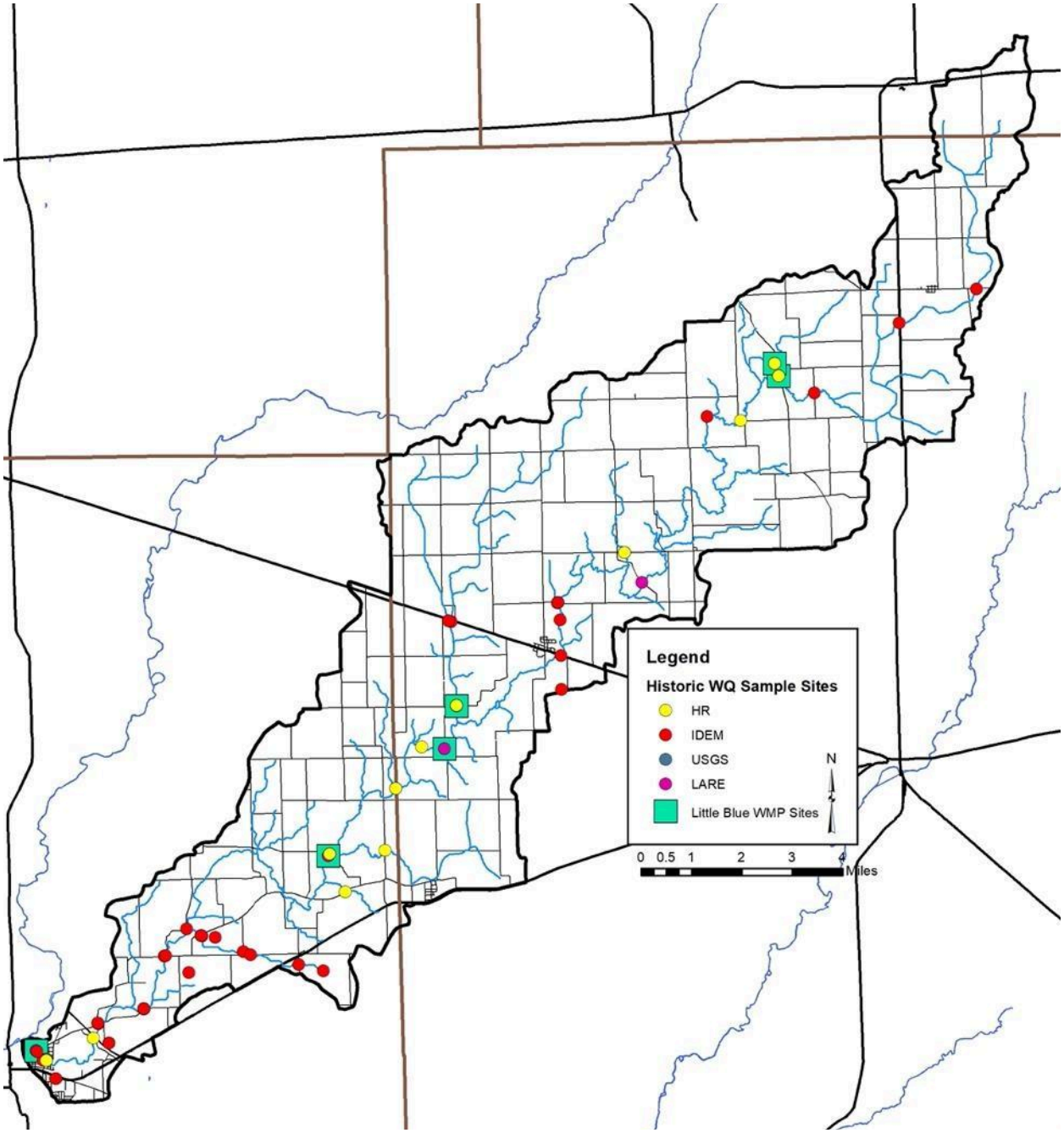

Figure 25. Historic water quality assessment locations.

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. In total, 24 stream segments in the Little Blue River Watershed are included on the list of impaired waterbodies. Table 13 details the listings in the watershed while Figure 26 maps the segments and their locations within the watershed. Waterbodies are listed as impaired for *E. coli* (124.6 miles), dissolved oxygen (52.3 miles) and impaired biotic communities (52.3 miles).

Table 13. Impaired waterbodies in the Little Blue River Watershed.

Stream Segment	Segment ID	Impairment
Little Blue River	INW0421_02	*E. coli*, dissolved oxygen, IBC
Little Blue River	INW0421_03	*E. coli*, dissolved oxygen, IBC
Little Blue River	INW0423_02	*E. coli*, dissolved oxygen, IBC
Beaver Meadow Creek	INW0422_02	*E. coli*
Beaver Meadow Creek	INW0422_03	*E. coli*
Linn Creek	INW0422_T1001	*E. coli*
Gilson Creek – Unnamed Tributary	INW0423_T1001A	*E. coli*
Gilson Creek	INW0423_T1002	*E. coli*
Little Blue River	INW0423_03	*E. coli*, dissolved oxygen, IBC
Little Blue River	INW0423_04	*E. coli*, dissolved oxygen, IBC
Little Blue River	INW0423_05	*E. coli*, dissolved oxygen, IBC
Little Blue River	INW0423_06	*E. coli*, dissolved oxygen, IBC
Little Blue River	INW0423_07	*E. coli*, dissolved oxygen, IBC
Newhouse Ditch	INW0423_T1003	*E. coli*, dissolved oxygen, IBC
Little Blue River	INW0423_T1004	*E. coli*, dissolved oxygen, IBC
Farmers Stream	INW0423_T1005	*E. coli*, dissolved oxygen, IBC
Little Blue River	INW0424_01	*E. coli*
Cotton Run	INW0424_T1001	*E. coli*
Manilla Branch	INW0424_T1002	*E. coli*
Little Blue River	INW0425_02	*E. coli*
Little Blue River	INW0425_03	*E. coli*
Little Blue River – Unnamed Tributary	INW0425_T1001	*E. coli*
Little Blue River - Unnamed Tributary	INW0425_T1002	*E. coli*
Little Blue River – Unnamed Tributary	INW0425_T1003	*E. coli*

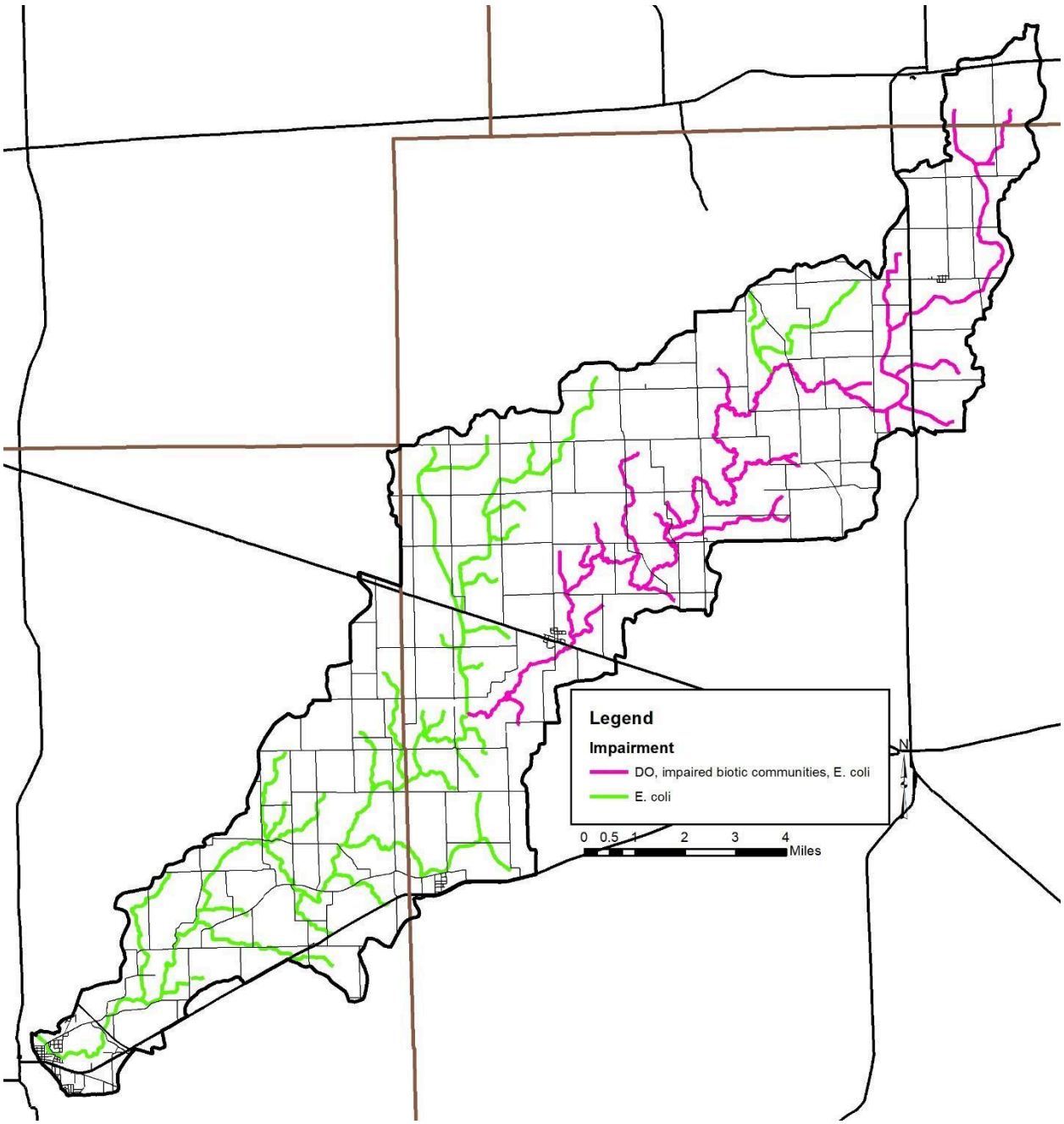

Figure 26. Impaired waterbody locations in the Little Blue River Watershed.

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 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.

There are no specific listings for the Little Blue River. However, based on county listings, the following conclusions can be drawn:
Sensitive populations should follow the statewide safe eating guidelines which include not consuming:

- Buffalo species up to 23 inches in size more than once per week and once per month for 23+ inches.
- All sizes of bullhead species more than once per week.
- Carpsucker species up to 16 inches in size more than once per week and once per month for 16+ inches.
- Channel catfish up to 21 inches in size more than once per week and once per month for 21+ inches.
- Common carp up to 20 inches in size more than once per week, once per month for 20-30 inches, and never for 30+ inches.
- Crappie species of all sizes more than once per week.
- Flathead catfish up to 19 inches more than once per week and once per month for 19+ inches.
- Freshwater drum up to 15 inches in size more than once per week and once per month for 15+ inches.
- Largemouth bass up to 16 inches in size more than once per week and once per month for 16+ inches.
- Northern pike up to 30 inches in size more than once per week and once per month for 30+ inches.
- Redhorse species up to 23 inches in size more than once per week and once per month for 23+ inches.
- Rock bass of all sizes more than once per week.
- Sauger up to 14 inches in size more than once per week and once per month for 14+ inches.
- Silver carp more than 24 inches in size more than once per week.
- Smallmouth bass up to 14 inches in size more than once per week and once per month for 14+ inches.
- Spotted bass up to 10 inches in size more than once per week and once per month for 10+ inches.
- Sunfish species of all sizes more than once per week.
- Walleye up to 19 inches in size more than once per week and once per month for 19+ inches.
- White/striped/hybrid bass up to 12 inches in size more than once per week and once per month for 12+ inches.

General populations should not consume:

- Buffalo species up to 27 inches in size more than once per week and once per month for 27+ inches.
- Bullhead species greater than 13 inches more than once per week.
- Carpsucker species up to 16 inches in size more than once per week and once per month for 16+ inches.
- Channel catfish up to 21 inches in size more than once per week and once per month for 21+ inches.

- Common carp up to 20 inches more than once per week, once per month for 20-30 inches, and six times per year for 30+ inches.
- Flathead catfish up to 30 inches in size more than once per week and once per month for 30+ inches.
- Freshwater drum greater than 13 inches more than once per week.
- Largemouth bass of all sizes more than once per week.
- Northern pike of all sizes more than once per week.
- Redhorse species greater than 15 inches more than once per week.
- Rock bass greater than 7 inches more than once per week.
- Sauger up to 20 inches in size more than once per week and once per month for 20+ inches.
- Silver carp greater than 24 inches more than once per week.
- Small mouth bass of all sizes more than once per week.
- Spotted bass of all sizes more than once per week.
- Walleye greater than 16 inches more than once per week.
- White/striped/hybrid bass up to 24 inches in size more than once per week and once per month for 24+ inches.
- The general population may have unrestricted consumption for crappie and sunfish species of all sizes.

3.2.3 U.S. Geological Survey Assessments (2007)

The USGS assessed streams within the Little Blue River Watershed at 2 locations. Based on the assessments, the following conclusions can be drawn:

- Ammonia, Orthophosphorus (OP) and pH measure within standard ranges during all sampling events.
- *E. coli* measured in exceedance for 2 of the 5 (40%) sampling events.

3.2.4 IDEM Rotational Basin Assessments (1993, 1997, 2002, 2004, 2007, 2010, 2013, 2019, 2022)

Between the years of 1993 and 2022, IDEM sampled water chemistry at several locations in the Little Blue River Watershed. Based on the water chemistry assessments, the following conclusions can be drawn:

- Ammonia concentrations exceeded state standards in 20% (1 of 5) of samples collected.
- *E. coli* concentrations exceeded the state standard in 55 of the 106 (52%) samples collected.
- Dissolved oxygen (DO) concentrations exceeded state standards (12 mg/L) in 15 of the 144 (10%) samples collected.
- pH concentrations remained within standard ranges for all 147 samples collected.
- Total Kjeldahl nitrogen (TKN) exceeded in 8 of the 16 (50%) samples collected.
- Total phosphorus (TP) concentrations exceeded target concentrations (0.08 mg/L) in 2 of the 3 (67%) samples collected.
- Total suspended solids (TSS) concentrations exceeded water quality targets (15 mg/L) in 5 of the 20 (25%) samples collected.
- Turbidity exceeded water quality targets (5.7 NTU) in 55% (76 of 139) of samples collected.

3.2.5 Big Blue River TMDL (2010 and 2013)

Water quality data was collected by IDEM within the Little Blue River Watershed in 2010 and 2013. Target *E. coli* reductions range from 0 to 90%.

Data collected by IDEM and used for TMDL calculation generate the following conclusions:

- An 11% reduction in *E. coli* is required in the Headwaters Little Blue River Subwatershed.

- A 16% reduction in *E. coli* is required in the Beaver Meadow Creek Subwatershed.
- A 0% reduction in *E. coli* is required in the Gilson Creek-Little Blue River Subwatershed.
- A 45% reduction in *E. coli* is required in the Manilla Branch-Little Blue River Subwatershed.
- A 72% reduction in *E. coli* is required in the Town of Rays-Crossing Subwatershed.

IDEM recommended addressing the following contributing sources:

- Wastewater treatment plants, livestock access to streams, wildlife access to streams, and onsite wastewater/unsewered areas.
- The above areas as well as impervious surfaces, tile drained agricultural fields, and riparian areas during dry conditions.
- The above areas as well as field drainage and upland stormwater issues during mid-range flows.
- The above as well as natural condition field drainage and bank erosion during moist conditions.

The TMDL prioritizes *E. coli* reductions for the Town of Rays Crossing-Little Blue River, Manilla Branch-Little Blue River, Beaver Meadow Creek, Headwaters Little Blue River, and Gilson Creek-Little Blue River Subwatersheds in that order.

3.2.6 Indiana DNR, Lake and River Enhancement Program (2003)

JFNew completed a diagnostic study for the Little Blue River utilizing Indiana Department of Natural Resources (IDNR) Lake and River Enhancement Program funding. JFNew assessed 10 sites for varying parameters within the Little Blue River Watershed. Based on data collected, the following conclusions can be drawn:

- Conductivity and pH remained within standards in all site samples collected.
- DO exceeded in 5% (1 of 20) of samples.
- *E. coli* concentrations exceeded standards in 70% (14 of 20) samples collected.
- Nitrate-nitrogen exceeded target concentrations in 100% of samples collected.
- TKN exceeded in 15% (3 of 20) samples collected.
- TSS exceeded in 25% (5 of 20) samples collected.
- Turbidity levels exceeded targets in 25% (5 of 20) of samples collected.
- TP concentrations exceeded target concentrations in 30% (6 of 20) of samples collected.

3.2.7 Hoosier Riverwatch Sampling (2004, 2006-2010, 2015, 2021)

Between 2004 and 2021, volunteers trained through the Hoosier Riverwatch program assessed 14 sites in the Little Blue River Watershed. Based on data collected, the water chemistry assessments suggest:

- DO exceeded in 1 of 186 (1%) sampling efforts made to measure the parameter.
- *E. coli* concentrations exceeded state standards in 41% (73 of 179) of sampling efforts made to measure the parameter.
- Nitrate-nitrogen exceeded target concentrations in 93% (170 of 182) of sampling efforts made to measure the parameter.
- Orthophosphorus (OP) concentrations exceeded in 6 of 186 (3%) of sampling efforts made to measure the parameter.
- pH did not measure in exceedance in the sampling efforts made to measure the parameter.
- Turbidity levels exceeded targets in 100% of samples collected to measure the parameter.

3.3 Current Water Quality Assessment

3.3.1 Water Quality Sampling Methodologies

The objective of the Quality Assurance Project Plan for the Little Blue River Watershed was to determine what water quality levels were occurring in the Little Blue River and its tributaries throughout the year and identify sources of pollution that may be reduced through implementation of a watershed management plan. Chemical, biological, and physical conditions on the selected streams were assessed. The collection of this data allowed for the identification of problem areas, determination of critical areas, characterization of the watershed, calculation of annual loading rates and laid a foundation for future assessment of implementation and education and outreach successes for Little Blue River. Ultimately, this monitoring program was designed to identify sources of water quality impairment and characterize current conditions within the watershed with the goal of rewriting the Little Blue River Watershed Management Plan. Figure 27 details sites sampled as part of this planning process. Site 6 represent the Headwaters Little Blue River subwatershed, Site 4 represent Beaver Meadow Creek subwatershed, Sites 3 and 5 represent Gilson Creek-Little Blue River subwatershed, Site 2 represents Manilla Branch-Little Blue River subwatershed and Site 1 represents Town of Rays Crossing-Little Blue River subwatershed.

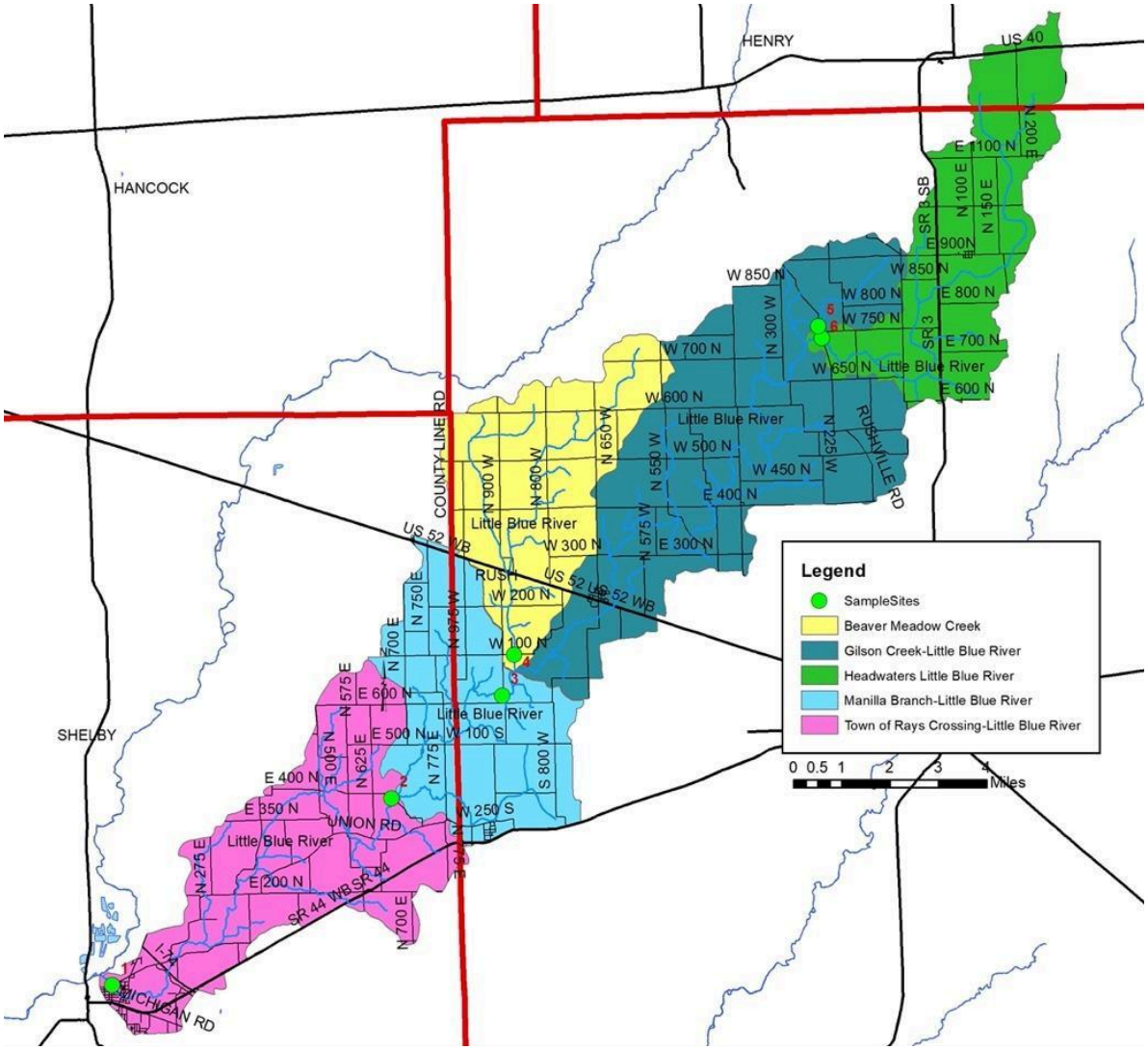

Figure 27. Current sampling sites as part of the Little Blue River Watershed Management Plan.

Stream Flow

Flow was measured for each of the 6 sample sites during each sampling event as possible using an OTT MF Pro. During high flow events when instream measurement was not possible, flow was scaled for each sample site during each sampling event using the Little Blue River USGS gage near Shelbyville (USGS 03361440).

Field and Laboratory Chemistry Parameters

Field and laboratory water chemistry data collection at each site included monitoring for nutrients (nitrate-nitrogen, total phosphorus), *E. coli*, total suspended solids, dissolved oxygen, conductivity, turbidity, temperature, and pH at all sites monitored. Monitoring occurred at 6 stations for one year with samples collected monthly (12 samples). Total phosphorus, total suspended solids and *E. coli* were determined in the laboratory using approved methods. Dissolved oxygen, temperature, conductivity, turbidity, pH (Hydrolab MS5), and nitrate-nitrogen (YSI Pro DSS) were determined on site using handheld probes.

Biological Community and Habitat

Benthic macroinvertebrates (primarily aquatic insect larvae and nymphs) were sampled at each site using the IDEM macroinvertebrate Index of Biotic Integrity methods at the same (6) six monitoring stations once between July and October. Macroinvertebrate samples were preserved in the field using 90% ethanol. Preserved samples were processed, and individuals were identified to the genus level. The macroinvertebrate IBI (mIBI) was calculated using protocols developed for use by the Indiana Department of Environmental Management.

Stream habitat at each site was evaluated using the Qualitative Habitat Evaluation Index (QHEI, Ohio Environmental Protection Agency, 2006). Habitat assessment occurred concurrent with biological sampling.

3.3.2 Field Chemistry Results

Figure 28 to Figure 32 display results for non-nutrient field chemistry data collected monthly at the six 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 28 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 1.7 and 23.3 °C in all streams. The highest temperatures generally occurred during June, July and August assessments depending on riparian cover and stream depth present at each location.

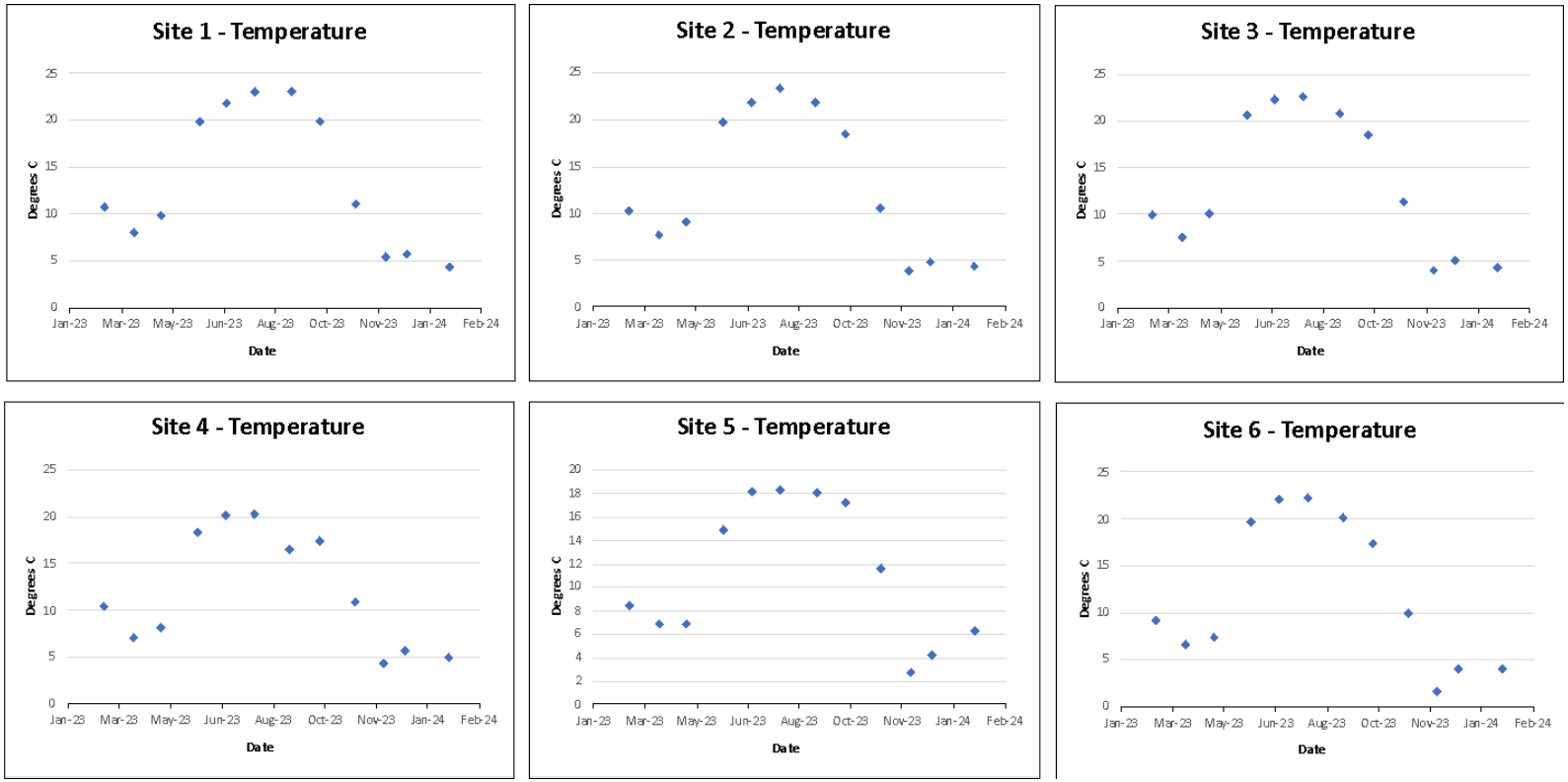

Figure 28. Temperature measurements in Little Blue River Watershed sample sites from February 2023-January 2024. Note differences in scale along the concentration (y) axis.

Dissolved Oxygen

Dissolved oxygen concentrations also display seasonal changes like those observed for temperature. However, as shown in Figure 29, dissolved oxygen concentrations are opposite those measured for temperature. This is as expected as colder water holds more dissolved oxygen than warmer water; therefore, when water temperatures are low, dissolved oxygen concentrations are high and vice-versa. As such, the dissolved oxygen graph shows a general pattern where dissolved oxygen concentrations 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 (Gilson Creek-Little Blue River) during August 2023 measuring 3.7 mg/L. In total, almost 12% of samples (8 of 68) measured below or above the lower and upper dissolved oxygen state standard (4 mg/L and 12 mg/L).

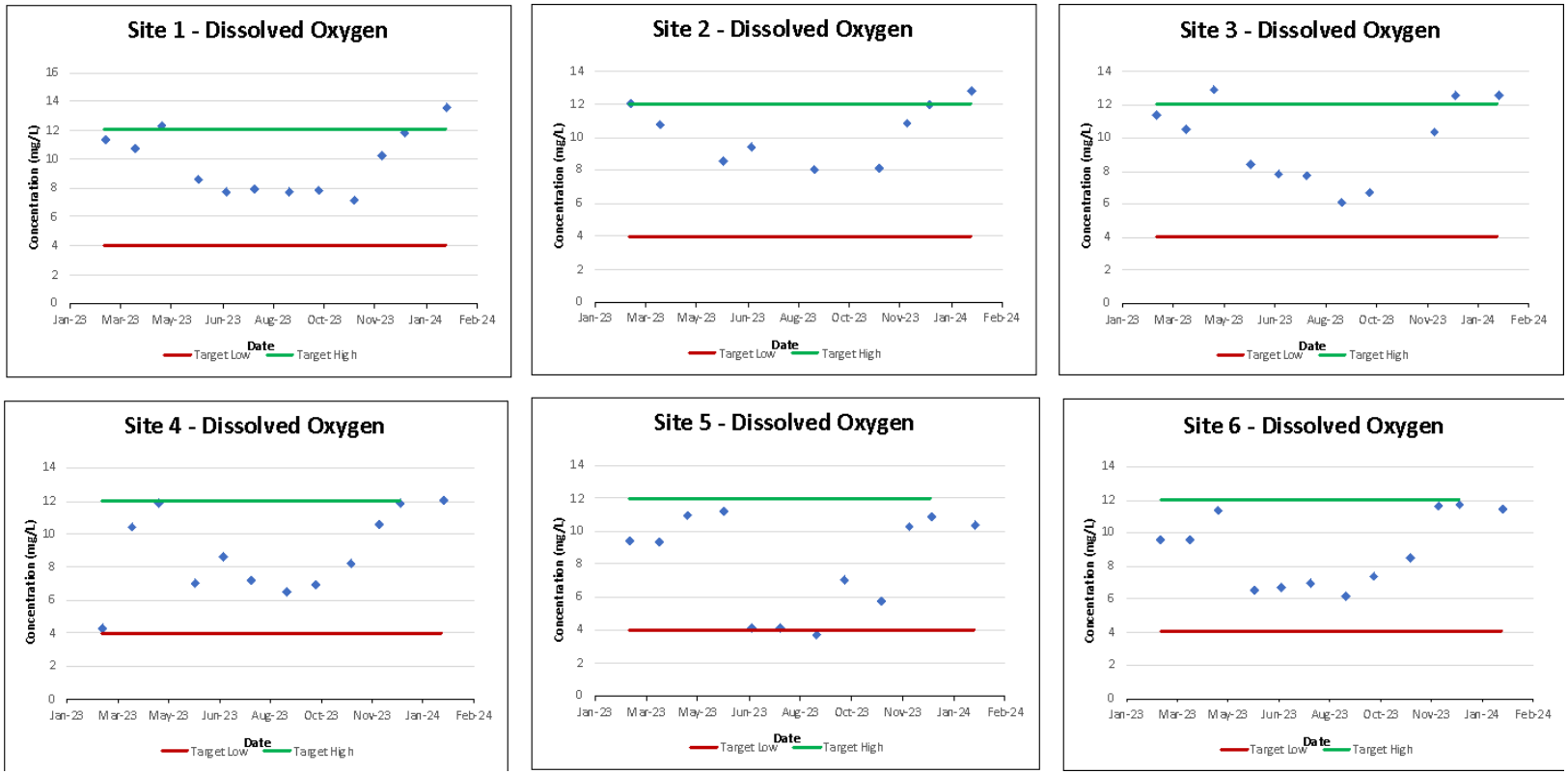

Figure 29. Dissolved oxygen measurements in Little Blue River Watershed sample sites from February 2023-January 2024. Note differences in scale along the concentration (y) axis.

pH

Throughout the sampling period, pH remained in an acceptable range in all watershed streams. Although one site, Site 1 (Little Blue River at Morris Ave), reached the pH state standard of 9.0. No samples were recorded outside of the state standard (6-9). No discernable pattern can be found in pH levels in any of the monitored streams (Figure 30). Elevated pH levels may be due to algal activities.

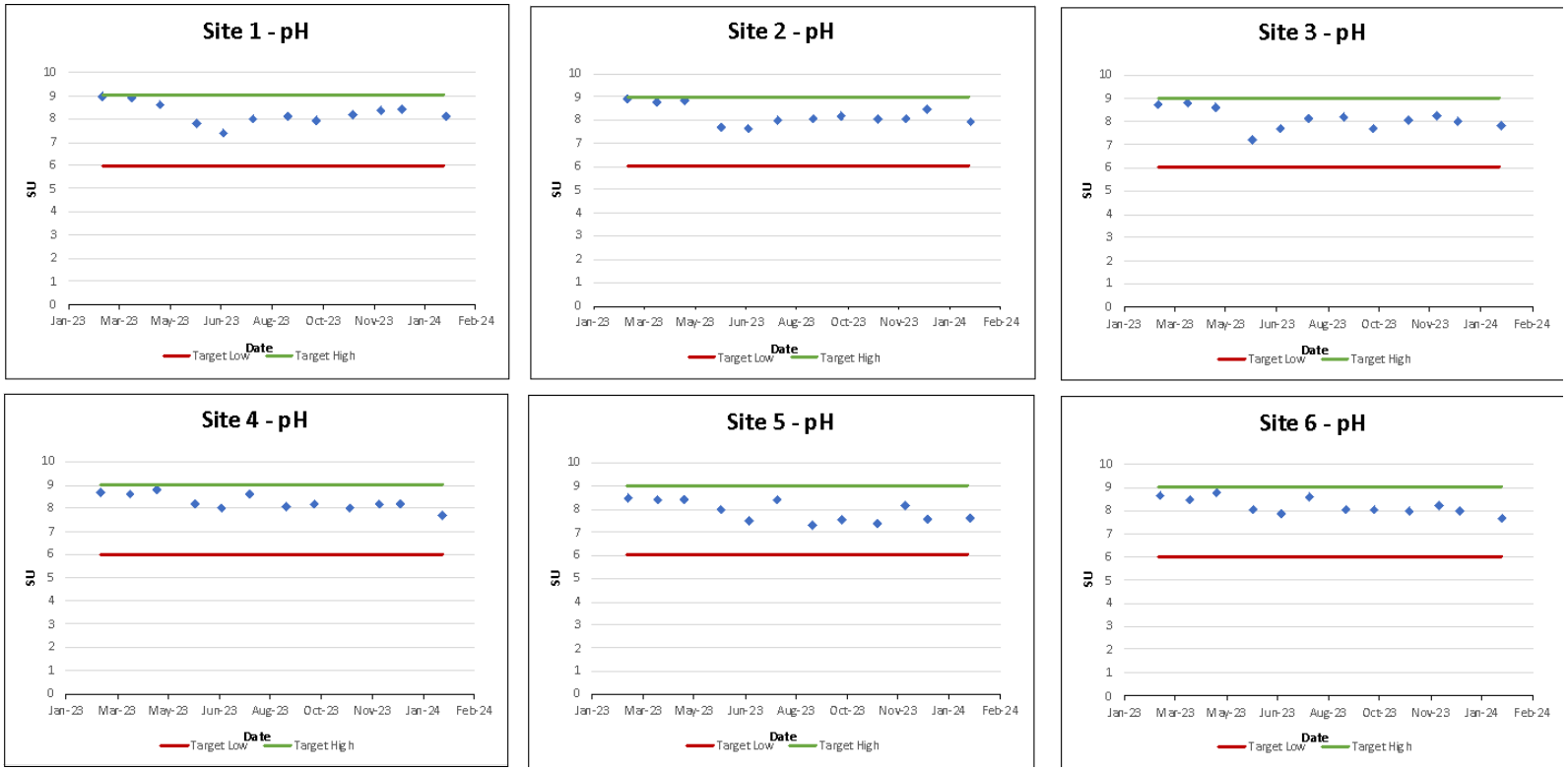

Figure 30. pH measurements in Little Blue River Watershed sample sites from February 2023-January 2024.

