VFC Index - Watershed (Plan)

Program: Watershed

IDEM Document Type: Plan

Document Date: 2/24/2020

Security Group: Public

Project Name: Lower Big Blue River WMP

Plan Type: Watershed Management Plan

HUC Code: 05120204 Driftwood

Sponsor: Shelby County SWCD

Contract #: 7-211

County: Shelby

Cross Reference ID: 80390079; 82755144

Comments: Hancock, Henry, Johnson, Rush

Additional WMP Information

Checklist: 2009 Checklist

Grant type: 205j

Fiscal Year: 2016

IDEM Approval Date: 2/24/2020

EPA Approval Date: 02/24/2020

Project Manager: Kathleen Hagan

LOWER BIG BLUE RIVER WATERSHED MANAGEMENT PLAN

SHELBY, JOHNSON, RUSH, HENRY AND HANCOCK COUNTIES

A PROJECT OF THE
SHELBY COUNTY SOIL AND WATER CONSERVATION DISTRICT
2779 SOUTH 840 WEST
MANILLA, INDIANA 46150

SARA PEEL, CLM
LOWER BIG BLUE RIVER PROJECT COORDINATOR
1610 N. AUBURN STREET
SPEEDWAY, INDIANA 46224

20 FEBRUARY 2020

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

PAGE

TABLE OF TABLES

PAGE

APPENDIX LIST

1.0 WATERSHED INTRODUCTION

1.1 Watershed Community Initiative

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

The Lower Big Blue River (LBBR) Watershed drains one 10 digit Hydrologic Unit Code (HUC) watershed (0512020408) that includes seven HUC-12 subwatersheds: Headwaters Six Mile Creek (051202040801), Anthony Creek (051202040802), Nameless Creek (051202040803), Prairie Branch (051202040804), Foreman Branch (051202040805), DePrez Ditch (051202040806) and Shaw Ditch (051202040807). For the purpose of this document from here forth the before described watershed will be referred to as the LBBR Watershed. The LBBR Watershed drains an area of approximately 112,291 acres (175 square miles) and contains 231 miles of lotic aquatic systems. The LBBR Watershed carries water from the southwest corner of Henry County, the northwest corner of Rush County, and the southeast corner of Hancock County flowing southwest through Shelby County where it outlets to the Driftwood River in the southeast corner of Johnson county just west of the Edinburgh town limits (Figure 1). Water from the Driftwood River flows south and west to join with the White River; this water eventually reaches the Wabash River and drains into the Gulf of Mexico.

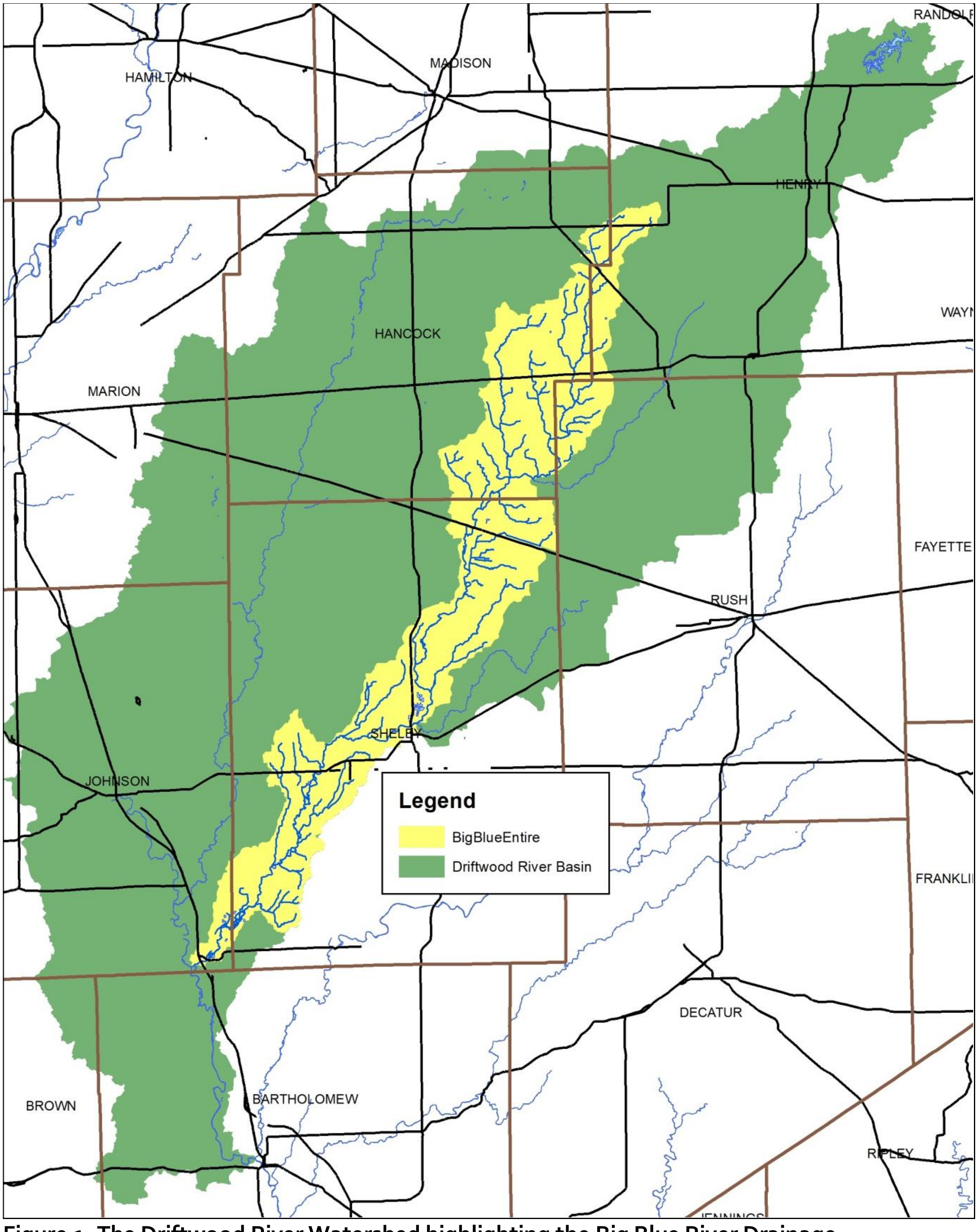

Figure 1. The Driftwood River Watershed highlighting the Big Blue River Drainage.

1.2 Project History

The LBBR Watershed project was initiated by the Shelby County Soil and Water Conservation District for the purpose of generating interest in conservation while drawing attention to the condition of the waters within its boundaries. It is concerning, to residents that are aware, that local waters are not surrounded by adequate best management practices and that bacteria, sediment, and nutrients are loading into waters used for recreation.

In 2014, Indiana Department of Environmental Management published a Total Maximum Daily Load (TMDL) for the Lower Big Blue River Watershed for the Escherichia coli (*E. coli*) bacteria. Increased E. coil concentrations can be an indicator of bigger issues, for example; failing septic systems or excessive livestock manure runoff. The majority of land use within the watershed is agricultural which provides conservation partners with the opportunity educate producers and serve as the catalyst for change in management practices.

The Soil and Water Conservation District (SWCD) is joined in this effort by several other individuals/groups that share the passion to protect our natural resources while educating and driving changes in management. The Natural Resources Conservation Service has taken a role to provide technical assistance as needed; soils information, specifications for conservation practices, and various other resources for planning and mapping conservation practices where they are best fit. Friends of the Big Blue River is another local group, in Shelbyville, that is dedicated to sharing information and working together to improve the condition of the Blue River. This group has been working together since 2012 to gather water sampling data to help establish a baseline for evaluating the results of installed practices and changes that may be taking place in the watershed. In that time, the group has organized several community river clean-up days and caught the attention of other community members and local media.

Together this group, along with the support of other local groups, is dedicated to developing a successful watershed management plan that will lead to positive change in the watershed.

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 LBBR Watershed.

1.3 Stakeholder Involvement

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

1.3.1 Steering Committee

Individuals representing the towns and counties within the watershed, environmental groups, natural resource professionals, agricultural and commercial representatives, and private citizens comprised the steering committee. Support from area businesses and community groups was generated by sending letters highlighting the steering committee concerns and goals of the project. The groups or individuals that chose to respond expressed interest in protecting our natural resources while serving as a resource for community outreach, education, and involvement. Additional stakeholder concerns were gathered by sending a survey to those that initially expressed their support asking them to pinpoint what they see to be the biggest concern within the watershed and what they perceive to be the best ways to combat these issues. Stakeholder involvement is a continuous process and as the project progresses, more concerns and efforts to increase involvement will be expressed.

The steering committee met no less than quarterly and was provided an update no less than monthly by the watershed coordinator. All steering committee members are asked for suggestions and to express any concerns they may have regarding the project and involvement. Table 1 identifies the steering committee members and their affiliation.

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

Individual	Organization(s) Represented
Daniel Clark	Soil and Water Conservation District Chairman/ Farmer
Christina Gates	Shelby County SWCD, Green County NRCS
Kris Schwickrath	Board of Zoning Appeals
Eric Fisher	USDA Farm Service Agency/Farmer
Derrick Byers	Storm Water Utility Director- Shelbyville
Chris Lux	Shelbyville High School Science Teacher
Dan Foltz	Foltz Farms- Owner
Jason Krummen	Water Quality and Hazardous Materials Management- Marion Co. Health Dept
Mike Bowman	Business Owner in Watershed
Russ Sparks	Resource Specialist- Shelby County SWCD
Frank Jones	USDA-Natural Resources Conservation Service District Conservationist

1.3.2 Public Meetings

Public participation is necessary for the long-term success of any watershed planning and subsequent implementation effort. One component of public participation for this project was public meetings. There were three public meetings held on 28 February 2017, February 2019 and February 2020 to introduce the project and develop a concerns list and allow individuals to provide their thoughts on potential projects that will be targeted in future implementation efforts. The purpose of the public meetings was to provide information on the overall planning effort and its progress; solicit stakeholder input, opinions, and participation; create opportunities for the public to recommend programs, policies, and projects to improve water quality; and build support for future phases of the project.

The public meetings were advertised through press releases distributed to local newspapers in the watershed and via postcards and emails sent to local landowners and conservation partners. The meetings were also advertised through word of mouth, and were posted on the Soil and Water Conservation District website and social media pages as well as through their mail distribution list.

The first public meeting was held on 28 February 2017. Attendees represented citizens, farmers, conservation partners, and city officials. During this meeting, the Shelby County SWCD detailed the history of the project; described opportunities for individuals to volunteer as part of the project; and provided attendees with the opportunity to identify their concerns about the LBBR Watershed and develop goals for the long-term vision of watershed streams. The first meeting occurred in a roundtable, open discussion type setting where attendees were asked to share: where they thought the watershed needed the most attention, what kinds of action they would like to take, how they can be involved, and the realistic, measurable outcomes they hope to see by engaging in this project.

A second public meeting was held as part of the 2019 Shelby County SWCD annual meeting in February 2019 while the third public meeting was held as part of the 2020 Shelby County annual meeting in February 2020.

1.4 Public Input

Throughout the planning process, project stakeholders, the steering committee, and the general public listed concerns for the LBBR Watershed including Big 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 and the watershed inventory process.

Stakeholder Concerns
Ditch maintenance on county roads—several areas pool and become stagnant, then wash to river
Protection of natural resources
Reduce soil loss
Reduce wetland loss
Poor water quality: elevated sediment, nutrient and pathogen concentrations
Quality of water used for recreation
Other potential water quality issues—PCB in Fish Tissues
Public Education needed: water quality, best management practices, pollution
Septic system maintenance or replacement of failing systems
Future funding opportunities for septic repair cost-share
Bank stabilization is needed
Sedimentation - agricultural BMP installation is needed to address sediment concerns
Manure from livestock and confined feeding operations
Livestock exclusion from waters
Reliable water sampling data
Public presence: First Fridays (monthly event in Shelbyville) county fairs, county board meetings, etc.
Lowhead dam – Thompson Mill Dam (Big Blue River confluence with the White River) proposed for removal due to hazard concerns
Irrigation impacts to groundwater

Flooding along the Big Blue River	
Trash and illegal dumping	

2.0 WATERSHED INVENTORY I: WATERSHED DESCRIPTION

2.1 Watershed Location

The LBBR Watershed drains one HUC-10 watershed (0512020408) that includes seven HUC-12 subwatersheds: Headwaters Six Mile Creek (051202040801), Anthony Creek-Big Blue River (051202040802), Nameless Creek (051202040803), Prairie Branch-Big Blue River (051202040804), Foreman Branch-Big Blue River (051202040805), DePrez Ditch-Big Blue River (051202040806) and Shaw Ditch-Big Blue River (051202040807). The LBBR Watershed drains an area of approximately 112,291 acres (175 square miles) and contains 210 miles of lotic aquatic systems. The LBBR Watershed carries water from the southwest corner of Henry County, the northwest corner of Rush County, and the southeast corner of Hancock County flowing southwest through Shelby County where it outlets to Driftwood River in the southeast corner of Johnson county just west of the Edinburgh town limits (Figure 1). Water from the Driftwood River flows south and west to join with the White River; this water eventually reaches the Wabash River and draining into the Gulf of Mexico.

2.2 Subwatersheds

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

Table 3. 12-digit Hydrologic Unit Code (HUC) watersheds in the Lower Big Blue River Watershed.

Subwatershed Name	Hydrologic Unit Code	Area (acres)	Percent of Watershed
Headwaters Six Mile Creek	051202040801	10,818	9.6%
Anthony Creek-Six Mile Creek	051202040802	18,340	16.3%
Nameless Creek	051202040803	10,516	9.4%
Prairie Branch-Big Blue River	051202040804	11,149	9.9%
Foreman Branch-Big Blue River	051202040805	24,792	22.1%
DePrez Ditch-Big Blue River	051202040806	17,910	15.9%
Shaw Ditch-Big Blue River	051202040807	18,766	16.7%
	Entire Watershed	**112,291**	**100%**

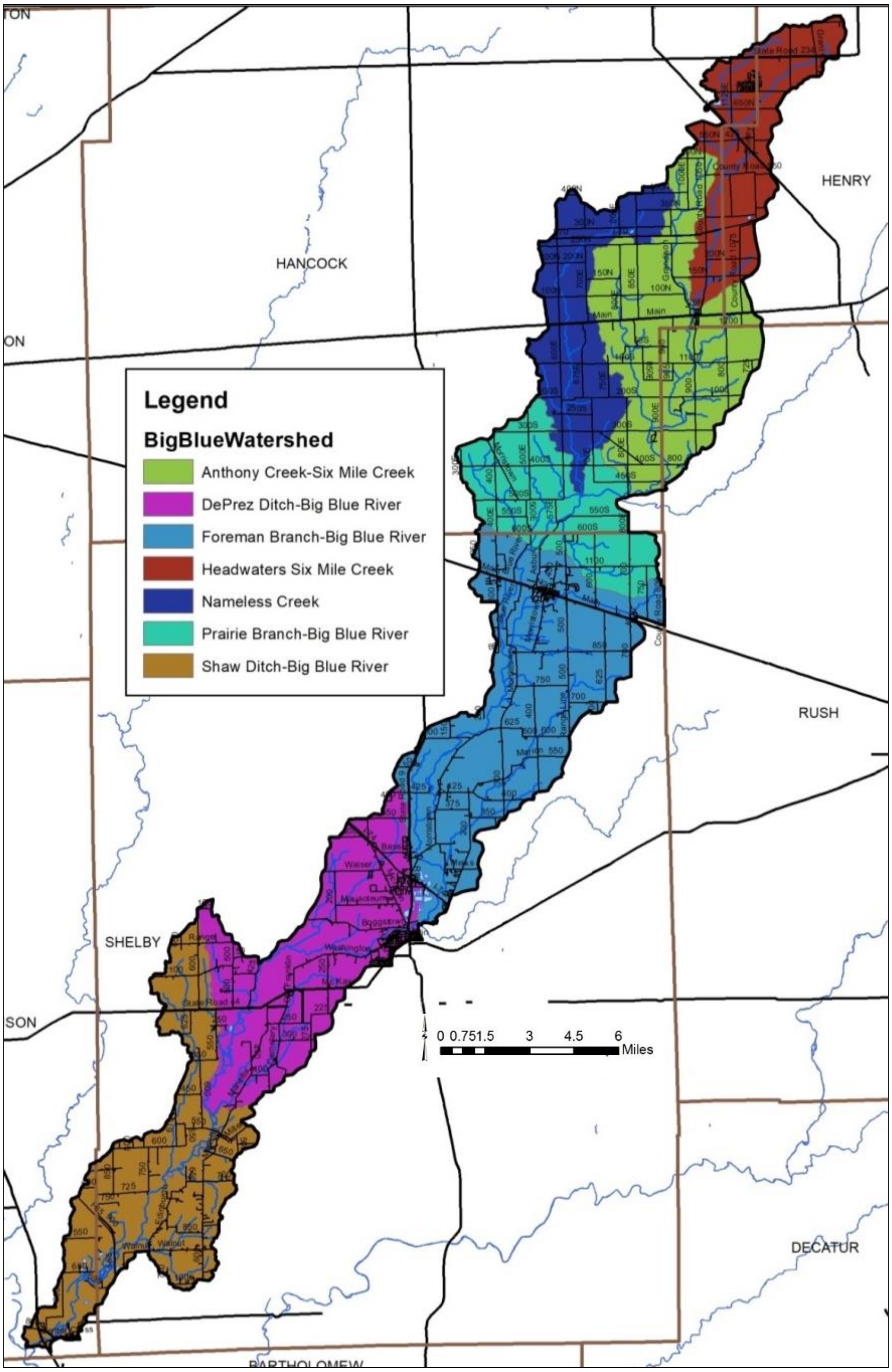

Figure 2. 12-digit subwatersheds in the Lower Big Blue River Watershed.

2.3 Climate

In general, Indiana has a temperate climate with warm summers and cool or cold winters. Climate in the LBBR Watershed is no different than the rest of the state. There are four seasons throughout the year. The average temperatures measure approximately 83°F in the summer, while low temperatures measure below freezing (24.5°F) in the winter. The growing season typically extends from April through

September. On average, 41.95 inches of precipitation occurs within the watershed per year; approximately 72% of this precipitation falls during the growing season (US Climate Data, 2019).

2.4 Geology and Topography

The LBBR Watershed is situated on three different classes of limestone. The Pleasant Mills Formation, which covers about 800 acres in the Morristown area is described by Indiana University as part of the Silurian System with a rock type of dolomite, limestone and argillaceous dolomite (Figure 3). Louisville Limestone covers approximately 200 acres in the Waldron area—this is also a Silurian System. The rest of the watershed is part of the Devonian System and in the Muscatatuck Group of rock units which are comprised of dolomite and limestone. Figure 4 details the surficial geology present in the Lower Big Blue River Watershed. Much of the Big Blue River lies within outwash, while Erie-Huron Lobe Till covers the majority of the watershed.

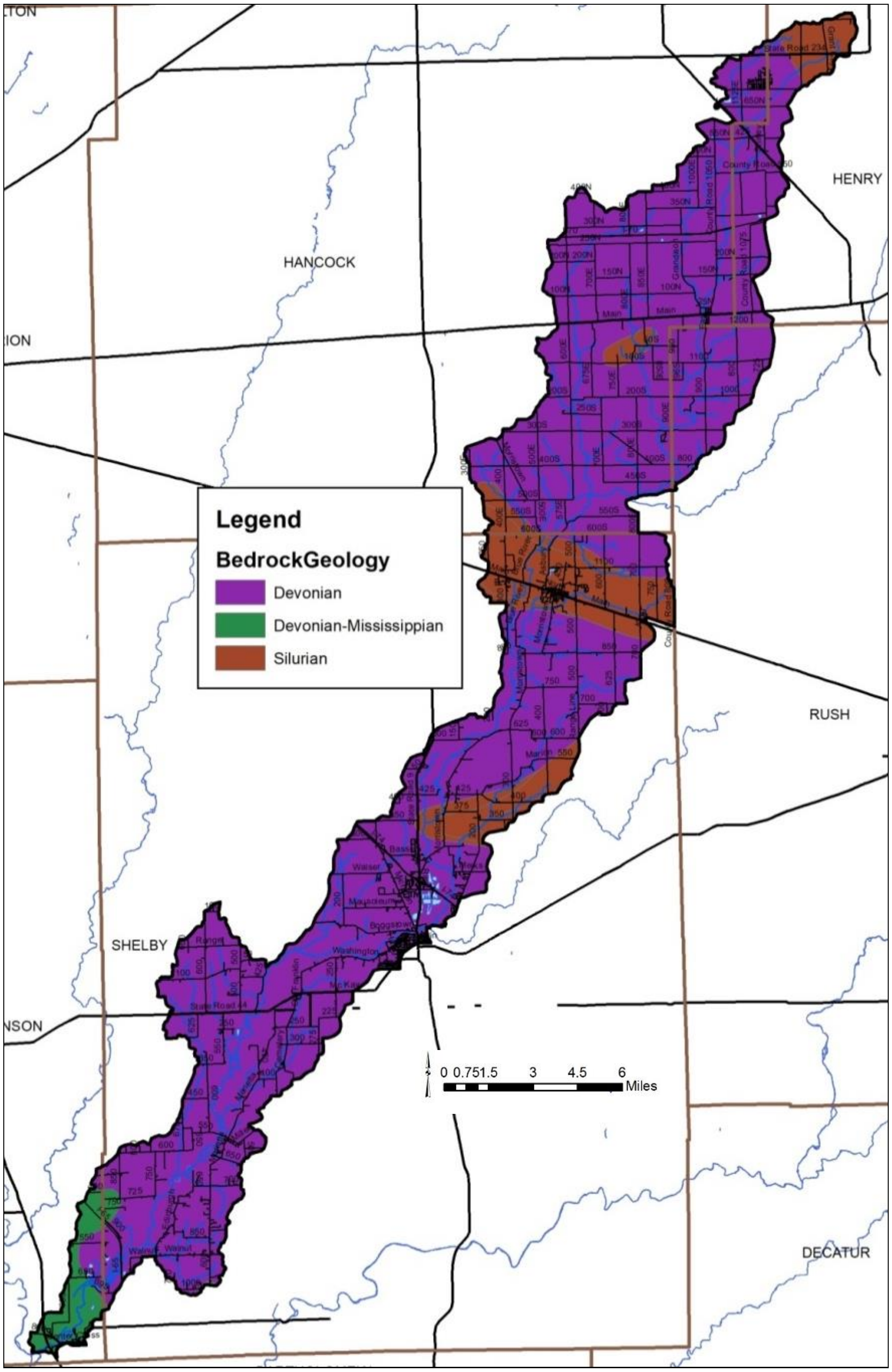

Figure 3. Bedrock in the Lower Big Blue River Watershed.

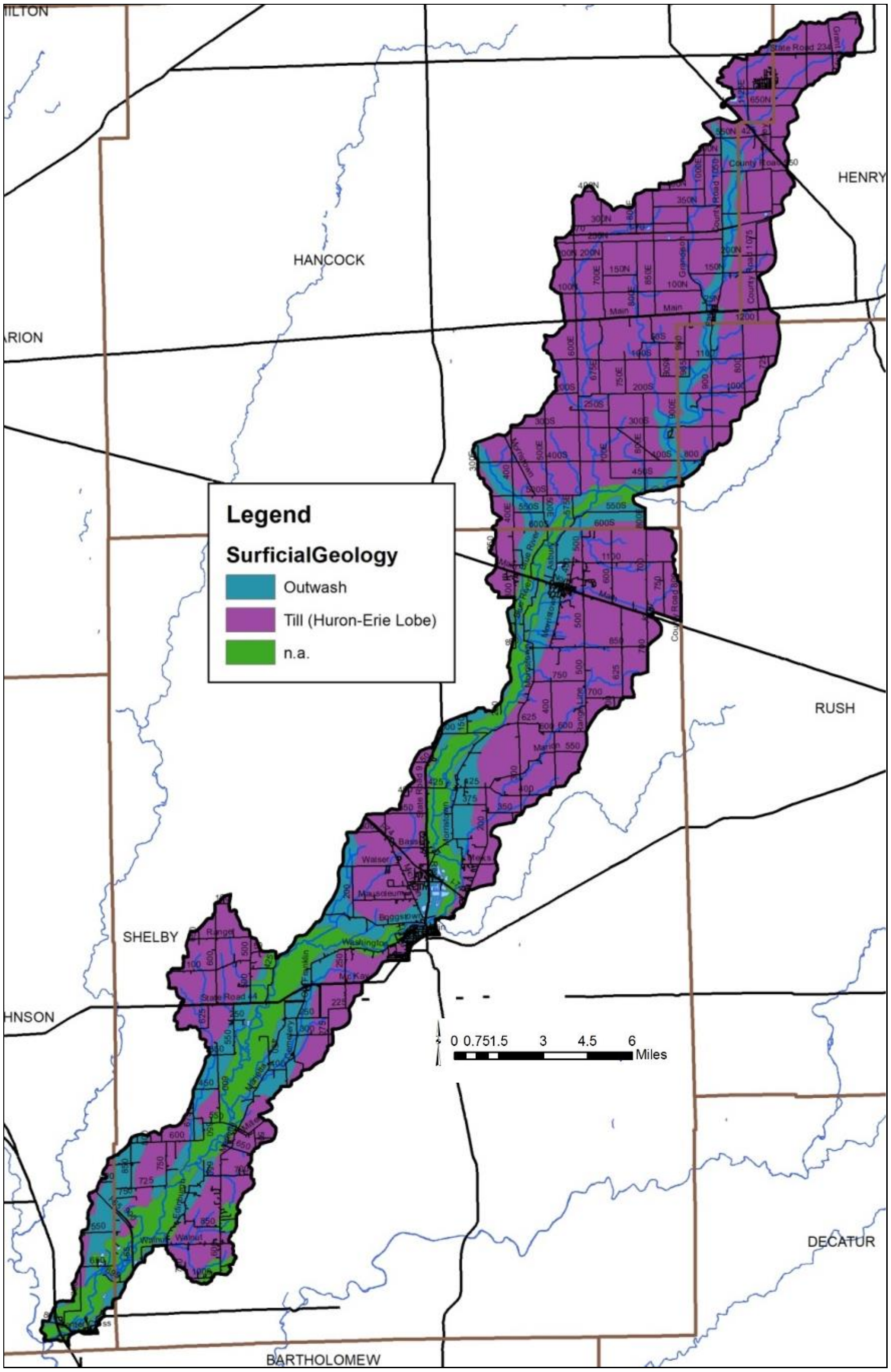

Figure 4. Surficial geology throughout the Lower Big Blue River Watershed.

The general topography is flat (0-4% slopes), with moderate rolling hills in areas that lead to broad bottomlands. Most farm fields have added subsurface tile drainage to move water down into the soil profile and across the landscape rather than ponding on the flat surfaces and in depression areas. Karst features are absent. The topography of the LBBR Watershed ranges from flat rolling agricultural fields to undulating hills and valleys and has an average elevation of 655 feet mean sea level (msl; Figure 5). The lowest elevation (580 feet msl) occurs near the intersection of Big Blue River with Mill Creek.

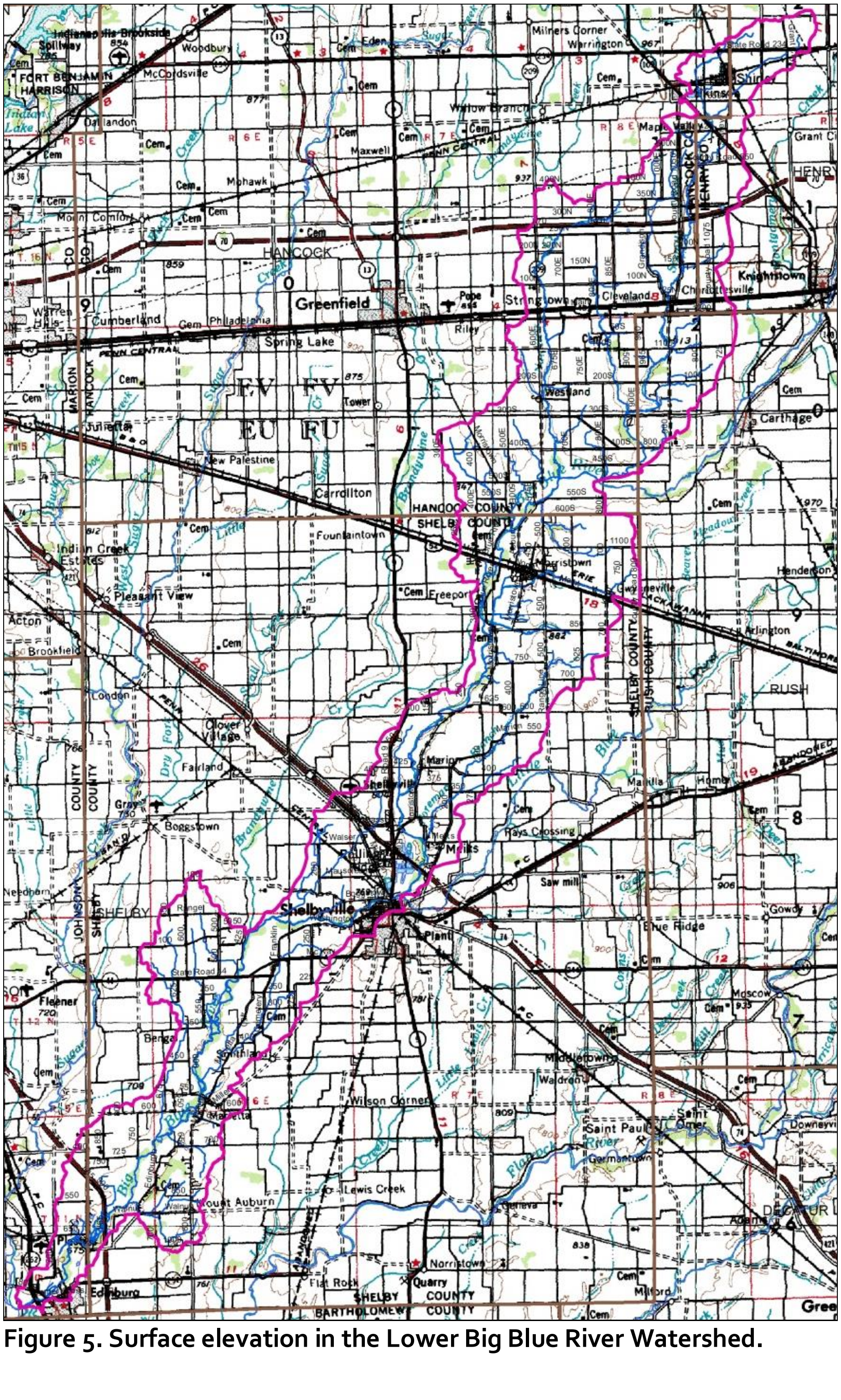

Figure 5. Surface elevation in the Lower Big Blue River Watershed.

2.5 Soil Characteristics

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

2.5.1 Soil Associations

The watershed is covered by 7 soil associations (Figure 6). The Crosby-Treaty-Miami soil association and Miami-Crosby-Treaty soil association are dominant throughout the entire watershed, primarily in Hancock and Shelby Counties and have a slope that is nearly level to strongly sloping at 60 percent. While these three soils are found in different proportions in each complex, they are found on till plains and have a native vegetation of deciduous forest. The Miami series are moderately well drained, the Crosby series are somewhat poorly drained, and the Treaty series are found in depressions and are poorly drained. The soils are generally suitable for crops and livestock farming if adequately drained but have limitations for septic systems.

The Fox-Ockley-Westland association is found throughout the central and southern parts of the watershed in Hancock, Johnson, Rush, and Shelby Counties and have a slope that is nearly level to 35 percent. The well drained Fox and Ockley soils are on the outwash plains and stream terraces and have a native vegetation of hardwood forest. The very poorly drained Westland soils are found in depressions in outwash plains, stream terraces, and glacial drainage channels, have a native vegetation of forested wetland, and are poorly suited for septic systems. These soils can be used to grow typical crops, such as corn and soybeans, when farmed on flat to gently sloping terrain.

The Sawmill-Lawson-Genesee association is found throughout the central and southern parts of the watershed in Hancock, Shelby, and Johnson Counties and have a slope that is nearly level to gently sloping. These soils consist of very deep, poorly drained soils formed in alluvium on floodplains. Flooding is rare to frequent for brief to long periods. Soils in this association are suitable for farming, with corn and soybean being the principal crops.

The remaining soil associations have a minor presence in the overall watershed. The Crosby-Cyclone-Miamian association covers a small portion of Henry and Rush Counties in the northern part of the watershed. These soils are deep, nearly level or gently sloping and are well suited to cropland and somewhat for pasture. The soils can be poorly drained; wetness limits the uses and are poorly suited for septic systems.

The Negley-Parke-Chetwynd association is found in the southern tip of the watershed in Shelby County and have a slope of nearly level to very steep at 80 percent. These upland soils consist of very deep, well drained soils and are formed on outwash, glacial till, or loess. The soils are used for pasture and cropland in areas that are not steep, with the native vegetation being hardwood and deciduous forest.

The Westland-Sleeth-Ockley association is in the central, western section of the watershed in Shelby County and have a slope of nearly level to 30 percent. These soils consist of deep, very poorly drained to somewhat poorly drained to well drained soils and are commonly found on outwash plains and stream terraces. The well drained Ockley and somewhat poorly drained Sleeth soils are on nearly level summits of outwash plains while the very poorly drained Westland soils are in the adjacent depressions. The soils can be used for crops such as corn and soybean.

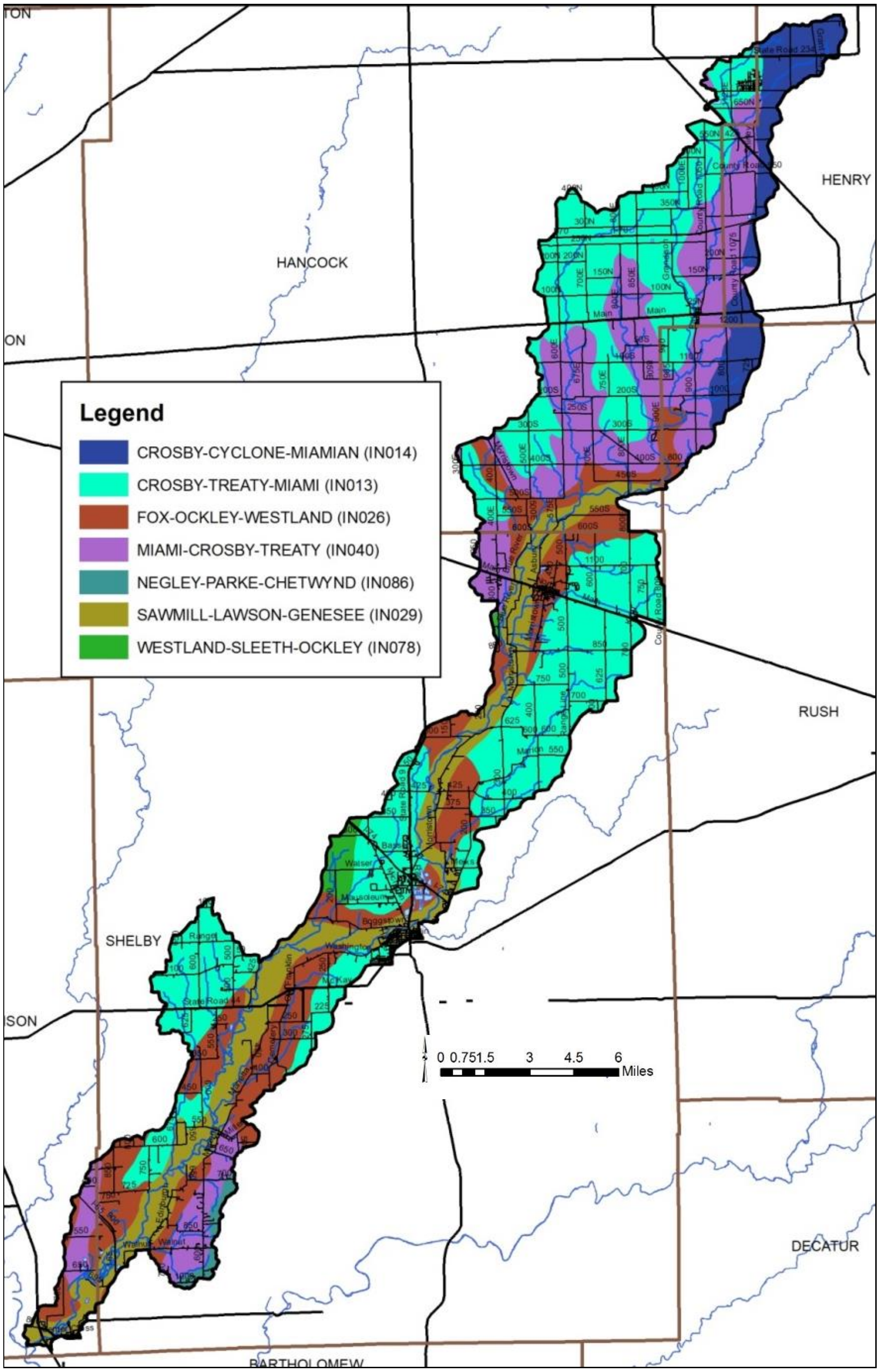

Figure 6. Soil associations in the Lower Big Blue River Watershed. Source: NRCS, 2018.

2.5.2 Soil Erodibility

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

As detailed above, soils which have high erodibility index values are those that are located on steep slopes and are easily moved by wind, water, or land uses. Figure 7 details locations of highly erodible and potentially highly erodible soils within the LBBR Watershed. Highly erodible soils cover 9.8% of the watershed or 11,038 acres, while potentially highly erodible soils cover an additional 9.4% of the watershed or approximately 10,574 acres. Highly erodible soils are found throughout the watershed with no discernable pattern of location. The remainder of the watershed's soils are considered not erodible per NRCS standards. Watershed stakeholders are concerned about soil erosion. Stakeholders' concerns of soil loss, water quality degradation, and nutrient/sediment loading can be linked back to highly erodible soil presence where there is a lack of existing best management practices in the land area. A soil's composition influences its susceptibility to erosion by wind and water. Large particles, such as sand, are transported in water that runs off and then settles in nearby lakes, streams, ditches and starts the process of filling in that area. Silt and clay particles are not heavy as sand and are easily translocated by wind and water to neighboring areas. All soils have the potential to erode if not properly managed, but highly erodible soils are an issue more often due to their position in the landscape; slope length and steepness increases the erodibility index. Tillage practices and bare soils in the LBBR watershed are the biggest concerns for soil erosion.

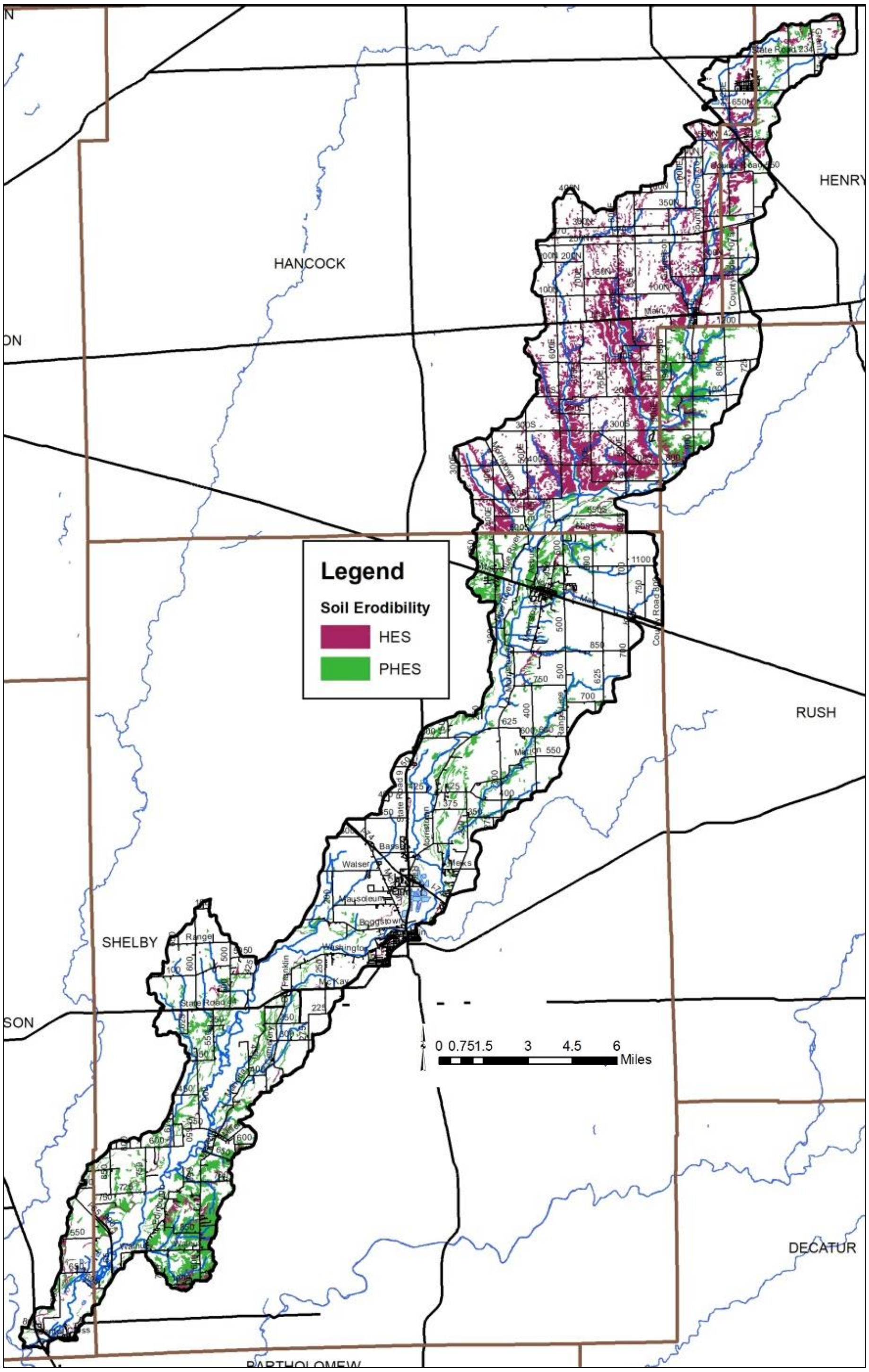

Figure 7. Highly erodible (HES) and potentially highly erodible soils (PHES) in the Lower Big Blue River Watershed. Source: NRCS, 2018.

2.5.3 Hydric Soils

Hydric soils are those which remain saturated for a sufficient period of time to generate a series of chemical, biological, and physical processes (Figure 8). The oxidation and reduction of iron in the soil, or "redox", causes color changes characteristic of prolonged fluctuations in the water table. After undergoing these processes, the soils maintain the resultant characteristics even after draining or use modification occurs.

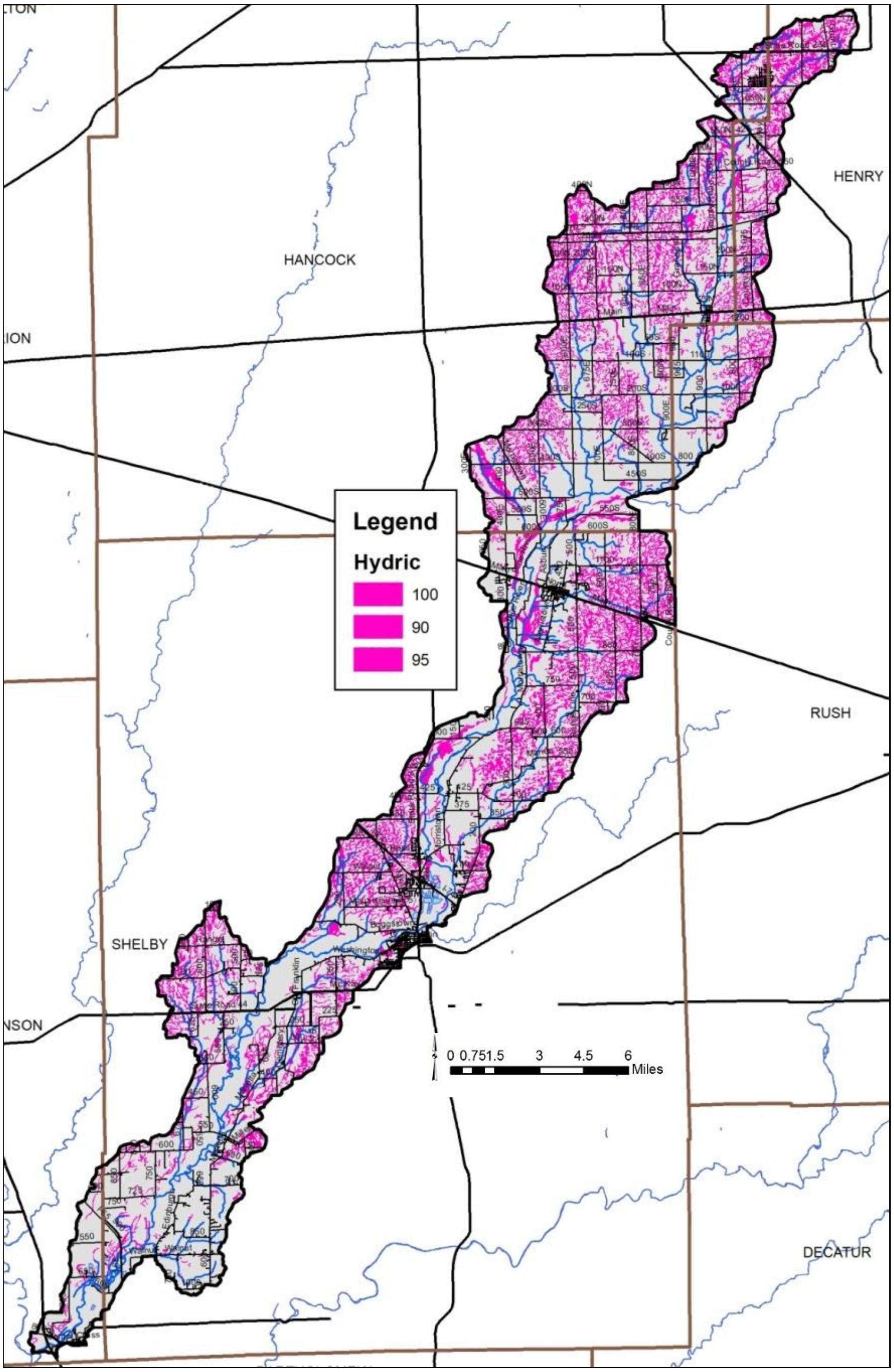

Figure 8. Hydric soils in the Lower Big Blue River Watershed. Source: NRCS, 2018.

Watershed stakeholders are concerned about the conversion of wetlands into agricultural and urban land uses. Historically, approximately 27,405 acres (24%) of the watershed was covered by hydric soils (Figure

8). Hydric soils are concentrated in the headwaters of the watershed, with the highest densities located on flat plains of Henry and Hancock Counties and western 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. Many of these soils have been drained for agricultural production or urban development.

2.5.4 Tile-Drained Soils

Soils drained by tile drains cover 70,824 acres or 63% of the LBBR 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 to stream water quality can be reduced by the use of tile control structures and drainage water management. A majority of tile-drained soils are located in the headwaters of the LBBR Watershed in Hancock, Henry, and Rush counties as well as along the eastern edge of the watershed in Shelby County (Figure 9). Most of these areas are relatively flat where drainage augmentation is required to move water from agricultural fields in order to produce row crops. In these areas, materials applied to agricultural soils are directly transported to downstream waterbodies.

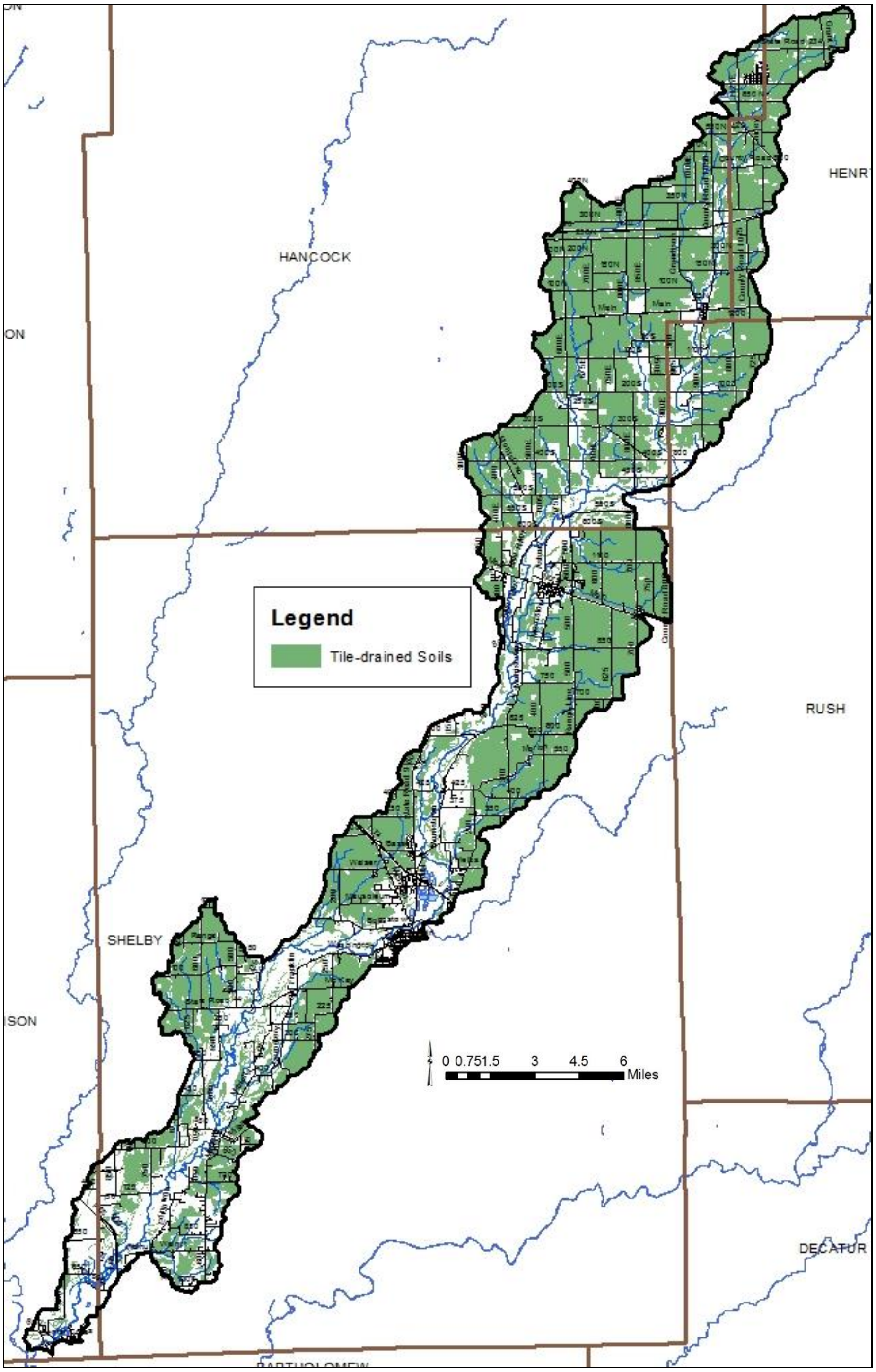

Figure 9. Tile-drained soils in the Lower Big Blue River Watershed. Source: NLCD, 2011 and NRCS, 2018.