Specific Conductivity

Figure 31 displays the conductivity measurements in the watershed streams. Conductivity measurements generally measured within state standards (1060 S/cm) except during four of 72 (5.6%) samples. Site 5 (Gilson Creek-Little Blue River) exceeded conductivity standards three times while Site 6 (Little Blue River at Rushville Road) exceeded once. Conductivity did not exceed state standards at any other site. The greatest conductivity level occurred at Site 5 with a measurement of 1683 mg/L.

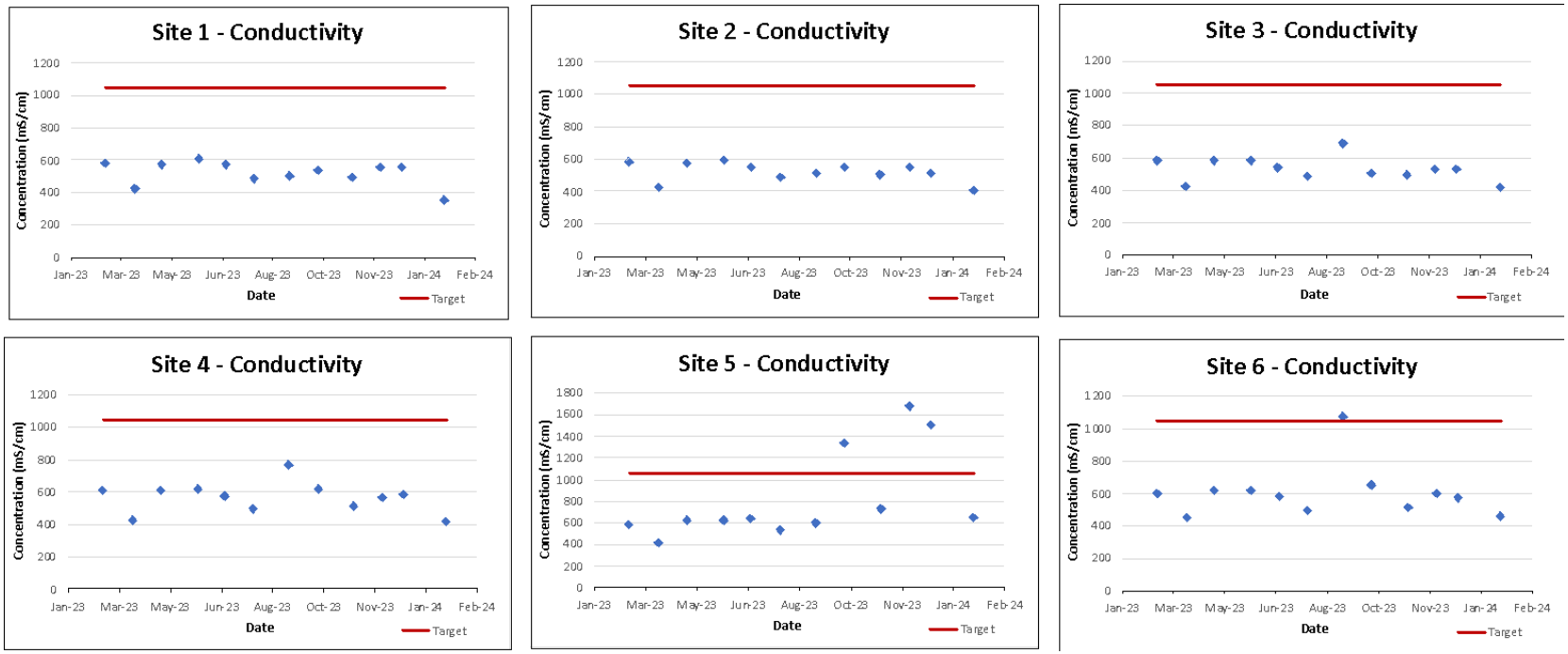

Figure 31. Conductivity measurements in Little Blue River Watershed sample sites from February 2023-January 2024.

Turbidity

Turbidity varied greatly among the six sites but generally exceeded target levels (5.7 NTU). In total, 47 of 72 samples exceeded turbidity targets with 65% of samples exceeding targets during the sampling period. Exceedances occurred at each site. Site 4 (Beaver Meadow Creek) had the most exceedances (nine of 12 samples) followed by Site 1 (Little Blue River at Morris Ave), Site 5 (Gilson Creek-Little Blue River) and Site 6 (Little Blue River at Rushville Road) (eight of 12 samples) and Site 2 (Manilla Branch) and Site 3 (Little Blue River at CR 900 W) (seven of 12 samples). Turbidity measurements were relatively lower during summer months with peak measurements occurring during cooler months. The highest turbidity level occurred at Site 4 with a measurement of 136 NTU.

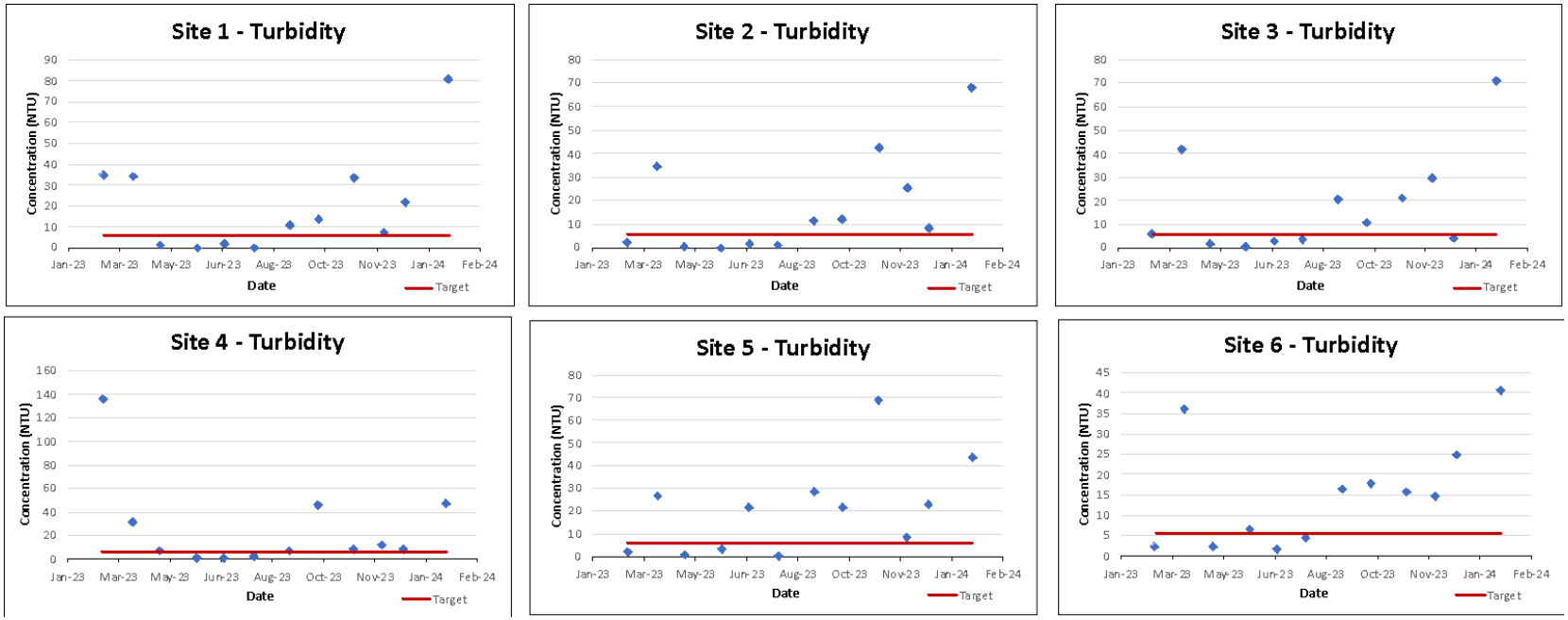

Figure 32. Turbidity measurements in Little Blue River Watershed sample sites from February 2023-January 2024.

3.3.3 Water Chemistry Results

Figure 33 to Figure 36 displays results for nitrate-nitrogen, total phosphorus, total suspended solids, and *E. coli* collected monthly from six locations in the Little Blue River 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 33 displays nitrate-nitrogen concentrations compared to target levels (1 mg/L). As shown below, nitrate-nitrogen concentrations exceeded targets levels in more than half (56%, or 40 of 72) of samples collected. Nitrate-nitrogen concentrations generally measured highest during spring, falling throughout summer, and increasing again in fall. It is important to note; however, Site 5 (Gilson Creek-Little Blue River) exceeded concentration targets during the entire sampling period. Exceedances occurred at each site with Site 5 possessing the highest average exceedance (5.5 mg/L) while Site 6 (Little Blue River at Rushville Road) measured with the lowest average exceedance (1.3 mg/L). Each site's average nitrate-nitrogen concentration level measured higher than target levels of 1 mg/L. The greatest nitrate-nitrogen concentration level occurred at Site 5 with a measurement of 14.7 during the January 2024 sampling period.

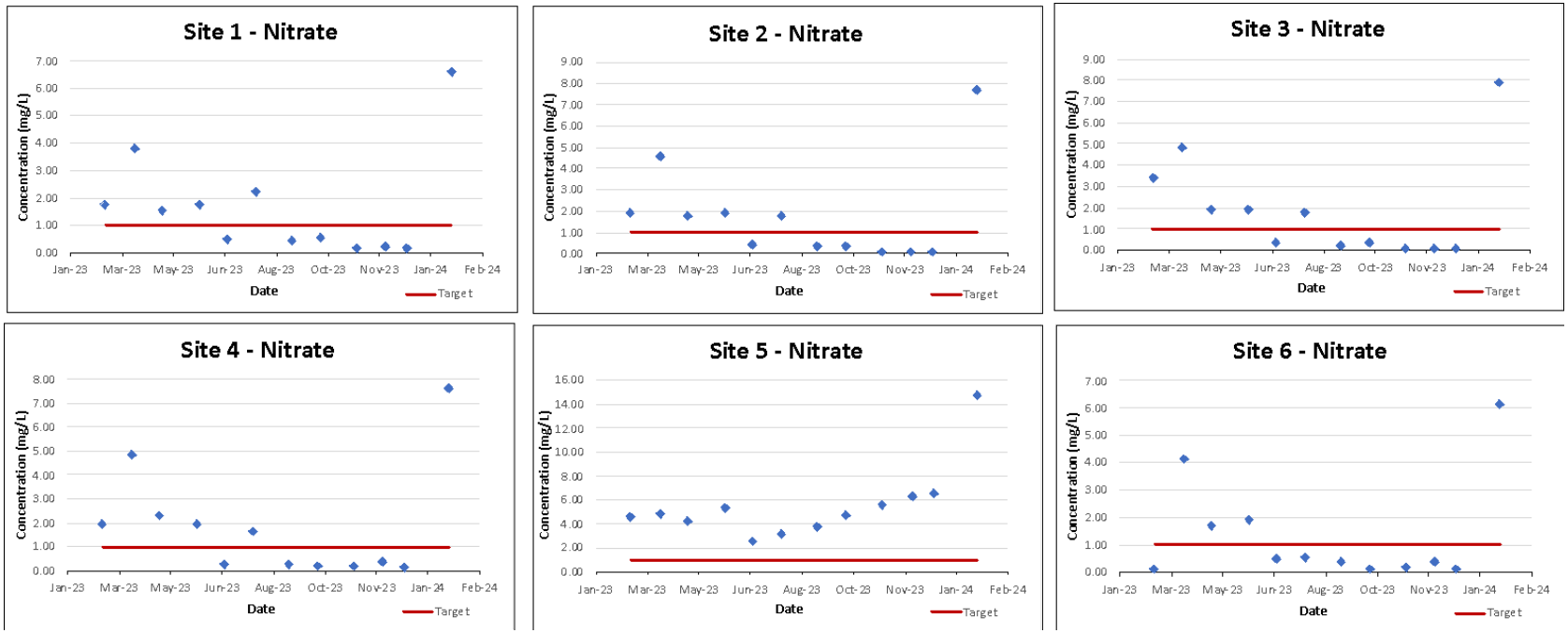

Figure 33. Nitrate-nitrogen measurements in Little Blue River Watershed sample sites from February 2023-January 2024. Note differences in scale along the concentration (y) axis.

Total Phosphorus

Total phosphorus concentrations exceed target concentrations in almost half (48.6%) of samples collected (35 of 72; Figure 34). All sites possess average total phosphorus concentrations in excess of the level at which biological impairments occur (0.08 mg/L). Site 3 (Little Blue River at CR 900 W), Site 5 (Gilson Creek-Little Blue River) and Site 6 (Little Blue River at Rushville Road) possessed the highest average total phosphorus concentrations while Site 1 (Little Blue River at Morris Ave) , Site 2 (Manilla Branch) and Site 4 (Beaver Meadow Creek) had the lowest the average total phosphorus concentrations.

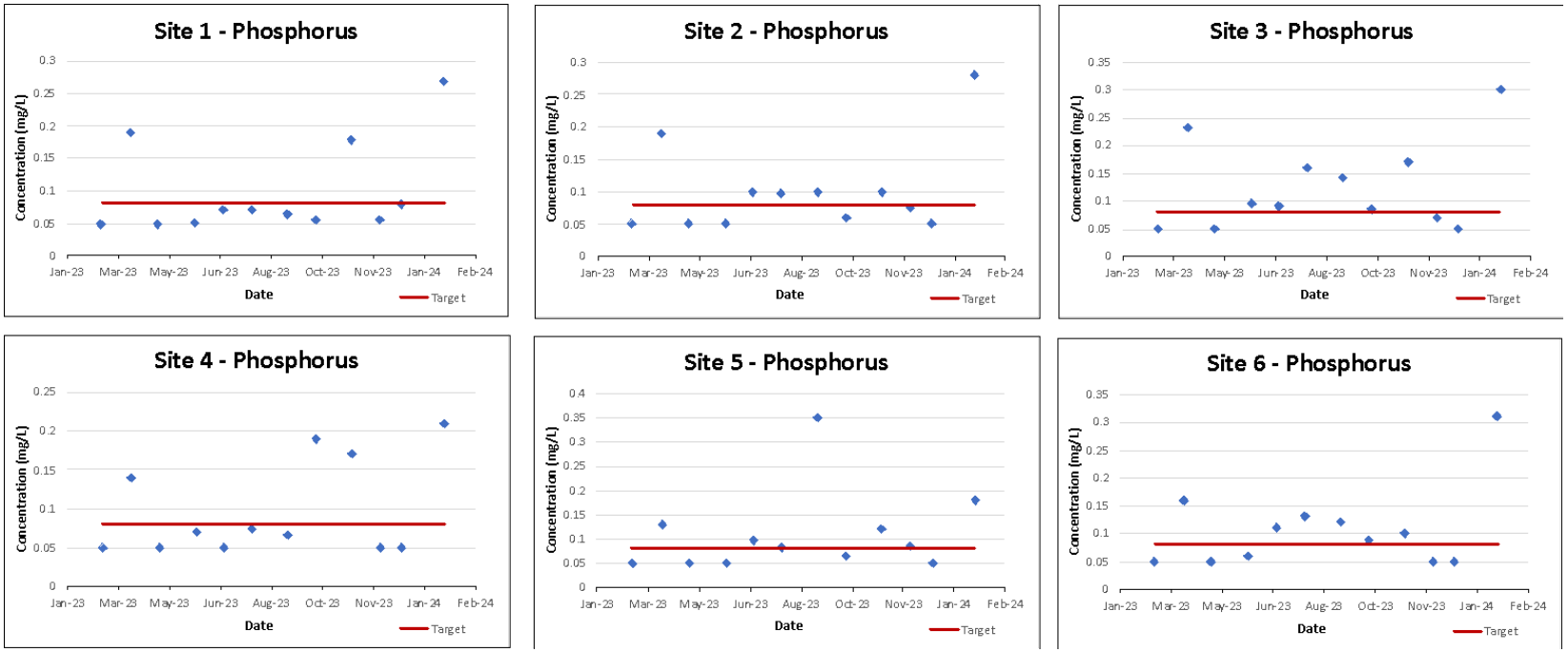

Figure 34. Total phosphorus concentrations measured in Little Blue River Watershed sample sites from February 2023-January 2024. Note differences in scale along the concentration (y) axis.

Total Suspended Solids

Total suspended solids (TSS) levels measured above target levels (15 mg/L) in 21 of 72 (29.2%) samples collected (Figure 35). Exceedances occurred at all sites at least once throughout the sampling period. Only Site 2 (Manilla Branch) and Site 4 (Beaver Meadow Creek) possess average concentrations that measure above target levels. Site 6 (Little Blue River at Rushville Road) had the lowest average concentrations while Site 3 (Little Blue River at CR 900 W) had the lowest number of exceedances. Site 4 had the highest TSS measurement with 106.0 mg/L during the September 2023 sampling event.

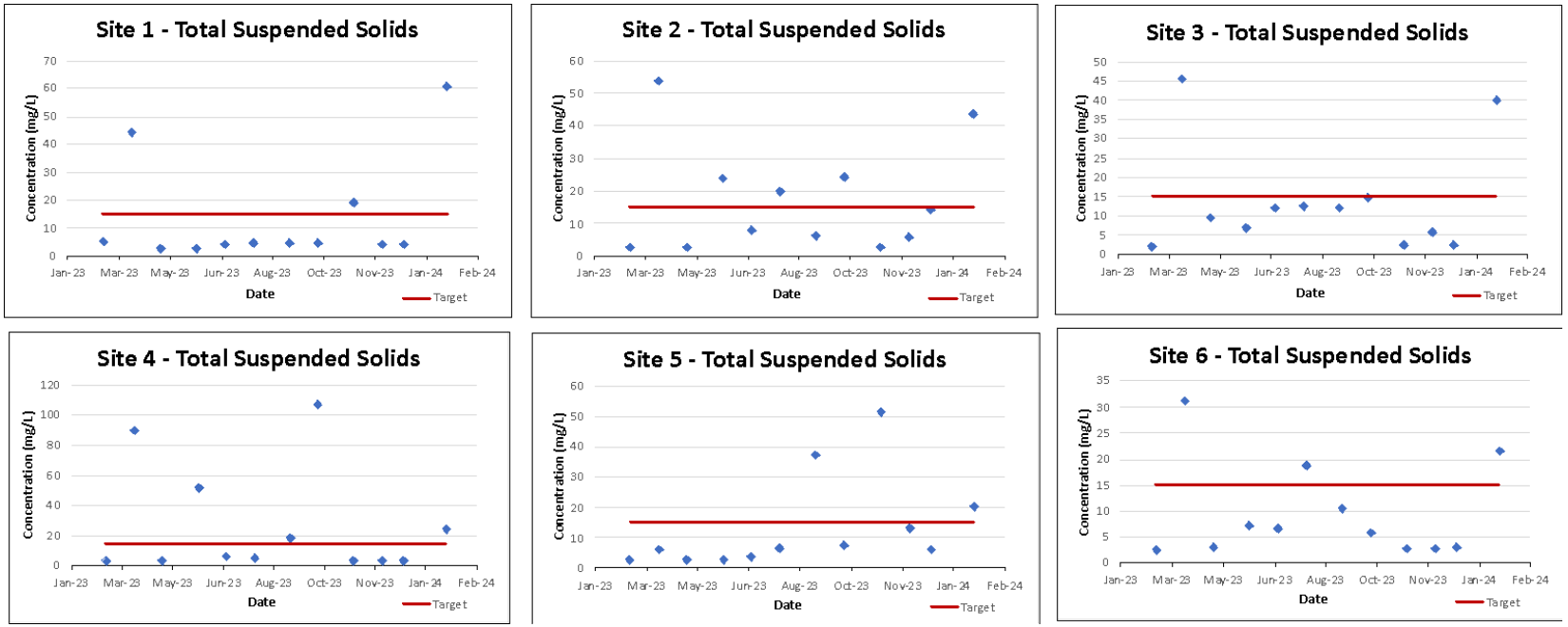

Figure 35. Total suspended solids concentrations measured in Little Blue River Watershed sample sites from February 2023-January 2024. Note differences in scale along the concentration (y) axis.

E. coli

E. coli concentrations observed at Little Blue River Watershed sample sites are shown in Figure 36. *E. coli* concentrations exceed state standards (235 col/100 mL) in 50% of collected samples (36 of 72 samples). Exceedances occurred at all sites in multiple instances. Site 5 (Gilson Creek-Little Blue River) and Site 6 (Little Blue River at Rushville Road) had the highest concentration measured during the July and August 2023 sampling event, respectively, with a level of 1986 col/100 mL. Site 5 and Site 6, along with Site 1 (Little Blue River at Morris Ave), Site 2 (Manilla Branch) and Site 4 (Beaver Meadow Creek), also possessed average *E. coli* concentrations in excess of state standards. Site 3 (Little Blue River at CR 900 W) had the lowest average *E. coli* concentrations while Site 2 had the lowest number of exceedances. *E. coli* exceedances at several sites appear to coincide with elevated flow conditions.

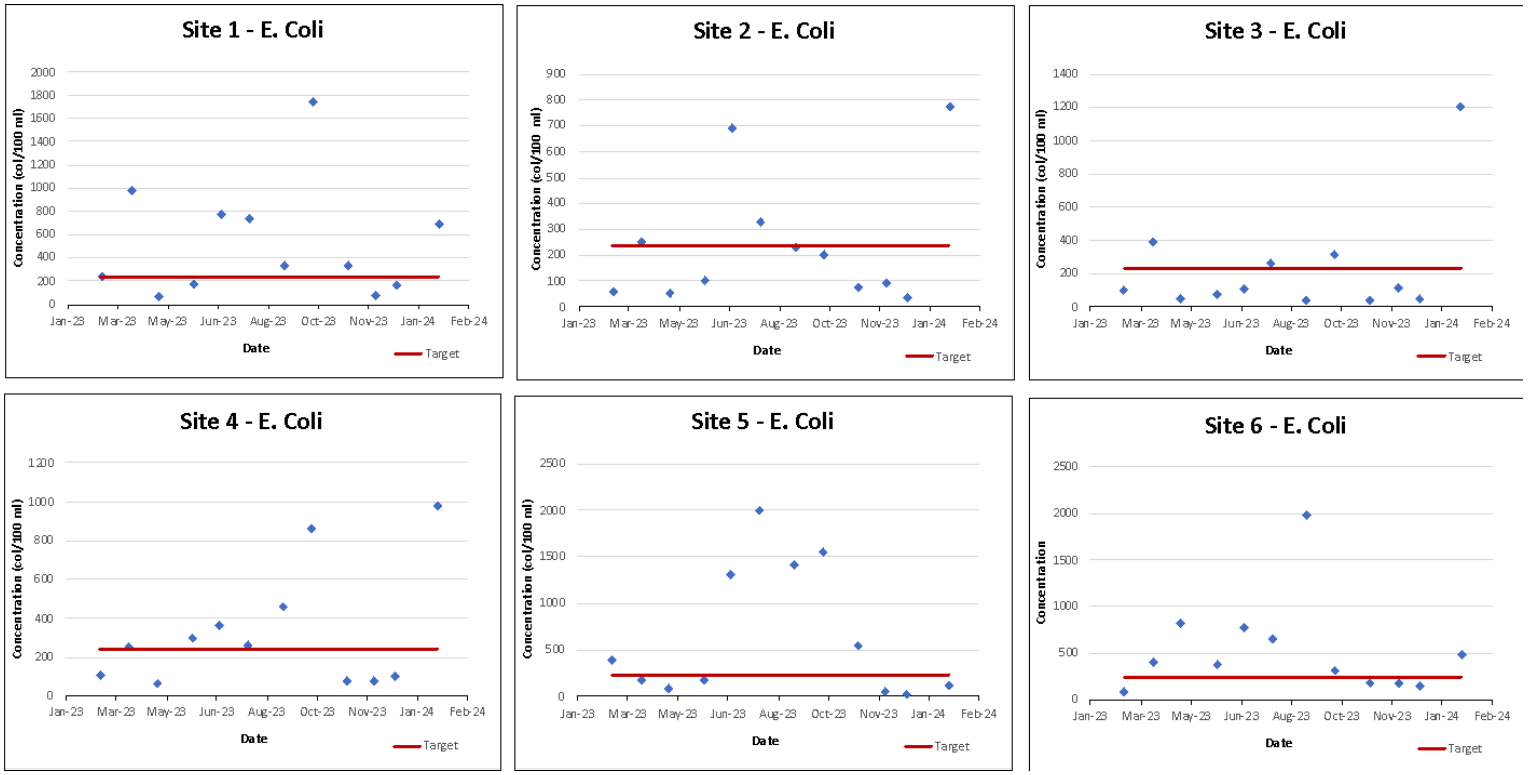

Figure 36. *E. coli* concentrations measured in Little Blue River Watershed sample sites from February 2023-January 2024. Note differences in scale along the concentration (y) axis.

3.3.4 Load Duration Curves

Load duration curves allow 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 six sample sites during the time of study from February 2023 to January 2024. Data used for the curves were calculated by scaling flow measured at Little Blue River at Shelbyville. Stream flow measured at the U.S. Geological Survey gauge was scaled to watershed size for each of the six monitoring stations as follow:

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

The individual load duration curves, also known as the allowable load curves, are displayed below (Figure 37 to Figure 40). In the graphs, the total daily load of each contaminant sample result (points) is plotted against the "percent time 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 with 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 generally measure higher than targets loads at most sites between high and mid-range flow conditions (Figure 37), indicating a steady stream of nitrate-nitrogen is available most during high flow and moist conditions. Nitrate-nitrogen loads measured below target levels mostly during dry or low flow conditions. Site 5 (Gilson Creek-Little Blue River) is the only site that consistently measured above target levels 100% of the time. This indicates there are sources of nitrate-nitrogen to this stream 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.

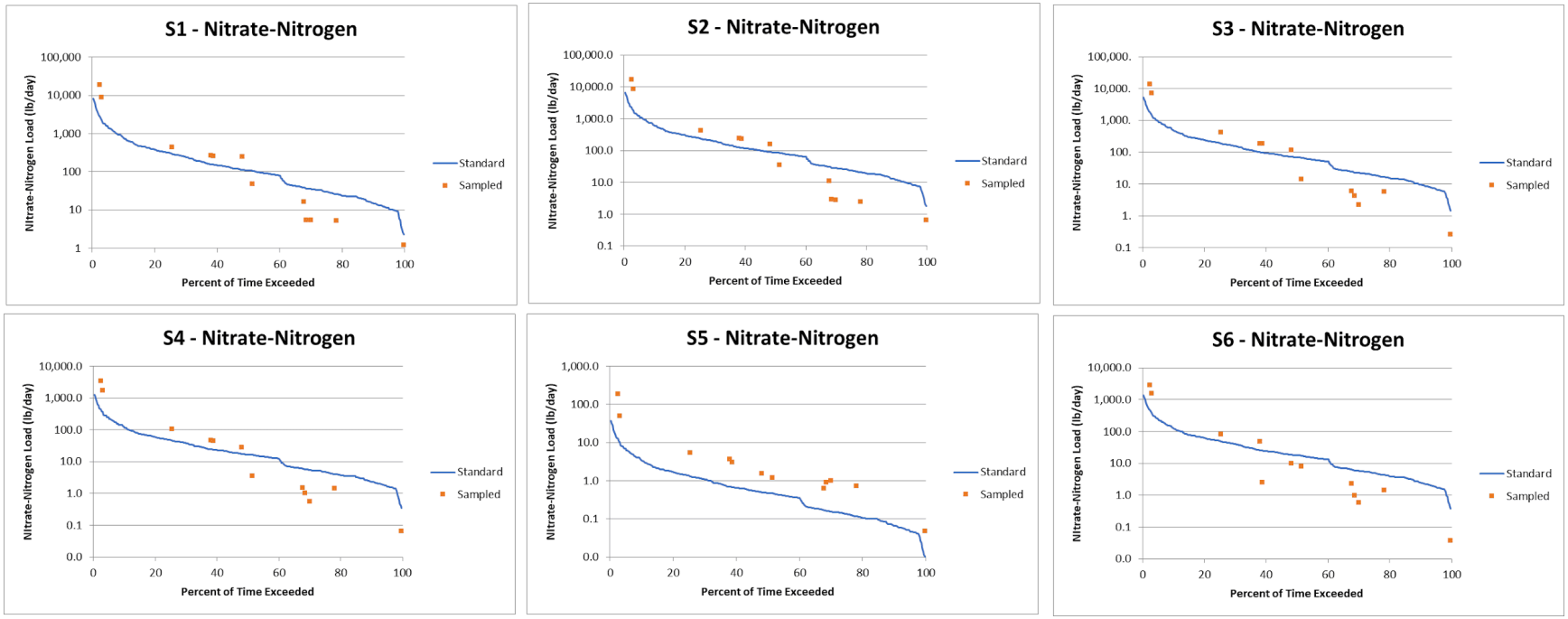

Figure 37. Nitrate-nitrogen load duration curves for Little Blue River Watershed sample sites from February 2023-January 2024.

Total Phosphorus Load Duration Curves

Total phosphorus (TP) levels generally measured below target loads under moist to low flow conditions (Figure 38). TP load levels measured near or above target load levels under high conditions at all sites, suggesting a steady stream of TP is present in much of the Little Blue River Watershed under high flow conditions. Only Site 5 (Gilson Creek-Little Blue River) displayed TP load exceedance under most flow conditions, indicating a relatively steady stream of TP is present for this stream.

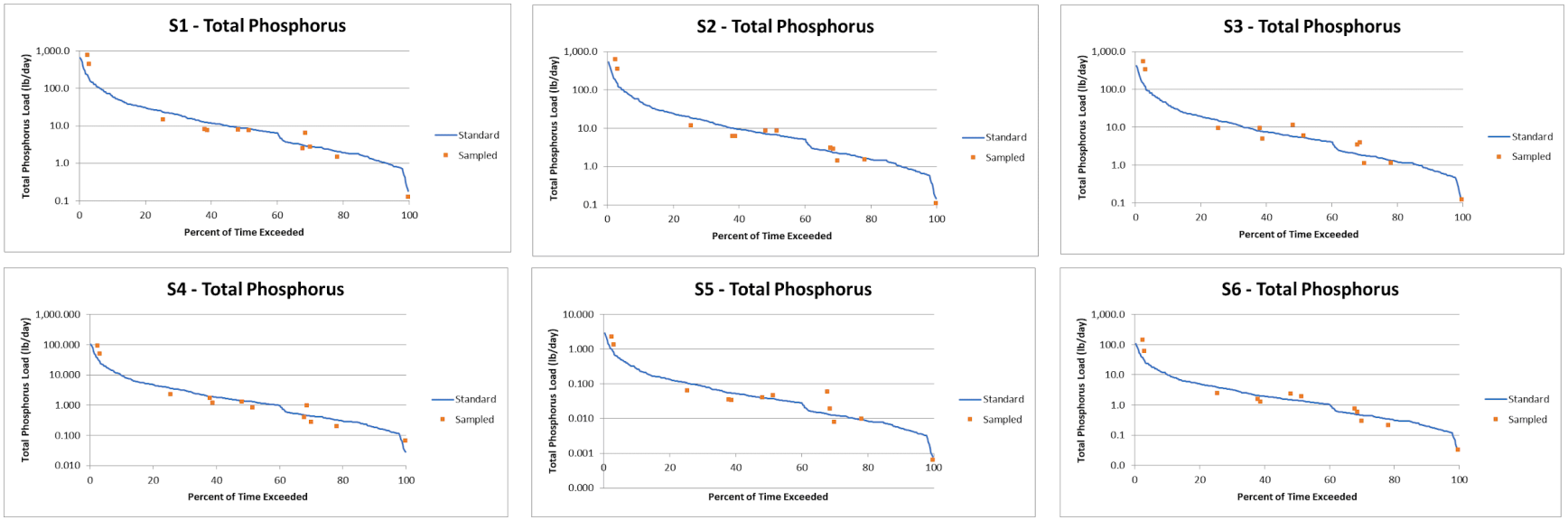

Figure 38. Total phosphorus load duration curves for Little Blue River Watershed sample sites from February 2023-January 2024.

Total Suspended Solids Load Duration Curves

Similar to total phosphorus load levels, total suspended solids (TSS) levels generally measured below target loads under moist to low flow conditions (Figure 39). TSS levels measured near or above target load levels under high flow conditions at all sites. Site 5 (Gilson Creek-Little Blue River) was the only site with TSS load exceedance levels during dry flow conditions. Possible sources of total suspended solids include livestock access or streambank and bed erosion, both of which can provide a continuous source of total suspended solids.

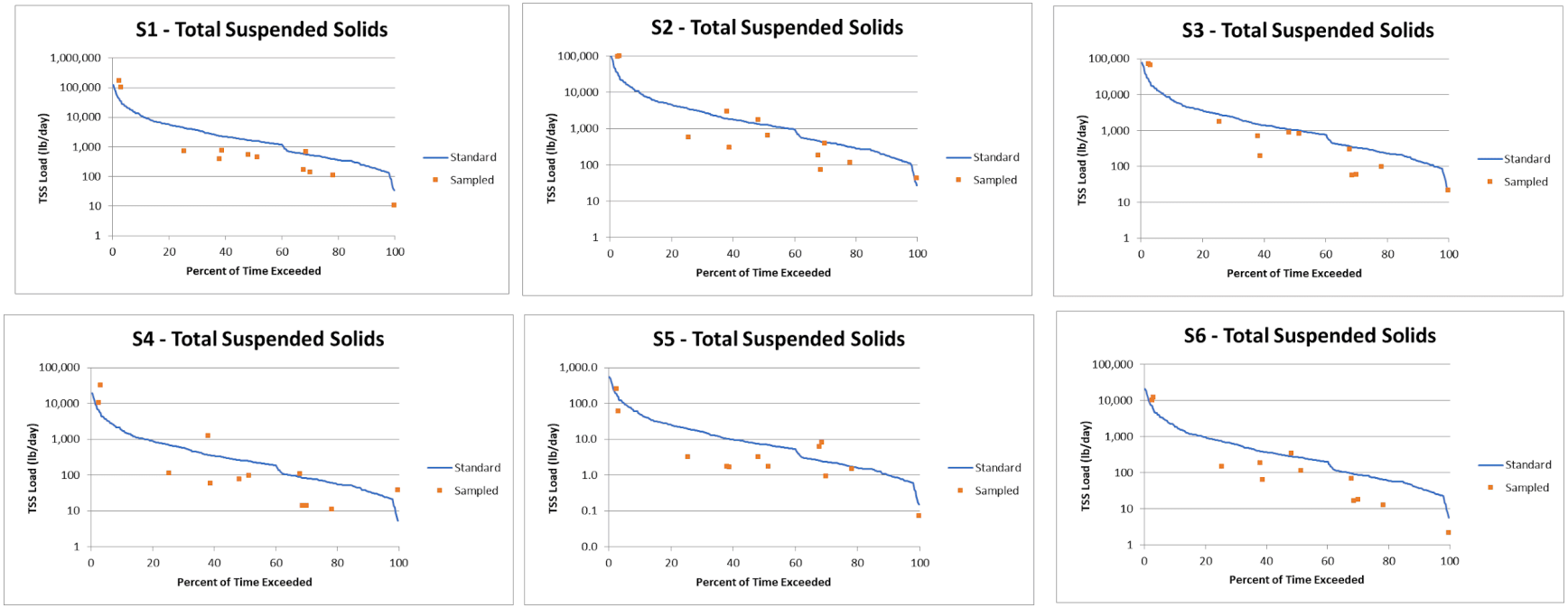

Figure 39. Total suspended solids load duration curves for Little Blue River Watershed sample sites from February 2023-January 2024.

E. coli Load Duration Curves

E. coli load duration curves indicate that *E. coli* levels exceed targets mostly during high flow conditions (Figure 40). Exceedances occurred during high flow conditions at all sites, with only Site 5 (Gilson Creek-Little Blue River) and Site 6 (Little Blue River at Rushville Road) showing exceedances under additional flow conditions. Site 6 had *E. coli* load exceedances under mid-range and dry flow conditions while Site 5 had multiple exceedances between moist and low flow conditions. These data suggest a relatively continuous source of *E. coli* within these streams during high flow conditions, and under most flow conditions for Site 5.

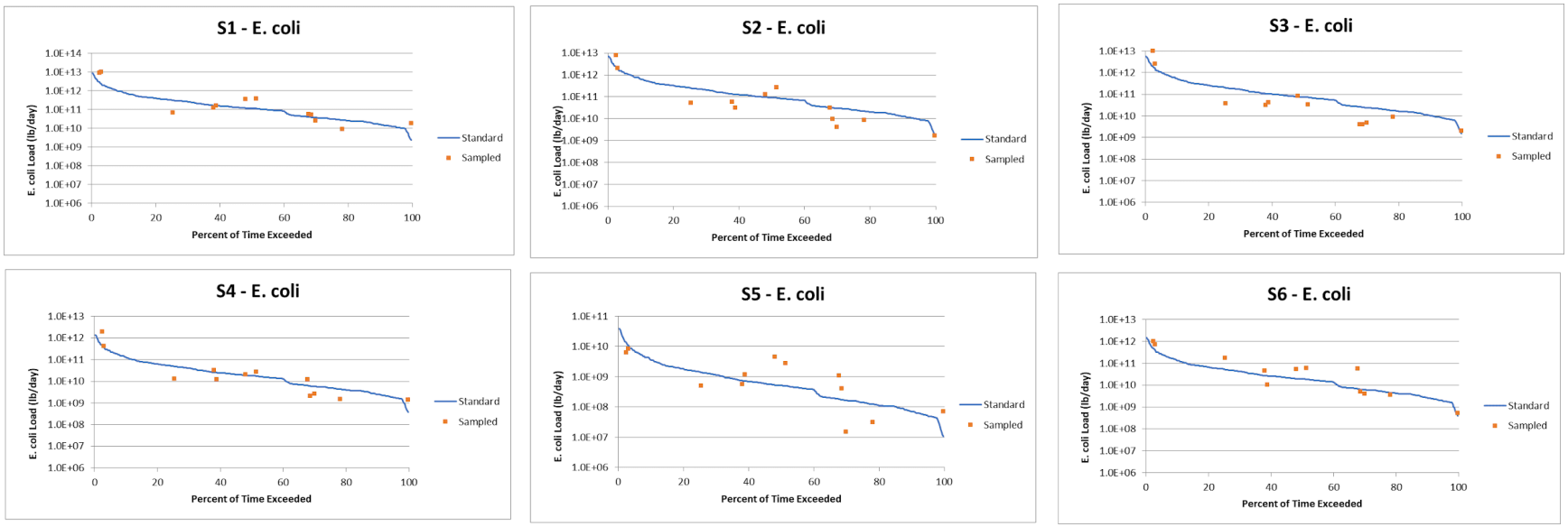

Figure 40. *E. coli* load duration curves for Little Blue River Watershed sample sites from February 2023-January 2024.

3.3.5 Macroinvertebrate Community Assessment

Site 2 (Manilla Branch) and Site 4 (Beaver Meadow Creek) supported the most diverse communities compared to the other sites in the Little Blue River Watershed with 26 and 25 taxa observed, respectively (Table 14, Figure 41). Additionally, Site 4 (Beaver Meadow Creek) and Site 3 (Little Blue River at County Road 900 West) possessed the highest mIBI score of 44 at each site. Site 2 (Manilla Branch) had the most EPT taxa observed with 15 individuals collected while having no species identified as tolerant. This site had the second highest mIBI score. Site 3 (Little Blue River at CR 900 West) had the greatest percentage of intolerant species, with 33% of observed taxa identified as intolerant while 3% were identified as tolerant. Site 1 (Little Blue River at Morris Ave) had the greatest percentage (100%) of individuals from the Chironomid family- one that typically represents low-quality streams or mobile species such as isopods, amphipods, beetles, damselflies and dragonflies. Site 1 (Little Blue River at Morris Ave) also had the lowest mIBI score of 30. Site 5 (Gilson Creek-Little Blue River) had the lowest percentage of intolerant species, with only 1% of observed taxa identified as intolerant while 89% were identified as tolerant. Macroinvertebrate data are detailed in Appendix B.

Table 14. Metric classification scores and mIBI score for the Little Blue River Watershed sample sites as sampled in 2023.

Metrics Scoring	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Total Taxa Score	1	3	1	3	1	1
Total # Individuals Score	5	5	5	5	5	5
#EPT Taxa Score	3	5	3	5	1	1
% Orthoclads &Tanytarsids Score	1	3	5	1	5	5
% Non-Insects Score	5	5	5	5	5	3
# Dipteran Taxa Score	1	1	1	3	1	1
% Intolerant Score	1	3	5	1	1	1
% Tolerant Score	5	5	5	5	1	1
%Predators Score	1	1	1	3	5	3
%Shredders & Scrapers Score	3	5	5	5	1	1
% Collector-Filterers Score	1	1	3	3	5	5
% Sprawlers Score	3	5	5	5	5	5
mIBI Score	30	42	44	44	36	32
Rating	**Poor**	**Fair**	**Fair**	**Fair**	**Fair**	**Poor**

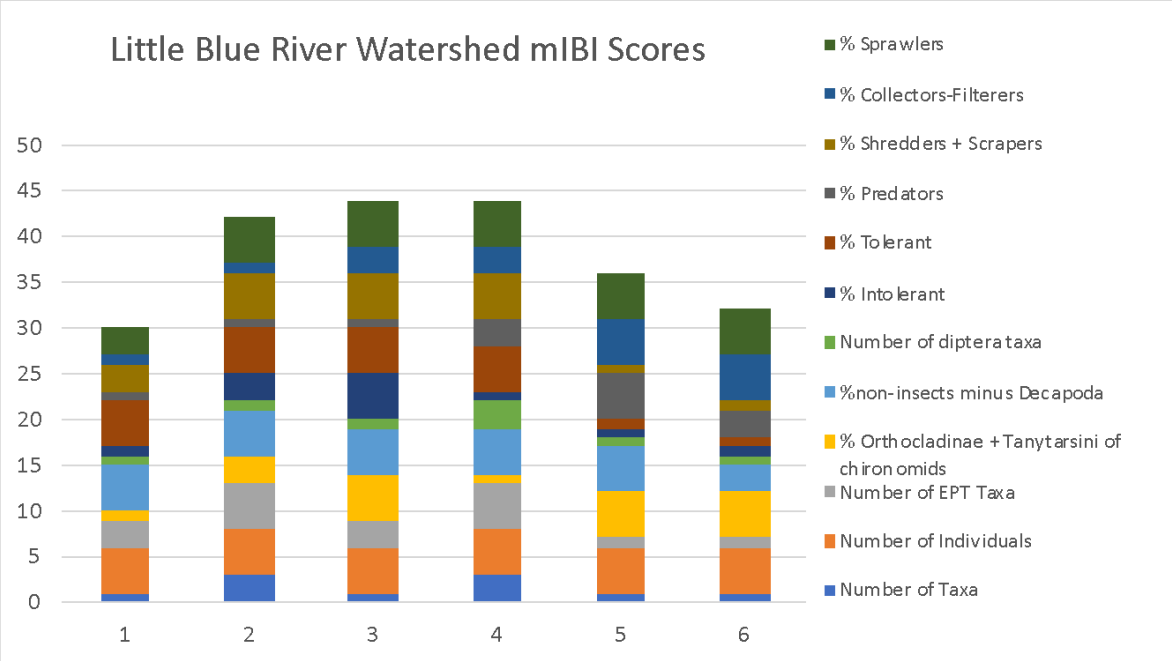

Figure 41. Cumulative metrics used to calculate mIBI scores for Little Blue River Watershed streams in 2023.

As shown in Figure 42, Site 1 (Little Blue River at Morris Ave) and Site 6 (Little Blue River at Rushville Road) possessed mIBI scores which rated as impaired. Site 2 (Manilla Branch), Site 3 (Little Blue River at CR 900 W), Site 4 (Beaver Meadow Creek) and Site 5 (Gilson Creek-Little Blue River) possessed mIBI scores which rated as not impaired.

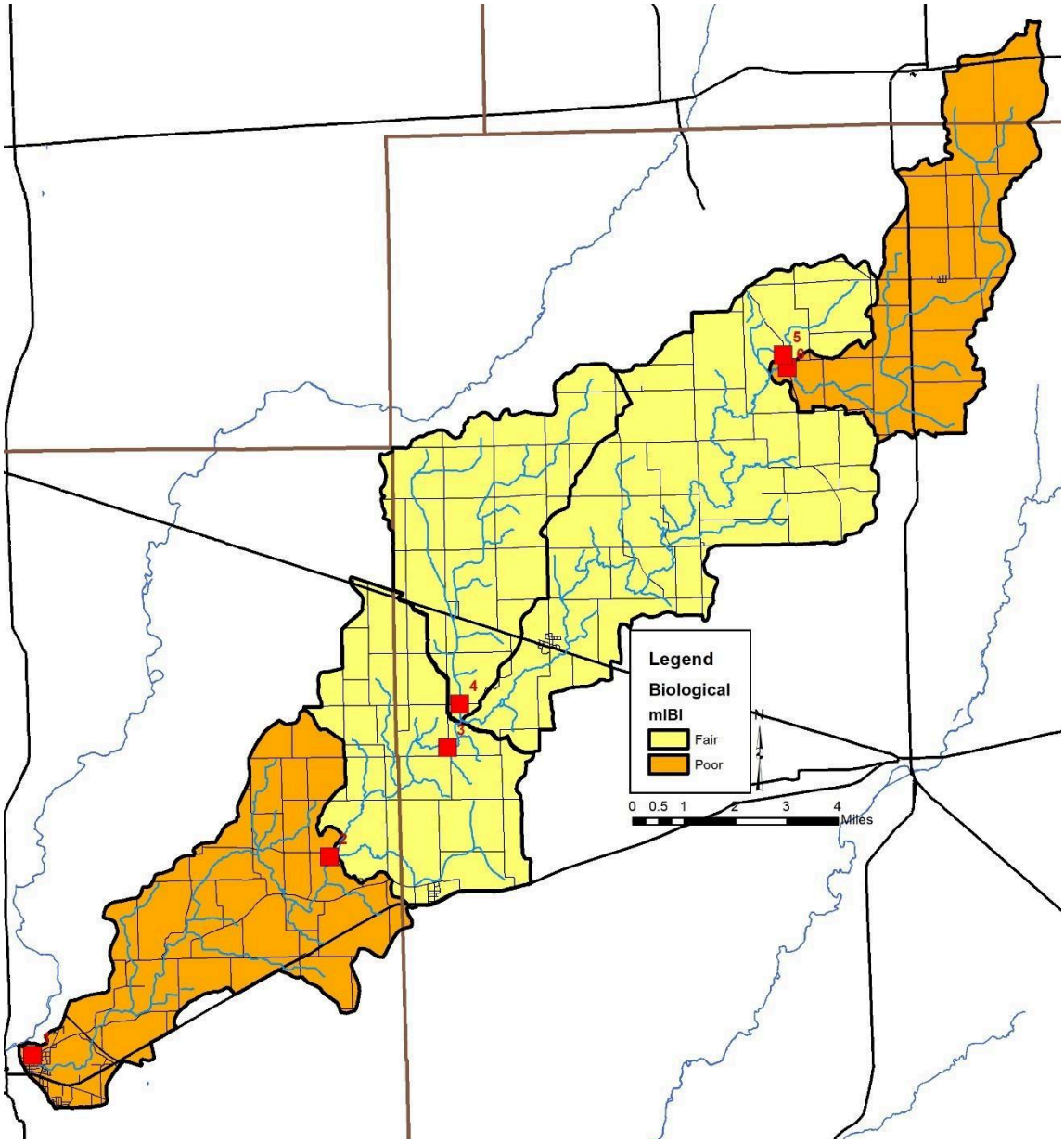

Figure 42. mIBI ratings for Little Blue River Watershed.

3.3.6 Habitat Quality Assessment

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 15 presents the results of QHEI assessments at each of the six stream sites sampled in the Little Blue River Watershed during October 2023. Figure 43 details metric and total scores for all sites. Site 1 (Little Blue River at Morris Ave) and Site 3 (Little Blue River at CR 900 W) possessed the greatest scores and rated as good. Stream substrate, instream cover, channel morphology, pool/riffle development scores and gradient contributed to higher QHEI scores at these sites. Site 5 (Gilson Creek-Little Blue River) possessed the lowest score and rated as very poor. Poor substrate, poor instream cover, limited riparian quality and underdeveloped pool/riffle complexes characterized Site 5. Habitat data are detailed in Appendix B.

Table 15. Qualitative Habitat Evaluation Index (QHEI) scores measured in the Little Blue River Watershed.

Site	Substrate	Cover	Channel	Riparian	Pool Quality	Riffle/Run Quality	Gradient	Total Score	Rating
1	13.5	12	16	5	10	5	3	64.5	Good
2	14	11	8	5.25	7	0	3	48.3	Fair
3	12	16	14.5	5.5	8	4	4	64.0	Good
4	12	13	8.5	4.5	4	0	3	45.0	Fair
5	0	6	7	2	3	0	2	20.0	Very Poor
6	5	10	9	4.5	8	0	3	39.5	Poor

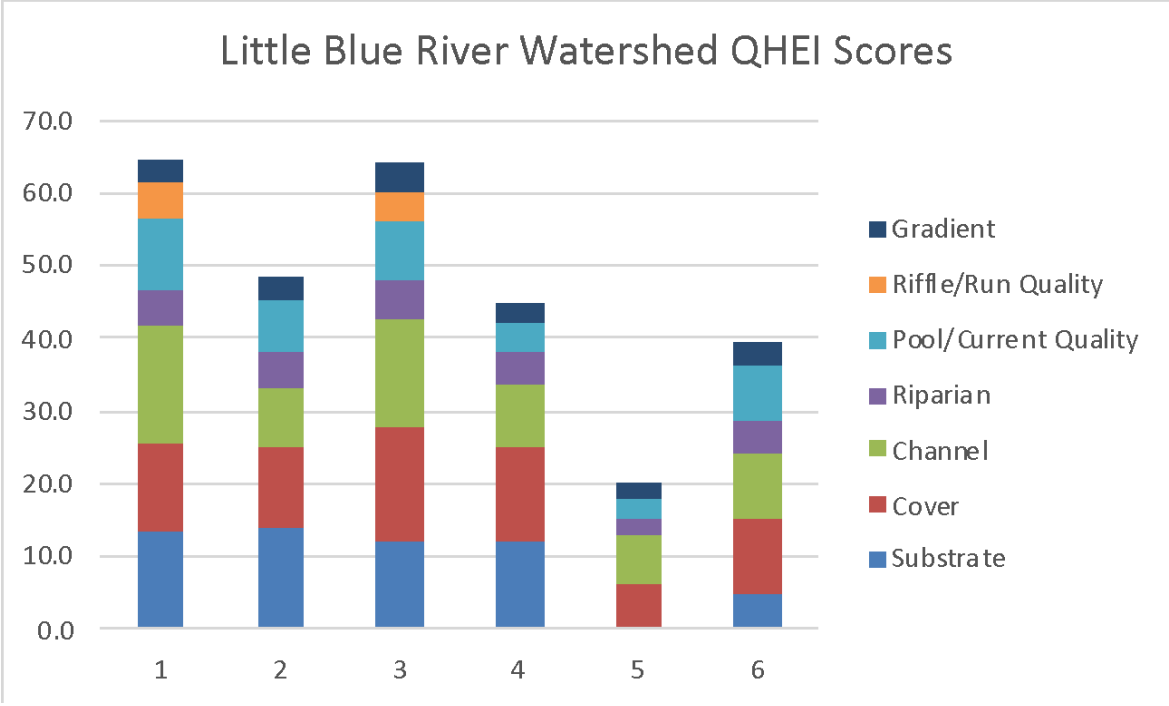

Figure 43. Cumulative metrics used to calculate QHEI scores for Little Blue River Watershed streams in 2023.

As shown in Figure 44, Site 1 (Little Blue River at Morris Ave) and Site 3 (Little Blue River at CR 900 W) rated as good. Site 2 (Manilla Branch) and Site 4 (Beaver Meadow Creek) rated as fair. Site 6 (Little Blue River at Rushville Road) rated as poor, while Site 5 (Gilson Creek-Little Blue River) rated as very poor.

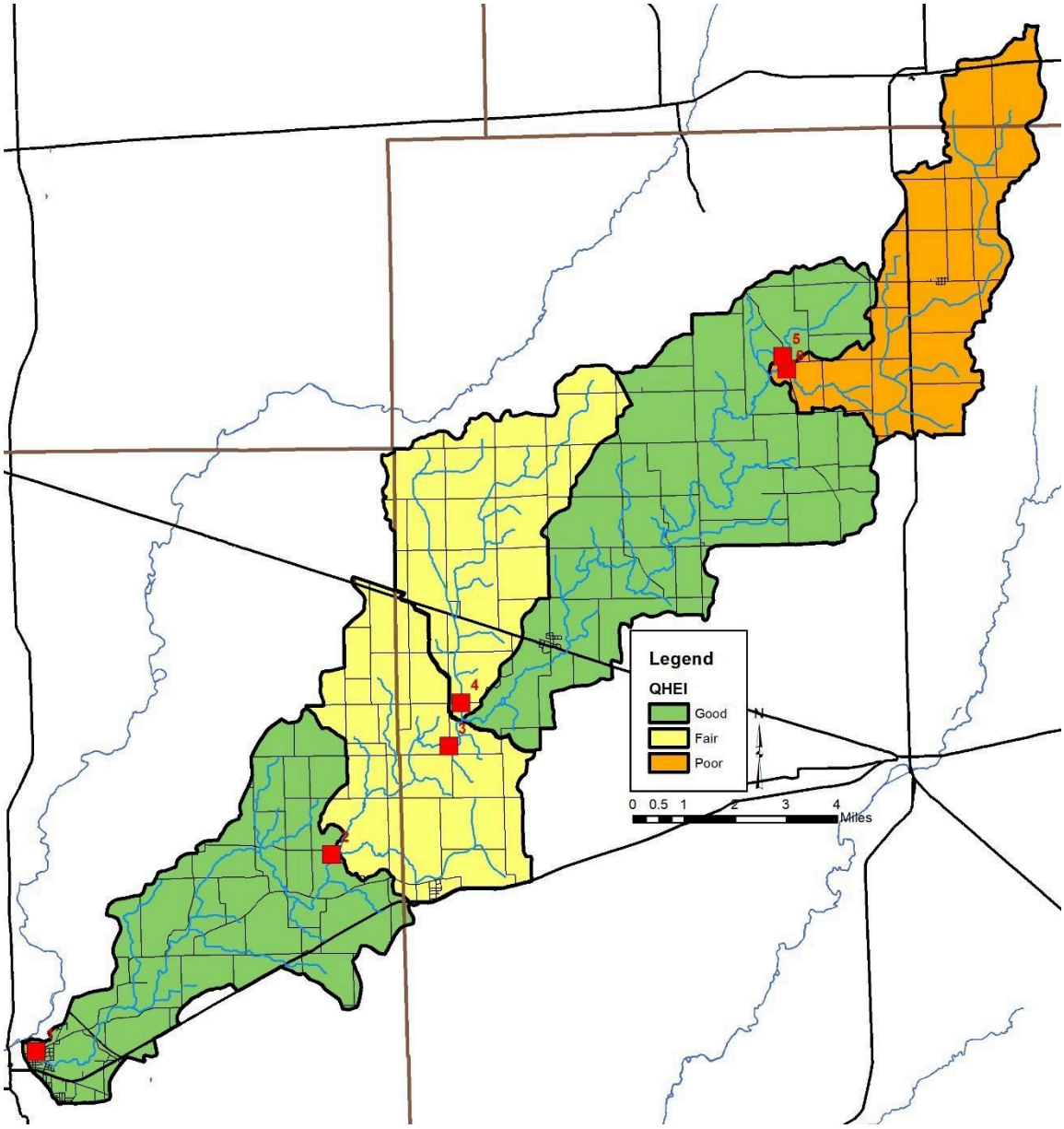

Figure 44. QHEI ratings for Little Blue River Watershed. Note Site 5 data are not displayed on the map. Site 5 rated as very poor.

3.4 Watershed Inventory Assessment

3.4.1 Watershed Inventory Methodologies

Windshield surveys were completed throughout the Little Blue River Watershed in the spring of 2023. 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 assess in surveying. Observations were recorded on the provided maps and data sheets, field conditions were documented using photographs, and additional notes were provided 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
- 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. Issues identified within the watershed fall under 3 categories: erosion, narrow buffer, and livestock access. Figure 45 details locations throughout the Little Blue River Watershed where problems are identified. A total of 9.9 miles of streams were eroded among 64 different locations, 2.0 miles possessed narrow buffers at 11 different locations, and livestock had access to 2.6 miles of streams at 11 different locations.

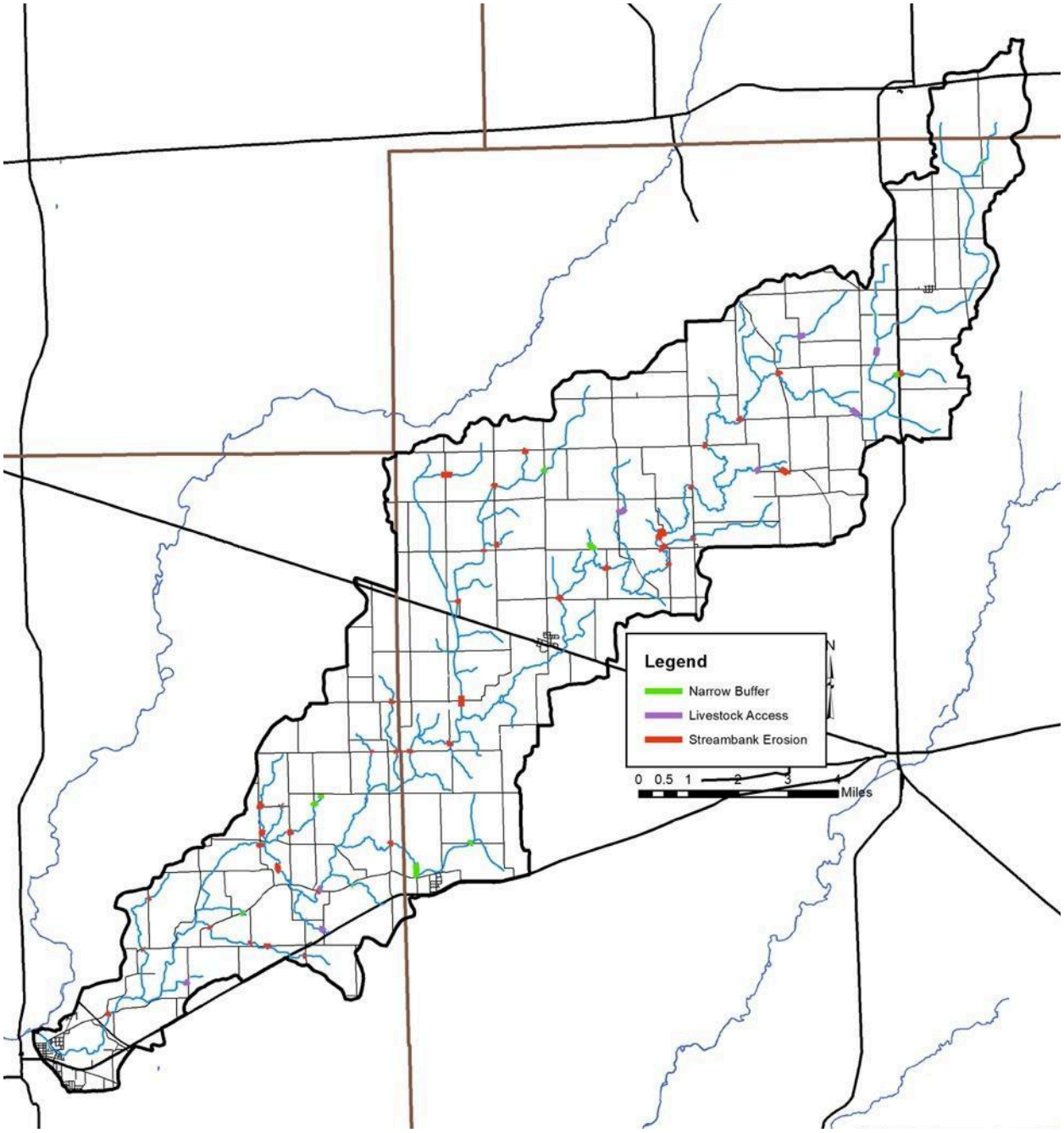

Figure 45. Stream-related watershed concerns identified during watershed inventory efforts.

4.0 WATERSHED INVENTORY II-B: SUBWATERSHED DISCUSSIONS

To gather more specific, localized data, the Little Blue River Watershed was divided into five (5) subwatersheds with each subwatershed reflecting one 12-digit Hydrologic Unit Code. 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.

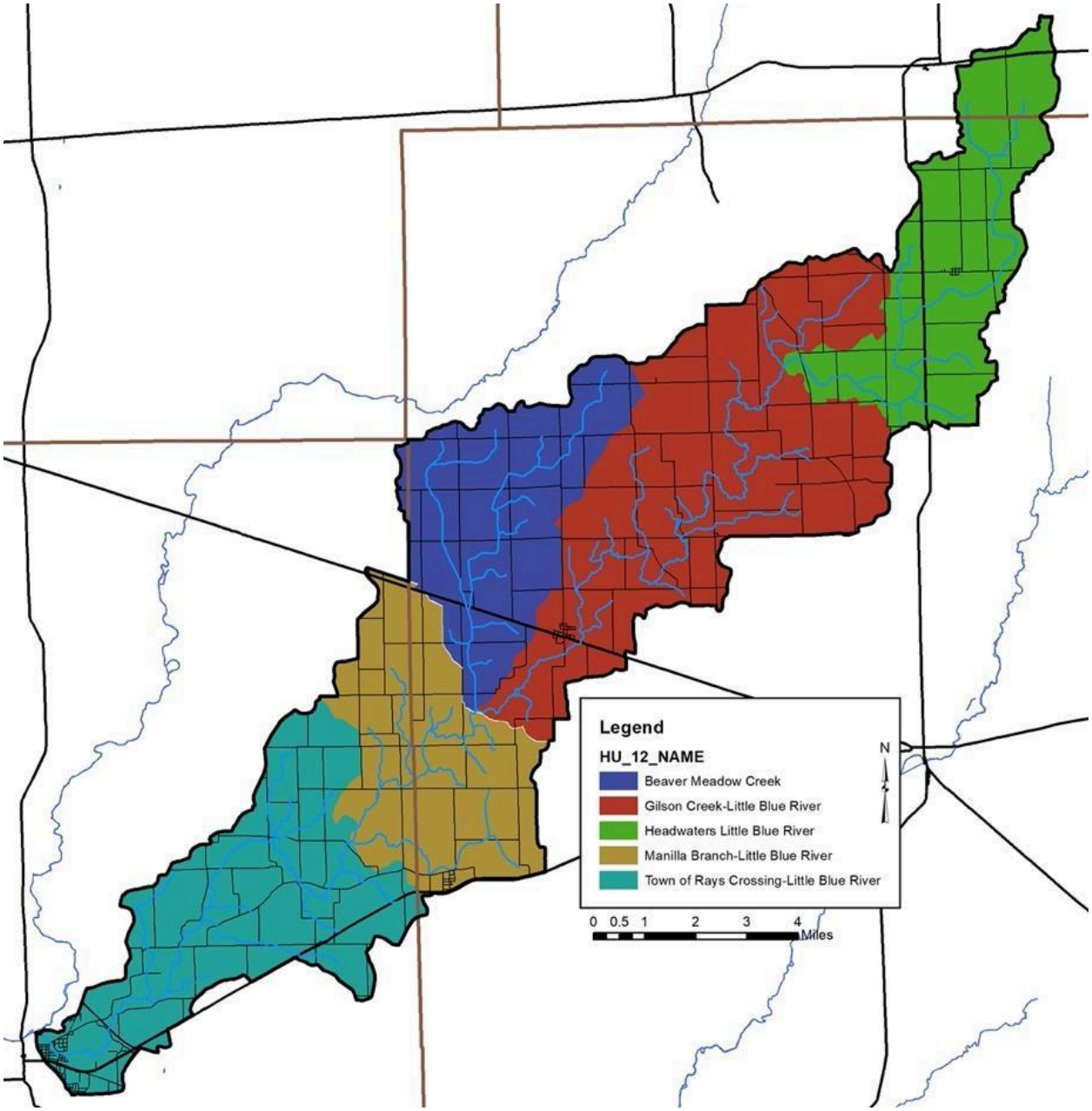

Figure 46. 12-digit Hydrologic Unit Codes Subwatersheds in the Little Blue River Watershed.

4.1 Headwaters Little Blue River Subwatershed

The Headwaters Little Blue River Subwatershed is the northernmost subwatershed of the Little Blue River Watershed and is primarily rural pasture and row crop agriculture. The Headwaters Little Blue River Subwatershed lies in Henry and Rush County. This subwatershed encompasses one 12-digit HUC watershed: 051202040201 and drains 11,091 acres, accounting for 17% of the total watershed area. There are 19.52 miles of stream. IDEM has classified 19.52 miles of stream as impaired for *E. coli*, dissolved oxygen (DO) and biotic communities (Figure 47).

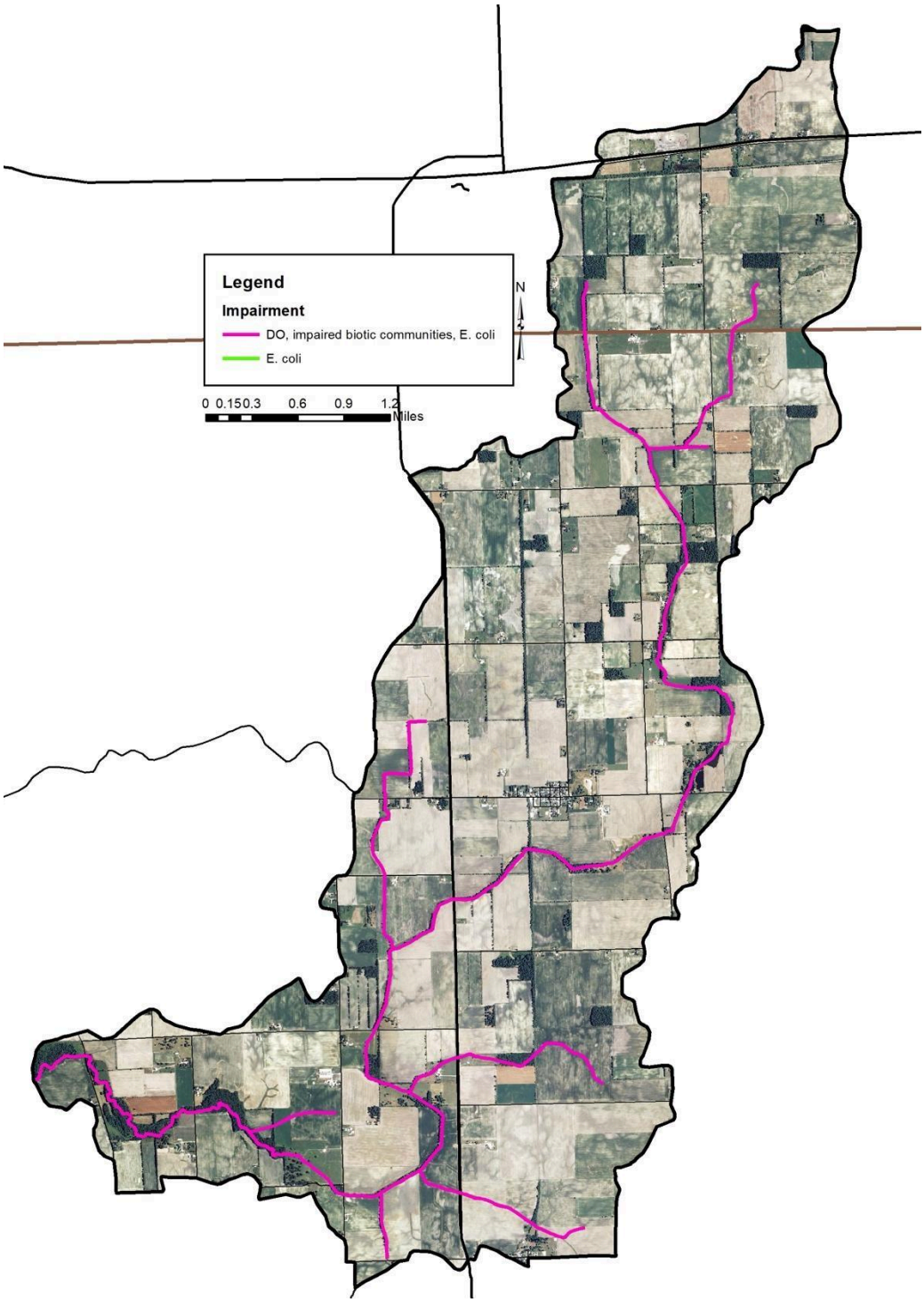

Figure 47. Impairments in the Headwaters Little Blue River Subwatershed.