2.6 Wastewater Treatment

2.6.1 Soil Septic Tank Suitability

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

Until 1990, residential homes located on 10 acres or more and occurring at least 1,000 feet from a neighboring residence were not required to comply with any septic system regulations. In 1990, a new septic code corrected this loophole. Current regulations address these issues and require that individual septic systems be examined for functionality. Additionally, newly constructed systems cannot be placed within the 100-year floodplain 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 is expelled in the state of Indiana annually per failing system. The true impact of these systems on the water quality in the watershed cannot be determined without a complete survey of systems.

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

Watershed stakeholders are concerned about the lack of maintenance associated with septic tanks, the use of soils that are not suited for septic treatment, and the presence of straight pipe systems within the watershed. These concerns are exacerbated by the fact that severely limited soils cover essentially the entire watershed (Figure 10). Nearly 110,204 acres or 98.2% of the watershed is covered by soils that are considered very limited for use in septic tank absorption fields. Nearly 204 acres (0.2%) are somewhat limited meaning that these soils are generally suitable for septic systems. The remaining 1,858 acres (1.7%) are not rated for septic usage as it is not generally industry standard to install a septic system in these geographic locations.

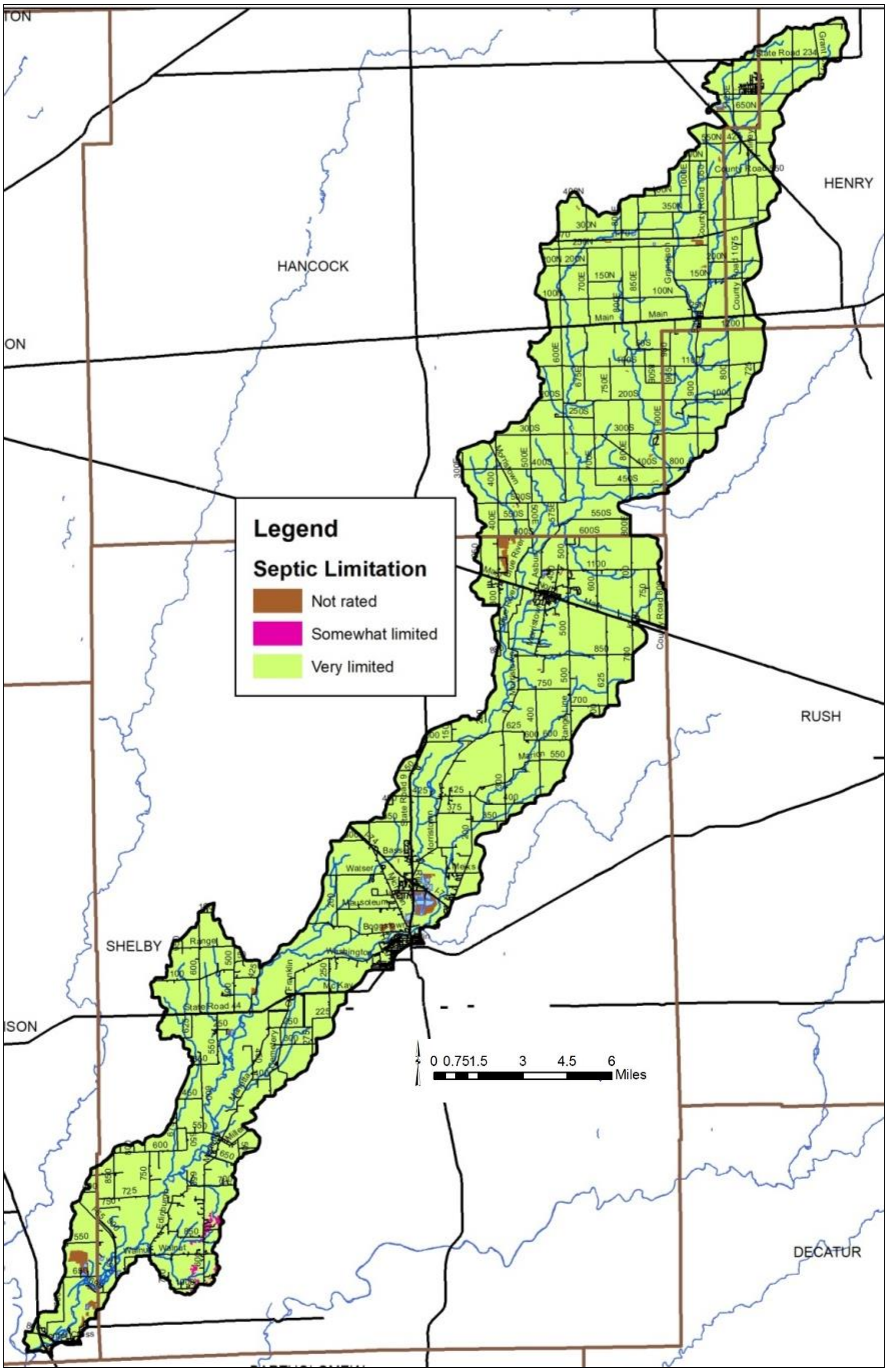

Figure 10. Suitability of soils for septic tank usage in the Lower Big Blue River Watershed. Source: NRCS, 2018.

2.6.2 Wastewater Treatment and Solids Disposal

Several facilities which treat wastewater and are permitted to discharge the treated effluent are located within the watershed. These facilities are regulated by National Pollution Discharge Elimination System (NPDES) permits. These include several wastewater treatment plants ranging in size from small, local plants to larger, publicly-owned facilities, and school facilities. In total, 11 NPDES-regulated facilities, including sewage treatment plants (STP) and wastewater treatment plants (WWTP) are located within the watershed (Figure 11). Table 4 details the NPDES facility name, activity, and permit number. No compliance issues have been documented for any of the NPDES facilities. More detailed information for each facility will be discussed on a subwatershed basis in subsequent sections.

Table 4. NPDES-regulated facility information.

Map ID	NPDES ID	Facility Name	Activity	Max Designed Flow (MGD)
1	IN0109797	DEL-CHAR MOBILE HOME COURT	STANDARD	--
2	IN0046060	ANR PIPELINE CO., SHELBYVILLE	STANDARD	--
3	IN0032867	SHELBYVILLE MUNICIPAL STP	STANDARD	8.0
4	IN0023841	MORRISTOWN MUNICIPAL WWTP	STANDARD	0.6
5	INP000147	FREUDENBURG-NOK, MORRISTOWN	PRETREATER	--
6	IN0060828	DETROIT STEEL PRODUCTS, INC.	STANDARD	--
7	INP000163	CENTRAL SOYA CO., INC. SHELBY	PRETREATER	--
8	IN0109541	TEXTRON AUTOMOTIVE EXTERIORS,	STANDARD	--
9	ING490003	CALDWELL GRAVEL SALES, INC.	GENERAL	--
10	IN0031593	EASTERN HANCOCK JR-SR H.S.	STANDARD	0.029
11	IN0024503	SHIRLEY MUNICIPAL STP	STANDARD	0.155

Source: USEPA EnviroFacts Warehouse, 2018

The Eastern Hancock Jr/Sr High School currently operates a Class I, 0.029 million gallons per day (MGD) extended aeration treatment facility consisting of a grinder, a raw surge tank, a splitter box, an aeration tank, a secondary clarifier, chlorination, an effluent meter, and two (2) two-day polishing ponds. Biosolids are stored within a sludge holding tank and hauled off- site. The collection system is comprised of 100% sanitary sewers by design with no overflow or bypass points.

The Shirley WWTP currently operates a Class I-SP, 0.155 MGD controlled discharge waste stabilization lagoon treatment facility consisting of two treatment lagoons totaling 31.6 million gallons in storage capacity, one storage/ polishing lagoon totaling 38.3 million gallons in storage capacity, influent and effluent flow meters and stream gage. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

The Edinburgh WWTP currently operates a class III, 1.5 MGD extended aeration treatment facility consisting of two (2) vertical loop reactors, an in-channel grinder, grit/fine screening, two (2) secondary clarifiers, ultra-violet light disinfection, influent/effluent flow meters, a 9.0 MGD two- celled surge lagoon and a cascade post aeration. The collection system is comprised of sanitary and storm sewers with no known overflow or bypass points. The combined sewers have been permitted with provisions. The collections system is comprised of combined sanitary and storm sewers with no known overflow or bypass points. Any discharge from any portion of the publicly owned treatment works (POTW), including the collections system, with the exception of outfall 001 (treated water outfall), is expressly prohibited. Based on our review of the Town of Edinburgh's NPDES permit renewal application, IDEM does not consider the town to have any active combined sewer overflow (CSO) outfalls. Therefore, there is no need for Edinburgh to develop a Long Term Control Plan (LTCP). However, because the collection system contains combined sewers, it is necessary to develop and submit a CSO Operational Plan.

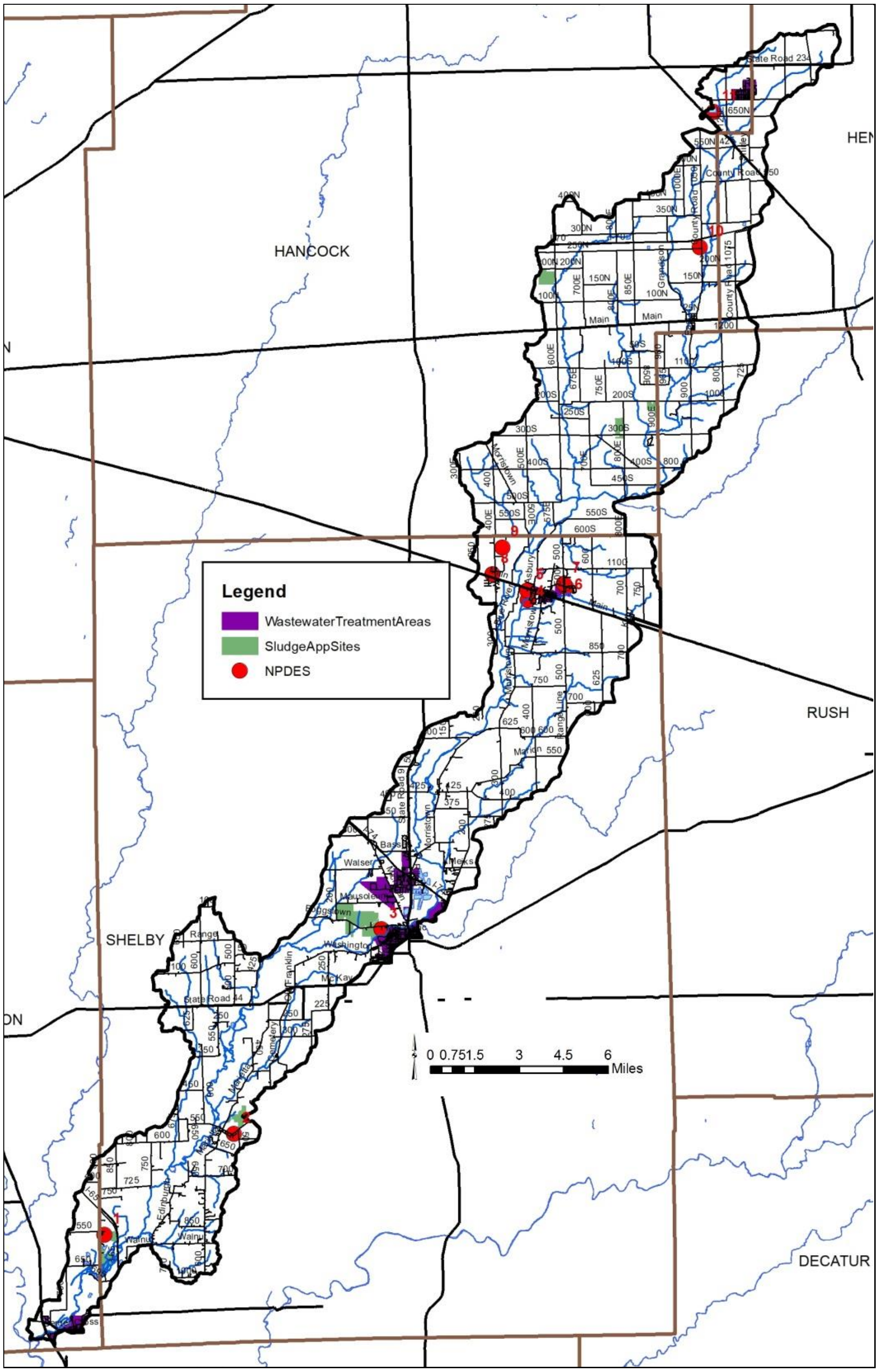

Figure 11. NPDES-regulated facilities, wastewater treatment plant service areas and municipal biosolids land application sites in the Lower Big Blue River Watershed.

The Morristown WWTP currently operates a class II, 0.6 MGD activated sludge oxidation ditch-type treatment facility consisting of aerated primary lagoon, primary flow metering, two manual grit removal channels, a mechanical fine screen, a two-ring extended aeration oxidation ditch, two secondary clarifiers, a chlorine contact tank with dechlorination, and an effluent flow meter. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

2.6.3 Municipal Wastewater Treatment and Combined Sewer Overflows

In the relatively rural LBBR Watershed, there are four wastewater treatment facilities located within and discharging to Big Blue River or a tributary, Shelbyville Municipal Sewage Treatment Plant, Morristown Municipal Wastewater Plant, Shirley Municipal Sewage Treatment Plant, and Del-Char Mobile Home Court as well as the Eastern Hancock Jr-Sr High School and six corporate dischargers. These municipal treatment facilities treat residences in 4,846 acres (4.3% of the watershed). Sludge from municipal wastewater treatment plants is applied on 1,122 acres throughout the watershed (Figure 11).

2.6.4 Unsewered Areas

Areas that have at least 25 houses within a square mile outside of the sanitary district boundaries were classified as dense, unsewered areas. No unsewered areas were identified within the 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 LBBR Watershed contains 231 miles of streams, regulated drains, and regulated tile drains (Figure 12). Of these, 25.8 miles are managed as regulated drains or ditches. Table 5 shows the length in miles, of streams within the LBBR watershed. The majority of streams in the LBBR Watershed are not regulated. It should be noted that regulated drains are maintained by the county surveyor's office and both 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 Big Blue River. Therefore, practices such as the two-stage ditch that minimize sediment transport should be considered in areas of the watershed with high densities of legal drains, or where they are otherwise desirable for reducing sediment and nutrient loads. The waters of the LBBR Watershed are valued for their contribution to recreational activities such as fishing, swimming, wading, canoeing/kayaking, and for their aesthetic value as many bodies of water meander through city/county parks. Some streams are used as a water source for livestock watering, which has been raised as a concern within the steering committee. Irrigation systems for agricultural crop fields draw water from the Big Blue River in various areas.

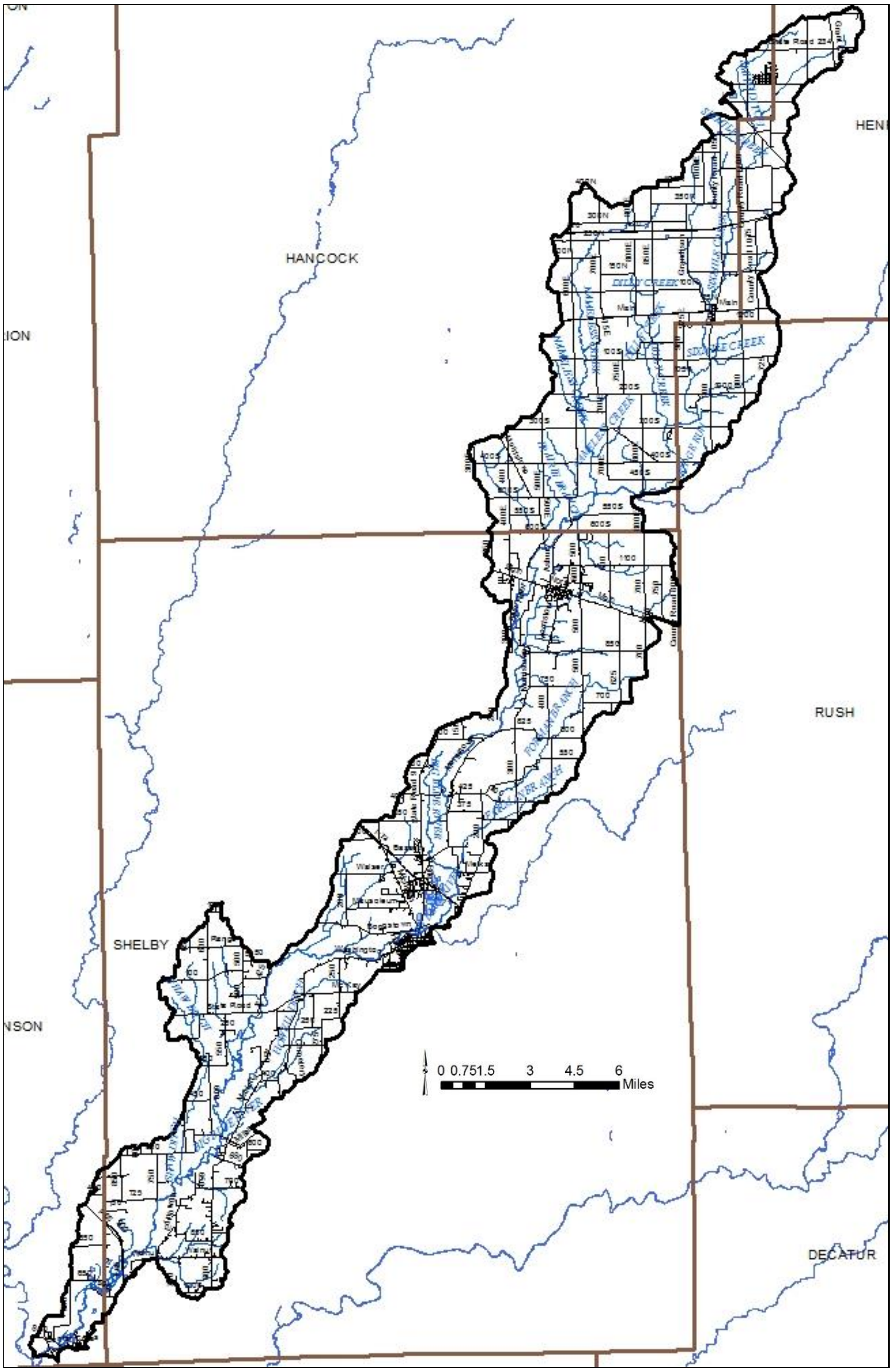

Figure 12. Streams in the Lower Big Blue River Watershed. Source: USGS, 2018; IDNR, 1999.

Table 5. Stream segments in the Lower Big Blue River Watershed.

Segment	Length (miles)
Anthony Creek	7.98
Big Blue River	70.89
Big Blue River - Unnamed Tributaries	41.52
Brandywine Creek	0.05
Dilly Creek	8.61
Forman Branch	12.82
Howell Ditch	10.36
Nameless Creek	17.80
Prairie Branch	9.05
Ridge Run	1.13
Shaw Ditch	8.41
Shaw Ditch - Unnamed Tributaries	2.47
Sixmile Creek	35.37
Smith Ditch	4.60

2.7.2 Lakes, Ponds and Impoundments

There are 245 mapped lakes and ponds in the LBBR area. No large lakes are present in the watershed; all waterbodies take up 605 acres of the LBBR or 0.54%. Indiana Department of Natural Resources identifies two (2) dams mapped in the LBBR: the Baker Dam and the Thompson Mill Dam.

The Baker Dam is located on Sixmile Creek in Morristown, Hancock County (Foreman Branch subwatershed). The Thompson Mill Dam is an in-channel dam in the LBBR Watershed located in Edinburgh, Johnson County at the confluence of the Big Blue River and the White River (Shaw Ditch-Lower Big Blue River subwatershed). This is an old, low-head dam that has been the site of many drownings. It has been proposed to be removed from the stream. This dam is a major concern to residents and stakeholders due to recreational value and the threat this this structure poses. Low-head dams have an adverse effect on water quality and ecology. Upstream movement is limited where a low-head dam is in channel because the stream is fragmented rather than fish or mussels being able to move freely. Turbidity and temperature may also be lower at the dam location which will negatively affect aquatic life.

2.7.3 Impaired Waterbodies (303(d) List)

The impaired waterbodies, or 303(d), list is prepared biannually by the Indiana Department of Environmental Management. Waterbodies are included on the list if water quality assessments indicate that they do not meet their designated use. More information on the listing process is included in section 3.2.1. Nearly 226 miles of streams in the LBBR Watershed are included on the 2018 list of impaired waterbodies for *E. coli* impairments (TMDL completed), while more than 36 miles are included for PCBs in fish tissue (IDEM, 2018). Table 6 details the listings in the watershed, while Figure 13 maps the segments and their locations within the watershed. Waterbodies are listed as impaired for *E. coli* and fish consumption for mercury and PCBs.

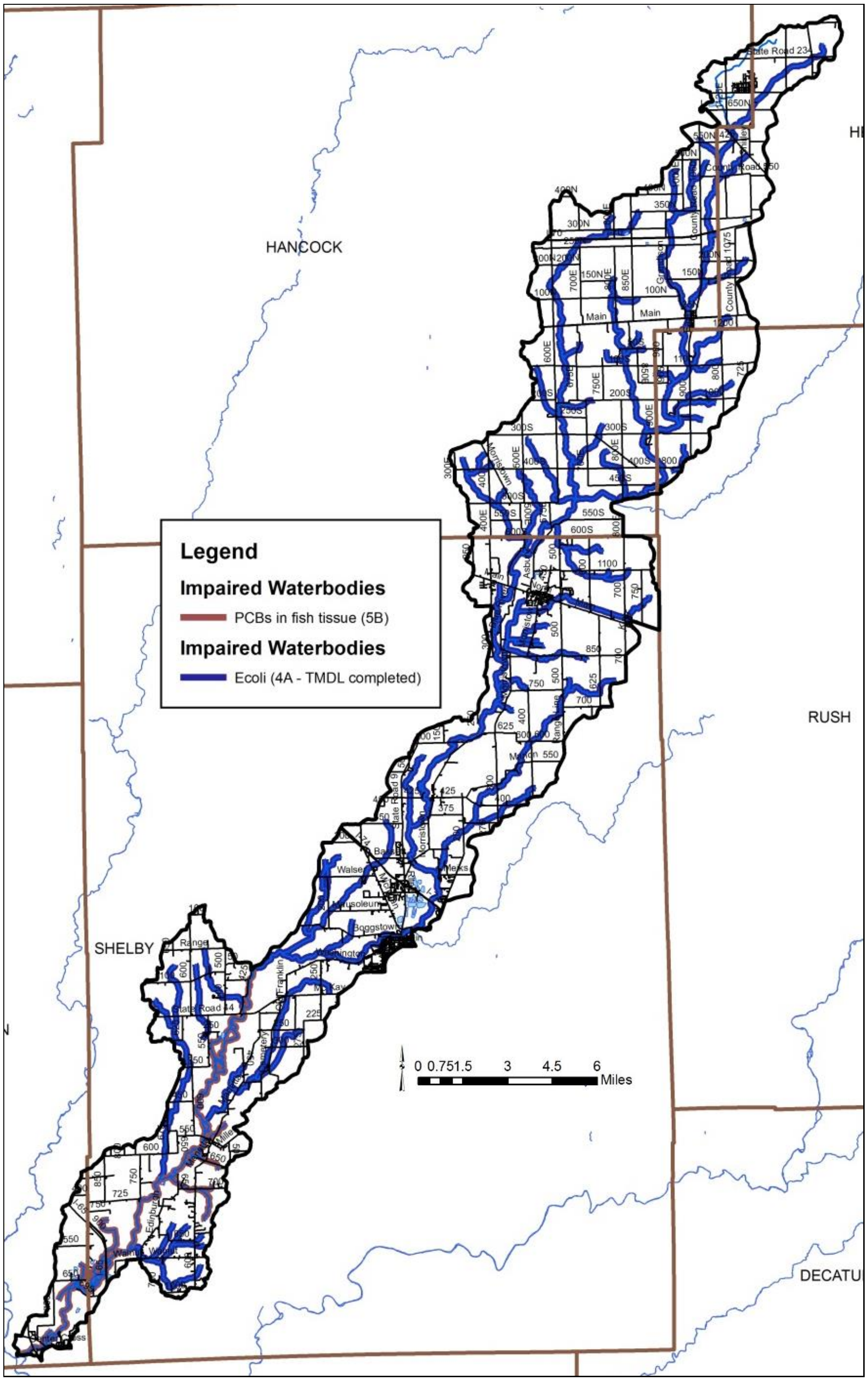

Figure 13. Impaired waterbody locations in the Lower Big Blue River Watershed. Source: IDEM, 2018.

Table 6. Impaired waterbodies in the Lower Big Blue River Watershed 2018 IDEM 303(d) list.

HUC	Waterbody	Assessment Unit	County	Impairment
051202040801	SIXMILE CREEK	INW0481_02	RUSH	E. COLI
051202040801	SIXMILE CREEK	INW0481_03	RUSH	E. COLI
051202040801	PERRY BROOK	INW0481_T1002	RUSH	E. COLI

HUC	Waterbody	Assessment Unit	County	Impairment
051202040801	CHARLOTTES BROOK	INW0481_T1003	RUSH	E. COLI
051202040801	MILLION BROOK	INW0481_T1004	RUSH	E. COLI
051202040802	ANTHONY CREEK	INW0482_T1001	RUSH	E. COLI
051202040802	SIXMILE CREEK	INW0482_02	RUSH	E. COLI
051202040802	SIXMILE CREEK	INW0482_03	RUSH	E. COLI
051202040802	CHARLOTTES BROOK	INW0482_T1003	RUSH	E. COLI
051202040802	SIXMILE CREEK	INW0482_T1004	RUSH	E. COLI
051202040802	SIXMILE CREEK - UNNAMED TRIBUTARY	INW0482_T1005	RUSH	E. COLI
051202040802	SIXMILE CREEK	INW0482_03	RUSH	E. COLI
051202040802	ANTHONY CREEK	INW0482_T1001	HANCOCK	E. COLI
051202040802	DILLY CREEK	INW0482_T1002	HANCOCK	E. COLI
51202040802	NAMELESS CREEK	INW0483_01	HANCOCK	E. COLI
051202040803	BIG BLUE RIVER	INW0484_02	HANCOCK	E. COLI
051202040804	BIG BLUE RIVER	INW0484_03	HANCOCK	E. COLI
051202040804	BIG BLUE RIVER - UNNAMED TRIBUTARY	INW0484_T1001	HANCOCK	E. COLI
051202040804	BIG BLUE RIVER - UNNAMED TRIBUTARY	INW0484_T1002	HANCOCK	E. COLI
051202040804	PRAIRIE BRANCH	INW0484_T1004	SHELBY	E. COLI
051202040804	PRAIRIE BRANCH	INW0484_T1005	HANCOCK	E. COLI
051202040804	PRAIRIE BRANCH	INW0484_T1006	HANCOCK	E. COLI
051202040804	BIG BLUE RIVER	INW0485_04	HANCOCK	E. COLI
051202040805	BIG BLUE RIVER	INW0485_05	SHELBY	E. COLI
051202040805	BIG BLUE RIVER	INW0485_05	SHELBY	E. COLI
051202040805	BIG BLUE RIVER	INW0485_03	SHELBY	E. COLI
051202040805	BIG BLUE RIVER - UNNAMED TRIBUTARY	INW0485_T1001		E. COLI
051202040805	FOREMAN BRANCH	INW0485_T1002	SHELBY	E. COLI
051202040805	BIG BLUE RIVER	INW0486_03		E. COLI
051202040806	BIG BLUE RIVER	INW0486_04	SHELBY	E. COLI
051202040806	BIG BLUE RIVER	INW0486_04	SHELBY	E. COLI
051202040806	BIG BLUE RIVER	INW0486_02	SHELBY	E. COLI
051202040806	DE PREZ DITCH	INW0486_T1001	SHELBY	E. COLI
051202040806	BIG BLUE RIVER - UNNAMED TRIBUTARY	INW0486_T1002	SHELBY	E. COLI
051202040806	HOWELL DITCH	INW0486_T1003	SHELBY	E. COLI
051202040806	SHAW DITCH - UNNAMED TRIBUTARY	INW0487_T1001A	SHELBY	E. COLI
51202040806	BIG BLUE RIVER	INW0487_02	SHELBY	MERCURY & PCBS (FISH TISSUE)
051202040807	BIG BLUE RIVER	INW0487_03	SHELBY	E. COLI
051202040807	BIG BLUE RIVER	INW0487_04	SHELBY	E. COLI
051202040807	BIG BLUE RIVER	INN0493_02	SHELBY	E. COLI
051202040807	BIG BLUE RIVER	INN0493_03	SHELBY	E. COLI
051202040807	BIG BLUE RIVER	INN0493_04	SHELBY	MERCURY & PCBS (FISH TISSUE)

HUC	Waterbody	Assessment Unit	County	Impairment
051202040807	BIG BLUE RIVER	INN0493_05	SHELBY	MERCURY & PCBS (FISH TISSUE)
051202040807	BIG BLUE RIVER	INN0493_06	SHELBY	MERCURY & PCBS (FISH TISSUE)
051202040807	BIG BLUE RIVER	INN0493_07	SHELBY	MERCURY & PCBS (FISH TISSUE)
051202040807	BIG BLUE RIVER	INN0493_08	SHELBY	MERCURY & PCBS (FISH TISSUE)

2.7.4 Floodplains

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

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

Figure 14 details the locations of floodplains within the LBBR Watershed. Narrow to wide floodplains lie adjacent to the mainstem of the Big Blue River. Approximately 15.4% (17,256.6 acres) of the LBBR Watershed lies within the 100-year floodplain (Figure 14). This 100-year floodplain is composed of three regions:

- Zone A is the area inundated during a 100-year flood event for which no base flood elevations (BFE) have been established. Most of the LBBR Watershed floodplain is in Zone A or nearly 10,030.8 acres (8.9% of the watershed).
- Zone AE is the area inundated during a 100-year flood event for which BFEs have been determined. The chance of flooding in Zone AE is the same as the chance of flooding in Zone A; however, floodplain boundaries in Zone A are approximated, while those in Zone AE are based on detailed hydraulic models which allows Zone AE floodplains to be more accurate. In total, 6,917.1 acres (6.2%) of the LBBR Watershed floodplain is in Zone AE.
- Zone X includes areas outside the 100-year and 500-year floodplains which have a 1% chance of flooding to a depth of one foot of water. No BFEs are available for these areas and no flood insurance is required. The remainder of the watershed is classified as Zone X. Approximately 0.3% (308.6 acres) of the LBBR Watershed floodplain is in Zone X.

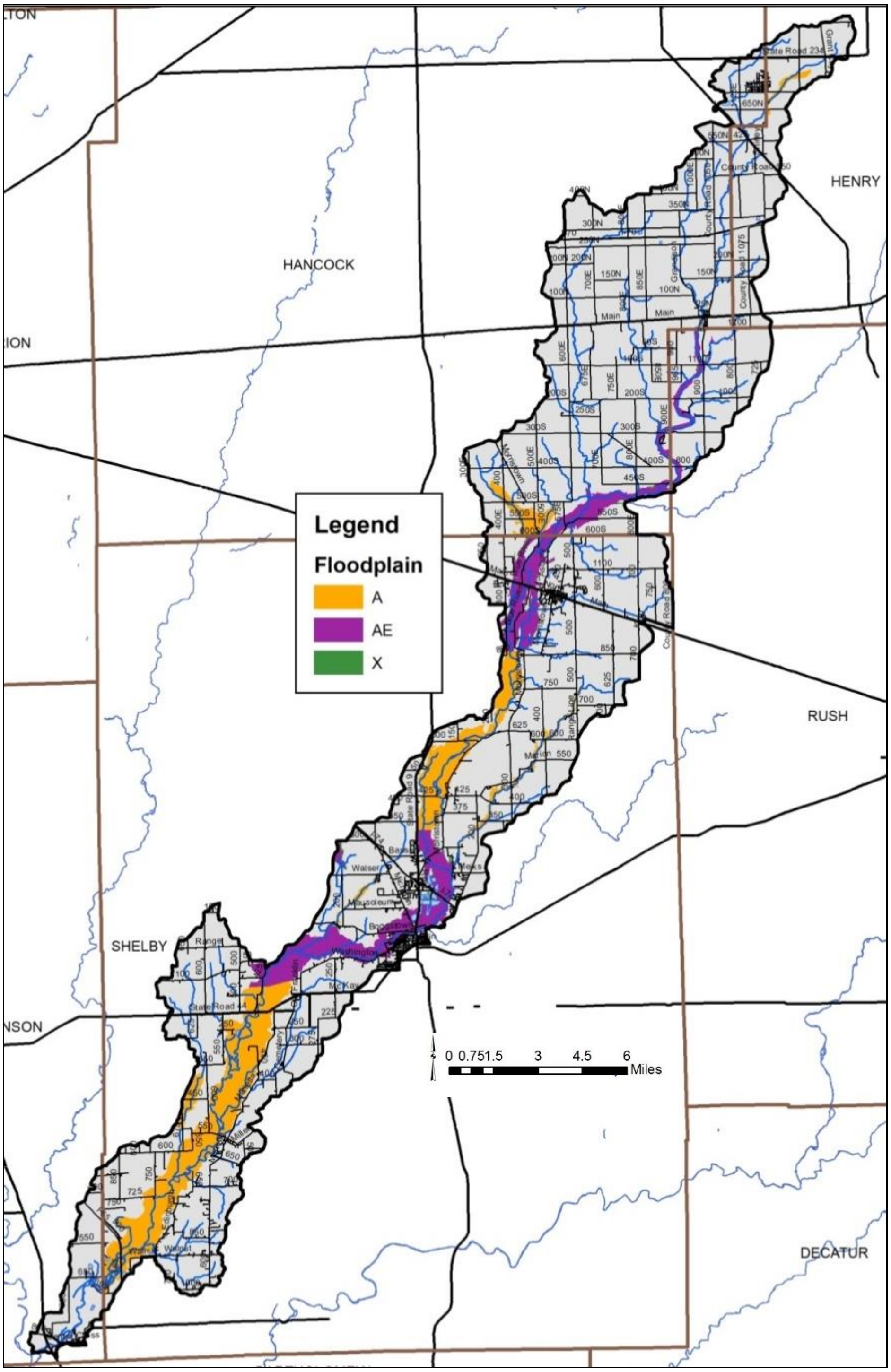

Figure 14. Floodplain locations within the Lower Big Blue River Watershed.

2.7.5 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.

Figure 15 shows the current extent of wetlands within the LBBR Watershed. Wetlands displayed in Figure 15 results from compilation efforts by the U.S. Fish and Wildlife Service as part of the National Wetland Inventory (NWI). The NWI was not intended to map specific wetland boundaries that would compare exactly with boundaries derived from ground surveys. As such, NWI boundaries are not exact and should be considered to be estimates of wetland coverage. Using this map will help us to identify which portions of the watershed would make ideal candidates for wetland restoration efforts which would reduce the amount of sediment and nutrients reaching the creek, as well as helping to restore the natural hydrology of the area which could help to reduce flooding impacts locally.

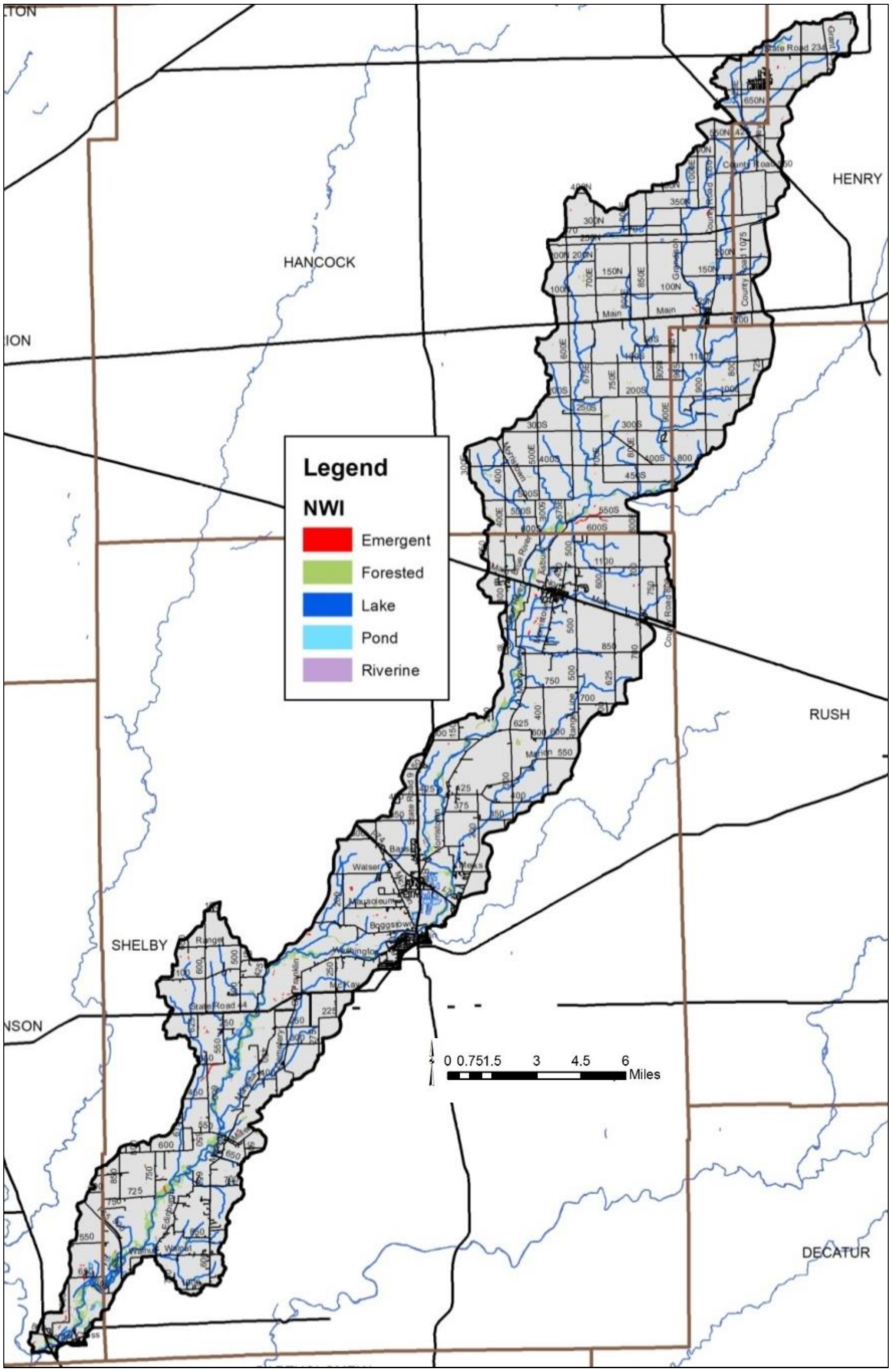

Figure 15. Wetland locations within the Lower Big Blue River Watershed. Source: USFWS, 2017.

According to the National Wetland Inventory, wetlands cover 4,435 acres, or 4%, of the watershed. When hydric soil coverage is used as an estimate of historic wetland coverage, it becomes apparent that more than 84% of wetlands have been modified or lost over time. This represents 22,970.5 acres of wetland loss within the LBBR Watershed. As commodity prices continue to go up and down, area land values remain high and as a result individuals are spending a great deal of money to drain small natural wetlands in their fields in order to be able to farm that additional couple acres of land as it is cheaper to tile it than to buy ground already in production.

2.7.6 Stormwater and Storm Drains

Under natural conditions, the majority of precipitation is allowed to infiltrate the soil and recharge groundwater resources. The volume of infiltration and groundwater recharge diminishes as development increases. To handle the large volume of precipitation falling in urban areas, stormwater systems have been constructed. Storm drain systems are present in most urban areas throughout the watershed. The City of Shelbyville as well as Hancock and Johnson counties are designated as a municipal separate storm sewer system (MS4). While Hancock and Johnson counties are also permitted MS4s, their boundaries do not include the Big Blue River Watershed. The City of Shelbyville has approximately 54.5 miles of stormwater pipe within the MS4.

2.7.7 Wellfields/Groundwater

In general, municipal water which supplies Shelbyville, Edinburgh, Shirley, and Morristown is taken from unconsolidated deposits of relatively clean, coarse-textured sand and gravel deposited in gravel outwash (Cable et al., 1971). Table 7 details wellhead protection areas within the Lower Big Blue River Watershed.

Table 7. Wellhead protection areas in and adjacent to the Lower Big Blue River Watershed.

County	PWSID	System name	Population	Next Plan due	Due date
Henry	5233005	Knightstown Water Utility	2182	5 Year Update	April 23, 2024
Henry	5233013	Shirley Municipal Water	960	5 Year Update	May 7, 2020
Johnson	5241002	Edinburgh Water Utility	4480	5 Year Update	August 3, 2021
Johnson	5241005	Indiana American Water - Johnson County	77828	5 Year Update	August 8, 2021
Shelby	5273001	Blue River Estates Mobile Home Park	99	5 Year Update	May 17, 2022
Shelby	5273002	Indiana American Water - Shelbyville	16845	5 Year Update	Dec 15, 2020
Shelby	5273003	Morristown Water Department	1218	5 Year Update	Sept 30, 2019
Shelby	5273004	Creekside Mobile Home Park	75	5 Year Update	Dec 15, 2020
Shelby	5273005	Countryside Estate Mobile Home Park	328	5 Year Update	Sept 29, 2021

2.8 <u>Endangered Species</u>

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 LBBR Watershed (Clark, personal communication). One bird: the Black-crowned Night-heron; two mammals: the American Badger and the Indiana Bat; six mussels: Clubshell, Northern riffleshell, Rabbitsfoot, Purple lillliput, Wavyrayed lampmussel, Little spectaclecase, and Kidneyshell; and two vascular plants: Thinleaf Sedge and Canada Burnet are listed as endangered or species of special concern in the LBBR Watershed. The listed mollusks are the biggest indicator of water quality degradation in the watershed. These are some of the important roles of mussels in the freshwater waterways of Indiana:

- They act as natural filters
- They stabilize the bottom of a waterbody and help to mix it as they burrow, increasing oxygen exchange.
- They are indicators of good water quality and habitat stability. Most mussels cannot survive in a waterway that is polluted or of poor quality.
- They accumulate contaminants in their shells which can be measured to help determine water quality issues.

Until 1991, freshwater mussels were heavily harvested for various uses—at that time it became, and still is illegal, to harvest or possess the shells of freshwater mussels in Indiana. The declining population of mussels in Indiana can be blamed almost entirely on human activity; harvesting for profit, altering waterways (channelization, dredging, and dam construction), changes in hydrology, introduction of exotic species, and pollution are all major threats to the freshwater mussels of Indiana. Within the LBBR watershed, data provided by IDNR places mussels in the Big Blue River, Brandywine Creek and Sixmile Creek. While threatened and endangered species were not highlighted as a specific stakeholder concern, it can be assumed that the goal of improving overall water quality will directly aid in the remediation of those conditions presently unfavorable for freshwater mussel habitat. It is our mission to improve water quality and quality of life for all within the watershed.

Table 8. Indiana Natural Heritage Data Center Threatened and Endangered Species (IDNR).

Common Name	**State/Federal Listing**	**Site**
Birds		
Black-crowned Night-heron	SE	Blank
Mammals		
Indiana Bat or Social Myotis	SE/LE	Big Blue River
American Badger	SSC	Blank
Mollusks		
Northern Riffleshell	SE/LE	Big Blue River
Clubshell	SE/LE	Big Blue River & Brandywine Creek
Rabbitsfoot	SE/LE	Big Blue River & Brandywine Creek
Rayed Bean	SE/LE	Big Blue River
Purple Lilliput	SSC/C	Brandywine Creek
Wavyrayed Lampmussel	SSC	Big Blue River, Brandywine & Sixmile Creeks
Little Spectaclecase	SSC	Big Blue River & Brandywine Creek
Kidneyshell	SSC	Big Blue River & Brandywine Creek
Vascular Plants		
Thinleaf Sedge	SE	
Canada Burnet	SE	EAM Inc. Site

SE=State endangered, SSC=state species of special concern, LE=listed for federal endangered, C=federal candidate species

2.8.1 Recreational Resources and Significant Natural Areas

A variety of recreational opportunities and natural areas exist within the LBBR Watershed. Recreational opportunities include parks, public access sites, and school grounds (Figure 16). There are several significant natural areas located within the LBBR Watershed. The Edinburgh Parks and Recreation, Shelbyville Parks and Recreation, the Indiana DNR, Shelby Eastern Schools, Eastern Hancock Community Schools, and Shirley Municipal Water Department maintain, preserve and protect these properties. Additional recreational opportunities exist at various schools, golf complexes and sport shooting facilities.

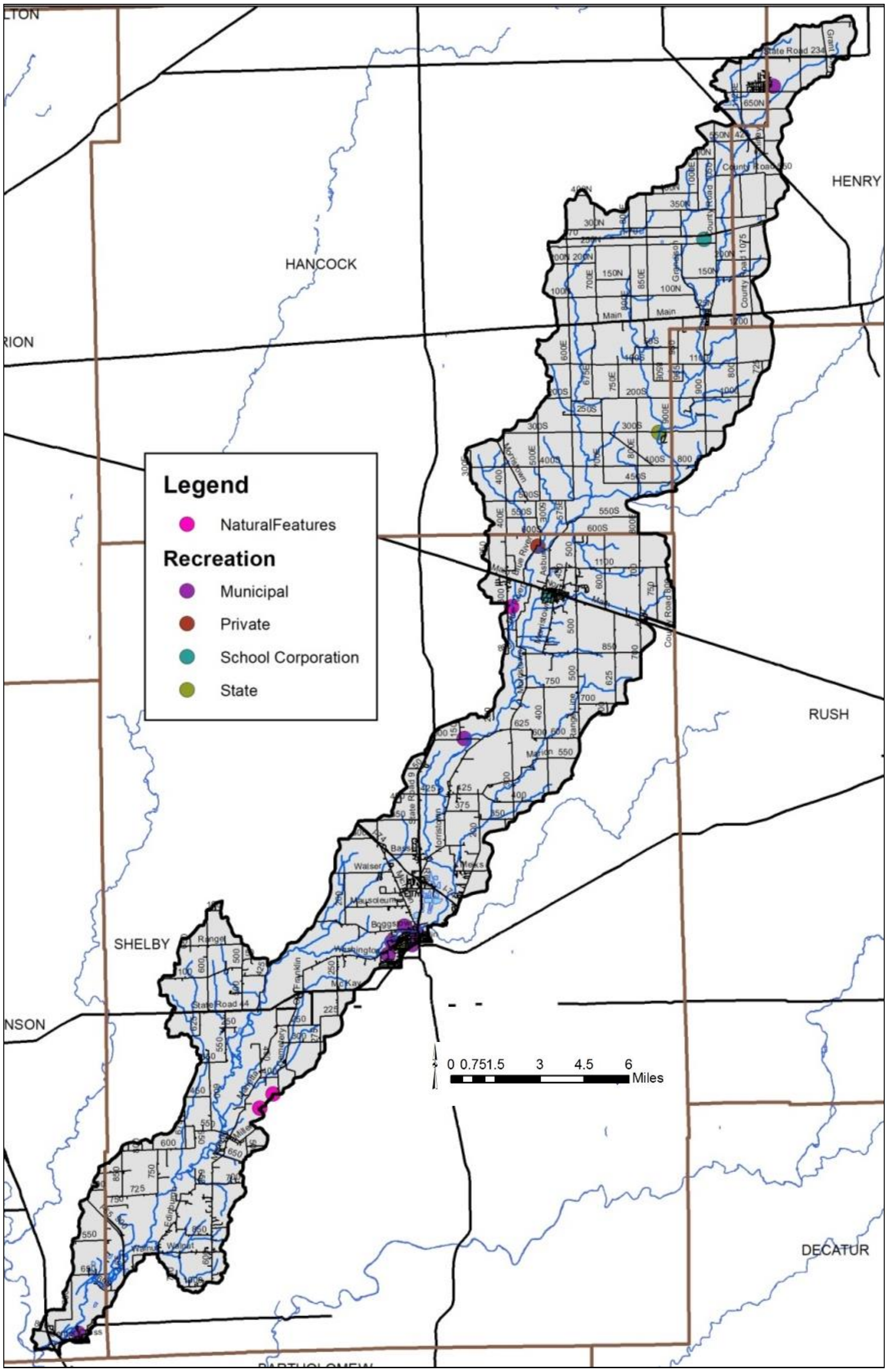

Figure 16. Recreational opportunities and natural areas in the Lower Big Blue River Watershed.

2.9 Land Use

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

2.9.1 Current Land Use

Today, the majority of the LBBR Watershed is covered by row crop agriculture or pastureland (83%; Figure 17, Table 9). Some areas are used as pasture or hay production areas where the plant biomass is baled and removed for livestock feed. Livestock operations, big and small, can be large contributors to nutrient, sediment and bacterial contaminants as livestock may have open access to bodies of water, bare soil in areas of animal travel and incorrect waste management practices. Nearly 8% of the watershed is mapped in forestland, while 7.8% of the watershed is covered by developed open space or is in low, medium, or high intensity developed areas. Developed areas have a greater chance of increased pollution loading with decreased infiltration due to more solid surfaces (paved roadways and parking areas), flash flood hazard, large waste water outputs and poor riparian habitat. Developed areas are of lesser concern than rural, agricultural area in the LBBR watershed. Grassland, open water, and wetlands cover the remaining 1.1% of the watershed.