4.1.1 Soils

Hydric soils currently cover 38% (4,184.3 acres) of the subwatershed. Highly erodible soils (HEL) are prevalent throughout the subwatershed, covering almost 62% (6,861.9 acres) of the area. Almost the entire subwatershed (99%, or 11,054 acres) has soils which are very limited for septic use. The majority of the 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 is prevalent throughout this subwatershed covering almost 92% of the area, 10,102.1 acres. This consists of cultivated row crop and pasture and hay land. Urban land use accounts for nearly 5% (539.8 acres) of the subwatershed. Forested land use accounts for approximately 2% (242.8 acres) of the land. Wetlands, open water, and grassland cover just under 2% (201.9 acres) of the subwatershed.

4.1.3 Point Source Water Quality Issues

There are no point source-based issues in the subwatershed.

4.1.4 Non-Point Source Water Quality

Agricultural land uses are predominant in the Headwaters Little Blue River Subwatershed. One active concentrated animal feeding operation (CAFO) is located within the Headwaters Little Blue River Subwatershed. Thirteen unregulated animal operations housing approximately 170 cows and sheep were identified during the windshield survey (Figure 48). In total, manure from the one CAFO and small animal operations is an estimated 76,699 tons per year, which contains an estimated 119,719 pounds of nitrogen, 65,120 pounds of phosphorus, and 5.61E+15 col of *E. coli*. Livestock have access to approximately 0.74 miles, or 4%, of stream length in the subwatershed based on observations during the windshield survey. Streambank erosion accounts for 1.4 miles, or 7%, of stream length within the subwatershed as observed in the windshield survey. Additionally, 0.3 miles, or 1%, of stream length within the subwatershed were identified as having narrow buffers.

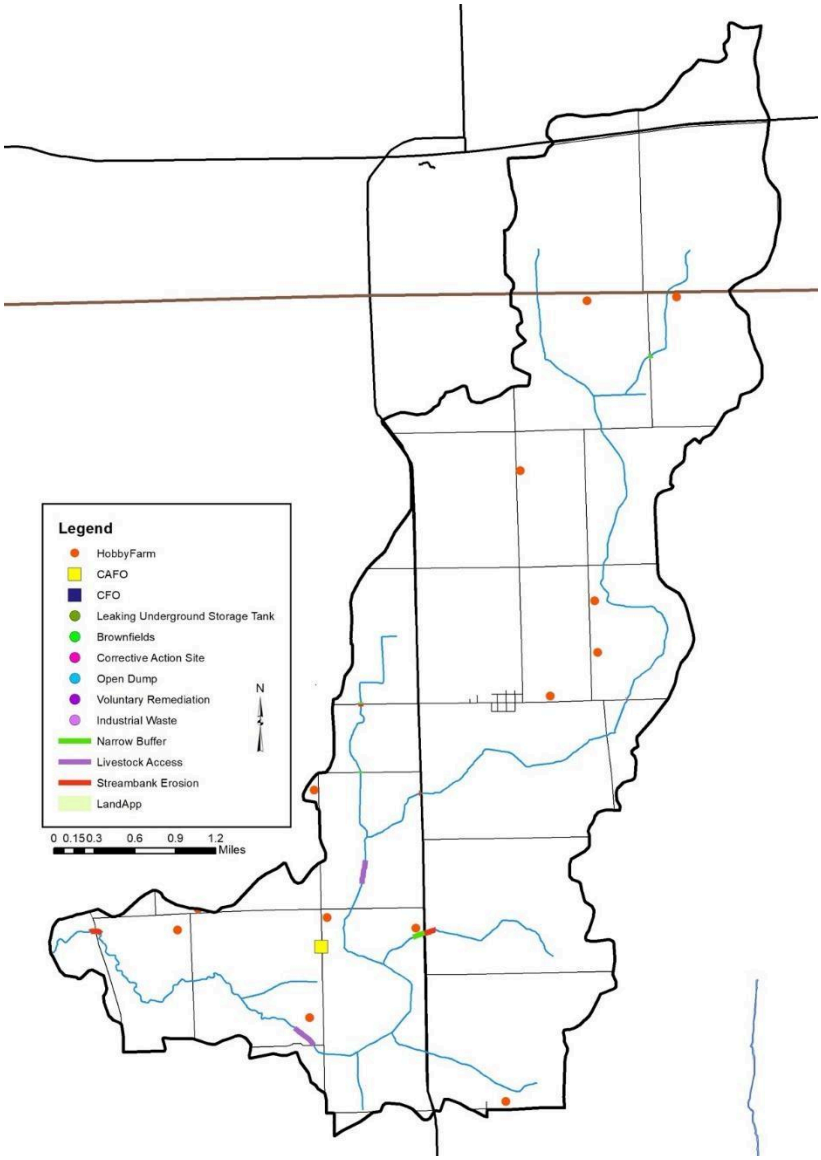

Figure 48. Point and non-point sources of pollution in the Headwaters Little Blue River Subwatershed.

4.1.5 Water Quality Assessment

Waterbodies within the Headwaters Little Blue River Subwatershed have been sampled at four locations (Figure 49). Assessments include collection of water chemistry data by IDEM at three different sites and Hoosier Riverwatch, DNR LARE, and Arion Consultants at one site.

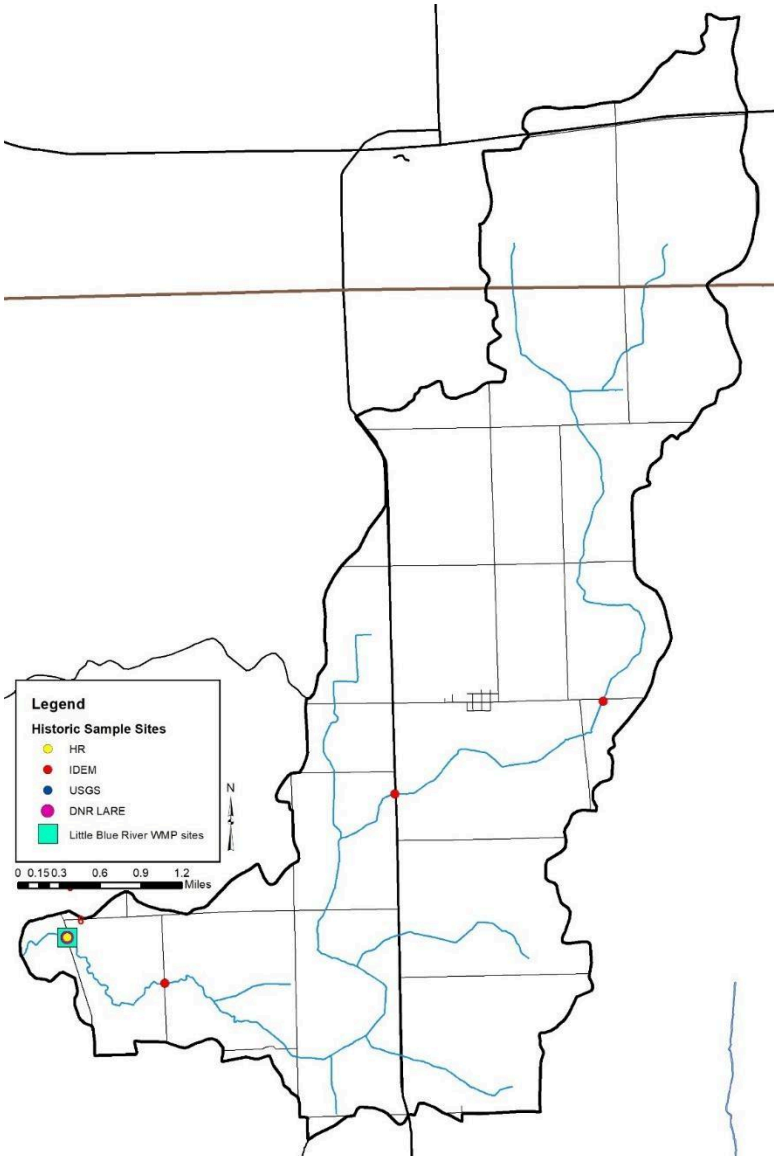

Figure 49. Locations of current (Little Blue River WMP sites) and historic water quality data collection in the Headwaters Little Blue River Subwatershed.

Table 16 details historic water quality data collected in the Headwaters Little Blue River Subwatershed. As shown in the table, conductivity, DO and pH did not exceed in any samples collected. *E. coli* samples exceed state sample standards (235 col/100 ml) in 26% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 100% of samples. Additionally, total Kjeldahl nitrogen (TKN) concentrations also exceed water quality targets (0.57 mg/L) in 50% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 50% of samples. Total suspended solids concentrations exceeded water quality targets (15 mg/L) in 50% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 87% of samples.

Table 16. Headwaters Little Blue River Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	632	632	0	1	0%
DO	5.9	12	0	31	0%
E. coli	0	1986.3	8	31	26%
Nitrate-Nitrogen	1.1	33	24	24	100%
OP	0	0.8	20	24	83%
pH	6.5	8.34	0	29	0%
TKN	0.435	0.615	1	2	50%
Total Phosphorus	0.01	0.12	1	2	50%
Total Suspended Solids	6	34.67	1	2	50%
Turbidity	3	35	27	31	87%

Table 17 details water quality data collected in the Headwaters-Little Blue River Subwatershed (Site 6) sampled during the current project. There were no dissolved oxygen exceedances. Conductivity samples exceed sample standards (1050 mg/L) in 8% of samples. pH did not exceed for any sample collected. As shown in the table, E. coli samples exceed state grab sample standards (235 col/100 ml) in 67% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 42% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 58% of samples. Total suspended solids concentrations exceed water quality targets (15 mg/L) in 25% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 67% of samples.

Table 17. Headwaters-Little Blue River Subwatershed water quality data summary, 2023-2024.

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)
6	Median	9.60	9.05	8.08	593.00	15.01	0.41	0.09	6.10	394.50
	Max	22.30	11.71	8.77	1075.00	40.50	6.10	0.31	31.30	1986.00
	Min	1.70	6.20	7.72	455.00	1.60	0.10	0.05	2.50	93.00
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		0	0	1	8	5	7	3	8
	% Exceed		0%	0%	8%	67%	42%	58%	25%	67%

Biological monitoring was conducted by JFNew as part of the Little Blue River Diagnostic Study at one site for macroinvertebrates and habitat. During that assessment, the macroinvertebrate community scored moderately impaired (4.76) while habitat rated as fully supporting for its aquatic life use designation scoring 51. During the current project, macroinvertebrate communities and habitat were assessed at one site. The Little Blue River (Site 6) rated as poor for mIBI (score of 32) and QHEI (score of 39.5).

4.2 Gilson Creek-Little Blue Subwatershed

The Gilson Creek-Little Blue Subwatershed is the largest of the five subwatersheds and is the only subwatershed that lies entirely in one county (Rush County; (Figure 46). It encompasses one 12-digit HUC watershed: 051202040203. This subwatershed drains 20,706 acres and accounts for more than a quarter (30.9%) of the total watershed area. There are 38.06 miles of stream. IDEM has classified 38.06 miles of stream as impaired for *E. coli*, DO and biotic communities (Figure 50).

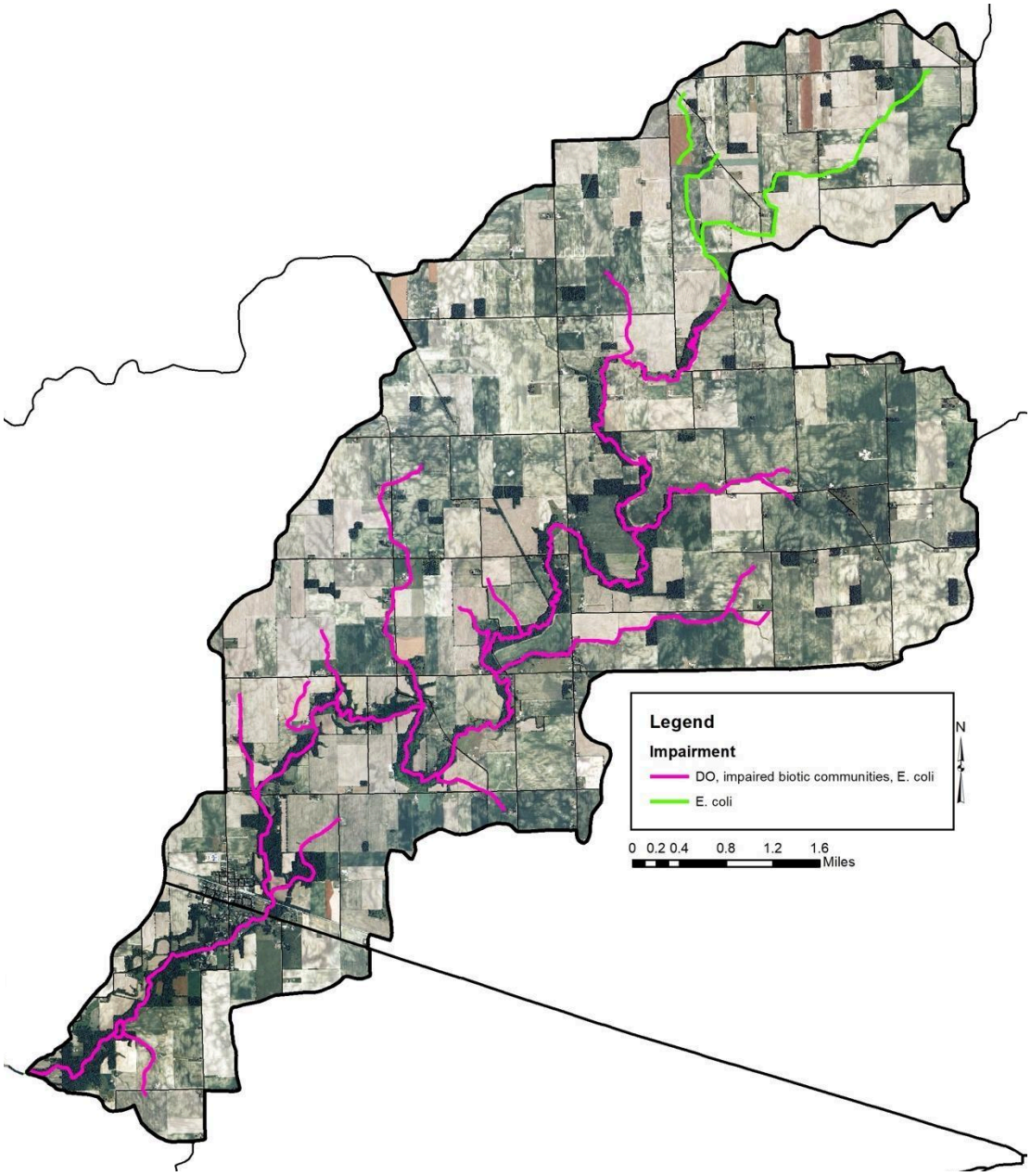

Figure 50. Impairments in the Gilson Creek-Little Blue Subwatershed.

4.2.1 Soils

Hydric soils cover 7,634.2 acres, or almost 37% of the subwatershed. Highly erodible soils cover 12,827.8 acres (62%) of the subwatershed. Almost the entire subwatershed (99.8% or 20,671.4 acres) is identified as very limited for septic use. The majority of the 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.

4.2.2 Land Use

Agricultural land use dominates this subwatershed, covering 87.5% (18,113.9 acres) of the area. Forested land use covers 1,112 acres, or 5.4% of the subwatershed. In total, 1,065.7 acres (5.1%) of the subwatershed is classified as urban. Wetlands, open water, and grassland cover the remainder of the subwatershed (405.5 acres or 2%) of the land.

4.2.3 Point Source Water Quality Issues

There are no point source-based issues in the Gilson Creek-Little Blue Subwatershed.

4.2.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Gilson Creek-Little Blue Subwatershed. One active concentrated animal feeding operation (CAFO) is located within the subwatershed. Twenty unregulated animal operations housing more than 223 cows, horses, sheep, pigs, and donkeys were identified during the windshield survey (Figure 51). In total, manure from the CAFO and small animal operations is an estimated 35,545 tons per year, which contains an estimated 53,613 pounds of nitrogen, 29,051 pounds of phosphorus, and 2.80E+15 col of *E. coli*. Treated wastewater treatment plant sludge is permitted to be applied on approximately 105 acres of the Gilson Creek-Little Blue River subwatershed. Based on windshield survey observations, livestock have access to approximately 1.24 miles (3%) of stream length in the subwatershed. Approximately three miles (8%) of streambank erosion were identified within the subwatershed. Additionally, 0.4 miles (1%) of narrowly buffered stream were observed in the Gilson Creek-Little Blue Subwatershed.

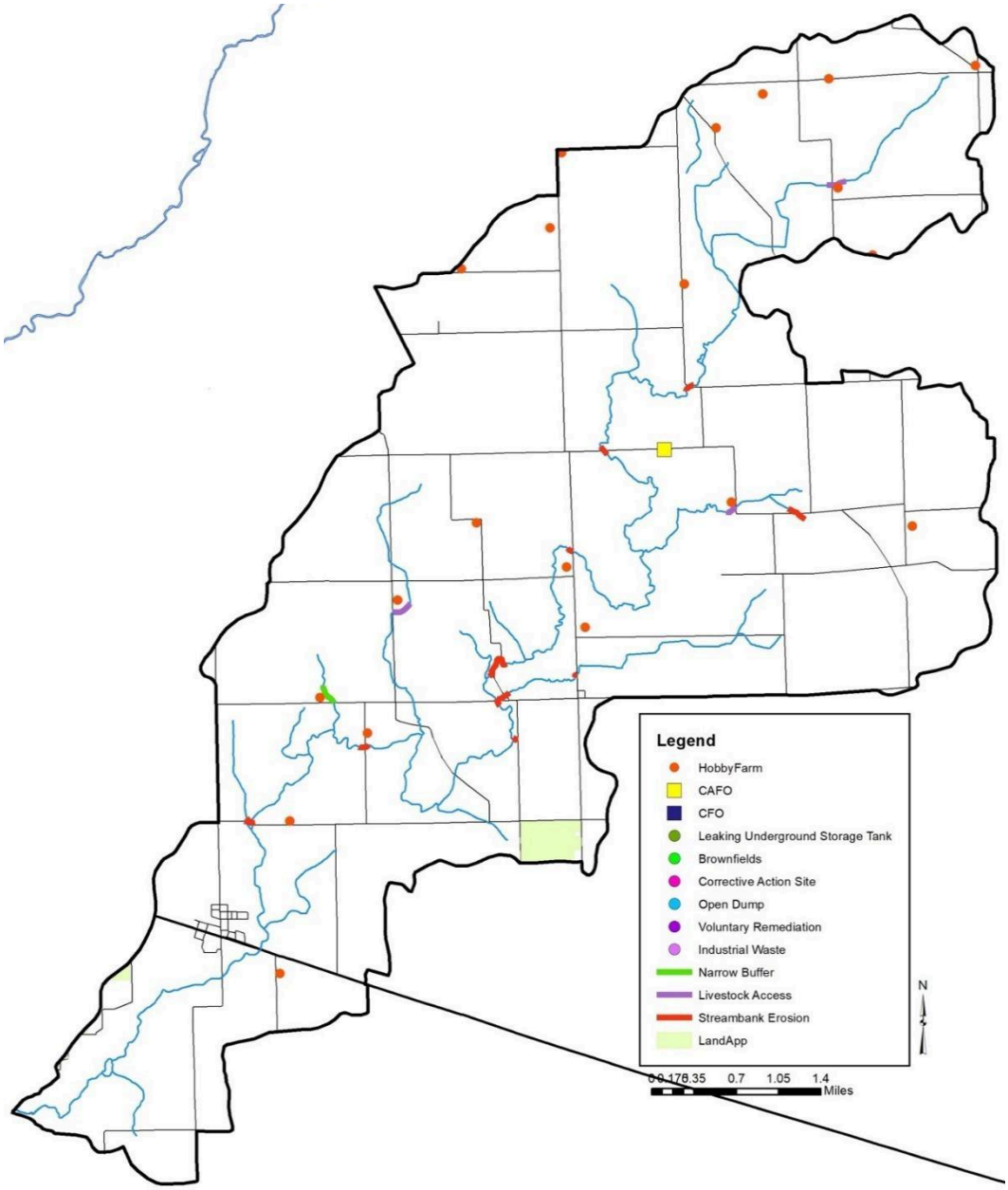

Figure 51. Point and non-point sources of pollution in the Gilson Creek-Little Blue River Subwatershed.

4.2.5 Water Quality Assessment

Waterbodies within the Gilson Creek-Little Blue River Subwatershed have been sampled at nine locations (Figure 52). Assessments include collection of water chemistry data by IDEM at five different sites and Hoosier Riverwatch, DNR LARE, and Arion Consultants at one site.

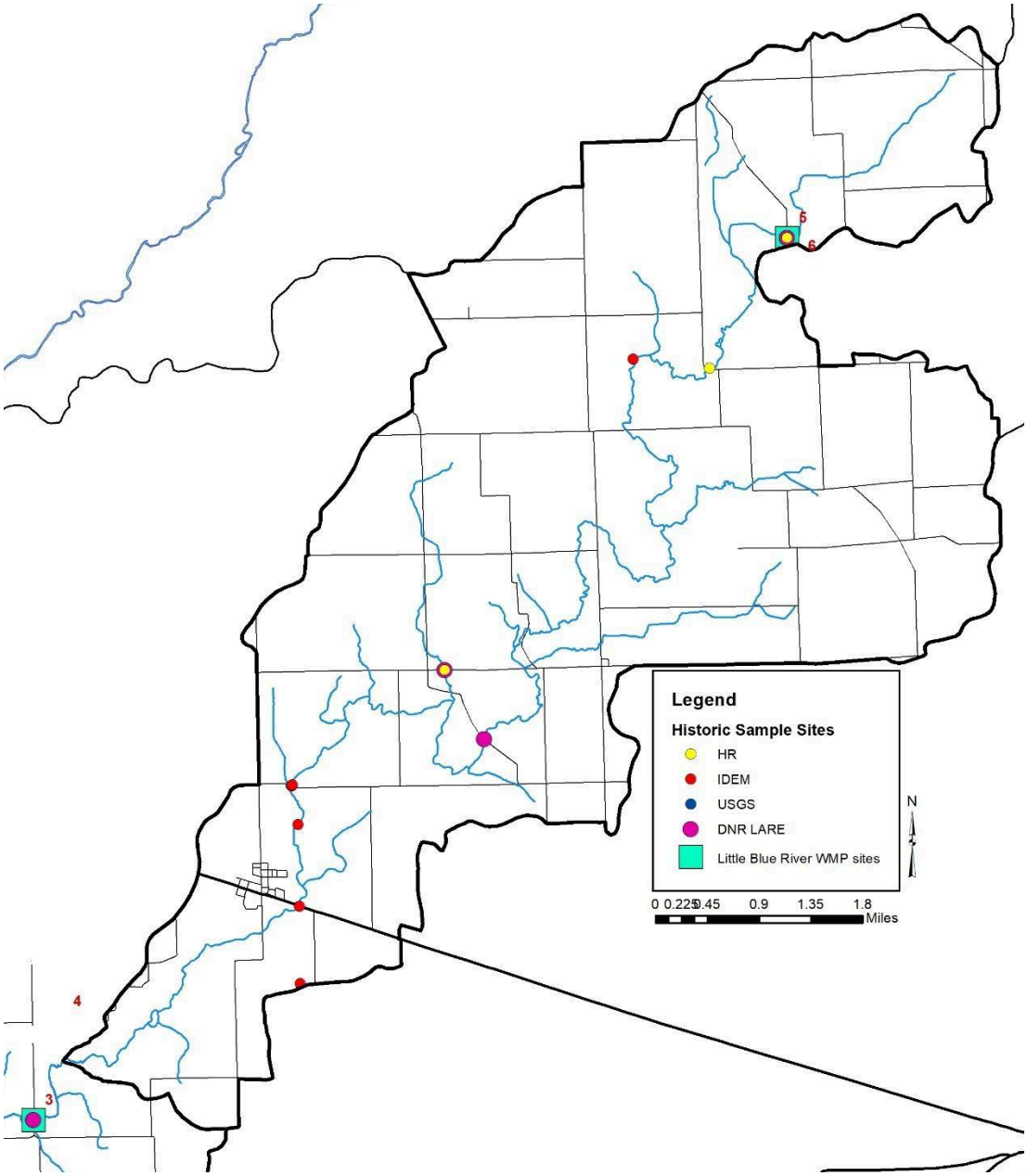

Figure 52. Locations of historic and current (Little Blue River WMP sites) water quality data collection in the Gilson Creek-Little Blue River Subwatershed.

Table 18 details historic water quality data collected in the Gilson Creek-Little Blue River Subwatershed. As shown in the table, ammonia, conductivity and pH did not exceed in any samples collected in this subwatershed. *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 40% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 100% of samples, while TKN 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 33% of samples. Total suspended solids concentrations exceeded water quality targets (15 mg/L) in 20% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 75% of samples.

Table 18. Gilson Creek-Little Blue River Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Ammonia	0.1	0.1	0	3	0%
Conductivity	632	665	0	4	0%
DO	3.9	13.4	4	49	8%
E. coli	0	3500	16	40	40%
Nitrate-Nitrogen	2.2	148.7	23	23	100%
OP	0	0.5	15	17	88%
pH	6.5	8.5	0	52	0%
TKN	0.23	1.2	3	9	33%
Total Phosphorus	0.017	0.23	3	9	33%
Total Suspended Solids	1.28	31.71	2	10	20%
Turbidity	0.508	46.1	36	48	75%

Table 19 details water quality data collected in the Gilson Creek-Little Blue River Subwatershed (Sites 3 and 5) sampled during the current project. Dissolved oxygen concentrations measured below water quality standards in 27% of samples collected at Site 3 and 8% of samples collected at Site 5. Conductivity samples exceed sample standards (1050 mg/L) in 25% of samples collected at Site 5. pH did not exceed for any sample collected. As shown in the table, E. coli samples exceed state grab sample standards (235 col/100 ml) in 33% of samples collected at Site 3 and 50% of samples collected in Site 5. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 50% of samples collected at Site 3 and 100% of samples in Site 5. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 67% of samples collected at Site 3 and 58% of samples collected at Site 5. Total suspended solids concentrations exceed water quality targets (15 mg/L) in 17% of samples collected at Site 3 and 25% of samples collected at Site 5, while turbidity levels exceed water quality targets (5.7 NTU) in 58% of Site 3 samples and 67% of Site 5 samples.

Table 19. Gilson Creek-Little Blue River Subwatershed water quality data summary, 2023-2024.

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	10.71	10.33	8.07	527.50	8.31	1.07	0.09	10.85	*103.50*
	Max	22.50	12.90	8.80	690.00	71.20	7.90	0.30	45.60	*1203.00*
	Min	4.00	6.10	7.20	411.00	0.50	0.10	0.05	2.00	*37.00*
	#Samples	12	11	12	12	12	12	12	12	*12*
	#Exceed		3	0	0	7	6	8	2	*4*
	% Exceed		27%	0%	0%	58%	50%	67%	17%	*33%*
5	Median	10.05	9.35	7.81	634.00	21.85	4.75	0.08	6.30	282.50
	Max	18.30	11.20	8.50	1683.00	68.80	14.70	0.35	51.60	1986.00
	Min	2.70	3.70	7.35	418.00	0.60	2.50	0.05	2.50	21.00
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		1	0	3	8	12	7	3	6
	% Exceed		8%	0%	25%	67%	100%	58%	25%	50%

Biological monitoring was conducted by IDEM at 2 sites, by JFNew at three sites as part of the Little Blue River Diagnostic Study and at one site as part of the current project. Macroinvertebrates were assessed four times using the kick method and twice using the multi-habitat method, while fish were assessed once. In total, seven habitat assessments occurred. Habitat scores ranged from 20 to 73 with 38% of sites scoring below the state target (51). The fish community assessment rated poor scoring 30 with the one assessment not meeting aquatic life use designation. Macroinvertebrate assessments rated moderately impaired to slightly impaired using the kick sampling method with all sites meeting their aquatic life use designation and from 34 to 42 with 33% of multihabitat samples not meeting their aquatic life use designation (Table 20). During the current assessment, the macroinvertebrate community rated fair (score of 44 at site 3, score of 36 at Site 5) and habitat rated good (score of 64 at Site 3) and very poor (score of 20 at Site 5).

Table 20. Gilson Creek-Little Blue River Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	20	73	3	9	33%
Fish (IBI)	30	30	1	1	100%
Macroinvertebrates (mIBI, Kick)	2.5	6.2	0	4	0%
Macroinvertebrates (mIBI, Multi Habitat)	34	44	1	4	25%

4.3 Beaver Meadow Creek Subwatershed

The Beaver Meadow Creek Subwatershed is located immediately west of the Gilson Creek-Little Blue River Subwatershed and lies in Rush and Shelby Counties (Figure 46). It encompasses one 12-digit HUC watershed: 051202040202. This subwatershed drains 10,494 acres and accounts for 15.7% of the total

watershed area. There are 19.7 miles of stream in this subwatershed, IDEM has classified all 19.7 miles of stream as impaired for *E. coli* (Figure 53).

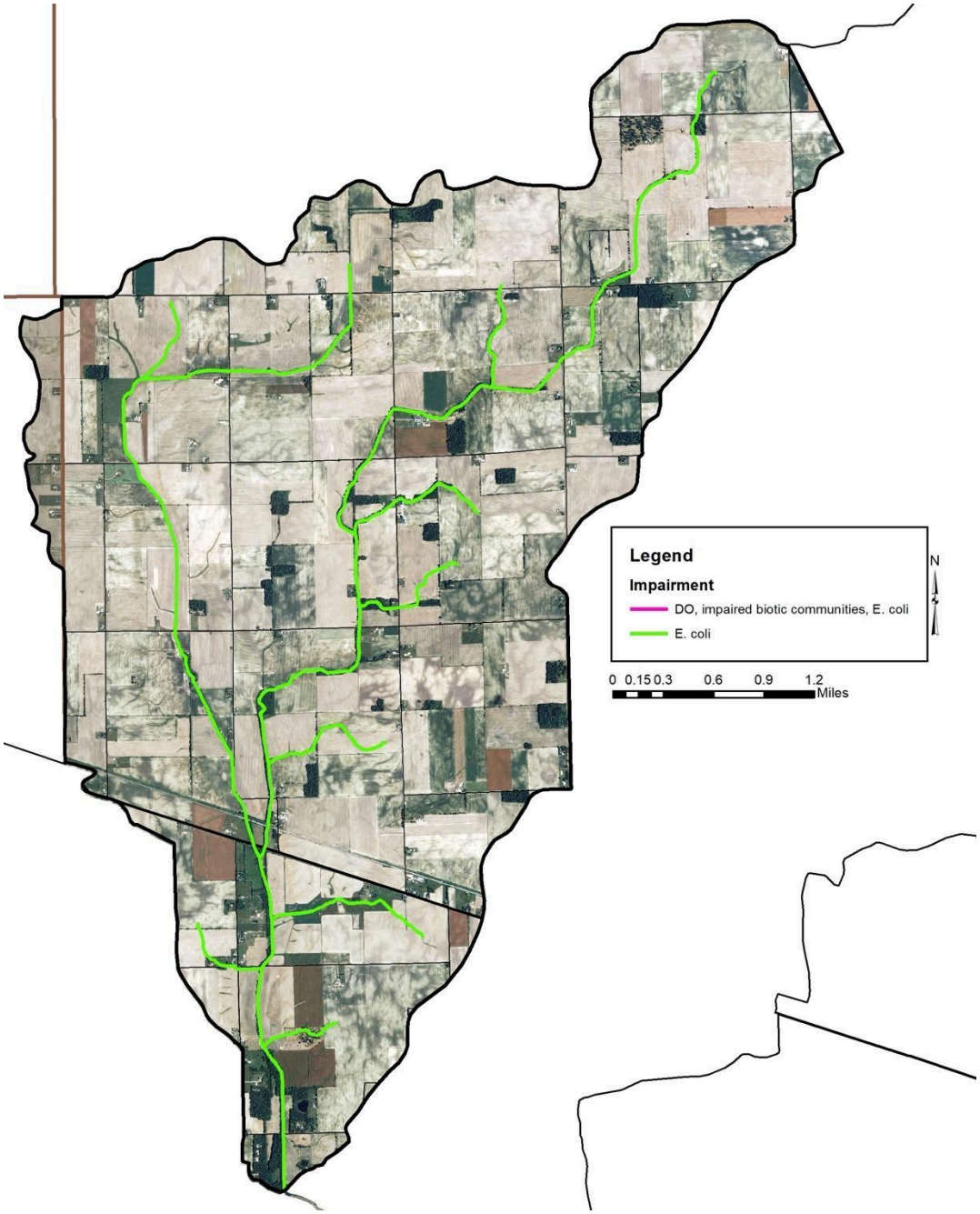

Figure 53. Impairments in the Beaver Meadow Creek Subwatershed.

4.3.1 Soils

Hydric soils cover 3,422.3 acres, or 32.6%, of the subwatershed. Highly erodible soils cover 6,798 acres, or 64.8% of the subwatershed. Almost all of the subwatershed (99.9%, or 10,485.3 acres) is identified as very limited for septic use. The majority of the 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.

4.3.2 Land Use

Beaver Meadow Creek Subwatershed has the greatest percentage of agricultural land use of all five subwatersheds with 93.1% (9,765.8 acres) of the land used for cultivated row crop and pasture and hay land. Urban land use accounts for 481.0 acres, or 4.6%, of the subwatershed. Forested land accounts for less than 2% (1.9%, or 198.8 acres) of land in the subwatershed. Wetland, open water, and grassland cover 43.4 acres, or 0.4%, of the subwatershed.

4.3.3 Point Source Water Quality Issues

There is one point source of water pollution in the Beaver Meadow Creek Subwatershed. One leaking underground storage tank (LUST) is located in the southern portion of the subwatershed, right off of US highway 52 (Figure 54).

4.3.4 Non-Point Source Water Quality Issues

Many agricultural non-point sources of pollution impact the Beaver Meadow Creek Subwatershed. In total, 13 unregulated animal operations housing more than 209 cows, horses, goats and sheep were identified during the windshield survey. One active concentrated animal feeding operation and two confined feeding operations are located within the subwatershed. (Figure 54). In total, manure from small animal operations, the CAFO and two CFOs is an estimated 52,305 tons per year, which contains an estimated 82,672 pounds of nitrogen, 45,011 pounds of phosphorus, and 4.19E+15 col of *E. coli*. Treated wastewater treatment plant sludge is permitted to be applied on approximately 654 acres of the Beaver Meadow Creek subwatershed. Based on windshield survey observations, livestock have access to none of the stream length in the subwatershed. Approximately 1.8 miles (9%) of streambank erosion were identified within the sub watershed. Additionally, 0.2 miles (1%) of narrowly buffered stream were observed in the Beaver Meadow Creek Subwatershed.

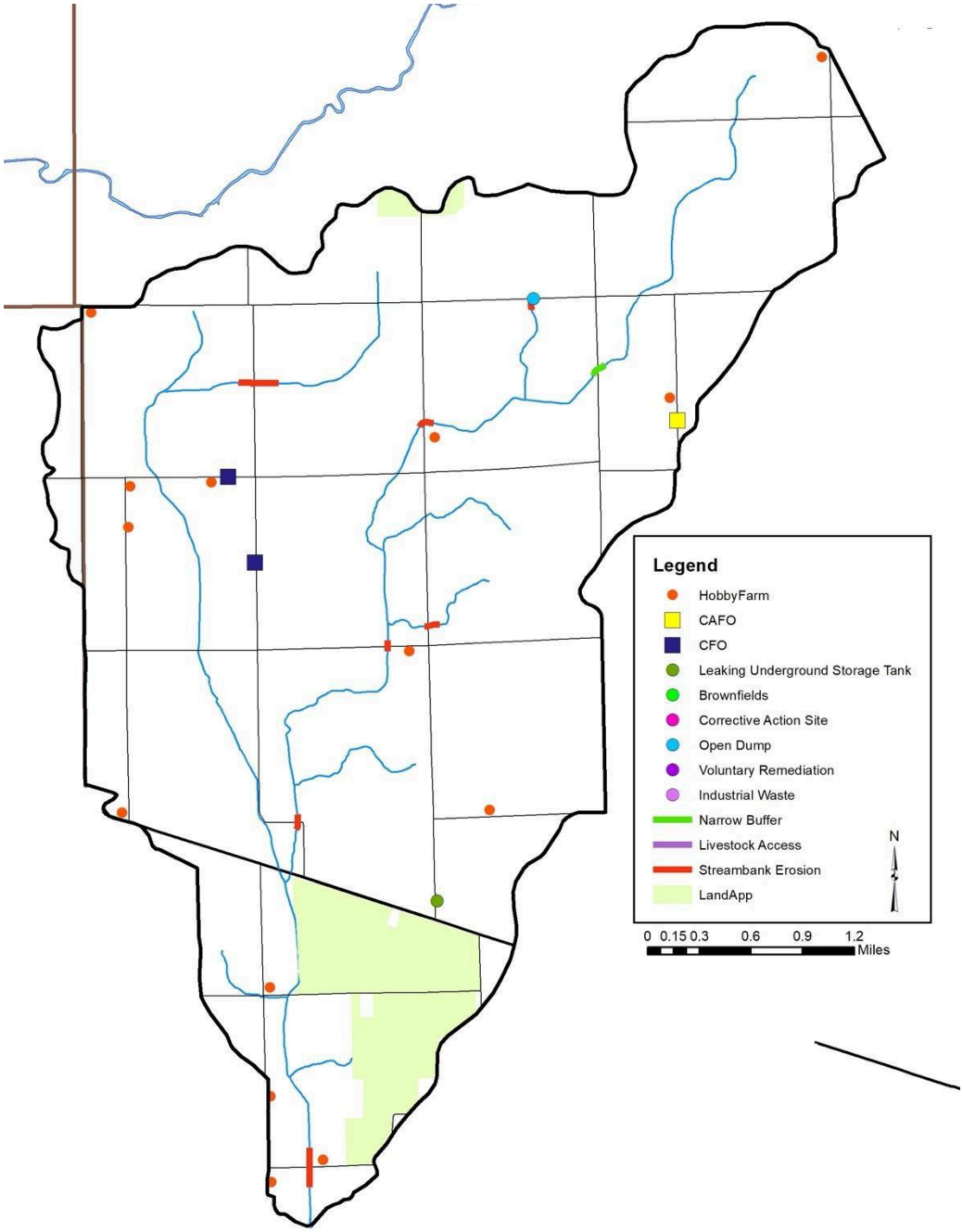

Figure 54. Point and non-point sources of pollution in the Beaver Meadow Creek Subwatershed.

4.3.5 Water Quality Assessment

Waterbodies within the Beaver Meadow Creek Subwatershed have been sampled at three locations (Figure 55). Assessments include collection of water chemistry data by IDEM at two sites and Hoosier Riverwatch, LARE, and Arion Consultants at the one site.

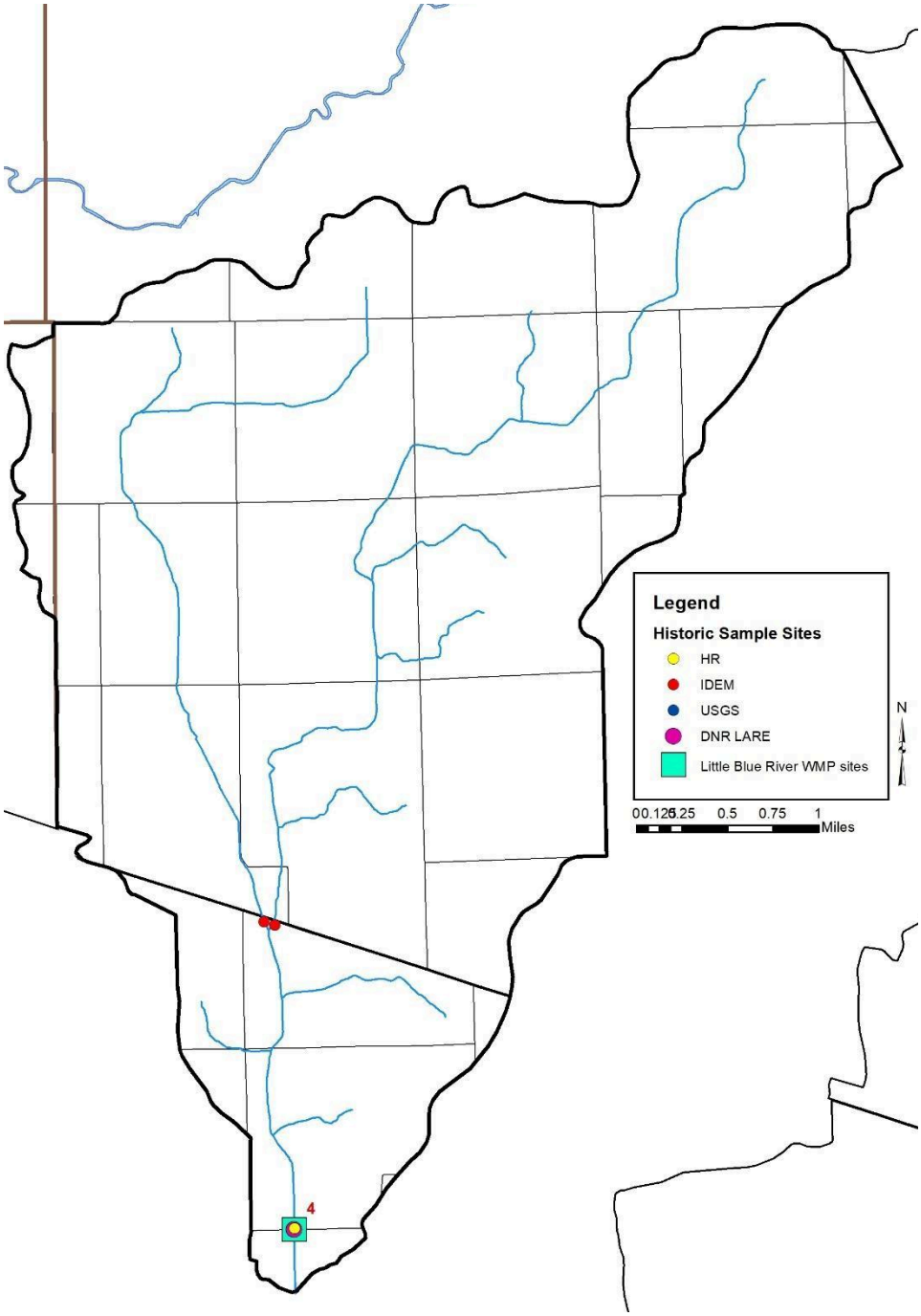

Figure 55. Locations of historic and current (Little Blue River WMP sites) water quality data collection in the Beaver Meadow Creek Subwatershed.

Table 21 details historic water quality data collected in the Beaver Meadow Creek Subwatershed (Site 4). As shown in the table, conductivity, DO, pH, TKN and total suspended solids did not exceed in any samples collected in this subwatershed. E. coli samples exceed state grab sample standards (235 col/100 ml) in 48% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 94% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 50% of samples. Turbidity levels exceed water quality targets (5.7 NTU) in 68% of samples.

Table 21. Beaver Meadow Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	610	610	0	1	0%
DO	6	12	0	21	0%
E. coli	0	11,000	12	25	48%
Nitrate-Nitrogen	0	33	16	17	94%
OP	0	2	10	12	83%
pH	6.5	8.5	0	20	0%
TKN	0.259	0.383	0	2	0%
Total Phosphorus	0.037	0.095	1	2	50%
Total Suspended Solids	1.2	11	0	2	0%
Turbidity	1.2	19	13	19	68%

Table 22 details water quality data collected in the Beaver Meadow Subwatershed (Site 4) sampled during the current project. As shown in the table, E. coli samples exceed state grab sample standards (235 col/100 ml) in 58% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 50% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 33% 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 75% of samples. Dissolved oxygen concentrations measured below water quality standards in 8% of samples collected. pH and conductivity did not exceed targets in any sample collected.

Table 22. Beaver Meadow Subwatershed water quality data summary, 2023-2024.

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)
4	Median	10.55	8.40	8.19	582.00	7.74	0.98	0.07	5.15	260.50
	Max	20.20	12.05	8.80	773.00	136.00	7.60	0.21	106.00	980.00
	Min	4.20	4.30	7.69	417.00	0.00	0.10	0.05	2.50	64.00
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		1	0	0	9	6	4	5	7
	% Exceed		8%	0%	0%	75%	50%	33%	42%	58%

Biological monitoring was conducted by IDEM at two sites and by JFNew at one site with three sites assessed for macroinvertebrates and three sites assessed for habitat. Habitat scores ranged from 52 to 60 with all sites scoring above the state target (51). Macroinvertebrate assessments rated moderately impaired to slightly impaired using the kick sampling method with all sites meeting their aquatic life use designation (Table 23). During the current assessment, the macroinvertebrate community rated fair (score of 44) and habitat rated fair (score of 45).

Table 23. Beaver Meadow Creek Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	44	60	1	4	25%
Fish (IBI)	--	--	--	--	--
Macroinvertebrates (mIBI, Kick)	3.8	5.0	0	3	0%
Macroinvertebrates (mIBI, Multi Habitat)	44	44	0	1	0%

4.4 Manilla Branch-Little Blue River Subwatershed

The Manilla Branch-Little Blue River Subwatershed is located immediately below Beaver Meadow Creek Subwatershed and Gilson Creek-Little Blue River Subwatershed and lies within Shelby and Rush Counties (Figure 46). It encompasses one 12-digit HUC watershed: 051202040204. This subwatershed drains 10,606 acres and accounts for 15.8% of the total watershed area. There are 18.94 miles of stream. IDEM has classified 18.94 miles of stream as impaired for *E. coli* (Figure 56).

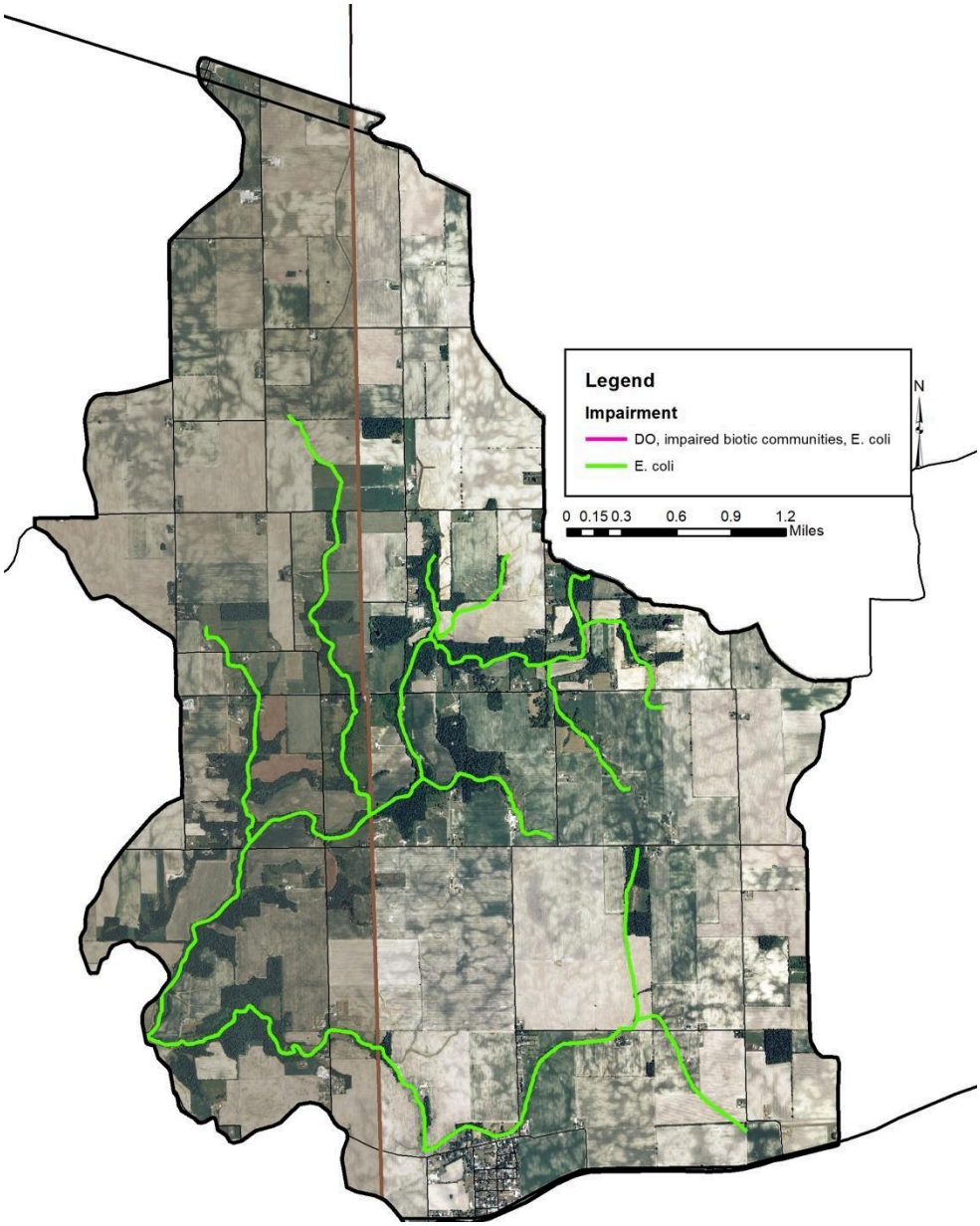

Figure 56.Impairments in Manilla Branch-Little Blue River Subwatershed.

4.4.1 Soils

Hydric soils cover 3,537.7 acres, or 33.4%, of the subwatershed. Highly erodible soils cover 6,498.2 acres, or 61.3% of the subwatershed. Almost all of the subwatershed (99.8%, or 10,587.6 acres) is identified as very limited for septic use. The majority of the 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.

4.4.2 Land Use

Agricultural land use is prevalent throughout this watershed, with 85.9% (9,097.0 acres) of the land used for cultivated row crop and pasture and hay land. Forested land accounts for 7.8% (830.6 acres) of

land in the subwatershed. Urban land use accounts for 615.3 acres, or 5.8%, of the subwatershed. Wetland, open water, and grassland cover 53.3 acres, or 0.5%, of the subwatershed.

4.4.3 Point Source Water Quality Issues

There is one point source of water pollution in the Manilla Branch-Little Blue River Subwatershed (Figure 57). One leaking underground storage tank (LUST) is located in the southern portion of the subwatershed, near Manilla.

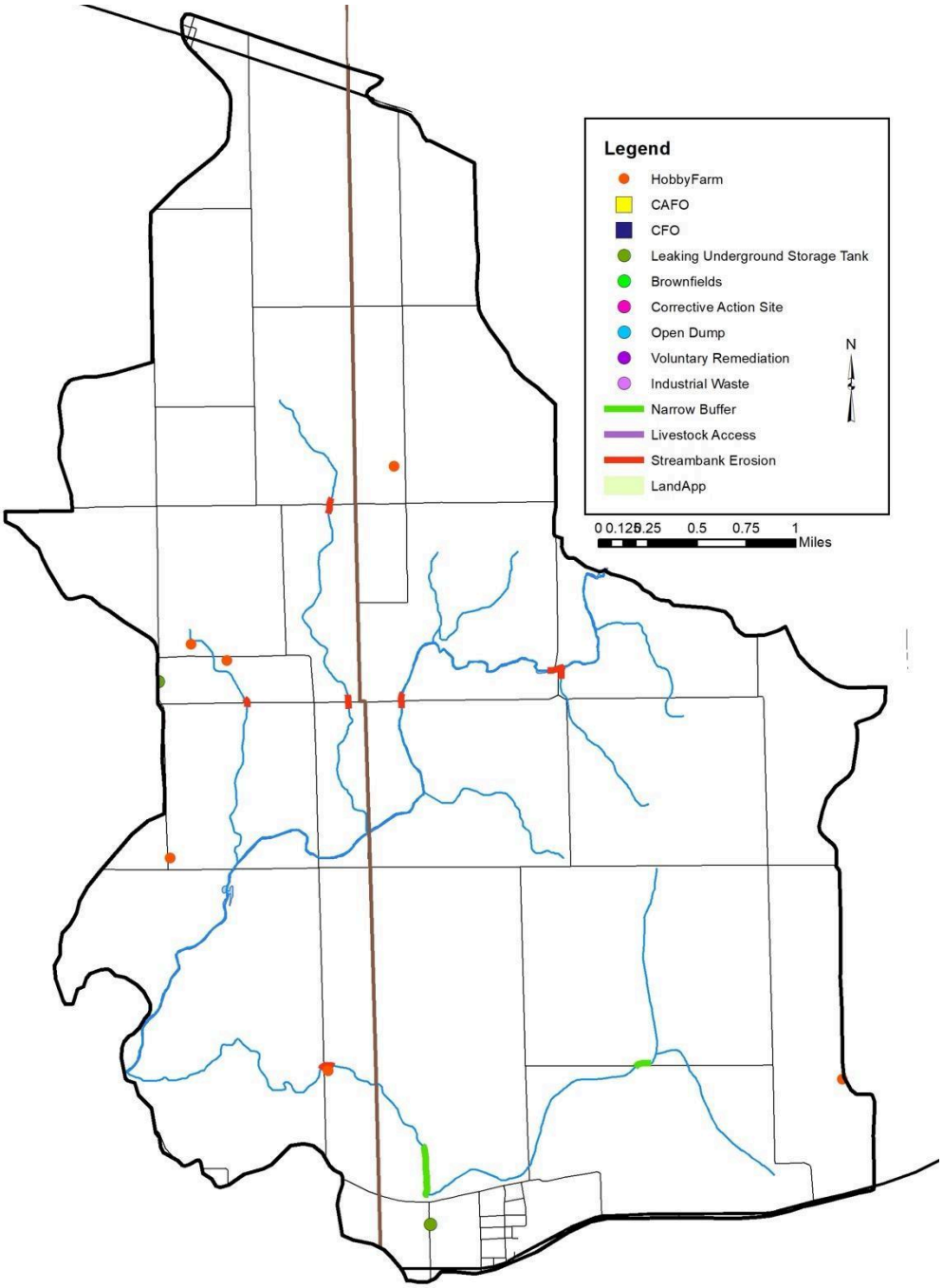

Figure 57. Point and non-point sources of pollution in the Manilla Branch-Little Blue River Subwatershed.

4.4.4 Non-point Source Water Quality Issues

Manilla Branch-Little Blue River Subwatershed has the smallest number of observed animal operations of all of the subwatersheds. Six unregulated animal operations housing more than 60 cows, horses and goats were identified during the windshield survey (Figure *57*). In total, manure from small animal operations is an estimated 1,187 tons per year, which contains an estimated 653 pounds of nitrogen, 344 pounds of phosphorus and 3.91E+13 col of *E. coli*. Based on windshield survey observations, livestock have access to none of the stream length in the subwatershed. Approximately 1 mile (5%) of streambank erosion was identified within the subwatershed. Additionally, 0.7 miles (4%) of narrowly buffered stream were observed in the Manilla Branch-Little Blue River Subwatershed.

4.4.5 Water Quality Assessment

Waterbodies within the Manilla Branch-Little Blue River Subwatershed have been sampled at four locations (Figure 58). Assessments include collection of water chemistry data by Hoosier Riverwatch at two sites, DNR LARE and Hoosier Riverwatch at the same one site, and Arion Consultants and DNR LARE at the same one site.

Table 24 details historic water quality data collected in Manilla Branch-Little Blue River Subwatershed. As shown in the table, conductivity, DO, pH and TKN did not exceed in any samples collected. *E. coli* samples exceed state sample standards (235 col/100 ml) in 53% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 95% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 25% 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 93% of samples.

Table 24. Manilla Branch-Little Blue River Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	470	612	0	2	0%
DO	5	11	0	40	0%
E. coli	0	2000	21	40	53%
Nitrate-Nitrogen	0	33	38	40	95%
OP	0	0.9	32	36	89%
pH	6	9	0	40	0%
TKN	0.23	0.463	0	4	0%
Total Phosphorus	0.04	0.103	1	4	25%
Total Suspended Solids	1.33	25.25	1	4	25%
Turbidity	0.9	60	37	40	93%

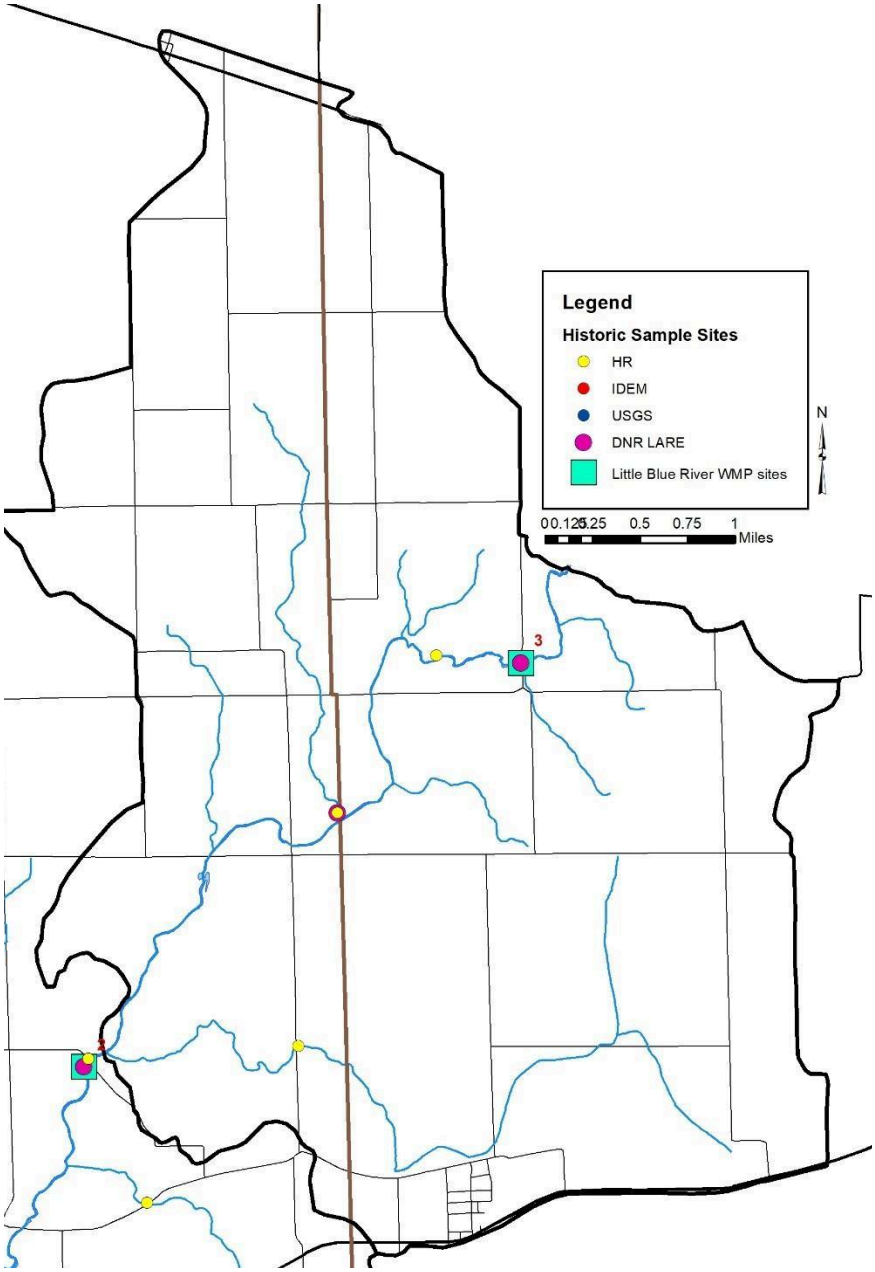

Figure 58. Locations of historic and current (Little Blue River WMP sites) water quality data collection in the Manilla Branch-Little Blue River Subwatershed.

Table 25 details water quality data collected in the Manilla Branch-Little Blue River 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 50% of samples collected. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 50% 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 58% of samples. Dissolved oxygen concentrations measured below water quality standards in 11% of samples collected. pH and conductivity did not exceed targets in any sample collected.

Table 25. Manilla Branch-Little Blue River Subwatershed water quality data summary, 2023-2024.

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	10.40	10.70	8.05	526.50	9.85	1.11	0.09	10.95	151.00
	Max	23.30	12.79	8.90	590.00	68.00	7.70	0.28	53.50	770.00
	Min	3.90	8.00	7.60	403.00	0.00	0.10	0.05	2.50	33.00
	#Samples	12	9	12	12	12	12	12	12	12
	#Exceed		1	0	0	7	6	6	5	4
	% Exceed		11%	0%	0%	58%	50%	50%	42%	33%

Biological monitoring was conducted by JFNew at two sites with all sites assessed for macroinvertebrates and habitat. Habitat scores ranged from 45 to 64 with 33% of sites scoring below the state target (51). Macroinvertebrate assessments rated moderately impaired to not impaired using the kick sampling method with all sites meeting their aquatic life use designation (Table 26). During the current assessment, the macroinvertebrate community rated fair (score of 42) and habitat rated fair (score of 48.3).

Table 26. Manilla Branch-Little Blue River Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	45	64	2	4	25%
Fish (IBI)	--	--	--	--	--
Macroinvertebrates (mIBI, Kick)	3.25	7.25	0	2	0%
Macroinvertebrates (mIBI, Multi Habitat)	42	44	0	2	0%

4.5 Town of Rays Crossing-Little Blue River Subwatershed

The Town of Rays Crossing-Little Blue River Subwatershed is the southernmost subwatershed receiving drainage from all of the other subwatersheds and lies within Shelby and Rush Counties (Figure 46). It encompasses one 12-digit HUC watershed: 051202040205. This subwatershed drains 14,140 acres and accounts for 21.1% of the total watershed area. There are 28.32 miles of stream. IDEM has classified 28.32 miles of stream as impaired for *E. coli* (Figure 59).

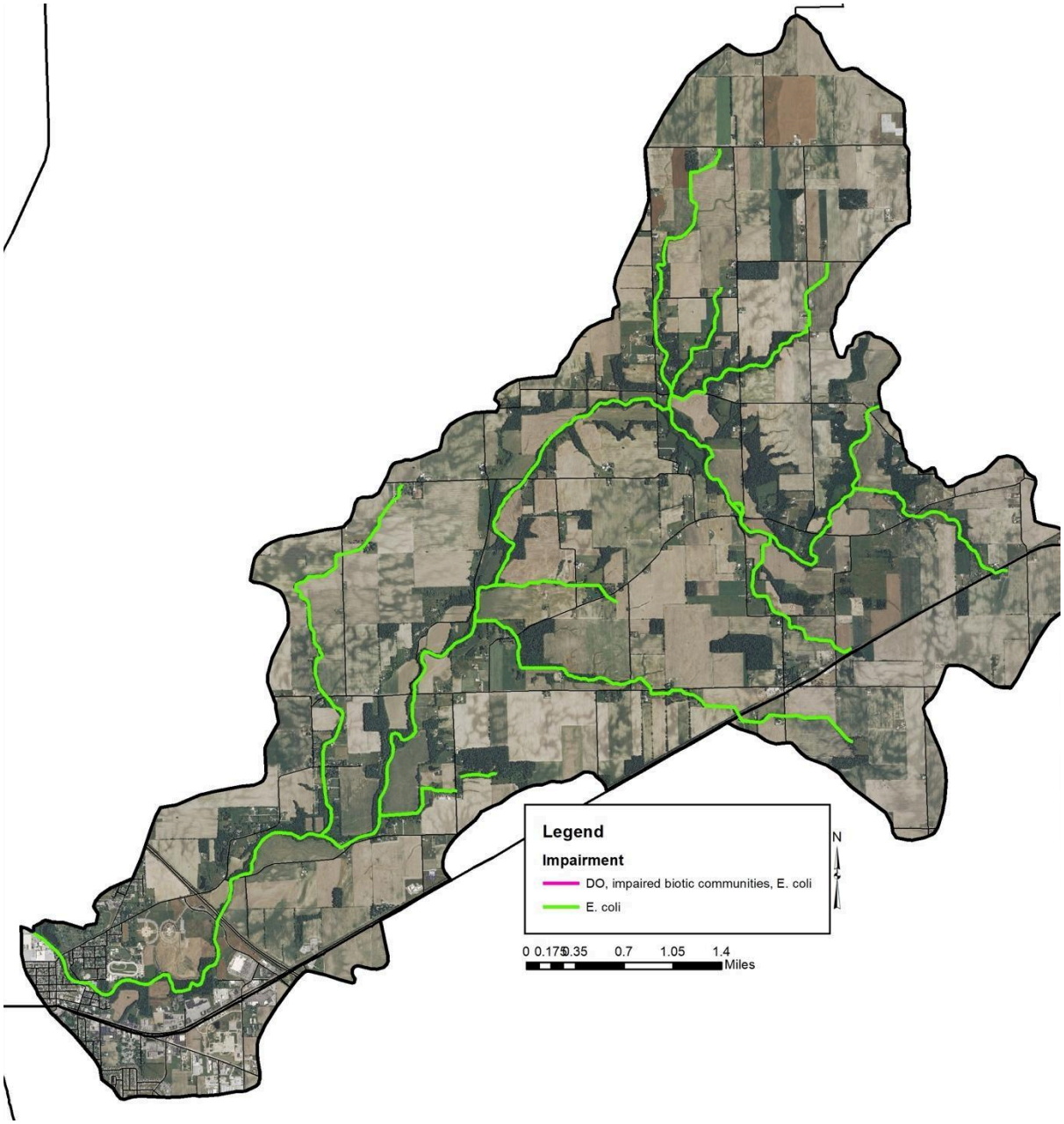

Figure 59. Impairments in the Town of Rays Crossing-Little Blue River Subwatershed.

4.5.1 Soils

Hydric soils cover 3,537.7 acres, or 25.0%, of the subwatershed. Highly erodible soils cover 8,607.9 acres, or 60.9%, of the subwatershed. A majority of the subwatershed (99.4%, or 14,056.2 acres) is identified as very limited for septic use. The majority of the 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.

4.5.2 Land Use

Town of Rays Crossing-Little Blue River Subwatershed has the lowest percent agricultural land use of all subwatersheds. Agricultural land uses are still prevalent with 78.1% (11,042.4 acres) of the land used for

cultivated row crop and pasture and hay land. Forested land use and urban land use is highest in this subwatershed compared to the others with 1,270.1 acres (9.0%) of forest and 1,721.2 acres (12.2%) of urban area. Wetland, open water, and grassland cover the remaining 100.1 acres, or 0.7%, of the subwatershed. Shelbyville, Indiana is located within this subwatershed contributing to the comparatively lower agricultural land use and greater urban land use.

4.5.3 Point Source Water Quality Issues

There are a number of point sources of water pollution in the Town of Rays Crossing-Little Blue River Subwatershed (Figure *60*). Ten leaking underground storage tanks (LUST) are in the southern portion of the subwatershed, primarily located near State Road 44. One brownfield and four industrial waste sites are in the subwatershed all located in or near the City of Shelbyville. Additionally, one voluntary remediation program (VRP) site is located In Shelbyville.

4.5.4 Non-point Source Water Quality Issues

In total, 18 unregulated animal operations housing more than 60 cows, horses, goats, and pigs were identified during the windshield survey (Figure 60). In total, manure from small animal operations is an estimated 2,563 tons per year, which contains an estimated 1,354 pounds of nitrogen, 690 pounds of phosphorus, and 7.02E+13 col of *E. coli*. Based on windshield survey observations, livestock have access to 0.6 miles (2%) of stream length in the subwatershed. Approximately 2.8 miles (10%) of streambank erosion was identified within the subwatershed. Additionally, 0.5 miles (2%) of narrowly buffered stream were observed in the Town of Rays Crossing-Little Blue River Subwatershed.