Table 9. Detailed land use in the Lower Big Blue River Watershed.

Land Use	Acres	Percent of LBBR Watershed
Row crop	87,799.7	78.2%
Deciduous forest	8,985.0	8.0%
Developed open space	6,063.9	5.4%
Pasture/hay	4,694.8	4.2%
Low intensity developed	1,760.3	1.6%
Grassland	846.3	0.8%
Medium intensity developed	661.8	0.6%
Open water	591.3	0.5%
Woody wetland	350.8	0.3%
High intensity developed	257.1	0.2%
Emergent wetland	168.1	0.2%
Shrub/scrub	74.5	0.1%
Evergreen forest	12.7	0.01%
	112,266.3	**100%**

Source: USGS, 2011

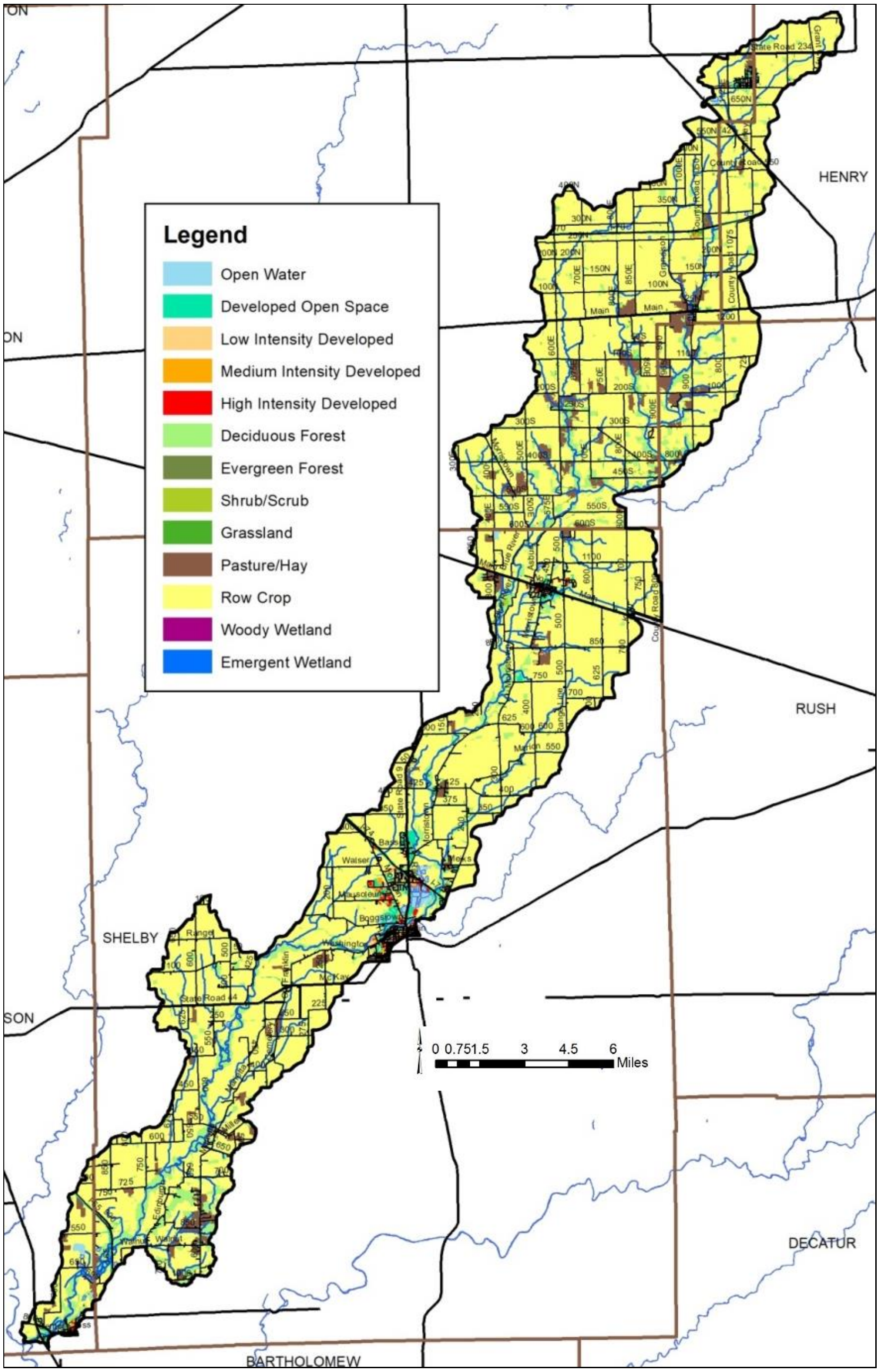

Figure 17. Land use in the Lower Big Blue River Watershed. Source: NLCD, 2011.

2.9.2 Agricultural Land Use

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

Tillage Transect

Tillage transect information data for Hancock, Henry, Johnson, Shelby, and Rush counties was compiled for 2017 (Table 10; ISDA, 2017A-C). As reported by ISDA, members of Indiana's Conservation Partnership (ICP) conduct a field survey of tillage methods. A tillage transect is an on-the-ground survey that identifies the types of tillage systems farmers are using and long-term trends of conservation tillage adoption using GPS technology, plus a statistically reliable model for estimating farm management and related annual trends. Table 10 provides the percent of acres on which conservation tillage was utilized for each county. The three categories being recorded are summarized below

- No-till: Any direct seeding system, including site preparation, with minimal soil disturbance (includes strip & ridge till)
- Conservation Till: Any tillage system leaving 16-75% residue cover after planting, excluding no-till (includes mulch & reduced tillage)
- Conventional Till: Any tillage system leaving less than 15% residue cover after planting.

Table 10. Tillage transect data by county (ISDA, 2017).

County	No-till	Conservation Till	Conventional Till
Hancock	55%	14%	30%
Henry	78%	21%	3%
Johnson	72%	19%	10%
Shelby	78%	20%	2%
Rush	79%	16%	5%

Producers in all counties of the watershed have continuously adopted no-till practices. No-till and conservation tillage practices allow for the soil to maintain a stronger structure that allows for greater water infiltration and reduced run off. Continued adoption of no-till and conservation tillage practices has a positive effect on water quality as sediment, nutrient and other undesirable products run off the soil surface and into receiving waters.

Agricultural Chemical Usage

The main areas of fertilizer use in the LBBR watershed are in farm fields. Corn, soybeans, wheat and hay are grown for the purposes of livestock feed and commodity sales; these crops have high nutrient demands that are supplemented with the use of commercial fertilizers. No-drift zones are established in areas where a sensitive crop or environmental need has been noted and these areas are avoided during application times. Local cooperatives employ sprayer operators that are trained and endorsed for fertilizer and chemical operation. Fertilizer and chemical run-off has not been cited as concern in the watershed, but areas where run-off is not controlled by permanent vegetation, no-till, or conservation tillage practices have an increased risk of increased pollution to waterbodies. Smaller quantities of fertilizer and other chemicals are applied to lawns of homes and businesses.

Confined Feeding Operations and Hobby Farms

A mixture of small, unregulated and larger, regulated livestock operations (confined feeding operations) is found within the LBBR Watershed. Small farms are those which house less than 300 animals, while larger farms that house large numbers of animals for longer than 45 days per year are regulated by IDEM. These regulations are based on the number and type of animals present. IDEM requires permit applications which document animal housing, manure storage and disposal, and nutrient management plans for farms which maintain 300 or more cows, 600 or more hogs, or 30,000 or more fowl. These facilities are considered confined feeding operations (CFO).

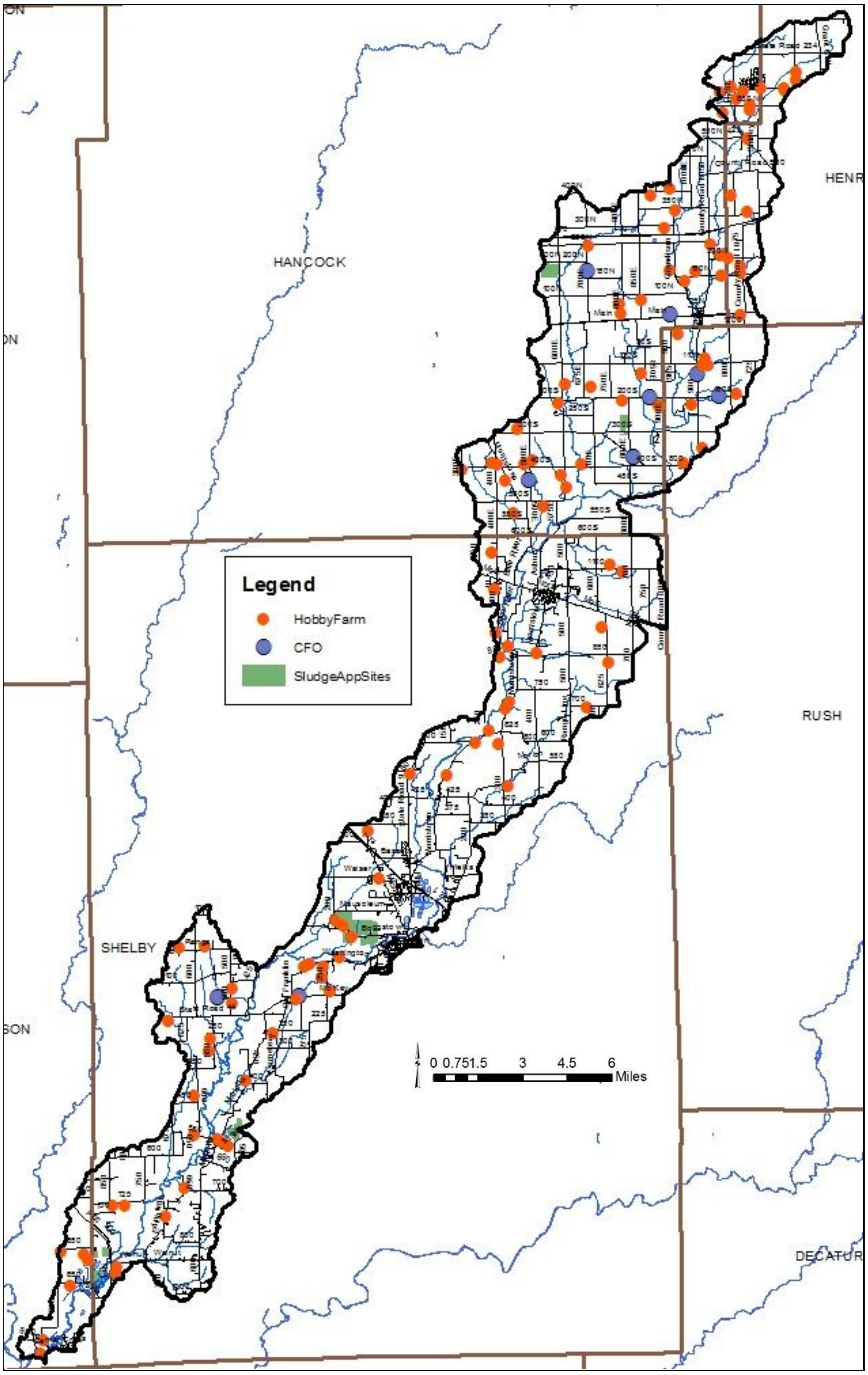

Figure 18. Confined feeding operation and unregulated animal farm locations within the Lower Big Blue River Watershed.

There are 8 active confined feeding operations located in the watershed, none of which are large enough to be classified as a concentrated animal feeding operation (CAFO; Figure 18). In total, 116 small, unregulated animal farms containing nearly 1,115 animals were identified during the windshield survey, which is most likely an underestimate of the actual number. These small "mini farms" contain small numbers of cattle, horses, llamas, alpacas, sheep, or goats, which could be sources of nutrients and *E. coli* as these animals exist on small acreage lots with limited ground cover. The facilities house hogs with a combined total of up to 1,968 gestating sows or sows with litters, 8,380 finishing hogs, and 8,045 feeding hogs. In total, approximately 19,500 animals per year are housed in CFOs and hobby farms in the watershed, generating approximately 96,896 tons of manure per year spread over the watershed. This volume of manure contains approximately 238,558 pounds of nitrogen and 177,298 pounds of phosphorus.

2.9.3 Urban Land Use

Urban land uses cover less than 8% of the watershed (Table 9). Although this is only a very small portion of the watershed, there are some significant issues related to the developed areas. Especially troublesome are issues related to failing septic systems, impervious surfaces, flooding, and stormwater runoff that allow untreated sewage and stormwater to flow into the watershed during heavy rain events.

Pet and Wildlife Waste

Pet and wildlife cause concern where waste is left to run off into nearby waterbodies and increase nutrient and bacteria load. The City of Shelbyville has a large trail system that is used by residents for recreation including walking pets. While removal of pet waste is encouraged, it is not guaranteed. A large, healthy riparian area lines the walkways of the Blue River trail so it is unlikely that there is a large contribution from that land use. Wildlife have free-range in waterbodies in less populated areas and are nearly impossible to control from entering. White-tailed deer, turkeys, raccoons and geese are common in the area and their E. coli contribution to water is inevitable though unmeasured in this project.

Remediation Sites

Remediation sites including industrial waste, leaking underground storage tanks (LUST), open dumps, voluntary remediation program (VRP) and brownfields are present throughout the LBBR Watershed (Figure 19). Most of these sites are located within the developed areas of the watershed including Shelbyville, Morristown, Edinburgh, and Shirley as well as along the corridors of US Highway 40, US Highway 52, State Road 109, State Road 44 and others. In total, 15 industrial waste sites, 35 LUST facilities, one open dump, three solid waste, one septage site, three brownfields, and one superfund site are present within the watershed.

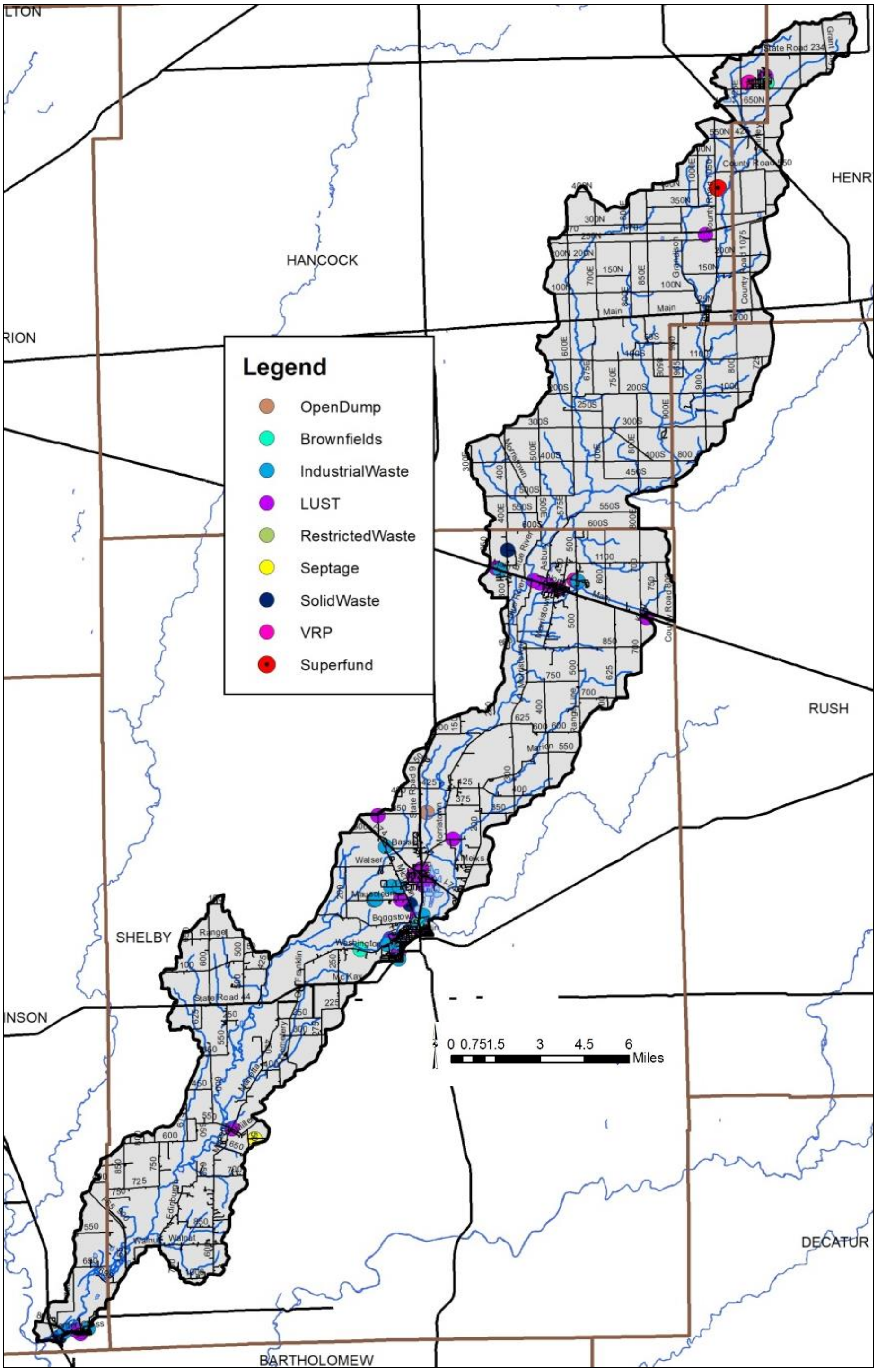

Figure 19. Industrial remediation and waste sites within the Lower Big Blue River Watershed. Source: IDEM.

2.10 Population Trends

The Lower Big Blue River Watershed is relatively a sparsely populated area in general. One city, Shelbyville, and several incorporated towns, including Morristown and Shirley, and unincorporated towns are located throughout the watershed. Tracking population changes within a watershed is challenging as data is published by counties and townships rather than watershed boundaries. Changes in watershed population and the associated land use changes and infrastructure impacts were noted by watershed stakeholders. Estimates of the population of the watershed are derived by calculating percentage of the watershed within a county and extrapolating from county-wide data. The LBBR Watershed mainly lies within five counties. It drains nearly 17% of Hancock; less than 2% of Henry, Johnson, and Rush counties, and 12% of Shelby County. Table 11 displays estimated populations for the portion of each county located within the watershed (StatsIndiana, 2018). These data indicate modest growth in all five counties over the past decade.

Table 11. County demographics for counties within Lower Big Blue River Watershed.

	Total Area of County (square miles)	County Population (2017)	Pop. Density (#/sq. mi)	Acres of County in Watershed	Percent of County in Watershed	Population
Hancock	307	75,754	246.7557	34,340	17.50%	13,240.0
Henry	627	225,813	360.1483	7,400	1.80%	4,164.2
Johnson	321	153,897	479.4299	3,293	1.60%	2,466.8
Rush	408	16,645	40.79657	6,026	2.30%	384.1
Shelby	785	936,961	1193.581	61,205	12.20%	114,145.5

2.11 <u>Planning Efforts in the Watershed</u>

Planning efforts are in place across the watershed as all counties have identified the rivers that run through it to be one of their most valuable assets.

Shelby County Comprehensive Plan

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.

Rush County Comprehensive Plan

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.

Hancock County Comprehensive Plans

The Greenfield/Hancock County 2015 Comprehensive Plan has many goals, but the two most relevant goals are to:

- Maintain buffer between agricultural and urbanized areas.
- Amend the floodplain ordinance to include "No Adverse Impact" and/or compensatory storage language for future development.

Greenfield/Hancock County faces rapid rates of urbanization as the Indianapolis metropolitan area continues to expand. The area of the LBBR watershed that is in Hancock County is still largely agricultural in land use.

Johnson County/Town of Edinburgh

The Town of Edinburgh Comprehensive Plan of 2011 recognizes the impact of the Big Blue River on the community and highlights the need to maintain a high level of storm water management and to implement best management practices in flood areas to reduce impact to natural resources. Restricting enhancement or new construction in the flood areas is also part of the plan.

Henry County Comprehensive Plan

Henry County has a 2018 Comprehensive Plan that is still being adjusted, but as it stands does not directly comment on water quality and measures that may be taken to ensure its improvement. Henry County is 48% agricultural land and the focus of the 2018 plan, overall, is to revitalize the county to bring a rise to population levels.

Rule 5/Unmanaged Urban Spread
Rule 5 reviews are completed for all construction sites in the watershed. There are no unmanaged areas of construction/sprawl. Shelbyville and Edinburgh are MS4 communities.

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 on the LBBR watershed. While areas of gentle rolling hills do exist in the LBBR—the topography's effect on the other three factors is minimal in comparison to the soils. Nearly 20% of the land area in the LBBR is considered highly erosive, or are especially susceptible to erosion, which can lead to increased sedimentation and contamination in water and wetlands (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 LBBR Watershed is agricultural; conservation tillage or no-till practices are being more widely implemented and have a positive impact on the LBBR watershed by reducing nutrient and sediment loads. The Indiana Conservation Partnership is active in each of five counties of the LBBR 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 Lower Big 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 monitoring 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
pH	6.0 to 9.0	Indiana Administrative Code
Dissolved Oxygen	Min: 4.0 mg/L Max: 12.0 mg/L	Indiana Administrative Code
Temperature	Monthly Standard	Indiana Administrative Code
E. coli	Geometric mean <125 cfu/100mL Single sample <235 cfu/100 mL	Indiana Administrative Code
Nitrate/Nitrite	1.2 mg/L	Dodds et al (1998)
Turbidity	10.4 NTU	U.S. EPA recommendation
Orthophosphorus	0.003 mg/L	Correll (1988)
Total Phosphorus	Max: 0.076 mg/L	U.S. EPA recommendation
Total Suspended Solids	15 mg/L	Waters (1989)
Citizens Qualitative Habitat Evaluation Index	>60 points	Hoosier Riverwatch
Macroinvertebrate Index of Biotic Integrity	>35 points	Indiana Administrative Code

3.2 Historic Water Quality Sampling Efforts

A variety of water quality assessment projects have been completed within the Lower Big Blue River Watershed (Figure 20). Statewide assessments and listings include the integrated water monitoring assessment, the impaired waterbodies assessment, and fish consumption advisories. Additionally, the Indiana Department of Environmental Management (IDEM) and U.S. Geological Survey (USGS) have all completed assessments within the watershed. Additionally, volunteer-based sampling of water quality through the Hoosier Riverwatch program also provides water quality data with which the watershed can be characterized. A summary of each assessment methodology and general results are discussed below. Specific data results are detailed within subwatershed discussions in subsequent section.

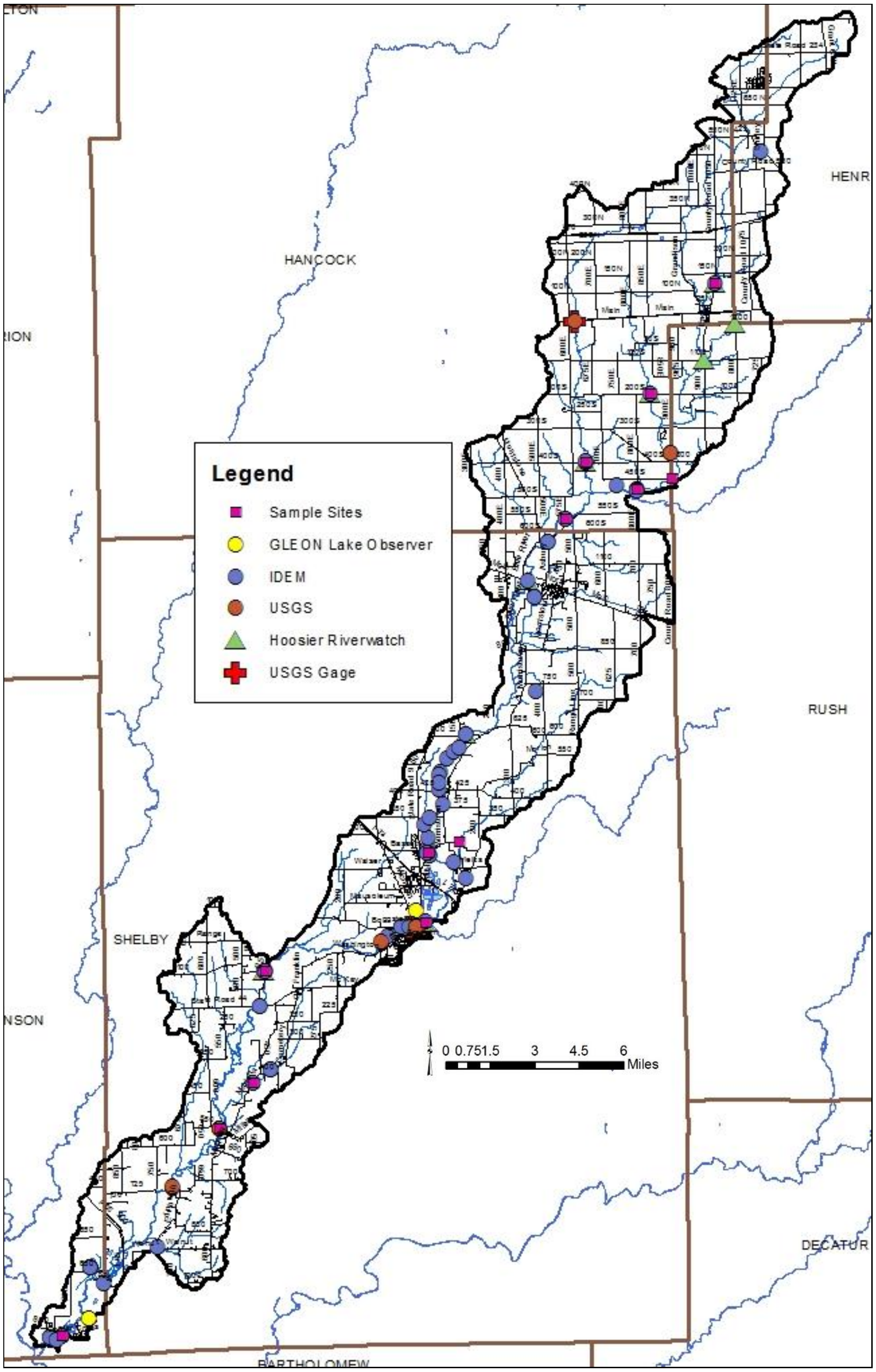

Figure 20. Current and historic water quality assessment locations.

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

The Indiana Department of Environmental Management (IDEM) is the primary agency tasked with monitoring surface water quality within the state of Indiana. Section 305(b) of the Clean Water Act requires that the state report on the quality of waterbodies throughout the state on a biennial basis. These assessments are known as the Integrated Water Monitoring Assessment (IWMA) or the 305(b)

Report. The most recent draft report was delivered to the USEPA and underwent public comment in 2018 (IDEM, 2018). To complete this report, the 305(b) coordinator reviews all data collected by IDEM and selected high-quality data collected by other organizations on a waterbody basis. Each assessed waterbody is then assigned a water quality rating based on its ability to meet Indiana's water quality standards (WQS). WQS are set at a level to protect Indiana waters' designated uses of swimmable, fishable, and drinkable. Waterbodies that do not meet their designated uses are proposed for listing on the impaired waterbodies list, which is discussed in more detail below. The 2018 IWMA includes 41 waterbody reaches in the Big Blue River Watershed (IDEM, 2018). Listings include the following:

- Two segments of Anthony Creek are listed for *E. coli* impairment.
- Twelve segments of the Big Blue River and six segments of unnamed Big Blue River tributaries are impaired for *E. coli*, while six segments are listed as impaired for PCBs in fish tissue.
- One segment of Charlottes Brook, Dilly Creek, Foreman Branch, Howell Ditch, Million Brook, Nameless Creek, Perry Brook, and Ridge Run are listed for *E. coli* impairments.
- One segment of Shaw Ditch and one unnamed tributary to Shaw Ditch is listed as impaired for E. coli.
- Seven segments of Sixmile Creek are listed as impaired for *E. coli*.

3.2.2 Impaired Waterbodies (303(d) List)

Waterbodies in the LBBR Watershed which are included on the Impaired Waterbodies list are detailed in section 2.7.3 above.

3.2.3 Fish Consumption Advisory (FCA)

Three state agencies collaborate annually to compile the Indiana Fish Consumption Advisory (FCA). The Indiana Department of Natural Resources, Indiana Department of Environmental Management, and Indiana State Department of Health have worked together since 1972 on this effort. Samples are collected through IDEM's rotating basin assessment for bottom feeding, mid-water column feeding, and top feeding fish. Fish tissue samples are then analyzed for heavy metals, PCBs, and pesticides. Advisories listed from the 2019 Fish Consumption Advisory Map (ISDH, 2019) 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.

The Big Blue River is under a fish consumption advisory for Johnson and Shelby counties (Table 13). Based on these listings, the following conclusions can be drawn:

- Members of the sensitive population should restrict consumption of common carp. Additionally, flathead catfish, rock bass, and smallmouth bass should be consumed sparingly.

Table 13. Big Blue River Fish Consumption Advisories, which are separate from the statewide safe eating guidelines.

Species	Size	Limitations
Common Carp	up to 13"	One meal per week
Common Carp	13" +	One meal per month/Do not Consume
Crappie Species	All sizes	One meal per week
Flathead Catfish	up to 28"	One meal per month
Flathead Catfish	28" +	Six meals per year
Largemouth Bass	All sizes	One meal per week
Redhorse Species	All sizes	One meal per week
Rock Bass	Up to 7"	One meal per week
Rock Bass	7" +	One meal per month
Smallmouth Bass	All sizes	One meal per month
Sunfish Species	All sizes	One meal per week

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

From 1966 through 2007, the U.S. Geological Survey (USGS) sampled water chemistry at several locations in the LBBR Watershed via National Water Quality Assessment program (NAWQA). Sampling occurred in the Big Blue River near Marietta, at State Road 9, downstream of the Shelbyville wastewater treatment plant, and near Interstate 65; in Sixmile Creek at CR 900 East, and in Nameless Creek near Stringtown. Based on the water chemistry assessments, the following conclusions can be drawn:

- Total phosphorus concentrations exceeded target concentrations in 20% of samples collected in the LBBR Watershed with concentrations measuring as high as 20 times the target concentration.
- Nitrate-nitrogen concentrations exceeded target concentrations in 63% of samples collected in the LBBR Watershed with concentrations measuring as high as 35 times the target concentration.
- Total suspended solids concentrations exceeded target concentrations in 88% of samples collected in the LBBR Watershed with concentrations measuring as high as 100 times the target concentration.
- Pesticide concentrations measure below detection levels for all samples assessed.

3.2.5 IDEM Rotational Basin Assessments (1992-2018)

In 1993, 1997, 2002, 2007, 2008, 2010, 2013, and 2014, IDEM sampled water chemistry, macroinvertebrates, fish and habitat at several locations in the LBBR Watershed via their rotational basin, watershed assessment, pesticide, and source ID assessment programs. Additionally, one site on the Big Blue River at U.S. Highway 31 is sampled monthly as part of IDEM's fixed station monitoring program from 1992 through 2018. Water chemistry sampling occurred in Sixmile Creek (3), Dilly Creek (2), Nameless Creek, the Big Blue River (29), Foreman Creek, and Howell Ditch. Macroinvertebrate community sampling occurred at four sites on Nameless Creek, Sixmile Creek, and the Big Blue River (2) in 1993 (4 sites) and 2002 (1 site). Fish community assessments occurred along two reaches of the Big Blue River in 2002, 2007, and 2008 and on Roberts Ditch in 1997. Habitat assessments occurred in concert with biological community assessments at each site.

A few of the assessments which occurred via various IDEM assessment program included a single sample event with most assessments including five sample events and a few assessments including up to 35 events. Based on the water chemistry assessments, the following conclusions can be drawn:

- *E. coli* concentrations exceeded the state standard in 65% of fixed station samples and in 39% of all other samples collected in the LBBR Watershed. Additionally, 22% of *E. coli* samples collected during the TMDL sampling project exceeded state standards.
- Nitrate-nitrogen concentrations exceeded target concentrations in 100% of fixed station samples and in 70% of all other samples collected in the LBBR Watershed.
- Total phosphorus concentrations exceeded the recommended criteria in 89% of fixed station samples and in 63% of all other samples collected in the LBBR Watershed.
- Total suspended solids concentrations exceeded the recommended criteria in 41% of fixed station and in 38% of all other samples collected in the LBBR Watershed.
- Turbidity levels routinely exceed the recommended standard in more than 45% of fixed station and 46% of all other samples collected in the LBBR Watershed.
- Macroinvertebrate community assessments indicate that the Big Blue River and its tributaries rate as slightly impaired to moderately impaired using the kick net sampling.
- Fish community assessments indicate that LBBR and its tributaries rate as good to excellent.
- Habitat assessments completed along LBBR and its tributaries indicate that habitat is fully supporting for aquatic life uses.

3.2.6 Lower Big Blue River TMDL

Water quality data collected by IDEM within the Lower Big Blue River Watershed in 2010 and 2013 indicated that 10 of 13 sites violated the *E. coli* state standard. Required *E. coli* reductions range from 0 to 72.8%. Based on these determinations, segments covering nearly 86% of LBBR Watershed streams have been included on the state's 303(d) list. The LBBR Watershed TMDL (IDEM, 2013) addressed *E. coli* throughout the LBBR Watershed.

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

- A 0% reduction in *E. coli* is required in the Headwaters Six Mile Creek Subwatershed.
- A 63% reduction in *E. coli* is required in the Anthony Creek-Six Mile Creek Subwatershed.
- A 73% reduction in *E. coli* is required in the Nameless Creek Subwatershed.
- A 56% reduction in *E. coli* is required in the Prairie Branch-Big Blue River Subwatershed.
- A 35% reduction in *E. coli* is needed in the Foreman Branch-Big Blue River Subwatershed.
- A 5% reduction in *E. coli* is needed in the DePrez Ditch-Big Blue River Subwatershed.
- A 0% reduction in *E. coli* is needed in the Shaw Ditch-Big Blue River Subwatershed.

IDEM recommended addressing the following contributing sources:

- Wastewater treatment plants, livestock access to streams, wildlife access to streams, onsite wastewater/unsewered areas, and on-site wastewater systems and 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.

Specific waste load allocations indicate that the Eastern Hancock Junior-Senior High School accounts for 0.26 billion colonies/day, the Shirley wastewater treatment plant accounts for 1.38 billion colonies/day, the Morristown wastewater treatment plant accounts for 5.34 billion colonies/day, the Shelbyville wastewater treatment plant accounts for 71.16 billion colonies/day, and the Edinburgh wastewater treatment plant accounts for 13.34 billion colonies/day. Additionally, the Shelbyville MS4 accounts for 41.04 billion colonies/day. Under wet weather conditions, the TMDL prioritizes *E. coli* reductions for the

DePrez Ditch-Big Blue River, Prairie Branch-Big Blue River, Anthony Creek-Six Mile Creek, and Nameless Creek subwatersheds in that order. IDEM indicates that this ranking should be considered when determining critical areas as part of this planning process (IDEM, 2014).

3.2.7 Hoosier Riverwatch Sampling (2002-2018)

From 2000 to 2018, volunteers trained through the Hoosier Riverwatch program assessed 11 sites in the LBBR Watershed including six sites on the Big Blue River, three sites on Sixmile Creek, and one site each on Nameless Creek and Dilly Creek. Assessments typically occurred monthly during the growing season. Volunteers monitored stream stage, flow rate, and discharge; collected water chemistry samples for analysis using HACH test kits; assessed instream habitat using the Citizen's QHEI; and surveyed the stream's macroinvertebrate community. Using the chemical data, the Water Quality Index (WQI) was calculated. Volunteers calculated a Pollution Tolerance Index (PTI) using the biological data.

Based on these data, the following conclusions can be drawn:

- *E. coli* concentrations exceeded state standards in 20% of samples collected by Hoosier Riverwatch volunteers.
- Nitrate-nitrogen concentrations exceeded target concentrations in 84% of collected samples.
- Turbidity levels exceeded targets in 98% of samples collected by Hoosier Riverwatch volunteers.

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

3.3.1 Water Quality Sampling Methodologies

Shelby County SWCD staff and Lower Big Blue River volunteers collected monthly Hoosier Riverwatch samples from 13 locations from November 2017 through October 2018 (Figure 20). Sample collection and analysis followed Hoosier Riverwatch protocols and the Quality Assurance Project Plan submitted to and approved by IDEM. *E. coli* was collected five times over 30 days during two sampling periods, which occurred 20 September through 24 October 2017 and 10 September through 17 October 2018.

3.3.2 Field Chemistry Results

All temperature and dissolved oxygen concentration samples meet state standards. In total, three pH samples (2%) measured above state standards. Nutrient concentrations were elevated in collected samples with 43% (67 samples) of orthophosphorus and 64% (100 samples) of nitrate-nitrogen samples exceeding target concentrations. More than half of the orthophosphorus samples collected in the Nameless Creek, Anthony Creek-Six Mile Creek and DePrez Ditch-Big Blue River subwatershed exceeded target concentrations, while more than 60% of samples collected in the DePrez Ditch-Big Blue River, Foreman Branch-Big Blue River, Anthony Creek-Six Mile Creek, Nameless Creek and Headwaters Six Mile Creek subwatersheds exceeded target concentrations for nitrate-nitrogen. Turbidity levels were elevated throughout the Lower Big Blue River Watershed; however, only 33% (51 samples) exceeded target levels. Turbidity levels in Nameless Creek, Anthony Creek-Six Mile Creek and DePrez Ditch-Big Blue River subwatersheds exceeded targets in 50% or more of samples. *E. coli* levels exceeded state standards in 44% of collected samples with concentrations exceeding targets in more than 50% of samples collected in the Nameless Creek and Anthony Creek-Six Mile Creek subwatersheds. The full dataset is contained in Appendix A.

3.3.3 Biological Community Results

In total 22 species were identified in LBBR Watershed streams during the July and September sampling events. During the July assessment, Sites 6 and 12 were the most diverse with 11 species identified while Site 3, 5 and 9 possessed the poorest diversity with only five species identified. All sites except Sites 1, 2 and 3 possessed mayfly species, while all sites except Sites 5, 9 and 13 possessed caddisfly species. These species are generally considered the most pollution intolerant species. During the September assessment, Site 11 was the most diverse with 13 species identified, while Site 5 was the least diverse with only 8 species identified. Pollution Tolerance Index scores ranged from 11 (Site 5) to 30 (Site 7) during the July assessment and from 15 (Site 5) to 33 (Sites 10 and 11) during the September assessment. The full dataset is contained in Appendix B.

3.3.4 Habitat Results

Habitat scores ranged between 50 (Site 13) and 89 (Site 6) during the September 2019 assessment and from 48 (Site 13) to 89 (Site 6) during the March 2020 assessment. In general, the Big Blue River mainstem sites possessed better habitat than that observed in tributary streams. Many of the tributaries possessed limited instream cover, poor riffle-pool complex development, embedded stream substrates, narrow riparian buffers and limited stream sinuosity. In general, the tributary streams show signs of county maintenance as most are legal drains. In total, 8 of 13 sites scores higher than 60 during both the September 2019 and March 2020 assessments, the target set for habitat by the LBBR steering committee. The full dataset is contained in Appendix B.

3.4 Watershed Inventory Assessment

3.4.1 Watershed Inventory Methodologies

Volunteers completed windshield surveys throughout the LBBR Watershed in February 2019. Volunteers conducted surveys by driving all accessible roads throughout the watershed. Large maps with aerial photographs, road and stream names, and public property labels were provided to each volunteer group. Volunteers recorded observations on the provided maps and data sheets, documented field conditions with photographs, and provided all notes to the Project Coordinator for review. The windshield surveys were also used to confirm GIS map layer data throughout the watershed. Items targeted during the surveys included, but were not limited to the following:

- Aerial land use category
- Field or gully erosion
- Pasture locations and condition
- Livestock access and impact to streams
- Buffer condition and width
- Bank erosion or head-cutting
- Logjams located within the stream
- Dumping areas or areas where trash or debris accumulate
- Abandoned mines or mine shafts
- Small, unregulated farms
- Environmental site confirmation (NPDES, CFO, open dump, Superfund, etc.)

3.4.2 Watershed Inventory Results

All accessible road-stream crossings were inventoried. A majority of issues identified fall into five categories: stream buffers limited in width or lacking altogether, areas of livestock access, streambank erosion, dumping areas, and unregulated farms. Figure 21 details locations throughout the LBBR Watershed where problems were identified. Much of the watershed is not visible from the road and additional assessments will be on-going; therefore, those identified in Figure 21 should not be considered exhaustive. More than 32 miles of streams possessed limited buffers, nearly 153.6 miles of streambank were eroded, and livestock had access to nearly 11.6 miles of streams. Additionally, 5 dumping areas and 26 miles of gully erosion were identified.

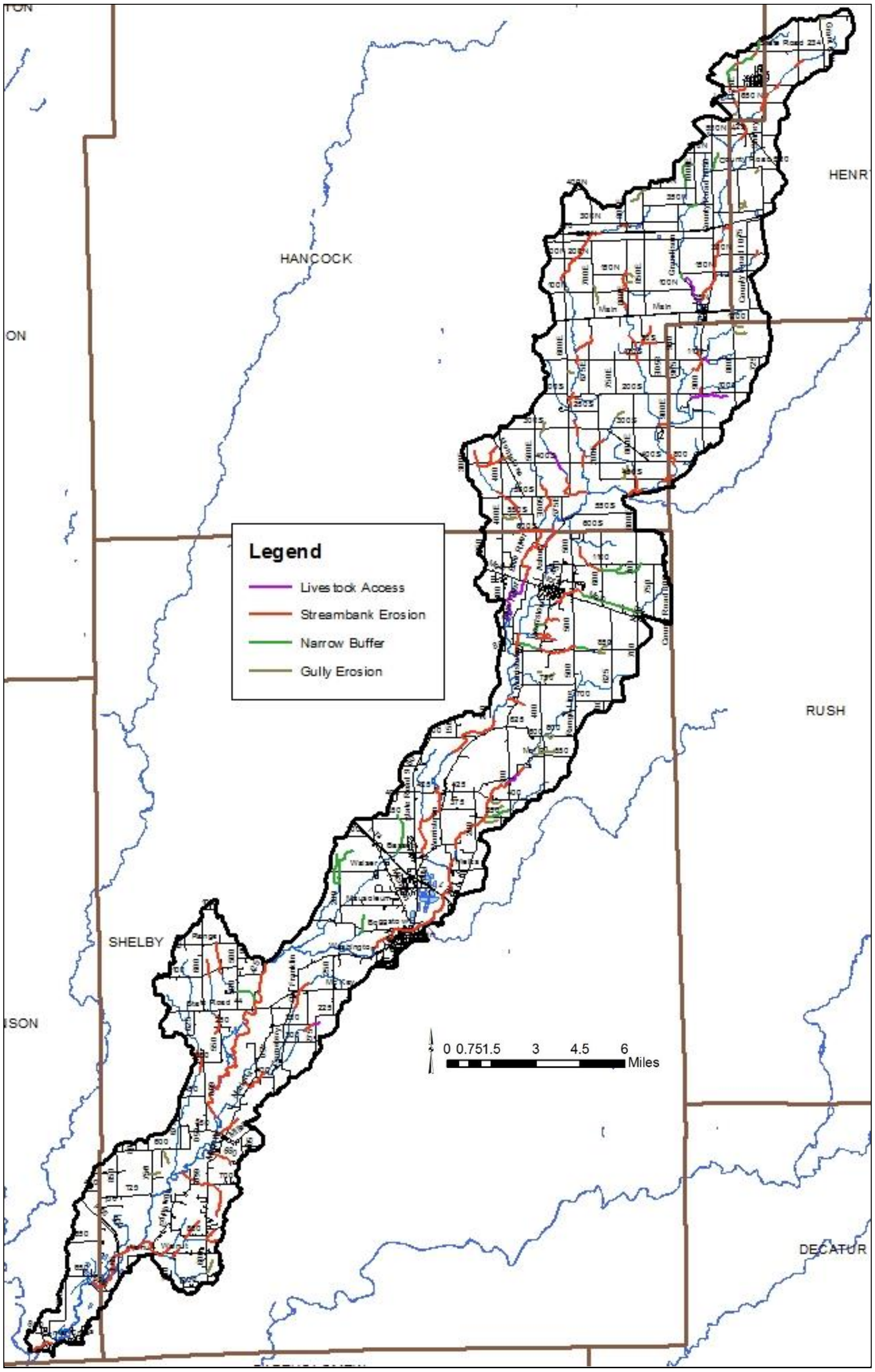

Figure 21. Stream-related watershed concerns identified during watershed inventory efforts.

4.0 WATERSHED INVENTORY II-B: SUBWATERSHED DISCUSSIONS

To gather more specific, localized data, the LBBR Watershed was divided into seven (7) subwatersheds with each subwatershed reflecting one 12-digit Hydrologic Unit Code (HUC; Figure 22). 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.

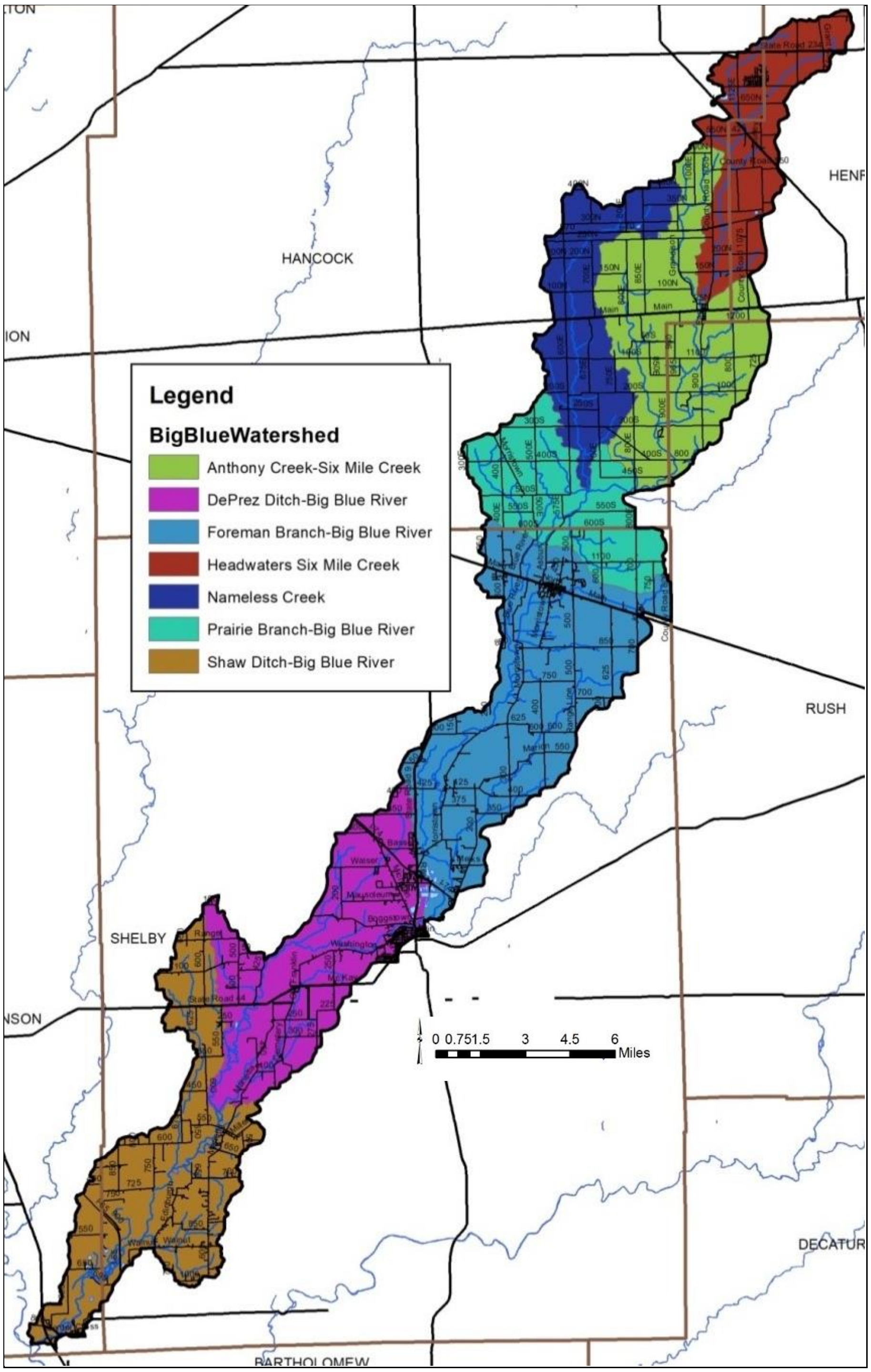

Figure 22. 12-digit subwatersheds in the Lower Big Blue River Watershed.

4.1 <u>Headwaters Six Mile Creek Subwatershed</u>

The Headwaters Six Mile Creek Subwatershed forms part of the northeastern boundary of the LBBR Watershed, including the community of Shirley, and lies within Henry and Hancock Counties (Figure 23). It encompasses one 12-digit HUC watershed: 051202040801. This subwatershed drains 10,818 acres, or 16.9 square miles, and accounts for 9.6% of the total watershed area. There are 19.6 miles of stream. IDEM has classified 14.95 miles as impaired for *E. coli*.

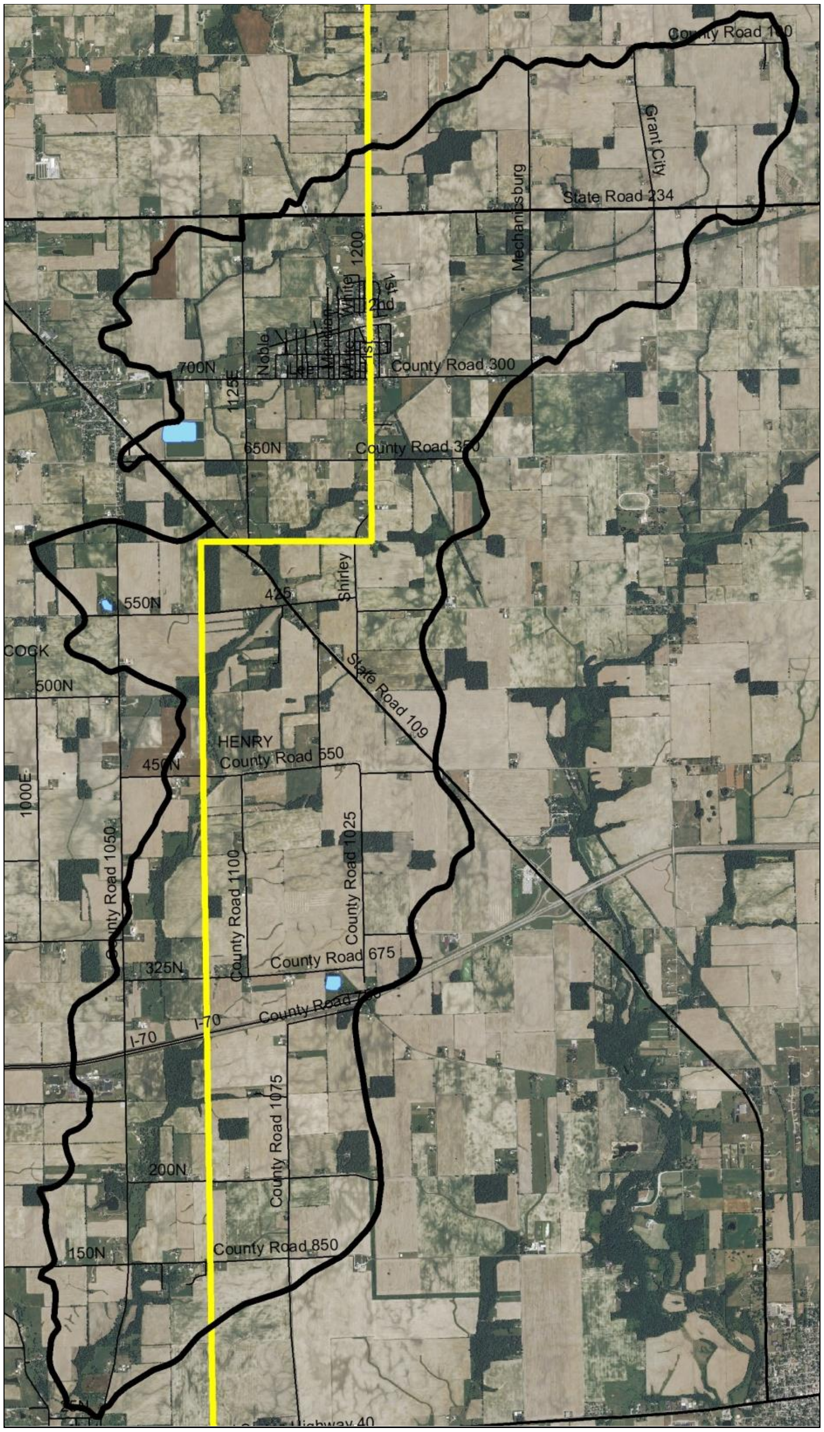

Figure 23. Headwaters Six Mile Creek Subwatershed.

4.1.1 Soils

Soils in the Headwaters Six Mile Creek Subwatershed are dominated by the Crosby-Cyclone-Miamian association, which covers a small portion of Henry and Rush Counties in the northern part of the watershed. These soils are deep, nearly level or gently sloping and are well suited to cropland and somewhat for pasture. The soils can be poorly drained; wetness limits the uses and are poorly suited for septic systems. Hydric soils cover 3,893 acres (36.0%) of the subwatershed, indicating that one third of the subwatershed was historically wetlands. Wetlands currently cover 1.5% (163.8 acres) of the subwatershed, representing a loss of 96% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 17.3% and 6.5% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.1.2 Land Use

Agricultural land use dominates the Headwaters Six Mile Creek Subwatershed with 85.3% (9,225 acres) in agricultural land uses, including row crop and pasture and 4.5% (484 acres) in forested land use. Wetlands, open water, and grassland cover just over 225 acres, or 2.1%, of the subwatershed. The community of Shirley lies within and the State Road 234, State Road 109, and Interstate 70 corridors bisect the Headwaters Six Mile Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 882 acres or 8.2% of the subwatershed are in urban land uses.

4.1.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are three leaking underground storage tanks (LUST), one brownfield, one voluntary remediation site, and two NPDES-permitted facilities (Figure 24). No open dumps, brownfields, solid waste sites, or industrial waste facilities are located within the Headwaters Six Mile Creek Subwatershed.

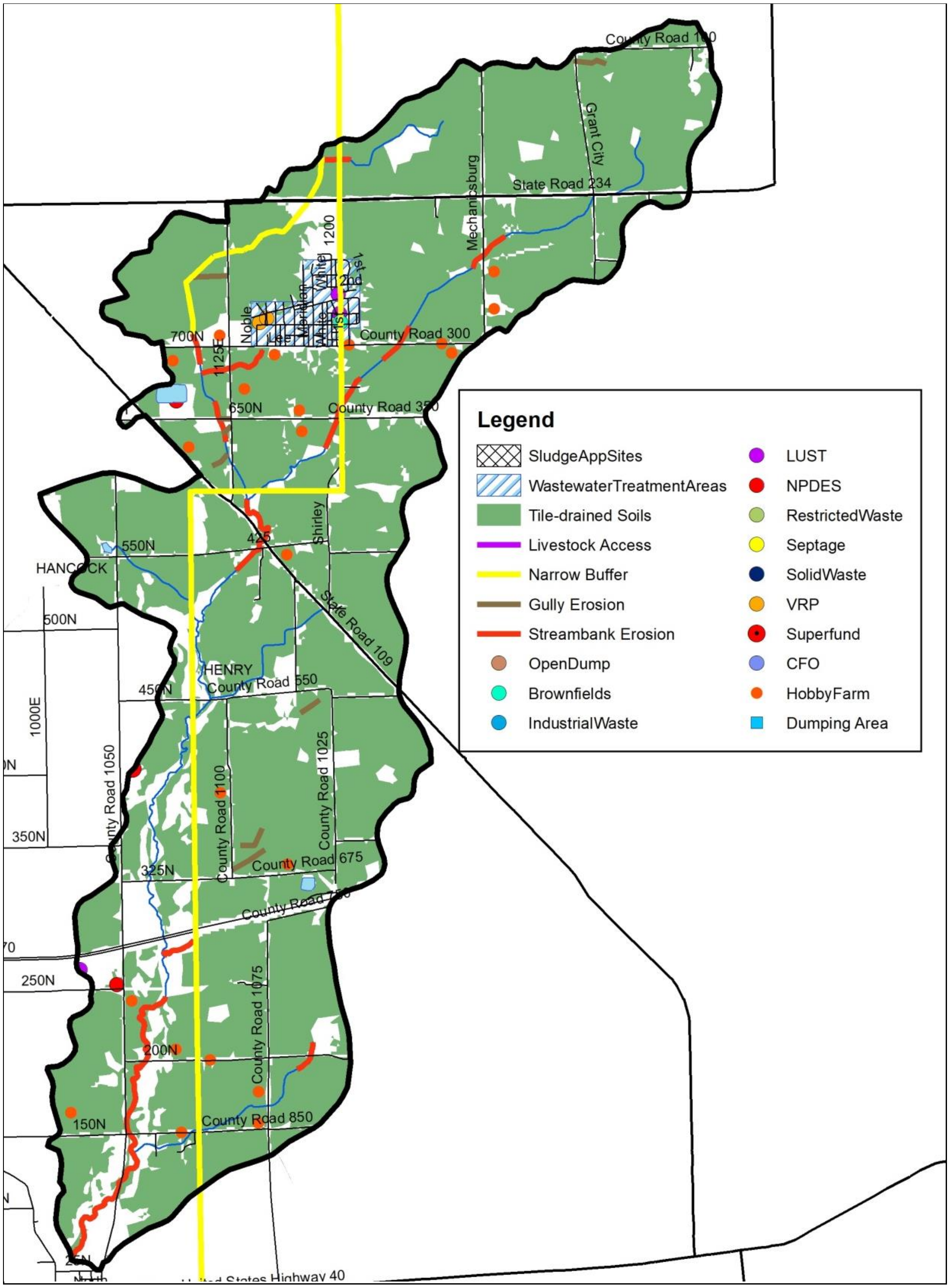

Figure 24. Point and non-point sources of pollution and suggested solutions in the Headwaters Six Mile Creek Subwatershed.

4.1.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Headwaters Six Mile Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Twenty-two unregulated animal operations housing more than 170 cows, horses, sheep, goats, and llamas were identified during the windshield survey. No active confined feeding operations (CFO) are located within the Headwaters Six Mile Creek Subwatershed. In total, manure from small animal operations total over 3,306 tons per year, which contains almost 1,938 pounds of nitrogen and almost 974 pounds of phosphorus. Streambank erosion, gully erosion, and lack of buffers are a concern in the subwatershed. Approximately 1.8 miles of insufficient stream buffers, 1.4 miles of gully erosion, and 6.4 miles of streambank erosion were identified within the subwatershed.

4.1.5 Water Quality Assessment

Waterbodies within the Headwaters Six Mile Creek Subwatershed have been sampled historically at 2 locations (Figure 25). Assessments include collection of water chemistry data by IDEM (2 sites sampled in 2007) and assessment at one site during the current project. No stream gages are located in the Headwaters Six Mile Creek subwatershed. Turbidity and *E. coli* were sampled five times in a 30-day period. None of the samples exceeded water quality targets or state standards (Table 14). During the current assessment, nitrate-nitrogen samples measured above target concentrations in 92% of collected samples, while orthophosphorus samples exceeded target concentrations in 50% of collected samples (Table 15). Macroinvertebrate communities rated as excellent during the July assessment and good during the September assessment with pollution tolerance index (PTI) scores ranging from 20 to 27. The habitat assessment scored 64 of a possible 114 points.

Table 14. Historic water quality data collected in the Headwaters Six Mile Creek Subwatershed, 1994-2018.

Parameter	Turbidity (NTU)	*E. coli* (col/100 mL)
Min	6.10	10.80
Max	17.96	77.6
#Samples	5	5
#Exceed	0	0
% Exceed	0%	0%

Table 15. Water quality data collected in the Headwaters Six Mile Creek Subwatershed during the current project.

Parameter	Temp	DO	pH	OrthoP	Nitrate	Turbidity	*E. coli*
Min	-1.2	6.0	7.0	0.0	0.5	8.0	0.0
Max	10.0	10.0	8.0	10.0	60.0	120.0	366.7
#Samples	12	12	12	12	12	12	10
#Exceed	N/A	0	0	6	11	1	4
%Exceed	N/A	0%	0%	50%	92%	8%	40%

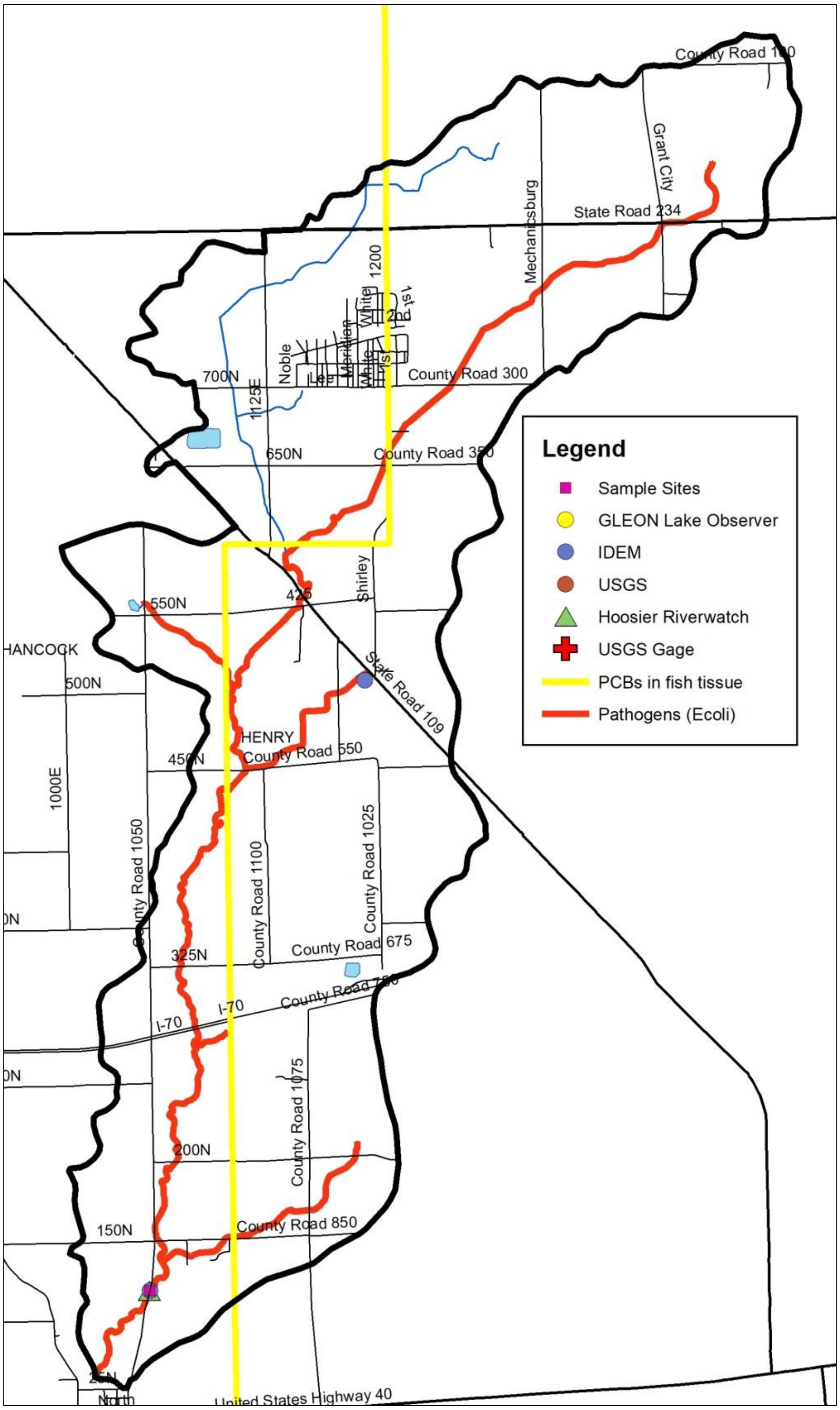

Figure 25. Locations of current and historic water quality data collection and impairments in the Headwaters Six Mile Creek Subwatershed.

4.2 Anthony Creek-Six Mile Creek Subwatershed

The Anthony Creek-Six Mile Creek Subwatershed forms part of the northeastern boundary of the LBBR Watershed, including the community of Charlottesville, and lies within Henry, Hancock, and Rush Counties (Figure 26). It encompasses one 12-digit HUC watershed: 051202040802. This subwatershed drains 18,340 acres, or 28.6 square miles, and accounts for 16.3% of the total watershed area. There are 38.0 miles of stream. IDEM has classified 38.0 miles of stream as impaired for *E. coli*.

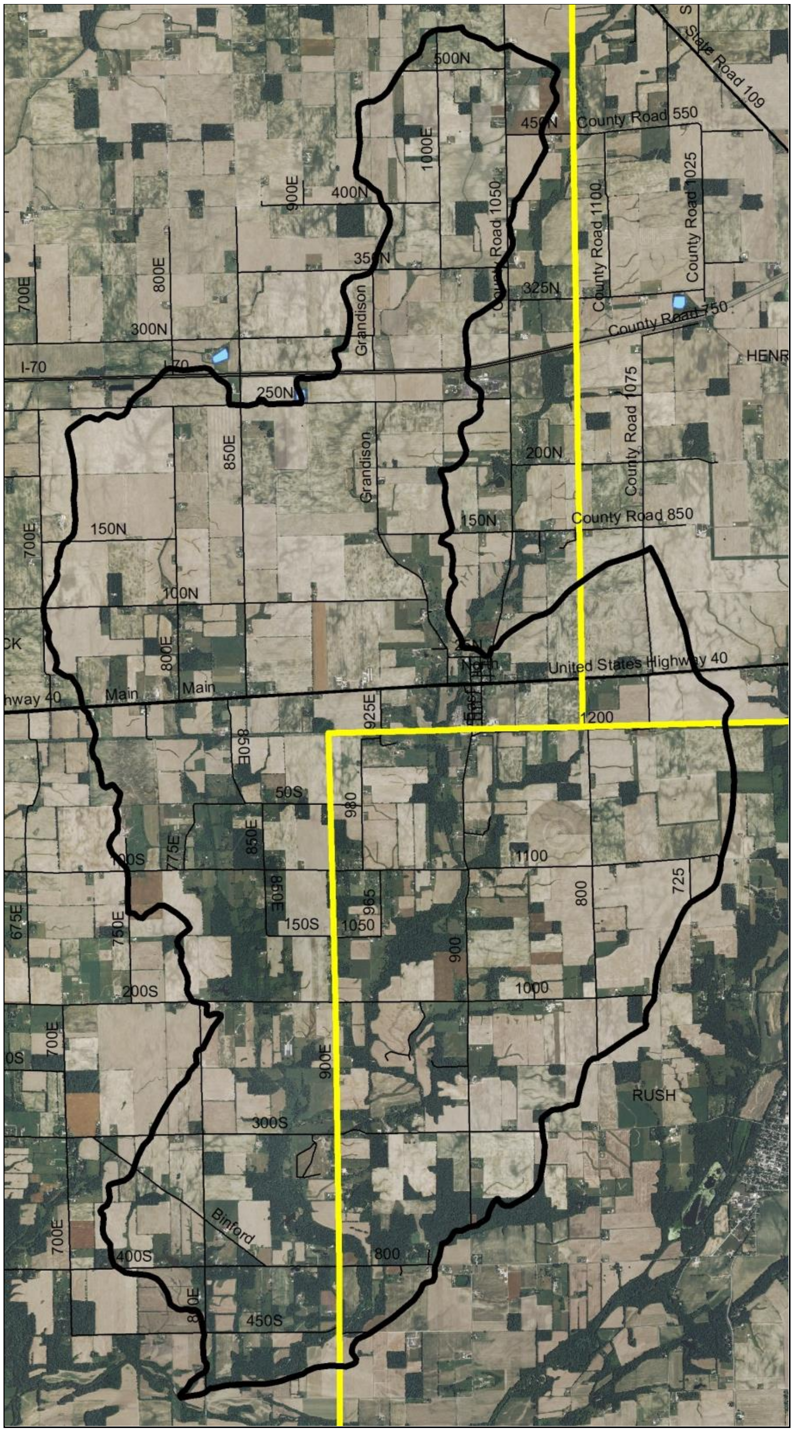

Figure 26. Anthony Creek – Six Mile Creek Watershed.

4.2.1 Soils

Soils in the Anthony Creek – Six Mile Creek Subwatershed are dominated by the Crosby-Treaty-Miami soil association and Miami-Crosby-Treaty soil associations, which are dominant throughout the entire watershed, primarily in Hancock and Shelby Counties and have a slope that is nearly level to strongly sloping at 60 percent. While these three soils are found in different proportions in each complex, they are found on till plains and have a native vegetation of deciduous forest. The Miami series are moderately well drained, the Crosby series are somewhat poorly drained, and the Treaty series are found in depressions and are poorly drained. The soils are generally suitable for crops and livestock farming if adequately drained but have limitations for septic systems. Hydric soils cover 4,087 acres (22.3%) of the subwatershed, indicating that over one-fifth of the subwatershed was historically wetlands. Wetlands currently cover 1.8% (323.3 acres) of the subwatershed, representing a loss of 92% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 21.7% and 8.2% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.2.2 Land Use

Agricultural land use dominates the Anthony Creek-Six Mile Creek Subwatershed with 84.2% (15,445 acres) in agricultural land uses, including row crop and pasture and 8.5% (1,566 acres) in forested land use. Wetlands, open water, and grassland cover 180 acres, or 1.0%, of the subwatershed. The community of Charlottesville lies within and the U.S. Highway 40 corridor bisect the Anthony Creek-Six Mile Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 1,148 acres or 6.3% of the subwatershed are in urban land uses.

4.2.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed (Figure 27). There is one superfund site. There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, industrial waste facilities, solid waste, LUST, or NPDES-permitted facilities located within the Anthony Creek-Six Mile Creek Subwatershed.

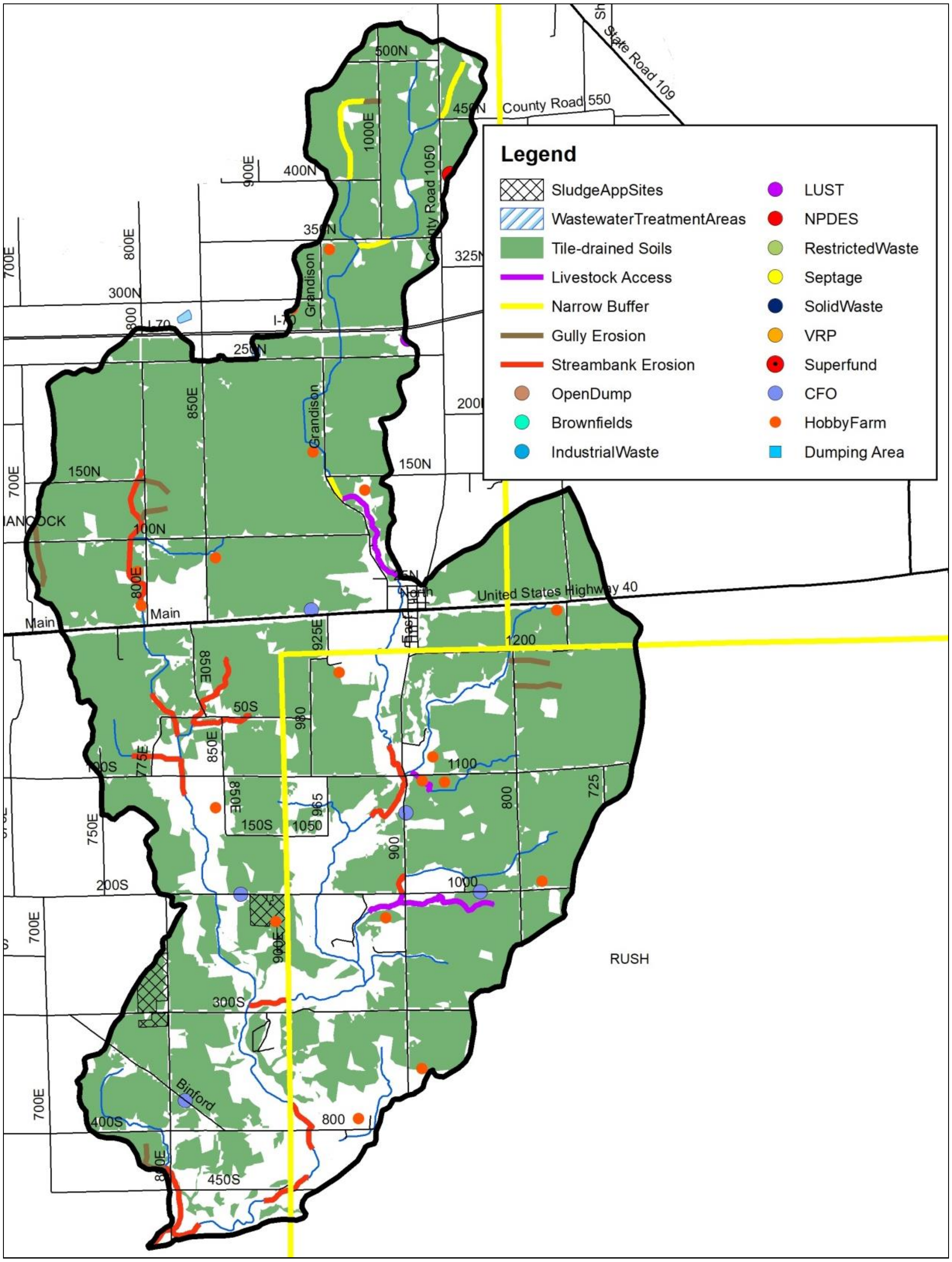

Figure 27. Point and non-point sources of pollution and suggested solutions in the Anthony Creek-Six Mile Creek Subwatershed.

4.2.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Anthony Creek-Six Mile Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Seventeen unregulated animal operations housing more than 279 cows, horses, bison, and sheep were identified during the windshield survey. Livestock have access to 2.5 miles of Anthony Creek-Six Mile Creek Subwatershed streams. Four active CFOs (hogs) are located within the subwatershed. In total, manure from small animal operations and the CFOs total over 67,039 tons per year, which contains 188,633 pounds of nitrogen and 141,835 pounds of phosphorus. Streambank erosion, gully erosion, and lack of buffers are a concern in the subwatershed. Approximately 1.9 miles of insufficient stream buffers, 2.7 miles of gully erosion, and 9.9 miles of streambank erosion were identified within the subwatershed.

4.2.5 Water Quality Assessment

Waterbodies within the Anthony Creek – Six Mile Creek Subwatershed have been sampled at four locations (Figure 28, Table 16). Historical assessments include collection of water chemistry data by IDEM (3 sites sampled in 2007 and 2010) and USGS (1 site sampled in 2010). Three sites were sampled during the current project. No stream gages are in the Anthony Creek-Six Mile Creek Subwatershed. Nutrient concentrations were elevated exceeding target concentrations in 71% of nitrate-nitrogen and 63% of total phosphorus samples collected by USGS and IDEM. Turbidity and total suspended solids concentrations exceeded targets mostly during storm events with 15% and 25% of samples, respectively exceeding targets in samples collected by USGS and IDEM. *E. coli* concentrations exceeded state standards in 71% of USGS and IDEM-collected samples. Nutrient levels were elevated during the current assessment period with nitrate-nitrogen concentrations exceeding targets in 72% of samples and orthphosphorus samples exceeding targets in 50% of samples. Turbidity levels also exceed targets with 56% of samples measuring above target levels. *E. coli* concentrations exceeded state standards in 15 of 30 collected samples (Table 17). PTI scores ranged from 15 to 24 rating as good to excellent at all three sites during both the July and September assessments. Habitat scores ranged from 50 to 56 of 114 points suggesting habitat may be limited at these sites.

Table 16. Historic water quality data collected in the Anthony Creek-Big Blue River Subwatershed, 1994-2018

Parameter	Turbidity (NTU)	Nitrate-Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	*E. coli* (col/100 mL)
Min	1.50	0.25	0.03	2.00	56.30
Max	568	7	0.12	15	1733
#Samples	29	7	8	4	24
#Exceed	4	5	5	1	17
% Exceed	14%	71%	63%	25%	71%

Table 17. Water quality data collected in the Anthony Creek-Big Blue River Subwatershed during the current project.

Parameter	Temp	DO	pH	OrthoP	Nitrate	Turbidity	*E. coli*
Min	-1.40	6.00	5.00	0.00	0.00	8.00	0.00
Max	25.9	10	8.2	0.43	10	120	500
#Samples	35	35	36	36	36	36	30
#Exceed	N/A	0	1	18	26	20	15
%Exceed	N/A	0%	3%	50%	72%	56%	50%

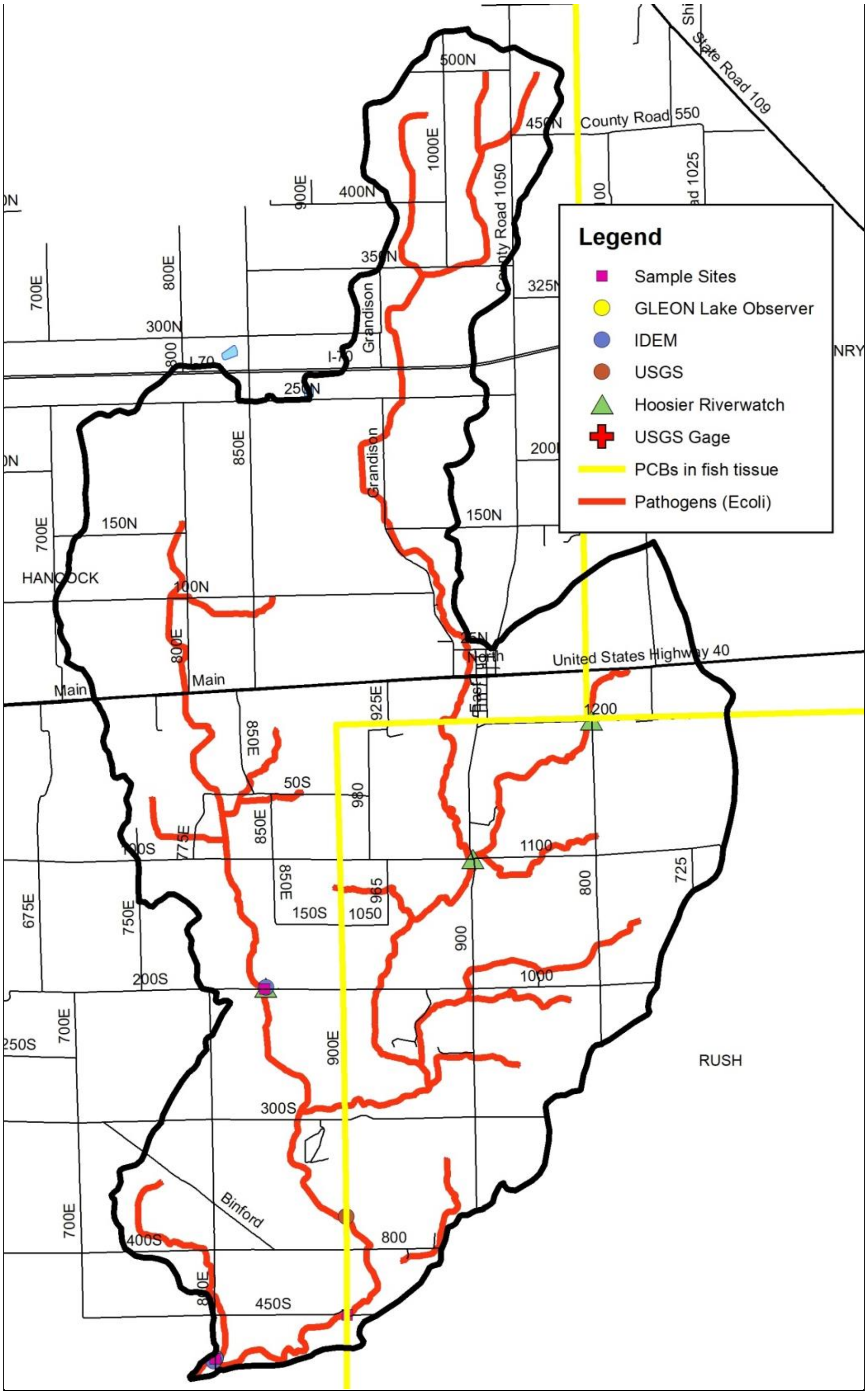

Figure 28. Locations of current and historic water quality data collection and impairments in the Anthony Creek-Six Mile Creek Subwatershed.

4.3 Nameless Creek Subwatershed

The Nameless Creek Subwatershed forms part of the northwestern boundary of the LBBR Watershed and lies completely within Hancock County (Figure 29). It encompasses one 12-digit HUC watershed: 051202040803. This subwatershed drains 10,516 acres, or 16.4 square miles, and accounts for 9.4% of the total watershed area. There are 17.7 miles of stream. IDEM has classified 17.7 miles of stream as impaired for *E. coli*.

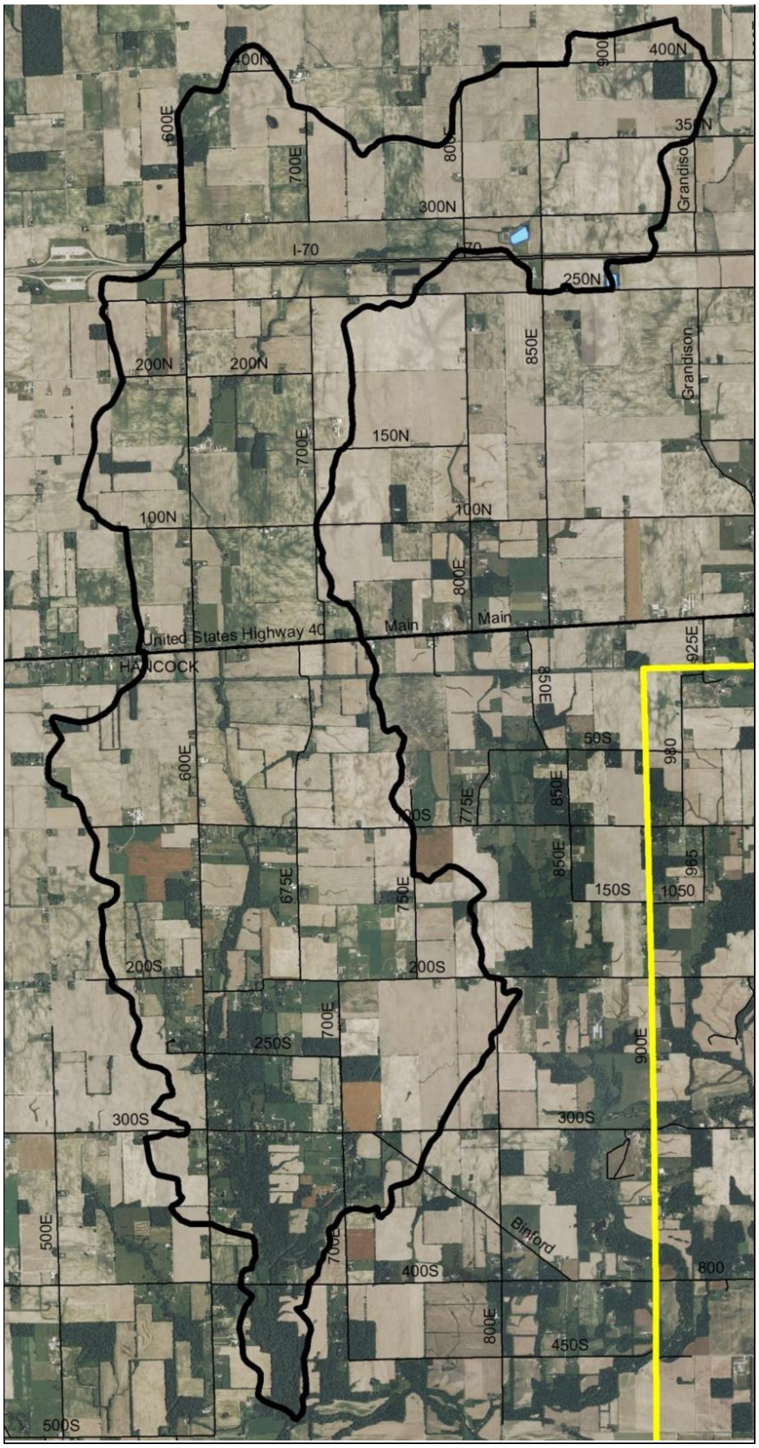

Figure 29. Nameless Creek Subwatershed.

4.3.1 Soils

Soils in the Nameless Creek subwatershed are dominated by the Crosby-Treaty-Miami soil association and Miami-Crosby-Treaty soil associations, which are dominant throughout the entire watershed, primarily in Hancock and Shelby Counties and have a slope that is nearly level to strongly sloping at 60 percent. While these three soils are found in different proportions in each complex, they are found on till plains and have a native vegetation of deciduous forest. The Miami series are moderately well drained, the Crosby series are somewhat poorly drained, and the Treaty series are found in depressions and are poorly drained. The soils are generally suitable for crops and livestock farming if adequately drained but have limitations for septic systems. Hydric soils cover 3,367 acres (32.0%) of the subwatershed, indicating that nearly one third of the subwatershed was historically wetlands. Wetlands currently cover 1.3% (138.4 acres) of the subwatershed, representing a loss of 97% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 20.2% and 0.2% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.3.2 Land Use

Agricultural land use dominates the Nameless Creek subwatershed with 87.0% (9,149 acres) in agricultural land uses, including row crop and pasture and 5.4% (562 acres) in forested land use. Wetlands, open water, and grassland cover 106 acres, or 1.0%, of the subwatershed. No communities lie within the subwatershed; the Interstate 70 corridor bisects the subwatershed accounting for much of the urban land use within the subwatershed. In total, 697 acres or 6.6% of the subwatershed are in urban land uses.

4.3.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed (Figure 30). There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, NPDES, LUST, solid waste, or industrial waste facilities located within the Nameless Creek Subwatershed.

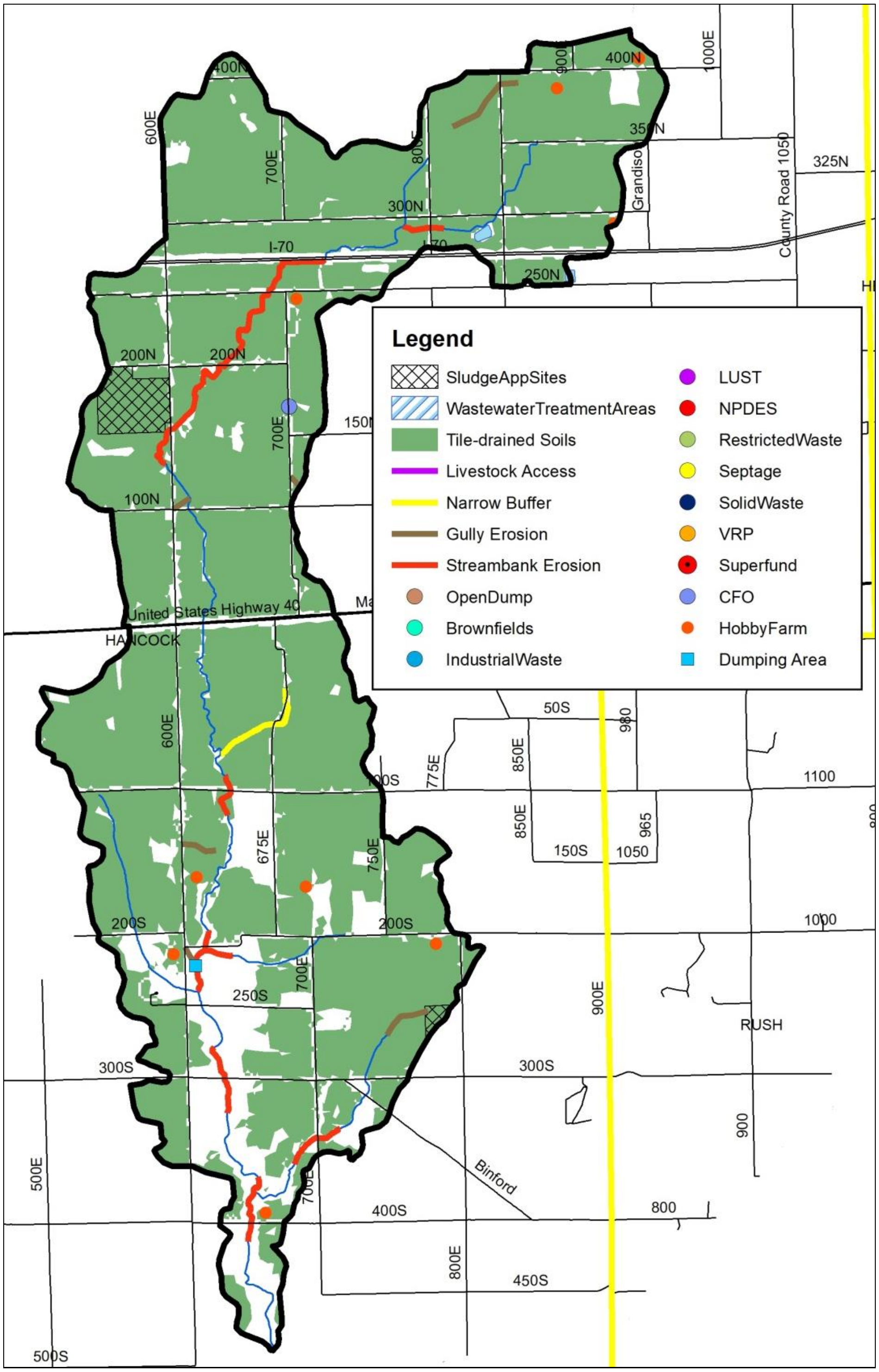

Figure 30. Point and non-point sources of pollution and suggested solutions in the Nameless Creek Subwatershed.

4.3.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Nameless Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Nine unregulated animal operations housing more than 66 cows, horses, sheep, and alpacas were identified during the windshield survey.

One active CFO (hogs) is located within the Nameless Creek Subwatershed. In total, manure from small animal operations and CFOs total over 5,875 tons per year, which contains 16,593 pounds of nitrogen and 12,378 pounds of phosphorus. Streambank erosion, gully erosion, and lack of buffers are a concern in the subwatershed. Approximately 0.8 miles of insufficient stream buffers, 1.6 miles of gully erosion, and 5.9 miles of streambank erosion were identified within the subwatershed. Additionally, one area with trash was identified during the windshield survey.

4.3.5 Water Quality Assessment

Waterbodies within the Nameless Creek Subwatershed have been sampled at 2 locations historically and at one site during the current assessment (Figure 31). Assessments include collection of water chemistry data by IDEM (2 sites sampled in 2010). One USGS stream gage is located in the Nameless Creek Subwatershed. In historic samples, turbidity levels generally measured low, exceeding target concentrations in 13% of collected samples (Table 18). *E. coli* concentrations were generally elevated with concentrations exceeding state standards in 71% of historically collected samples. Turbidity levels exceeded targets in 75% of samples collected during the current project (Table 19). Nitrate-nitrogen concentrations were also elevated exceeding targets in 75% of samples. *E. coli* concentrations exceeded state standards in 60% of collected samples. Macroinvertebrate communities rated as fair (15-17) during both the July and September assessments. Habitat scored 56 of 114 points suggesting habitat may be limited in the Nameless Creek subwatershed.

Table 18. Historic water quality data collected in the Nameless Creek Subwatershed, 1994- 2018.

Parameter	Turbidity (NTU)	*E. coli* (col/100 mL)
Min	3.50	79.00
Max	17.3	1986
#Samples	15	14
#Exceed	2	9
% Exceed	13%	64%

Table 19. Water quality data collected in the Nameless Creek Subwatershed during the current project.

Parameter	Temp	DO	pH	OrthoP	Nitrate	Turbidity	*E. coli*
Min	-1.20	7.00	7.50	0.01	0.80	8.00	0.00
Max	26.1	10	8	10.2	8.4	120	866.7
#Samples	12	12	12	12	12	12	10
#Exceed	N/A	0	0	6	9	9	6
%Exceed	N/A	0%	0%	50%	75%	75%	60%

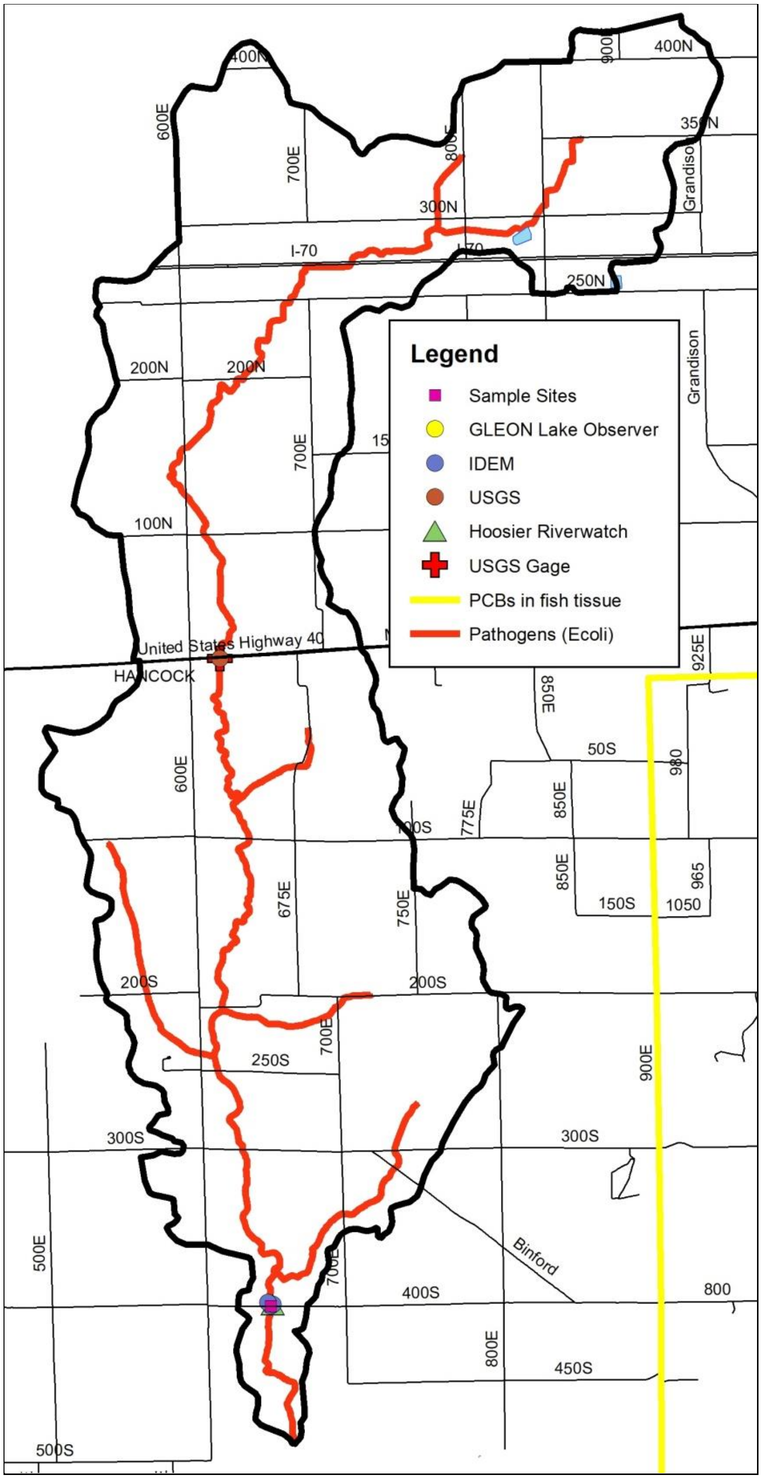

Figure 31. Locations of current and historic water quality data collection and impairments in the Nameless Creek Subwatershed.

4.4 Prairie Branch-Big Blue River Subwatershed

The Prairie Branch-Big Blue River Subwatershed forms part of the central region of the LBBR Watershed and lies within Hancock and Shelby Counties (Figure 32). It encompasses one 12-digit HUC watershed: 051202040804. This subwatershed drains 11,149 acres, or 17.4 square miles, and accounts for 9.9% of the total watershed area. There are 21.5 miles of stream. IDEM has classified 21.5 miles of stream as impaired for *E. coli*.

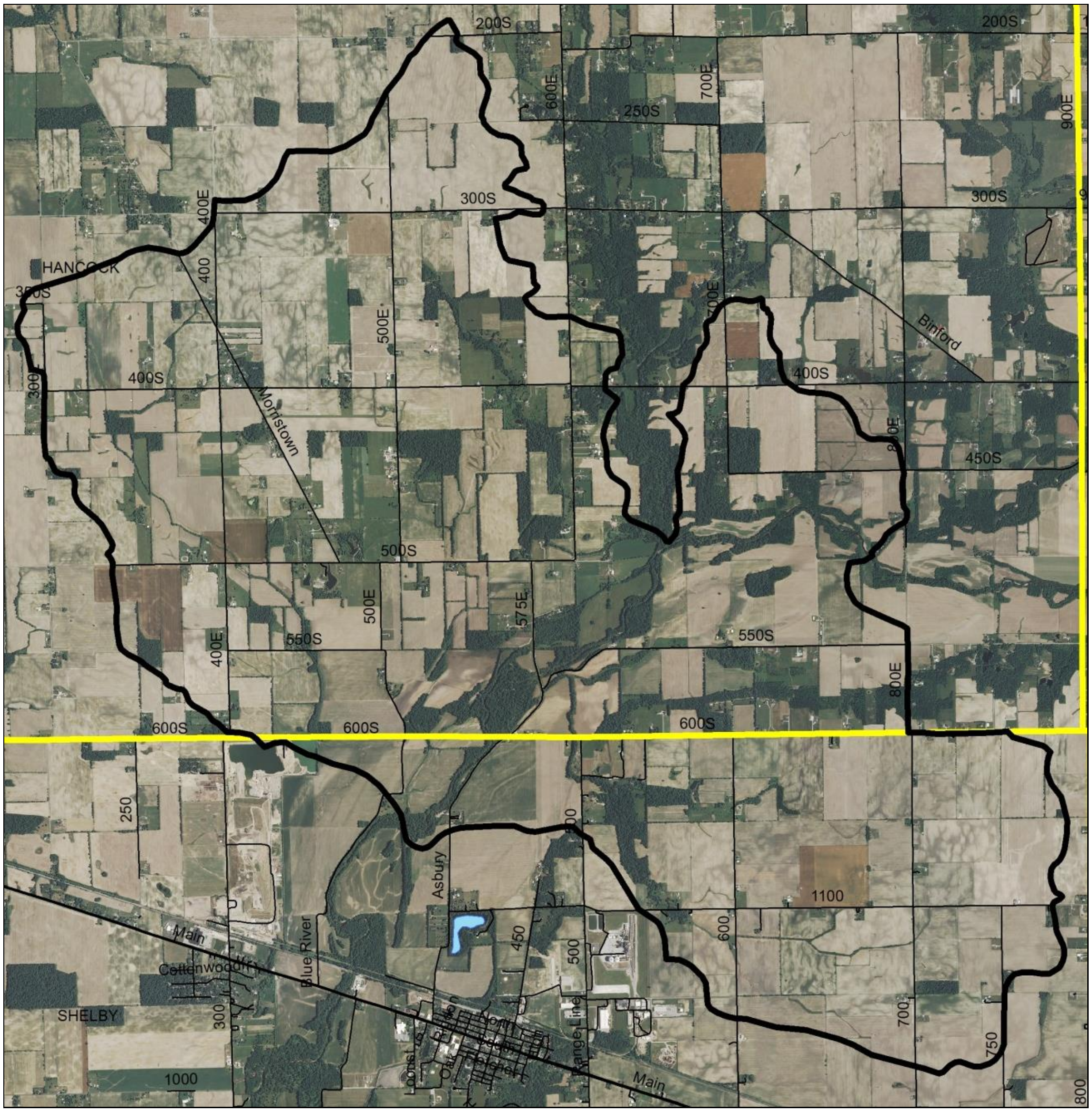

Figure 32. Prairie Branch-Big Blue River Subwatershed.