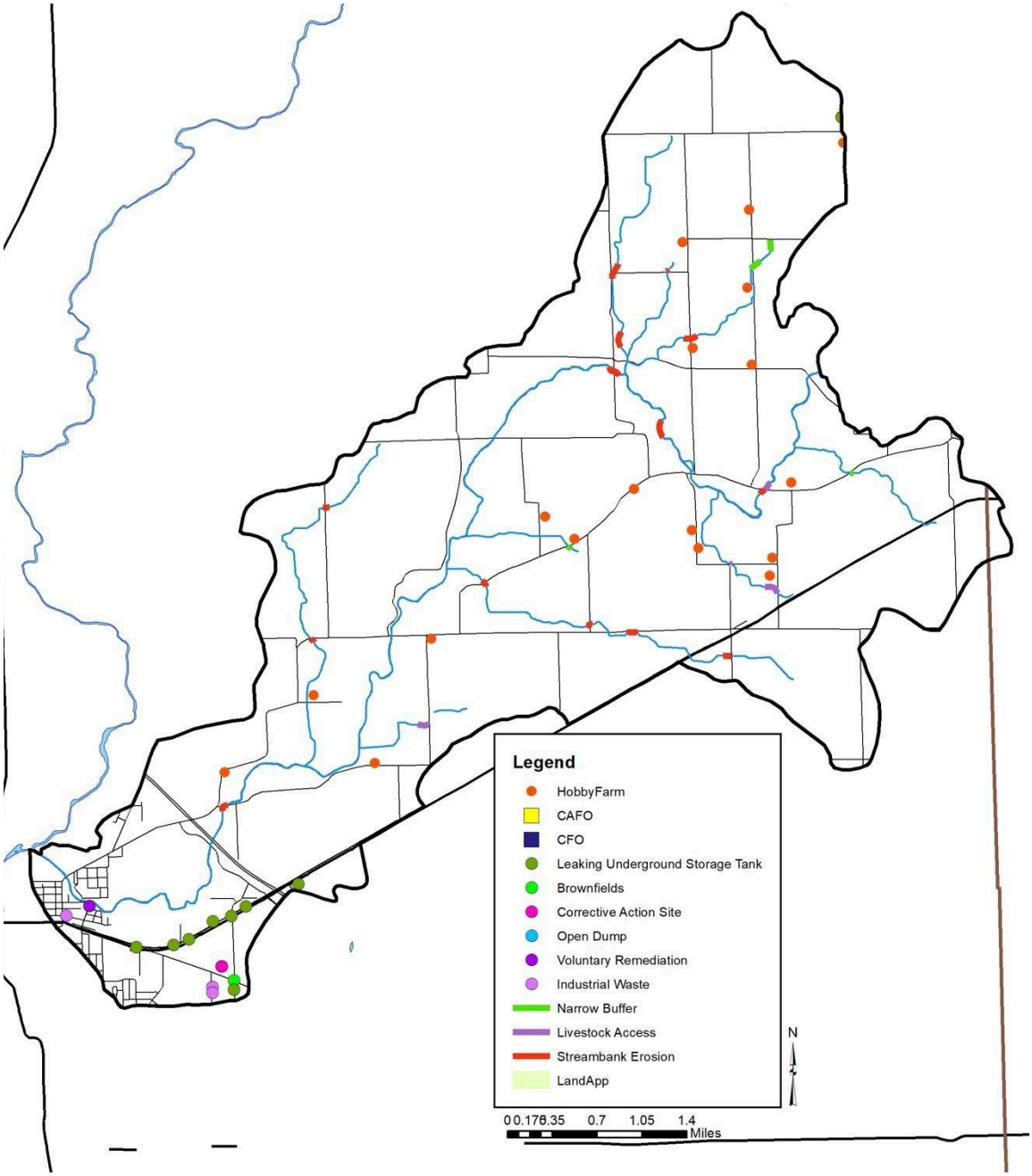

Figure 60. Point and non-point sources of pollution in the Town of Rays Crossing-Little Blue River Subwatershed.

4.5.5 Water Quality Assessment

Waterbodies within the Town of Rays Crossing-Little Blue River Subwatershed have been sampled at 19 locations (Figure 61). Assessments include collection of water chemistry data IDEM at 11 sites, Hoosier Riverwatch at five sites, USGS at two sites, DNR LARE at three sites, and Arion Consultants at one site.

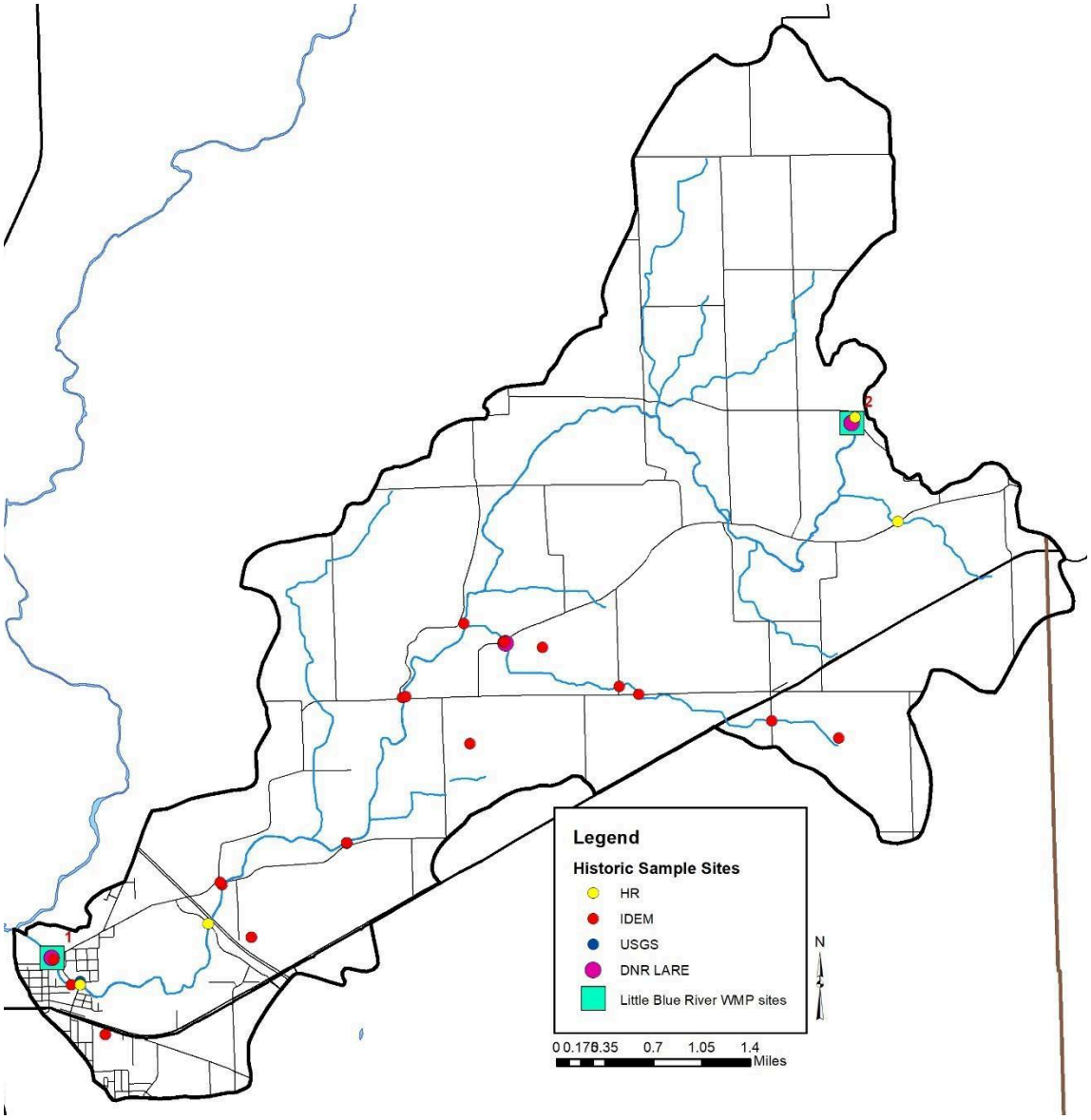

Figure 61. Locations of historic and current (Little Blue River WMP sites) water quality data collection in the Town of Rays Crossing-Little Blue River Subwatershed.

Table 27 details historic water quality data collected in the Town of Rays Crossing-Little Blue River Subwatershed. As shown in the table, conductivity and pH did not exceed in any samples collected in this subwatershed. Ammonia exceeded standards in 25% of samples. *E. coli* samples exceed state sample standards (235 col/100 ml) in 50% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 84% of samples, while TKN concentrations exceed water quality targets (0.57 mg/L) in 37% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 33% of samples. Total suspended solids concentrations exceeded water quality targets (15 mg/L) in 26% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 73% of samples.

Table 27. Town of Rays Crossing-Little Blue River Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Ammonia	0.02	0.25	1	4	25%
Conductivity	608	635	0	3	0%
DO	3	14.3	13	209	6%
E. coli	0	18000	87	174	50%
Nitrate-Nitrogen	0	88	92	109	84%
OP	0	4	88	107	82%
pH	6	9	0	216	0%
TKN	0.23	1.8	7	19	37%
Total Phosphorus	0.061	0.196	2	6	33%
Total Suspended Solids	0	62	6	23	26%
Turbidity	1.2	395	146	200	73%

Table 28 details water quality data collected in the Town of Rays Crossing-Little Blue River Subwatershed (Site 1) sampled during the current project. As shown in the table, *E. coli* samples exceed state grab sample standards (235 col/100 ml) in 58% 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 25% of samples at Site 1. Total suspended solids concentrations exceed water quality targets (15 mg/L) in 25% of samples, while turbidity levels exceed water quality targets (5.7 NTU) in 67% of samples. Dissolved oxygen concentrations measured below water quality standards in 17% of samples collected. pH and conductivity did not exceed targets in any sample collected.

Table 28. Town of Rays Crossing-Little Blue River Subwatershed water quality data summary, 2023-2024.

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	10.90	9.40	8.17	540.00	12.49	1.01	0.07	4.60	326.00
	Max	23.00	13.50	9.00	605.00	80.60	6.60	0.27	60.60	1733.00
	Min	4.40	7.10	7.40	350.00	0.00	0.15	0.05	2.50	53.00
	#Samples	12	12	12	12	12	12	12	12	12
	#Exceed		2	0	0	8	7	3	3	7
	% Exceed		17%	0%	0%	67%	58%	25%	25%	58%

Biological monitoring was conducted by IDEM at two sites and by JFNew at three sites with four sites assessed for macroinvertebrates, two sites assessed for fish and five sites assessed for habitat. Habitat scores ranged from 30 to 81 with 25% of sites scoring below the state target (51). Fish community assessments rated poor with 100% of assessments not meeting their aquatic life use designation. Macroinvertebrate assessments rated moderately impaired to slightly impaired using the kick sampling

method with all sites meeting their aquatic life use designation and from 30 to 44 with 50% of multihabitat samples not meeting their aquatic life use designation (Table 29). During the current assessment, the macroinvertebrate community rated poor and fair (score of 30) and habitat rated good (score of 64.5).

Table 29. Town of Rays Crossing-Little Blue River Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	43	81	2	11	18%
Fish (IBI)	44	48	3	3	100%
Macroinvertebrates (mIBI, Kick)	2.75	5.25	0	4	0%
Macroinvertebrates (mIBI, Multi Habitat)	44	44	2	4	50%

5.0 WATERSHED INVENTORY III: WATERSHED INVENTORY SUMMARY

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

5.1 Water Quality Summary

Several water quality impairments were identified during the watershed inventory process, based on historic data collected from Indiana Department of Environmental Management, Indiana Department of Natural Resources, JFNew via the Indiana DNR Lake and River Enhancement Program (LARE) and U.S. Geological Survey (USGS) and Hoosier Riverwatch volunteers as well as current water quality assessments conducted during the current project. These impairments include elevated nutrient, sediment and *E. coli* concentrations. Based on historic data, Table 30 highlights those locations within the Little Blue River Watershed where concentrations of these parameters measured higher than the target concentrations or those locations where impaired waterbodies were identified by IDEM. Table 30 summarizes where historic samples were outside the target values and are grouped by subwatershed. Figure 62 shows the locations of historical sites that exceeded target values. Sample sites are mapped only if 50% or more of samples collected at those sites were outside the target values.

Table 30. Percent of samples historically collected in Little Blue River subwatersheds which measured outside target values.

Subwatershed	DO (mg/L)	Ecoli (col/100 ml)	Nitrate (mg/L)	OP (mg/L)	TKN (mg/L)	TP (mg/L)	TSS (mg/L)	Turb (NTU)
Beaver Meadow Creek	0%	48%	94%	83%	0%	50%	0%	68%
Gilson Creek-LBR	8%	40%	100%	88%	33%	33%	20%	75%
Headwaters LBR	0%	26%	100%	83%	50%	50%	50%	87%
Manilla Branch-LBR	0%	53%	95%	89%	0%	25%	25%	93%

Town of Rays Crossing-LBR	6%	50%	84%	82%	37%	33%	26%	73%

Historic nitrate-nitrogen concentrations sampled in all subwatersheds exceeded targets in more than 50% of samples collected. Total phosphorus concentrations in the Beaver Meadow Creek and Headwaters Little Blue River subwatersheds exceeded water quality targets in 50% of samples collected. Total Kjeldahl nitrogen concentrations measured in the Headwaters Little Blue River subwatershed exceeded water quality targets in 50% of historic samples. E. coli concentrations measured in Manilla Branch-Little Blue River exceeded state standards in more than 50% of samples collected while Town of Rays Crossing-Little Blue River exceeded state standards in 50% of collected samples. A limited number of dissolved oxygen exceedances occurred historically in the Gilson Creek-little Blue River and Town of Rays Crossing-Little Blue River subwatersheds. No conductivity or pH exceedances occurred in the Little Blue River historically. TSS concentrations exceeded water quality targets in 50% of collected samples in the Headwaters Little Blue River subwatershed, while turbidity levels exceeded water quality targets in more than 50% of collected samples in all subwatersheds historically.

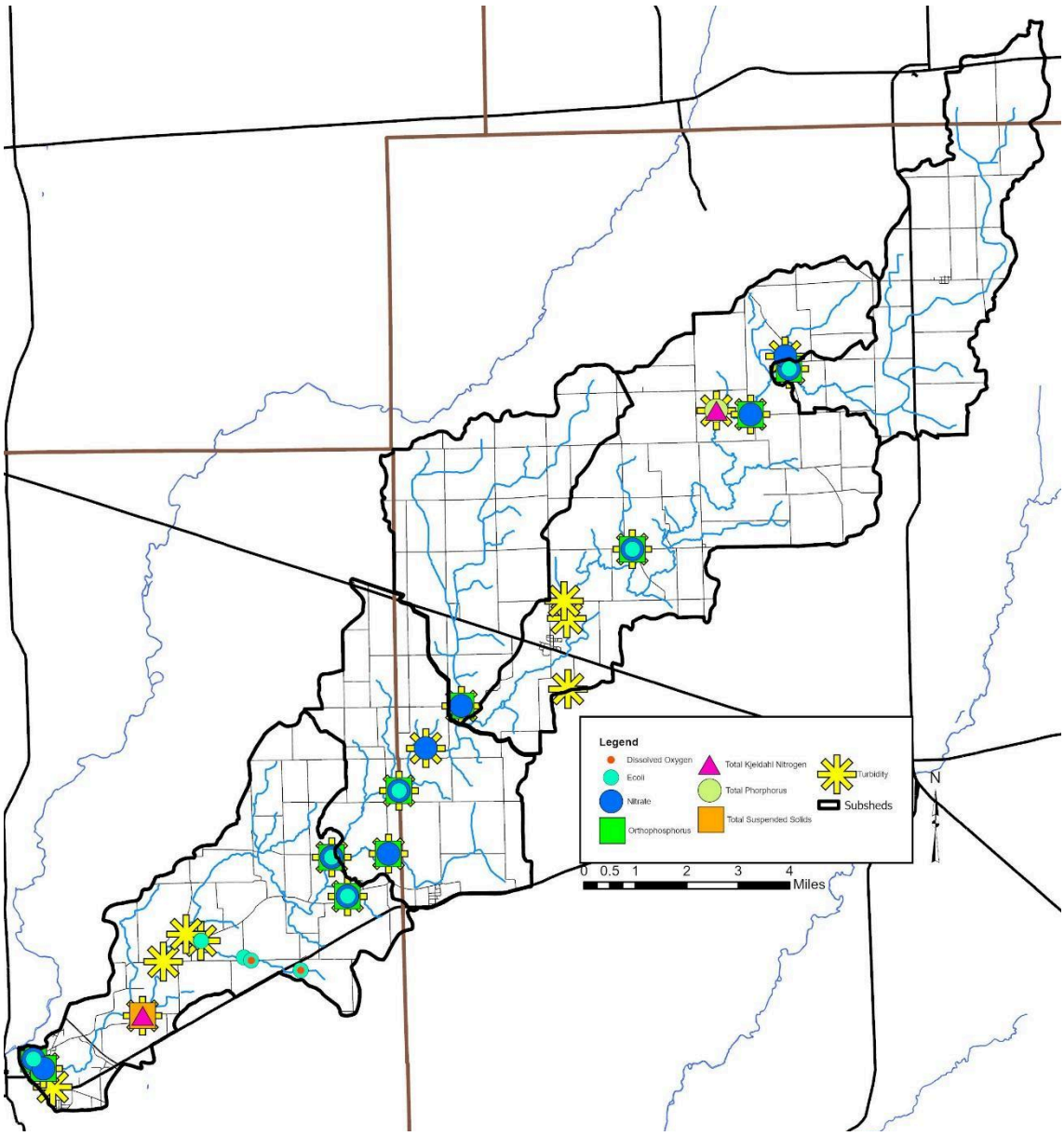

Figure 62. Little Blue River Watershed historical sampling sites that exceed target values.

Table 31 summarizes current samples which measured outside the target values during the current assessment. Figure 63 provides a map of current sampling sites that exceed target values. Elevated nitrate-nitrogen concentrations were observed in all subwatershed with sites in Beaver Meadow Creek, Gilson Creek-Little Blue River, Manilla Branch-Little Blue River and Town of Rays Crossing-Little Blue River in 50% or more of collected samples. In total, 56% of collected samples throughout the watershed exceeded nitrate-nitrogen target concentrations. Elevated total phosphorus concentrations were observed at all sample sites with concentrations exceeding total phosphorus targets in 49% of collected samples. Headwaters Little Blue River, Gilson Creek-Little Blue River and Manilla Branch-Little Blue River samples exceeded target total phosphorus concentrations in 50% or more of collected samples. Elevated total suspended solids concentrations were observed at all sites with 29% of all samples exceeding targets. However, no site exceeded target TSS concentrations in more than half of collected

samples. Rather, TSS concentrations generally measured low then increased to concentrations higher than targets during storm flow events. *E. coli* concentrations that exceeded the state grab sample standard were measured at all sites. Exceedances were most common at Beaver Meadow Creek, Headwaters Little Blue River and Town of Rays Crossing-Little Blue River sites. In total, 50% of samples exceeding state standards.

Table 31. Percent of samples collected in the Little Blue River Watershed during the 2023-2024 sample collection which measured outside target values.

	DO (mg/L)	Turbidity (NTU)	Cond	TP (mg/L)	Nitrate (mg/L)	TSS (mg/L)	E. coli (col/100 ml)
Beaver Meadow Creek (S4)	8%	75%	0%	33%	50%	42%	58%
Headwaters LBR (S6)	0%	67%	8%	58%	42%	25%	67%
Gilson Creek-LBR (S3, S5)	17%	63%	13%	63%	75%	21%	42%
Manilla Branch-LBR (S2)	11%	58%	0%	50%	50%	42%	33%
Town of Rays Crossing-LBR (S1)	17%	67%	0%	25%	58%	25%	58%

All sites exceeded dissolved oxygen state standards; however, none of the sites exceeded dissolved oxygen standards in a majority of collected samples. Specific conductivity exceeded targets at one site in the Headwaters Little Blue River and one site in the Gilson Creek-Little Blue River subwatershed. pH concentration did not exceed water quality targets.

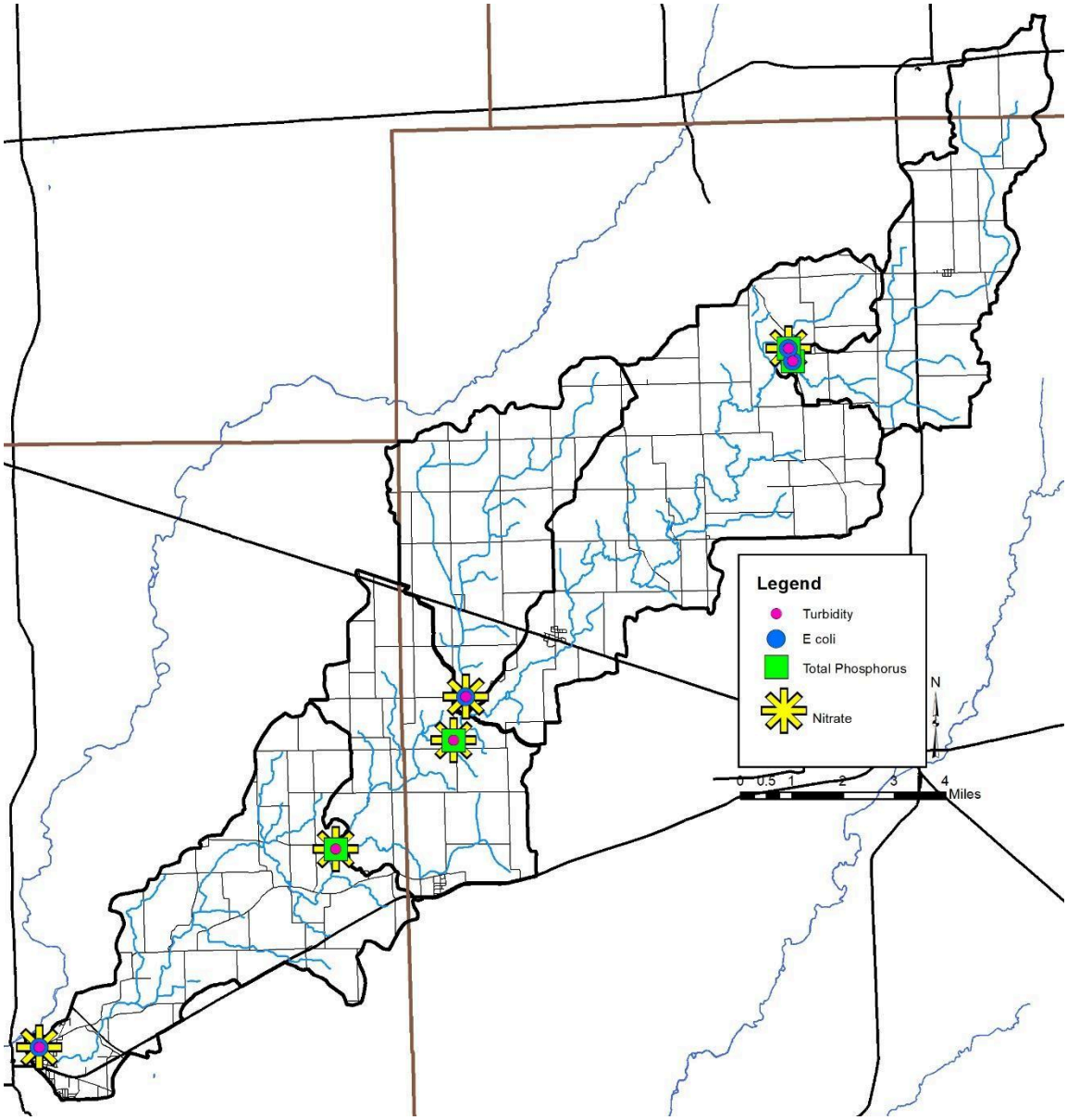

Figure 63. Little Blue River Watershed sampling sites that exceed target values during the current sampling period.

Biological assessments of the macroinvertebrate community and an associated habitat assessment occurred once during the project. There is not pattern between habitat, macroinvertebrate community and fish community ratings (Table 32). Site 1 (Little Blue River at Morris Ave) possessed the highest rated habitat but its macroinvertebrate community rated as poor (impaired), while Site 3 (Little Blue River at CR 900 W) possessed the second highest habitat score and the highest macroinvertebrate community rating (good).

Table 32. Biological and habitat assessment summary for Little Blue River Watershed streams. Green shading indicates the highest rated stream reaches, while red indicates the poorest rated reaches.

Site	Subwatershed	QHEI	mIBI
1	Town of Rays Crossing	Good	Poor
2	Manilla Branch	Fair	Fair
3	Gilson Creek	Good	Fair
4	Beaver Meadow	Fair	Fair
5	Gilson Creek	Very Poor	Fair
6	Headwaters-Little Blue River	Poor	Poor

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 33. 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.

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:

- Local recreation options should be improved.
- High quality habitats need protected
- Illegal dumping along the river, its tributaries and in rural areas.
- Can we eat the fish in the stream?
- Newly designated legal drain in Rush County - potential impacts for water quality, quantity, management and funding.
- Make drainage more effective.

The steering committee noted that illegal dumping and fish consumption concerns would be addressed through education and outreach only. The committee noted that local recreation and the protection of high quality habitats are important but determined that the promotion of recreation, protection of high quality habitat and additional river access should be handled through means outside of this planning process. Additionally, the committee identified that drainage does impact water quality within the Little Blue River; however, modification of drainage was not deemed something that the committee could impact and thus, it was determined to be outside the project's scope.

Table 33. Analysis of stakeholder concerns identified in the Little Blue River Watershed.

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Elevated nutrient levels	Yes	Historic data indicate 94% of nitrate, 31% of TKN, 14% of ammonia, 35% of TP and 3% of orthophosphorus samples exceed water quality targets. 70% of nitrate and 71% of TP samples collected Feb 2023-Jan 2024 exceed water quality targets.	Yes	No	Yes
Water is cloudy, especially after it rains	Yes	Historic data indicate 25% of TSS and 77% of turbidity samples exceed water quality targets. 33% of TSS samples and 43% of turbidity samples collected Feb 2023-Jan 2024 exceed water quality targets.	Yes	No	Yes
Impaired biotic communities	Yes	52.3 miles of watershed streams are impaired for biotic communities.	Yes	No	Yes
E. coli levels are high (impaired streams) Can we swim/canoe on the stream?	Yes	125 miles of watershed streams are impaired for E. coli. IDEM calculated an 11% E. coli reduction required in the Headwaters LBR, 16% in the Beaver Meadow Creek, 0% in Gilson Creek-LBR and 65% in the Town of Rays Crossing-LBR subwatersheds. 46% of historic samples exceed state standards for E. coli. 33% of samples collected Feb 2023-Jan 2024 exceed state standards for E. coli.	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Low dissolved oxygen levels	Yes	52 miles of watershed streams are impaired for DO. 8% of samples collected Feb 2023-Jan 2024 exceed state standards for DO.	Yes	No	Yes
Can we eat the fish in the stream?	Yes	Fish consumption advisories are in place for Shelby and Rush county streams including buffalo, bullhead, carpsuckers, channel catfish, common carp, crappie, flathead catfish, freshwater drum, large/smallmouth bass, northern pike, redhorse, rock bass, sauger, silver carp, spotted bass, sunfish, walleye and white striped bass.	Yes	Yes	No – education only
Flooding Flooding impacts to agricultural cropland, property value impacts	Yes	Category C/D and B/D soils dominate the watershed - C/D and B/D soils risk frequent flooding and high amounts of runoff when undrained, while still having slow to moderate infiltration rates when drained. Approximately 63% of the watershed is tile drained. Approximately 4% of the watershed lies within the 100-year floodplain.	Yes	No	Yes
Local recreation options should be improved	Yes	There are 10 recreational resources and natural areas including parks, fairgrounds, campgrounds and school grounds. Only	Yes	Yes	No Planning/recreation not focus

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
		two provide access to the Little Blue River.			
Illegal dumping along the river, its tributaries and in rural areas Trash	Yes	Personal observations indicate several locations where trash piles or illegal dumping locations occur throughout the watershed.	Yes	Yes	Yes – Education only
Newly designated legal drain in Rush County - potential impacts for water quality, quantity, management and funding	Yes	Regulated or legal drains are maintained by the county surveyor's office. 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.	Yes	Yes	No
Make drainage more effective	Yes		Yes	Yes	No
Stormwater runoff	Yes	A portion of the Shelbyville MS4 (1,161 acres) is located in the watershed. Nearly 7% of the watershed is covered by urban land uses.	Yes	No	Yes
Streambank erosion	Yes	9.9 miles of eroding streambank were noted during the windshield survey. 2.6 miles of streams with livestock access were noted during the windshield survey.	Yes	No	Yes
Logjams, logjam impacts, logjam removal	Yes	Logjams were identified during the windshield inventory. Anecdotal information documents the presence of logjams.	Yes	No	Yes **DNR log jam rules education – newsletter or handout
Wind and water erosion of soil impacts field productivity	Yes	62% of the watershed is covered by highly erodible soils.	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Mussel species need protected - good water quality, regular instream flows, limit hydromodification	Yes	8 mussel species (state/federally endangered, species of special concern) have been identified in the Little Blue River.	Yes	No	Yes
High quality habitats need protected	Yes	The DNR lists Central Till Plain Flatwoods as a high quality natural community in the watershed.	Yes	Yes	No

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 34. Problems represent the condition that exists due to a particular concern or group of concerns, then details potential causes of problems identified.

Table 34. Problems and causes identified for the Little Blue River watershed based on stakeholder and inventory concerns.

Concern(s)	
● Streambank Erosion ● Wind and water erosion of soil impacts field productivity ● Water is cloudy, especially after it rains ● Flooding impacts to agricultural cropland, property value impacts ● Flooding ● Stormwater runoff	**Problem:** Sediment: area streams are cloudy/turbid
	Cause(s): Suspended Sediment concentration levels exceed the target set by this project
● Elevated nutrient levels ● Streambank erosion ● Wind and water erosion of soil impacts field productivity ● Water is cloudy, especially after it rains ● Flooding impacts to agricultural cropland, property value impacts ● Flooding ● Stormwater runoff ● Low dissolved oxygen levels	**Problem:** Nutrients: Area streams have nutrient levels exceeding the target set by this project
	Cause(s): Nutrient levels exceed the target set by this project Targeted nutrient reduction education does not exist
● E. coli levels are high (impaired streams)	**Problem**: E. coli: Area streams are impaired for recreational contact by IDEM's 303(d) list
	Cause(s): E.coli levels exceed the water quality standard

• High quality habitats need protected • Mussel species need protected – good water quality, regular instream flows, limit hydromodification • Impaired biotic communities	**Problem:** Habitat impacts **Cause(s)**: Habitat modification both historic and present day altered the watershed use and impacted biological communities
• Logjams, logjam impacts, logjam removal • Trash • Illegal dumping along the river, its tributaries and in rural areas • Flooding	**Problem**: Education and cohesion is lacking **Cause(s)**: Local regulations are key to minimizing impacts from development in the watershed. Lack of focused education programming focused on agricultural/rural area and agricultural area highlighting their common ground and differences.

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 Little Blue River Watershed. These and other potential sources of these causes are discussed in further detail in subsequent sections. A summary of potential sources identified in the Little Blue River Watershed for each of our concerns is listed below:

Sediment:

- Conventional tillage cropping practices
- Streambank and bed erosion
- Poor riparian buffers
- Poor forest management
- Gully or ephemeral erosion
- Cropped floodplains
- Livestock access to streams
- Altered hydrology (ditching and draining, altered stream courses)
- Urban land use and development impacts (diffuse, disorganized, lack of proper stabilization technique use)
- Invasive species impacts to land cover/soil stability
- Stormwater from municipal sources (MS4s)

Nutrients (Nitrogen and Phosphorus):

- Conventional tillage cropping practices
- 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, sanitary sewer overflows, inadequately treated wastewater)
- 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, sanitary sewer overflows, inadequately treated wastewater)
- Animal waste (livestock in streams, poor manure management, domestic and wildlife runoff)

7.2 Potential Sources of Pollution

The steering committee used GIS data, water quality data, watershed inventory observations and anecdotal information as available to evaluate the potential sources of nonpoint pollution in the Little Blue River Watershed. Appendix B contains tables detailing each potential source within each subwatershed. Table 35 through Table 39 summarizes the magnitude of potential sources of pollution for each problem identified in the Little Blue River Watershed. Several sources listed above are not included below as specific data for each concern is not available: conventional tillage by subwatershed; 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; invasive species (a list was developed but the volume was not assessed).

Table 35. 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:	● 9.9 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization Town of Rays Crossing-Little Blue River (10%), Beaver Meadow Creek (9%) and Gilson Creek-Little Blue River (8%) subwatersheds. ● Livestock access (2.6 miles of streams) was observed in the Headwaters Little Blue River, Gilson Creek-Little Blue River and Town of Rays Crossing-Little Blue River Subwatershed. This does not mean livestock do not have access at other locations, but rather they were not observed during the windshield survey. ● 2 miles of stream lack adequate buffers with observations occurring in all subwatersheds. ● 17-42% of soybean fields and 22-35% of corn fields are under conservation tillage. ● Nearly 790 animals were observed on unregulated animal operations throughout the watershed. The highest density of animals was identified in the Beaver Meadow Creek and Gilson Creek-Little Blue River subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. ● 41,594 acres of highly erodible land occur within the watershed. The highest density of HES occurs in Beaver Meadow Creek (65%), Gilson Creek-Little Blue River (62%) and Headwaters Little Blue River (62%) subwatersheds. ● The City of Shelbyville MS4 lies partially within the Little Blue River Watershed.

Table 36. Potential sources causing nutrient problems.

Problems:	Area streams have nutrient levels exceeding the target set by this project.
Potential Causes:	Nutrient concentrations exceed target values set by this project.
Potential Sources:	● 9.9 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization Town of Rays Crossing-Little Blue River (10%), Beaver Meadow Creek (9%) and Gilson Creek-Little Blue River (8%) subwatersheds. ● Livestock access (2.6 miles of streams) was observed in the Headwaters Little Blue River, Gilson Creek-Little Blue River and Town of Rays Crossing-Little Blue River Subwatershed. This does not mean livestock do not have access at other locations, but rather they were not observed during the windshield survey. ● 2 miles of stream lack adequate buffers with observations occurring in all subwatersheds. ● 17-42% of soybean fields and 22-35% of corn fields are under conservation tillage. ● Nearly 790 animals were observed on unregulated animal operations throughout the watershed. The highest density of animals was identified in the Beaver Meadow Creek and Gilson Creek-Little Blue River subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. ● More than 19,345 animals are permitted on confined feeding operations in the watershed. Animals are most dense in the Gilson Creek-Little Blue River, Beaver Meadow Creek and Headwaters Little Blue River subwatersheds. ● Animals in the watershed produce more than 90,345 tons of manure annually which produces 237,595 tons of phosphorus, 177,335 tons of phosphorus and 4.3E+16 colonies of E. coli annually. ● Soils which are severely limited for septic use cover 66,855 aces or 99% of the Little Blue River Watershed. Failing septic systems could contribute *E. coli* to the system within the rural portion of the watershed. ● 41,594 acres of highly erodible land occur within the watershed. The highest density of HES occurs in Beaver Meadow Creek (65%), Gilson Creek-Little Blue River (62% and Headwaters Little Blue River (62%) subwatersheds. ● The City of Shelbyville MS4 lies partially within the Little Blue River Watershed.

Table 37. Potential sources causing *E. coli* problems.

Problems:	Area streams are listed by IDEM as impaired for recreational contact.
Potential Causes:	*E. coli* concentrations exceed target values and the state standard.
Potential Sources:	• 9.9 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization Town of Rays Crossing-Little Blue River (10%), Beaver Meadow Creek (9%) and Gilson Creek-Little Blue River (8%) subwatersheds. • Livestock access (2.6 miles of streams) was observed in the Headwaters Little Blue River, Gilson Creek-Little Blue River and Town of Rays Crossing-Little Blue River Subwatershed. This does not mean livestock do not have access at other locations, but rather they were not observed during the windshield survey. • 2 miles of stream lack adequate buffers with observations occurring in all subwatersheds. • Nearly 790 animals were observed on unregulated animal operations throughout the watershed. The highest density of animals was identified in the Beaver Meadow Creek and Gilson Creek-Little Blue River subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • More than 19,345 animals are permitted on confined feeding operations in the watershed. Animals are most dense in the Gilson Creek-Little Blue River, Beaver Meadow Creek and Headwaters Little Blue River subwatersheds. • Animals in the watershed produce more than 90,345 tons of manure annually which produces 237,595 tons of phosphorus, 177,335 tons of phosphorus and 4.3E+16 colonies of E. coli annually. • Soils which are severely limited for septic use cover 66,855 aces or 99% of the Little Blue River Watershed. Failing septic systems could contribute *E. coli* to the system within the rural portion of the watershed.

Table 38. Potential sources causing instream and terrestrial habitat problems.

Problems:	Habitat in the Little Blue River Watershed is impacted by terrestrial and riparian alterations.
Potential Causes:	Habitat modification both historic and present day altered the watershed use and impacted biological communities
Potential Sources:	N/A

Table 39. Potential sources causing education and cohesion problems.

Problems:	Focused cohesive education and outreach activities and promotion of activities is needed to build public awareness and cohesion.
Potential Causes:	Interest and benefits are lacking.
Potential Sources:	N/A

7.3 Load Estimates – Monitored Results

Nonpoint source pollution is generated from diffuse sources found on public and private lands. The USEPA notes that sources of nonpoint source pollution include stormwater runoff, construction activities, solid waste disposal, atmospheric deposition, streambank erosion, and more. Inventory data in Table 35 through Table 39 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 Little Blue River Watershed: 1) measured results from the monitoring regime completed as part of the current watershed planning project 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 monitoring data to draft long term goals and critical areas.

As discussed in Section 3.4 six monitoring sites were sampled monthly from February 2023 to January 2024. Five of these represent the outlet of each of the five subwatersheds: Site 6 represents the Headwaters Little Blue River subwatershed, Site 4 represents Beaver Meadow Creek subwatershed, Sites 3 and 5 represent Gilson Creek-Little Blue River subwatershed, Site 2 represents Manilla Branch-Little Blue River subwatershed and Site 1 represents Rays Crossing-Little Blue River subwatershed. There is clear value in using these measurements from the Little Blue River Watershed to estimate loads and load reductions. However, there are some limitations in the measured dataset. Sampling methods did not allow for continuous flow measurements at each site, so data from the Little Blue River USGS gage (03361440) was used to approximate flow. As discussed in Section 3.1, the steering committee selected water quality benchmarks that will significantly improve water quality in Little Blue River (Table 12). Target loads needed to meet these benchmarks were calculated for each subwatershed for each parameter. Sample site data from the subwatershed's pour point sampling site was used to calculate annual loading rates and load reductions. The load reduction needed was then calculated for each subwatershed, which corresponds to each sample site, in lb/year or col/year and as a percent of the current load (Table 40 to Table 43). It should be noted that sample sites and subwatershed names shown represent the loading rate to that point inclusive of drainage upstream of the subwatershed.

Table 40. Estimated nitrogen load reduction by subwatershed needed to meet water quality target concentrations in the Little Blue River Watershed.

Subwatershed Name	Site(s)	Current Loading Rate (lb/year)	Target Loading Rate (lb/year)	Load Reduction (lb/year)	% Reduction
Headwaters-Little Blue River	S6	132,354.1	21,178.6	111,175.5	84%
Beaver Meadow Creek	S4	154,475.4	20,021.1	134,454.3	87%
Gilson Creek-Little Blue River	S3	632,757.6	82,009.9	550,747.7	87%
Manilla Branch-Little Blue River	S2	783,567.9	102,376.2	681,191.7	87%
Town of Rays Crossing-Little Blue River	S1	839,838.3	128,863.9	710,974.4	85%

Table 41. Estimated phosphorus load reduction by subwatershed needed to meet water quality target concentrations in the Little Blue River Watershed.

Subwatershed Name	Site(s)	Current Loading Rate (lb/year)	Target Loading Rate (lb/year)	Load Reduction (lb/year)	% Reduction
Headwaters-Little Blue River	S6	6,330.5	1,694.3	4,636.3	73%
Beaver Meadow Creek	S4	4,418.3	1,601.7	2,816.6	64%
Gilson Creek-Little Blue River	S3	26,960.3	6,560.8	20,399.5	76%
Manilla Branch-Little Blue River	S2	29,896.7	8,190.1	21,706.6	73%
Town of Rays Crossing-Little Blue River	S1	36,685.3	10,309.1	26,376.2	72%

Table 42. Estimated total suspended solids load reduction by subwatershed needed to meet water quality target concentrations in the Little Blue River Watershed.

Subwatershed Name	Site(s)	Current Loading Rate (lb/year)	Target Loading Rate (lb/year)	Load Reduction (lb/year)	% Reduction
Headwaters-Little Blue River	S6	653,949.8	317,679.1	336,270.8	51%
Beaver Meadow Creek	S4	1,232,918.7	300,316.8	932,601.9	76%
Gilson Creek-Little Blue River	S3	4,152,816.7	1,230,148.9	2,922,667.8	70%
Manilla Branch-Little Blue River	S2	5,805,865.5	1,535,643.0	4,270,222.5	74%
Town of Rays Crossing-Little Blue River	S1	8,023,065.2	1,932,959.1	6,090,106.1	76%

Table 43. Estimated E. coli load reduction by subwatershed needed to meet water quality target concentrations in the Little Blue River Watershed.

Subwatershed Name	Site(s)	Current Loading Rate (col/year)	Target Loading Rate (col/year)	Load Reduction (col/year)	% Reduction	TMDL Reduction Required
Headwaters-Little Blue River	S6	6.36E+13	2.26E+13	4.10E+13	64%	11%
Beaver Meadow Creek	S4	7.40E+13	2.14E+13	5.26E+13	71%	16%
Gilson Creek-Little Blue River	S3	3.73E+14	8.75E+13	2.86E+14	77%	NRN
Manilla Branch-Little Blue River	S2	3.10E+14	1.09E+14	2.00E+14	65%	45%
Town of Rays Crossing-Little Blue River	S1	5.82E+14	1.37E+14	4.45E+14	76%	75%

7.4 Load Estimates – Modeled Results

After reviewing the loading rates calculated, the steering committee was concerned by the low loading rates calculated. Upon review against the Little Blue River gaging station, it appears that 1) the sampling period occurred in a period of relatively high drought conditions and 2) nearly all samples were collected under low or moderate flow events and likely do not represent more typical conditions present in the watershed. Due to these limitations with monitoring load rates, the steering committee

reviewed modeling data for each subwatershed as an option for calculating loading rates. Hydrologic models detail the transport of pollutants across the land surface as surface runoff. Rainwater flows over the land and through the groundwater collecting pollutants, including sediment and nutrients as it moves. The soil characteristics and land uses influence the way that water moves through the system and each hydrologic model simulates the movement in a different way. These computer models provide useful information that can serve as a baseline for future land use changes. They also serve as a check on the water chemistry samples and GIS-based watershed data.

Watershed loading rates can be estimated using a variety of loading models for a variety of parameters. A tabular-based nonpoint source pollution loading model (STEPL) was used to assess the nonpoint source pollution of four of the pollutants of concern: total nitrogen, total phosphorus, total suspended solids, and E. coli. These results were utilized to estimated current loading rates for each subwatershed. The load duration curve data were scaled to the drainage area for each subwatershed in order to generate target loading rates. The difference between the two were utilized to calculate load reductions necessary to meet these target loading rates. Table 44 to Table 47 detail modeled loading rates and target reductions for the Little Blue River Watershed.

Table 44. Estimated nitrogen load reduction by subwatershed needed to meet water quality target concentrations in the Little Blue River Watershed.

Subwatershed Name	Current Loading Rate (lb/year)	Target Loading Rate (lb/year)	Load Reduction (lb/year)	% Reduction
Headwaters Little Blue River	142,725.2	21,178.6	121,547	85%
Beaver Meadow Creek	135,417.4	23,246.6	112,171	83%
Gilson Creek-Little Blue River	255,245.5	95,222.1	160,023	63%
Manilla Branch-Little Blue River	129,377.6	118,869.4	10,508	8%
Town of Rays Crossing-Little Blue River	154,443.3	149,624.4	4,819	3%
Watershed Total	817,209.0	149,624.4	667,584.6	82%

Table 45. Estimated phosphorus load reduction by subwatershed needed to meet water quality target concentrations in the Little Blue River Watershed.

Subwatershed Name	Current Loading Rate (lb/year)	Target Loading Rate (lb/year)	Load Reduction (lb/year)	% Reduction
Headwaters Little Blue River	39,501.9	1,694.3	37,808	96%
Beaver Meadow Creek	37,245.5	1,859.7	35,386	95%
Gilson Creek-Little Blue River	70,453.7	7,617.8	62,836	89%
Manilla Branch-Little Blue River	35,875.7	9,509.6	26,366	73%
Town of Rays Crossing-Little Blue River	41,421.8	11,970.0	29,452	71%
Watershed Total	224,498.5	11,970.0	212,528.6	95%

Table 46. Estimated total suspended solids load reduction by subwatershed needed to meet water quality target concentrations in the Little Blue River Watershed.

Subwatershed Name	Current Loading Rate (lb/year)	Target Loading Rate (lb/year)	Load Reduction (lb/year)	% Reduction
Headwaters Little Blue River	16,299,444.6	317,679.1	15,981,766	98%
Beaver Meadow Creek	15,958,467.8	348,699.1	15,609,769	98%
Gilson Creek-Little Blue River	25,074,694.8	1,428,330.9	23,646,364	94%
Manilla Branch-Little Blue River	13,843,557.1	1,783,041.3	12,060,516	87%
Town of Rays Crossing-Little Blue River	15,488,382.4	2,244,366.6	13,244,016	86%
Watershed Total	86,664,546.7	2,244,366.6	84,420,180.1	97%

Table 47. Estimated E. coli load reduction by subwatershed needed to meet water quality target concentrations in the Little Blue River Watershed.

Subwatershed Name	Current Loading Rate (col/year)	Target Loading Rate (col/year)	Load Reduction (col/year)	% Reduction
Headwaters Little Blue River	2.25E+15	2.26E+13	2.23E+15	99%
Beaver Meadow Creek	1.79E+15	2.48E+13	1.76E+15	99%
Gilson Creek-Little Blue River	3.89E+15	1.02E+14	3.79E+15	97%
Manilla Branch-Little Blue River	8.65E+16	1.27E+14	8.64E+16	100%
Town of Rays Crossing-Little Blue River	1.29E+16	1.60E+14	1.27E+16	99%
Watershed Total	1.07E+17	1.60E+14	1.07E+17	100%

It should be noted that modeled results may not fully mimic water quality monitoring results for the following reasons:

- The STEPL model uses soil and land use information to evaluate surface runoff and is unaware of increased nitrogen transport rates due to tile drainage located in the agricultural portions of the Little Blue River Watershed.
- Sediment and phosphorus generated from overland is accounted for in the STEPL model; however, non-field sediment and phosphorus, such as that originating from streambank erosion or channel erosion, are only accounted for using the STEPL model when streambank erosion was directly observed and the length of erosion calculated.

8.0 CRITICAL AND PRIORITY AREA DETERMINATION

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

Using the list of potential sources developed for each parameter of concern as a base, the steering committee developed a mechanism for determining critical areas for each parameter. GIS-based mapping data from desktop and windshield survey efforts, loading calculations, and current and historic water quality data were used as a basis for decision-making. Data for each subwatershed are detailed in Appendix E. The steering committee reviewed subwatershed data and developed a criteria list for each parameter. For each parameter, each subwatershed was evaluated to determine whether it met each criterion developed by each steering committee team. The steering committee reviewed available data and selected a suite of data they considered most useful for their parameter. Once selected, data for each criterion were ranked based on each subwatersheds available data. Lower numbers were used for subwatershed with higher subwatershed coverage, volume of material or percent exceedance and higher numbers were used for lower coverage, volume or exceedance. A score was not assigned to the subwatershed if data were not available for that criterion. Subwatersheds scoring 3.0 or less were deemed critical for each parameter.

8.1 Critical Areas for Nitrate-Nitrogen and Total Phosphorus

Nitrate-nitrogen was the nitrogen form used to determine Little Blue River critical areas. Total phosphorus was the form of phosphorus used to determine phosphorus critical areas. Nitrate-nitrogen and total phosphorus are readily available in watershed, entering surface water via; human and animal waste, fertilizer use, and tile drains on agricultural lands. Phosphorus enters the watershed through streambank and bed erosion, unfiltered runoff, agricultural land use in floodplains, stormwater runoff, and livestock access. Based on the data reviewed by the steering committee (Table 48), the following datasets were priorities for nutrients critical areas:

- Nitrogen exceedance – historic and current – percent exceedance
- Phosphorus exceedance – historic and current – percent exceedance
- Livestock access normalized by percent of stream miles
- Highly erodible land normalized by percent of acres
- Streambank erosion normalized by percent of stream miles
- Manure volume estimate normalized by tons/acre

Critical subwatersheds were determined as follows: Headwaters Little Blue River (201), Beaver Meadow Creek (202), Gilson Creek-Little Blue River (203; Figure 64).

Table 48. Nutrient critical area criterion ranking based on source evaluation and average rating.

HUC	HEL	Septic-Very Limited	Manure estimate	Livestock Access	Streambank Erosion	Nitrate historic	Nitrate current	TP historic	TP current	Score
201	3	4	2	1	4	1	5	1	2	2.56
202	1	1	3	4	2	4	3	2	4	2.67
203	2	2	1	2	3	2	1	3	1	1.89
204	4	3	5	5	5	3	3	5	3	4.00
205	5	5	4	3	1	5	2	4	5	3.78

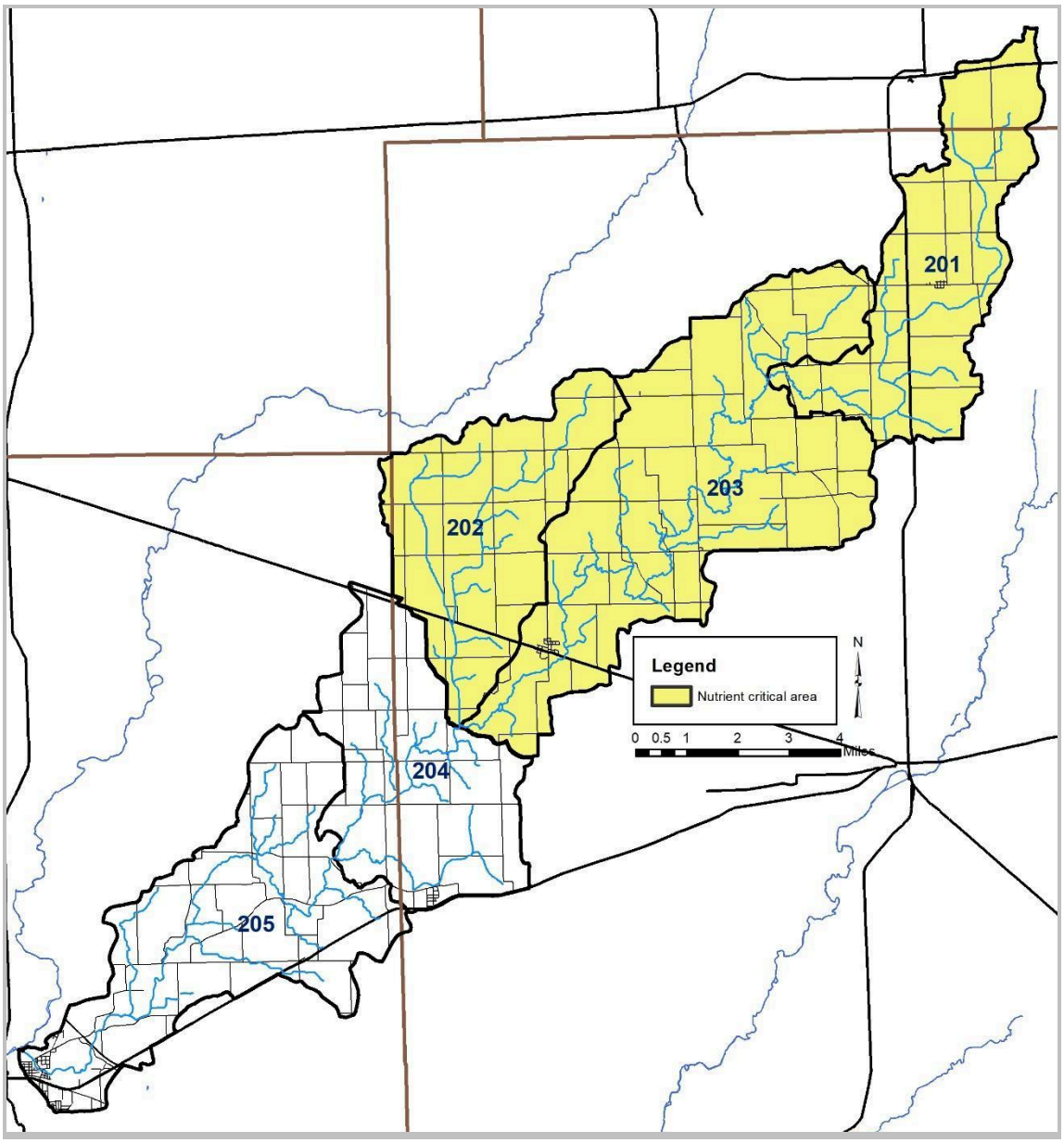

Figure 64. Critical areas for nutrients in the Little Blue River Watershed.

8.2 Critical Areas for Sediment

Total suspended solids concentrations were used to determine sediment-based critical areas (Figure 65). Total suspended solids enter streams the watershed through streambank and bed erosion, unfiltered runoff, agricultural land use in floodplains, stormwater runoff, and livestock access. Based on the data reviewed by the steering committee (Table 49), the following datasets were priorities for sediment critical areas:

- Total suspended sediment exceedance – historic and current – percent exceedance
- Turbidity exceedance – current – percent exceedance
- Highly erodible land normalized by percent of acres
- Streambank erosion normalized by percent of stream miles

Table 49. Sediment critical area criterion ranking based on source evaluation and average rating.

HUC	HEL	Streambank Erosion	Turbidity Historic	Turbidity Current	TSS Historic	TSS Current	Score
201	3	4	2	2	1	2	2.33
202	1	2	5	1	5	1	2.50
203	2	3	3	3	4	3	3.00
204	4	5	1	4	3	1	3.00
205	5	1	4	2	2	2	2.67

Critical subwatersheds were determined as follows: Headwaters Little Blue River (201), Beaver Meadow Creek (202), and Town of Rays Crossing-Little Blue River (205; Figure 65).

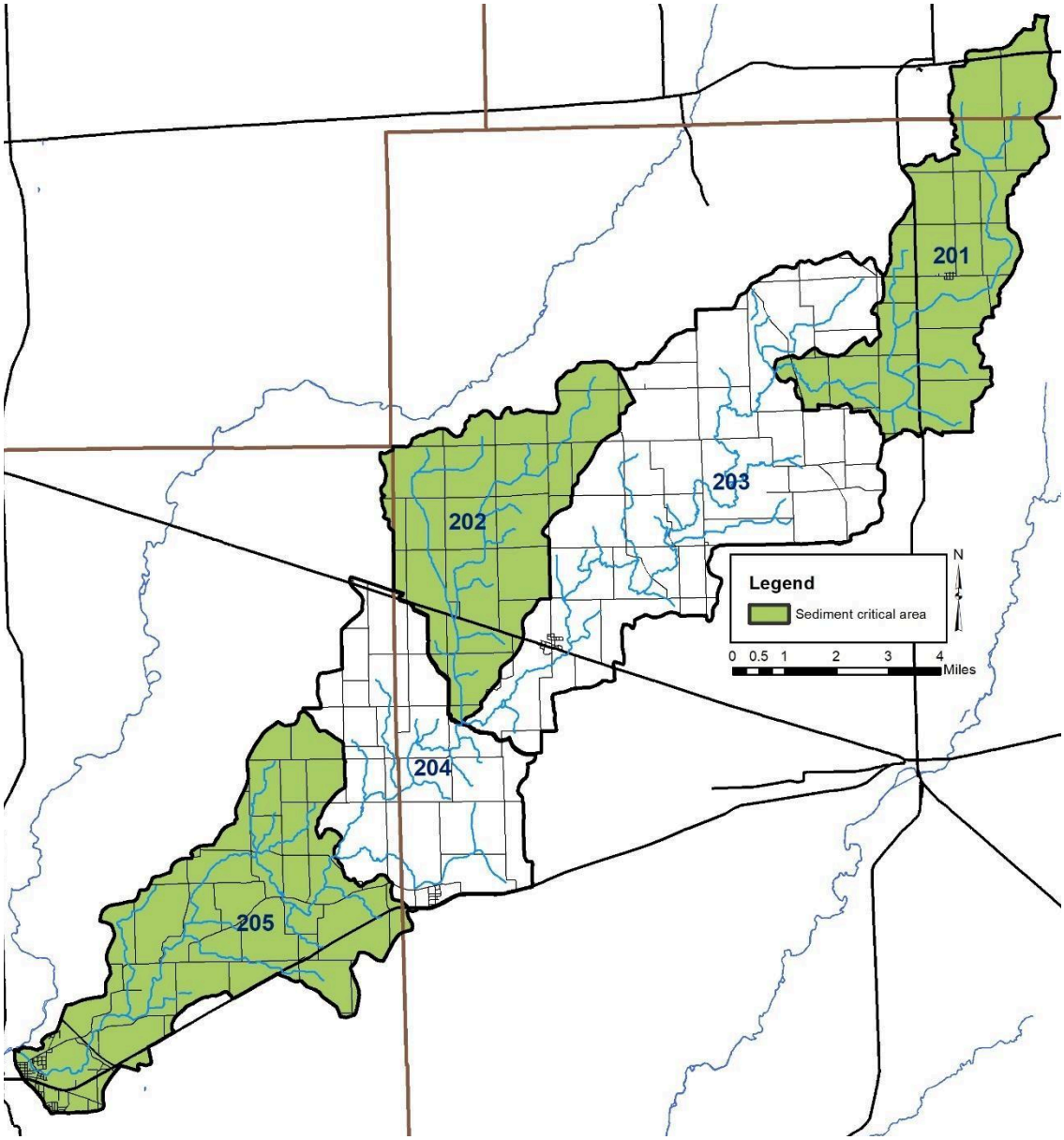

Figure 65. Critical areas for sediment in the Little Blue River Watershed.

8.3 Critical Areas for *E. coli*

E. coli concentrations were used to determine *E. coli*-based critical areas (Figure 66). *E. coli* enters streams in the watershed through human and animal waste, livestock access, and infrastructure issues. Additional areas of concern, such as areas with manure management issues or failing septic systems, may also be included. While those areas have not been quantified, dense unsewered areas were included as a method for identifying these areas. Based on the data reviewed by the steering committee (Table 50), the following datasets were priorities for sediment critical areas:

- Highly erodible land normalized by percent of acres
- Septic soil limitations normalized by percent of acres
- Manure volume estimate normalized by tons/acre
- Livestock access normalized by percent of stream miles
- Streambank erosion normalized by percent of stream miles

- E. coli concentration exceedance – historic and current – percent exceedance

Table 50. E. coli critical area criterion ranking based on source evaluation and average rating.

HUC	Septic-Very Limited	Manure estimate	Livestock Access	E. coli historic	E. coli current	Score
201	4	2	1	5	1	2.60
202	1	3	4	3	2	2.60
203	2	1	2	4	4	2.60
204	3	5	5	1	5	3.80
205	5	4	3	2	3	3.40

Critical subwatersheds were determined as follows: Headwaters Little Blue River (201), Beaver Meadow Creek (202) and Gilson Creek-Little Blue River (203; Figure 66).

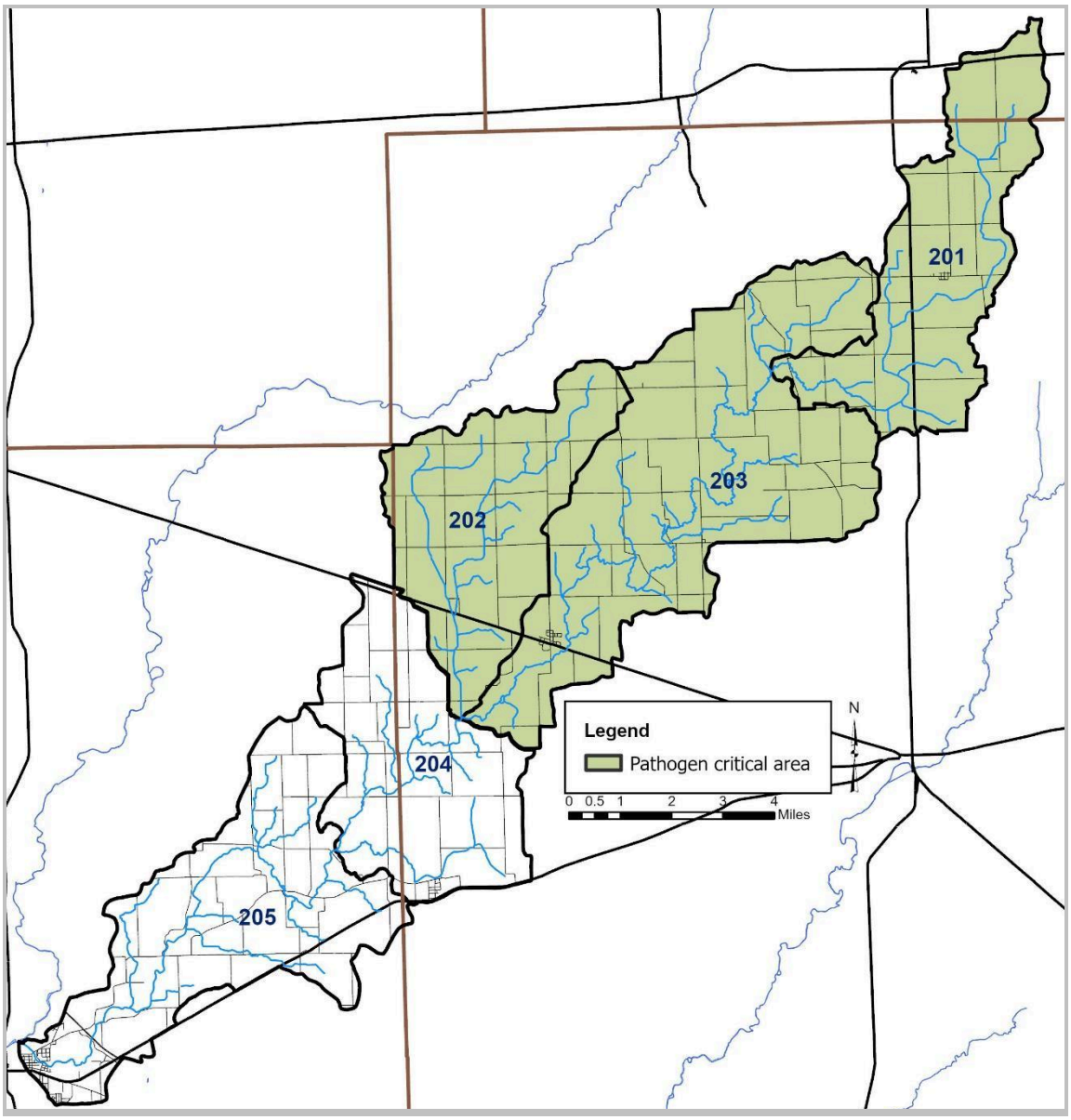

Figure 66. Critical areas for *E. coli* in the Little Blue River Watershed.

8.4 Critical Areas Summary

The subwatersheds identified as critical areas for each parameter are summarized in Figure 64 to Figure 66. To identify the highest priority subwatersheds, the steering committee decided to divide them into three tiers (high, medium and low priority), based on the number of parameters that were determined to be critical. The highest priority subwatersheds are those that were determined to be critical for three of the potential parameters (nutrients, sediment, *E. coli*). The medium priority subwatersheds are those that were determined to be critical for two of three potential parameters. The lowest priority subwatersheds were critical for one of three potential parameters (Figure 68). Subwatersheds were prioritized as follows:

- High priority: Headwaters Little Blue River (201) and Beaver Meadow Creek (202)
- Medium priority: Gilson Creek-Little Blue River (203)
- Low priority: Town of Rays Crossing-Little Blue River (205)

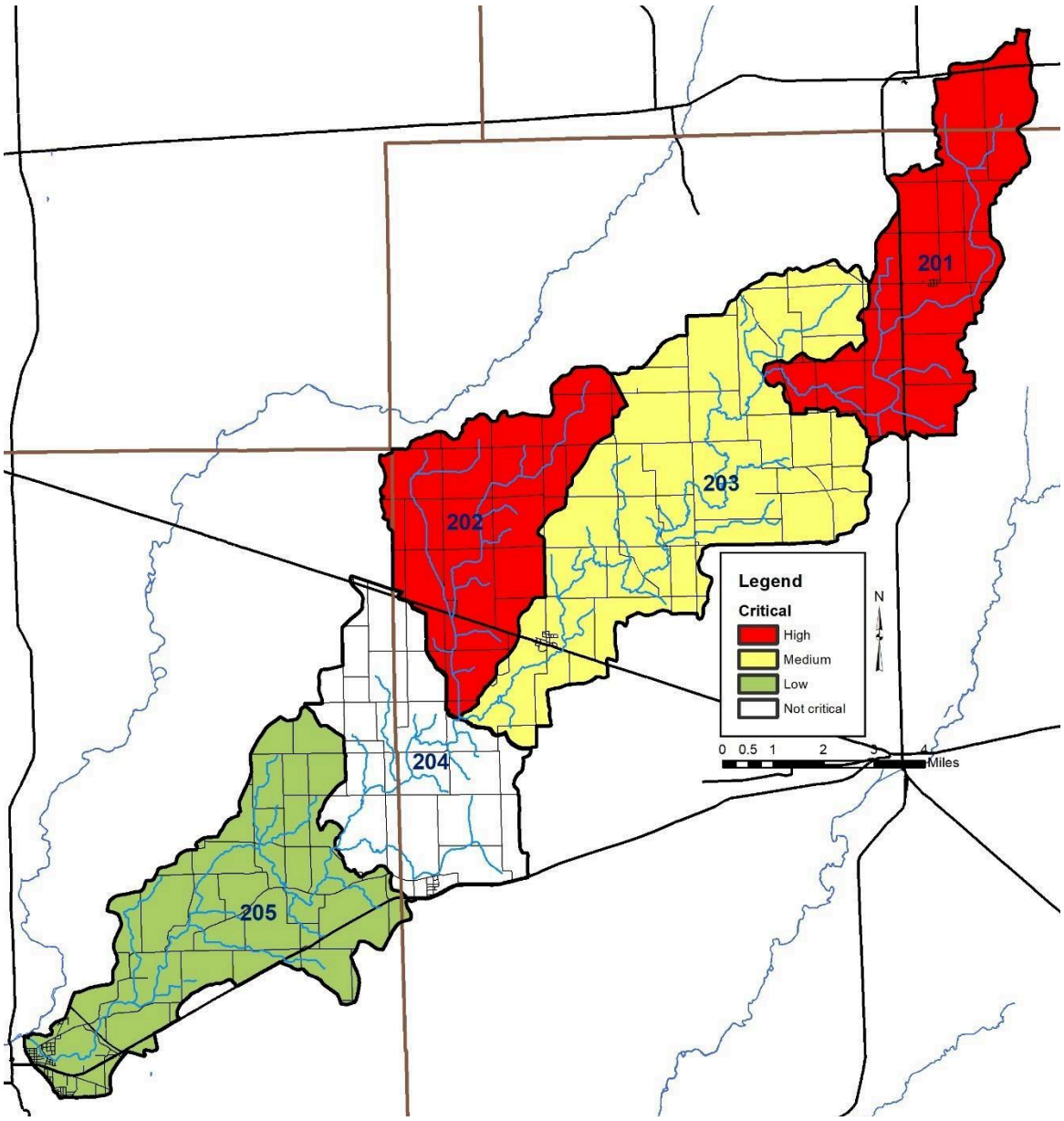

Figure 67. Prioritized critical areas in the Little Blue River Watershed.