4.4.1 Soils

Soils in the Prairie Branch-Big Blue River Subwatershed are dominated by the Fox-Ockley-Westland association, which is found throughout the central and southern parts of the watershed in Hancock, Johnson, Rush, and Shelby Counties and have a slope that is nearly level to 35 percent. The well drained Fox and Ockley soils are on the outwash plains and stream terraces and have a native vegetation of hardwood forest. The very poorly drained Westland soils are found in depressions in outwash plains, stream terraces, and glacial drainage channels, have a native vegetation of forested wetland, and are poorly suited for septic systems. These soils can be used to grow typical crops, such as corn and soybeans, when farmed on flat to gently sloping terrain. Additionally, the Sawmill-Lawson-Genesee association is found throughout the central and southern parts of the watershed in Hancock, Shelby, and

Johnson Counties and have a slope that is nearly level to gently sloping. These soils consist of very deep, poorly drained soils formed in alluvium on floodplains. Flooding is rare to frequent for brief to long periods. Soils in this association are suitable for farming, with corn and soybean being the principal crops. Hydric soils cover 2,957 acres (26.5%) of the subwatershed, indicating that nearly one-quarter of the subwatershed was historically wetlands. Wetlands currently cover 3.2% (354 acres) of the subwatershed, representing a loss of 88% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 18.4% and 5.5% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.4.2 Land Use

Agricultural land use dominates the Prairie Branch-Big Blue River Subwatershed with 87.4% (9,738 acres) in agricultural land uses, including row crop and pasture and 6.5% (721 acres) in forested land use. Wetlands, open water, and grassland cover 206 acres, or 1.9%, of the subwatershed. No communities lie within the subwatershed; no major road corridors bisect the Prairie Branch-Big Blue River Subwatershed. In total, 477 acres or 4.3% of the subwatershed are in urban land uses.

4.4.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed (Figure 33). There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, NPDES, LUST, solid waste, or industrial waste facilities located within the Prairie Branch-Big Blue River Subwatershed.

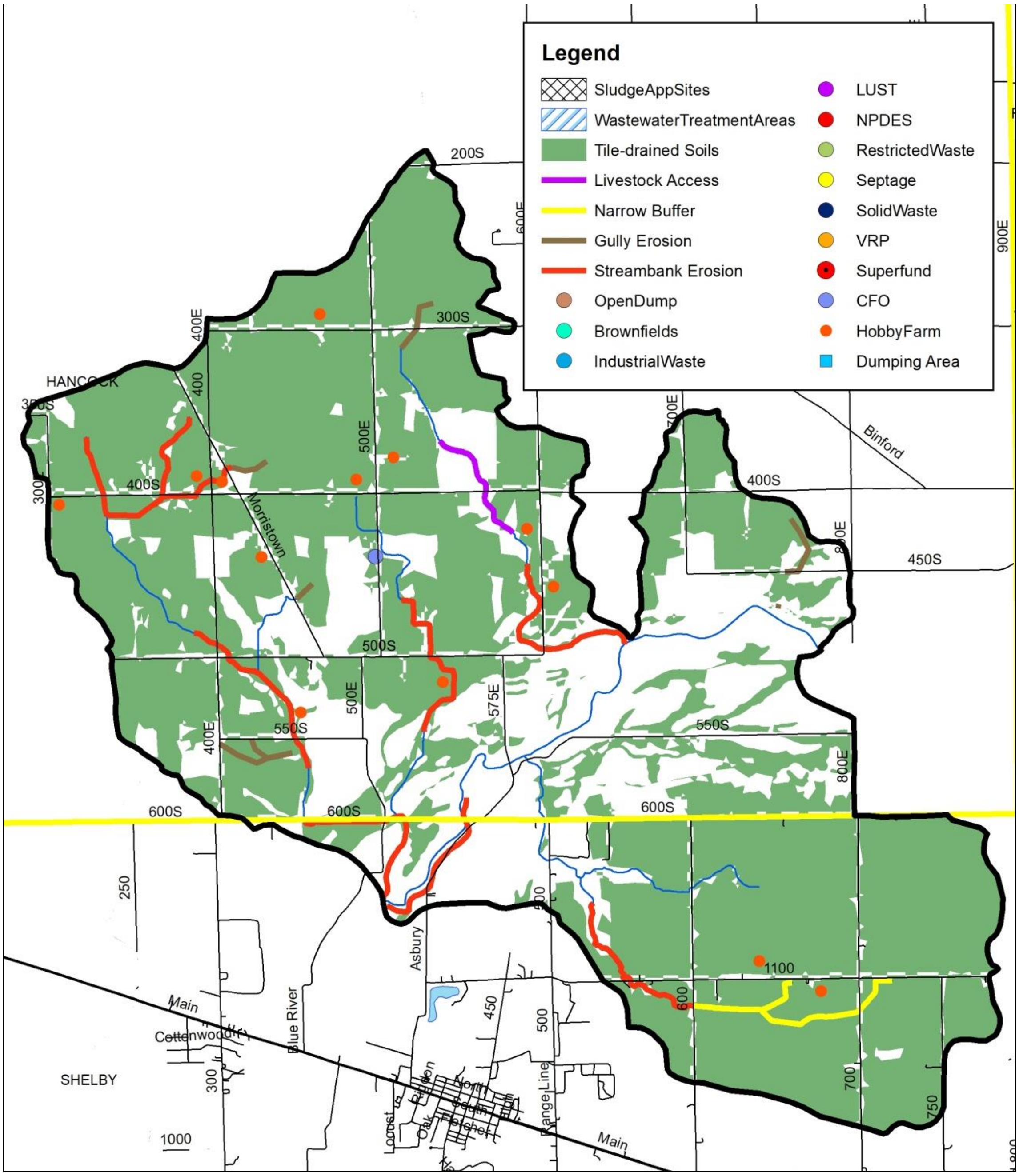

Figure 33. Point and non-point sources of pollution and suggested solutions in the Prairie Branch-Big Blue River Subwatershed.

4.4.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Prairie Branch – Big Blue River Subwatershed. Additionally, a number of small animal operations and pastures are also present. Thirteen unregulated animal operations housing more than 130 cows, sheep, and horses were identified during the windshield survey. Livestock have access to 0.8 miles of streams. No active CFOs are located within the Prairie Branch – Big Blue River Subwatershed – one CFO formerly operated in the Prairie Branch-Big Blue River Subwatershed but closed in 1973. In total, manure from small animal operations total over 2,740 tons per year, which contains almost 1,412 pounds of nitrogen and almost 696 pounds of phosphorus.

Streambank erosion, gully erosion, and lack of buffers are a concern in the subwatershed. Approximately 1.7 miles of insufficient stream buffers, 1.8 miles of gully erosion, and 9.8 miles of streambank erosion were identified within the subwatershed.

4.4.5 Water Quality Assessment

Waterbodies within the Prairie Branch-Big Blue River Subwatershed have been sampled at 3 locations historically; one site was sampled during the current assessment (Figure 34). Historic assessments include collection of water chemistry data by IDEM (3 sites sampled in 2010) and by USGS (1 site sampled in 2007 co-located with IDEM sample site on CR 575 E). No stream gages are in the Prairie Branch-Big Blue River Subwatershed. Nutrient concentrations were elevated during historic assessments with nitrate-nitrogen and total phosphorus concentrations exceeding targets in 100% of collected samples (Table 20). Turbidity and total suspended solids concentrations were also elevated in historic samples with 56% of turbidity and 50% of total suspended solids concentrations exceeding target concentrations. *E. coli* levels exceeded state standards in 82% of historic samples. Conditions measure slightly better during the current assessment with only nitrate-nitrogen concentrations measuring above target concentrations in 50% of samples (Table 21). Orthophosphorus and *E. coli* concentrations exceeded targets and state standards, respectively, with exceedances occurring in only 4 of 12 collected samples and in 4 of 10 samples, respectively. Macroinvertebrate PTI scores ranged from 25 to 29 rating as excellent during the July and September assessments. Habitat scored 56 of 114 points.

Table 20. Historic water quality data collected in the Prairie Branch-Big Blue River Subwatershed, 1994- 2018.

Parameter	Turbidity (NTU)	Nitrate-Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	*E. coli* (col/100 mL)
Min	0.60	3.80	0.11	10.00	29.00
Max	24	6.1	0.13	24	866
#Samples	18	5	4	4	11
#Exceed	10	5	4	2	9
% Exceed	56%	100%	100%	50%	82%

Table 21. Water quality data collected in the Prairie Branch-Big Blue River Subwatershed during the current project.

Parameter	Temp	DO	pH	OrthoP	Nitrate	Turbidity	*E. coli*
Min	-1.50	7.00	7.50	0.00	0.00	8.00	0.00
Max	24.7	10	8	0.3	8.4	120	433.3
#Samples	12	12	12	12	12	12	10
#Exceed	N/A	0	0	4	6	1	4
%Exceed	N/A	0%	0%	33%	50%	8%	40%

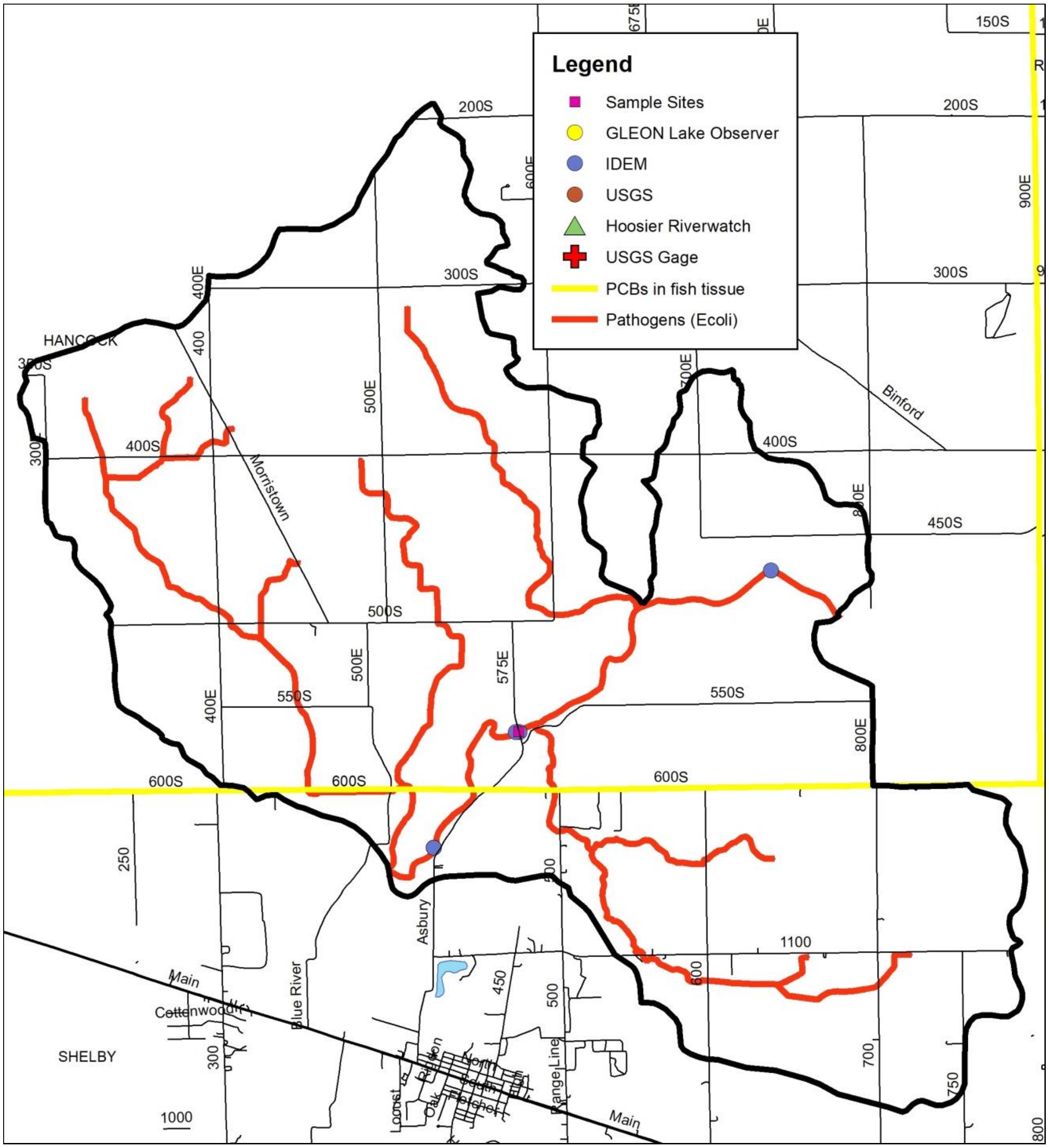

Figure 34. Locations of current and historic water quality data collection and impairments in the Prairie Branch-Big Blue River Subwatershed.

4.5 Foreman Branch-Big Blue River Subwatershed

The Foreman Branch – Big Blue River Subwatershed forms part of the central region of the LBBR Watershed, including the community of Morristown, and lies within Hancock and Shelby Counties (Figure 35). It encompasses one 12-digit HUC watershed: 051202040805. This subwatershed drains 24,792 acres, or 38.7 square miles, and accounts for 22.1% of the total watershed area. There are 48.2 miles of stream. IDEM has classified 48.2 miles of stream as impaired for *E. coli*.

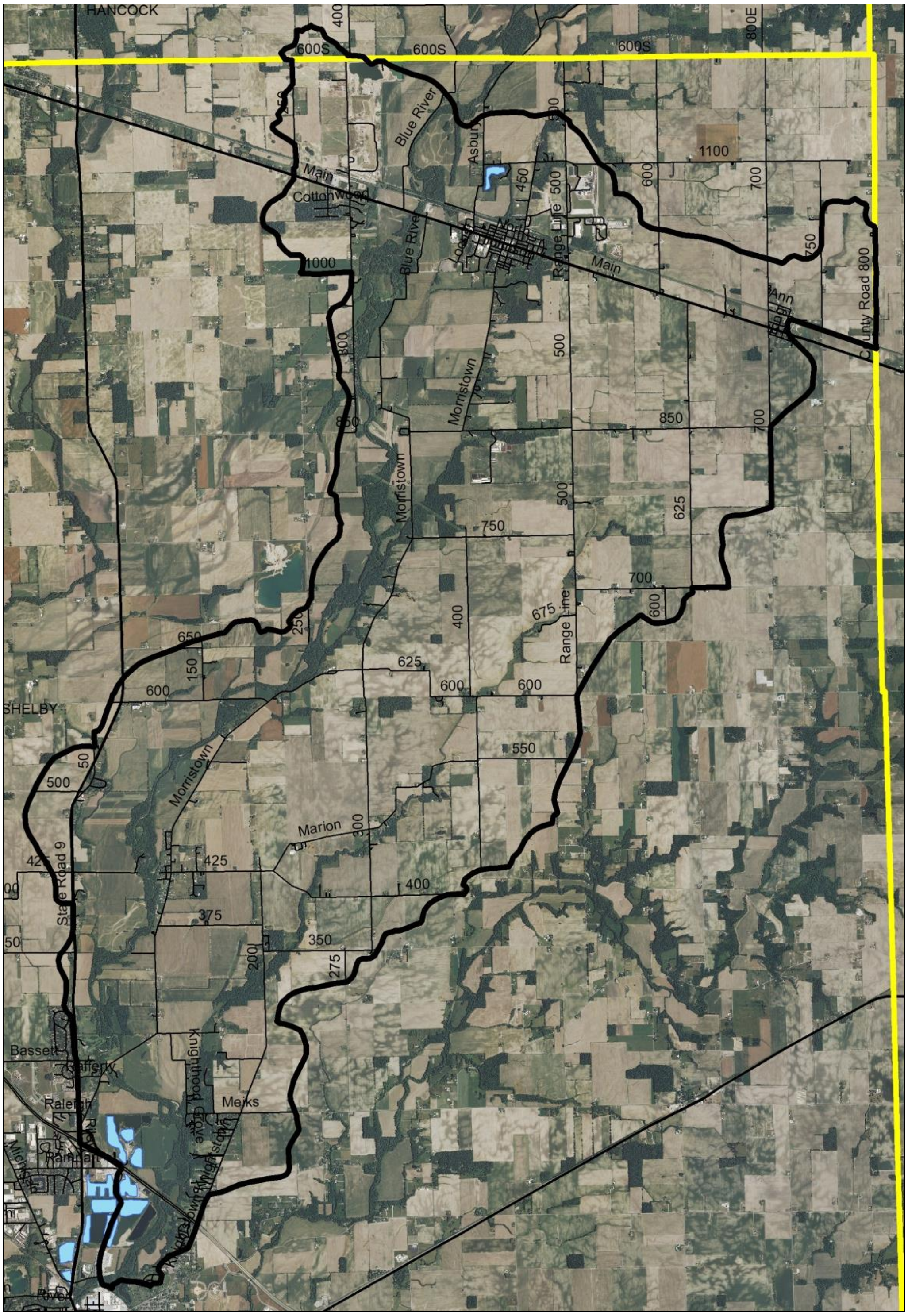

Figure 35. Foreman Branch-Big Blue River Subwatershed.

4.5.1 Soils

Soils in the Foreman Branch-Big Blue River Subwatershed are dominated by the Crosby-Treaty-Miami soil association, which is primarily located in Hancock and Shelby Counties, and have a slope that is nearly level to strongly sloping at 60 percent. While these three soils are found in different proportions, they are found on till plains and have a native vegetation of deciduous forest. The Miami series are moderately well drained, the Crosby series are somewhat poorly drained, and the Treaty series are found in depressions and are poorly drained. The soils are generally suitable for crops and livestock farming if adequately drained but have limitations for septic systems. Hydric soils cover 6,400 acres (25.8%) of the subwatershed, indicating that approximately one-quarter of the subwatershed was historically wetlands. Wetlands currently cover 4.6% (1,128.9 acres) of the subwatershed, representing a loss of 82% of historic wetlands. Highly erodible and potentially highly erodible soils occur throughout the subwatershed, covering 0.8% and 11.5% of the subwatershed, respectively. Nearly the entire subwatershed (97%) has soils which are severely limited for septic use.

4.5.2 Land Use

Agricultural land use dominates the Foreman Branch-Big Blue River Subwatershed with 82.5% (20,450 acres) in agricultural land uses, including row crop and pasture and 6.8% (1,689 acres) in forested land use. Wetlands, open water, and grassland cover 655 acres, or 2.6%, of the subwatershed. The community of Morristown lies within and the U.S. Highway 52 and Interstate 74 corridors bisect the Foreman Branch-Big Blue River Subwatershed accounting for much of the urban land use within the subwatershed. In total, 1,985 acres or 8.0% of the subwatershed are in urban land uses.

4.5.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are eight LUST, one voluntary remediation site, two waste industrial sites, one solid waste site, two voluntary remediation sites, and six NPDES-permitted facilities (Figure 36). No open dumps, brownfields, or corrective action sites are located within the Foreman Branch-Big Blue River Subwatershed.

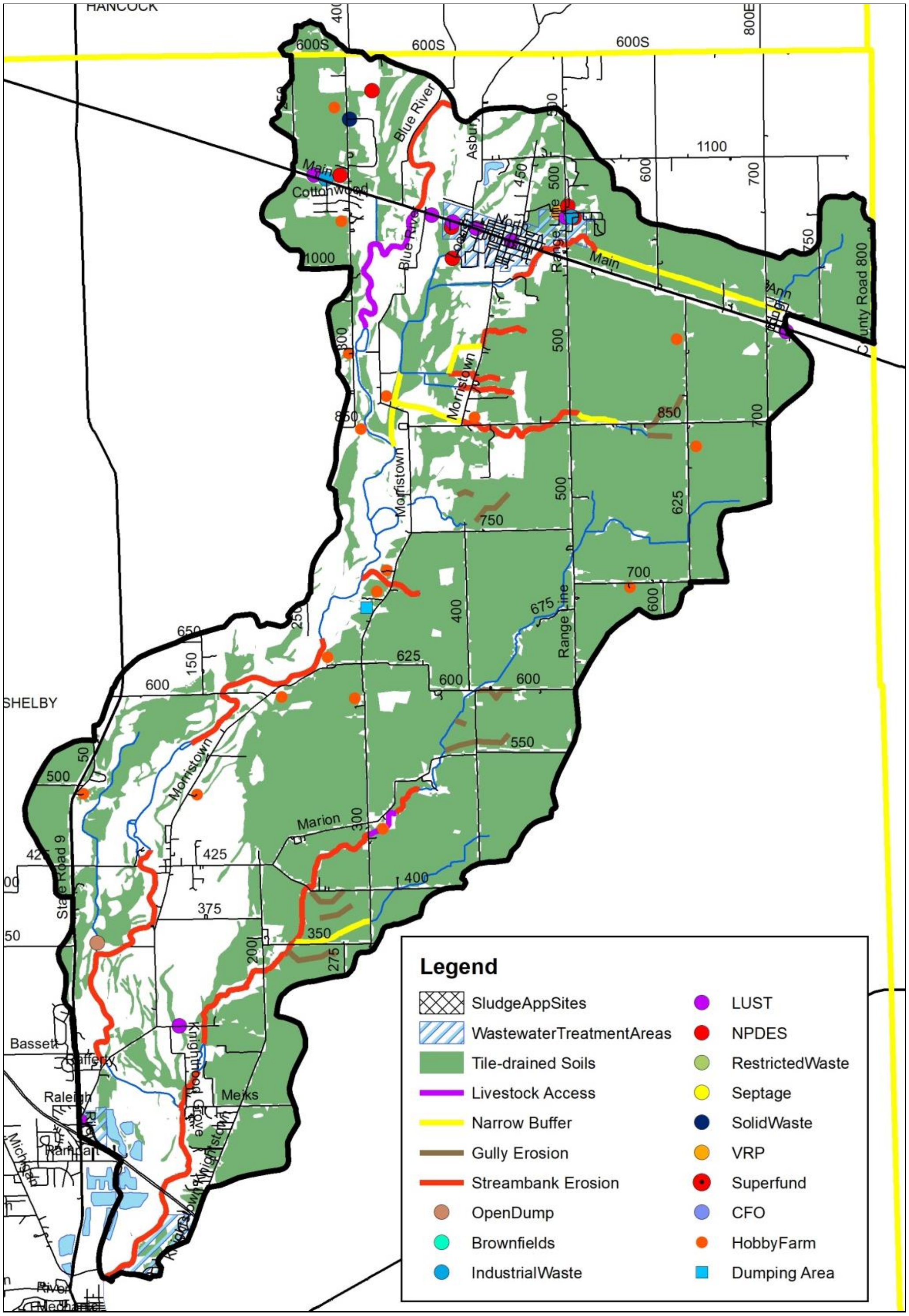

Figure 36. Point and non-point sources of pollution and suggested solutions in the Foreman Branch-Big Blue River Subwatershed.

4.5.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Foreman Branch – Big Blue River Subwatershed. Additionally, a number of small animal operations and pastures are also present.

Seventeen unregulated animal operations housing more than 149 cows, horses, and alpacas were identified during the windshield survey. Livestock have access to 2.2 miles of streams. No active CFOs are located within the Foreman Branch – Big Blue River Subwatershed. In total, manure from small animal operations total over 3,157 tons per year, which contains almost 1,571 pounds of nitrogen and almost 780 pounds of phosphorus. Streambank erosion, gully erosion, and lack of buffers are a concern in the subwatershed. Approximately 4.9 miles of insufficient stream buffers, 10.0 miles of gully erosion, and 19.7 miles of streambank erosion were identified within the subwatershed. Additionally, one area with trash was identified during the windshield survey.

4.5.5 Water Quality Assessment

Waterbodies within the Foreman Branch-Big Blue River Subwatershed have been sampled at 21 locations (Figure 37). Historic assessments include collection of water chemistry data by IDEM (19 sites sampled in 2002, 2008 and 2010) and by USGS (4 sites sampled in 1994 and 2002). During the current project, Foreman Branch-Big Blue River streams were assessed at three locations. There are no stream gages in the Foreman Branch-Big Blue River Subwatershed. Historically, nutrient concentrations are elevated within the Foreman Branch-Big Blue River Subwatershed (Table 22). Nitrate-nitrogen concentrations were elevated with 100% of samples exceeding target concentrations. Turbidity and total phosphorus concentrations were also generally elevated with 70% of turbidity and 50% of total phosphorus concentrations exceeding target levels. *E. coli* concentrations exceed state standards in 56 % of collected samples. During the current assessment, nutrient concentrations were elevated with 61% of nitrate-nitrogen samples and 39% of orthophosphorus samples exceeding target concentrations (Table 23). Only 23% of *E. coli* samples exceeded state standards. Macroinvertebrate PTI scores ranged from 11 to 32 with Site 5 rating as fair during both assessments and Sites 6 and 7 rating as excellent. Habitat scores ranged from 74 to 89 of 114 points.

Table 22. Historic water quality data collected in the Foreman Branch-Big Blue River Subwatershed, 1994- 2018.

Parameter	Turbidity (NTU)	Nitrate-Nitrogen (mg/L)	Total Phosphorus (mg/L)	*E. coli* (col/100 mL)
Min	2.30	5.92	0.01	3.10
Max	61.8	9.4	0.11	770
#Samples	37	2	2	18
#Exceed	26	2	1	10
% Exceed	70%	100%	50%	56%

Table 23. Water quality data collected in the Foreman Branch-Big Blue River Subwatershed during the current project.

Parameter	Temp	DO	pH	OrthoP	Nitrate	Turbidity	*E. coli*
Min	-1.20	6.00	6.50	0.00	0.00	8.00	0.00
Max	27.3	10	8.2	4	10	120	533.3
#Samples	36	36	36	36	36	36	30
#Exceed	N/A	0	0	14	22	9	7
%Exceed	N/A	0%	0%	39%	61%	25%	23%

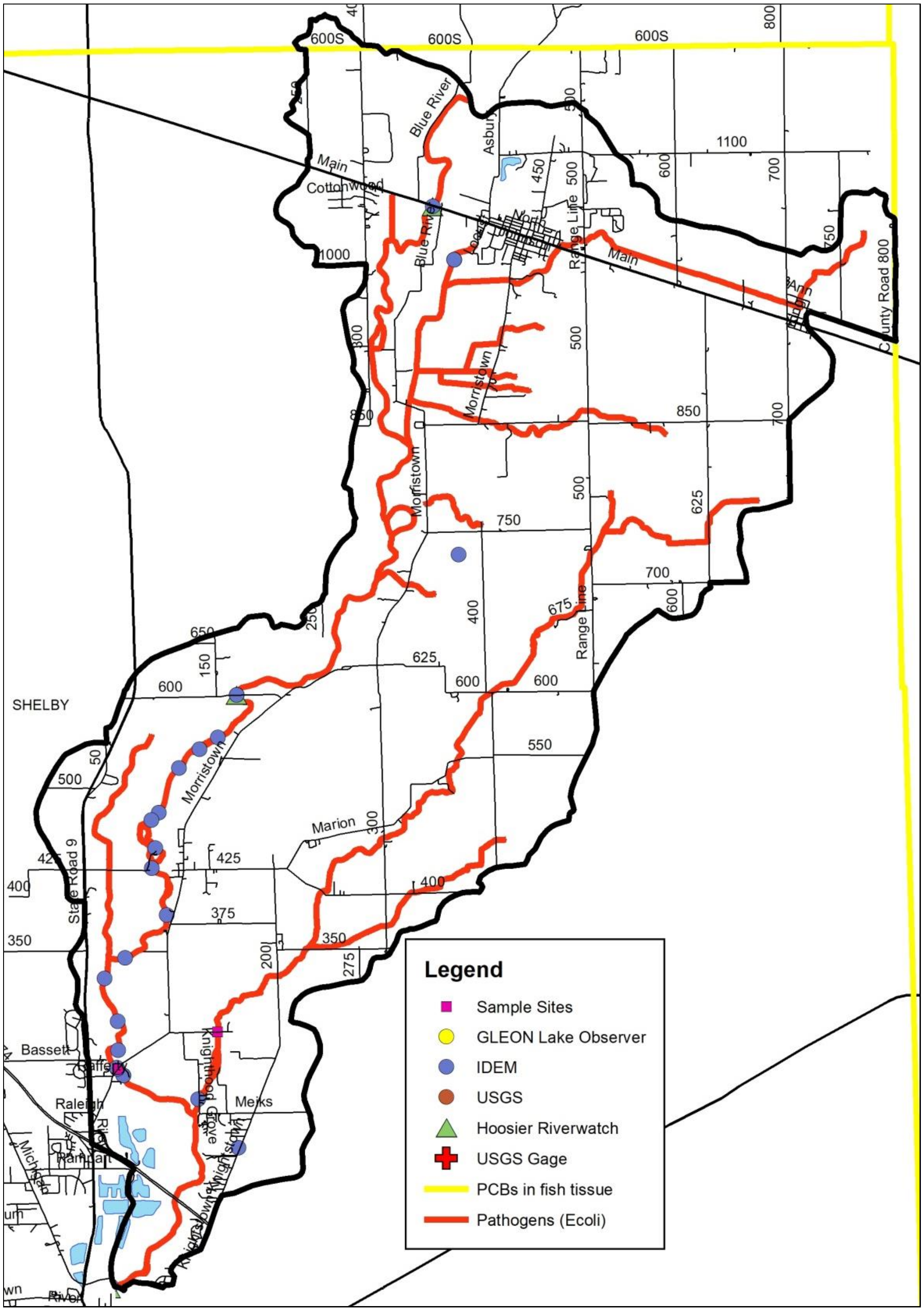

Figure 37. Locations of current and historic water quality data collection and impairments in the Foreman Branch-Big Blue River Subwatershed.

4.6 DePrez Ditch-Big Blue River Subwatershed

The DePrez Ditch-Big Blue River Subwatershed forms part of the western boundary of the LBBR Watershed, including the community of Shelbyville, and lies completely within Shelby County (Figure 38). It encompasses one 12-digit HUC watershed: 051202040806. This subwatershed drains 17,910 acres, or 27.9 square miles, and accounts for 15.9% of the total watershed area. There are 43.3 miles of stream. IDEM has classified 40.6 miles of stream as impaired for *E. coli* and 9.9 miles as impaired for PCBs in fish tissue.

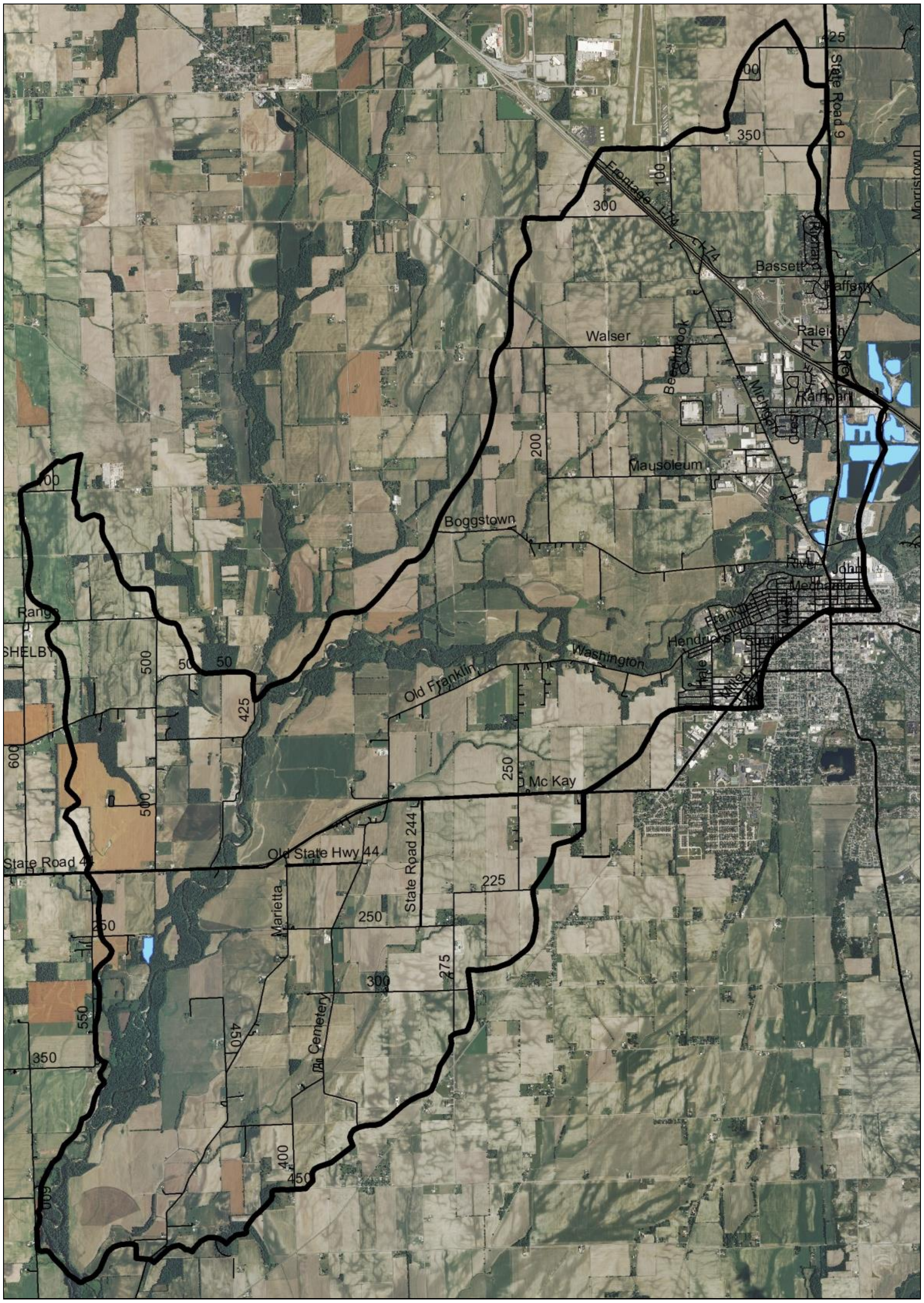

Figure 38. DePrez Ditch-Big Blue River Subwatershed.

4.6.1 Soils

Soils in the DePrez Ditch – Big Blue River Subwatershed are dominated by the Sawmill-Lawson-Genesee association which is found throughout the central and southern parts of the watershed in Hancock, Shelby, and Johnson Counties and have a slope that is nearly level to gently sloping. These soils consist of very deep, poorly drained soils formed in alluvium on floodplains. Flooding is rare to frequent for brief to long periods. Soils in this association are suitable for farming, with corn and soybean being the principal crops. Hydric soils cover 4,320 acres (24.1%) of the subwatershed, indicating that nearly one-quarter of the subwatershed was historically wetlands. Wetlands currently cover 5.4% (961.0 acres) of the subwatershed, representing a loss of 78% of historic wetlands. Highly erodible and potentially highly erodible soils occur throughout the subwatershed, covering 0.8% and 6.1% of the subwatershed, respectively. Nearly the entire subwatershed (97%) has soils which are severely limited for septic use.

4.6.2 Land Use

Agricultural land use dominates the DePrez Ditch-Big Blue River Subwatershed with 77.8% (13,926 acres) in agricultural land uses, including row crop and pasture and 7.0% (1,255 acres) in forested land use. Wetlands, open water, and grassland cover 309 acres, or 1.7%, of the subwatershed. The community of Shelbyville lies within and State Road 9, State Road 44, and the Interstate 74 corridor bisects the DePrez Ditch-Big Blue River Subwatershed accounting for much of the urban land use within the subwatershed. In total, 2,409 acres or 13.5% of the subwatershed are in urban land uses.

4.6.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are two brownfields, one NPDES-permitted facility, twenty LUST sites, eleven waste industrial sites, and one solid waste site located in the subwatershed (Figure 39). No open dumps, corrective action sites, or voluntary remediation sites are located within the DePrez Ditch-Big Blue River Subwatershed.

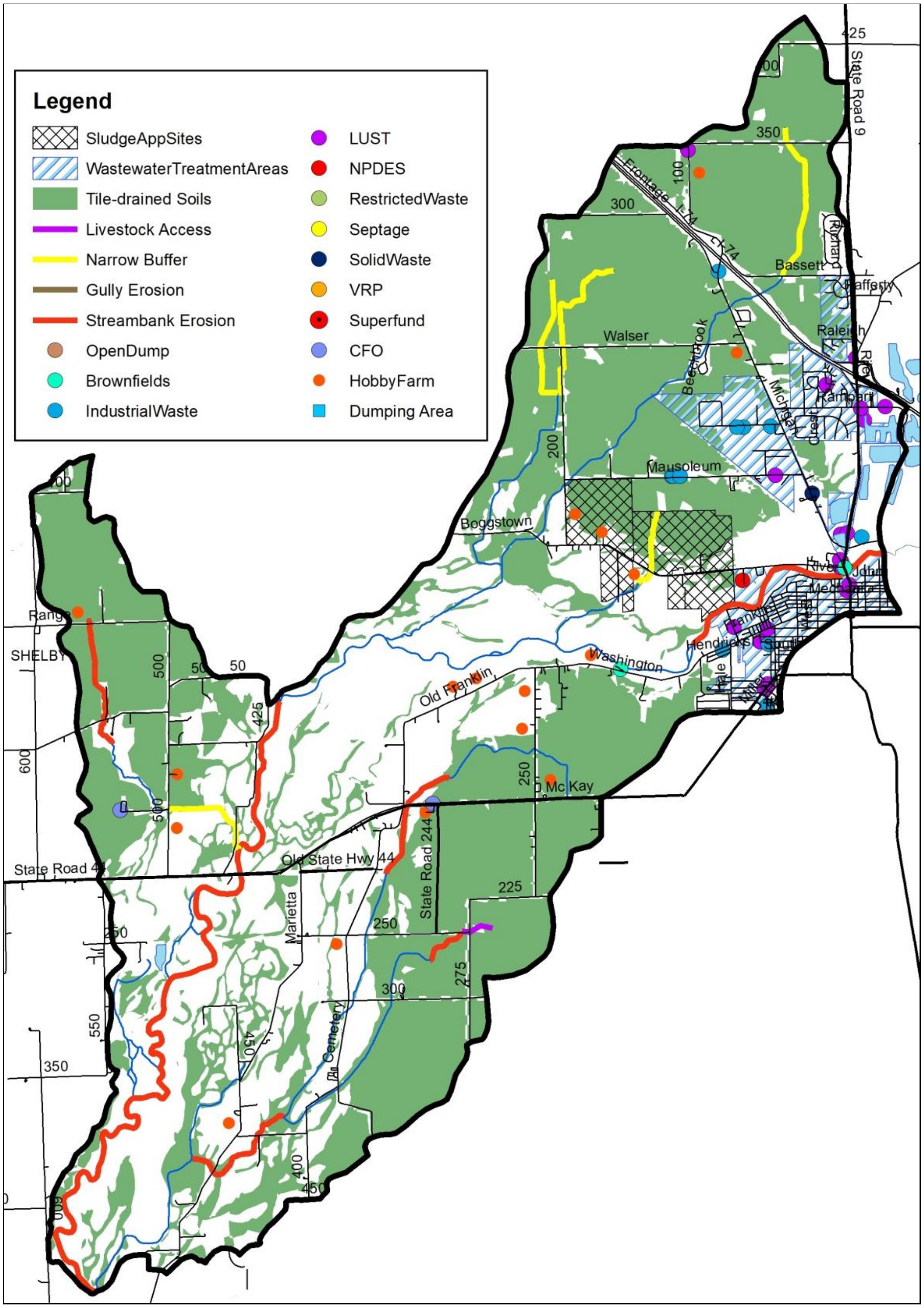

Figure 39. Point and non-point sources of pollution and suggested solutions in the DePrez Ditch-Big Blue River Subwatershed.

4.6.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the DePrez Ditch – Big Blue River Subwatershed. Additionally, a number of small animal operations and pastures are also present. Seventeen unregulated animal operations housing more than 197 cows, horses, and goats were identified during the windshield survey. Livestock have access to 0.3 miles of DePrez Ditch – Big Blue River Subwatershed streams. Two CFOs (hogs) are located within the DePrez Ditch – Big Blue River Subwatershed. In total, manure from small animal operations and the CFOs total over 11,622 tons per year, which contains almost 26,840 pounds of nitrogen and almost 19,855 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 5.0 miles of insufficient stream buffers and 12.6 miles of streambank erosion were identified within the subwatershed.

4.6.5 Water Quality Assessment

Waterbodies within the DePrez Ditch-Big Blue River Subwatershed have been sampled at 10 locations (Figure 40Table 24). Assessments include collection of water chemistry data by IDEM (5 sites sampled in 1997, 2002 and 2010), by USGS (6 sites sampled in 1997 and 2002) and at two sites during the current assessment. There is one stream gage in the DePrez Ditch-Big Blue River Subwatershed. Historically, nutrient concentrations were elevated within the DePrez Ditch-Big Blue River Subwatershed with 100% of nitrate-nitrogen and total phosphorus concentrations exceeding targets (Table 24). Total suspended solids concentrations were also generally high historically with 83% of samples exceeding targets. Conversely, only 44% of turbidity samples exceeded water quality targets historically. Additionally, only 27% of *E. coli* samples exceeded state standards historically. During the current assessment, nutrient concentrations were elevated with 52% of orthophosphorus and 63% of nitrate-nitrogen samples exceeding target concentrations (Table 25). Turbidity levels were also elevated with 54% of samples exceeding targets. Macroinvertebrate PTI scores ranged from 15 to 32 or from fair to excellent during both assessments. Habitat scores ranged from 56 to 82 of 114 points with Site 9 rating poorer than Site 12 for all assessments.

Table 24. Historic water quality data collected in the DePrez Ditch-Big Blue River Subwatershed, 1994- 2018.

Parameter	Turbidity (NTU)	Nitrate-Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	*E. coli* (col/100 mL)
Min	0.10	2.80	0.08	8.00	7.40
Max	857	6.3	0.15	66	1046
#Samples	48	6	7	6	30
#Exceed	21	6	7	5	8
% Exceed	44%	100%	100%	83%	27%

Table 25. Water quality data collected in the DePrez Ditch-Big Blue River Subwatershed during the current project.

Parameter	Temp	DO	pH	OrthoP	Nitrate	Turbidity	*E. coli*
Min	-1.50	6.00	7.50	0.00	0.00	8.00	0.00
Max	26.4	10	8	0.35	10	240	966.6
#Samples	24	24	24	23	24	24	20
#Exceed	N/A	0	0	12	15	13	7
%Exceed	N/A	0%	0%	52%	63%	54%	35%

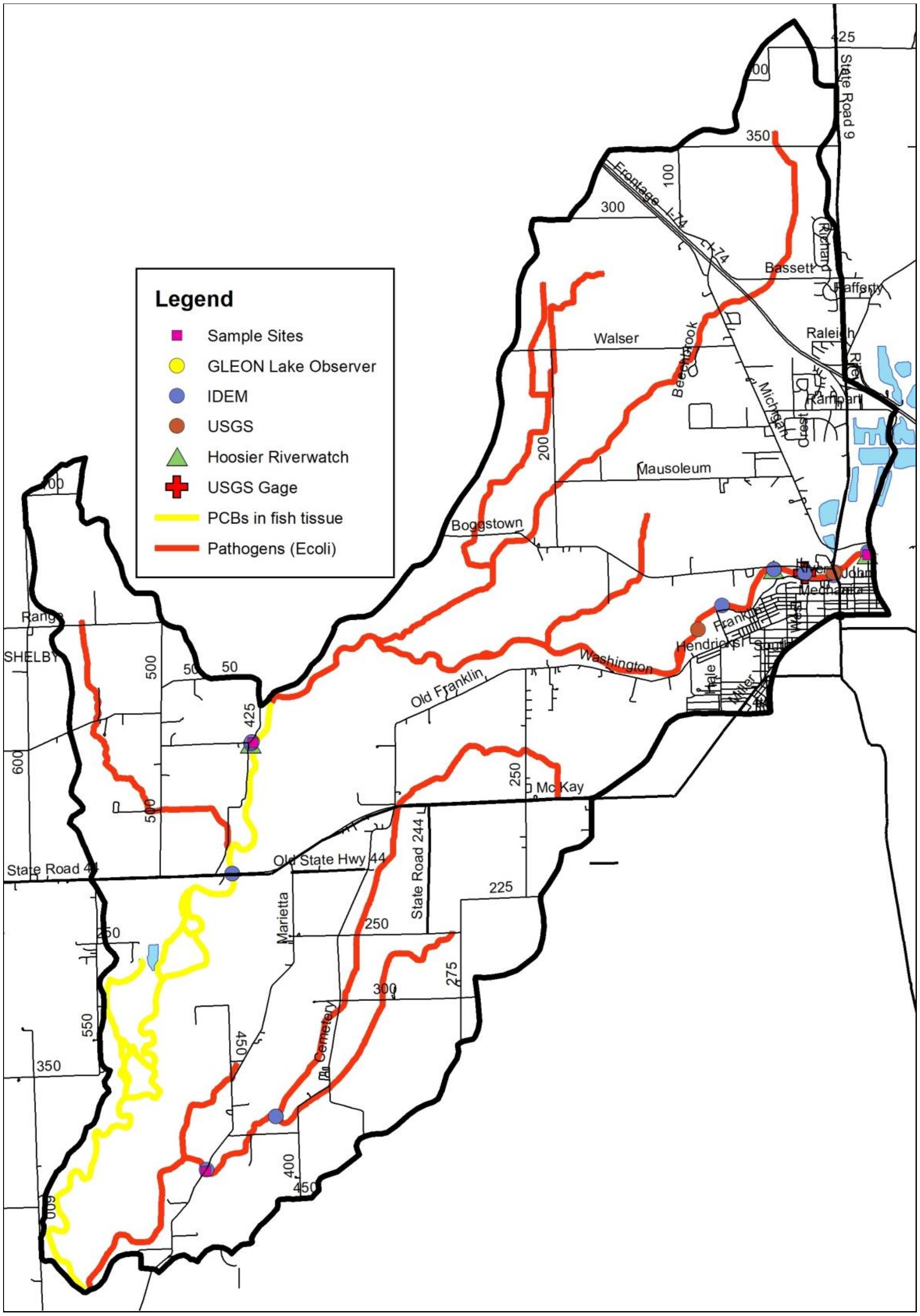

Figure 40. Locations of current and historic water quality data collection and impairments in the DePrez Ditch-Big Blue River Subwatershed.

4.7 Shaw Ditch-Big Blue River Subwatershed

The Shaw Ditch-Big Blue River Subwatershed forms part of the southern boundary of the LBBR Creek Watershed, including the community of Edinburgh, and lies within Shelby and Johnson Counties (Figure 41). It encompasses one 12-digit HUC watershed: 051202040807. This subwatershed drains 18,766 acres, or 45.3 square miles, and accounts for 16.7% of the total watershed area. There are 45.3 miles of stream. IDEM has classified 44.56 miles as impaired for *E. coli* and 26.7 miles of stream as impaired for PCBs in fish tissue.

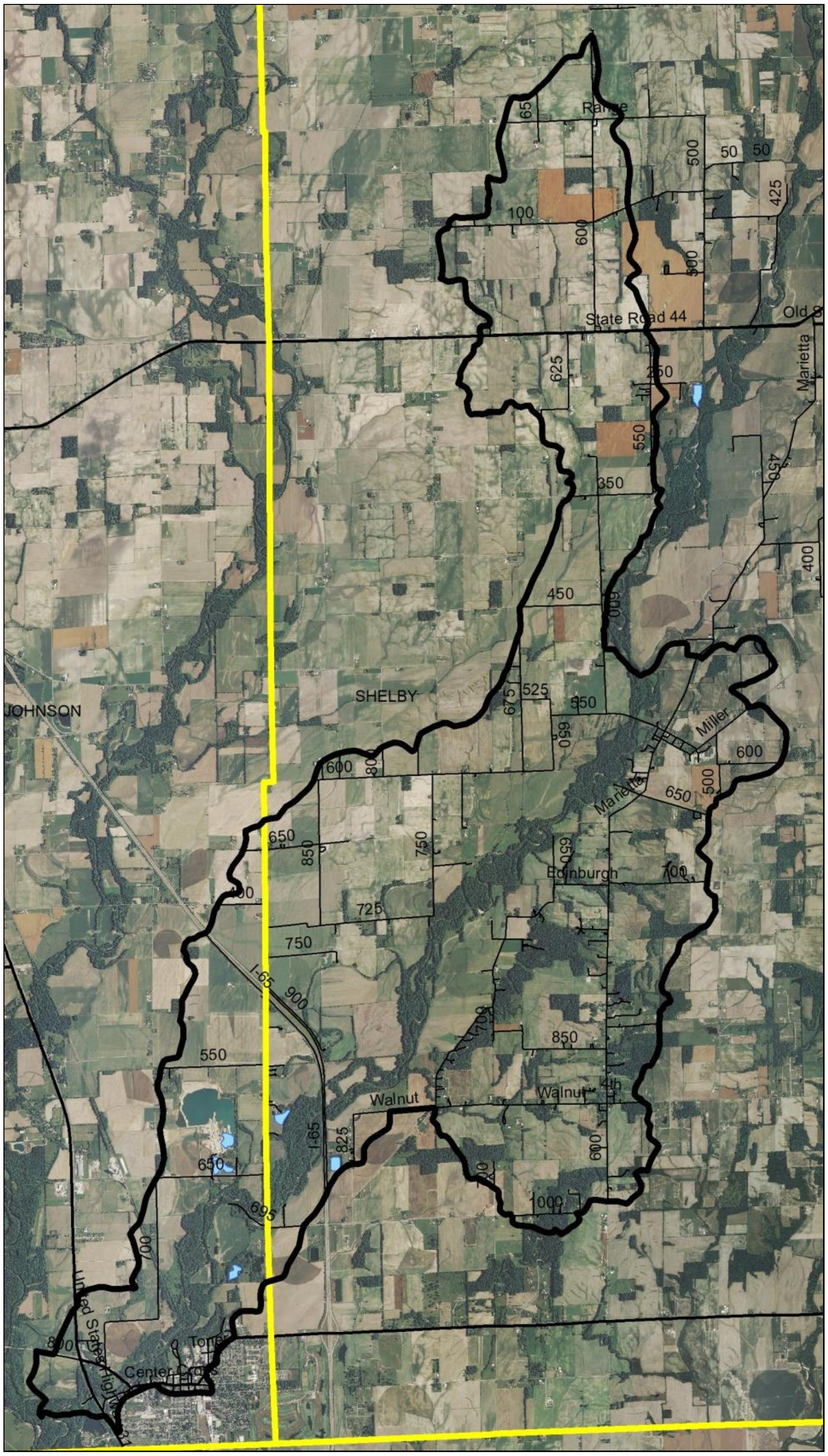

Figure 41. Shaw Ditch-Big Blue River Subwatershed.