After reviewing critical areas, the steering committee noted that the highest location of concern occurred within the watershed's floodplain (Figure 68). With this in mind, the committee voted to include the floodplain for the entire watershed as a high priority critical area. One subwatershed, Manilla Branch-Little Blue River (204) was not prioritized as critical areas meaning it was not identified as the areas of highest concern for any of the three parameters (nutrients, sediment, pathogens). Implementation efforts will target high priority critical areas first, followed by medium priority then low priority areas. It is anticipated that implementation efforts will be targeted in medium and low priority subwatersheds as part of EPA-funded implementation efforts only after implementation efforts are exhausted in higher priority areas. Implementation via other funding sources, via landowner interest in NRCS-based federal funding programs will occur as landowners are interested. The Little Blue River

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

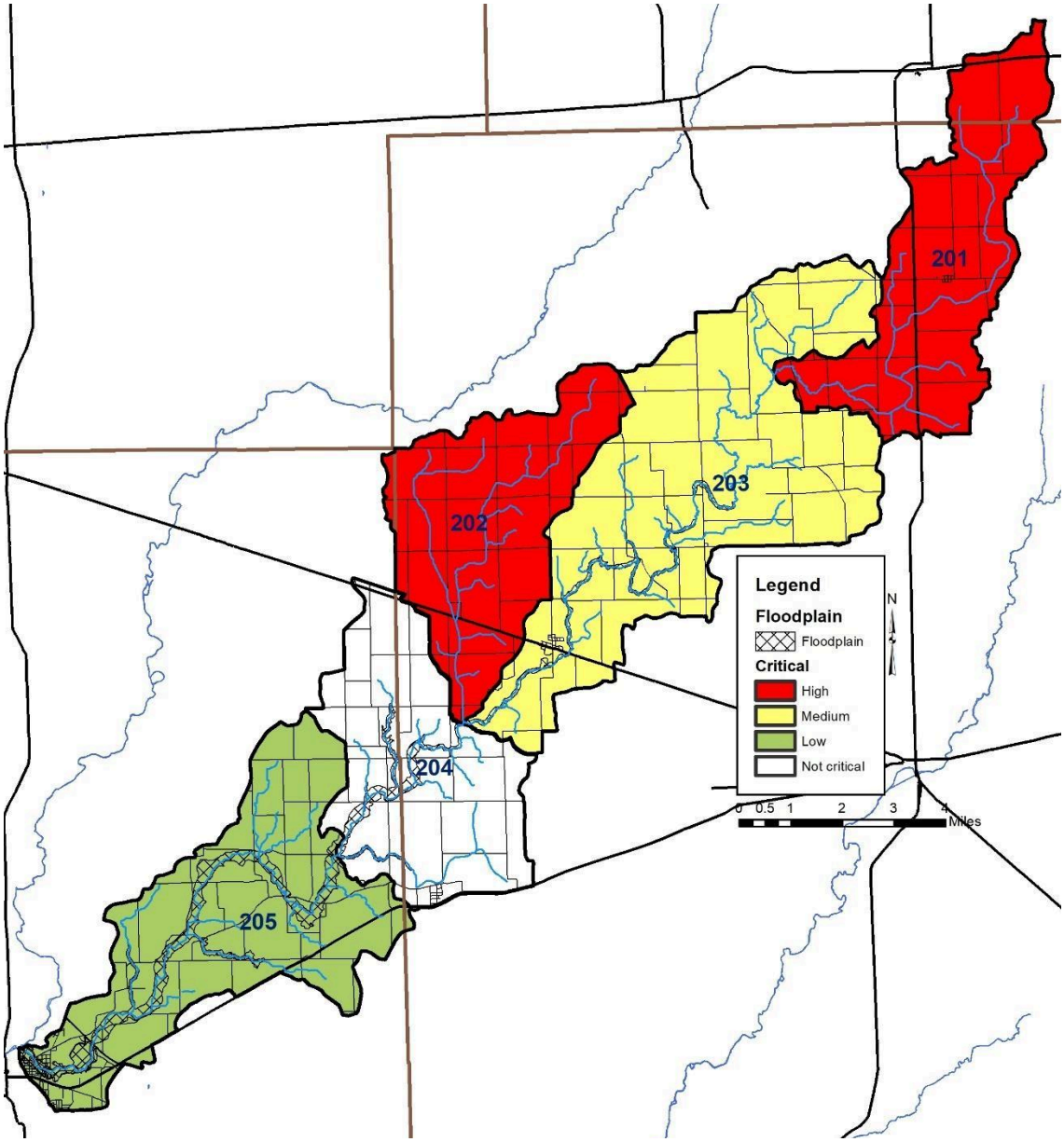

Figure 68. Prioritized critical areas in the Little Blue River Watershed.

8.5 Current Level of Treatment

Based on data from the Indiana Conservation Partnership, more than 11,941 acres of best management practices including but not limited to cover crops, conservation cover, fencing, forage and biomass planting, conservation tillage, watering facility and heavy use protection area construction and more have been implemented over the last 5 years in the Little Blue River Watershed. Table 51 details practices by acre.

Table 51. Practices installed from 2019-2023 in the Little Blue River Watershed based on Indiana Conservation Partner data in acres.

Practice	Units	201	202	203	204	205	Total
Cover Crop	acres	1,401.3		791	1,494.9	877.3	4,564.5
Fence	feet	22,095	16,058	8,435			46,588
Field Border	acres			3.2			3.2
Forage and Biomass Planting	acres		141.6	17	38.4		197
Grade Stabilization Structure	count	2					2
Grassed Waterway	acres	1.4		3.6	6.9		11.9
Heavy Use Area Protection	sq feet	22,900	7,500				30,400
Lined Waterway or Outlet	feet	40					40
Conservation Tillage	acres	4,012.6		595	980.4	1577.1	7,165.1
Watering Facility	count		12				12

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 modeled data (STEPL). Target loading rates were calculated for each subwatershed using water quality targets outlined in Section 3 and flow data from the USGS Little Blue River stream gage at Shelbyville (USGS 03361440). Flow data were scaled to the drainage area for Little Blue River sample sites. 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:

1. Current loading rates were generated using monitored and modeled (STEPL) data. Modeled data were selected by the steering committee.
2. Target loading rates were determined for the Little Blue River sample sites. Loading rates and target reductions for the entire watershed were calculated using data generated for the most downstream Little Blue River mainstem site (Site 1).

Reduce Nutrient Loading

Based on collected water quality data for the Little Blue River Watershed, the committee set the following long-term goals: Reduce nitrate-nitrogen loading from 817,209 lb/year to 149,624 lb/year (82%) by 2054 and reduce total phosphorus loading from 224,499 lb/year to 11,970 lb/ year (95%) by 2054.

Short term goal: Reduce total phosphorus inputs from 224,499 pounds per year to 153,656 pounds per year (32% reduction) and nitrate-nitrogen from 817,209 pounds per year to 594,681 pounds per year (27% reduction) in the Little Blue River in 10 years (2034).

Medium term goal: Reduce total phosphorus inputs from 153,656 pounds per year to 82,813 pounds per year (46% reduction) and nitrate-nitrogen from 594,681 pounds per year to 372,153 pounds per year (37% reduction) in the Little Blue River in 20 years (2044).

Long term goal: Reduce total phosphorus inputs from 82,813 pounds per year to 11,970 pounds per year (86% reduction) and nitrate-nitrogen from 372,153 pounds per year to 149,624 pounds per year (60% reduction) in the Little Blue River in 30 years (2054).

Table 52. Nitrate-nitrogen short, medium, and long-term goal calculations for prioritized critical areas in Little Blue River.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	817,209.0	222,528.2	594,680.8	27%
Medium Term (20 years)	594,680.8	222,528.2	372,152.6	37%
Long Term (30 years)	372,152.6	222,528.2	149,624.4	60%

Table 53. Total phosphorus short, medium, and long-term goal calculations for prioritized critical areas in Little Blue River.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	224,498.5	70,842.9	153,655.7	32%
Medium Term (20 years)	153,655.7	70,842.9	82,812.8	46%
Long Term (30 years)	82,812.8	70,842.9	11,970.0	86%

Reduce Sediment Loading

Based on collected water quality data for the Little Blue River Watershed, the committee set the following long-term goal: reduce total suspended solids loading from 86,664,547 lb/year to 2,244,367 lb/year (97%) by 2054.

Short term goal: Reduce total suspended solids inputs from 86,664,547 pounds per year to 58,524,487 pounds per year (32% reduction) in Little Blue River in 10 years (2034).

Medium term goal: Reduce total suspended solids inputs from 58,524,487pounds per year to 30,384,427 pounds per year (48% reduction) in Little Blue River in 20 years (2044).

Long term goal: Reduce total suspended solids inputs from 30,384,427 pounds per year to 2,244,367 pounds per year (93% reduction) in Little Blue River in 30 years (2054).

Table 54. Total suspended solids short, medium, and long-term goal calculations for prioritized critical areas in Little Blue River.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	86,664,546.7	28,140,060.0	58,524,486.7	32%
Medium Term (20 years)	58,524,486.7	28,140,060.0	30,384,426.7	48%
Long Term (30 years)	30,384,426.7	28,140,060.0	2,244,366.6	93%

Reduce *E. coli* Loading

Based on collected water quality data for the Little Blue River Watershed, the committee set the following long-term goal: reduce E. coli loading from 1.07E+17 to 1.60E+14 (99%) by 2054.

Short term goal: Reduce E. coli inputs from 1.07E+17 colonies per year to 7.16+E16 colonies per year (33% reduction) in Little Blue River in 10 years (2034).

Medium term goal: Reduce E. coli inputs from 7.16+E16 colonies per year to 3.59E+16 colonies per year (50% reduction) in Little Blue River in 20 years (2044).

Long term goal: Reduce E. coli inputs from 3.59E+16 colonies per year to 1.60E+14 colonies per year (99% reduction) in Little Blue River in 30 years (2054).

Table 55. E. coli short, medium, and long-term goal calculations for prioritized critical areas in Little Blue River.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	1.07E+17	3.57E+16	7.16E+16	33%
Medium Term (20 years)	7.16E+16	3.57E+16	3.59E+16	50%
Long Term (30 years)	3.59E+16	3.57E+16	1.60E+14	99%

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 in 2023 - Property owners: 837 parcel addresses; Producers: 273 based on DTN contact list

Habitat Impacts

Long term: Natural habitat (grasslands, forest, wetlands) will increase by a total of 5% with a focus on improving habitat connectivity across the Little Blue River Watershed by 2054.

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 Little Blue River Watershed. A list of potential best management practices was reviewed by the project steering committee. From this list, the practices which were

deemed most appropriate to remediate the sources of pollution in the watershed and most likely to successfully meet loading reduction targets were identified. It should be noted that no practice list is exhaustive and that additional techniques may be both possible and necessary to reach water quality goals.

10.1 Best Management Practices Descriptions

A list of potential BMPs were reviewed by the Little Blue River Watershed steering committee. Committee members reviewed potential practices taking into account the identified resource concerns, watershed land uses, and Little Blue River Watershed Project goals. From the potential practice list, the most appropriate BMPs to remediate sources of pollution and address resource concerns in the Little Blue River Watershed was developed. This practice list is not exhaustive and new and emerging technologies and techniques should be considered as possible and necessary options to meet water quality targets within the Little Blue River Watershed. A combination of practices detailed below aimed at avoiding, controlling and trapping nutrients and sediment and the implementation of a conservation system could be necessary to make lasting, measurable changes in Little Blue River 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 various small towns 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 include the following:

Access Control
Alternate Watering System
Animal Mortality Facility
Bioreactor
Bioretention – Rain Garden, Bioswale
Composting Facility
Conservation Tillage: Residue and Tillage Management, No till/Strip till/Direct Seed
Cover Crop
Diversion structures
Drainage Water Management
Fencing
Field Border or Filter Strip
Forage and Biomass Planting
Grade Stabilization Structure
Grassed Waterway
Habitat Corridor Identification and Improvement
Heavy Use Area Protection
Infrastructure Retrofits
Lined Waterway or Outlet
Livestock Restriction/Prescribed Grazing
Livestock Pipeline
Manure Management Planning
Mulching

Nutrient and/or Pest Management Plans
Point Source Discharge Reduction
Rain Barrel
Regular Soil Tests
Education: Septic System Care and Maintenance
Soil testing - Consider soil characteristics to minimize runoff
Streambank Stabilization
Subsurface Drain (Agricultural)
Threatened and Endangered Species Protection
Tree/Shrub Establishment
Two Stage Ditch
Education: University fertilization recommendations
Variable Rate application
Vegetated Swale
Water Storage Facility
Waste Utilization
Water and Sediment Control Basin
Wetland Creation, Wetland Enhancement, Wetland Restoration

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.

Alternate Watering Systems/Fencing
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.

Animal Mortality Facility
An on-farm facility for the treatment or disposal of animal carcasses due to routine mortality. This standard applies to animal carcass storage, treatment, or disposal for routine mortality in livestock and poultry operations to protect air and water quality including drinking water source protection. Routine mortality is that which occurs at the normally anticipated rate.

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 Seeding/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, conservation cover and critical area seeding 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 vegetation recovers plant-available nutrients in the soil and recycles them through the plant biomass for succeeding crops.

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.

Field Border/Buffer Strip/Filter Strip

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

Many researchers have verified the effectiveness of filter strips in removing sediment from runoff with reductions ranging from 56-97% (Arora et al., 1996; Mickelson and Baker, 1993; Schmitt et al., 1999; Lee et al, 2000; Lee et al., 2003). Most of the reduction in sediment load occurs within the first 15 feet of installed buffer. Smaller additional amounts of sediment are retained and infiltration is increased by increasing the width of the strip (Dillaha et al., 1989). Filter strips have been found to reduce sediment-bound nutrients like total phosphorus but to a lesser extent than they reduce sediment load itself. Phosphorus predominately associates with finer particles like silt and clay that remain suspended longer and are more likely to reach the strip's outfall (Hayes et al., 1984). Filter strips are least effective at reducing dissolved nutrients like those of nitrate and phosphorus, and atrazine and alachlor, although reductions of dissolved phosphorus, atrazine, and alachlor of up to 50% have been documented (Conservation Technology Information Center, 2000). Simpkins et al. (2003) demonstrated 20-93% nitrate-nitrogen removal in multispecies riparian buffers. Short groundwater flow paths, long residence times, and contact with fine-textured sediments favorably increased nitrate-nitrogen removal rates. Additionally, up to 60% of pathogens contained in runoff may be effectively removed. Computer modeling also indicates that over the long run (30 years), filter strips significantly reduce amounts of pollutants entering waterways.

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

Forage and Biomass Planting

Forage and biomass plantings establish adapted and/or compatible species, varieties, or cultivars of herbaceous species suitable for pasture, hay or biomass production. Plantings occur to 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.

Habitat Corridor Identification and Improvement
Protection of habitat corridors requires a multi-phase program including identification of appropriate habitat corridors, development of a corridor management plan, and creation of an improvement plan. Most long-term corridor protection will require land transfer into protected status. There are several options for land transfer ranging from donation to fee simple land purchase. Donations can be solicited and encouraged through incentive programs. Outright purchase of property offers a secondary option and is frequently the least complicated and most permanent protection technique but is also the costliest. A conservation easement is a less expensive technique than outright purchase that does not require the transfer of land ownership but rather a transfer of use rights. Conservation easements might be attractive to property owners who do not want to sell their land at the present time but would support perpetual protection from further development. Conservation easements can be donated or purchased.

Several techniques can be used for protecting natural areas and open space in both public and private ownership. The first step in the process is to identify and prioritize properties for protection. The highest priority natural areas should be permanently protected by the ownership or under the management of public agencies or private organizations dedicated to land conservation. Other open space can be protected using conservation design development techniques and is more likely to be managed by homeowner associations.

Heavy Use Area Protection (HUAP)
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

Animal Waste Management (AWM) is a planning/design tool for animal feeding operations that can be used to estimate the production of manure, bedding, and process water and determines the size of storage/treatment facilities. The procedures and calculations used in AWM are based on the USDA-NRCS Agricultural Waste Management Field Handbook.

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.

Pollinator Planting

Pollinator plantings focus on selecting plants and providing recommendations on plants which will enhance pollinator populations throughout the growing season. These wildflowers, trees, shrubs, and grasses are an integral part of the conservation practices that landowners and farmers.

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.

Septic System Care and Maintenance

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 Little Blue River Watershed. Because of the prohibitive cost of providing centralized sewer systems to many areas, septic tank systems will remain the primary means of treatment into the future. Annual maintenance of septic systems is crucial for their operation, particularly the annual removal of accumulated sludge. The cost of replacing failed septic tanks is about $5,000-$15,000 per unit based on industry standards.

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

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.

Subsurface Drain

A subsurface drain is a conduit, such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water. Subsurface drains are used to improve the environment for crops, reduce erosion, improve water quality, regulate water tables, collect groundwater for beneficial uses, or to remove salts and other contaminants from the soil profile.

Subsurface drainage is used in areas having a high-water table where the benefits of lowering the water level are worth the expense. The practice also applies to areas that will benefit from controlling ground water and/or surface runoff. The soil must meet certain suitability requirements and an adequate outlet must be available to assure the drain will function properly.

The operation and maintenance of a subsurface drainage system includes periodic inspection and prompt repair of system components (e.g. structures for water control, underground outlets, vents, drain outlets, trash and rodent guards). In cold climates, winterization protection from freezing conditions will be necessary.

T&E Species Protection (Habitat Improvement)

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

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

Tree/Shrub Establishment/Reforestation and site prep 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

Two-stage ditches are drainage ditches that have been modified by adding benches that serve as floodplains within the overall channel. This form is more consistent with fluvial form and process, and therefore leads to greater channel stability. The benches can also function as wetlands during certain times of the year, reducing ditch nutrient loads. This results in a more sustainable ditch that restores some of the beneficial natural processes within the ditch environment while providing the drainage capacity necessary for production.

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

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

10.2 Best Management Practice Selection and Load Reduction Calculations

Table 56 details selected agricultural 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 57 outlines suggested BMPs, estimated load reduction for nutrients and sediment (if

available), Table 58 details the target volume (area, length) of each practice, while Table 59 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 56. Suggested Best Management Practices to address Little Blue River critical areas. Note BMPs were selected by the steering committee.

Practice	Nutrients	Sediment	Pathogens
Access Control	X	X	X
Alternate Watering System	X	X	X
Animal Mortality Facility	X	X	X
Bioreactor	X		
Bioretention – Rain Garden, Bioswale	X	X	X
Composting Facility	X		X
Conservation Cover	X	X	X
Conservation Tillage	X	X	X
Cover Crop	X	X	X
Diversion Structures	X	X	X
Drainage Water Management	X	X	
Field Border or Filter Strip	X	X	X
Forage and Biomass Planting	X	X	X
Grade Stabilization Structure	X	X	
Grassed Waterway	X	X	X
Habitat Corridor Identification and Improvement			X
Heavy Use Area Protection	X	X	X
Infrastructure Retrofits	X	X	X
Lined Waterway or Outlet	X	X	X
Livestock Pipeline	X	X	X
Manure Management Planning	X		X
Mulching	X	X	X
Nutrient and/or Pest Management Plans	X		
Pollinator Planting	X	X	X
Prescribed Grazing	X	X	X
Rain Barrel	X	X	
Education: Septic System Care and Maintenance	X		X
Soil testing	X	X	X
Streambank Stabilization	X	X	
Subsurface Drain (Agricultural)	X	X	X
Threatened and Endangered Species Protection	X	X	
Tree/Shrub Establishment	X	X	
Two Stage Ditch	X	X	X
Underground outlet	X	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. BMPs with dashes (-) do not have load reductions available using the Region V Model or other

identifiable source. The target volumes of BMPs proposed to be installed are not required to be implemented as the quantities suggest (Table 57 to Table 58). 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 57 is met, then the target loading rates detailed in Table 52 through Table 55 will be achieved for high priority critical areas (Headwater Little Blue River, Beaver Meadow Creek); medium priority critical areas (Gilson Creek-Little Blue River); and low priority critical areas (Little Blue River-Town of Rays Crossing). The steering committee realizes that the model's calculations are only an estimate, and actual reductions could be beyond the model's estimation. The Region V model does not provide estimated reductions for all suggested BMPs; these load reductions cannot be included in the calculations.

Table 57. Suggested Best Management Practices, target volumes to meet 30-year goals, their estimated load reduction and estimated cost.

Suggested BMPs:	30 year BMP Targets	Unit	Nitrogen (lb/year)	Phosphorus (lb/year)	Sediment (t/year)	Total Estimated Cost
Conservation Cover (327)	3,000	acre	11	5	5	$225,000
Cover Crop (340)	30,000	acre	8	4	4	$1,200,000
Fence (382)	1,000	acre	0.4	0.4	0.4	$1,000
Filter Strip (393)	500	units	24	12	10	$75,000
Forage and Biomass Planting (512)	1,500	acre	11	5	5	$112,500
Grassed Waterway (412)	100	acre	232.9	116.4	101.3	$500,000
Heavy Use Area Protection (561)	3,600	Ft2	0.14463	0.0712	0.0941	$10,800
Livestock Restriction (Alt Watering System, Access Control)	1,500	acre	2.8	0.83	7.52	$1,500,000
Nutrient/Pest Management (590)^	12,000	Ft2	4.16	6.24	-	$48,000
Pollinator planting (CP42)	1,600	feet	11	5	5	$167,520
Prescribed Grazing (528)	1,000	Acre	8	4	4	$15,000
Residue and Tillage Management (329)	30,000	acre	11	5	6	$450,000
Two Stage Ditch (582)	100	acres	6	12	14	$2,000
Streambank Stabilization**	360	Feet	0	0.83	7.52	$360,000
Urban BMPs (bioretention, rain barrel, rain garden)*	100	Units	24	12	10	$100,000

^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 25 feet.
*Assumes average bioretention reduction – estimates could be higher or lower depending on the BMP selected and practice installed.

Table 58. Suggested Best Management Practices, target volumes, and their estimated load reduction per practice to meet high priority, medium priority and low priority goals.

Suggested BMPs:	High priority BMP Targets	Medium priority BMP Targets	Low priority BMP Targets	Unit	Nitrogen (lb/year)	Phosphorus (lb/year)	Sediment (t/year)
Conservation Cover (327)	1,000	1,000	1,000	acre	33,000	15,000	15,000
Cover Crop (340)	10,000	10,000	10,000	acre	240,000	120,000	120,000
Fence (382)	333	333	333	feet	400	400	400
Filter Strip (393)	167	167	167	acre	12,000	6,000	5,000
Forage and Biomass Planting (512)	500	500	500	acre	16,500	7,500	7,500
Grassed Waterway (412)	33	33	33	acre	23,290	11,640	10,130
Heavy Use Area Protection (561)	1,200	1,200	1,200	sqft	500	300	300
Livestock Restriction (Alt Watering System, Access Control)	500	500	500	Feet, units	4,200	1,245	11,280
Nutrient/Pest Management (590)^	4,000	4,000	4,000	Acre	49,920	74,880	
Pollinator planting (CP42)	533	533	533	acres	17,600	8,000	8,000
Prescribed Grazing (528)	333	333	333	acre	8,000	4,000	4,000
Residue and Tillage Management (329)	10,000	10,000	10,000	acres	330,000	150,000	180,000
Two Stage Ditch (582)	0	0	100	feet	600	1,200	1,400
Streambank Stabilization**	120	120	120	feet	0	299	2,707
Urban BMPs (bioretention, rain barrel, rain garden)*	33	33	33	Unit	100	150	7,000
Total Reduction					**735,515**	**400,166**	**365,421**

^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 25 feet.
*Assumes average bioretention reduction – estimates could be higher or lower depending on the BMP selected and practice installed.

Table 59. Estimated cost for selected Best Management Practices to meet high priority, medium priority and low priority goals.

Suggested BMPs:	Estimated Cost per Unit	Short-term Estimated Cost	Medium-term Estimated Cost	Long-term Estimated Cost
Conservation Cover (327)	$75-$300	$75,000	$75,000	$75,000
Cover Crop (340)	$25-$40	$400,000	$400,000	$400,000
Fence (382)	$1.00 temp./ $3.00 perm.	$333	$333	$333
Filter Strip (393)	$75-$300	$25,000	$25,000	$25,000
Forage and Biomass Planting (512)	$75-$300	$37,500	$37,500	$37,500
Grassed Waterway (412)	$5,000	$166,667	$166,667	$166,667
Heavy Use Area Protection (561)	$3	$3,600	$3,600	$3,600
Livestock Restriction (Alt Watering System, Access Control)	$4	$500,000	$500,000	$500,000
Nutrient/Pest Management (590)	$175	$16,000	$16,000	$16,000
Pollinator planting (CP42)	$15	$56,250	$56,250	$56,250
Prescribed Grazing (528)	$15	$5,000	$5,000	$5,000
Residue and Tillage Management (329)	$1,000	$150,000	$150,000	$150,000
Two Stage Ditch (582)	$450	$667	$667	$667
Streambank Stabilization	$1,000	$120,000	$120,000	$120,000
Urban BMPs (bioretention, rain barrel, rain garden)	$1,000	$30,000	$30,000	$30,000
Total Cost		**$1,555,607**	**$1,555,607**	**$1,555,607**

10.3 Action Register

All activities to be completed as part of the Little Blue River Watershed management plan are identified in Table 60. The goals set by the steering committee are listed below. Each objective in the action register corresponds to one or more goals and reflects the estimated amount of each BMP that will be needed in order to achieve the target load reductions. Nutrient and sediment removal efficiencies were not available for all BMPs, so the estimated number of BMPs needed was calculated based only on those BMPs that had load reduction estimates. For those BMPs that did not have associated load reduction estimates, the objective was developed with an amount of each BMP that the steering committee determined to be reasonably achievable. Therefore, if all the BMPs listed in all objectives are implemented, the total load reductions achieved will far exceed the load reductions needed to meet the water quality benchmarks.

Table 60. Action Register.

Education and Outreach Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Nutrients, Sediment, *E. coli*	Coordinate on-the-ground cost-share program starting in 2025.	Landowners, agricultural producers (livestock and row crop), land users	Develop a cost-share program (2025).	$25,000 annually staffing	PP/TA: NRCS, SWCD, City of Shelbyville, Purdue Extension, CISMA FSA
			Implement cost-share program (2025-2054).		
			Identify and apply for potential funding sources to augment cost-share program including IDEM Section 319, MRBI, RCPP, LARE, CWI and others. Once received, implement cost-share program per program guidance.		
Nutrients, Sediment, Habitat, *E. coli*	Promote and fund conservation practices which emphasize soil health, livestock and manure management, natural resources restoration and management and target urban BMP implementation (Table 56).	Landowners, agricultural producers (livestock and row crop), land users	Meet BMP annual targets detailed above (Table 58).	$158,919 annually BMP implementation	PP/TA: NRCS, SWCD, City of Shelbyville, Purdue Extension PP: CISMA, FSA
			Increase adoption of conservation plans and nutrient (including manure management) plans.		
			Work with the City of Shelbyville MS4 and any future 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: 27% reduction in nitrate loading, 32% reduction in total phosphorus loading and 32% reduction in total suspended solids loading.		
			Achieve medium-term load reductions: 37% reduction in nitrate loading, 46% reduction in total phosphorus loading and 48% reduction in total suspended solids loading.		

Education and Outreach Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
			Achieve long-term load reductions: 60% reduction in nitrate loading, 86% reduction in total phosphorus loading and 93% reduction in total suspended solids loading.		
Education; E. coli	Work with contractors and Health Depts to increase septic system maintenance and installation awareness	Homeowners, land users	Produce and distribute septic maintenance brochure at local events, field days, city festivals and county fairs.	$5,000 annually	PP/TA: Purdue Extension, SWCDs, contractors, WWTP, Health Departments
			Offer cost-share incentives to producers proving voluntary septic maintenance.		
			Explore options for future septic system maintenance or upgrade assistance funding.		
Education	Work with local entities to establish an inorganic pollution education program	Landowners, agricultural producers (livestock and row crop), land users	Continue to promote trash pick up, annual clean up events and identify new opportunities (adopt a road, community corrections clean up events, student engagement) to reduce trash pollution.	$2,000 annually	PP/TA: NRCS, SWCD, City of Shelbyville, Purdue Extension, CISMA, FSA
			Establish an annual reporting mechanism to determine how much trash was saved from entering and removed from Little Blue River streams.		
			Work with the City of Shelbville MS4 to implement their minimum control measures.		
			Coordinate efforts with the Shelby and Rush County Master Plans.		
			Identify individual residents who can serve as ambassadors for residential BMP implementation, identify funding opportunities and implement a residential BMP demonstration program.		
Sediment, Nutrients, Habitat	Protect and restore floodplains and stream buffers	Landowners, producers, cities, counties, MS4s	Develop and implement a floodplain maintenance and reforestation program targeting urban and row crop agricultural areas.	$15,000 annually	PP/TA: NRCS, SWCD, City of Shelbyville, Purdue Extension, CISMA FSA
			Identify high quality riparian lands and their owners.		
			Work with riparian landowners to protect high quality riparian lands via conservation easements, reforestation and/or restoration.		

Education and Outreach Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Nutrients, Sediment, *E. coli*	Increase storage and filtration	Landowners, producers, cities, counties, MS4s	Increase tree canopy cover across the watershed.	$10,000 annually	PP/TA: NRCS, SWCD, City of Shelbyville, Purdue Extension, CISMA FSA
			Increase stormwater storage capacity through agricultural storage, wetland restoration and reforestation efforts.		
Education	Educate Little Blue River project stakeholders about soil erosion, increase awareness about applicable BMPs, inorganic pollution and cost share opportunities	Schools, producers, landowners, city/county councils	Develop an education plan targeting each practice identified above by 2025.	$25,000 annually	PP/TA: NRCS, SWCD, City of Shelbyville, Purdue Extension, CISMA FSA, Parks and Recreation, Local schools, SWMDs
			Create mechanisms 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.		
Education	Work with partners to identify and promote hands-on opportunities to improve natural areas and habitat within the Little Blue River Watershed.	Landowners, developers, local residents, City of Shelbyville	Identify partner organizations which host field days, workdays, and clean-up events.	$5,000 annually	PP/TA: NRCS, SWCD, City of Shelbyville, Purdue Extension, CISMA FSA
			Promote local natural areas which provide access to the Little Blue River and its tributaries. Highlight options to engage with or get out onto water.		
			Annually, identify partner workdays for river clean-up, float trip, invasive species control, low-head dam safety education, septic system maintenance and education, trash removal,		

Education and Outreach Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
			illegal dumping or habitat restoration opportunities and promote throughout the watershed.		
Nutrients, Sediment, *E. coli*	Monitor annual loading rates using IDEM fixed station data and consider options for delisting streams currently on IDEM's 303(d) list for E. coli	State agencies, SWCD, MS4s	Establish an annual volunteer or professional monitoring program to assess nutrient and sediment impacts to the Little Blue River Watershed. Every 10 years complete geometric mean E. coli monitoring (5 samples collected over 30 days) at the outlets of each Little Blue River 12-digit HUC.	$55,000 per gaging station per year	PP/TA: NRCS, SWCD, City of Shelbyville, Purdue Extension, CISMA FSA
Nutrients, Sediment, Habitat	Improve water quality and habitat to obtain passing mIBI, IBI, and QHEI scores and delist streams currently on IDEM's 303(d) list for IBC	State agencies, SWCD, MS4s	Implement BMPs noted above targeting sediment, nutrients and E. coli reductions, flood mitigation and riparian habitat improvement. Monitor macroinvertebrate populations every five years and habitat annually.	$10,000 per assessment	PP/TA: NRCS, SWCD, City of Shelbyville, Purdue Extension, CISMA FSA

11.0 FUTURE ACTIVITIES

The next steps for the project include starting implementation of the Little Blue River Watershed Management Plan. The Shelby County SWCD in partnership with the project steering committee and other regional partners will consider options for submitting implementation-focused grant applications for IDEM Section 319 funds, Mississippi River Basin Initiative Funds, DNR LARE, Clean Water Indiana and other funds. 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 Little Blue River Watershed, helping reach goal statements by 2054(Table 61). For each practice identified which the committee deemed familiar and routinely utilized in the Little Blue River 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 61). 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 61 will be used to document changes and aid in the plan re-evaluation. The steering committee listed potential partners and technical assistance providers as both unless otherwise noted. Activities to be completed as part of this watershed management plan are identified in the action register Table 60). Table 62 identifies the annual target for the number or acres of BMPs to be installed during each implementation phase. Work completed toward 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 Shelby County SWCD will be responsible for keeping the mentioned records.

Table 61. 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
Volunteer or Professional Chemistry Monitoring	Every year	$250/site volunteer	Local partners
E. coli Monitoring	10 years	$50/ sample lab fees + staff time	SWCD
Macroinvertebrate Monitoring	5 years	$500/event	SWCD
Habitat Monitoring	1 year	$500 annually	SWCD

Table 62. Annual targets for best management practices.

Suggested BMPs:	Annual BMP Targets High	Annual BMP Targets Medium	Annual BMP Targets Low	Units
Conservation Cover (327)	100	100	100	acre
Cover Crop (340)	1,000	1,000	1,000	acre
Fence (382)	33	33	33	feet
Filter Strip (393)	17	17	17	acre
Forage and Biomass Planting (512)	50	50	50	acre
Grassed Waterway (412)	3	3	3	acre
Heavy Use Area Protection (561)	120	120	120	sq ft
Livestock Restriction (Alt Watering System, Access Control)	50	50	50	Feet, unit
Nutrient/Pest Management (590)	400	400	400	Acre
Pollinator planting (CP42)	53	53	53	acres
Prescribed Grazing (528)	33	33	33	acre
Residue and Tillage Management (329)	1,000	1,000	1,000	acres
Two Stage Ditch (582)	0	0	10	feet
Streambank Stabilization	12	12	12	feet
Urban practices	30	30	30	count

11.2 Indicators of Success

Water quality, social, and administrative indicators will be used to monitor progress towards successful achievement of the goals for the critical areas. 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. 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 annually at the WMP sample sites. 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.
- Administrative Indicator: The number of BMPs that can reduce nitrate-nitrogen and total phosphorus will be tracked annually. The total number of acres will be compared against annual targets identified in Table 62. Individual load reductions calculated for each BMP will be reviewed to determine if cumulative loading rates for nitrate-nitrogen and phosphorus are sufficient to meet the target reductions.

Reduce Sediment Loading

- Water Quality Indicator: Total suspended solids will be measured annually at the WMP sample sites. After five years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the target level for total suspended solids of 15 mg/L.

- Administrative Indicator: The number of BMPs that can reduce total suspended solids will be tracked annually. The total number of acres will be compared against annual targets identified in Table 62. 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 by volunteers. After ten 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 acres will be compared against annual targets identified in Table 62.

Improve Habitat Quality

- Administrative Indicator: The number of habitat assessments occurring annually (volunteer or professional) and associated scores.
- Water Quality Indicator: Habitat (QHEI or CQHEI) will be assessed no less than annually at the WMP sample sites. After five years of implementation, habitat stores will show an increasing trend with more sites annually scoring higher metric and total scores.

Increase Public Awareness and Participation

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

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 56.

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 Little Blue River Watershed will require an Environmental Assessment or an Environmental Impact Statement.

11.4 Outreach Plan

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

- Targeted landowner and producer mailings to announce the program and encourage the adoption of conservation practices. Mailings will occur no less than once but may occur annually, as needed.
- Practice specific field days and workshops. No less than 2 workshops or field days will occur annually.
- Newsletters. The Little Blue River steering committee will work with partners to distribute information on a quarterly basis within partner newsletters including SWCD, county extension, FSA, and others.
- Post information at public locations such as farm and garden centers.
- Work with regional CCAs to provide information about the program.
- Maintain a project website which will be used to promote project events, announce fund availability and detail funding deadlines. 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 Shelby, Rush and Henry County service centers provide assistance for Little Blue River Watershed.
- Shelby, Rush and Henry 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 Little Blue River Watershed Project will provide education and outreach assistance and assist with program promotion.

11.5 Adapting Strategies in the Future

Due to the uncertainty of 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 Little Blue River Project Steering Committee can adjust the watershed management plan to ensure project success. A four-step adaptive management strategy has been outlined for the Little Blue River Watershed Project and can be found below.

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

Step 2: Implementation The action register and schedule will be implemented to achieve the goals of the Little Blue River Watershed Project objectives and goals. Partnering agencies such as NRCS, SWCD, ISDA, and IDEM will carry out the implementation. Implementation will include a cost-share program and education events targeting both 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 61 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 60) 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 reached through outreach, etc. The evaluations will be conducted by the Little Blue River Project Steering Committee. The group will then provide recommendations that will improve project success. Progress against the watershed management plan will be reviewed no less than every two years (i.e. 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 Little Blue River Project coordinated by the Shelby 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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