4.7.1 Soils

Soils in the Shaw Ditch-Big Blue River Subwatershed are co-dominated by several soil associations. The Sawmill-Lawson-Genesee association is found throughout the central and southern parts of the watershed in Hancock, Shelby, and Johnson Counties and have a slope that is nearly level to gently sloping. These soils consist of very deep, poorly drained soils formed in alluvium on floodplains. Flooding is rare to frequent for brief to long periods. Soils in this association are suitable for farming, with corn and soybean being the principal crops. The Fox-Ockley-Westland association is found throughout the central and southern parts of the watershed in Hancock, Johnson, Rush, and Shelby Counties and have a slope that is nearly level to 35 percent. The well drained Fox and Ockley soils are on the outwash plains and stream terraces and have a native vegetation of hardwood forest. The very poorly drained Westland soils are found in depressions in outwash plains, stream terraces, and glacial drainage channels, have a native vegetation of forested wetland, and are poorly suited for septic systems. These soils can be used to grow typical crops, such as corn and soybeans, when farmed on flat to gently sloping terrain. Hydric soils cover 2,378 acres (12.7%) of the subwatershed, indicating that only one tenth of the subwatershed was historically wetlands. Wetlands currently cover 7.3% (1,365.5 acres) of the subwatershed, representing a loss of 43% of historic wetlands. Highly erodible and potentially highly erodible soils occur throughout the subwatershed, covering 3.5% and 20.1% of the subwatershed, respectively. Nearly the entire subwatershed (96%) has soils which are severely limited for septic use.

4.7.2 Land Use

Agricultural land use dominates the Shaw Ditch-Big Blue River Subwatershed with 77.6% (14,558 acres) in agricultural land uses, including row crop and pasture and 14.5% (2,716 acres) in forested land use. Wetlands, open water, and grassland cover 348 acres, or 1.9%, of the subwatershed. The community of Edinburgh partially lies within and the US Highway 31 and Interstate 65 corridor bisects the Shaw Ditch-Big Blue River Subwatershed accounting for much of the urban land use within the subwatershed. In total, 1,142 acres or 6.1% of the subwatershed are in urban land uses.

4.7.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are two NPDES-permitted facilities, four LUST sites, two waste industrial sites, one waste septage site, and one solid waste site (Figure 42). There are no open dumps, brownfields, corrective action sites, or voluntary remediation sites located within the Shaw Ditch – Big Blue River Subwatershed.

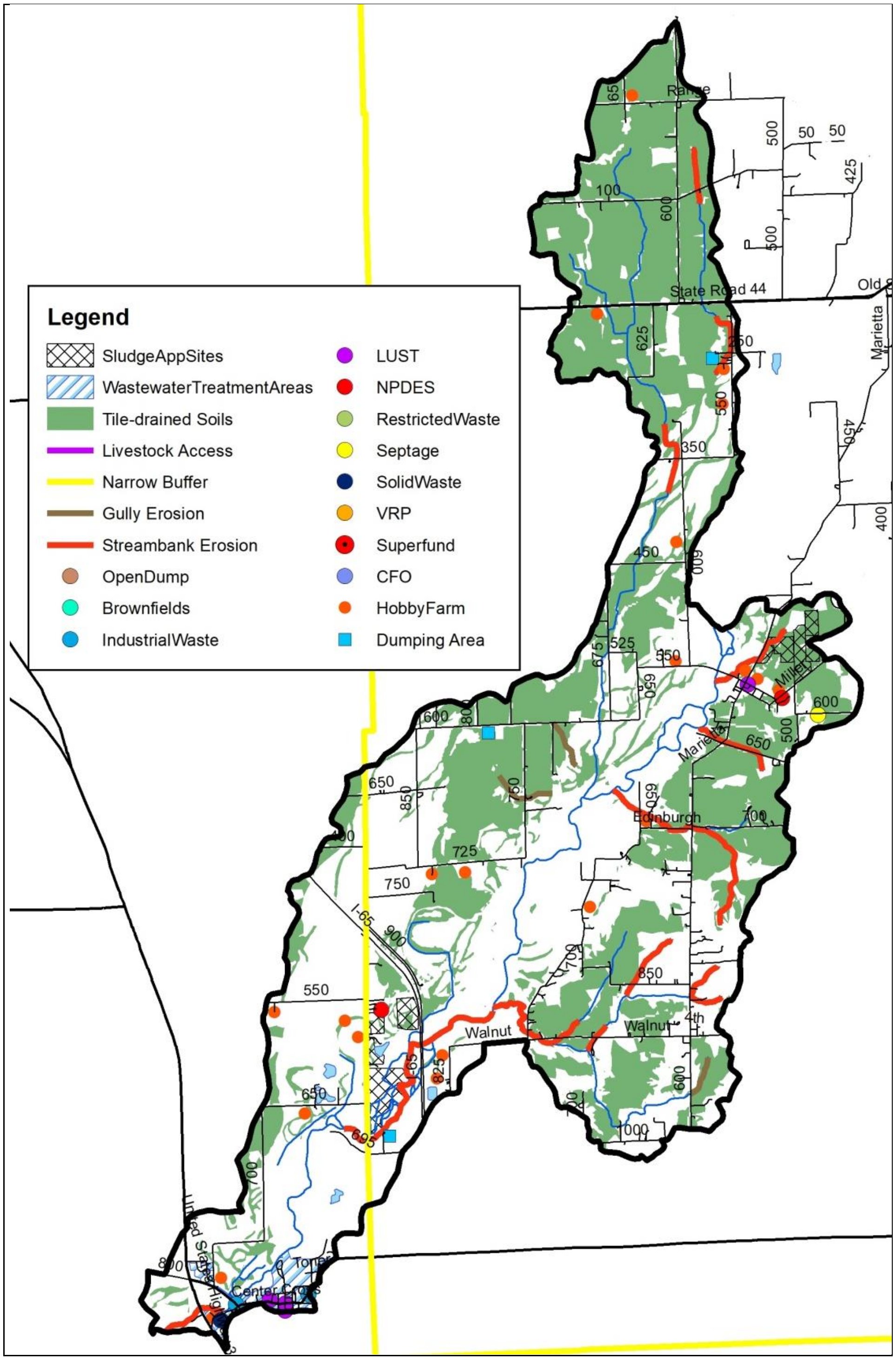

Figure 42. Point and non-point sources of pollution and suggested solutions in the Shaw Ditch-Big Blue River Subwatershed.

4.7.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Shaw Ditch-Big Blue River Subwatershed. Additionally, a number of small animal operations and pastures are also present. Nineteen unregulated animal operations housing more than 151 cows, horses, and goats were identified during the windshield survey. No CFOs are located within the Shaw Ditch-Big Blue River Subwatershed. In total, manure from small animal operations total over 2,861 tons per year, which contains almost 1,710 pounds of nitrogen and almost 918 pounds of phosphorus. Streambank erosion and gully erosion are a concern in the subwatershed. Approximately 1.5 miles of gully erosion and 12.3 miles of streambank erosion were identified within the subwatershed. Additionally, three areas with trash were identified during the windshield survey.

4.7.5 Water Quality Assessment

Waterbodies within the Shaw Ditch-Big Blue River Subwatershed have been sampled at 8 locations (Figure 43). Historical assessments include collection of water chemistry data by IDEM (6 sites sampled in 1994, 1997, 2002 and 2010), by USGS (3 sites sampled in 2002), and by GLEON (1 site sampled in 2011). Two sites were sampled during the current assessment. There are no stream gages in the Shaw Ditch-Big Blue River Subwatershed. Samples exceeded nitrate-nitrogen target concentrations in 97% of historically collected samples, while total phosphorus concentrations exceeded targets in 86% of historically-collected samples (Table 26). Turbidity and total suspended solids concentrations were elevated during storm conditions; however, only 39% of turbidity and 47% of total suspended solids concentrations exceed target concentrations in historical collections. Historically, *E. coli* concentrations exceed state standards in 82% of collected samples. During the current assessment, all parameters measured relatively low within Shaw Ditch-Big Blue River subwatershed streams (Table 27). None of the sample parameters exceeded target concentrations or state standards in more than 45% of collected samples. Macroinvertebrate PTI scores ranged from 25 to 33 or excellent at all sites during both assessments. Habitat scores ranged from 70 to 80 of 114 points.

Table 26. Historic water quality data collected in the Shaw Ditch-Big Blue River Subwatershed, 1994-2018.

Parameter	Turbidity (NTU)	Nitrate-Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	*E. coli* (col/100 mL)
Min	1.00	1.20	0.03	4.00	129.00
Max	25.2	7	0.344	241	866
#Samples	337	286	294	249	11
#Exceed	130	278	253	117	9
% Exceed	39%	97%	86%	47%	82%

Table 27. Water quality data collected in the Shaw Ditch-Big Blue River Subwatershed during the current project.

Parameter	Temp	DO	pH	OrthoP	Nitrate	Turbidity	*E. coli*
Min	-1.50	0.00	7.50	0.00	0.00	8.00	0.00
Max	24.6	10	8	0.4	8.6	120	300
#Samples	24	24	24	24	24	24	20
#Exceed	N/A	0	0	7	10	2	3
%Exceed	N/A	0%	0%	29%	42%	8%	15%

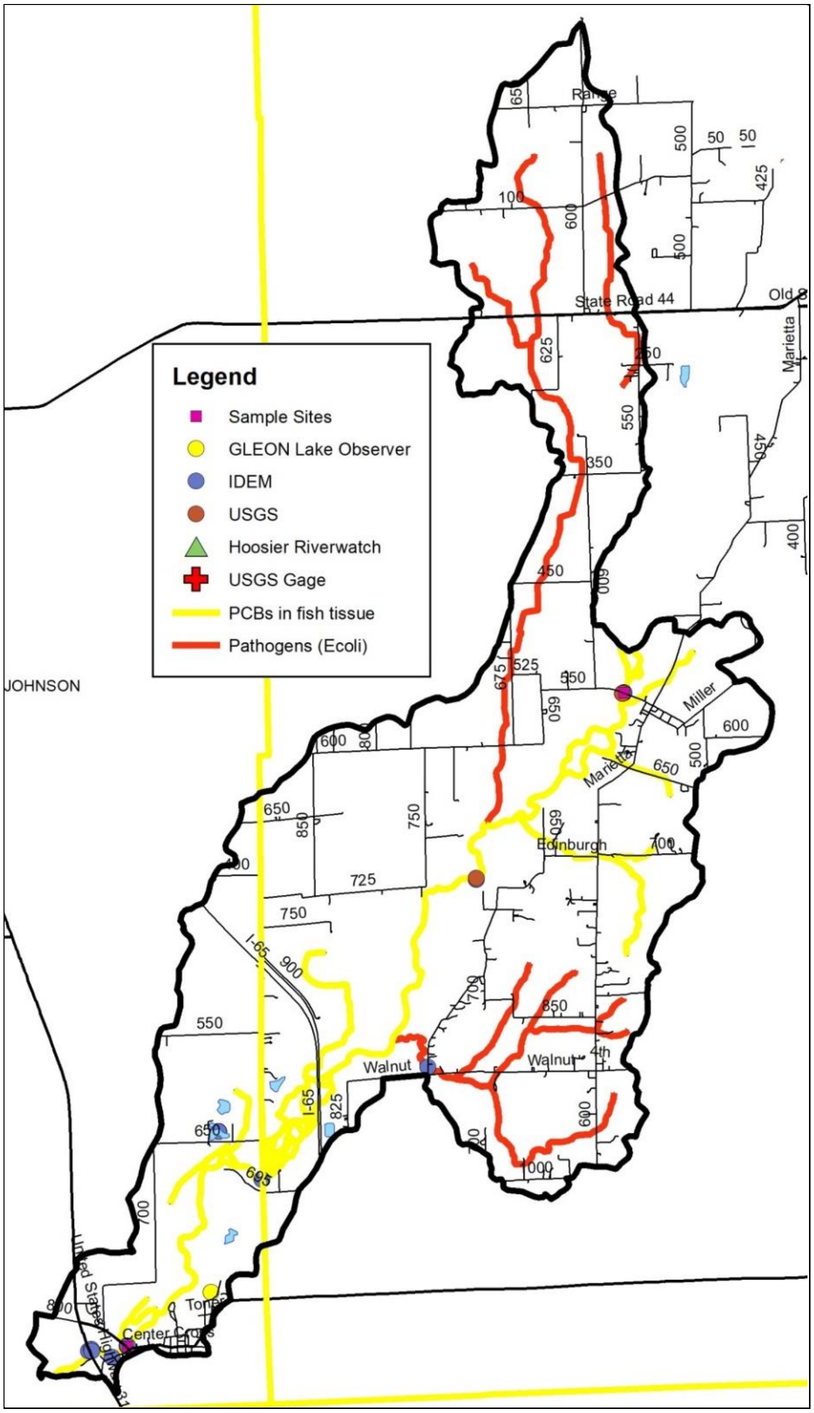

Figure 43. Locations of current and historic water quality data collection and impairments in the Shaw Ditch-Big Blue River Subwatershed.

5.0 WATERSHED INVENTORY III: WATERSHED INVENTORY SUMMARY

Several important factors and relationships become apparent when the Lower Big 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 current and historic data collected from IDEM, IDNR, U.S. Geological Survey, and Hoosier Riverwatch. These include elevated nitrate-nitrogen, total phosphorus, total suspended solids or turbidity, and *E. coli* concentrations at some sites.

Table 28 summarizes current samples, which measured outside the target values during Hoosier Riverwatch sampling conducted as part of this project. Table 29 summarizes historic samples which measured outside the target values during any previous assessments collected by IDEM, USGS, or GLEON from 2002 through 2018. Figure 44 details locations where exceedances of current or historic water quality data occur for each parameter. Elevated nitrate-nitrogen concentrations were in all subwatersheds except DePrez Ditch-Big Blue River during the current project – concentrations exceed target concentrations in 50% or more of samples collected. Additionally, sites within Anthony Creek-Six Mile Creek, Prairie Branch- Big Blue River, DePrez Ditch-Big Blue River, and Foreman Branch-Big Blue River exceeded target nitrate concentrations in 50% or more of historically collected samples. Elevated orthophosphorus concentrations were observed at many sample sites during the current project with concentrations exceeding targets during 50% or more of collected samples in Headwaters Six Mile Creek, Nameless Creek, Anthony Creek-Six Mile Creek and Shaw Ditch-Big Blue River subwatersheds. Habitat scores ranged from 50 to 89 of 114 total points with five sites (Sites 2, 3, 4, 9 and 13) scoring lower than the target level (60 points). Macroinvertebrate communities rated as fair to excellent during the July and September assessments. As habitat and macroinvertebrate community assessments were limited to one to two assessments, they are not listed in Table 28 or displayed as exceeding in Figure 44.

Historically, total phosphorus concentration exceeded targets within all subwatersheds where samples were collected. Elevated total suspended solids concentrations were observed in the Prairie Branch-Big Blue River and DePrez Ditch-Big Blue River subwatersheds, while TSS concentrations exceeding nearly 50% of samples in the Shaw Ditch-Big Blue River historically as well. Turbidity concentrations exceeded targets in Prairie Branch-Big Blue River and Foreman Branch-Big Blue River historically and in Nameless Creek, Anthony Creek-Six Mile Creek and Shaw Ditch-Big Blue River during current assessments. *E. coli* concentrations that exceeded the state grab sample standard were measured in Nameless Creek, Anthony Creek-Six Mile Creek, Prairie Branch-Big Blue River, Shaw Ditch-Big Blue River and Foreman Branch-Big Blue River historically and in Anthony Creek-Six Mile Creek and Nameless Creek during the current assessment.

Table 28. Percent of samples collected in the Lower Big Blue River Watershed which measured outside of target values during the current sample collection period.

Subwatershed	Temp	DO	pH	OrthoP	Nitrate	Turbidity	*E. coli*
Headwaters Six Mile Creek	N/A	0%	0%	50%	92%	8%	40%
Anthony Creek-Six Mile Creek	N/A	0%	3%	50%	72%	56%	50%
Nameless Creek	N/A	0%	0%	50%	75%	75%	60%
Prairie Branch-Big Blue River	N/A	0%	0%	33%	50%	8%	40%
Foreman Branch-Big Blue River	N/A	0%	6%	39%	61%	25%	23%
DePrez Ditch-Big Blue River	N/A	0%	0%	29%	42%	8%	15%
Shaw Ditch-Big Blue River	N/A	0%	0%	52%	63%	54%	35%

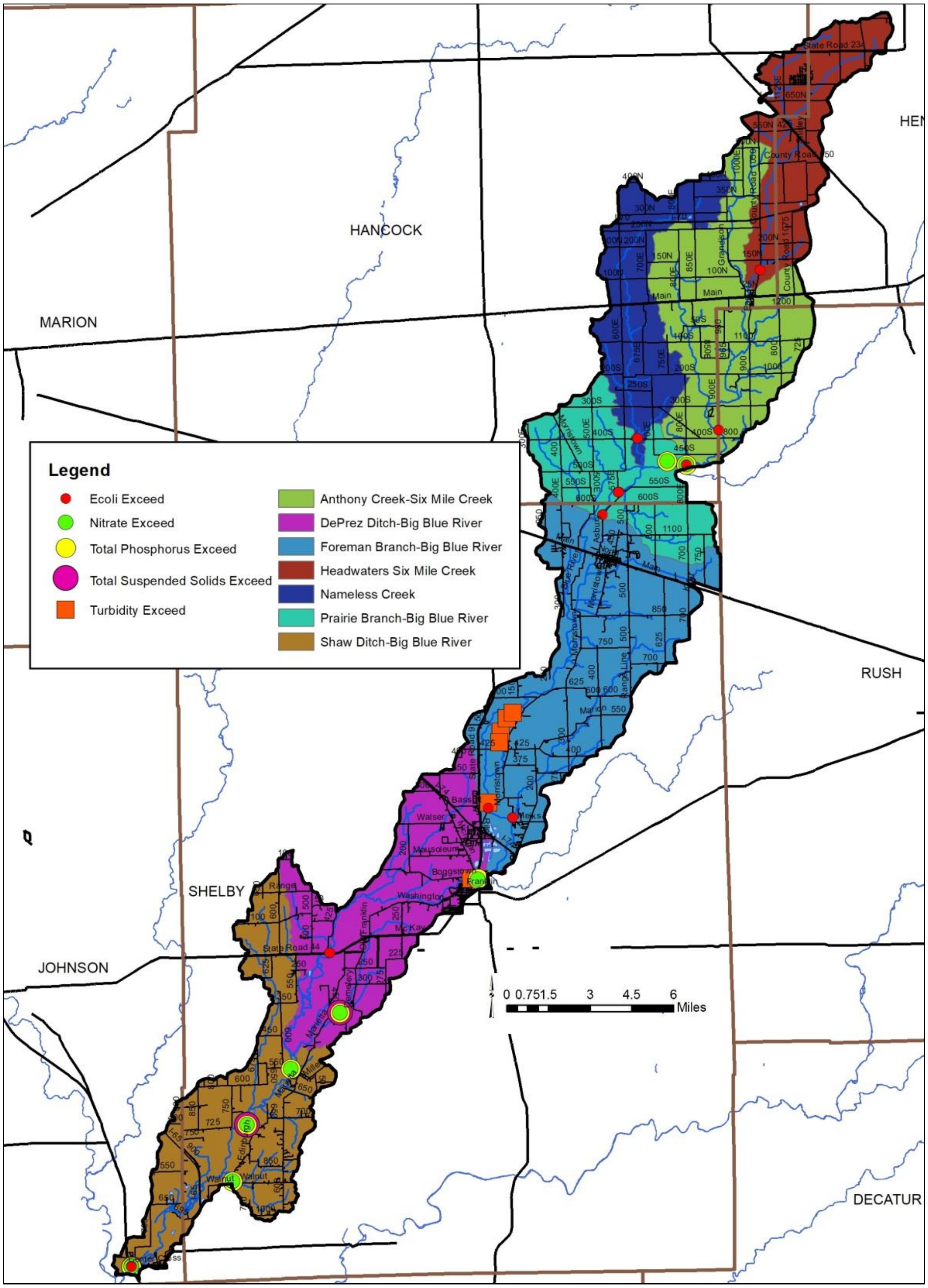

Figure 44. Sample sites with poor water quality as measured by exceeding targets in 50% or more of samples collected during historic or current water quality monitoring.

Table 29. Percent of samples collected in the Lower Big Blue River Watershed which measured outside of target values in historically collected samples.

Subwatershed	Turbidity	Nitrate	Total P	TSS	Ecoli
Headwaters Six Mile Creek	0%	No samples	No samples	No samples	0%
Anthony Creek-Six Mile Creek	14%	71%	63%	25%	71%
Nameless Creek	13%	No samples	No samples	No samples	64%
Prairie Branch-Big Blue River	56%	100%	100%	50%	82%
Foreman Branch-Big Blue River	70%	100%	50%	No samples	56%
DePrez Ditch-Big Blue River	44%	100%	100%	83%	27%
Shaw Ditch-Big Blue River	39%	97%	86%	47%	82%

5.2 Stakeholder Concern Analysis

All of the identified concerns generated both from stakeholder input and through water quality and watershed inventory efforts are detailed in Table 30. This list represents a work in progress and additional concerns may be added as the steering and monitoring committees work through data analysis. The steering committee rated each concern as to whether it is supported by watershed-based data, what evidence does or does not support the concern, whether the concern is quantifiable, whether it is in the scope of the watershed management plan, and if it is something on which the committee wants to focus. Nearly all concerns were quantifiable and many were rated as being within the scope and items on which the committee wants to focus. Additionally, several items the committee deemed outside the scope for implementation purposes were deemed to be inside the scope for educational purposes.

More than 32 miles of streams possessed limited buffers, nearly 153.6 miles of streambank were eroded, and livestock had access to nearly 11.6 miles of streams. Additionally, 5 dumping areas and 26 miles of gully erosion were identified.

Table 30. Analysis of stakeholder concerns identified in the Lower Big Blue River Watershed.

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Reduce wetland loss	Yes	Wetlands cover 4,435 acres (4%) of the watershed. Hydric soils data suggest wetlands historically covered 27,405 acres (24%). This represents an 84% reduction in wetland acres.	Yes	Yes	Yes, education only
Future funding opportunities for septic repair cost-share	Yes	There is limited availability of septic system funding in Indiana.	No	Yes	No

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Reduce soil loss	Yes	26 miles of gully erosion and 32 miles of narrow stream buffers were noted during the windshield survey. Turbidity levels are elevated within LBBR streams indicating soil loss is occurring. 41% of historic samples include TSS concentrations in excess of targets while 33% of current samples contain elevated turbidities.	Yes	No	Yes
Poor water quality: elevated sediment, nutrient and pathogen concentrations	Yes	Historic data collected by IDEM indicate that phosphorus samples exceed targets in 63% of samples, while nitrate samples exceed targets in 70% of samples and sediment samples exceed targets in 41% of samples. Pathogen concentrations exceed targets in 65% of samples. During the current assessment, 43% of orthoP, 64% of nitrate and 44% of E.coli samples exceed targets or state standards.	Yes	No	Yes
Quality of water used for recreation	Yes	89% of LBBR Watershed stream miles are impaired for recreational contact.	Yes	No	Yes
Other potential water quality issues—PCB in Fish Tissue	Yes	15% of LBBR Watershed stream mils are impaired for PCBs.	Yes	Yes	Yes, education only

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Public Education needed: water quality, BMPs, pollution	Yes	Anecdotal evidence based on communication with stakeholders.	Yes	No	Yes
Septic system maintenance or replacement of failing systems	No	Nearly 98% of watershed soils are rated as very limited for septic tank absorption field use. The health departments suggest that septic system maintenance is an issue but data are not available.	No	Yes	Yes, education
Bank stabilization is needed	Yes	A windshield survey data indicate 153.6 miles of streambank stabilization is needed. Highly erodible soils and potentially highly erodible soils cover approximately 18% of the LBBR watershed.	Yes	No	Yes
Sedimentation - agricultural BMP installation is needed to address sediment concerns	Yes	78% of the watershed is covered by row crop agriculture. No till/conservation till data suggest that more than 70% of each watershed county utilized these practices. Data are not available for other conservation practices.	Yes	No	Yes
Manure from livestock and confined feeding operations	Yes	CFO facilities house more than 18,000 hogs which produce more than 75,000 tons of manure annually. Small livestock operations have not been inventoried but are anticipated to increase the total volume of manure produced in the watershed.	Yes	No, small farm only	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Livestock exclusion from waters	Yes	Livestock have access to more than 11.6 miles of stream; photo evidence documents livestock in LBBR watershed streams.	Yes	No	Yes
Reliable water sampling data	Yes	IDEM, USGS and Hoosier Riverwatch volunteers sampled sporadically in the past. In 2018, monthly water quality samples were collected.	Yes	No	Yes, additional engagement of volunteers in needed
Public presence: First Fridays (monthly event in Shelbyville) county fairs, county board meetings, etc.	Yes	There are opportunities to present information about the LBBR Watershed project.	Yes	No	Yes
Lowhead dam – Thompson Mill Dam (Big Blue River confluence with the White River) proposed for removal due to hazard concerns	Yes	Thompson Mill Dam is present on the BBR and removal has been discussed.	Yes	No	Yes, education only
Irrigation impacts to groundwater	Yes	Indiana Chamber of Commerce data (2014) suggest that irrigation continues to increase in Shelby County with nearly 600 MG/Mon. currently used. Irrigation accounts for 75% of groundwater use.	Yes	Yes	No
Roadside ditch maintenance—several areas pool and become stagnant, then wash to river	Yes	Anecdotal evidence indicates that flooding of county roads occurs within the watershed. Beaver dams have not been observed	Yes	Yes	No

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Preservation of natural resources	Yes	Nearly 8% of the LBBR is mapped in forest or wetland uses.	Yes	No	Yes, education only
Flooding along the Big Blue River	Yes	USGS Flood Inundation maps suggest that flooding of Shelbyville occurs when the Big Blue reaches 9 ft, with flooding at 19.3 ft, water to a depth of 22 ft could cover more than 70% of Shelbyville.	Yes	No	No
Trash and illegal dumping	Yes	Anecdotal evidence indicates trash is an issue in the LBBR Watershed. Box springs, tires and general trash was observed throughout the watershed during the inventory effort.	Yes but it hasn't been quantified	No	Yes

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 for implementation purposes but inside the scope for educational programming: reducing wetland loss, PCBs in fish tissue, septic maintenance or replacement (education only). Additionally, future funding for septic area repair/replacement, manure from confined feeding operations, impacts from irrigation, and legal drain maintenance along county roads were identified as outside the scope of the project. Therefore, these concerns will not be addressed in this watershed management plan. The steering committee determined that flooding concerns were beyond their role and noted that many of the practices which would be suggested would address flooding indirectly.

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 31. Problems represent the condition that exists due to a particular concern or group of concerns. Table 32 details potential causes of problems identified in Table 31.

.

Table 31. Problems identified for the Lower Big Blue River Watershed based on stakeholder and inventory concerns.

Concern(s)	Problem
• Bank stabilization is needed • Sedimentation – agricultural BMP installation is needed to address sediment concerns • Reduce soil loss • Poor water quality, elevated sediment, nutrient and pathogen concentrations • Livestock exclusion from waters	Area streams are very cloudy and turbid
• Poor water quality, elevated sediment, nutrient and pathogen concentrations • Reliable water sampling data are needed • Quality of water for recreation • Manure from livestock and confined feeding operations • Livestock exclusion from waters	Area streams are impaired for recreational contact by IDEM's 303(d) list (high *E. coli*)
• Sedimentation – agricultural BMP installation is needed to address sediment concerns • Reduce soil loss • Poor water quality, elevated sediment, nutrient and pathogen concentrations • Bank stabilization is needed • Reliable water sampling data are needed • Manure from livestock and confined feeding operations • Livestock exclusion from waters	Area streams have nutrient levels exceeding the target set by this project
• Public Education needed: water quality, BMPs, pollution • Public presence: First Fridays (monthly event in Shelbyville) county fairs, county board meetings, etc. • Lowhead dam – Thompson Mill Dam (Big Blue River confluence with the White River) proposed for removal due to hazard concerns • Other potential water quality concerns – PCBs in fish • Septic maintenance • Reduce wetland loss • Preservation of natural resources • Trash and illegal dumping	A unified education program for entire watershed does not currently exist

Table 32. Potential causes of identified problems in the Lower Big Blue River Watershed.

Problem	Potential Cause(s)
Area streams are very cloudy and turbid	Total Suspended Sediment concentrations and turbidity levels exceed the targets set by this project
Area streams have nutrient levels exceeding the targets set by this project	Nutrient levels exceed the target set by this project
Areas streams are impaired by IDEM for recreational contact	*E. coli* levels exceed the water quality standard
A unified education program for entire watershed does not currently exist	Educational efforts targeting funders, local agencies, and the public are lacking.

7.0 SOURCE IDENTIFICATION AND LOAD CALCULATION

7.1 Source Identification: Key Pollutants of Concern

Nonpoint pollution sources are varied, yet common throughout almost any watershed. Several earlier sections of this document identify potential sources of the pollutants of concern in the Lower Big 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 Lower Big Blue River Watershed for each of our concerns is listed below:

Nutrients (Nitrogen and Phosphorus):

- Conventional tillage cropping practice
- Wastewater treatment discharges
- Gully or ephemeral erosion
- Agricultural and residential fertilizer
- Poor riparian buffers
- Poor forest management
- Streambank and bed erosion
- Animal waste (livestock in streams, poor manure management, domestic and wildlife runoff)
- Confined feeding operations
- Human waste (failing septic systems, package plants, inadequately treated wastewater)
- Stormwater and flooding impacts

Sediment:

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

E. coli:

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

7.1.1 Potential Sources of Pollution

The steering committee used GIS data, water quality data, watershed inventory observations and anecdotal information as available to evaluate the potential sources of nonpoint pollution in the Lower Big Blue River Watershed. Table 33 through Table 36 summarizes the magnitude of potential sources of pollution for each problem identified in the Lower Big Blue River Watershed.

Table 33. Potential sources causing nutrient problems.

Problems:	Nutrient levels exceed the target set by this project
Potential Causes:	Nutrient concentrations exceed target values set by this project.
Potential Sources:	• 30,624 linear feet of streams were observed with livestock access. The highest percent of stream miles accessed by livestock were found in the Anthony Creek – Six Mile Creek (7%) and Foreman Branch – Big Blue River (5%) subwatersheds. • 114 unregulated animal operations were observed housing nearly 1,142 animals throughout the watershed. The highest number of operations was observed in the Headwaters Six Mile Creek (22) and Shaw Ditch-Big Blue River (19) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • 16.0 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in DePrez Ditch-Big Blue River (12%) and Foreman Branch-Big Blue River (10%) subwatersheds. • 19.0 miles of fields exhibit active gully erosion. • 76.6 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization were found in the Prairie Branch-Big Blue River (46%) and Foreman Branch-Big Blue River (41%) subwatersheds. • Manure from confined feeding operations is applied in the Anthony Creek-Six Mile Creek, DePrez Ditch-Big Blue River, and Nameless Creek subwatersheds. • Manure from small animal operations is applied across the watershed with more than 96,600 tons produced annually. More than 238,697 lb of N and 177,466 lb of P are delivered annually with this manure. • Failing septic systems add nutrients to the system within the rural portion of the watershed. • 3.66 square miles of MS4 entities lie within the watershed. • Between 2 and 30% of crop land is conventionally tilled in Lower Big Blue River Watershed counties. • 54.5 miles of urban pipe carry stormwater within developed portions of the watershed from the Shelbyville MS4.

Table 34. Potential sources causing sediment problems.

Problems:	Total Suspended Sediment concentrations and turbidity levels exceed the targets set by this project
Potential Causes:	Suspended sediments and/or turbidity exceed target values set by this project.
Potential Sources:	• 30,624 linear feet of streams were observed with livestock access. The highest percent of stream miles accessed by livestock were found in the Anthony Creek – Six Mile Creek (7%) and Foreman Branch – Big Blue River (5%) subwatersheds. • 16.0 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in DePrez Ditch-Big Blue River (12%) and Foreman Branch-Big Blue River (10%) subwatersheds. • 19.0 miles of fields exhibit active gully erosion. • 3-30% of agricultural fields in Hancock, Henry, Johnson, Rush and Shelby Counties are under conventional tillage. • 76.6 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization were found in the Prairie Branch-Big Blue River (46%) and Foreman Branch-Big Blue River (41%) subwatersheds. • 114 unregulated animal operations were observed housing nearly 1,142 animals throughout the watershed. The highest number of operations was observed in the Headwaters Six Mile Creek (22) and Shaw Ditch-Big Blue River (19) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • 11,037 acres of agricultural land are located on highly erodible soils while 10,573 acres of agricultural land are located on potentially highly erodible soils. The highest density of HES and PHES occur in Anthony Creek – Six Mile Creek (22% HES, 8% PHES) subwatershed. • 54.5 miles of urban pipe carry stormwater within developed portions of the watershed from the Shelbyville MS4. • Between 2 and 30% of crop land is conventionally tilled in Lower Big Blue River Watershed counties.

Table 35. Potential sources causing *E. coli* problems.

Problems:	*E.coli* levels exceed the water quality standard
Potential Causes:	*E. coli* concentrations exceed target values and the state standard.
Potential Sources:	• 30,624 linear feet of streams were observed with livestock access. The highest percent of stream miles accessed by livestock were found in the Anthony Creek – Six Mile Creek (7%) and Foreman Branch – Big Blue River (5%) subwatersheds. • 114 unregulated animal operations were observed housing nearly 1,142 animals throughout the watershed. The highest number of operations was observed in the Headwaters Six Mile Creek (22) and Shaw Ditch-Big Blue River (19) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • Manure from confined feeding operations is applied in the Anthony Creek-Six Mile Creek, DePrez Ditch-Big Blue River, and Nameless Creek subwatersheds. • Failing septic systems contribute *E. coli* to the system within the rural portion of the watershed and in areas of dense unsewered housing. • Manure from small animal operations is applied across the watershed with more than 96,600 tons produced annually. More than 238,697 lb of N and 177,466 lb of P are delivered annually with this manure. • 3.66 square miles of MS4 entities lie within the watershed. • 54.5 miles of urban pipe carry stormwater within developed portions of the watershed from the Shelbyville MS4.

Table 36. Potential sources causing education problems.

Problems:	Educational efforts targeting funders, local agencies, and the public are lacking.
Potential Causes:	Educational efforts targeting funders, local agencies, and the public are lacking.
Potential Sources:	N/A

7.2 Load Estimates

Nonpoint source pollution is generated from diffuse sources found on public and private lands. The USEPA notes that sources of nonpoint source pollution include stormwater runoff, construction activities, solid waste disposal, atmospheric deposition, streambank erosion, and more. Inventory data in Table 33 through Table 36 identify potential sources of nonpoint pollution within the watershed. These tables – generated using GIS, water quality data, windshield surveys, local knowledge, and other sources of data – are useful for generally identifying water quality problems. Two methods could be used to understand the loading of nutrients, sediment, and pathogens in waterbodies in the Lower Big Blue River Watershed: 1) measured results from the monitoring regime and 2) modeled results. Each method can estimate both the current load and the reduction in load needed to reach target concentrations. These methods each present advantages and disadvantages for understanding the loading in this watershed in particular. The steering committee considered the monitoring data to draft long term goals and critical areas. These data were used to calculate final goals and set long term goals, short term goals, and critical areas.

Results from monitoring data can be used to estimate loads of nonpoint source pollution. Concentrations of nutrients, sediments, and pathogens taken at sampling sites can be combined with flow data to estimate the current loads in those waterbodies. Target loads for those waterbodies can also be calculated using available flow data. As discussed above, thirteen locations were sampled from November 2017 through October 2018 using Hoosier Riverwatch methods. *E. coli* was collected five times over 30 days during two sampling periods, which occurred 20 September through 24 October 2017 and 10 September through 17 October 2018. While there is clear value in using these measurements from the Lower Big Blue River Watershed to identify problem areas, the sample parameters will not allow for calculation of total phosphorus or total suspended solids loading rates as neither parameter was collected as part of this assessment.

7.2.1 Current Load Estimates

Based on the limitation of monthly sample data, L-THIA was initially utilized to calculate the estimated loading for nitrate-nitrogen, total phosphorus, and total suspended solids; however, the steering committee felt those results did not accurately portray the sediment loading of the waterway from streambank erosion and other sources. Instead, load duration curves were selected as the best option for estimating load reductions. This method uses approximate flow data from the closest USGS gage (Big Blue River near Shelbyville USGS 03361500). Since this gage includes the entire drainage of the Big Blue River to Shelbyville, watershed drainage was scaled to remove drainage from the Upper Big Blue River and the Little Blue River watersheds. The stream flow was scaled from the drainage at Shelbyville to include the entire drainage area of the Lower Big Blue River Watershed. Data collected from the IDEM fixed station at Edinburgh was used for nitrate-nitrogen, total phosphorus and total suspended solids load calculations. IDEM collects data at this fixed station monthly for these parameters. The scaled instream flow data were combined with IDEM fixed station grab sample data were used to create load duration curves. These curves represent the current loading rate for each parameter for the entire watershed.

7.2.2 Load Duration Curves Load Reductions

Load duration curves allows for comparison of instream loading with stream flow so that conditions of concern can be identified. The load duration curves present the flow characteristics for the entire Lower Big Blue River drainage during the time of study from January to December 2018. Data used for the curves were calculated by scaling flow measured at Big Blue River stream gage near Shelbyville, Indiana and used the monthly data collected by IDEM as part of their fixed station monitoring network.

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 45). In the graphs, the total daily load of each contaminant sample result (points) is plotted against the "percent time flow is exceeded" for the day of sampling (curve). Those points above the curve exceed the state criterion or target concentration. Values on a load duration curve can be grouped by hydrologic condition to help identify possible sources and conditions that result in the material being present in the system under those flow conditions. Most often, the flow ranges fall in High (0 to 10), Moist (10-40), Mid-Range (40-60), Dry (60-90), and Low (90-100). Exceedances falling in the moist range (10-40) are typically associated surface runoff or stormwater loads, while exceedances associated with the dry zone are most often associated with dry conditions. These exceedances are suggested to result from point sources that are the most likely source. The curves shown in Figure 45 represent the current loading rate for each parameter calculated for the entire Lower Big Blue River drainage.

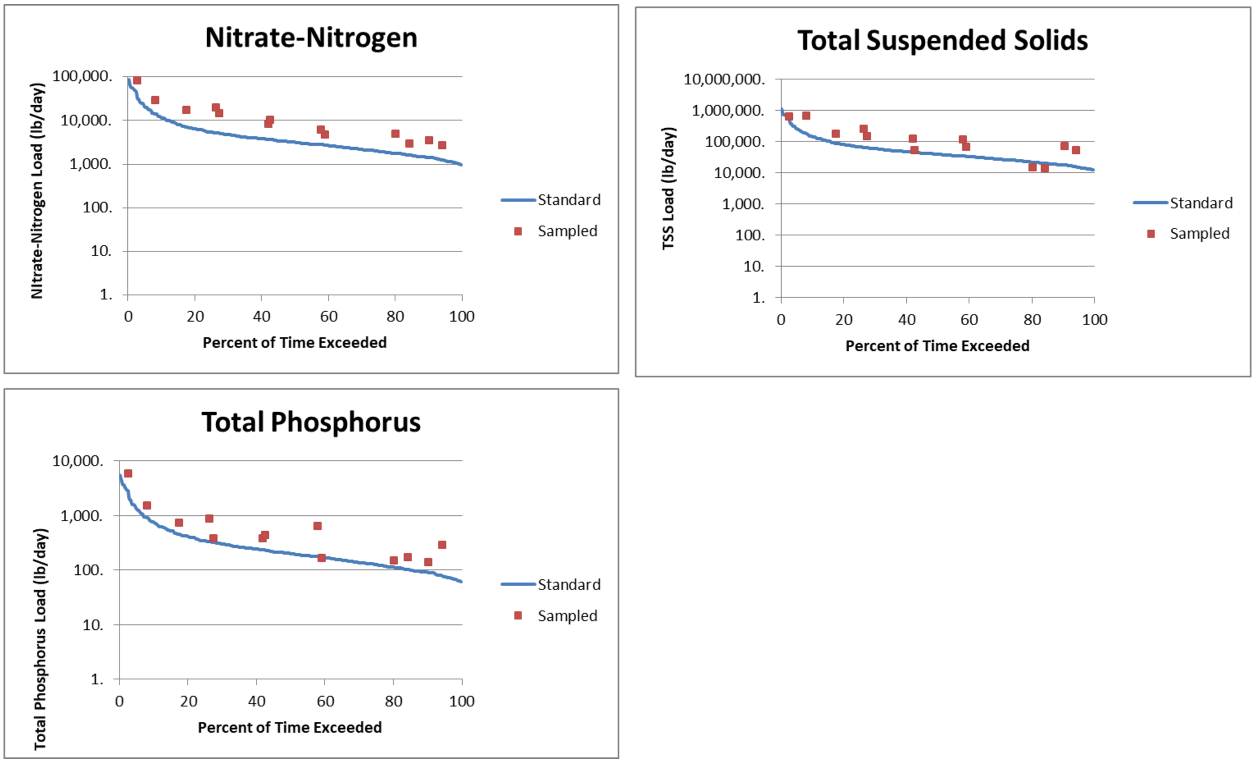

Figure 45. Nitrate-Nitrogen, Total Phosphorus and Total Suspended Solids load duration curves.

7.2.3 Load Reductions

As discussed in Section 3.3 the steering committee selected water quality benchmarks for nitrate-nitrogen, total phosphorus, and total suspended solids that will significantly improve water quality in Lower Big Blue River (Table 12). Target loads needed to meet these benchmarks were calculated for the entire watershed for each parameter. IDEM fixed station data was used to calculate annual loading rates and load reductions. The current loading rate was calculated using the load duration curves detailed above. Concentration data collected monthly at the fixed station was multiplied by the representative days between sampling events (typically 30 days) and then by the average flow during that period of time. Load reduction targets were calculated using the water quality targets selected by the steering committee for each parameter. These targets were multiplied by the same scaled average continuous flow data used to calculate current loading rates and the number of days between sampling events. All calculations are in lb/year and are shown as percent of the current load (Table 37). Appendix C details the load duration curve and load reduction calculations.

Table 37. Estimated load reductions needed to meet water quality target concentrations in the Lower Big Blue River Watershed.

	Current Load (lb/year)	Reduction Needed (lb/year)	Target Load (lb/year)	Percent Reduction
Nitrate-nitrogen	2,630,265	1,721,527	908,738	65%
Total phosphorus	147,680	90,127	57,553	61%
Total suspended solids	31,857,512	20,498,281	11,359,230	64%

Additionally, the Lower Big Blue River *E. coli* TMDL was used to confirm *E. coli* reductions needed in the Lower Big Blue River Watershed. The required *E. coli* load reduction was determined using the TMDL for each 12-digit HUC within the LBBR Watershed (IDEM, 2014). The TMDL states that between a 0 and 63% reduction in *E. coli* geometric mean concentration (col/100 mL) is needed in order to achieve the state water quality standard, while between a 0 and 93% reduction is needed (billion/day) to achieve loading targets (Table 38).

Table 38. Estimated *E. coli* load reductions needed to meet water quality target concentrations in the Lower Big Blue River Watershed.

Subwatershed	Current Geomean (col/100 mL)	Target Geomean (col/100 mL)	% Reduction Based on Geomean	Load Reduction (bil MPN/day	Percent Load Reduction (bil/day)
Anthony Creek-Six Mile Creek	380.65	125	62.5%	7.73	64.7%
DePrez Ditch-Big Blue River	130.92	125	4.5%	42.76	93.2%
Foreman Branch-Big Blue River	191.56	125	34.8%	N/A	0%
Headwaters Six Mile Creek	30.16	125	0%	N/A	0%
Nameless Creek	>460.27	125	72.8%	4.39	72.8%
Prairie Branch-Big Blue River	281.24	125	55.6%	22.43	51.6%
Shaw Ditch-Big Blue River	114.21	125	0%	N/A	0%

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 D. The steering committee divided into teams to review subwatershed data and develop 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. Teams presented their suggested criteria for each parameter to the entire steering committee and the steering committee reviewed, modified, if needed, and finalized criteria for each parameter. Each parameter's criterion is detailed in subsequent sections. Each subwatershed was scored based on the total number of criteria that were met (1=yes, 0=no) and the subwatersheds with the highest scores were prioritized as critical areas for each parameter.

8.1 Critical Areas for Nitrate-Nitrogen and Total Phosphorus

Nitrate-nitrogen was the nitrogen form used to determine our critical areas. Total phosphorus was the form of phosphorus used to determine phosphorus critical areas (Figure 46). Nitrate-nitrogen and total phosphorus are readily available in the Lower Big Blue River Watershed, entering surface water via;

human and animal waste, fertilizer use, and tile drains on agricultural lands. Phosphorus enters the Lower Big Blue River watershed through streambank and bed erosion, unfiltered runoff, agricultural land use in floodplains, stormwater runoff, and livestock access. Based on the data reviewed by the steering committee, the following criteria were priorities for nutrient critical areas:

- Narrow buffers greater than 5% of stream miles
- Gully erosion 5% or higher
- Nitrate and TP current data – average more than 50% exceedance between the two
- HES that exceeds 15% of the subwatershed

Critical subwatersheds were determined as follows: Anthony Creek-Six Mile Creek, Foreman Branch-Big Blue River, Nameless Creek, Prairie Branch-Big Blue River, and Shaw Ditch-Big Blue River

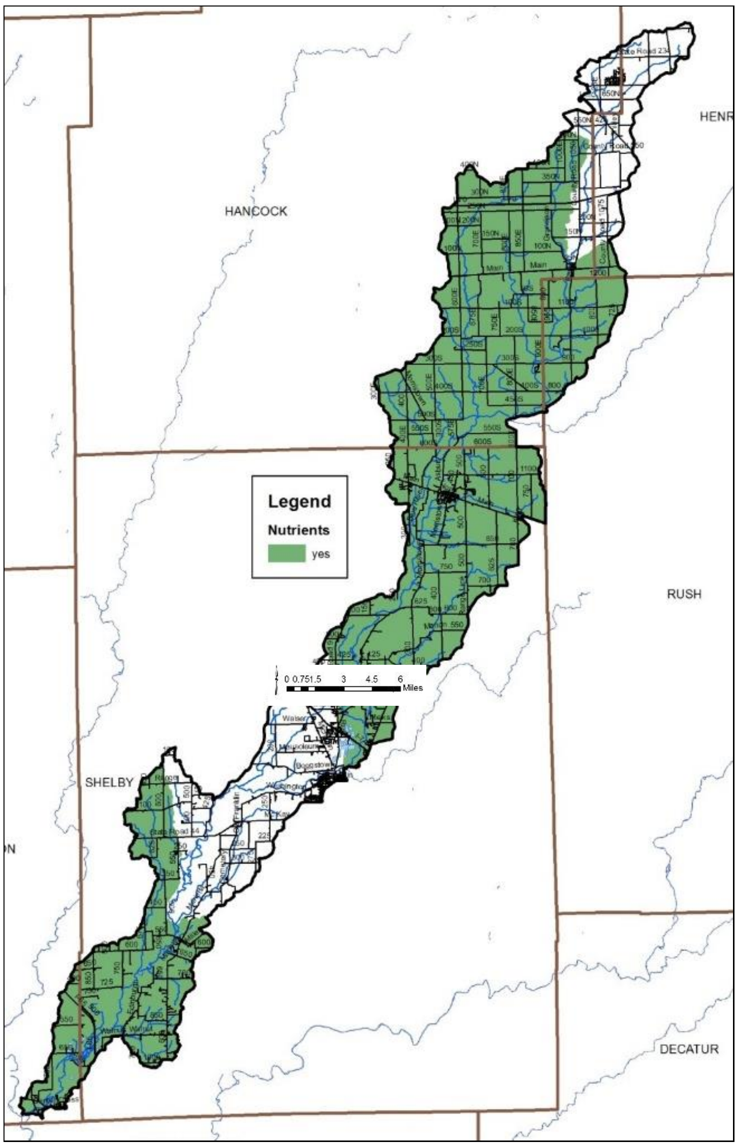

Figure 46. Critical areas for nutrients in the Lower Big Blue River Watershed.

8.2 Critical Areas for Sediment

Total suspended solids concentrations were used to determine sediment-based critical areas (Figure 47). Total suspended solids enter streams in Lower Big Blue River through streambank and bed erosion, unfiltered runoff, agricultural land use in floodplains, stormwater runoff, and livestock access. Based on the data reviewed by the steering committee, the following targets were priorities for sediment critical areas:

- Water quality data: current or historic turbidity exceeding 25% of samples, historic TSS exceeding 25% of samples
- HES that exceeds 15% of the subwatershed
- Streambank erosion 30% of miles or more
- Gully erosion 5% or higher
- Highest loading rates by subwatershed based on L-THIA estimates.

Critical subwatersheds were determined as follows: Anthony Creek, Foreman Branch-Big Blue River, Nameless Creek, and Prairie Branch-Big Blue River.

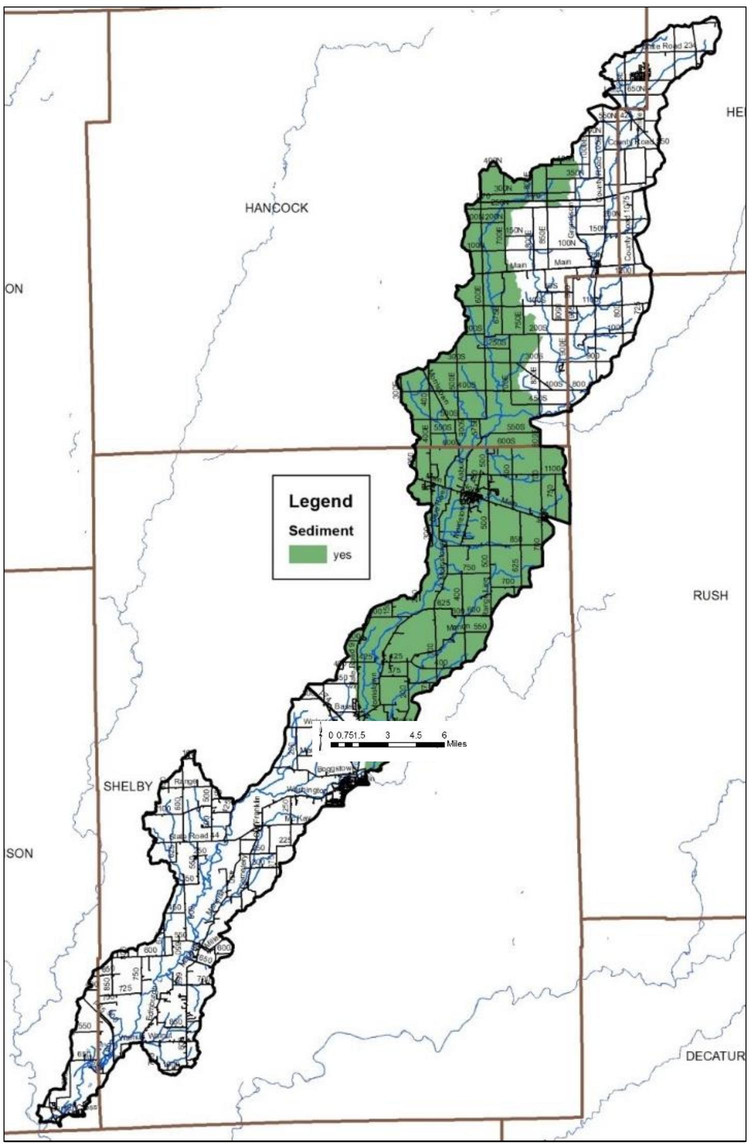

Figure 47. Critical areas for sediment in the Lower Big Blue River Watershed.

8.3 Critical Areas for *E. coli*

E. coli concentrations were used to determine *E. coli*-based critical areas (Figure 48). *E. coli* enters streams in the Lower Big Blue River Watershed through human and animal waste, livestock access, and infrastructure issues. Additional areas of concern, such as areas with manure management issues or failing septic systems, may also be included. Parks along the Lower Big Blue River were discussed as a source of *E. coli* including the potential new dog park being build adjacent to the Big Blue River. These include Kennedy Park and Sunset Park, as well as Big Blue Park, which connects to the Shelby County Fairgrounds. As these parks could not be quantified, they were not included on the list of criteria for inclusion in the *E. coli* critical area determination. Stormwater was deemed to not be a concern for pathogens. Based on the data reviewed by the steering committee, the following targets were priorities for *E. coli* critical areas:

- % exceedance for both current and historic data – any subwatershed exceeding in 40% of samples
- Impaired water body miles for *E. coli* measuring 90% or higher
- Livestock access measuring 0.5 mile or longer
- E. coli load reductions greater than 30% by loading calculation from the Big Blue River TMDL

Critical subwatersheds were determined as follows: Anthony Creek-Six Mile Creek, Nameless Creek, Foreman Branch-Big Blue River, and Prairie Branch-Big Blue River.

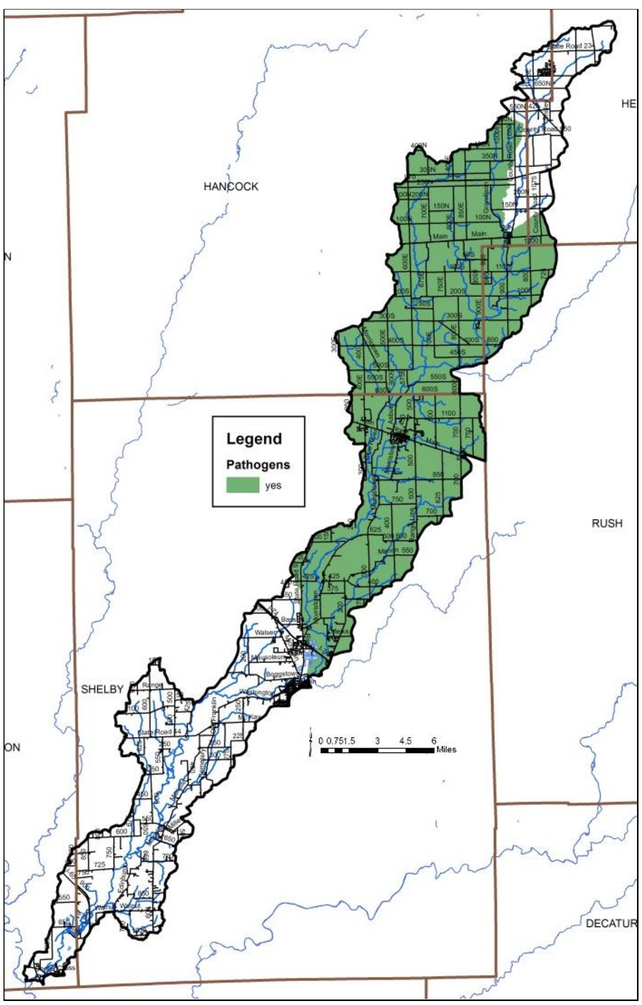

Figure 48. Critical areas for *E. coli* in the Lower Big Blue River Watershed.

8.4 Critical Areas Summary

The subwatersheds identified as critical areas for each parameter are summarized in Figure 49. 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 parameters of the three potential parameters (nutrients, sediment and *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. As there were not any subwatersheds prioritized for two of three parameters, low priority subwatersheds were moved to medium priority levels (Shaw Ditch-Big Blue River; Figure 49). The steering committee discussed the large area of the Lower Big Blue River Watershed that was not prioritized and identified the large density of individuals present in the DePrez Ditch-Big Blue River Subwatershed as a target population for education and outreach, engagement with the Big Blue River and the potential to impact water quality in both urban and agricultural areas of the subwatershed. Based on the potential to target these individuals as well as urban best management practices, DePrez Ditch-Big Blue River subwatershed was added as a low priority. Critical area priorities are as follows:

- High Priority: Nameless Creek, Anthony Creek-Six Mile Creek, Prairie Branch-Big Blue River, and Foreman Branch-Big Blue River
- Medium Priority: Shaw Ditch-Big Blue River
- Low Priority: DePrez Ditch-Big Blue River
- Not prioritized: Headwaters Six Mile Creek

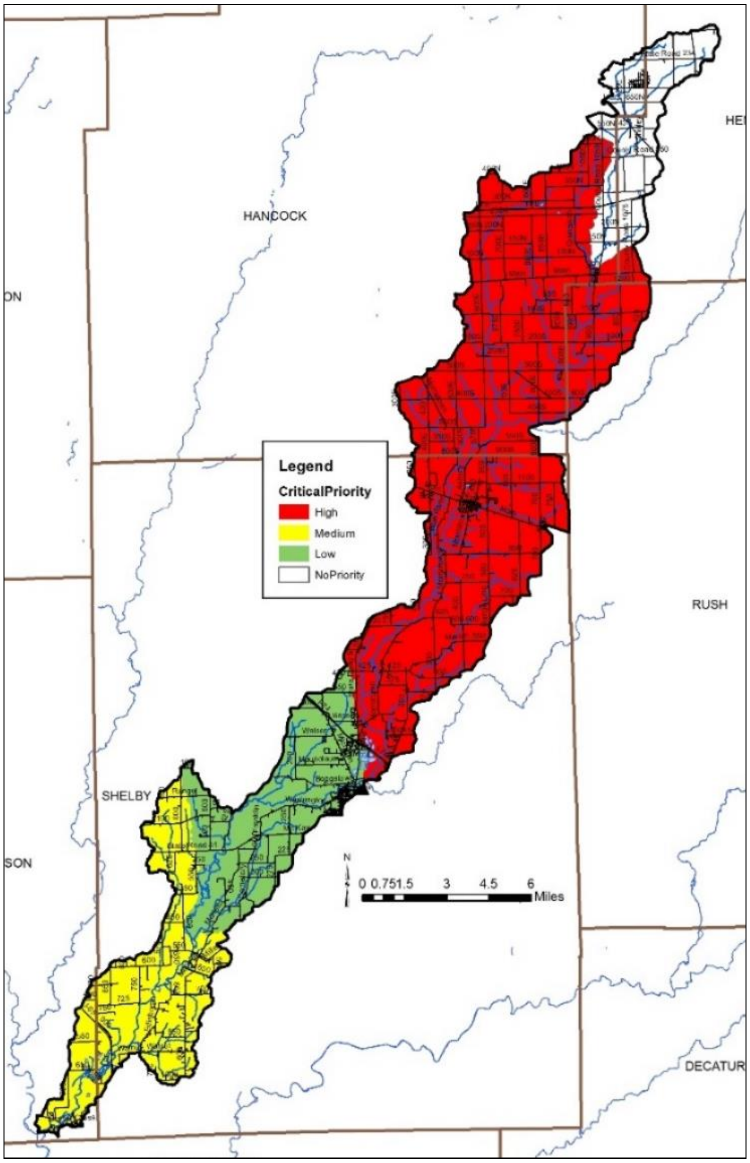

Figure 49. Prioritized critical areas in the Lower Big Blue River Watershed.

9.0 GOAL SETTING

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

9.1 Goal Statements

The steering committee wrote goals for each parameter or area of concern based on a goal of meeting the target concentrations identified by the committee. In an effort to scale goals to manageable levels, a thirty-year timeframe was used for most goals. Short term (10 year goals), medium term goals (20 years) and long term (30 year goals) were generated. Each 10 year time period targets a 30% reduction in loading across all parameters. The steering committee anticipates targeting high priority critical areas (Nameless Creek, Anthony Creek-Six Mile Creek, Prairie Branch-Big Blue River and Foreman Branch-Big Blue River) first, then moving on to address medium priority critical areas (Shaw Ditch-Big Blue River), then on to low priority critical areas (Deprez Ditch-Big Blue River). Based on load reduction calculations, it is anticipated that implementation within the high priority critical areas will meet short term and medium term goals for nutrients and sediment, while implementation targeting medium and low priority critical areas will generate sufficient load reductions to meet long term sediment and nutrient goals. E. coli reductions will target meeting short term goals of individual grab sample targets within high priority critical areas, then targeting individual grab sample targets within low priority critical areas (medium term), and finally reducing E. coli concentrations to meet Big Blue River TMDL targets throughout the watershed to meet the long term goal. Note that the medium priority critical area (Shaw Ditch-Big Blue River) does not require an E. coli reduction according to the TMDL.

Reduce Nutrient Loading

Based on IDEM fixed station water quality data and USGS stream gage data collected, the committee set the following goals for nitrate-nitrogen and total phosphorus (Table 39 and Table 40).

Short Term, 10-Year Goal: Reduce nitrate-nitrogen from 2,630,265 pounds per year to 2,056,423 pounds per year (22% reduction) and phosphorus from 147,680 pounds per year to 117,638 pounds per year (20% reduction) in the Lower Big Blue River Watershed.

Medium Term, 20-Year Goal: Reduce nitrate-nitrogen from 2,056,423 pounds per year to 1,482,580 pounds per year (28% reduction) and phosphorus from 117,638 pounds per year to 87,595 pounds per year (26% reduction) in the Lower Big Blue River Watershed.

Long Term, 30-Year Goal: Reduce nitrate-nitrogen from 1,482,580 pounds per year to 908,738 pounds per year (39% reduction) and phosphorus from 87,595 pounds per year to 57,553 pounds per year (34% reduction) in the Lower Big Blue River Watershed.

Table 39. Nitrate-nitrogen goal calculations for Lower Big Blue River Watershed.

	Current/Starting Load (lb/year)	Target Load (lb/year)	Reduction Needed (lb/year)	Percent Reduction	Cumulative Percent Reduction
Short term – 10 year goal	2,630,265	2,056,423	573,842	22%	
Medium term – 20 year goal	2,056,423	1,482,580	573,842	28%	
Long term – 30 year goal	1,482,580	908,738	573,842	39%	65%

Table 40. Total phosphorus goal calculations for LLBR Watershed.

	Current/Starting Load (lb/year)	Target Load (lb/year)	Reduction Needed (lb/year)	Percent Reduction	Cumulative Percent Reduction
Short term – 10 year goal	147,680	117,638	30,042	20%	
Medium term – 20 year goal	117,638	87,595	30,042	26%	
Long term – 30 year goal	87,595	57,553	30,042	34%	61%

Reduce Sediment Loading

Based on collected water quality data collected, the committee set the following goals for total suspended solids (Table 41).

Short term, 10-Year Goal: Reduce total suspended solids from 31,857,512 pounds per year to 25,024,751 pounds per year (21% reduction) in the Lower Big Blue River Watershed.

Medium term, 20-Year Goal: Reduce total suspended solids from 25,024,751pounds per year to 18,191,990 pounds per year (27% reduction) in the Lower Big Blue River Watershed.

Long term, 30-Year Goal: Reduce total suspended solids from 18,191,990 pounds per year to 11,359,230 pounds per year (38% reduction) in the Lower Big Blue River Watershed.

Table 41. Total Suspended Solids goal calculations for LLBR Watershed.

	Current/Starting Load (lb/year)	Target Load (lb/year)	Reduction Needed (lb/year)	Percent Reduction	Cumulative Percent Reduction
Short term – 10 year goal	31,857,512	25,024,751	6,832,760	21%	
Medium term – 20 year goal	25,024,751	18,191,990	6,832,760	27%	
Long term – 30 year goal	18,191,990	11,359,230	6,832,760	38%	64%

Reduce *E. coli* Loading

Based on collected water quality data collected, the committee elected to pursue the same type of goals for pathogens as the other pollutant sources. The committee set the following goals for *E. coli* (Table 42). The table provides the targeted percent reduction for each subwatershed.

Short term, 10-Year Goal: Reduce *E. coli* concentrations to meet individual grab sample Indiana state standards (235 col/100 ml) in high priority subwatersheds: Nameless Creek, Anthony Creek-Six Mile Creek, and Prairie Branch-Big Blue River.

Medium term, 20-Year Goal: Reduce *E. coli* concentrations to meet individual grab sample Indiana state standards (235 col/100 ml) in low priority watersheds where E. coli reductions are needed per the Big Blue River TMDL: DePrez Ditch-Big Blue River. Note the medium priority critical area (Shaw Ditch-Big Blue River) does not require and E. coli reduction per the Big Blue River TMDL.

Long term, 30-Year Goal: Reduce *E. coli* concentrations to current state standards (125 CFU/100 mL) in the Lower Big Blue River Watershed such that the Anthony Creek-Six Mile Creek, DePrez Ditch-Big Blue River, Nameless Creek and Prairie Branch-Big Blue River Subwatersheds meet the Big Blue River TMDL load reductions (Table 42).

Table 42. *E. coli* goal calculations for LBBR Subwatersheds.

Subwatershed	Current Geomean (col/100 mL)	Target Geomean (col/100 mL)	Percent Reduction Based on Geomean	Percent Load Reduction (bil/day)
Anthony Creek-Six Mile Creek	380.65	125	62.5%	64.7%
DePrez Ditch-Big Blue River	130.92	125	4.5%	93.2%
Foreman Branch-Big Blue River	191.56	125	34.8%	0%
Headwaters Six Mile Creek	30.16	125	0%	0%
Nameless Creek	>460.27	125	72.8%	72.8%
Prairie Branch-Big Blue River	281.24	125	55.6%	51.6%
Shaw Ditch-Big Blue River	114.21	125	0%	0%

Increase Public Awareness and Participation

Long term: Increase public awareness and knowledge about the Lower Big Blue River and what individuals and communities can do to improve the quality of these waterways by 2040 (20 years).

10.0 IMPROVEMENT MEASURE SELECTION

A wide variety of practices are available for on-the-ground implementation to reduce sediment, nutrient, and *E. coli* loading within the Lower Big 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 Lower Big Blue River steering committee. Committee members reviewed potential practices taking into account the identified resource concerns, watershed land uses, and Lower Big 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 Lower Big 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 Lower Big 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 Big Blue River water quality. Selected practices are appropriate for all critical areas since they all contain agriculture land use and pasture, and crop resource concerns were identified in all subwatersheds. Urban practices selected are likely more appropriate for the DePrez Ditch-Big Blue River subwatershed, which is more urban in nature. Selected practices with descriptions are listed below.

Potential best management practices include the following:

Bioreactor
Bioretention
Composting Facility
Conservation Tillage
Cover Crop/Critical Area Planting/Conservation Cover
Drainage Water Management
Fencing
Field Border/Buffer Strip
Forage/Biomass Planting
Grade Stabilization Structure
Grassed Waterway/Mulching/Subsurface Drain
Greenways and Trails
Heavy Use Protection Area
Infrastructure Retrofit
Lined Waterway/Outlet
Livestock Restriction/Prescribed Grazing
Manure Management Planning
Nutrient/Pest Management
Pervious Pavement
Rain Barrel
Rain Garden
Saturated Buffer
Septic System Care/Maintenance
Streambank Stabilization
T&E Species Protection (Habitat Improvement)
Tree/Shrub Establishment
Two Stage Ditch
Waste Storage Facility
Water and Sediment Control Basin

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

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

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

Conservation Tillage (No-till)
Conservation tillage refers to several different tillage methods or systems that leave at least 30% of the soil covered with crop residue after planting (Holdren et al., 2001). Tillage methods encompassed by conservation tillage include no-till, mulch-till, ridge-till, and strip till. The purpose of conservation tillage is to reduce sheet and rill erosion, maintain or improve soil organic matter content, conserve soil moisture, increase available moisture, reduce plant damage, and provide habitat and cover for wildlife. The remaining crop residue helps reduce soil erosion and runoff volume.

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

Cover Crops/Critical Area Planting/Conservation Cover
Cover crops include legumes, such as clover, hairy vetch, field peas, alfalfa, and soybean, and non-legumes, such as rye, oats, wheat, radishes, turnips, and buckwheat which are planted prior to or following crop harvest. Cover crops typically grow for one season to one year and are typically grown in non-cropping seasons. Cover crops are used to improve soil quality and future crop harvest by improving soil tilth, reducing wind and water erosion, increasing available nitrogen, suppressing weed cover, and encouraging beneficial insect growth. Cover crops reduce phosphorus transport by reducing soil erosion and runoff. Both wind and water erosion move soil particles that have phosphorus attached. Sediment that reaches water bodies may release phosphorus into the water. Runoff water can wash soluble phosphorus from the surface soil and crop residue and carry it off the field. The cover crop vegetation

recovers plant-available nutrients in the soil and recycles them through the plant biomass for succeeding crops.

Drainage Water Management/Subirrigation

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

Fencing/Alternate Watering Systems

Fencing livestock out of stream systems allows for the restoration of the stream channel. Alternative watering systems provide an alternate location for livestock to seek water rather than using a surface water source. This removes the negative impacts of livestock access to streams including direct deposit of manure and bank erosion and destabilization, while improving the health of livestock by providing a clean water source and better footing while drinking. This results in less *E. coli*, phosphorus, nitrogen, and sediment entering a surface waterbody. Alternative watering systems may include pump systems or gravity systems connected to a well, or running pipe from a pond or spring.

Field Border/Buffer Strip/Filter Strip

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

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

Additionally, up to 60% of pathogens contained in runoff may be effectively removed. Computer modeling also indicates that over the long run (30 years), filter strips significantly reduce amounts of pollutants entering waterways.

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

Forage and Biomass Planting

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

Grade Stabilization

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

Grassed Waterway

Grassed waterways are natural or constructed channels established for transport of concentrated flow at safe velocities using adequate channel dimensions and proper vegetation. They are generally broad and shallow by design to move surface water across farmland without causing soil erosion. Grassed waterways are used as outlets to prevent rill and gully formation. The vegetative cover slows the water flow, minimizing channel surface erosion. When properly constructed, grassed waterways can safely transport large water flows downslope. These waterways can also be used as outlets for water released from contoured and terraced systems and from diverted channels. The amount of precipitation that runs off the soil surface rather than infiltrating down into the soil profile is increased by tillage and other farming activities that increase soil compaction and decrease soil organic matter and macro-pore content. For these reasons, the establishment or refurbishing of a grassed waterway should, when possible, be coupled with other practices that aim to increase the rate of water infiltration into the soil. This BMP can reduce sediment concentrations of nearby waterbodies and pollutants in runoff. The vegetation improves the soil aeration and water quality due to its nutrient removal through plant uptake and absorption by soil. The waterways can also provide wildlife corridors and allows more land to be natural areas.

Greenways and Trails

Greenways can provide a large number of functions and benefits to nature and the public. For plants and animals, greenways provide habitat, a buffer from development, and a corridor for migration. Greenways located along streams include riparian buffers that protect water quality by filtering sediments and nutrients from surface runoff and stabilizing streambanks. By buffering the stream from adjacent developed land use, riparian greenways offset some of the impacts associated with increased impervious surface in a watershed. Maintaining a good riparian buffer can mitigate the negative impacts of approximately 5% additional impervious surface in the watershed.

Heavy Use Protection Area (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/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 pasture land and move the animals from one paddock to the next, ensuring adequate vegetation growth for nutrient removal. Using this system of rotational grazing no one piece of land gets overgrazed and ensures a high quality food for the livestock and adequate ground cover for nutrient and sediment retention. Education and outreach programs focusing on rotational grazing and exclusionary fencing are important in the success of this BMP.

Manure Management Planning

Large volumes of manure are generated by both small, unregulated animal operations and by confined feeding operations located throughout the Big Pine watershed. Many entities have manure management plans in place and are currently using these plans to manage the volume of manure produced on their facility. Manure management planning includes consideration of the volume and type of manure produced annually, crop rotations by field, the volume of manure and nutrients needed for each crop, field slope, soil type, and manure collection, transportation, storage, and distribution methods. Manure management planning uses similar techniques to nutrient management planning with regards to nutrient budgets.

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

Nutrient/Pest Management Planning including Variable Rate Application and Waste Storage Facility
Nutrient management is the management of the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments to minimize the transport of applied nutrients into surface water or groundwater and can be in commercial/non-manure fertilizer or manure-based fertilizers. Nutrient management seeks to supply adequate nutrients for optimum crop yield and quantity, while also helping to sustain the physical, biological, and chemical properties of the soil. A nutrient budget for nitrogen, phosphorus, and potassium is developed considering all potential sources of nutrients including, but not limited to, animal manure, commercial fertilizer, crop residue, and legume credits. Realistic yields are based on soil productivity information, potential yield, or historical yield data based on a 5-year average. Nutrient management plans specify the form, source, amount, timing, and method of application of nutrients on each field in order to achieve realistic production levels while minimizing transport of nutrients to surface and/or groundwater.

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

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

Rain Barrel
A rain barrel is a container that collects and stores rainwater from your rooftop (via your home's disconnected downspouts) for later use on your lawn, garden, or other outdoor uses. Rainwater stored in rain barrels can be useful for watering landscapes, gardens, lawns, and trees. Rain is a naturally soft water and devoid of minerals, chlorine, fluoride, and other chemicals. In addition, rain barrels help to reduce

peak volume and velocity of stormwater runoff to streams and storm sewer systems. Although rain barrels don't specifically reduce nutrient or sediment loading to waterbodies, their presence can reduce the first flush of water reaching storm drains. This impact is great especially in portions of the watershed where combined sewers are still in operation. Although a high percentage of urban residents indicated a general knowledge of rain barrels, only 3% of survey respondents indicate that they have installed a rain barrel. Furthermore, 75% of respondents indicate a willingness to consider installing a rain barrel.

Rain Garden

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

Saturated Buffer

Saturated buffers are an option in situations where a field is bordered by a riparian buffer. The conventional practice is to extend the tile main line from the field, through the buffer and discharge the water directly into the receiving stream. Subsurface drainage water, therefore, bypasses the buffer and has no opportunity for interaction with the biota in the buffer. Saturated buffers provide a means for distributing some or all of the drainage water through the buffer. For the purpose of utilizing the buffer, a diverter box, or control structure, is installed on the tile main line at the edge between the field and the buffer. The diverter box is used to direct the water into a subsurface distribution pipe running parallel to the stream along the edge of the field. The distribution pipe is regular perforated drainage pipe. The drainage water can then seep out of the distribution pipe and into the soil and make its way down gradient to the stream. The nitrate in the water is removed by the buffer through denitrification, immobilization in bacterial biomass and plant uptake. An overflow discharge pipe to the stream is connected to the diverter box to allow bypass flow during times of high drainage flow rates, thereby ensuring that no water is being backed up in the main tile line.

Septic System Care, Maintenance, and Upgrades

Septic, or on-site waste disposal systems, are the primary means of sanitary flow treatment outside of incorporated areas including most of the small towns and unincorporated areas in the Lower Big 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.

Streambank Stabilization

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

T&E Species Protection (Habitat Improvement)

Threatened and endangered species are those plant and animal species whose survival is in peril. Federally and state listed species identified within the Lower Big 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 including Invasive Control/Timber Stand Improvement

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

Two-Stage Ditch

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

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

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

10.2 Best Management Practice Selection and Load Reduction Calculations

Table 43 details selected agricultural and urban best management practices and reflect those parameters which NRCS eFOTG, if appropriate, indicate can be utilized to impact each parameter. The critical area and the selected best management practices are based on subwatershed characteristics and available water quality data. Table 44 outlines suggested BMPs, estimated load reduction for nutrients and sediment (if available), and the target volume (area, length) of each practice, while Table 45 details estimated costs for implementing each practice based on the target volume. The steering committee identified BMPs that would be of interest to local producers, while the project coordinator calculated volume of BMPs necessary to meet project goals. The Region V model was used to estimate the approximate load reductions for BMPs unless otherwise noted. BMPs with dashes (-) do not have load reductions available using the Region V Model or other identifiable source. The target volumes of BMPs proposed to be installed are not required to be implemented as the quantities suggest. These targets are simply guidelines for achieving goals. Load reductions solely using this model meet the project targets for nitrogen, phosphorus and sediment goals for both short and long term goals. If the volume of practices specific in Table 44 is met, then the target loading rates detailed in Table 39 through

Table **42** will be achieved for Nameless Creek, Anthony Creek-Six Mile Creek, Prairie Branch-Big Blue River and Foreman Branch-Big Blue River (high priority); for Shaw Ditch-Big Blue River (medium priority); and for DePrez Ditch-Big Blue River (low priority). However, if the steering committee chooses to target only nitrogen and phosphorus load reductions and forego meeting sediment target loading rates, then the volume of each BMP targeted can be reduced. The steering committee realizes that the model's calculations are only an estimate, and actual reductions could be beyond the model's estimation. The Region V model does not provide estimated reductions for all suggested BMPs; these load reductions cannot be included in the calculations. The steering committee acknowledges that they have set the bar high by establishing ambitious water quality targets that may be difficult to obtain. The group is committed to improve water quality the best that they can, even in the event that the original load reduction goals are not met.

Table 43. Suggested Best Management Practices to address Lower Big Blue River critical areas. Note BMPs were selected by the steering committee.

Practice	Nutrients	Sediment	Pathogens
Bioreactor	X		
Bioretention	X	X	X
Composting Facility	X		X
Conservation Tillage	X	X	X
Cover Crop/Critical Area Planting/Conservation Cover	X	X	X
Drainage Water Management	X	X	
Fencing	X	X	X
Field Border/Buffer Strip	X	X	X
Forage/Biomass Planting	X	X	X
Grade Stabilization Structure	X	X	
Grassed Waterway/Mulching/Subsurface Drain	X	X	X
Greenways and Trails	X	X	
Heavy Use Protection Area	X	X	X
Infrastructure Retrofit	X	X	
Lined waterway/outlet	X	X	X
Livestock Restriction/Prescribed Grazing/ Access control/Alt watering system	X	X	X
Manure Management Planning	X		X
Nutrient/Pest Management	X		
Pervious pavement	X	X	
Rain Barrel/Rain garden	X	X	
Saturated Buffer	X	X	
Septic System Care/Maintenance	X		X
Streambank Stabilization	X	X	
T&E Species Protection (Habitat Improvement)	X	X	
Tree/Shrub Establishment	X	X	
Two Stage Ditch	X	X	X
Waste Storage Facility/Waste utilization	X		X
Water and Sediment Control Basin	X	X	
Wetland Creation/Enhancement/Restoration	X	X	X

Table 44. Suggested Best Management Practices, target volumes, and their estimated load reduction per practice Lower Big Blue River Watershed goals.

Suggested BMPs	BMP Targets	Unit	Nitrogen (lb/year)	Phosphorus (lb/year)	Sediment (tons/year)
Cover Crop (340)	60,000	acre	15	7	7
Critical Area Planting (342)	12	acre	23	11	10
Fence (382)	12,000	feet	0.4	0.4	0.4
Filter Strip (393)	60,000	acre	24	12	10
Forage and Biomass Planting (512)	4,500	acre	23	11	10
Grassed Waterway (412)	27	acre	232.9	116.4	101.3
Livestock Restriction (Alt Watering System, Access Control)	40	feet for access control; unit for AWS	2.8	0.83	7.52
Nutrient/Pest Management (590)^	60,000	Acre	4.16	6.24	-
Prescribed Grazing (528)	23	acre	17	9	8
Residue and Tillage Management (329)	60,000	acres	21	10	11
Streambank Stabilization*	160,000	feet	0	0.83	14
Trails and Walkways (575)	500	Ft (.5 ac units)	22	11	14
Tree/shrub Establishment (612)	1,000	acre	10	5	5
Water and Sediment Control Basin (638)	25	unit	129.8	64.9	56.4
Wetland Creation/Restoration	10	acre	8.2	2.9	12.7

^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 erosion of 5 feet.

Table 45. Estimated cost for selected Best Management Practices to meet Lower Big Blue River Watershed goals by 2039.

Suggested BMPs	BMP Targets	Unit	Estimated Cost per Unit	Total Estimated Cost
Cover Crop (340)	60,000	acre	25	$1,500,000
Critical Area Planting (342)	12	acre	$650	$7,800
Fence (382)	12,000	feet	1	$12,000
Filter Strip (393)	60,000	acre	75	$4,500,000
Forage and Biomass Planting (512)	4,500	acre	75	$337,500
Grassed Waterway (412)	27	acre	$5,000	$135,000
Livestock Restriction (Alt Watering System, Access Control)	40	feet for access control; unit for AWS	$1,000	$40,000
Nutrient/Pest Management (590)	60,000	Acre	$4.00	$240,000
Prescribed Grazing (528)	23	acre	$15.00	$341
Residue and Tillage Management (329)	60,000	acres	$15	$900,000
Streambank Stabilization	160,000	feet	$1,000	$160,000,000
Trails and Walkways (575)	500	Ft (.5 ac units)	3	$1,500
Tree/shrub Establishment (612)	1,000	acre	$450	$450,000
Water and Sediment Control Basin (638)	25	unit	$2,500	$62,500
Wetland Creation/Restoration	10	acre	$1,000	$10,000
			TOTAL	**$168,271,640.50**

10.3 Action Register

All activities to be completed as part of the Lower Big Blue River Watershed management plan are identified in Table 46. 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 46. Action Register.

Education and Outreach Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Nutrients, Sediment, *E. coli*	Coordinate on-the-ground cost-share program by 2021.	Local producers, local landowners, city and county residents.	Develop a cost-share program.	$25,000 annually	PP=Indiana American Water, City and County schools, CCAs, REMC, Technical assistance providers, river enthusiasts, city and county MS4s. TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, County surveyor, CCAs
			Implement cost-share program.		
			Identify potential funding sources to augment cost-share program including MRBI, RCPP, LARE, CWA and others.		
Education	Develop an education plan targeting each practice identified above by 2021.		Create mechanism to promote each practice using methods including but not limited to press releases; stream clean up; float trip; stream, field or pasture walk; website creation; local events; county fair booth; educational booth; workshop; field days and public meetings.	$10,000	
			Develop funding mechanism for education efforts.		
			The education program should include educational efforts which includes but is not limited to the following: all practices identified by the steering committee and noted in tables above; septic system use, maintenance and care; high quality natural areas; wetland protection and preservation and general stream processes.	$25,000 annually	
Education	Continue to cultivate quarterly Hoosier Riverwatch-based volunteer monitoring program.		Create annual training and consider retraining volunteers as needed.	$5,000	
			Identify watershed-wide monitoring locations.		
			Recruit volunteer monitors.		
			Profile volunteers and their monitoring efforts on partner websites and through marketing effort.		
			Complete quarterly sampling at the 13 sites monitored as part of the planning project using Hoosier Riverwatch methods.		
Education	Promote hands-on opportunities to improve natural areas and habitat within the Lower Big Blue River Watershed.		Identify partner organizations which host field days, work days, and clean-up events.	$15,000	
			Annually, identify partner work days for river clean-up, exotic species control, or habitat restoration opportunities and promote throughout the watershed.		

Nutrient Goal	Objective	Target Audience	Milestones	Cost (includes BMPs, staff and supplies)	Potential Partners/ Technical Assistance
Reduce nitrate-nitrogen from 2,630,265 lb/yr to 908,738 lb/yr and reduce total phosphorus from 147,680 lb/yr to 57,553 lb/yr by 2050.	Educate and promote installation of BMPs through field days/workshops	Local producers, local landowners, city and county residents.	Host at least one local event (field day, public meeting, workshop) annually targeting agricultural BMPs and one local event every two years targeting urban or habitat-based BMPs.	$5,609,054.68 annually	PP=Indiana American Water, City and County schools, CCAs, REMC, Technical assistance providers, river enthusiasts, city and county MS4s. TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, County surveyor, CCAs
	Education through publications, web posts, and press releases		Develop quarterly (4) print materials publications, press releases, web updates, social media posts or other publications annually.		
			Implement one third of practices within each 10 year target period.		
			Achieve short-term (10 year) goal by reducing nitrate-nitrogen loading to 2,056,423 lb/yr and total phosphorus to 117,638 lb/yr by 2030.		
	Implement 319, MRBI CWI, LARE and other cost-share programs to put nutrient-reducing BMPs in place		Achieve medium-term (20 year) goal by reducing nitrate-nitrogen loading to 1,482,580 lb/yr and total phosphorus to 87,595 lb/yr by 2040.		
			Achieve long-term (30 year) goal by reducing nitrate-nitrogen to 908,737 lb/yr and total phosphorus to 57,553 lb/yr by 2050.		

Sediment Goal	Objective	Target Audience	Milestones	Cost (includes BMPs, staff and supplies)	Potential Partners/ Technical Assistance
Reduce total suspended solids loading from 31,857,512 lb/yr to 11,359,230 lb/yr by 2050.	Educate and promote installation of BMPs through field days/workshops	Local producers, local landowners, city and county residents.	Host at least one local event (field day, public meeting, workshop) annually targeting agricultural BMPs and one local event every two years targeting urban or habitat-based BMPs.	See above for annual cost	PP=Indiana American Water, City and County schools, CCAs, REMC, Technical assistance providers, river enthusiasts, city and county MS4s. TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, County surveyor, CCAs
	Education through publications/press releases		Develop quarterly (4) print materials publications, press releases, web updates, social media posts or other publications annually.		
	Implement 319, CWI, LARE and other cost-share programs to put erosion-reducing BMPs in place		Implement one third of practices within each 10 year target period.		
			Achieve short-term (10 year) goal by reducing total suspended solids loading from 31,8577,512 lb/yr to 25,024,751 lb/yr by 2030.		
			Achieve medium-term (20 year) goal by reducing total suspended solids loading from 25,024,751 lb/yr to 18,191,990 lb/yr by 2030.		
			Achieve long-term (30 year) goal by reducing total suspended solids loading from 18,991,990 lb/yr to 11,359,230 lb/yr by 2030.		

***E. coli* Goal**	**Objective**	**Target Audience**	**Milestones**	**Cost (includes BMPs, staff and supplies)**	**Potential Partners/ Technical Assistance**
Reduce *E. coli* concentrations from those detailed in Table 41 to targets calculated by IDEM as part of the Lower Big Blue River TMDL.	Educate and promote installation of BMPs through field days/workshops	Local producers, local landowners, city and county residents.	Host at least one local event (field day, public meeting, workshop) annually targeting agricultural BMPs and one local event every two years targeting urban or habitat-based BMPs.	See above for annual cost	PP=Indiana American Water, City and County schools, CCAs, REMC, Technical assistance providers, river enthusiasts, city and county MS4s. TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, County surveyor, CCAs
	Education through publications/press releases		Develop quarterly (4) print materials publications, press releases, web updates, social media posts or other publications annually.		
	Implement 319, CWI, LARE and other cost-share programs to put *E.coli*-reducing BMPs in place		Implement one third of practices within each 10 year target period.		
			Achieve short-term (10 year) goal by reducing *E. coli* concentrations by 1/3 by 2030.		
	Educate and promote proper septic maintenance		Achieve medium-term (20 year) goal by reducing *E. coli* concentrations by 2/3 by 2040.		
			Achieve long-term (30 year) goal by reducing *E. coli* concentrations to meet IDEM TMDL targets by 2050.		

11.0 FUTURE ACTIVITIES

The next steps for the project include starting implementation of the Lower Big Blue River Watershed Management Plan. The Shelby County SWCD in partnership with the project steering committee and other regional partners are in the process of submitting an implementation-focused grant application. If funded, this grant would provide funds for a cost-share program to install BMPs, promotion of the cost-share program, and an education and outreach program. If the grant is awarded, the steering committee will develop a cost-share program that will include steps to meeting the goals and management strategies of this plan. The anticipated cost-share program will use a ranking system to fund applications that will have the most impact in improving water quality. Factors such as location within watershed (priority areas), distance from streams, number of resource concerns addressed, and number of practices planned will be considered as part of the ranking process to further prioritize BMPs. It is anticipated that implementation efforts will target high priority critical areas and focus on the implementation of short-term goals.

11.1 Tracking Effectiveness

Implementation of policies, programs, and practices will improve water quality and watershed conditions within the Lower Big Blue River Watershed, helping reach goal statements for high, medium and low priority critical areas by 2050. For each practice identified, an annual target for the acres or number of each BMP implemented is included in the action register (Table 46). Measurement of the success of implementation is a necessary part of any watershed project. Both social indicator and water quality data will be used to measure observable changes following implementation. In order to track the project's progress of reaching goals and improving water quality, information and data will need to be continually collected during implementation.

Table 47. Strategies for and indicators of tracking goals and effectiveness of implementation.

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

The tracking strategies illustrated in Table 47 will be used to document changes and aid in the plan re-evaluation. Activities to be completed as part of this watershed management plan are identified in the action register in Table 46. Table 48 identifies the annual target for the number or acres of BMPs to be installed during each implementation phase. Work completed towards each goal/objective documented will include scheduled and completed activities, numbers of individuals attending or efforts completed toward each objective, and load calculations for each goal, objective, and strategy. Overall, project progress will be tracked by measurable items such as workshops held, BMPs installed, meetings held, number of attendees, etc. Load reductions will be calculated for each BMP installed. These values and associated project details including BMP type, location, dimensions, load reductions, and more will be tracked over time and documented on the Indiana State Department of Agriculture Conservation Tracking sheet. Individual landowner contacts and information will be tracked for both identified and installed BMPs. Volunteer water monitoring results will be documented on the Hoosier Riverwatch website. The Lower Big Blue River Project Coordinator will be responsible for keeping the mentioned records. The Shelby County SWCD will be responsible for the long-term housing of records.

Table 48. Annual targets for short term, medium term and long term goals for each best management practice.

Suggested BMPs:	Short Term Targets	Medium Term Target	Long Term Targets
Cover Crop (340)	2000.0	2000.0	2000.0
Critical Area Planting (342)	0.4	0.4	0.4
Fence (382)	400.0	400.0	400.0
Filter Strip (393)	2000.0	2000.0	2000.0
Forage and Biomass Planting (512)	150.0	150.0	150.0
Grassed Waterway (412)	0.9	0.9	0.9
Livestock Restriction (Alt Watering System, Access Control)	1.3	1.3	1.3
Nutrient/Pest Management (590)^	2000.0	2000.0	2000.0
Prescribed Grazing (528)	0.8	0.8	0.8
Residue and Tillage Management (329)	2000.0	2000.0	2000.0
Streambank Stabilization**	5333.3	5333.3	5333.3
Trails and Walkways (575)	16.7	16.7	16.7
Tree/shrub Establishment (612)	33.3	33.3	33.3

11.2 <u>Indicators of Success</u>

Water quality, social, and administrative indicators will be used to monitor progress towards successful achievement of the goals for the high, medium and low priority 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 IDEM fixed station monitoring program, at a minimum. If local laboratory partners will continue to analyze collected samples as an in-kind service, laboratory data will be utilized as an indicator for each parameter. Administrative indicators will be listed with each strategy included in the action register.

Reduce Nutrient Loading

- <u>Water Quality Indicator:</u> Nitrate-nitrogen and total phosphorus will be measured monthly as part of the IDEM fixed station monitoring program. After 10 years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the target level for nitrate-nitrogen of 1.2 mg/L and for total phosphorus of 0.076 mg/L. The same test will occur after each implementation period with assessment occurring at 20 years and again at 30 years.

- Administrative Indicator: The number of BMPs that can reduce nitrate-nitrogen total phosphorus will be tracked annually. The total number of acreage will be compared against annual targets identified in Table 44. Individual load reductions calculated for each BMP will be reviewed to determine if cumulative loading rates for nitrate-nitrogen and phosphorus are sufficient to meet the target reductions.

Reduce Sediment Loading

- Water Quality Indicator: Total suspended solids will be measured monthly as part of the IDEM fixed station monitoring program. After 10 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. The same test will occur after each implementation period with assessment occurring at 20 years and again at 30 years.
- Administrative Indicator: The number of BMPs that can reduce total suspended solids will be tracked annually. The total number of acreage will be compared against annual targets identified in Table 44. Individual load reductions calculated for each BMP will be reviewed to determine if the cumulative loading rate for total suspended solids is sufficient to meet the target reduction.

Reduce *E. coli* Loading

- Water Quality Indicator: *E. coli* will be measured monthly as part of the IDEM fixed station monitoring program After 10 years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the state standard. The same test will occur after each implementation period with assessment occurring at 20 years and again at 30 years.
- Administrative Indicator: The number of BMPs that can reduce *E. coli* will be tracked annually. The total number of acreage will be compared against annual targets identified Table 44.

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 Adapting Strategies in the Future

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

Step 1: Planning The planning process used to develop the Lower Big Blue River WMP follows the IDEM 2009 Watershed Management Checklist. The project coordinator worked in concert with and was guided by the Lower Big 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 Lower Big 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 for youth and adults. Practices implemented through the cost-share program will follow the NRCS Field Office Technical Guide (FOTG) Practice Standards or other technical standards as detailed in the cost-share program, once developed. The cost-share program will include but will not be limited to practices such as cover crops, watering facilities, fencing, conservation buffers, grassed waterways, and nutrient and pest management plans. Cost-share funding will be implemented in priority areas, addressing high priority areas before the medium priority area. A ranking system will be used to prioritize applications that will have the greatest impact on water quality improvement.

Step 3: Evaluate & Learn Evaluations of indicators identified above and in Table 47 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 46) 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 Lower Big 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. 2022, 2024, 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 Shelby County SWCD is responsible for maintaining records for the project including tracking plan successes and failures and any necessary revisions.

Shelby County SWCD
2779 South 840 West
Manilla, Indiana 46150
765-544-2051

12.0 LITERATURE CITED

Cable, L.W., F.A. Watkins, Jr and T.M. Robison. 1971. Bulletin No 34 of the Division of Water. Hydrogeology of the principle aquifers in Vigo and Clay Counties, Indiana. U.S. Geological Survey in cooperation with the Indiana Department of Natural Resources, Division of Water

Indiana Department of Environmental Management. 2014. E. coli total maximum daily load report for the Lower Big Blue River Watershed. Indianapolis, Indiana.

Indiana State Department of Agriculture. 2019. [web page] Tillage transect data. http://www.in.gov/isda/2383.htm [Accessed 4 February 2019]

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

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

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

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

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

Appendix A: Water Chemistry Data

Subshed	Site	date	ecoli cfu/100	Temp	DO	pH	OrthoP	Nitrate	Transparency	Turbidity
Sixmile	1	9/20/2017	66.7	25.2	7.3	7.8	0.02	8.7	10	120
Sixmile	1	9/30/2017	0							
Sixmile	1	10/14/2017	0							
Sixmile	1	10/24/2017	66.7	18.9	9.6	7.9	0.6	7.5	60	8
Sixmile	1	11/14/2017		12.4	10	7.9	0.11	2.5	60	8
Sixmile	1	12/6/2017		4.6	10	8	0.05	3.35	60	8
Sixmile	1	1/15/2018		-1.2	10	8	0.01	1.5	60	8
Sixmile	1	2/19/2018		3.6	10	8	0	2	60	8
Sixmile	1	3/14/2018		6.2	6	8	0.01	0.5	60	8
Sixmile	1	4/2/2018		8.5	6	7.5	0	2	60	8
Sixmile	1	5/5/2018		13.7	8	7	0.4	5	60	8
Sixmile	1	6/8/2018		18.9	10	7.5	3	5	60	8
Sixmile	1	7/9/2018		24.6	9	7.5	0.2	10	60	8
Sixmile	1	8/5/2018		21.5	8	7.5	0.2	8.8	60	8
Sixmile	1	9/10/2018	366.7							
Sixmile	1	9/22/2018	133.3							
Sixmile	1	9/30/2018	366.7							
Sixmile	1	10/6/2018	0							
Sixmile	1	10/8/2018	233.3							
Sixmile	1	10/17/2018	166.7							
Anthony	2	9/20/2017	200	24.2	7.7	8	0.02	8.6	10	120
Anthony	2	9/30/2017	266.7							
Anthony	2	10/14/2017	66.7							
Anthony	2	10/24/2017	0	17.9	9.9	7.9	0.4	4.6	60	8
Anthony	2	11/14/2017		12.5	10	8	0.2	2.5	60	8
Anthony	2	12/6/2017		4.5	10	5	0.04	3.5	25	30
Anthony	2	1/15/2018		-0.2	10	8	0.01	1.5	60	8
Anthony	2	2/19/2018		3.8	10	8	0	0	60	8
Anthony	2	3/14/2018		6.9	6.5	8	0.01	0.5	60	8
Anthony	2	4/2/2018		8.9	6	8	0.01	2	40	15
Anthony	2	5/5/2018		14.1	8	7.5	0.3	2	40	15
Anthony	2	6/8/2018		19.2	10	7.5	0.2	5	40	15
Anthony	2	7/9/2018		24.6	8	7.5	0.1	0.5	40	15
Anthony	2	8/5/2018		2.1	8	7.5	0.2	10	25	30
Anthony	2	9/10/2018	500							
Anthony	2	9/22/2018	66.7							
Anthony	2	9/30/2018	166.7							
Anthony	2	10/6/2018	166.7							
Anthony	2	10/8/2018	100							
Anthony	2	10/17/2018	66.7							
nameless	3	9/20/2017	33.3	26.1	8	8	0.02	8.4	10	120
nameless	3	9/30/2017	0							
nameless	3	10/14/2017	166.7							
nameless	3	10/24/2017	133.3	17.5	9.3	8	0.35	5.1	60	8
nameless	3	11/14/2017		12	10	7.9	0.2	2.3	60	8
nameless	3	12/6/2017		4.3	10	8	0.04	4.5	30	24
nameless	3	1/15/2018		-1.2	10	8	0.01	1.5	60	8
nameless	3	2/19/2018		3.6	10	8	0.01	1	60	8
nameless	3	3/14/2018		6.4	7	7.5	0.01	0.8	60	8
nameless	3	4/2/2018		8.8	7	7.5	0.01	2	50	11
nameless	3	5/5/2018		13.9	8	8	0.2	5	40	15
nameless	3	6/8/2018		18.9	9	7.5	0.1	2	40	15
nameless	3	7/9/2018		25.3	8	7.5	0.2	2	60	8

Subshed	Site	date	ecoli cfu/100	Temp	DO	pH	OrthoP	Nitrate	Transparency	Turbidity
nameless	3	8/5/2018		21	8	7.5	10.2	5	60	8
nameless	3	9/10/2018	533.3							
nameless	3	9/22/2018	466.7							
nameless	3	9/30/2018	866.7							
nameless	3	10/6/2018	33.3							
nameless	3	10/8/2018	466.7							
nameless	3	10/17/2018	166.7							
Anthony	4	9/20/2017	366.7	23	8	8.2	0.01	8.4	10	120
Anthony	4	9/30/2017	233.3							
Anthony	4	10/14/2017	33.3							
Anthony	4	10/24/2017	100	16.8	8.6	8	0.4	5.3	60	8
Anthony	4	11/14/2017		11.7	10	8	0.1	1.6	60	8
Anthony	4	12/6/2017		4.2	10	8	0.03	3.5	40	15
Anthony	4	1/15/2018		-1.4	10	8	0.01	1.5	60	8
Anthony	4	2/19/2018		3.2	10	8	0.02	0	60	8
Anthony	4	3/14/2018		6.3	6	8	0.02	0.5	60	8
Anthony	4	4/2/2018		8.6	6	7.5	0.01	2	40	15
Anthony	4	5/5/2018		13.8	8	8	0.1	2	60	8
Anthony	4	6/8/2018		19.6	10	7.5	0.3	1	60	8
Anthony	4	7/9/2018		25.6	8	8	0.1	0.5	60	8
Anthony	4	8/5/2018		22.1	8	7.5	0.2	5	60	8
Anthony	4	9/10/2018	100							
Anthony	4	9/22/2018	233.3							
Anthony	4	9/30/2018	300							
Anthony	4	10/6/2018	66.7							
Anthony	4	10/8/2018	166.7							
Anthony	4	10/17/2018	133.3							
Foreman	5	9/20/2017	166.7	23.1	8.8	8.2	0.01	8.6	10	120
Foreman	5	9/30/2017	66.7							
Foreman	5	10/14/2017	66.7							
Foreman	5	10/24/2017	0	16.9	8.7	7.9	0.5	5.4	60	8
Foreman	5	11/14/2017		10.8	10	8	0.2	1.5	60	8
Foreman	5	12/6/2017		4.2	10	8	0.04	4	60	8
Foreman	5	1/15/2018		-1.2	10	8	0.01	2	60	8
Foreman	5	2/19/2018		3.4	10	8	0.01	1.5	60	8
Foreman	5	3/14/2018		6.6	6	7.5	0.03	1	25	30
Foreman	5	4/2/2018		8.5	6	7.5	0.02	10	20	40
Foreman	5	5/5/2018		14.2	8	7.5	4	2	25	30
Foreman	5	6/8/2018		17.8	9	7.5	0.4	10	25	30
Foreman	5	7/9/2018		27.3	8	7.5	0.3	10	25	30
Foreman	5	8/5/2018		22.4	8	7.5	0.3	5	25	30
Foreman	5	9/10/2018	66.7							
Foreman	5	9/22/2018	0							
Foreman	5	9/30/2018	200							
Foreman	5	10/6/2018	100							
Foreman	5	10/8/2018	533.3							
Foreman	5	10/17/2018	0							
Foreman	6	9/20/2017	300	23.3	8.1	8	0.016	8.4	10	120
Foreman	6	9/30/2017	266.7							
Foreman	6	10/14/2017	300							
Foreman	6	10/24/2017	0	17.6	8.7	7.9	0.46	5.36	60	8
Foreman	6	11/14/2017		11.4	10	8	0.2	2.5	60	8
Foreman	6	12/6/2017		3.7	10	8	0.015	3	60	8

Subshed	Site	date	ecoli cfu/100	Temp	DO	pH	OrthoP	Nitrate	Transparency	Turbidity
Foreman	6	1/15/2018		-1.2	10	8	0.01	2	60	8
Foreman	6	2/19/2018		2.6	10	8	0	0.1	60	8
Foreman	6	3/14/2018		6	7	8	0.01	0.5	60	8
Foreman	6	4/2/2018		8.3	8	8	0.01	0.5	60	8
Foreman	6	5/5/2018		13.5	8	7.5	0.2	0	60	8
Foreman	6	6/8/2018		18.4	10	7.5	0.1	0.5	60	8
Foreman	6	7/9/2018		25.6	8	7.5	0	0	60	8
Foreman	6	8/5/2018		21	8	8	0	0	60	8
Foreman	6	9/10/2018	0							
Foreman	6	9/22/2018	0							
Foreman	6	9/30/2018	0							
Foreman	6	10/6/2018	233.3							
Foreman	6	10/8/2018	133.3							
Foreman	6	10/17/2018	0							
Foreman	7	9/20/2017	33.3	23.8	8.1	8	0.01	8.5	10	120
Foreman	7	9/30/2017	100							
Foreman	7	10/14/2017	0							
Foreman	7	10/24/2017	0	17.6	10	8	0.4	6.2	60	8
Foreman	7	11/14/2017		11.5	10	8	0.1	1.7	60	8
Foreman	7	12/6/2017		3.6	10	8	0.02	3.5	60	8
Foreman	7	1/15/2018		2.4	10	8	0.02	1.5	60	8
Foreman	7	2/19/2018		3.1	10	8	0.01	1.5	60	8
Foreman	7	3/14/2018		6.3	8	6.5	0.01	0.5	60	8
Foreman	7	4/2/2018		8.3	8	7.5	0.01	0.5	60	8
Foreman	7	5/5/2018		13.2	10	7.5	0.01	0	60	8
Foreman	7	6/8/2018		18.2	10	7.5	0.1	0.5	60	8
Foreman	7	7/9/2018		24.9	8	7.5	0.1	0.5	60	8
Foreman	7	8/5/2018		20.8	8	7.5	0	0	60	8
Foreman	7	9/10/2018	33.3							
Foreman	7	9/22/2018	100							
Foreman	7	9/30/2018	100							
Foreman	7	10/6/2018	100							
Foreman	7	10/8/2018	133.3							
Foreman	7	10/17/2018	0							
prairie	8	9/20/2017	166.7	23.2	8.4	8	0.02	8.4	10	120
prairie	8	9/30/2017	133.3							
prairie	8	10/14/2017	0							
prairie	8	10/24/2017	33.3	17.2	7.9	8	0.3	4.4	60	8
prairie	8	11/14/2017		11.2	10	8	0.2	2.3	60	8
prairie	8	12/6/2017		3.5	10	8	0.03	2.2	60	8
prairie	8	1/15/2018		-1.5	10	8	0.01	1.5	60	8
prairie	8	2/19/2018		2.7	10	8	0	2	60	8
prairie	8	3/14/2018		6.3	8	7.5	0.01	0.5	60	8
prairie	8	4/2/2018		8.3	7	8	0	0	60	8
prairie	8	5/5/2018		13.4	8	8	0.01	0.5	60	8
prairie	8	6/8/2018		18.4	10	7.5	0.01	0.5	60	8
prairie	8	7/9/2018		24.7	8	7.5	0.1	0	60	8
prairie	8	8/5/2018		21.6	8	7.5	0.2	0	60	8
prairie	8	9/10/2018	166.7							
prairie	8	9/22/2018	0							
prairie	8	9/30/2018	200							
prairie	8	10/6/2018	66.7							
prairie	8	10/8/2018	433.3							

Subshed	Site	date	ecoli cfu/100	Temp	DO	pH	OrthoP	Nitrate	Transparency	Turbidity
prairie	8	10/17/2018	66.7							
deprez	9	9/20/2017	133.3	23.2	8.1	7.6	0.01	8.2	5	240
deprez	9	9/30/2017	0							
deprez	9	10/14/2017	400							
deprez	9	10/24/2017	200	19.9	10	8	0.13	4.5	23.3	35
deprez	9	11/14/2017		11.3	10	8	0.2	2.5	15	65
deprez	9	12/6/2017		3.9	10	8	0.02	3.5	10	120
deprez	9	1/15/2018		-1.5	10	8	0.01	1.5	10	120
deprez	9	2/19/2018		2	10	8	0	1	10	120
deprez	9	3/14/2018		7.2	7	7.5	0.02	1	25	30
deprez	9	4/2/2018		8.8	6	7.5	0.02	5	45	13
deprez	9	5/5/2018		14.2	9	7.5	0.3	2	25	30
deprez	9	6/8/2018		19.6	9	7.5	0.2	10	25	30
deprez	9	7/9/2018		26.4	8	7.5	0.3	10	25	30
deprez	9	8/5/2018		23.2	7	7.5	0.3	10	40	15
deprez	9	9/10/2018	266.7							
deprez	9	9/22/2018	400							
deprez	9	9/30/2018	633							
deprez	9	10/6/2018	0							
deprez	9	10/8/2018	966.6							
deprez	9	10/17/2018	300							
shaw	10	9/20/2017	0	23.2	8.6	7.7	0.027	8.6	10	120
shaw	10	9/30/2017	0							
shaw	10	10/14/2017	33.3							
shaw	10	10/24/2017	0	17.5	10	8	0.4	4.4	60	8
shaw	10	11/14/2017		11.1	10	8	0.1	0.5	60	8
shaw	10	12/6/2017		4.3	10	8	0.027	4	60	8
shaw	10	1/15/2018		1	10	8	0.02	1.5	60	8
shaw	10	2/19/2018		2.9	10	8	0	2.5	60	8
shaw	10	3/14/2018		6.5	8	7.5	0.01	0.5	60	8
shaw	10	4/2/2018		8.4	7	8	0.01	0.5	60	8
shaw	10	5/5/2018		13.7	10	8	0.01	0	60	8
shaw	10	6/8/2018		19.4	10	7.5	0.01	0.5	60	8
shaw	10	7/9/2018		24.6	8	7.5	0	0	60	8
shaw	10	8/5/2018		21.4	8	7.5	0.1	0.5	60	8
shaw	10	9/10/2018	266.7							
shaw	10	9/22/2018	0							
shaw	10	9/30/2018	266.7							
shaw	10	10/6/2018	0							
shaw	10	10/8/2018	300							
shaw	10	10/17/2018	66.7							
shaw	11	9/20/2017	0	23.3	8.8	8	0.04	8.4	10	120
shaw	11	9/30/2017	0							
shaw	11	10/14/2017	66.7							
shaw	11	10/24/2017	33.3	17.5	10	8	0.36	4.3	60	8
shaw	11	11/14/2017		11.2	10	8	0.1	0.5	60	8
shaw	11	12/6/2017		4.2	10	8	0.04	4	60	8
shaw	11	1/15/2018		-1.5	0	8	0.01	2.5	60	8
shaw	11	2/19/2018		3.2	10	8	0.01	1.5	60	8
shaw	11	3/14/2018		6.4	8	8	0.01	0.5	60	8
shaw	11	4/2/2018		8.4	7	8	0.01	0.5	60	8
shaw	11	5/5/2018		13.9	8	7.5	0.2	0	60	8
shaw	11	6/8/2018		18.7	10	7.5	0	0.5	60	8

Subshed	Site	date	ecoli cfu/100	Temp	DO	pH	OrthoP	Nitrate	Transparency	Turbidity
shaw	11	7/9/2018		24.5	8	7.5	0.01	0.5	60	8
shaw	11	8/5/2018		21.7	8	7.5	0.1	0	60	8
shaw	11	9/10/2018	133.3							
shaw	11	9/22/2018	0							
shaw	11	9/30/2018	100							
shaw	11	10/6/2018	0							
shaw	11	10/8/2018	133.3							
shaw	11	10/17/2018	0							
deprez	12	9/20/2017	33.3	22.9	8.9	7.7		8.8	10	120
deprez	12	9/30/2017	66.7							
deprez	12	10/14/2017	0							
deprez	12	10/24/2017	0	17.5	10	8	0.35	5.1	60	8
deprez	12	11/14/2017		11.2	9.9	8	0.2	1.7	60	8
deprez	12	12/6/2017		4.1	10	8	0.02	4.5	60	8
deprez	12	1/15/2018		-1.5	10	8	0.01	2	60	8
deprez	12	2/19/2018		3.6	10	8	0	1	60	8
deprez	12	3/14/2018		6.2	7	7.5	0.01	0.5	60	8
deprez	12	4/2/2018		8.4	8	8	0.01	0.5	60	8
deprez	12	5/5/2018		13.8	9	7.5	0.2	0	60	8
deprez	12	6/8/2018		18.6	10	7.5	0.1	0	60	8
deprez	12	7/9/2018		24.9	8	7.5	0.1	0.5	60	8
deprez	12	8/5/2018		21.2	8	7.5	0.1	0	60	8
deprez	12	9/10/2018	66.7							
deprez	12	9/22/2018	0							
deprez	12	9/30/2018	66.7							
deprez	12	10/6/2018	33.3							
deprez	12	10/8/2018	100							
deprez	12	10/17/2018	33.3							
Anthony	13	9/20/2017	66.7	23	8.6	8	0.01	8.2	10	120
Anthony	13	9/30/2017	100							
Anthony	13	10/14/2017	200							
Anthony	13	10/24/2017	133.3	17.4	10	8	0.43	4.4	60	8
Anthony	13	11/14/2017		11	10	8	0.2	2.5	25	30
Anthony	13	12/6/2017		4.4	10	8	0.02	3	25	30
Anthony	13	1/15/2018		-1.4	10	8	0.02	3	60	8
Anthony	13	2/19/2018		3.4	10	8	0	1	10	120
Anthony	13	3/14/2018		6.8	6	7.5	0.01	0.5	40	15
Anthony	13	4/2/2018		8.6	7	7.5	0.02	5	45	13
Anthony	13	5/5/2018		13.9	9	7.5	0.2	5	40	15
Anthony	13	6/8/2018		19.7	10	7.5	0.1	2	40	15
Anthony	13	7/9/2018		25.9	7	7.5	0.1	5	40	15
Anthony	13	8/5/2018				7.5	0.1	0.5	40	15
Anthony	13	9/10/2018	500							
Anthony	13	9/22/2018	266.7							
Anthony	13	9/30/2018	133.3							
Anthony	13	10/6/2018	166.7							
Anthony	13	10/8/2018	33.3							
Anthony	13	10/17/2018	200							

Appendix B: Macroinvertebrate &Habitat Data

SiteID	1	2	3	4	5	6	7	8	9	10	11	12	13
HR ID	2544	2545	2546	2547	2549	2550	2551	2552	2553	2554	2555	2556	2414
Date	7/10/2019	7/10/2019	7/10/2019	7/10/2019	7/17/2019	7/17/2019	7/17/2019	7/17/2019	7/26/2019	7/26/2019	7/26/2019	7/26/2019	7/26/2019
Mayfly				2	1	5	3	8		12	7	5	1
Riffle beetle						6	3	4		2	4	2	1
Right snail						1	2		8				4
Waterpenny													
Dobsonfly										1			
Stonefly							1					1	
Caddisfly	1	2	1	1		5	1	2		10	8	2	
Clam						1						1	4
Crawfish						1	2	1		1	2	2	1
Damselfly	2	1	9	4	5	3	1	1	1		4	3	2
Dragonfly	1	1	3	1	1	3	1	1		4	5	1	2
Sowbug	8		5	9	2	1		1	8	6	1	8	
Scud	8	6				1	1	1	4	2	1	6	
Cranefly	1												
Midge	3	5	6	8	11	2	1	1	6	3	2	2	8
Blackfly	1												
Flatworm	2												
Leech	1												
Left snail													4
Blood midge		4											2
	10	6	5	6	5	11	10	9	5	9	9	11	10
PTI	27	16	15	15	11	32	30	25	15	26	25	32	24
	E	F	F	F	F	E	E	E	F	E	E	E	G

SiteID	1	2	3	4	5	6	7	8	9	10	11	12	13
HR ID	2544	2545	2546	2547	2549	2550	2551	2552	2553	2554	2555	2556	2414
Date	9/26/2019	9/26/2019	9/26/2019	9/26/2019	9/27/2019	9/27/2019	9/27/2019	9/27/2019	9/28/2019	9/28/2019	9/28/2019	9/28/2019	9/28/2019
Mayfly		1		3	2	4	2	6		8	4	7	2
Riffle beetle						2	4	6		1	6	3	
Stonefly													
Caddisfly	2	2	2			2	3	1		8	4	4	
Dobsonfly											1		
Right snail						2	1		6	2			
Clam						3							1
Crawfish							4	2		1	1	1	1
Damselfly	3	3	4	2	4		2	2	2	3	5	4	1
Dragonfly	1	3	2	2	2	4	2	2	1	2	2	2	1
Sowbug	6		6	6	3	2		6	4	4	8	6	
Scud	2	8		4		2	4	8	2	1	4	4	
Midge	4	4	4	4	8	4	2	4	4	2	4	6	6
Flatworm			1										
Leech	1												
Blood midge		2											1
Left snail													3
	10	9	9	9	8	12	12	12	9	13	13	12	9
PTI	20	20	17	18	15	30	30	29	18	33	33	29	20
	G	G	G	G	F	E	E	E	G	E	E	E	G

SiteID	1	2	3	4	5	6	7	8	9	10	11	12	13
HR ID	2544	2545	2546	2547	2549	2550	2551	2552	2553	2554	2555	2556	2414
Substrate	14	10	10	10	16	18	16	10	10	10	18	18	10
Fish Cover	10	6	4	6	8	10	12	14	8	8	12	14	6
Stream Shape	12	12	14	8	16	18	12	14	10	14	16	10	8
Stream Forest/Wetlands	8	8	10	12	14	16	10	8	12	10	10	18	8
Depth&Velocity	10	10	8	12	12	13	10	8	8	16	10	12	10
Riffles&Runs	10	10	10	8	14	14	14	8	8	12	14	10	8
Total	64	56	56	56	80	89	74	62	56	70	80	82	50

SiteID	1	2	3	4	5	6	7	8	9	10	11	12	13
HR ID	2544	2545	2546	2547	2549	2550	2551	2552	2553	2554	2555	2556	2414
Date	3/4/2020	3/4/2020	3/4/2020	3/5/2020	3/5/2020	3/5/2020	3/5/2020	3/5/2020	3/5/2020	3/5/2020	3/5/2020	3/5/2020	3/5/2020
Substrate	14	10	10	10	16	18	16	10	10	10	18	18	10
Fish Cover	8	4	4	5	9	11	10	12	9	9	8	11	5
Stream Shape	12	12	14	8	16	18	12	14	10	14	16	10	8
Stream Forest/Wetlands	8	8	10	12	14	16	10	8	12	10	10	18	8
Depth&Velocity	9	9	9	11	11	12	11	9	9	15	9	11	9
Riffles&Runs	10	10	10	8	14	14	14	8	8	12	14	10	8
Total	61	53	57	54	80	89	73	61	58	70	75	78	48

Appendix C: Load Duration Curve Calculations

Date	DailyDischarge	Rank	PercentExceeded	NO_3 Load	TP Load	TSS Load
4/4/2018	13605.98	1	0	88003.45	5573.55	1833405.25
9/10/2018	10435.22	2	1	67494.98	4274.68	1406145.48
9/9/2018	9127.22	3	1	59034.84	3738.87	1229892.46
2/25/2018	8803.13	4	1	56938.63	3606.11	1186221.48
4/5/2018	8718.93	5	1	56394.06	3571.62	1174876.19
2/26/2018	7894.32	6	2	51060.45	3233.83	1063759.39
4/3/2018	7718.34	7	2	49922.22	3161.74	1040046.24
3/30/2018	7296.12	8	2	47191.31	2988.78	983152.32
11/6/2017	6964.57	9	2	45046.87	2852.97	938476.40
9/11/2018	5095.14	10	3	32955.38	2087.17	686570.51
2/22/2018	4703.54	11	3	30422.50	1926.76	633802.15
3/31/2018	4701.58	12	3	30409.81	1925.95	633537.69
2/23/2018	4120.52	13	4	26651.53	1687.93	555240.23
11/7/2017	3859.10	14	4	24960.69	1580.84	520014.31
2/24/2018	3838.96	15	4	24830.36	1572.59	517299.20
1/12/2018	3764.76	16	4	24350.44	1542.19	507300.89
11/19/2017	3448.40	17	5	22304.25	1412.60	464671.88
3/29/2018	3185.02	18	5	20600.71	1304.71	429181.50
9/8/2018	3129.17	19	5	20239.44	1281.83	421655.00
1/13/2018	3064.91	20	5	19823.84	1255.51	412996.61
4/6/2018	3013.23	21	6	19489.56	1234.34	406032.53
8/26/2018	2760.33	22	6	17853.81	1130.74	371954.36
2/27/2018	2659.83	23	6	17203.79	1089.57	358412.30
2/16/2018	2654.55	24	7	17169.60	1087.41	357700.03
3/2/2018	2565.50	25	7	16593.63	1050.93	345700.64
11/20/2017	2294.92	26	7	14843.55	940.09	309240.58
3/28/2018	2290.47	27	7	14814.77	938.27	308641.14
4/16/2018	2290.08	28	8	14812.24	938.11	308588.25
2/17/2018	2194.17	29	8	14191.92	898.82	295665.03
11/8/2017	2186.46	30	8	14141.99	895.66	294624.82
4/1/2018	2136.87	31	9	13821.26	875.35	287942.83
9/12/2018	1972.01	32	9	12754.96	807.81	265728.28
4/7/2018	1903.58	33	9	12312.36	779.78	256507.48
8/1/2018	1896.25	34	9	12264.97	776.78	255520.17
6/22/2018	1874.63	35	10	12125.08	767.92	252605.83
8/18/2018	1836.98	36	10	11881.61	752.50	247533.51
2/28/2018	1770.91	37	10	11454.24	725.44	238630.06
1/23/2018	1752.59	38	10	11335.77	717.93	236161.78
3/3/2018	1727.73	39	11	11174.97	707.75	232811.97
6/23/2018	1704.05	40	11	11021.80	698.05	229620.83
3/1/2018	1633.00	41	11	10562.28	668.94	220047.42
1/14/2018	1530.60	42	12	9899.90	626.99	206247.95
2/21/2018	1516.89	43	12	9811.21	621.38	204400.27
4/2/2018	1514.20	44	12	9793.86	620.28	204038.84
8/17/2018	1512.59	45	12	9783.46	619.62	203821.98
4/17/2018	1507.66	46	13	9751.55	617.60	203157.31

4/8/2018	1482.28	47	13	9587.37	607.20	199736.98
2/18/2018	1435.40	48	13	9284.16	588.00	193419.93
8/27/2018	1386.75	49	13	8969.51	568.07	186864.88
11/21/2017	1381.61	50	14	8936.26	565.96	186172.00
9/13/2018	1336.42	51	14	8643.95	547.45	180082.39
1/24/2018	1332.48	52	14	8618.48	545.84	179551.71
3/4/2018	1294.89	53	15	8375.35	530.44	174486.44
4/9/2018	1255.47	54	15	8120.37	514.29	169174.34
1/28/2018	1254.89	55	15	8116.64	514.05	169096.77
11/9/2017	1252.59	56	15	8101.75	513.11	168786.47
4/15/2018	1250.82	57	16	8090.33	512.39	168548.46
9/27/2018	1203.77	58	16	7786.01	493.11	162208.50
4/18/2018	1153.20	59	16	7458.93	472.40	155394.27
6/27/2018	1146.30	60	16	7414.24	469.57	154463.38
1/22/2018	1142.21	61	17	7387.84	467.90	153913.30
9/26/2018	1118.23	62	17	7232.72	458.07	150681.62
2/19/2018	1093.33	63	17	7071.67	447.87	147326.51
4/10/2018	1090.07	64	18	7050.60	446.54	146887.51
3/5/2018	1079.06	65	18	6979.34	442.03	145403.02
6/14/2018	1061.34	66	18	6864.76	434.77	143015.83
6/24/2018	1049.45	67	18	6787.83	429.90	141413.21
1/29/2018	1043.97	68	19	6752.38	427.65	140674.49
2/20/2018	1040.39	69	19	6729.27	426.19	140193.18
8/2/2018	1024.76	70	19	6628.14	419.78	138086.32
9/14/2018	1017.92	71	20	6583.88	416.98	137164.24
6/9/2018	1015.39	72	20	6567.55	415.94	136823.97
3/27/2018	1008.90	73	20	6525.58	413.29	135949.49
1/15/2018	1005.93	74	20	6506.37	412.07	135549.28
4/11/2018	974.63	75	21	6303.94	399.25	131332.04
4/19/2018	967.90	76	21	6260.36	396.49	130424.07
3/6/2018	967.37	77	21	6256.97	396.27	130353.54
1/25/2018	963.50	78	21	6231.92	394.69	129831.68
11/22/2017	962.83	79	22	6227.60	394.41	129741.76
8/22/2018	957.30	80	22	6191.81	392.15	128995.99
8/19/2018	941.51	81	22	6089.66	385.68	126867.98
4/12/2018	902.35	82	23	5836.37	369.64	121591.14
6/11/2018	895.63	83	23	5792.96	366.89	120686.69
11/10/2017	876.99	84	23	5672.37	359.25	118174.33
3/7/2018	868.60	85	23	5618.12	355.81	117044.21
6/15/2018	852.52	86	24	5514.12	349.23	114877.41
11/18/2017	845.48	87	24	5468.59	346.34	113928.88
4/13/2018	842.66	88	24	5450.31	345.19	113548.06
9/28/2018	834.77	89	24	5399.28	341.95	112484.94
9/15/2018	833.46	90	25	5390.81	341.42	112308.63
4/20/2018	832.06	91	25	5381.76	340.84	112119.99
8/28/2018	827.19	92	25	5350.28	338.85	111464.13
1/27/2018	819.84	93	26	5302.72	335.84	110473.29

6/28/2018	819.17	94	26	5298.40	335.57	110383.37
1/30/2018	809.61	95	26	5236.54	331.65	109094.58
6/12/2018	805.38	96	26	5209.21	329.92	108525.11
4/14/2018	798.67	97	27	5165.79	327.17	107620.66
6/26/2018	794.52	98	27	5138.96	325.47	107061.77
1/26/2018	789.71	99	27	5107.82	323.50	106412.96
3/8/2018	776.16	100	27	5020.23	317.95	104588.20
7/31/2018	773.84	101	28	5005.17	316.99	104274.37
11/16/2017	772.93	102	28	4999.33	316.62	104152.72
11/23/2017	764.57	103	28	4945.25	313.20	103026.13
4/21/2018	761.89	104	29	4927.91	312.10	102664.70
4/24/2018	748.54	105	29	4841.59	306.63	100866.38
6/10/2018	746.86	106	29	4830.67	305.94	100638.94
4/25/2018	744.08	107	29	4812.73	304.81	100265.18
1/16/2018	738.35	108	30	4775.65	302.46	99492.66
6/17/2018	735.92	109	30	4759.92	301.46	99165.03
11/5/2017	730.38	110	30	4724.12	299.19	98419.25
6/25/2018	726.37	111	30	4698.14	297.55	97877.99
4/22/2018	725.35	112	31	4691.54	297.13	97740.48
9/16/2018	717.27	113	31	4639.33	293.82	96652.67
4/23/2018	713.19	114	31	4612.92	292.15	96102.59
3/9/2018	712.63	115	32	4609.29	291.92	96026.78
11/17/2017	701.97	116	32	4540.31	287.55	94589.89
4/26/2018	698.98	117	32	4521.02	286.33	94187.91
1/31/2018	687.65	118	32	4447.73	281.69	92661.10
11/11/2017	682.31	119	33	4413.21	279.50	91941.77
8/23/2018	678.57	120	33	4389.00	277.97	91437.54
3/10/2018	665.13	121	33	4302.09	272.47	89626.88
11/24/2017	661.07	122	34	4275.77	270.80	89078.57
4/27/2018	658.84	123	34	4261.38	269.89	88778.85
9/29/2018	655.74	124	34	4241.33	268.62	88361.00
8/21/2018	649.71	125	34	4202.32	266.15	87548.23
6/13/2018	648.78	126	35	4196.31	265.77	87423.05
10/6/2018	644.50	127	35	4168.63	264.01	86846.53
9/17/2018	638.52	128	35	4129.96	261.56	86040.81
10/7/2018	635.88	129	35	4112.86	260.48	85684.68
8/20/2018	631.91	130	36	4087.22	258.86	85150.47
6/16/2018	631.63	131	36	4085.36	258.74	85111.68
8/3/2018	626.94	132	36	4055.06	256.82	84480.51
2/1/2018	625.96	133	37	4048.72	256.42	84348.28
6/29/2018	624.89	134	37	4041.78	255.98	84203.71
6/2/2018	624.88	135	37	4041.69	255.97	84201.94
4/28/2018	624.59	136	37	4039.83	255.86	84163.16
3/11/2018	619.76	137	38	4008.60	253.88	83512.59
7/22/2018	614.30	138	38	3973.31	251.64	82777.39
1/17/2018	612.40	139	38	3961.01	250.86	82520.97
11/3/2017	608.22	140	38	3933.96	249.15	81957.57

11/2/2017	604.37	141	39	3909.08	247.58	81439.23
8/16/2018	602.00	142	39	3893.77	246.61	81120.12
6/8/2018	601.90	143	39	3893.09	246.56	81106.01
6/21/2018	600.04	144	40	3881.07	245.80	80855.66
11/25/2017	590.22	145	40	3817.52	241.78	79531.60
6/18/2018	588.46	146	40	3806.18	241.06	79295.35
9/18/2018	587.04	147	40	3796.95	240.47	79103.18
3/12/2018	585.66	148	41	3788.07	239.91	78918.06
7/23/2018	580.44	149	41	3754.30	237.77	78214.59
4/29/2018	579.54	150	41	3748.46	237.40	78092.94
11/12/2017	577.67	151	41	3736.36	236.64	77840.83
8/29/2018	577.29	152	42	3733.91	236.48	77789.70
1/11/2018	573.52	153	42	3709.53	234.94	77281.94
5/23/2018	566.14	154	42	3661.80	231.91	76287.57
8/9/2018	564.43	155	43	3650.72	231.21	76056.61
6/3/2018	558.49	156	43	3612.30	228.78	75256.18
3/13/2018	557.92	157	43	3608.66	228.55	75180.37
9/30/2018	556.34	158	43	3598.42	227.90	74967.04
4/30/2018	544.75	159	44	3523.44	223.15	73404.97
1/18/2018	541.96	160	44	3505.41	222.01	73029.44
9/19/2018	535.33	161	44	3462.51	219.29	72135.57
5/1/2018	532.54	162	45	3444.48	218.15	71760.03
3/14/2018	531.04	163	45	3434.75	217.53	71557.28
2/2/2018	525.15	164	45	3396.67	215.12	70763.91
1/21/2018	522.15	165	45	3377.29	213.89	70360.17
1/19/2018	522.06	166	46	3376.70	213.86	70347.82
5/4/2018	519.39	167	46	3359.43	212.76	69988.16
6/1/2018	517.30	168	46	3345.89	211.91	69706.07
5/2/2018	517.25	169	46	3345.55	211.89	69699.02
3/26/2018	516.24	170	47	3339.04	211.47	69563.26
5/3/2018	514.73	171	47	3329.30	210.86	69360.51
7/21/2018	514.59	172	47	3328.37	210.80	69341.12
3/15/2018	514.04	173	48	3324.82	210.57	69267.07
11/26/2017	507.76	174	48	3284.20	208.00	68420.80
6/30/2018	507.47	175	48	3282.34	207.88	68382.01
10/8/2018	504.62	176	48	3263.89	206.71	67997.67
11/13/2017	500.87	177	49	3239.60	205.17	67491.67
5/5/2018	496.77	178	49	3213.11	203.50	66939.83
8/8/2018	493.22	179	49	3190.18	202.04	66462.04
9/20/2018	491.30	180	49	3177.74	201.26	66202.87
10/1/2018	490.99	181	50	3175.71	201.13	66160.56
3/18/2018	488.59	182	50	3160.22	200.15	65837.92
3/16/2018	487.15	183	50	3150.91	199.56	65643.98
8/24/2018	484.01	184	51	3130.60	198.27	65220.85
11/15/2017	483.48	185	51	3127.13	198.05	65148.56
3/17/2018	478.00	186	51	3091.67	195.81	64409.84
6/20/2018	473.42	187	51	3062.05	193.93	63792.77

5/6/2018	469.53	188	52	3036.92	192.34	63269.14
3/25/2018	464.70	189	52	3005.69	190.36	62618.57
5/22/2018	464.18	190	52	3002.31	190.15	62548.05
5/7/2018	464.10	191	52	3001.80	190.11	62537.47
1/20/2018	460.67	192	53	2979.63	188.71	62075.55
3/24/2018	457.36	193	53	2958.22	187.35	61629.50
2/4/2018	455.27	194	53	2944.68	186.50	61347.41
6/19/2018	451.02	195	54	2917.17	184.75	60774.41
2/3/2018	450.43	196	54	2913.36	184.51	60695.08
5/24/2018	447.64	197	54	2895.34	183.37	60319.54
8/30/2018	445.98	198	54	2884.59	182.69	60095.64
3/19/2018	443.89	199	55	2871.05	181.83	59813.55
9/21/2018	443.86	200	55	2870.88	181.82	59810.02
11/27/2017	443.43	201	55	2868.09	181.65	59751.84
3/22/2018	442.25	202	55	2860.47	181.16	59593.16
9/25/2018	441.01	203	56	2852.43	180.65	59425.67
3/20/2018	438.65	204	56	2837.20	179.69	59108.32
3/21/2018	437.15	205	56	2827.47	179.07	58905.57
5/8/2018	435.84	206	57	2819.00	178.54	58729.26
10/2/2018	435.11	207	57	2814.27	178.24	58630.53
11/4/2017	434.62	208	57	2811.13	178.04	58565.30
11/14/2017	434.23	209	57	2808.60	177.88	58512.41
3/23/2018	433.29	210	58	2802.50	177.49	58385.47
10/9/2018	431.29	211	58	2789.55	176.67	58115.72
12/24/2017	429.60	212	58	2778.64	175.98	57888.29
7/1/2018	428.63	213	59	2772.38	175.58	57757.82
8/4/2018	424.84	214	59	2747.83	174.03	57246.53
5/10/2018	418.74	215	59	2708.40	171.53	56424.95
8/10/2018	417.90	216	59	2702.98	171.19	56312.11
5/9/2018	413.66	217	60	2675.56	169.45	55740.88
9/22/2018	410.64	218	60	2656.01	168.21	55333.61
10/3/2018	409.10	219	60	2646.03	167.58	55125.57
11/28/2017	408.40	220	60	2641.54	167.30	55032.13
2/5/2018	405.80	221	61	2624.70	166.23	54681.28
5/11/2018	405.68	222	61	2623.94	166.18	54665.41
8/25/2018	404.59	223	61	2616.92	165.74	54519.08
10/5/2018	403.87	224	62	2612.26	165.44	54422.11
12/25/2017	398.09	225	62	2574.86	163.07	53642.84
10/4/2018	394.19	226	62	2549.64	161.48	53117.45
7/4/2018	391.89	227	62	2534.74	160.53	52807.15
6/4/2018	387.72	228	63	2507.75	158.82	52244.73
9/24/2018	386.50	229	63	2499.88	158.33	52080.77
9/23/2018	384.63	230	63	2487.78	157.56	51828.65
5/27/2018	380.74	231	63	2462.64	155.97	51305.02
5/12/2018	380.23	232	64	2459.34	155.76	51236.26
7/3/2018	376.93	233	64	2438.01	154.41	50791.97
11/29/2017	375.95	234	64	2431.67	154.01	50659.74

7/2/2018	373.14	235	65	2413.47	152.85	50280.68
7/6/2018	371.92	236	65	2405.60	152.35	50116.72
2/6/2018	369.37	237	65	2389.10	151.31	49772.92
5/13/2018	366.26	238	65	2368.96	150.03	49353.32
5/25/2018	364.02	239	66	2354.49	149.12	49051.83
8/31/2018	363.99	240	66	2354.32	149.11	49048.31
5/14/2018	362.15	241	66	2342.39	148.35	48799.72
9/2/2018	359.82	242	66	2327.32	147.40	48485.89
5/20/2018	357.75	243	67	2313.95	146.55	48207.33
11/30/2017	355.49	244	67	2299.31	145.62	47902.32
5/15/2018	355.18	245	67	2297.28	145.49	47860.00
5/16/2018	351.32	246	68	2272.32	143.91	47339.90
5/26/2018	348.80	247	68	2256.07	142.88	47001.39
2/7/2018	348.07	248	68	2251.33	142.58	46902.66
7/24/2018	346.25	249	68	2239.56	141.84	46657.60
5/19/2018	345.48	250	69	2234.57	141.52	46553.58
5/21/2018	342.83	251	69	2217.39	140.43	46195.68
12/1/2017	342.21	252	69	2213.42	140.18	46112.81
5/17/2018	337.77	253	70	2184.73	138.37	45515.14
9/3/2018	333.71	254	70	2158.41	136.70	44966.82
2/15/2018	331.57	255	70	2144.61	135.83	44679.45
9/1/2018	331.39	256	70	2143.43	135.75	44654.76
5/28/2018	329.53	257	71	2131.41	134.99	44404.41
2/8/2018	326.71	258	71	2113.13	133.83	44023.59
7/5/2018	326.56	259	71	2112.20	133.77	44004.19
5/18/2018	324.94	260	71	2101.71	133.11	43785.57
7/7/2018	323.70	261	72	2093.67	132.60	43618.08
12/2/2017	323.43	262	72	2091.98	132.49	43582.82
12/6/2017	321.84	263	72	2081.65	131.84	43367.73
6/5/2018	321.56	264	73	2079.87	131.73	43330.71
8/5/2018	320.80	265	73	2074.97	131.41	43228.45
2/10/2018	319.93	266	73	2069.30	131.06	43110.32
2/9/2018	317.48	267	73	2053.47	130.05	42780.63
12/5/2017	316.12	268	74	2044.67	129.50	42597.27
2/11/2018	314.43	269	74	2033.75	128.80	42369.84
8/11/2018	313.94	270	74	2030.54	128.60	42302.84
12/26/2017	311.86	271	74	2017.08	127.75	42022.52
12/3/2017	309.79	272	75	2003.71	126.90	41743.95
8/7/2018	306.82	273	75	1984.50	125.68	41343.74
5/31/2018	302.19	274	75	1954.54	123.79	40719.61
9/7/2018	299.61	275	76	1937.87	122.73	40372.29
12/4/2017	298.39	276	76	1930.00	122.23	40208.33
5/29/2018	298.25	277	76	1929.07	122.17	40188.93
6/6/2018	297.33	278	76	1923.14	121.80	40065.52
12/7/2017	296.47	279	77	1917.56	121.45	39949.16
2/12/2018	295.19	280	77	1909.27	120.92	39776.38
5/30/2018	287.73	281	77	1861.03	117.87	38771.43

7/17/2018	286.39	282	77	1852.40	117.32	38591.60
9/4/2018	285.30	283	78	1845.29	116.87	38443.51
6/7/2018	283.58	284	78	1834.20	116.17	38212.54
1/10/2018	281.51	285	78	1820.83	115.32	37933.98
7/8/2018	278.62	286	79	1802.13	114.13	37544.35
12/8/2017	277.92	287	79	1797.56	113.85	37449.14
7/25/2018	276.06	288	79	1785.54	113.08	37198.79
2/14/2018	274.79	289	79	1777.33	112.56	37027.77
1/1/2018	273.43	290	80	1768.53	112.01	36844.41
8/6/2018	272.85	291	80	1764.81	111.77	36766.84
2/13/2018	272.60	292	80	1763.20	111.67	36733.34
1/2/2018	270.18	293	80	1747.50	110.68	36406.28
12/9/2017	269.41	294	81	1742.55	110.36	36303.15
12/23/2017	268.76	295	81	1738.32	110.09	36215.00
8/12/2018	266.68	296	81	1724.86	109.24	35934.67
12/29/2017	266.49	297	82	1723.68	109.17	35909.99
9/5/2018	266.44	298	82	1723.34	109.14	35902.94
12/10/2017	265.22	299	82	1715.47	108.65	35738.97
7/9/2018	257.90	300	82	1668.08	105.65	34751.66
12/11/2017	255.91	301	83	1655.22	104.83	34483.67
12/28/2017	255.87	302	83	1655.00	104.82	34479.14
12/27/2017	252.95	303	83	1636.08	103.62	34085.09
12/12/2017	251.26	304	84	1625.17	102.93	33857.79
12/30/2017	249.63	305	84	1614.60	102.26	33637.41
1/5/2018	249.25	306	84	1612.14	102.10	33586.28
7/10/2018	246.15	307	84	1592.08	100.83	33168.43
9/6/2018	245.79	308	85	1589.80	100.69	33120.83
12/31/2017	244.43	309	85	1580.96	100.13	32936.77
12/13/2017	244.08	310	85	1578.71	99.99	32889.87
12/14/2017	242.63	311	85	1569.32	99.39	32694.17
7/26/2018	237.94	312	86	1539.02	97.47	32062.99
8/13/2018	236.53	313	86	1529.88	96.89	31872.58
12/15/2017	236.37	314	86	1528.87	96.83	31851.43
7/11/2018	233.19	315	87	1508.30	95.53	31423.00
1/4/2018	233.14	316	87	1507.97	95.50	31415.95
12/16/2017	231.02	317	87	1494.26	94.64	31130.34
1/9/2018	229.69	318	87	1485.62	94.09	30950.50
12/17/2017	229.16	319	88	1482.24	93.88	30879.98
7/27/2018	226.78	320	88	1466.84	92.90	30559.10
1/3/2018	226.78	321	88	1466.81	92.90	30558.48
12/18/2017	225.42	322	88	1458.04	92.34	30375.75
8/15/2018	224.86	323	89	1454.40	92.11	30299.94
12/19/2017	224.09	324	89	1449.40	91.80	30195.91
12/20/2017	222.48	325	89	1438.99	91.14	29979.06
7/12/2018	221.54	326	90	1432.90	90.75	29852.12
1/8/2018	221.46	327	90	1432.39	90.72	29841.54
1/6/2018	219.16	328	90	1417.53	89.78	29531.95

12/21/2017	218.42	329	90	1412.76	89.47	29432.51
8/14/2018	217.76	330	91	1408.44	89.20	29342.59
7/28/2018	217.23	331	91	1405.06	88.99	29272.07
12/22/2017	216.38	332	91	1399.56	88.64	29157.47
7/30/2018	215.27	333	91	1392.37	88.18	29007.61
7/18/2018	213.80	334	92	1382.89	87.58	28810.15
7/13/2018	212.13	335	92	1372.05	86.90	28584.48
7/14/2018	205.91	336	92	1331.86	84.35	27747.03
1/7/2018	204.54	337	93	1322.95	83.79	27561.37
11/1/2017	198.68	338	93	1285.06	81.39	26772.05
7/15/2018	197.44	339	93	1277.02	80.88	26604.56
7/29/2018	197.16	340	93	1275.24	80.77	26567.54
7/16/2018	193.51	341	94	1251.63	79.27	26075.65
7/20/2018	193.25	342	94	1249.94	79.16	26040.38
10/12/2017	190.29	343	94	1230.81	77.95	25641.93
7/19/2018	190.06	344	95	1229.29	77.86	25610.20
10/25/2017	185.65	345	95	1200.77	76.05	25016.05
10/26/2017	183.19	346	95	1184.86	75.04	24684.59
10/13/2017	183.03	347	95	1183.84	74.98	24663.43
10/29/2017	178.01	348	96	1151.35	72.92	23986.42
10/28/2017	175.04	349	96	1132.14	71.70	23586.21
10/30/2017	174.87	350	96	1131.04	71.63	23563.29
10/27/2017	174.42	351	96	1128.16	71.45	23503.34
10/14/2017	174.06	352	97	1125.79	71.30	23453.98
10/31/2017	173.18	353	97	1120.12	70.94	23335.85
10/24/2017	172.63	354	97	1116.57	70.72	23261.80
10/16/2017	167.59	355	98	1083.99	68.65	22583.03
10/15/2017	167.25	356	98	1081.78	68.51	22537.19
10/17/2017	165.60	357	98	1071.12	67.84	22315.04
10/18/2017	161.95	358	98	1047.51	66.34	21823.15
10/19/2017	159.75	359	99	1033.29	65.44	21526.95
10/20/2017	156.30	360	99	1010.95	64.03	21061.51
10/23/2017	155.75	361	99	1007.40	63.80	20987.46
10/21/2017	153.85	362	99	995.13	63.02	20731.81
10/22/2017	148.86	363	100	962.80	60.98	20058.32
TOTAL NUMBER OF DAYS FOR PER		363				
	Target Concentration			1.20	0.08	25.00
	Conversion Factor			5.39	5.39	5.39

Date	Flow	NO_3_N (mg/L)	TP (mg/L)	TSS (mg/L)	% Flow Exceed
10/12/2017	190.29	2.6	0.273	51	94.23
11/8/2017	2186.46	2.4	0.125	55	8.24
12/21/2017	218.42	2.9	0.118	60	90.38
1/11/2018	573.52	2.6	0.123	40	42.03
2/13/2018	272.60	3.3	0.101	10	80.22
3/8/2018	776.16	3.4	0.089	34	27.47
4/10/2018	1090.07	2.9	0.123	29	17.58
5/10/2018	418.74	2.1	0.072	29	59.07
6/12/2018	805.38	4.5	0.199	58	26.37
7/10/2018	246.15	2.2	0.128	10	84.34
8/9/2018	564.43	3.3	0.14	17	42.58
9/11/2018	5095.14	3	0.213	22	2.75
10/9/2018	431.29	2.6	0.273	49	57.97
11/8/2018	0				0
Conversion Factor		5.39	5.39	5.39	

NO3 Act Load	TP Act Load	TSS Act Load	Ann Load Proxy Range
2666.761009	280.0099059	52309.54287	27
28283.98275	1473.124102	648174.6047	43
3414.171163	138.9214473	70638.02406	21
8037.321374	380.2271266	123651.0981	33
4848.80063	148.402686	14693.33524	23
14223.99478	372.3339811	142239.9478	33
17038.9515	722.6865634	170389.515	30
4739.695476	162.5038449	65452.93752	33
19534.51946	863.8598605	251778.2508	28
2918.822055	169.8223741	13267.37298	30
10039.47254	425.9170169	51718.49491	33
82388.46091	5849.580725	604182.0467	28
6044.034869	634.6236613	113906.811	30

	NO_3 Ann Load	TP Ann Load	TSS Ann Load
	72002.54724	7560.267461	1412357.657
	1216211.258	63344.33637	27871508
	71697.59442	2917.350394	1483398.505
	265231.6054	12547.49518	4080486.236
	111522.4145	3413.261777	337946.7106
	469391.8279	12287.02138	4693918.279
	511168.5449	21680.5969	5111685.449
	156409.9507	5362.626881	2159946.938
	546966.5448	24188.07609	7049791.022
	87564.66164	5094.671222	398021.1893
	331302.5939	14055.26156	1706710.332
	2306876.906	163788.2603	16917097.31
	181321.0461	19038.70984	3417204.33
TOTAL	6,327,667.5	355,277.9	76,640,072.0
TARGET	2,186,165.0	138,457.1	45,545,103.6

Gage Estimate: Uses gaging data scaled for the entire watershed and IDEM fixed station data

Big Blue @ Gage	NO_3 Ann Load	TP Ann Load	TSS Ann Load
TOTAL	6,327,667.5	355,277.9	76,640,072.0
TARGET	2,186,165.0	138,457.1	45,545,103.6

<--reflects TSS target of25 mg/L rather than the 15 mg/L target previously listed here

Scaled: Lower Big Blue	NO_3 Ann Load	TP Ann Load	TSS Ann Load
TOTAL	2,630,265.59	147,680.85	31,857,512.10
REDUCTION	1,721,527.18	90,127.42	12,925,461.89
TARGET	908,738.41	57,553.43	18,932,050.20
% Reduction	65%	61%	41%

	Area (sq mi)
BigBlue @Gage	421
Lower Big Blue	175
Lower Big Blue @ fixed station	107.8

Lower Big Blue	NO_3 Ann Load	TP Ann Load	TSS Ann Load
10 year goal			
TOTAL	2,630,265.59	147,680.85	31,857,512.10
REDUCTION	573,842.39	30,042.47	4,308,487.30
TARGET	2,056,423.19	117,638.38	27,549,024.80
% Reduction	22%	20%	14%
20 year goal			
TOTAL	2,056,423.19	117,638.38	27,549,024.80
REDUCTION	573,842.39	30,042.47	4,308,487.30
TARGET	1,482,580.80	87,595.91	23,240,537.50
% Reduction	28%	26%	16%
30 year goal			
TOTAL	1,482,580.80	87,595.91	23,240,537.50
REDUCTION	573,842.39	30,042.47	4,308,487.30
TARGET	908,738.41	57,553.43	18,932,050.20
% Reduction	39%	34%	19%

Appendix D: Subwatershed Data

Subwatershed Name	Anthony Creek-Six Mile Creek	DePrez Ditch-Big Blue River	Foreman Branch-Big Blue River	Headwaters Six Mile Creek	Nameless Creek	Prairie Branch-Big Blue River	Shaw Ditch-Big Blue River
HUC	51202040802	51202040806	51202040805	51202040801	51202040803	51202040804	51202040807
Area (acres)	18,340	17,910	24,792	10,818	10,516	11,149	18,766
% of Watershed	16.3%	15.9%	22.1%	9.6%	9.4%	9.9%	16.7%
Watershed (sq mi)	28.6	27.9	38.7	16.9	16.4	17.4	29.3
Stream (miles)	38.0	43.3	48.2	19.6	17.7	21.5	45.3
Impaired Fish 5B (miles)	0	0	0	0	0	0	0
Impaired ALUS 5A (miles)	0	0	0	0	0	0	0
Impaired RECR 4A (miles)	0	0	0	0	0	0	0
Impaired ECOLI 4A (miles)	38.0	40.6	48.1	15	17.7	21.5	45
Impaired RECR 5A (miles)	0	0	0	0	0	0	0
Impaired ECOLI 5A (miles)	0	0	0	0	0	0	0
	100%	94%	100%	76%	100%	100%	98%
Impaired Nutr 5A (miles)	0	0	0	0	0	0	0
Impaired PCBs 5B (miles)	0	9.9	0	0	0	0	26.7
HES (acres)	3,975.9	147.8	208.7	1,870.8	2,125.8	2,051.9	657.0
HES (%)	21.7%	0.8%	0.8%	17.3%	20.2%	18.4%	3.5%
PHES (acres)	1,511.9	1,095.9	2,859.3	703.9	16.2	607.7	3,778.7
PHES (%)	8.2%	6.1%	11.5%	6.5%	0.2%	5.5%	20.1%
Wetland Loss (acres)	92%	78%	82%	96%	96%	88%	43%
NWI Current (acres)	323.3	961.0	1,128.9	163.8	138.4	354.1	1,365.5
NWI Current (%)	1.8%	5.4%	4.6%	1.5%	1.3%	3.2%	7.3%
Hydric (acres)	4,087.8	4,320.4	6,400.9	3,893.4	3,367.8	2,957.0	2,378.3
Hydric (%)	22.3%	24.1%	25.8%	36.0%	32.0%	26.5%	12.7%
Septic-VeryLimited	18,281.1	17,409.4	24,128.6	10,751.4	10,488.1	11,077.3	18,068.5
Septic-VL (%)	99.7%	97.2%	97.3%	99.4%	99.7%	99.4%	96.3%
CFO (animals)	4	2	0	0	1	0	0
Hobby Farm (count)	17	17	17	22	9	13	19
Hobby Farm (animals)	279	197	149	170	66	130	151
Manure estimate (tons)	67039	11622	3157	3306	5875	2740	2861
Manure N estimate (lb)	188633	26840	1571	1938	16593	1412	1710
Manure P estimate (lb)	141835	19885	780	974	12378	696	918
MS4 area							

Subwatershed Name	Anthony Creek-Six Mile Creek	DePrez Ditch-Big Blue River	Foreman Branch-Big Blue River	Headwaters Six Mile Creek	Nameless Creek	Prairie Branch-Big Blue River	Shaw Ditch-Big Blue River
Livestock Access (miles)	2.5	0.3	2.2	0.0	0.0	0.8	0.0
Streambank Erosion (miles)	9.9	12.6	19.7	6.4	5.9	9.8	12.3
Gully Erosion (miles)	2.7	0.0	10.0	1.4	1.6	1.8	1.5
Narrow Buffer (miles)	1.9	5.0	4.9	1.8	0.8	1.7	0.0
Land Use (acres)	18,340.4	17,900.9	24,780.9	10,818.3	10,516.3	11,143.9	18,766.2
Ag - Row +Pasture	15,445.1	13,926.7	20,450.6	9,225.7	9,149.8	9,738.0	14,558.7
Forest	1,566.4	1,255.6	1,689.6	484.5	562.9	721.9	2,716.9
Wetland + Open water + grass	180.9	309.1	655.0	225.3	106.5	206.4	348.1
Urban	1,148.0	2,409.5	1,985.7	882.8	697.1	477.6	1,142.5
Land Use (%)							
Ag - Row +Pasture	84.2%	77.8%	82.5%	85.3%	87.0%	87.4%	77.6%
Forest	8.5%	7.0%	6.8%	4.5%	5.4%	6.5%	14.5%
Wetland + Open water + grass	1.0%	1.7%	2.6%	2.1%	1.0%	1.9%	1.9%
Urban	6.3%	13.5%	8.0%	8.2%	6.6%	4.3%	6.1%
Open Dump	0	0	1	0	0	0	0
Brownfield	0	2	0	1	0	0	0
CorrectiveAction	0	0	0	0	0	0	0
VRP	0	0	2	1	0	0	0
NPDES	0	1	6	2	0	0	2
LUST	0	20	8	3	0	0	4
Waste Industrial	0	11	2	0	0	0	2
Waste Septage	0	0	0	0	0	0	1
Waste Solid	0	1	1	0	0	0	1
Superfund	1	0	0	0	0	0	0
Logjam	0	0	0	0	0	0	0
Trash Area	0	0	1	0	1	0	3